

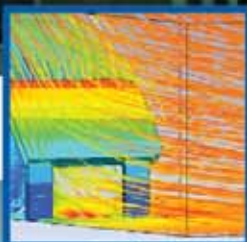
EnginSoft International Conference 2009

500 attendees from around the globe, from various industries, research and academic institutions came together to hear and discuss how CAE Computer Aided Engineering and Virtual Simulation Technologies can innovate and perfect today's product development

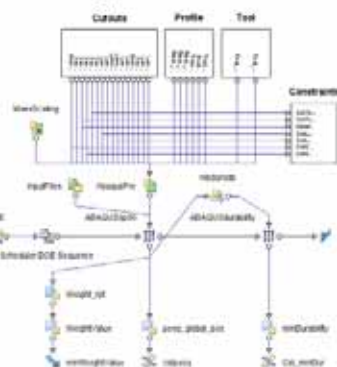
Designing low-emission cars with modeFRONTIER and Sculptor: external shape aerodynamic optimization



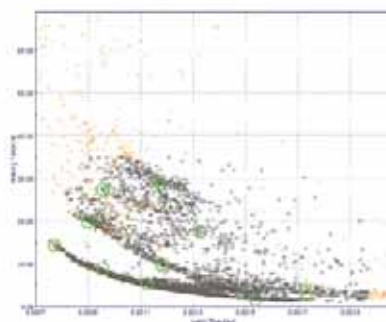
Solar Industry, numerical simulation and optimization



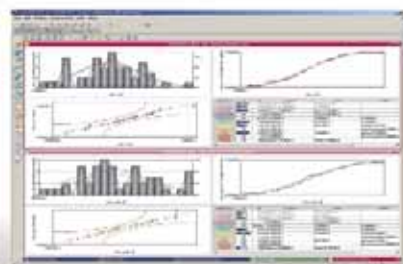
Multi-objective optimization of an aluminium automotive part using modeFRONTIER

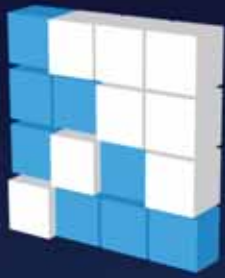


Optimization software drives Multi Body simulations in a Circuit Breaker design at ABB



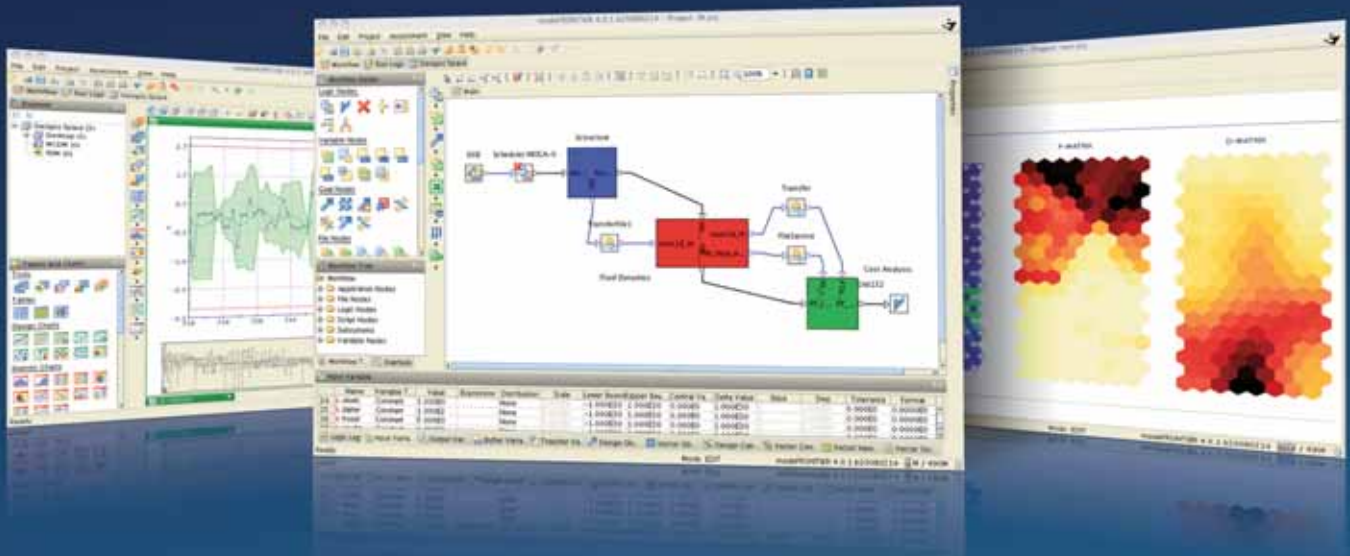
The optimal solution of
a mixture problem
with modeFRONTIER



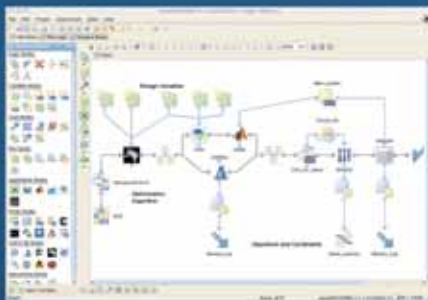


modeFRONTIER®

the multi-objective optimization and design environment



modeFRONTIER® is a multi-objective optimization and design environment written to allow easy coupling to almost any computer aided engineering (CAE) tool.



Process Automation

The user-friendly GUI allows all the software tools in use to be linked together, to create an integrated CAE environment.



Optimization Algorithms

Whether the problem is single or multi-objective, modeFRONTIER® offers a wide variety of state-of-the-art algorithms, ranging from Simplex and Derivative Methods to Genetic Algorithms, Particle Swarm and Game Theory.



Post Processing

The user can take advantage of the advanced post-processing toolkit to create multi-dimensional plots and perform sophisticated statistical analyses, giving more insight into results. The automatic report generator is ideal for project documentation.



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Newsletter EnginSoft Year 6 n°3 - Autumn 2009

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EnginSoft Flash

Autumn is always a busy time for everyone involved in CAE and Technology. It is also a time when we start reflecting on the past months and how our lives and businesses have evolved since the beginning of the year.

EnginSoft, our Community and Teams, just returned from Bergamo where the EnginSoft International Conference 2009 and ANSYS Italian Conference took place. The Event and the interest of the 500 attendees from around the world showed, more than ever before, that CAE and Virtual Prototyping, complemented with expertise in engineering and simulation, are indispensable for competitive product design in today's fast changing global environment.

This Edition of the Newsletter features a Conference Review and articles on some of the topics which were presented in Bergamo, for example: ABB and the use of Optimization for Circuit Breaker Design in Switzerland and Germany, or the developments in the frame of the Norwegian Research Program AluPart which A-Dev Norway, SINTEF Raufoss Manufacturing and EnginSoft ESTECO Nordic are conducting. It also brings to our readers application knowledge from the Renewable Energy sector about the use of Numerical Simulation and Optimization in Solar Panel design.

We are proud to present an interview which we have had the pleasure to conduct with Mr Barberis of Ansaldo Energia Italy. Mr Barberis is one of the pioneers in the use of ANSYS. His experiences date back to the 70's and have enriched EnginSoft's Team and expertise through the years. Livio Furlan, EnginSoft's Technical Manager, speaks about his 20 years with the company and shares his inspirations for life and work with us !

...talking about life, we also show you how to find optimal solutions with modeFRONTIER, even for your apple pie !



Ing. Stefano Odorizzi
EnginSoft CEO and President

EnginSoft is growing its CAE product portfolio and gladly announces a new Distribution Relationship with Optimal Solutions Software to offer Sculptor, a leading CAE/CAD model deformation and optimization tool in Europe. Further software news emphasize the capabilities of ANSYS 12, the Diffpack Expert Tools by inuTech Germany and the Anybody Technologies for Ergonomics from Denmark. Linflow, a Fluid Structure Interaction FSI software, is brought to us from ANKER-ZEMER AB Sweden. Barbalab and CST Italy are outlining a case study on a reciprocating gas compressor.

We are also striving for a better sound environment - our Japan Column, this time, presents WAON, a FMBEM solution for acoustic analysis from Cybernet Systems Co.,Ltd. Japan's cultural richness is reflected in the article about Sho, the art of drawing characters as masterly done by Ms Shizu Usami, a famous, contemporary calligrapher.

Many more contributions and information on events, projects, are included which we hope our readership will enjoy.

To me and to the Editorial Team, this is already a special Edition of the Newsletter as it features the pioneers and the "youngest" users of CAE, the first clients of EnginSoft, such as the SCM Group Spa and Ansaldo Energia, and our latest involvement in the CAE business in Europe, the USA and Japan.

It is also a special edition in remembrance of Professor Olek Zienkiewicz, a founder of the Finite Element and Simulation sectors, to whom we pay tribute for his outstanding achievements and commitment to what has become our today's working environment.

Stefano Odorizzi
Editor in chief

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R&D e Trasferimento Tecnologico: sinergie tra pubblico e privato a livello regionale per l'innovazione e la competitività delle imprese

Lo scorso 1 ottobre, nel corso della Conference EnginSoft 2009 "Le tecnologie CAE nell'industria" si è tenuta la seconda edizione della Sessione dedicata alla Ricerca, Sviluppo e Trasferimento Tecnologico.

La Sessione, alla quale hanno partecipato un centinaio di persone, è stata dedicata all'analisi di come le sinergie tra pubblico e privato, anche e soprattutto attraverso l'utilizzo di strumenti di co-finanziamento di tipo "regionale", siano in grado, in un tessuto industriale come quello italiano caratterizzato da una fortissima presenza di PMI e sviluppato in Distretti Industriali, di contribuire efficacemente alla competitività delle imprese ed allo sviluppo dell'economia del territorio.

Tra gli strumenti di co-finanziamento dei progetti di Ricerca, Sviluppo, Competitività ed Innovazione il più importante, nei vari contesti regionali, è sicuramente il FESR (Fondo Europeo di Sviluppo Regionale) che metterà a disposizione del PON Ricerca e Competitività (Piano Operativo Nazionale), e, in cascata, dei vari POR (Piani Operativi Regionali) circa 3.100 milioni di Euro per il periodo 2007-2013. La peculiarità di questo Fondo, e, a parer nostro, la vera ragione del suo successo, almeno in termini di sprone alla propositività (delle Regioni e dei vari soggetti potenzialmente beneficiari del co-finanziamento di progetti di R&D) è che i co-finanziamenti verranno elargiti soltanto alla conclusione dell'iter che comprende la pubblicazione di Bandi specifici e la relativa fase di valutazione delle proposte progettuali da parte delle strutture competenti delle varie Regioni. In sintesi le Regioni sono fortemente spinte a pubblicare i Bandi, altrimenti non ricevono la quota di Fondi a loro destinata in sede di programmazione.

I fondi del FESR hanno così avuto il positivo effetto di spronare ad agire nella giusta direzione le Regioni che non hanno (o non avevano) nelle loro politiche una grande attenzione per la Ricerca e Sviluppo (volgarmente traducibile in un valore basso della quota del PIL o del bilancio regionale destinata allo scopo) e di sommare risorse importanti a quelle già destinate allo scopo dalle Regioni più "lungimiranti" (es. Provincia Autonoma di Trento, Regione Lombardia, Regione Puglia, Regione Piemonte, e poche altre).

Nel corso della Sessione sono state esposte, da speaker di assoluto rilievo nel rappresentare le diverse tipologie di attori coinvolti in questi processi sinergici (Enti Istituzionali, Centri di Ricerca, Agenzie di Sviluppo, Consorzi e Imprese private), le esperienze maturate in diversi contesti regionali: Lombardia, Puglia, Trentino, Veneto, Emilia Romagna e Toscana.

Esperienze che vanno dalle aggregazioni di imprese private che hanno deciso di investire insieme in attività di R&D (nella meccatronica) come il Consorzio Intellimech che opera all'interno del Parco Tecnologico Kilometrorosso di Bergamo, alle aggregazioni tra imprese private e soggetti pubblici intorno ad uno specifico Settore Industriale, come il neonato Distretto Tecnologico Aerospaziale di Brindisi. E' stato presentato anche il "Sistema Trentino", con i vari strumenti a supporto della Ricerca & Sviluppo e del Trasferimento Tecnologico per la competitività e l'innovazione delle imprese: nel 2007 la Provincia Autonoma di Trento ha destinato per R&D il 2,54% degli stanziamenti totali, circa 200Euro/abitante, quota decisamente superiore alla media italiana (pari a circa 160Euro/abitante) ed in linea con le migliori realtà territoriali dell'Europa a 15.

Due presentazioni (Università di Trento e di Padova) sono state dedicate alle modalità con le quali da un'idea si può passare ad un'impresa e ad illustrare lo strumento dello spin-off della ricerca e le altre vie per il trasferimento di tecnologia tra università ed imprese.

Altre due presentazioni hanno evidenziato gli sforzi e le modalità con il quale due realtà pubbliche (o di derivazione pubblica) come l'ENEA di Brindisi (in particolare nel settore dell'Edilizia Sostenibile) ed il CINECA (il più grande centro per Calcoli ad Elevate Prestazioni d'Italia e tra i primissimi in Europa) cercano di fornire supporto per la ricerca, il trasferimento tecnologico e l'innovazione alle imprese.

Le ultime due presentazioni sono state dedicate a due esempi concreti di come l'utilizzo di strumenti di co-finanziamento regionali abbiano contribuito a far cooperare imprese di grandi, medie e piccole dimensione in attività di ricerca e sviluppo e su tematiche innovative altrimenti difficilmente seguite (in termini di priorità di investimenti) in un contesto di crisi economica come quello attuale.

In sintesi crediamo, e ci auguriamo, che l'obiettivo che ci eravamo posti per la sessione R&D di fornire agli intervenuti un quadro d'insieme dei vari approcci utilizzati a livello regionale per supportare l'innovazione delle imprese attraverso la ricerca e sviluppo, evidenziando gli aspetti comuni ed esponendo esempi di best practice, sia stato raggiunto. Al centinaio di persone intervenute l'ardua sentenza.

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ENGINSOFT INTERNATIONAL CONFERENCE 2009

CAE Technologies for Industry and ANSYS Italian Conference 2009

1-2 OCTOBER
BERGAMO-IT

During the first days of October 2009, the city of Bergamo in Northern Italy, saw one of the largest gatherings of Virtual Simulation experts in the world. As many as 500 attendees from around the globe, from various industries, research and academic institutions came together to hear and discuss how CAE Computer-Aided Engineering and Virtual Simulation Technologies can innovate and perfect today's product development.

EnginSoft and ANSYS Italy had the great pleasure to welcome a most diverse audience of new simulation users and longtime experts, of industrial and academic professionals, researchers, CAE software developers and vendors, and engineers from nearly all disciplines.

They all brought an immense wealth of engineering and simulation expertise to the International Conference which will be remembered as a milestone and turning point for the simulation community in challenging times.

To many in the business and in attendance, the Conference

motto: "CAE Technologies for Industry" means first of all: Fast ROI Return on Investment has never been more important!

In this spirit, the Plenary Speakers representing some of the world's leading engineering simulation technology providers: ANSYS, Flowmaster, ESTECO, Optimal Solutions Software, MAGMA, enthused the audience from the very beginning with highly innovative views and advancements. The subsequent parallel sessions featured applications of virtual simulation software and user knowledge across a variety of industrial sectors: Aerospace, Automotive, Oil&Gas, Marine, MCC, Power and Turbo, Industry Equipment. Attendees could experience the latest technology advancements in hands-on sessions in the Demo Room. What has always been clear for all those involved in Simulation and CAE, became even more evident in Bergamo: the implementation and application of state-of-the-art simulation tools in industry and research is indispensable in order to:



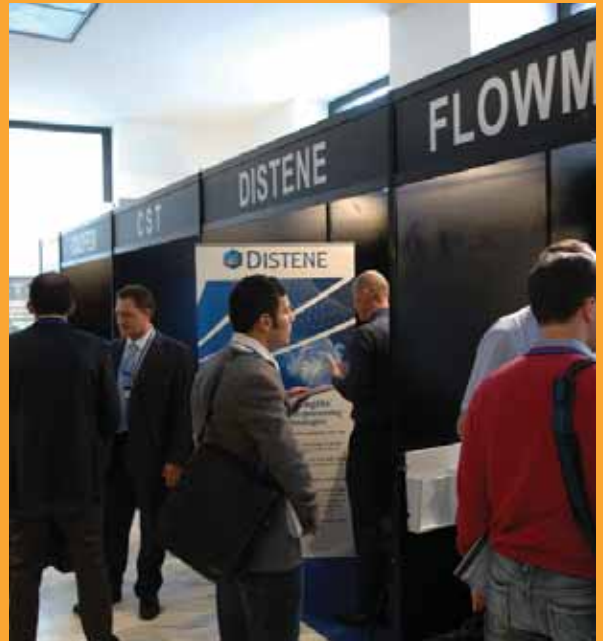
THANKS TO THE 500 PARTICIPANTS!

- leverage knowledge and potentials
- speed up and perfect product and development processes
- achieve savings in time and resources
- stay competitive in an ever increasing global market.

As in the past, the accompanying exhibition served as a networking forum to discuss applications, technology advancements, gain new insights, share experiences and find new business partners.

EnginSoft and ANSYS proudly welcomed Microsoft, E4 Computer Engineering and INTEC as Gold Sponsors, NAFEMS as the official patron of the event, and as exhibitors: CADFEM, CST, DISTENE, ELYSIUM, ESTECO, E-Xstream Engineering, FIGES, Flowmaster, Fraunhofer Institute for Algorithms and Scientific Computing SCAI, Intelligent Light, MAGMA, HP, Tecniche Nuove, The MathWorks, Transvalor...

The global approach of the 2009 Conference is a reflection of EnginSoft's growing presence in Europe and the USA and the company's major international collaborations. EnginSoft supports a wide network of experts consisting of key industrial companies, research centers and universities that maintain leading roles in their respective fields. The efforts of EnginSoft and its partners aim at fostering and strengthening the global CAE community in a true spirit of innovation.



CONFERENCE PROCEEDINGS

To download the Conference Proceedings, please register via the following link:
www.enginsoft.com/proceedings



ENGINSOFT INTERNATIONAL CONFERENCE 2009

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BERGAMO-IT

A dispetto della crisi dell'economia, e delle restrizioni che le aziende tendono a porre alla partecipazione di proprio personale a conferenze e convegni, l'annuale conferenza internazionale di EnginSoft sulle "Tecnologie CAE per l'industria" – condotta assieme alla conferenza italiana degli utilizzatori di ANSYS – è stata un successo di pubblico. Il Centro Congressi Giovanni XIII di Bergamo ha ospitato, infatti, nei giorni 1 e 2 ottobre scorsi, oltre 500 tra relatori ed uditori ed oltre 20 espositori.

Nella relazione introduttiva, Stefano Odorizzi, presidente di EnginSoft - oltre a porgere il benvenuto a tutti, ed, in particolare, al gran numero di partecipanti stranieri provenienti dai Paesi Europei, dagli Stati Uniti, e dal Giappone – ha rimarcato che il convegno del 2009 segna un doppio anniversario: il 25-ennale dalla fondazione di EnginSoft, ed il 25-ennale dalla prima edizione della conferenza internazionale ("First International Conference

on Engineering Software for Microcomputers", tenutasi all'Isola di San Giorgio a Venezia, nell'ottobre del 1984). E' un anniversario carico di significato perché pone in evidenza come EnginSoft abbia accompagnato l'evoluzione del CAE in Italia a partire dai tempi pionieristici dei metodi di simulazione al computer, non solo offrendo alle aziende con cui ha collaborato e collabora tecnologie d'avanguardia, competenza professionale, ed attenzione all'utilità, alla correttezza ed all'affidabilità delle applicazioni, ma sostenendo anche, costantemente, il ruolo imprescindibile delle conoscenze.

Nella sessione plenaria del convegno hanno poi parlato i referenti delle principali tecnologie sostenute da EnginSoft: ANSYS, modeFRONTIER, Flowmaster e MAGMASoft. Ha chiuso la sessione Tim Morris, direttore centrale di NAFEMS, l'associazione internazionale che si occupa della corretta applicazione industriale dei software per il CAE.

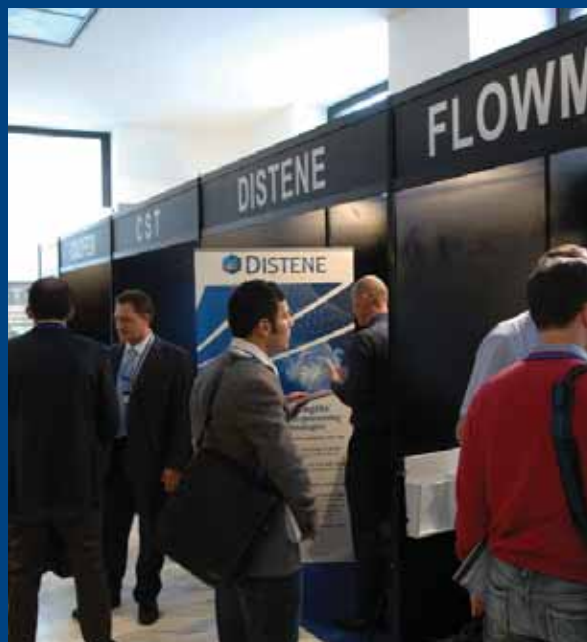


THANKS TO THE 500 PARTICIPANTS!

Nelle successive, distinte sessioni, sono state presentate un centinaio di relazioni – contribute da esponenti del mondo dell'industria, dell'università e della ricerca – consentendo agli intervenuti di scegliere propri percorsi di aggiornamento secondo una matrice a due chiavi di lettura: quella delle tecnologie abilitanti, e quella del settore industriale di destinazione.

Frequentatissima è stata anche la sessione dedicata alla ricerca co-finanziata, sia per l'illustrazione di alcuni, notevolissimi progetti in corso, sia, soprattutto, per l'informazione sulle diverse opportunità offerte a livello internazionale, nazionale e locale.

Nell'insieme – a sommosso parere degli organizzatori – il convegno ha rispettato e, forse, superato le attese offrendo a tutti non solo un'occasione unica di aggiornamento su quanto riguarda il CAE – e, più in generale la sperimentazione virtuale e le discipline a questa connesse – nell'ottica delle applicazioni industriali, ma anche la vivacità, l'entusiasmo, ed il calore che - forse riscoperti ogni anno con stupore – caratterizzano lo stile di EnginSoft.



ATTI DELLA CONFERENZA

Per scaricare gli atti della Conferenza si prega di effettuare una registrazione all'indirizzo:
www.enginsoft.com/proceedings



Intervista ad Ubaldo Barberis, responsabile del calcolo scientifico in Ansaldo

Ubaldo Barberis, laureato in Ingegneria Nucleare nel 1971, dopo una breve esperienza come assistente incaricato alla cattedra di "Calcolo e Progetto di Macchine" del Politecnico di Torino, ha sempre lavorato in Aziende del gruppo Ansaldo (Finmeccanica): Nucleare, Ricerche e Power Energy come analista strutturale e responsabile del calcolo scientifico, FEM in particolare.

In questo ruolo ha curato l'implementazione, la promozione e l'utilizzo di ANSYS all'interno delle aziende del gruppo fin dal 1979, anno in cui Ansaldo divenne il primo gruppo industriale italiano utente del software.

Negli anni 90 è stato anche Professore a Contratto per 3 anni della Cattedra "Analisi strutturale con l'elaboratore Elettronico" presso la facoltà di Ingegneria dell'Università di Perugia e per 5 anni della cattedra "Progettazione assistita di Strutture Meccaniche" al Politecnico di Torino.



1) Ing. Barberis: come è cambiata la figura dell'analista strutturale negli ultimi 30 anni nelle aziende di medie-grandi dimensioni come quelle in cui ha lavorato?

E' cambiata molto: negli anni 70 e ancora nei primi anni 80 si lavorava in prevalenza con le schede e i tabulati a modulo continuo, con hardware limitato, servers remoti, linee di comunicazione lente e attese estenuanti; spesso era necessario disporre del source del software da modificare ad hoc anche solo per normali esigenze di post processing. Era allora necessario avere ottime competenze di informatica perchè bisognava guidare una pesante locomotiva senza sbagliare nelle richieste di RAM o nella perforazione dell'input allorchè un errore anche minimo significava ore e ore sprecate. Il bravo analista sapeva trarre il massimo delle informazioni da una sola analisi ben costruita, ma il metodo era più un metodo di verifica che di progettazione.

Oggi l'interattività e la potenza dell'hardware consentono di provare e confrontare infinite soluzioni con poco sforzo e in breve tempo, trasformando il FEM in un vero strumento di progettazione, esaltando la creatività dell'analista. E' tuttavia talvolta forte la tentazione di provare anche un pò a caso e, da bravi figli di Windows, pretendere il suggerimento della soluzione definitiva dal software. Però il FEM non è CAD: occorre sapere dove si vuole arrivare, con quale precisione, giudicare la qualità dell'output ottenuto e allora ci vuole più preparazione teorica a livello ingegneristico, più capacità di comunicazione con chi ti propone il problema o il calcolo di verifica, conoscenza degli algoritmi più complessi (contatti,

non linearità, ecc.) perchè la risposta è sì in real time ma rimane in virtual solution, sempre da verificare con la realtà.

2) Esiste la figura del FEM manager e quale è il suo ruolo in azienda?

Era più facile fare il manager quando c'erano i servers, si aggiornavano univocamente le nuove releases, si poteva controllare chi usava il software e come, si riusciva ad analizzare le necessità dell'utenza e standardizzare su questa base l'uso del software; oggi l'informatica distribuita (e dispersa...) nei vari PCs rende il calcolo scientifico e il FEM settori dove è più

difficile avere una politica aziendale, fare proposte concrete di investimenti e risorse a responsabili di progetto o di prodotto che hanno in genere pochissime conoscenze in questo campo. E allora, in questa frammentazione, prima che di un manager l'azienda deve avere un tutor (persona o gruppo di lavoro), un referente con capacità di comunicazione, conoscenza dei campi di applicazione, suggeritore di soluzioni volanti; un server in carne ed ossa abile a interagire, capire, tradurre perchè chi espone i problemi spesso non li sa proporre in modo corretto. E' vero: può essere difficile per le grandi imprese con i dipartimenti decentralizzati anche in sedi remote, ma oggi i mezzi di comunicazione sono potenti: intranet, vpn, videoconferenza e allora il salto di qualità è più di mentalità che di tecnologia.

3) Il software FEM in che modo è un investimento per l'azienda?

Il software FEM in un'azienda di medie-grandi dimensioni è un investimento da programmare bene come lo è l'architettura di una catena di montaggio che deve tener conto non solo del



prodotto finale ma della razionalizzazione della manutenzione, dell'interfaccia con l'operatore, della robustezza del funzionamento senza interruzioni e pause impreviste.

In termini economici l'investimento nel software si rivela consistente quando pensiamo ai costi delle licenze, ma soprattutto al tempo che vi viene dedicato. E' difficile tornare indietro se si sbaglia nelle scelte e nello stesso tempo bisogna saper decidere rapidamente in tal senso se diventa necessario. Ci sono i costi nascosti: l'obsolescenza, la mentalità dei progettisti non sufficientemente idonea; non ci si può fidare dell'esperienza degli altri, non ci si può affidare in toto a un consulente che non può conoscere

bene i nostri metodi di progettazione e i nostri prodotti: il consulente ti può dare delle buone indicazioni ma alla fine bisogna decidere consapevolmente da soli e prima di

tutto dotarsi delle infrastrutture adeguate in termini di hardware e anche di brainware di chi ci dovrà lavorare. Dentro il FEM ci sono redini invisibili per guidare e organizzare i nostri uffici di progettazione, ma questo non lo spiegano ancora bene i corsi universitari di Ingegneria Gestionale.

4) La formazione è dunque un aspetto importante dell'investimento nel software FEM. Per lei che ha anche esperienze di insegnamento all'interno e all'esterno dell'industria, come va impostato il training degli analisti FEM?

Guardi, secondo me è molto difficile organizzare oggi un buon corso FEM. Il percorso del training è sulla struttura del codice di calcolo ma è anche sulla struttura dell'azienda e del prodotto da progettare e/o verificare. Anzitutto bisogna sapere bene a chi rivolgerlo: beginners, experts, managers; a ciascuno di loro dare le best practises del suo ruolo e interessare tutti i partecipanti nel modo giusto. A differenza di qualche anno fa, oggi i giovani arrivano dall'università con buone cognizioni di base sugli elementi finiti e anche i corsi per principianti ne devono tenere conto senza annoiarli con nozioni tecniche ripetute ma, semmai, mostrando la capacità del software ad accreditare quelle nozioni che in questo modo vengono anche fornite a chi non le ha.

Per gli esperti invece il training dovrebbe essere sempre "interno" (non necessariamente nel senso fisico della parola) per finalizzarlo agli strumenti disponibili, alle applicazioni specifiche a cui è rivolto, alle potenzialità reali introdotte

dalle nuove releases. Così l'istruttore dovrebbe essere sempre almeno parzialmente cosciente dei campi di applicazione, dei problemi aziendali – soprattutto i più attuali - che ci si aspetta di risolvere con il software FEM.

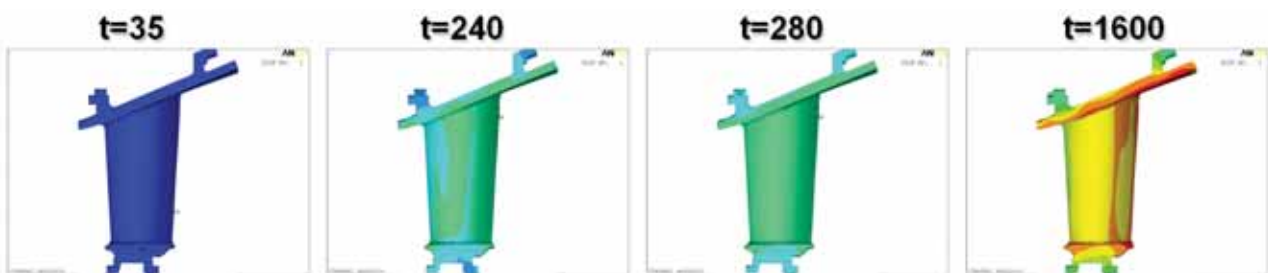
Alle software houses invece bisogna chiedere di più nella formazione a distanza on line: organizzare bene un portale specifico per il training (quello di ANSYS con i suoi animated tutorials, la documentazione ben organizzata, le technotes, le segnalazioni di errore, i tips and tricks... è esemplare) perchè in questa era telematica è l'utente in prima persona che cerca l'informazione nel momento e nel luogo in cui ha voglia e modo di cercarla; spesso l'utente cerca informazione e trova formazione riuscendo così ad apprendere nel modo a lui più congeniale. Questo vale poi in particolare per gli utenti delle piccole imprese che non troveranno mai i 2 giorni disponibili per un corso "completo" lontano dall'azienda, nè tantomeno potranno pensare a un corso "interno" organizzato per i propri prodotti e le proprie esigenze

5) I brokers sono protagonisti di rilievo in questo contesto, come vede il loro ruolo oggi?

Oggi un general purpose FEM è un prodotto molto complesso articolato in moduli diversi; l'utente deve capire cosa gli serve ma, senza esperienza diretta, non sa leggere i cataloghi del software e deve essere aiutato ad acquisire solo ciò che userà veramente.

Il broker ci introduce un suo grande amico -il software- a cui presentiamo i nostri vecchi amici –i nostri dati- ma bisogna conoscerli bene entrambi per farli relazionare in perfetta armonia. Io mi aspetto che questi mediatori vengano ad aggiornarsi spesso sulle mie necessità; mi diano l'assistenza in tempo reale anche sulla disciplina ingegneristica sia pur solo con dei link a qualche istituto di ricerca o Università disposti ad ascoltarmi. Devono favorire le relazioni tra utenti: FEM è una delle discipline in cui quando risolvi un problema sei felice di mostrare la soluzione a chi la può capire. Devono aiutarmi a configurare sul loro prodotto il patrimonio dei miei dati aziendali: le caratteristiche dei materiali, il feedback dell'esercizio per esempio, altrimenti è tutta progettazione virtuale.

Mi rendo conto di descrivere il profilo di un broker tecnologico sul corpo di un broker commerciale ma in questo campo le aziende vogliono acquisire più un servizio, una collaborazione che un prodotto usa e getta a prezzo scontato: attenzione perciò alle distinzioni troppo nette tra ufficio tecnico e ufficio commerciale.



Analisi Termica in Transitorio



Nuove funzionalità per la simulazione dei contatti in ANSYS 12

1. Il problema del contatto

Nelle analisi di componenti meccanico-strutturali è frequente dover considerare che due o più corpi possano entrare in contatto a causa delle forze che li sollecitano, o che le condizioni di contatto siano alterate dall'applicazione dei carichi (come avviene, ad esempio, nei collegamenti flangiati, in cui il precarico dei bulloni contrasta la separazione delle flange per effetto delle azioni esterne).

In questi casi, quando si discute della simulazione al computer, si parla funzionalità ed algoritmi per trattare il contatto, affrontando sia il tema della non-compenetrazione dei corpi, che quello della valutazione delle forze che essi si cambiano. E' ovvio, infatti, che il "percorso" delle forze tra ed entro i corpi cambia in funzione di come, sotto carico, cambiano l'estensione e la disposizione delle parti in contatto. E così cambia, di conseguenza, lo stato tensionale.

Dal punto di vista algoritmico, il problema del contatto

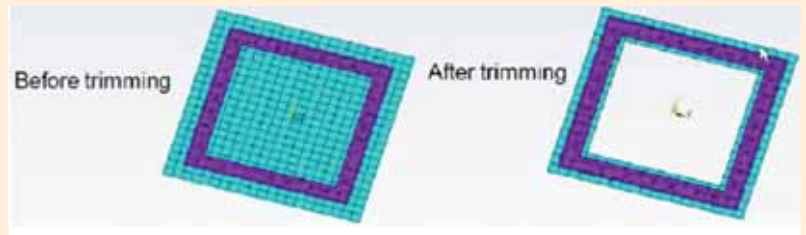


Figura 1 New contact pair trimming logic

essere simulata l'effettiva interazione fisica tra le parti. La descrizione dei contatti non si ferma alle sole applicazioni meccanico-strutturali, ma si applica anche a problemi termici, elettrici ed elettro-magnetici, e, quindi, in generale, ad applicazioni di natura multi fisica.

La definizione degli elementi di contatto è resa semplice attraverso l'interfaccia WB, sia che si tratti di contatto tra corpi nel piano, che tra corpi nello spazio, o, ancora, tra corpi orientati, quali travi e gusci. Questo vale sia in sede di pre-processamento dei dati che in sede di post-processamento dei risultati.

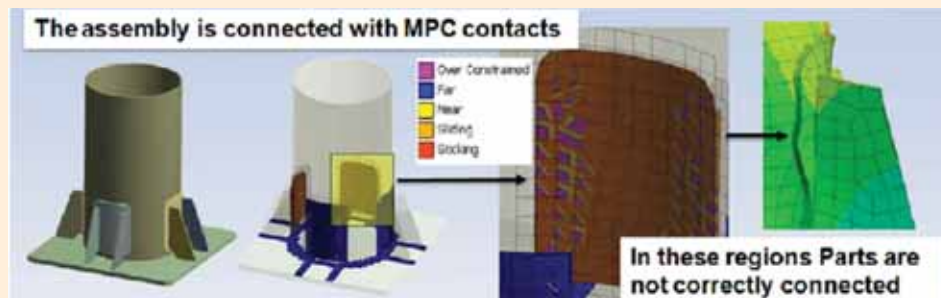


Figura 2 Over-constrained regions in ANSYS WB

rientra nella categoria dei problemi non-lineari per geometria, in quanto a diversi livelli del carico corrispondono stati tensionali che non sono, tra loro, in semplice proporzione ai carichi. La soluzione passa, quindi, necessariamente per un processo iterativo, in cui il singolo passo è linearizzato, e, specificamente, la matrice dei coefficienti delle equazioni di equilibrio viene aggiornata.

2. Le funzionalità per i contatti in ANSYS

ANSYS offre una grande varietà di soluzioni per trattare fenomeni di contatto fra differenti parti di un assieme meccanico.

Tra queste, la più complessa ed efficace riguarda il contatto superficie-superficie. La "surface-to-surface technique" prende in considerazione in modo notevolmente realistico l'interazione che si produce fra parti differenti in contatto attraverso superfici, entrambe deformabili, od in accoppiamento rigido-deformabile. Operativamente ANSYS utilizza elementi "target" e "contact" per formare una coppia di contatto; una volta definita la relazione può

Una volta importato l'assieme geometrico nell'ambiente di simulazione, sulle superfici di parti diverse, al disotto di una certa tolleranza geometrica (di default o definibile dall'utente), vengono automaticamente costruite le superfici di contatto. Sempre attraverso l'interfaccia utente, si possono poi definire i principali

"real" e "keypoint" dei contatti (rigidezza, "pinball region", ecc.), e visualizzare, sia in sede di pre-processamento lo stato del contatto iniziale, ed in sede di post-processamento, le grandezze più significative (pressione di contatto, attrito, "sliding distance", e simili).

3. Le principali novità in ANSYS 12.

Le principali novità riguardanti la simulazione dei contatti in ANSYS 12 riguardano:

- nuovi algoritmi e metodi per la ricerca e per la definizione dei contatti;
- un nuovo tipo di contatto per modellare la "fluid pressure penetration";
- nuove opzioni per definire l'attrito alla Coulomb.

3.1 Nuovi algoritmi

Nella versione 12 di ANSYS è stato implementato un nuovo algoritmo per la ricerca automatica dei contatti. Come accennato precedentemente la tecnologia di Workbench consente di determinare automaticamente le regioni di



BOOTSEAL 3D			
Elem: 11090			
Nodes: 5040			
Dofs: 30240			
Rigid-Deformable-Self Contact			
	11.0	12.0	Speedup
Contact database	11.72	0.216	54.26
Contact Search	3465.04	75.64	45.80
Contact Elements	505.64	188.95	2.67
Other Elements	4907.18	2301.7	2.13
Eq. Solver	276.77	211.35	1.30
Total CPU	9154.65	2777.64	3.29
Elapsed Time	9207	2788	3.30
No. of Iterations	246	240	1.02
No. of Substeps	42	43	0.97

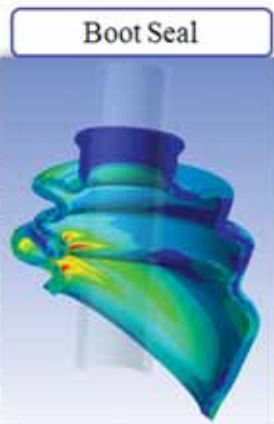


Figura 3 Speed-Up in ANSYS 12

contatto in base alla posizione delle superfici delle parti che compongono l'assieme.

In ANSYS 12 questa operazione viene sensibilmente accelerata (Figura 3) portando evidenti vantaggi nelle operazioni e nel tempo per il pre-processamento.

La determinazione automatica delle superfici di contatto comporta che spesso venga generato un numero rilevante di

da un fluido. L'algoritmo permette di stimare se, sotto l'effetto di tale pressione, si perde, localmente, il contatto, e, quindi, si potrebbe avere trafilamento.

Il nuovo tipo di contatto è utilizzabile sia in modelli bi-dimensionali che tri-dimensionali, tra corpi considerati entrambe deformabili, od in coppia deformabile-rigida.

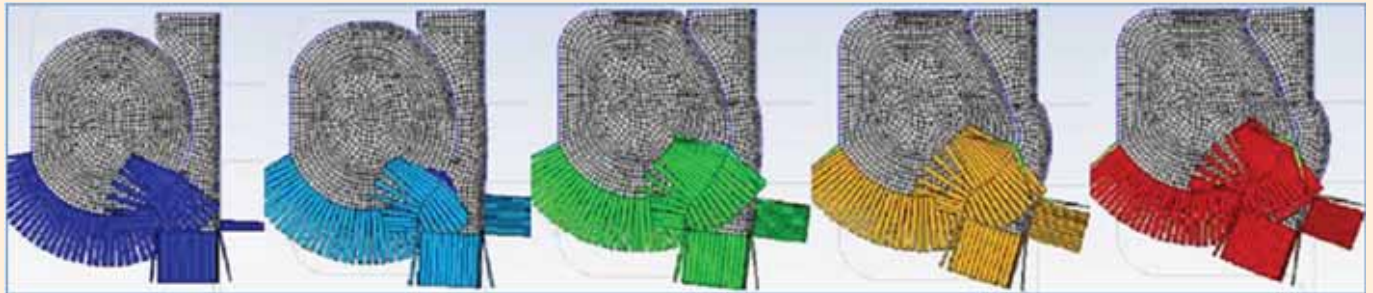


Figura 4 Fluid pressure penetration

elementi privi di utilità nei casi in cui le aree delle superfici che vanno a contatto siano sensibilmente diverse tra loro. Nella versione 12 di ANSYS questo problema è superato attraverso un metodo che svolge il "trimming" automatico degli elementi non necessari (figura 1).

Analogamente nella versione 12 è implementato un algoritmo che individua ed elimina automaticamente le regioni "over-constrained". Queste possono essere una conseguenza degli automatismi nella determinazione dei contatti, quando si utilizzino vincoli a formulazione multi-punto (MPC "multi-point-constraint"), (figura 2).

Queste nuove funzionalità portano non solo ad una drastica riduzione del tempo necessario per la formulazione del modello ed il suo pre e post-processamento, ma riducono anche il numero complessivo delle equazioni risultanti, facilitando la convergenza della soluzione e, frequentemente, consentendo una maggiore accuratezza nei risultati.

Il benchmark di figura 3 evidenzia l'abbattimento dei tempi di pre-processamento e di analisi che si riscontra in ANSYS 12 rispetto ad ANSYS 11 a seguito dell'impiego delle nuove funzionalità.

```

TB,FRIC,1,2,,ISO
TBFIELD,TEMP,100.0
TBFIELD,SLDI,0.1
TBDATA,1,0.8
TBFIELD,SLDI,0.5
TBDATA,1,0.6
TBFIELD,TEMP,200.0
TBFIELD,SLDI,0.2
TBDATA,1,0.6
TBFIELD,SLDI,0.7
TBDATA,1,0.5

```

Figura 5 New coulomb friction definition example

L'esempio della figura 4 è relativo alla simulazione del trafilamento per una guarnizione in gomma.

3.3 Coulomb Friction Definition

La modellazione dell'attrito di contatto è un argomento complesso e riguarda diversi campi di applicazione. In ANSYS 12 esiste una nuova "tabular data" che consente di definire l'attrito alla Coulomb attraverso l'utilizzo di 2 o più variabili indipendenti quali "time", "temperature", "pressure", "sliding distance" o "sliding velocity".

Nel processo iterativo in un dato step, l'attrito è, poi, riferito alla situazione dello step precedente.

In figura 5 si riporta la procedura esemplificativa di definizione dell'attrito in funzione della temperatura e della "sliding distance".

Oltre a questo, l'utente può programmare autonomamente un proprio modello di attrito alla Coulomb, sia per elementi di contatto 2/D che 3/D, attraverso la nuova subroutine "userfric".

Per ulteriori informazioni:

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Optimal Solutions and EnginSoft announce Distribution Relationship for Sculptor® Software in Europe



Idaho Falls, ID, USA -
Trento, Italy: Optimal
Solutions Software,
LLC, developer of

Sculptor, a leading Computer-Aided Design/Computer-Aided Engineering (CAD/CAE) model deformation and optimization tool, and EnginSoft, an international CAE consulting company, are pleased to announce a distribution relationship which will see EnginSoft as the distributor for the Sculptor software in Europe.

Sculptor is a shape deformation software capable of arbitrarily deforming a computerized model whose shape is defined by a CAE mesh. These mesh models are typically created using one of the leading CFD or FEA codes, (i.e., FLUENT, CFX, ANSYS, SIMULIA, Star CCM+, OpenFoam, NASTRAN, etc.). A new Sculptor module, called Back2CAD®, gives users the ability to deform their CAD models to match the optimized CAE shapes or to deform CAD models directly. Coupling Sculptor with a user's existing CAD and CAE tools opens the full potential of design optimization. By using Sculptor's proprietary Arbitrary Shape Deformation (ASD) technology, design engineers and analysts can reshape objects in just a few minutes, find better solutions faster, and ultimately save time and money. Sculptor also provides automated shape optimization which eliminates trial-and-error methods and methods that use CAD parameters for shape change, always replacing them with the Optimal Solution.

The decision to collaborate with Optimal Solutions Software and to distribute Sculptor underlines EnginSoft's strategy to strengthen its portfolio of CAE solutions, services and expertise. EnginSoft's core product in Europe is modeFRONTIER®, a state-of-the-art process integration and design optimization software developed by ESTECO, EnginSoft Technologie per l'Ottimizzazione, Trieste – Italy.

"As a globally-proven smooth, volumetric morpher, Sculptor perfectly complements modeFRONTIER and offers a state-of-the-art technology package to our customers in Europe. We are excited to jointly exploit the markets with our partner Optimal Solutions, to combine our teams' expertise and in this way, offer a highly innovative combination of technologies to our customers", stated Stefano Odorizzi, CEO and President of EnginSoft S.p.A.

With its network of expert engineers in the Italian Headquarters and at subsidiaries/partner offices in France, the German-speaking markets, Sweden, the UK, Spain, Greece, EnginSoft represents one of the major players in the field of simulation in Europe.

Giorgio Buccilli, COO of EnginSoft S.p.A., underlined the importance of the distribution relationship:

"Optimal Solutions' flagship product Sculptor will add to EnginSoft's existing portfolio of CAE software and services. Sculptor's unique Back2CAD functionality and mesh deformation capabilities go hand in hand with the multi-objective optimization techniques provided by modeFRONTIER. We are excited to develop our partnership which I feel will be a great success for both companies, and more importantly for our customers".

"We are very excited to begin our relationship with EnginSoft," explains Phil Belnap, President of Optimal Solutions Software, LLC. "They are experts in all the key areas of design optimization that our customers need. Their excellent sales and support network will enable engineers all over Europe to learn how much power they can use to find optimized designs in less time and money by incorporating Sculptor and Back2CAD into their current CAD/CAE process."

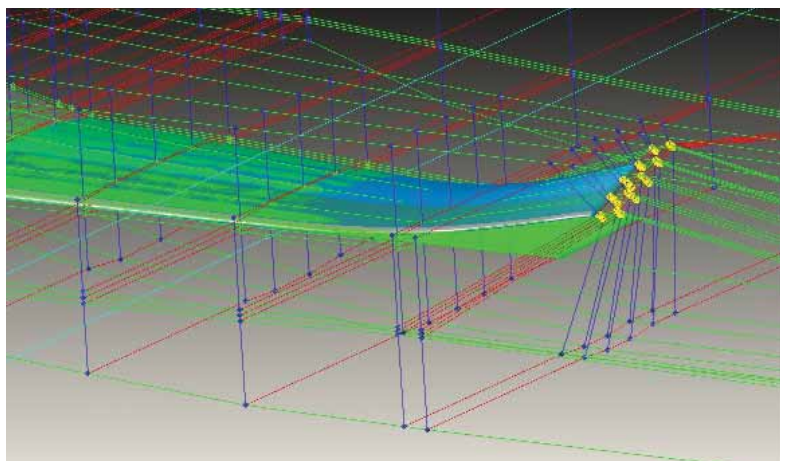
About Optimal Solutions Software:

Optimal Solutions Software, LLC, is the developer of Sculptor, a unique technology which performs optimal shape design for the computational fluid dynamic (CFD) and finite element analysis (FEA) industries.

Sculptor is used to deform analysis meshes used in both CFD and FEA simulations. Using proprietary Arbitrary Shape Deformation (ASD) technology, the user can easily and intuitively change the shape of a model in a smooth and controlled manner. Major changes that previously took months can now be achieved in days; or formerly weeks, now successfully attained in hours.

www.optimalsolutions.us

sculptor@enginsoft.com



Deformed CAD wingtip with ASD volume with undeformed wingtip overlay



Diffpack® - Expert Tools for Expert Problems

*inu*Tech



Diffpack, developed and marketed by inuTech GmbH, is an object-oriented software system for the numerical modeling and solution of partial differential equations. User applications cover a wide range of engineering areas and span from simple educational applications to

major product development projects. Examples of customers in different segments include AREVA NP, Air Force Research Laboratory, Bosch, Cambridge, Canon, CEA, Cornell, Daimler, Furukawa, Intel, Mitsubishi, Natexis Banque, NASA, Nestlé, Shell, Siemens, Stanford, Statoil, Petrobras, Veritas, and XEROX, just to mention a few.

Complementary to Main-Stream Analysis

Diffpack is a problem-solving environment designed to provide maximum modeling flexibility for construction of highly customized FEM solvers. For users of FEM-applications like ANSYS, CFX, FLUENT, NASTRAN, LS-DYNA, etc. ... Diffpack offers a complementary approach which can give significant benefits for solving problems with special model features.

Selected Customer Applications

There are more than 350 customers in more than 30 countries world-wide, including major industrial enterprises, consulting companies, software vendors, and research institutes employing Diffpack in such diverse areas as (amongst others) multi-phase flow in porous media, fuel cells, tribology, biomedical sciences, seismic and financial modeling.

Powerful Numerics

Diffpack is organized as a collection of C++ libraries embedded in an environment of software engineering tools.

It contains over 600 C++ classes ranging from basic data structures to major modules for e.g. mixed FEM, adaptive meshing, multi-level algorithms and parallel computing.

Basic to Advanced FEM

Diffpack is designed for the engineer with insight into the mathematics of his simulation problem. When programming in Diffpack, he can concentrate

entirely on the essential numerics. The code of a basic FEM solver can fit on one or two sheets of paper and advanced multi-physics simulators can be constructed by linking simpler sub-simulators together.

Numerical Plug'n Play

Diffpack allows run time selection of all application entities, from simple numerical parameters to abstract quantities such as elements, matrices, solvers, etc. The user can set up advanced experiments, for example looping over different solvers or preconditioners, and he can automatically create reports containing e.g. numerical results, images and movies.

Extensions and Interfaces

The user can make his own development fully interoperable with Diffpack. Existing code, for example in FORTRAN, can be made interoperable via a thin communication interface. This makes it easy to extend Diffpack into a tool tailored to the user's particular application area.

For preprocessing, Diffpack can interface several tools, such as ANSYS, ABAQUS, and NASTRAN. Postprocessing supports popular programs like MATLAB, Gnuplot, IRIS Explorer, AVS and Vtk.

Flexibility and Efficiency

In Diffpack, low-level computing intensive operations are always

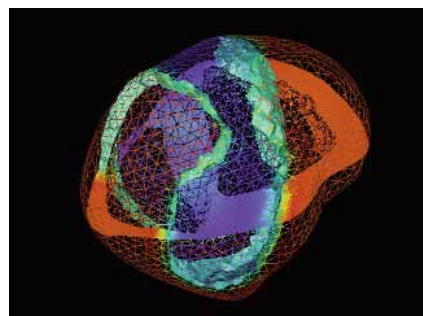
performed in a FORTRAN-like style, while object-oriented principles are only used for higher-level administrative tasks. This ensures flexible APIs and computational efficiency competing with tailored FORTRAN codes.

Strong Collaboration with Springer

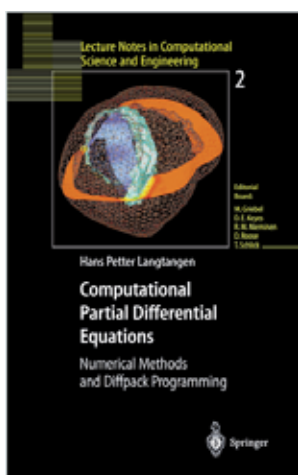
The Diffpack learning process is supported by a comprehensive volume published by Springer-Verlag. This book introduces Diffpack programming via the style of typical FORTRAN or C codes, and then gradually introduces the object-oriented techniques characterizing more advanced Diffpack applications. The book contains over 50 application examples, which are all part of the product as delivered to customers. These examples form also a valuable resource as application templates for the user's own development.

Electrocardial Simulations with Diffpack

As an example of a very complicated problem solved by Diffpack we consider a model of the electrical activity in the human heart (courtesy of Simula Research Laboratory AS). The mathematical model consists of 3 coupled partial differential equations (PDE) - One is modeling the



Electrical signal in the human heart



propagation of the electrical signal in the heart chambers, the second one in the heart tissue, and the third models the transport from the heart surface to throughout the body. In addition to the PDEs there is a set of 12 coupled ODEs modeling the chemical reactions defined locally for each node. The problem was solved by finite elements using Diffpack standard FEM tools, multigrid methods and adaptive gridding (wave front). The ODEs were solved in parallel. Sub-problem simulators were built and tested separately and joint by administration class. For an accurate 3D solution a grid of approx. 40.000.000 nodes was used, resulting in a

discretized system of more than 900 million unknowns. On a Linux cluster of 64 processors, the solution took around 15 days (1000 sec. per time step).

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Designing low-emissions vehicles with modeFRONTIER®, Sculptor® and AVL FIRE®: external shape aerodynamic optimization

The Rationale

External shape aerodynamic optimization plays a major role in achieving low-emissions in designing the next generation of vehicles, no matter the underlying propulsion and powertrain technologies. To tackle such a challenge, parametric fluid-dynamics simulations, driven by efficient numerical optimization algorithms, represent a key know-how. In this context, the modeFRONTIER multi-objective optimization tool brings a user-friendly and powerful solution to designers. It can connect in the optimization loop Computational Fluid Dynamic (CFD) models, as well as mesh-deformation software such as Sculptor ("mesh" is the computational grid that is built around the geometry to perform the fluid flow simulation). Together, modeFRONTIER® and Sculptor represent a flexible solution to optimize shapes with only few key parameters but great freedom, without involving "expensive" parametric Computer Aided Design (CAD) and mesh-generator software in the optimization loop.

This approach is applied at Chalmers University of Technology on a simplified Volvo car model in a project supported by AVL List GmbH, which provide the CFD simulation software AVL FIRE, involving pure fluid-dynamics optimization objectives (Fig. 1). It should be also underlined that such concept is fully and easily expandable to cover the real multi-disciplinary nature of the design challenge. In fact, it could be easily completed simply by plugging into the modeFRONTIER "optimization workflow" suitable comfort simulation (i.e. handling, cross-wind stability, aero-acoustics, ...) and aesthetic design and cost models.

The challenge

As mentioned, aerodynamic shape optimization is an important element

in improving cars of the future, where there is a demand for more energy-efficient and comfortable vehicles.

The project described here aims at creating an automated shape optimization process, able to optimize any geometry with respect to aerodynamic properties. Such an optimization process is always multi-objective, and often such objectives are connected in a way that improvement in one objective leads to deterioration in another. Here, two conflicting goals are considered: the vehicle lift coefficient (Cl), to be decreased for better handling performances; the drag coefficient (Cd), to be decreased for lower consumption and hence to achieve the low-emission concept.

Since the rear end of any personal car is responsible for most of the aerodynamic drag, the choice was to focus the shape modifications on such a region, while keeping the rest at the previously defined frozen-design stage. In this case, the optimization is performed on the rear end of a simplified full size car model from Volvo Cars Corporation.

To tackle such a challenge within a timeframe compatible with the ever accelerating development pace of the automotive industrial standards and environmental requirements, all the phases of this process should take advantage of the best-in-class technologies. Hence, the software used is modeFRONTIER for the "process integration" and "design optimization" part, Sculptor for mesh morphing and AVL FIRE for initial mesh creation and CFD calculations.

One need is to limit the number of considered independent parameters controlling the shape. They should be as few as possible, to speed up the optimization search. On the other hand, they should be able to generate the widest set of shapes to be explored. Sculptor's mesh deformation technology makes the difference compared to a traditional parametric CAD approach, allowing to control the key shape-features of the

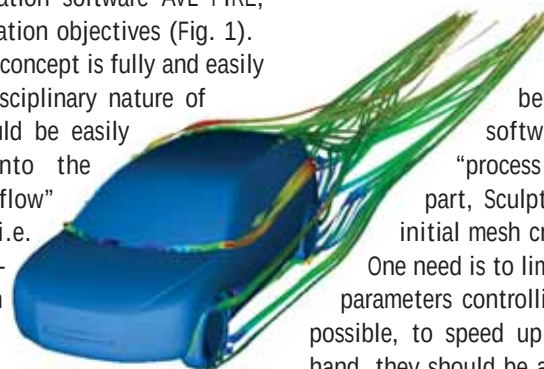


Fig. 1 The original simplified Volvo car model with streamlines. Hot colors represent higher velocities of the flow.



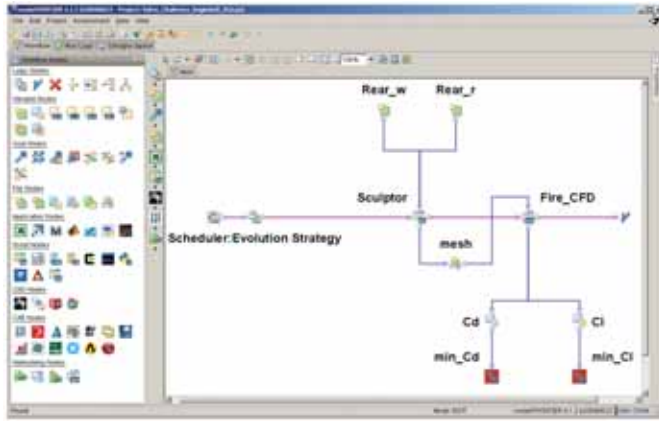


Fig. 2 - The modeFRONTIER® workflow integrating Sculptor and AVL FIRE®

vehicle's rear end with only two parameters.

Another key factor is the efficiency of multi-objective numerical optimization algorithms, that should be able to find an optimal shape configuration out of billions of possible ones, by evaluating only a few variants. Here modeFRONTIER plays again a major role in achieving the expected improvements with its sophisticated "Evolutionary Strategy" optimization algorithm with multi-objective capability.

Last but not least, the CFD model needs an accurate tuning. When performing CFD computer simulations, huge computational power is required and proper pre-processing is necessary to keep the simulation time within reasonable limits. The simulation time ranges from days to months, and therefore a compromise must be done between the resolution of the simulation and simulation time, where the goal is to get enough information to improve the aerodynamic properties of the vehicle in as short simulation time as possible. This optimization process ran twice, initially using a "k-ε" turbulence model, and it has been repeated with a higher-accuracy "large-eddy simulation" (LES)



Fig. 3 - A sketch of a single step of the optimization loop, as managed by modeFRONTIER

approach using the Smagorinsky model. The optimization with the lower-accuracy k-ε model took around 18400 CPU hours to be completed, while the LES took 46100 CPU hours (the sum of computational time over all the CPU's used, here around 40).

The solution

The optimization process is fully automated by connecting the software in a closed optimization loop within modeFRONTIER® (so called "process integration"), where the two deformation parameters are controlled by the "Evolution Strategy" optimization algorithm, capable to improve both the two considered conflicting objectives simultaneously (so called "design optimization"). To do so, a symbolic representation of the process is created inside modeFRONTIER, through a block-diagram called "workflow" (see Fig. 2). Once the "workflow" is ready and the models (Sculptor and AVL FIRE) are plugged-in, together with the specifications of hardware resources to be used, modeFRONTIER takes completely care of managing the whole process. It generates new models with Sculptor, submits the calculations to AVL FIRE, and collects back the results (see Fig. 3). The designer is involved again when the process is completed, in order to focus on the final analysis result and on the decision

process for the best trade-off solution between the two conflicting needs. With only two parameters, and through "Arbitrary Shape Deformation" (ASD), Sculptor controls the mesh and the associated geometry of the whole rear end of the car, one of the main responsible regions for its aerodynamic efficiency (see Figs. 4 and 5). Additionally, this meshdeformation approach allows to keep the CAD and the meshing software out of the optimization loop, with great benefits in terms of such software license usage and on the optimization speed itself. In fact, they're used only twice, to create the initial computational grid ("mesh") and to acquire the final optimum. During the whole optimization loop, instead, the mesh is directly accessed, parameterized and manipulated by Sculptor.

The chosen modeFRONTIER "Evolution Strategy" optimization algorithm is very efficient in searching for the global optima: it requires computation of only a few variants over the thousands possible, in order to reach the optimal design. Another crucial benefit is in its capability to generate and handle multiple configurations to be run

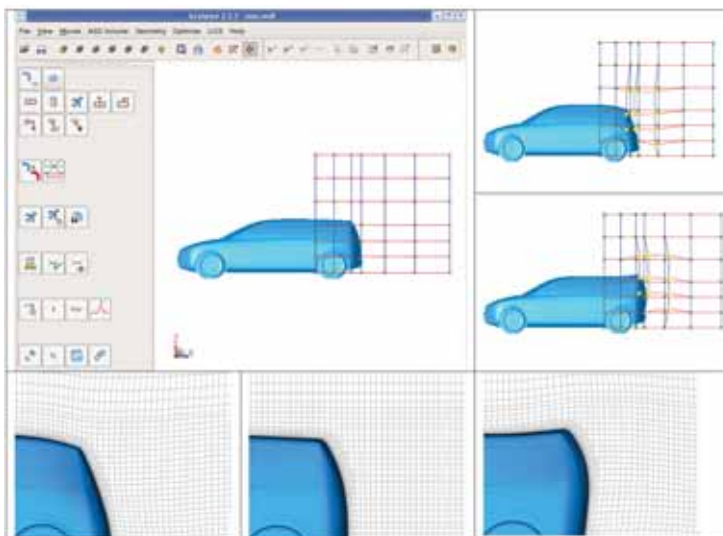


Fig. 4 - One-parameter Sculptor's ASD volume in the XZ plane deforms the whole rear-end geometry and the mesh around it: original shape(up)/mesh(down) in the center, two possible configurations at left and right.

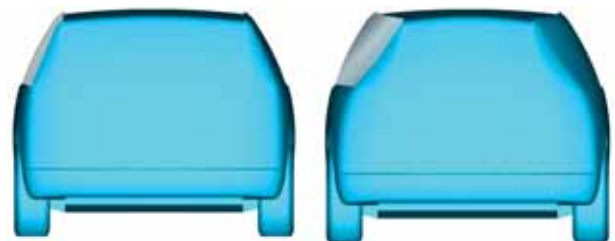


Fig. 5 - The second parameter manipulates the geometry of the rear end of the vehicle and the mesh around it, by compressing/expanding it in the X direction.



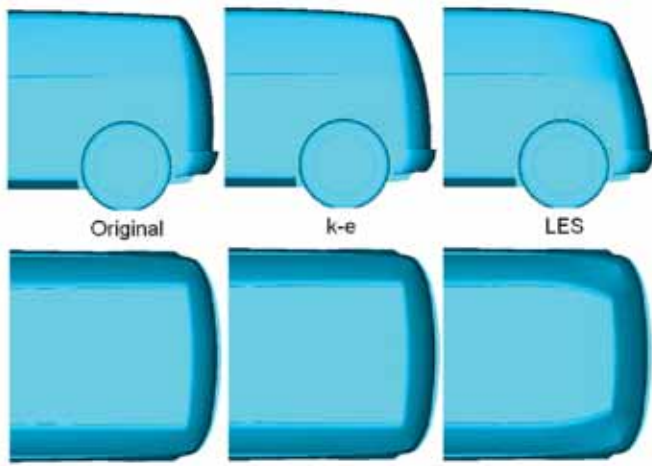


Fig. 6 - The original car compared to the optimal designs from the $k-\epsilon$ model and LES

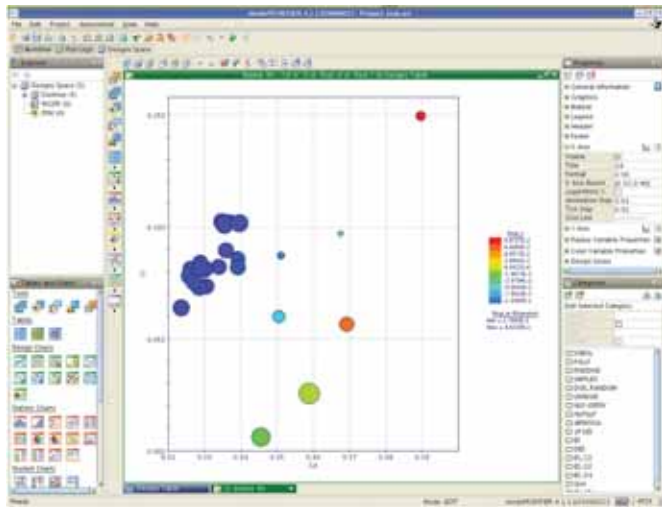


Fig. 7. – Results from the optimization viewed as a bubble graph in modeFRONTIER design space.

simultaneously. This way, the available computational power and the solver software licenses are fully exploited, speeding up the overall optimization process by four times respect to any traditional “sequential” optimizer.

In fact, modeFRONTIER managed four design evaluations at the same time, sending CFD computations on a remote cluster where each single design evaluation was itself parallelized.

Results

Using a faster but low-precision CFD model (the $k-\epsilon$ turbulence model) might result in a failure of the CFD in catching fundamental physical turbulence structures. This could lead to less realistic performance evaluations, and hence have a great impact in the optimization itself. The final comment is that it's worth to take advantage of the high CFD resolution granted by the LES technique, while speeding up the optimization by using high-efficiency and parallel Optimizers such as

modeFRONTIER's Evolution Strategies. Finally, when the optimal design has been obtained, re-creating the optimal CAD geometry is simple: the Sculptor deformation tool can deform the original CAD geometry in the same way as the mesh.

Conclusions

This work shows that the automatic shape optimization loop is fully functional: modeFRONTIER is able, through its “workflow”, to link and manage the Sculptor mesh-deformation software and the CFD solver AVL FIRE.

Sculptor itself, thanks to its mesh deformation technology, allows to keep CAD and mesh generator software out of the optimization loop, sparing time and resources. In the same moment, it allowed to control the shape of the rear end of the Volvo Cars' vehicle model with only two parameters.

A “twin” optimization has been run, featuring both a standard $k-\epsilon$ turbulence model and an high-accuracy LES. The last approach shows significant improvements in the CFD evaluations, but also a huge increase in computational time.

Thanks to the efficiency of the modeFRONTIER “Evolutionary Strategy” algorithm and its parallel nature, it has been possible to fully exploit the available hardware and software resources, and hence to complete the optimization in an acceptable timeframe even using high accuracy physical models.

This proves that optimization and mesh deformation are key-enabler techniques for the virtual multi-disciplinary design of the next generation of low emissions and high comfort vehicles.

A team at Chalmers University of Technology is pioneering this approach, with their know-how and cutting-edge software technologies.

*Prof. Siniša Krajnović, Eysteinn Helgason and Haukur E. Hafsteinsson, Chalmers University of Technology, Sweden
Luca Fuligno, EnginSoft SpA, Italy*

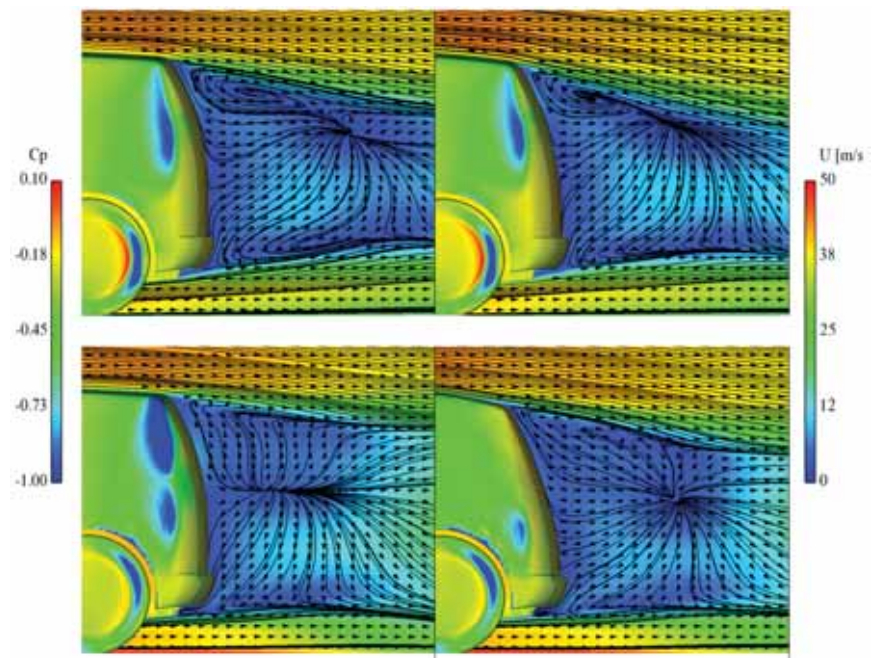


Fig. 8 - The flowfield around the original car(left) and the optimal design(right) found using $k-\epsilon$ turbulence model(top) and LES (bottom). The car is colored with pressure and the flow with velocity.



Impeller Dynamics in a Diesel Engine Converter

To be able to avoid fatigue problems in impeller pumps for torque converters, the engineer must have a thorough understanding of the nature of the fluid-structure interaction characteristics of the impeller pump. In this article, we show how this was obtained by combining the outcome of fluid-structure interaction simulations with results obtained through experiments and CFD-calculations.

Introduction

With increasingly more powerful tools for the computation of physical quantities (e.g. software for structural analysis and for computational fluid dynamics), it has become possible to design lighter and more energy-efficient mechanical devices like torque converters used for cars, excavators, and a variety of other drive-trains. However, limit design with respect to certain features often causes new and unknown problems to occur. Among many "nasty" phenomena that may be difficult to get a grip on, are flow-induced vibrations. Flow-induced vibrations may result in fatigue problems and ultimately failure of the subject. In this paper, we show how the results from prototype testing of a new torque converter could be explained by means of combining the outcome of structural, CFD, and Fluid-Structure Interaction simulations, thereby establishing the foundation for an advanced and reliable design. The work was performed in cooperation between a major Swedish producer of movable equipment and its German supplier of torque converters with the assistance of ANKER - ZEMER Engineering AB.

The working Principle of a torque Converter

A torque converter has three main parts: Impeller (or Pump), the Stator, and the Turbine (see Fig. 1).

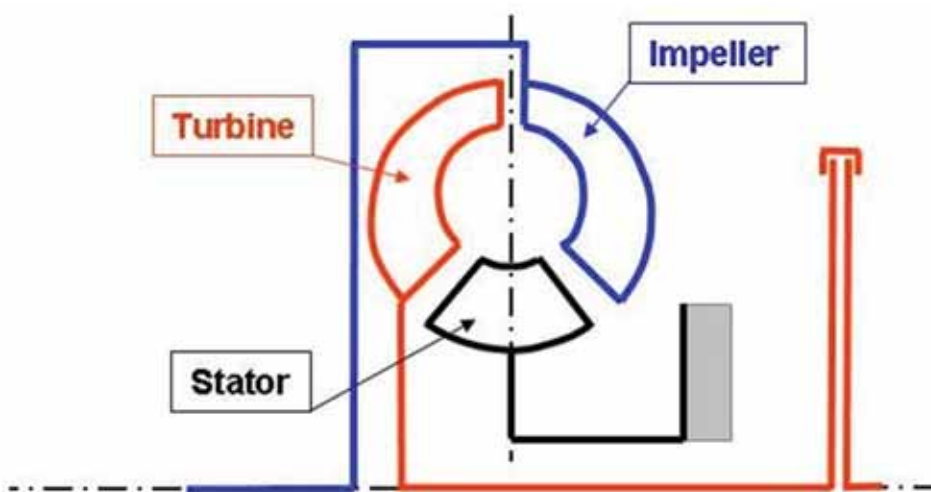


Fig. 1: Torque Converter Work Schematic

Impeller Problems

During prototype testing, it became apparent that very small changes in the geometry of the impeller can lead to serious fatigue problems and ultimately total failure of the converter (a typical torque converter is shown in Figure 2).

However, the influence of the various geometrical parameters was very difficult to apprehend, as the physics of the problem was not very well understood.

Therefore, a project with the purpose to investigate the problem was initiated.

The Project

At the start of the project, it was clear that the problem could not be efficiently studied by only using testing

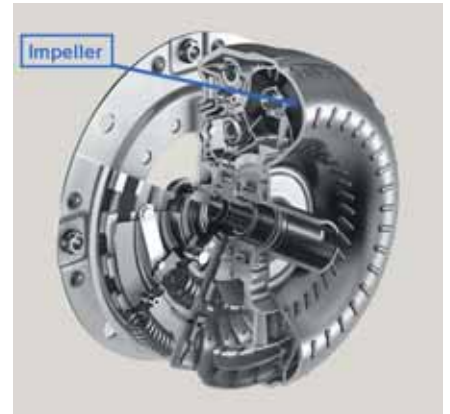


Fig. 2: Torque Converter

and/or conventional numerical simulations alone, as the project was most likely facing a Fluid-Structure Interaction ("FSI") problem involving relatively high frequencies. To simulate a flow field having high frequency oscillations due to phenomena's such as rotor-stator interaction, vortex shedding etc, very fine grids and small time steps in the unsteady simulations yielding excessive computer running times are required. Furthermore, if fluid-structure resonance points are to be found, an excessively high number of CFD simulations interacting with structural simulations have to

be performed. Due to the presumed difficulties of the task, it was decided to perform the project based on concerted testing and numerical simulations to find the cause of the vibrations resulting in limited fatigue life of the impeller. Testing would yield factual data to be used in their own right and also data needed for the calibration of the numerical simulations, and the numerical simulations would reveal the influence of the various parameters and (hopefully) give a better understanding of the physics of the problem. The project setup included the following tasks and tools to be utilized:



1. Investigate several impeller configurations by testing.
2. Perform steady and unsteady CFD fluid dynamic analysis of the initial design and suggested design changes.
3. Perform Fluid-Elastic analysis of the initial impeller design in the frequency domain. This was performed by ANKER-ZEMER Engineering AB (Sweden).

The numerical simulations performed under tasks 2 and 3 above comprised structural dynamics (utilizing the ANSYS Finite Element program), fluid dynamics (utilizing the FLUENT CFD software), and fluid-elastic analysis (applying the LINFLOW Fluid-Structure Interaction analyzer utilizing modes and eigenfrequencies computed in ANSYS).

Tasks and Findings

The experimental work (Task 1) showed that small changes in impeller geometry would result in significant variations in impeller fatigue life. However, testing did not give any conclusion as to why.

The CFD simulations of steady and unsteady fluid flow (Task 2) did not reveal any significant changes in impeller blade load due to geometrical modifications. This may sound like a

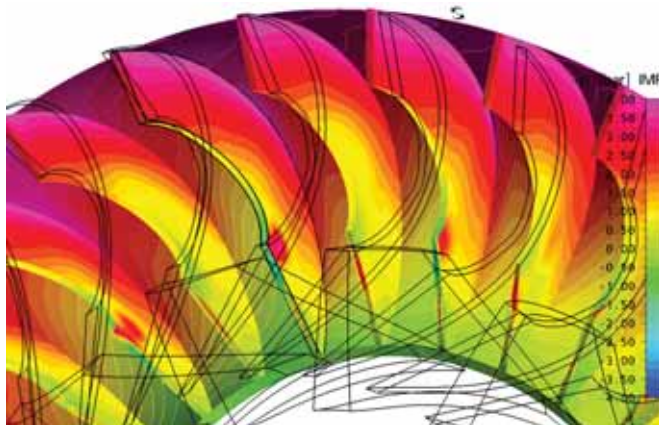


Fig. 3: Pressures on Impeller as computed in Fluent

surprise considering the large variations in fatigue life, but was not totally unexpected. A picture of the pressures on the impeller from the CFD calculations is shown in figure 3.

The evaluation of the fluid-elastic characteristics of the impeller was performed as Task 3. Since the concept utilized for determining the fluid-elastic characteristics is not widely known, it will be briefly described here:

- The dynamics of the system is studied in modal coordinates, hence
- The dynamic properties of the structure is established based on modal information (i.e. eigenfrequencies, mode shapes).
- The dynamic properties of the fluid is established based linearized fluid dynamics due the characteristics of the participating modes.
- Structure and fluid must be in equilibrium at any point in time, this can be expressed as an eigenvalue problem.

- The characteristics of the fluid-structure interaction problem is given by the solution(s) to the eigenvalue problem

Following the concept outlined above, a structural finite element model of the impeller was built and modal analysis of the model was performed in order to establish the structure dynamic characteristics of the impeller. With this

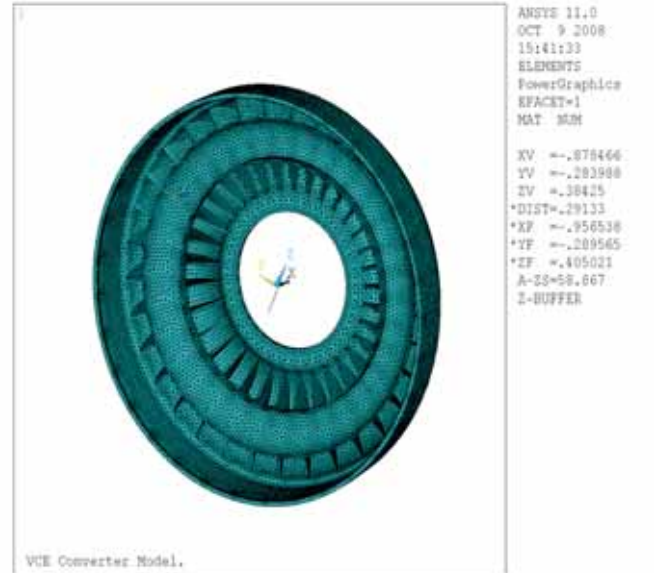


Fig. 4: Impeller as Modelled for ANSYS

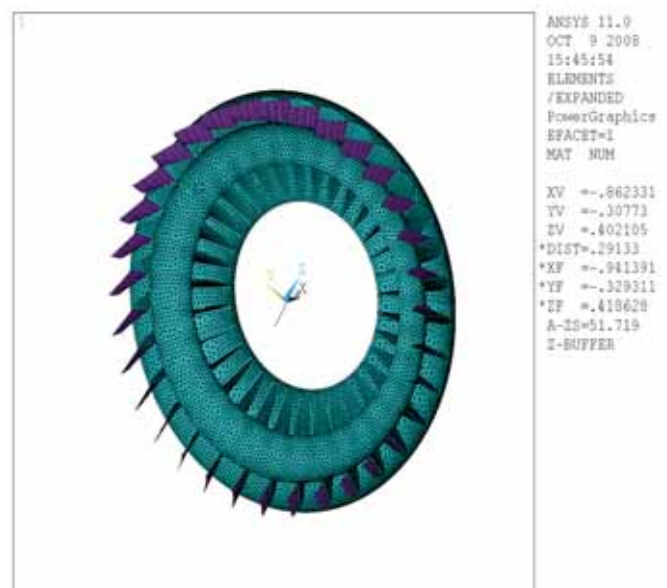


Fig. 5: Impeller Modelled for LINFLOW (Note Wake Elements)

information included as the structure dynamics model, a series of fluid-elastic eigenvalue analyses were performed. A picture of the structural dynamics model is shown at figure 4.

The LINFLOW unsteady fluid flow model of the system is shown in figure 5. The dark coloured elements in the model are the wake elements, which are attached for lift generating surfaces in LINFLOW. The picture is a graphical representation of the model, the actual analysis model include 3 of the blades only.



The reason for modelling 3 blades of the impeller only and not including turbine and stator is that experience shows that this is sufficient as long as only the fluid-elastic characteristics of the impeller is considered. Figure 6 shows steady flow vectors for the flow field at the operating point at which stability of the system has been investigated.

When studying the fluid-elastic characteristics of the impeller at the high pressure operational conditions it was found that there are fluid-elastic modes that pick-up energy for the fluid dynamics if excited. On the other hand the fluid-

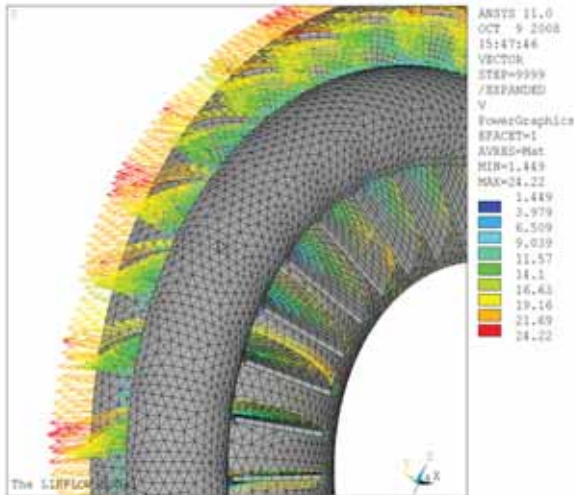


Fig. 6: Impeller Modelled for LINFLOW

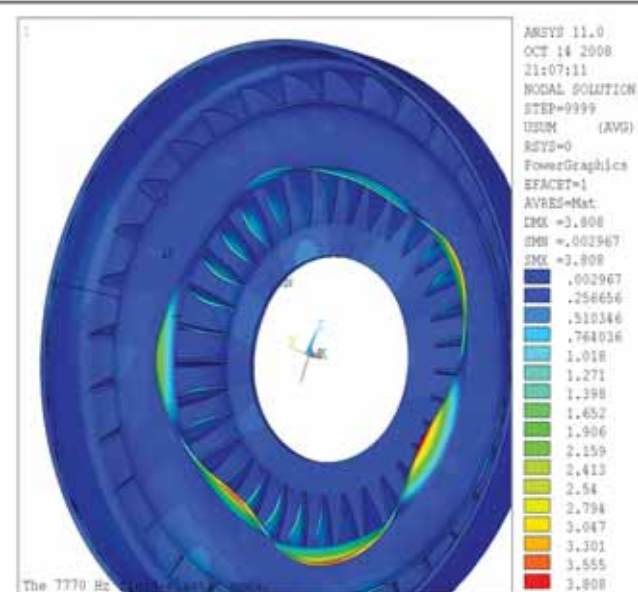


Fig. 7: Impeller Modelled for LINFLOW

elastic modes involved most likely have a much larger frequency than the frequencies of pressure oscillations appearing in the flow field (the effect has so far not been studied). An example of a impeller fluid-elastic mode is displayed in figure 7.

The damping requirement for neutral stability for a few of the most critical modes as a function of flow rate is shown in figure 8. The diagram illustrate that the modes do pick up the same amount of energy from the fluid dynamics as they lose

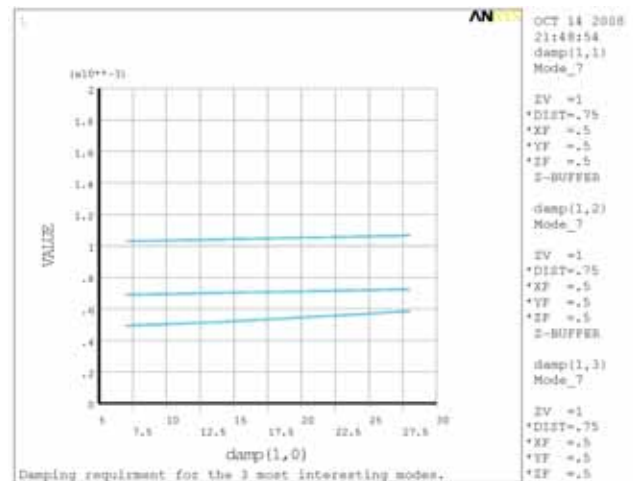


Fig. 8: Damping Requirements for Critical Modes

through material damping. These modes are said to be sensitive to flow excitation.

Conclusions

A conclusion that was drawn by studying the fluid-elastic mode animations was that if there is a strong pressure pulse propagating through the impeller channels (even if the frequencies are lower than the frequencies of the modes), this pressure pulse will make the impeller structure deform radially in a way that will generate large strain levels in the region where cracks had been found to develop. As the crack grows in length the trailing end of the blade will become increasingly unstable and a faster failure will appear. By reviewing the fluid-dynamic behaviour in the converter seen in the performed CFD calculations, it could be concluded that there was indeed a large difference in the pressure pulse propagation between the designs that experimentally gave short fatigue life for the impeller and the impeller geometry that showed fatigue life above the requirements set in the specification.

A final remark is that, through the combined use of tests, structural FEA analysis, fluid dynamic CFD analysis, and LINFLOW fluid-elastic analysis it was possible to get an understanding of why one design work well and the others did not. It is also clear that without performing all 4 tasks (testing, structural FEA analysis, CFD, and FSI), the insight needed to arrive at a final design and have confidence in that the system is not fatigue sensitive would have been difficult.

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EnginSoft supports LINFLOW from ANKER-ZEMER Engineering AB Sweden whose parent Company is a Founding Member of the TechNet Alliance"



Solar Industry - Numerical Simulation and Optimization

1. Introduction

Nowadays, the renewable energies attract a lot of attention from politicians and the public. On the one hand, this is a consequence of an increased environmental awareness all over the world. On the other hand, new technologies can become the best strategy to face and overcome the global economic slump. A loan of hundreds of millions of dollars provided by the U.S. Department of Energy to a solar panel company based in Silicon Valley, California, is another clear proof of the commitment and investments made in this field.

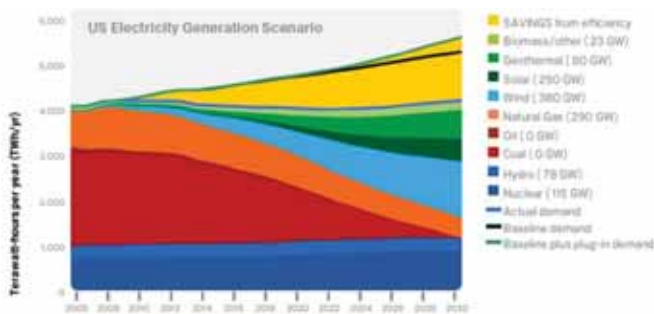


Figure 1: US Expected electricity generation scenario

Also, financial institutions and banks are ready and eager to invest in a promising sector with expectations for growing revenues. For instance, the fourth largest bank in the US, signed an agreement to fund SunPower, one of the most important solar panel manufacturers in the United States. Figure 1 illustrates the expected electricity generation scenario in the USA.

The main goal of the companies involved in this business is to develop new technologies to improve the efficiency and reliability of solar panels. This task is not at all trivial, since there is a relevant amount of parameters that affect the performances and the costs of the solar modules. Despite the fact that efficiency is crucial and that the multi-junction technology should reach a remarkable value of 40.8%, there are other very important factors needed to guarantee the commercial success of solar panels. Under this point of view, reliability, robustness, operational life, manufacturing processes and the use of materials can not be considered less important than the conversion efficiency. All these factors could dramatically affect the future of solar technology compared to others. In this context, only optimized solutions can stand out and survive.

2. Numerical simulations

In order to reach the optimum result, the first step is to acquire a deep understanding of the behavior of the solar panel. Numerical simulations are by definition tools devoted

to investigate and evaluate the behavior of systems or their functional parts, allowing in this way, to improve the efficiency and to tremendously decrease the cost of the prototypes. This article describes a demo case, mainly focussed on the evaluation of the mechanical performance of a solar panel. Some of the simulations executed have been performed in order to verify if the analyzed solar panels comply with EC Standard. A better understanding of the solar panel behavior has been achieved by performing not only mechanical analysis, but also fluid dynamics and thermal-electric simulations.

The EC Standard requires that solar panels are robust enough to resist hail impact. Following the standardized test, if a steel ball (1.18lb) was dropped from 51 inches, an approved panel will not crack. Since ANSYS WorkBench R11.0 has been used to simulate the drop test, a command snippet was inserted in the GUI to set the explicit solution. Maximum principal stress, evaluated at the impact point on the glass layer, was 43MPa (see figure 2), lower than the breaking limit value. The new Release 12.0 does not need scripts for explicit analysis because of the new capabilities.

The second analysis evaluated the effect of a static load (400lb) applied on the top layer (glass) of the solar panel. In addition, a transient dynamic analysis has been performed to gain a deeper understanding of the structural behavior. The dynamic load has been applied as a transient sine function with a period equal to the first natural frequency of the panel.

In some particular cases, transportation may be a matter of concern because of the vibrations induced in this phase. This also pushed to evaluate the suitability of the modules to support random vibration loads.

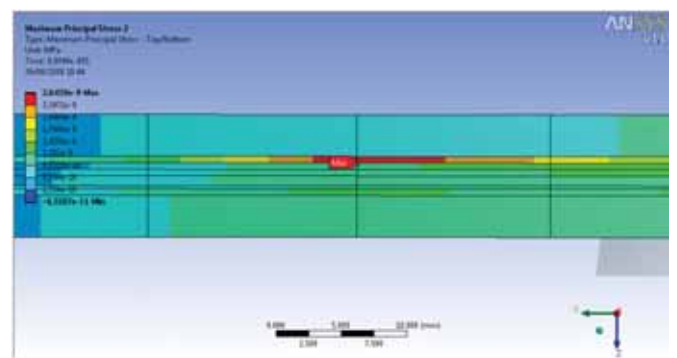
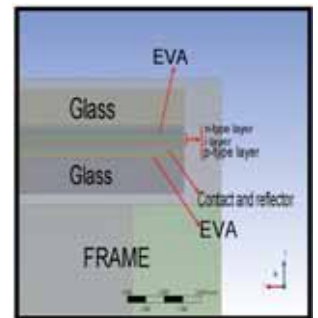


Figure 2: Solar panel cross section - Principal stress



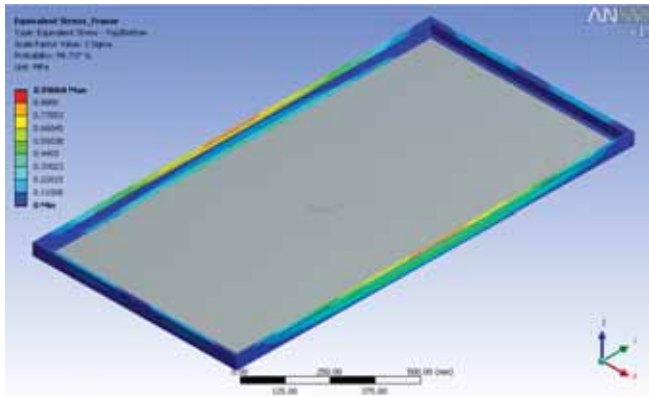


Figure 3: von Mises stress induced by PSD

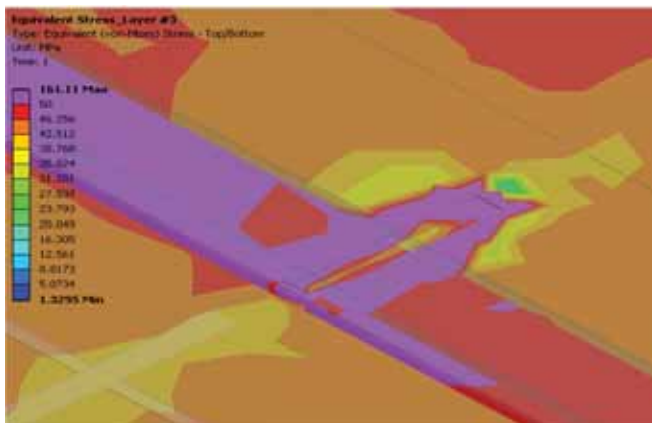


Figure 4: von Mises stress induced by thermal cycling test

The analysis performed revealed that in all cases considered, stress levels are lower than the admissible values.

After installation of the solar panel, thermal conditions become a severe cause for mechanical stress, mainly on the solder connections. Because of the relevance of this issue, a thermal cycle test is required based on the EC standard. The standard test requires the sample to undergo thermal cycles from a low temperature of -40°C , to high temperatures equal to $+85^{\circ}\text{C}$ with a dwell time equal to 10 minutes at both higher and lower temperatures.

As expected, the junctions between cell and connector are the most sensitive parts with respect to the thermal cycle test. The following figure reports a detailed view of the stress spot.

High temperature is not only challenging from a mechanical point of view, but also considerably affects the electrical performance. It has been determined that the decrease in efficiency can be $0.5\%/^{\circ}\text{C}$ (depending on the technology used), as high temperatures reduce the open-circuit voltage. Consequently, under severe sun irradiation conditions during the operational phase, the negative effects of high temperatures can result in bad performances. Because of the importance of this issue, a thermal-electric simulation on a single cell has been performed to analyze the temperature field triggered by the Joule heating induced by the current collected by the cell. Moreover, a fluid dynamic analysis has

been performed in order to take into account the air flux around the solar panel to evaluate both the ventilation around the panel and the stress on the support frame induced by the wind pressure (see figure 5).

The analysis revealed that under a structural point of view, the frame support is properly designed to resist the standard code wind. From a fluid dynamic aspect, as expected, a low pressure zone was detected on the back side of the panel causing inefficient heat dissipation.

3.Optimization

Numerical simulations are a powerful tool to evaluate the performance of a design, but in a market where only the best technologies can survive, the optimization process plays a crucial role and is as important as numerical simulations. As explained above, the goal for manufacturers and researchers is not only to increase performances, but also to reduce cost and time of production, so that significant optimization can be achieved, from the early design stages to the final product manufacturing processes.

The original design has been optimized by modeFRONTIER, a multi-objective optimization software tailored to be coupled with other programs, such as, for example, Finite Element Methods or Computational Fluid Dynamics software (not only engineering software though). The main task of the optimizer is to drive the initial set of parameters that define the model, to the/an final optimized set of parameters which define a new better performing model. Basically, the optimization process is made by modifying the input variables, using mathematical algorithms, and analyzing the outputs in accordance with the objectives and constraints of the design. The first phase of the process starts with the Design of Experiments (DOE) to generate an initial population of possible designs. Starting from the initial population, modeFRONTIER explores all parameter domains. It searches for the maximum or minimum of the objective function(s) using a variety of state-of-the-art optimization techniques. An Optimization process, with many and conflicting objective functions, cannot deliver "the" optimal solution as a result, but rather a "full set" of optimal solutions called Pareto frontier. Each solution of the Pareto frontier maximizes/minimizes at least one of the objective functions, but none of them maximizes/minimizes all objective

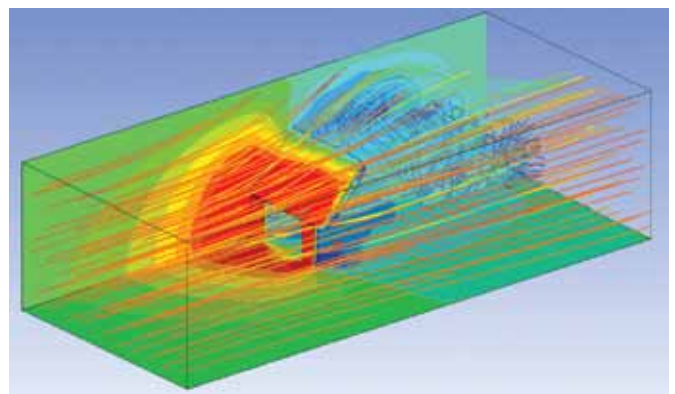


Figure 5: Pressure Distribution and Velocity Streamlines.



functions. This article presents two case studies. The first one is a multi-objective and multi-disciplinary optimization; the second one is a mono-objective structural rigidity of a solar panel mount optimization.

3.1 Solar panel case study. Multi Objective Optimization

3.1.2 Optimization Problem and Objectives

The structural and thermal behavior of the solar panel during the operational phase is determined by the geometric and material characteristics. Hence by modifying the geometric and material parameters, an optimum solution can be achieved.

We have searched for an optimum solution by maximizing/minimizing the following objectives:

- Maximize the exposure area to sunlight;
- Maximize the first frequency of the solar panel;
- Minimize the displacements due to thermal cycling;

The input parameters and their variability range which have been used in the optimization problem, are shown in Figure 6. Since the defined objectives are conflicting, a certain

PARAMETER	VARIABILITY RANGE
Young's Modulus	6.0e+10 – 7.0e+10 [Pa]
Length	1300 – 1900 [mm]
Width	400 – 1500 [mm]
Thickness	-4.5 – -1.5 [mm]

Figure 6: Input parameters and variability range.

trade-off will be accepted. The finite element model has been generated and parametrized in Workbench R11 and the Optimization "Workflow" has been defined in the modeFRONTIER Graphical User Interface (GUI), as shown in figure 7. The GUI allows to control any process setting included in the optimization algorithm.

3.2.Evaluation of the optimization results

After the optimization algorithm has completed its process, due to the many objectives, several optimum solutions have been generated. At this point, a careful evaluation of the results is indispensable. Despite the fact that a "design table" provides all input and output parameters of the process, a comparison of the designs is necessary in order to understand the effectiveness of the optimization. A parallel chart can be used for this task. To speed up the post-processing, it is possible to work on the parallel chart output ranges, in such a way that a reduced subset of optimized designs can be obtained (see figure 8).

To focus on the most relevant output parameters, a bubble plot has been used (see figure 9).

Finally, by merging the information provided by the parallel chart and the bubble chart, an optimum design has been selected. The improvements achieved are reported below:

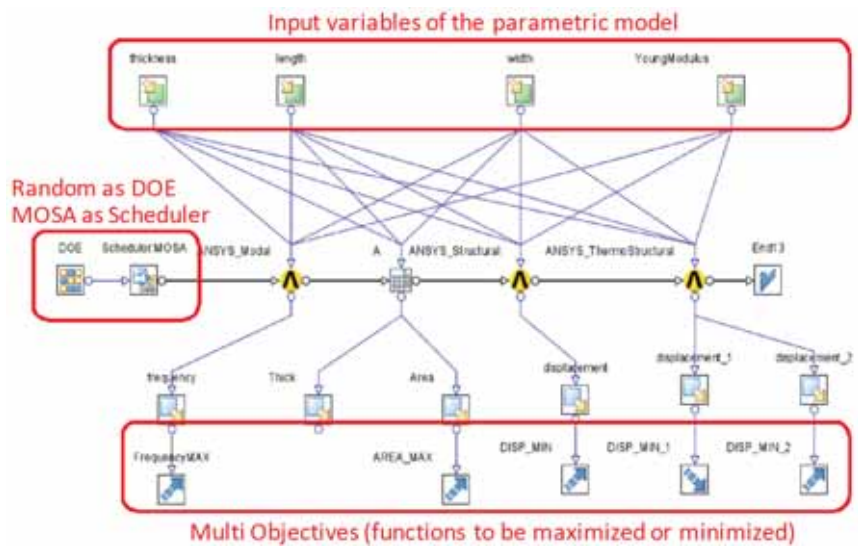


Figure 7: modeFRONTIER Workflow

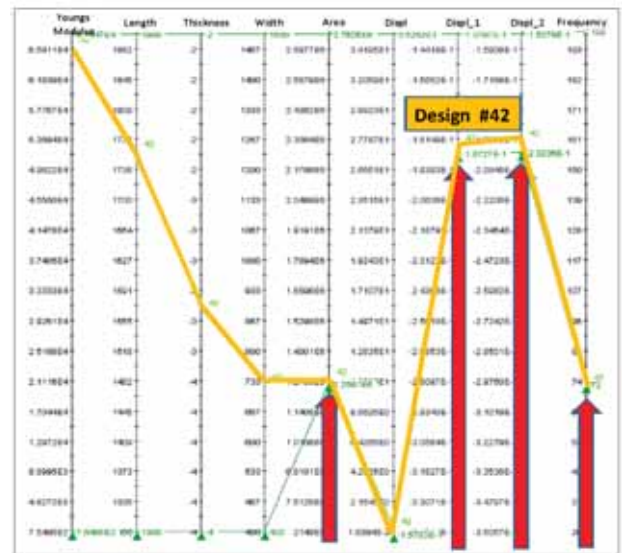


Figure 8: Parallel chart

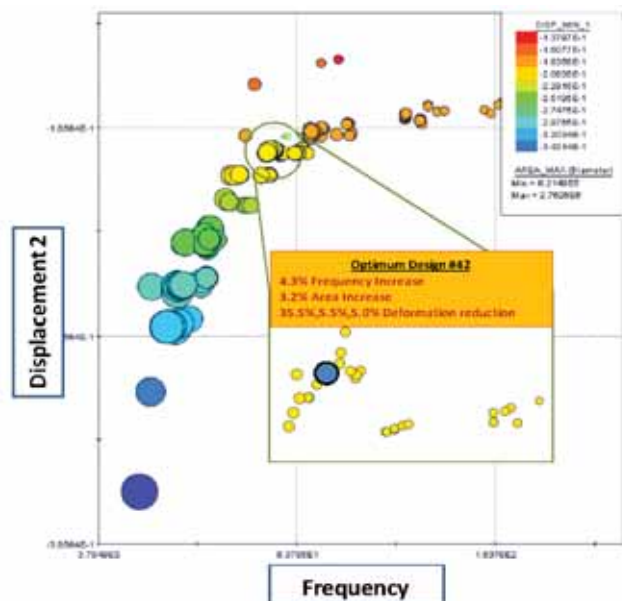


Figure 9: Bubble chart



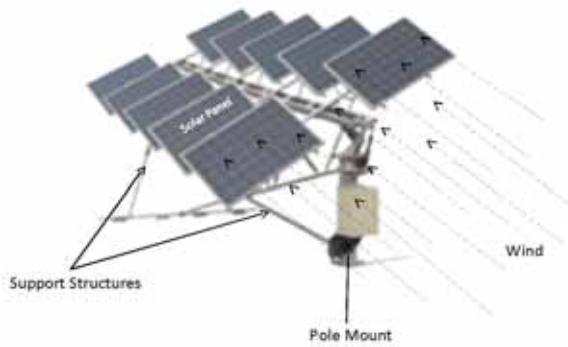


Figure 10: Solar Panel with Pole Mounts Schematic Diagram

5. Conclusions

In recent years, the interest in the solar industry, its developments and advancements, has been growing steadily; economic, scientific and technical sectors have contributed to this trend and process.

In this context, numerical simulations have proved to be mature, powerful and reliable technologies whose capabilities can be exploited to reduce cost related to test phases, to gain a better understanding of the behavior of solar panel systems, and to prevent possible causes for failure or low efficiency.

Furthermore, since the solar sector is expected to assume a major role in the global energy market, and specifically in domestic energy demands, the primary objective is to guarantee that solar panels deliver best performances in costs, efficiency, reliability, robustness, safety, durability and aesthetics. Existing difficulties for designers are linked to the huge number of parameters and the conflicting ways in which they affect the final results. In order to overcome these difficulties and to reach the targets, design processes have to take into account multi-disciplinary and multi-objective optimization techniques to achieve optimum results.

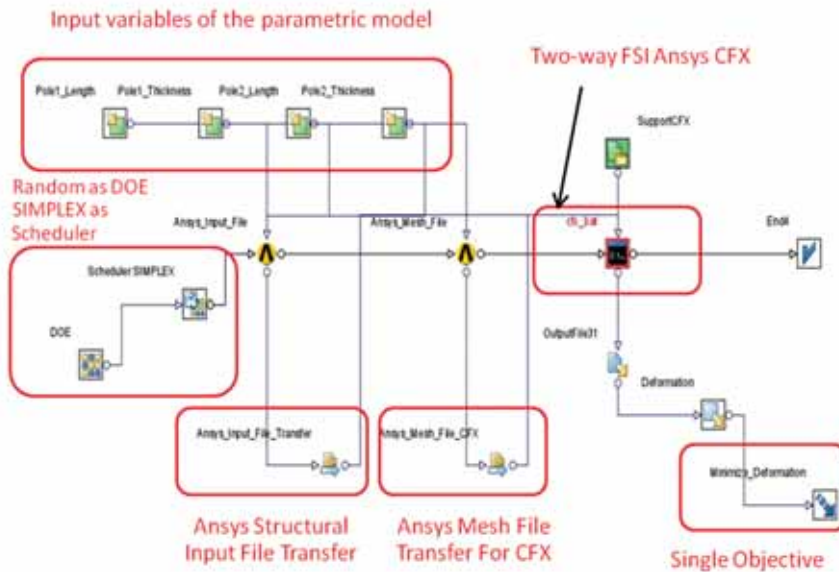


Figure 11: modeFRONTIER Workflow

- maximized power output (+3.2%)
- maximized robustness (+4.3% first frequency; -35.5% displacement)

4. Solar panel case study. Structural Optimization of the pole mount supports

The second case study analyzed has been focussed on the structural optimization of the solar panel pole mount supports (see figure 10). The goal of this optimization case study has been to identify the best geometric configuration of the pole mount support structure when subjected to a wind load equal to 5 m/s. The analysis was performed with the aim to find the maximum displacement of the solar panel. Since the problem involved only one objective function, the optimization process is defined mono- objective. In order to generate the optimization workflow, ANSYS Structural has been coupled with ANSYS CFX. Consequently, a Two-way Fluid Structure Interface analysis needed to be performed. In figure 12, the optimization workflow is shown. The improvements achieved on the structural rigidity are equal to 56%.

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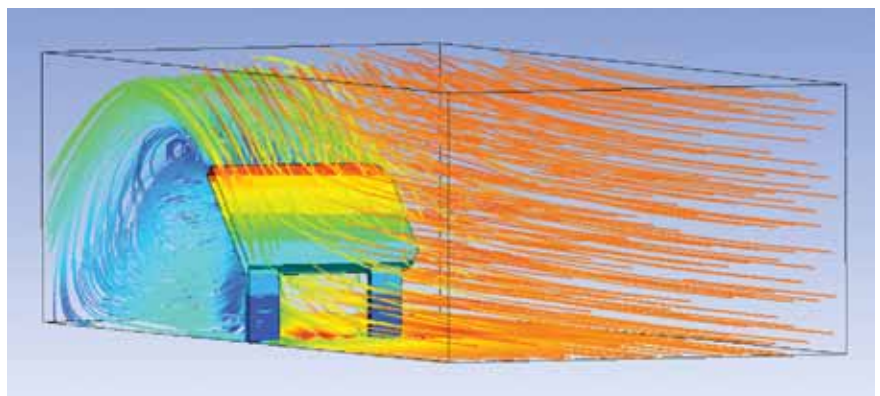


Figure 12: Deformation and Air-flux Streamlines

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Multi-phase CFD study of a reciprocating gas compressor with liquid slug ingestion

Contents

The thermo-fluid-dynamics phenomena that occur in a cycle of a reciprocating compressor, and in particular the pressure loss through automatic valves, ducts and manifolds, cannot be investigated and detected easily with a traditional experimental approach. The investigation is even more difficult when it comes to biphasic fluids. They can be studied only by means of advanced simulation techniques.

The effects of a liquid slug ingestion in a reciprocating compressor cylinder for gaseous hydrocarbons have been analyzed using Multi-phase CFD with the goal to calculate the pressure distribution on the piston. It has been demonstrated that the pressure forces can reach high values which may cause structural failure in the crank mechanism. The study was conducted using the software ANSYS FSI simulating the behavior of a mixture of gaseous and liquid hydrocarbons during the delivery of the crank end of a cylinder of a horizontal reciprocating compressor.

Introduction

The reciprocating compressor is a machine which consists primarily of: (see Figure 1):

- Frame
- Crankshaft
- Connecting rod
- Crosshead
- Rod
- Piston
- Cylinder
- Automatic valves
- Ancillary equipment (coolers, separators, dampers bottles etc)

Figure 1 illustrates an horizontal balanced opposed reciprocating compressor of the same type as the one considered in the analysis.

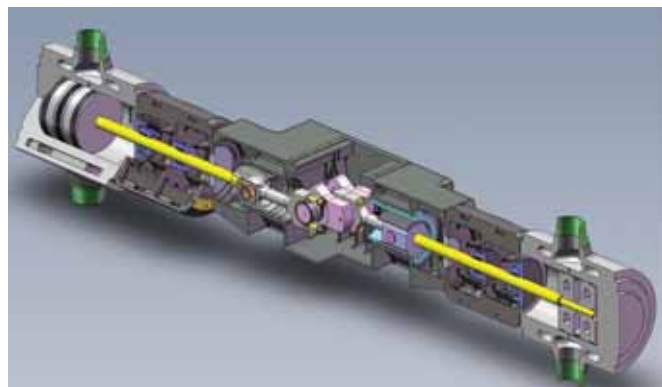


Figure 1: Schematic picture of a typical horizontal reciprocating compressor

The type of fluid handled by this kind of machine has to be strictly limited to gas, under no circumstances can there be a liquid fraction. This is also explicitly stated in the standards API618 - Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services - Ref [1] governing the design and the operation of these machines.

Moreover, the compressor is typically inserted into a complex plant, which contains equipment, such as reactors, heat exchangers, separators, etc., while it is very common that the type of fluid treated represents a mixture of hydrocarbons. The hydrocarbons may have a rather high temperature, dew point (condensation), while the complexity of the plant, most often installed in open fields, can lead to uncontrolled cooling of pipes as well as to defects in the operation of the liquid fraction separators.

The particular case described here is about the remote possibility of the machine being in the abnormal condition of liquid ingestion.

Purpose of the study

The phenomenon of liquid inlet is as dangerous as insidious: beyond the extreme cases (continuous suction of only liquid with consequent stoppage or sudden destruction of the compressor), sporadic incidents frequently occur in which one or more cylinders suck important liquid fractions for a certain number of cycles. The study showed that the damage resulting from these events may seriously affect the life and safety of the machine, even if at the time of the event, no apparent damage was observed.

The purpose of this article is the simulation of the arrival of fluid at the intake of the crank end of a double acting cylinder of a reciprocating compressor, to determine the intensity of the forces that are generated in the various machine components, with the purpose of investigating whether they may be responsible for damages, and if so, for what kind of damages.

Examined case

The machine used is described below:

- 4 double acting cylinders
- Power 400 kWatt
- Rotation speed 500 RPM
- Automatic discs valves
- Rated inlet pressure 15 bara
- Rated Delivery pressure 21.2 bara

This is a refinery compressor and the fluid handled is a mixture of hydrocarbons with the following characteristics:

gas phase:

- Molecular weight 11.7



Liquid phase:

- Density 600 [kg/m³]
- Viscosity 2.7e-4 [kg / (m s)]
- Specific heat 2238.0 [J / (kg ° K)]
- Thermal conductivity 0.1344 [W / (m ° K)]

Normal operation (gas)

Figure 2 shows the pattern of pressures in the cycle when the machine is in normal running condition, handling gas. For example, for the crank end and starting from Bottom Dead Center, the steps of:

- Clearance volume expansion
- Suction up to Top Dead Center (the pressure inside the cylinder is below the nominal value of suction pressure due to the valve pressure drop)
- Compression
- Delivery (the pressure inside the cylinder rises beyond the nominal value of the discharge pressure of the pressure drop due to valves)

The forces on the crank mechanism depend, other conditions remaining equal, on the maximum discharge pressure.

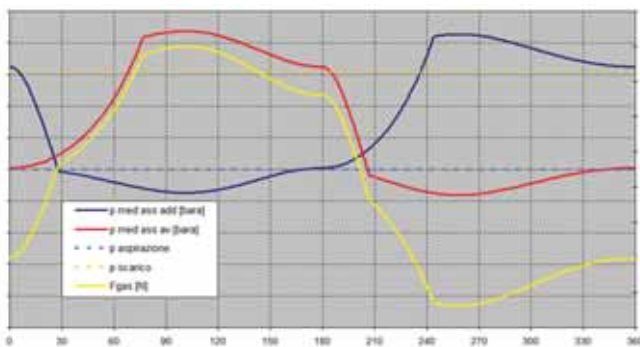
Operation in abnormal conditions (liquid ingestion)

Figure 2: Evolution of pressure in a cylinder of a reciprocating compressor

If a cylinder is beginning to ingest a certain amount of liquid at every turn, one will find an increasing fraction of liquid in the cylinder during the subsequent phases of compression, in a way that is not simple nor unique to represent.

The diagrams of the discharge pressure will change dramatically and, as described in detail below, different models have been implemented (analytic one-dimensional) that allow to estimate the liquid fraction inside the cylinder, the trends of pressure and the peak value reached. These models are highly sensitive to the values of pressure and the loss factor assigned to the valve cylinder – the valve port system.

Importance of transients

The pressure loss factors of valves are known with good approximation for the normal operation with gas in steady state

(usually are found experimentally on test benches in steady state conditions). In the conditions that we want to investigate (liquid ingestion), one faces an operation with a gas-liquid mixture fractions variable which is not predictable by analytical calculation methods. Of particular importance is the influence of the opening and closure transient of valves, covering a rate close to 35% of the duration of the whole delivery phase.

All this shows how inadequate it is to perform calculations using constant parameters, that consider a steady flow in such a transient phenomenon.

Innovative method for and approach to the problem

We have observed how the nature of the physical phenomenon does not allow us to investigate and obtain sufficiently accurate results with a one-dimensional approach.

Also a CFD two-dimensional approach is not adequate to the problem complexity as it not possible to identify symmetry conditions.

The only adequate method to quantitatively analyze what happens in the cylinder and through the valve is a three-dimensional CFD simulation.

Moreover, to achieve the aim of investigating the actions on the most critical parts of the machine, one needs to simulate the fluid dynamic transients and dynamic structural constraints that determine the concentrations, flows and pressure behavior not only in terms of mean values but point by point and at every instant of time.

The new method of investigation develops in the following steps:

- 1D gas (single phase)
- 3D CFX Direct Analysis (mobile mesh, rigid valve rings with rigid translational motion, single phase).
- Validation of the model by means of absorbed power measurement.
- 1D analysis multi phase involving more consecutives cycles
- Definition of the initial conditions of the subsequent 3D analysis
- 3D CFX Direct Analysis (movable meshes, rigid valve rings with rigid traslation motion, multi phase).

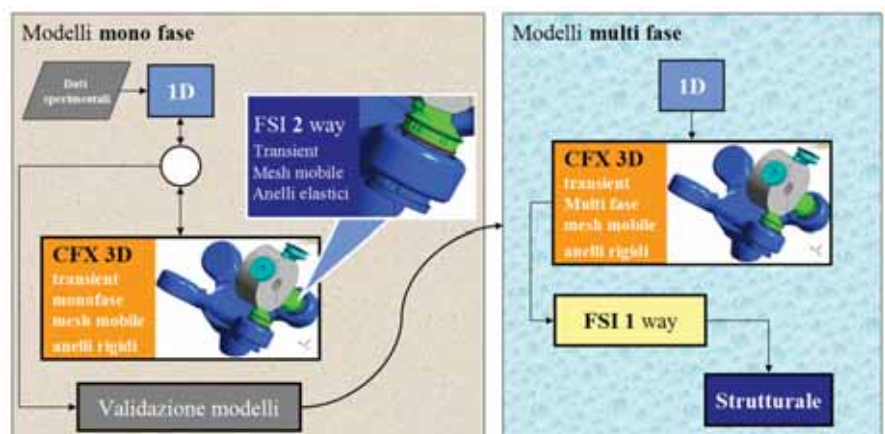


Figure 3



- Valuation of the importance of the transient phase during the cycle (single phase).
- Transient analysis by means of FSI 2Way.

Models of analysis for the method development

One-dimensional method description

The one-dimensional calculation (Visual Basic code implemented in Excel) considers the crank end of a reciprocating compressor cylinder. Its purpose is to analyze the abnormal operating conditions in which the pumping cylinder ends, starting from the rated operating conditions with only gas, performing cycles with liquid, resulting in pressure peaks during the compression phase (see Figure 4). The thermodynamic transformation is considered isentropic. The sheet contains all the input data for the calculations, including the value of the step of calculation in terms of fractions of crank angle.

The calculations related to the cycle start from the suction phase (BDC for the crank end and UDC for the head end) with a zero amount of liquid inside the cylinder, and gas at delivery pressure. Then, a suction phase of only one type of liquid mixed with a residual gas in the clearance volume of

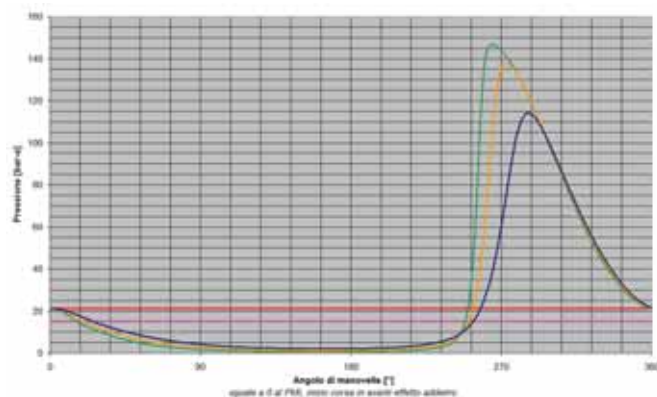


Figure 4

the cylinder is simulated. The harmful gas-liquid mixture will be compressed and discharged through the delivery valves. The final quantities of gas and liquid in the clearance volume conditions at the end of each cycle, are taken as initial conditions for the next cycle. The volume of fluid inside the cylinder increases during every subsequent cycle, since only liquid is sucked, and a mixture of gas and liquid is discharged.

3D CFD Model

The thermo – fluid dynamic analysis was conducted using a fluid dynamic model that reproduces a symmetrical portion of the cylinder crank end and covers, by symmetry, one delivery valve and an one inlet valve (Figure 5).

The fluid analysis was performed in transient and turbulent condition, under the assumption of compressible mono or multiphase flow, and using deformable mesh calculation. The deformation of the 3D domain changes the configuration of the cylinder, whose volume is reduced with a time law imposed by the law of motion of the piston, and changes the

configuration of the valve also, whose rings are moving according to fluid dynamic forces acting on them.

The mobile surfaces are those of the piston and valve rings within the valve. The simulation of opening and closure of the valve rings in CFX is obtained by solving the equation of the motion of the rings, treated as not deformable and with only one degree of freedom (translational).

In the motion calculation, the dynamic forces acting on the rings, the characteristics of inertia and the forces due to springs, have been taken into account. At this stage, it has been considered acceptable to consider the rings as infinitely rigid and to calculate a movement of pure translation, since the rings are fully open in the zone of the cycle where the maximum pressure occurs. This was the main objective of this study, and it is even more correct in the operation with liquid + gas (multiphase).

The software used for analysis are:

- ANSYS ICEM-CFD for the generation of geometry and mesh calculation
- ANSYS-CFX for fluid analysis

At the end of a functional construction of the calculation mesh and the definition of 3D regions with flexible walls, 4 different fluid domains were defined.

In the various regions of fluid, meshes with hexahedral elements are realized, which allow better quality control of the mesh during the motion of the piston and rings, while tetrahedral prism mesh are used in those regions where deformations of the geometry do not occur: in fact a tetrahedral mesh is able to better describe in detail the geometric complexity of the areas close to the valve.

The flow was considered transitional and turbulent (k- ϵ turbulence model standard).

The resolution of the equation of total energy allowed to take into account the conditions of compressible flow.

Not being negligible the action of gravity of the liquid phase, also the gravity effect was taken into account.

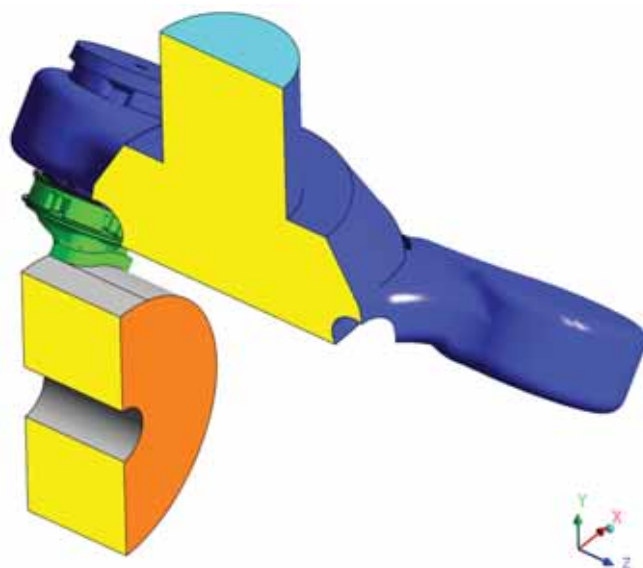


Figure 5



In the multi-phase analysis, a homogeneous model with regard to speed, temperature and turbulence was used.

The use of a multi-phase model involves the solution of transport equation for the variable "volume fraction". This variable allows to describe the distribution of two phases in the system.

The use of a homogeneous multi-phase model on a particular variable assumes that the two phases share the same field for the variable in question.

With reference to the speed, this means that at every point of the domain, gas and liquid are characterized by the same velocity vector.

The basis of this model is the assumption that the exchange of the momentum, energy and turbulence between the phases are sufficiently high to ensure that the two phases are found everywhere in equilibrium and therefore share the same fields.

Under this hypothesis, it is possible to solve the transport equations using the properties of "bulk" that are calculated locally on the basis of physical properties and depending on the volume fractions of the two phases.

Other parameters for the analysis are listed below:

- In the Multiphase analysis, liquid + gas are considered with immutable percentages, without the effects of evaporation or condensation.
- Mechanical parts are considered as undeformable (the profile of motion of the piston is known, and its deformation does not influence significantly the fluid dynamic field).
- The load of each valve spring of the rings (a total of 18 springs, the outer ring 8, 6 on the central, 4 on the inside with $k = 3.06 \text{ N / mm}$ housed in the holes of the counterseat) is 3.672 N
- To the rings of the discharge valve the only degree of freedom of axial translation was assigned
- The initial conditions for the 3D analyses are derived from the one-dimensional analysis method at the time of the compression start.

Method application

First, it was necessary to develop a model and to validate it. Since for gas operation values, the factors of compressor valves loss in steady state conditions are available, a single-phase one-dimensional model to evaluate the pressure curve of suction and delivery, was first implemented.

Then, the delivery phase of the cylinder has been simulated in a 3D model CFX mono phase.

The pressure loss factor was verified, calculated with CFX, where the rings are fully open. It was in agreement with experimental values, while in the opening and closing transients, they were much higher.

For this reason, the absorbed

power has been evaluated. Again the result was in agreement with the experimental data.

The model, thus validated, was used again to re-run the same cycle of analysis with the multiphase fluid.

Given the characteristics of the plant where the machine operates, the pattern of arrival of the liquid in the cylinder tests was the suction of fluid from the cylinder with liquid for two subsequent cycles. With these assumptions and through the one-dimensional model, the complete first and second cycle (intake and discharge) have been simulated - Starting from the UDC, to determine at the start of the delivery phase of the third round, the fraction of liquid and the values of pressure and temperature in the cylinder. The latter are then to be used as the initial conditions for the subsequent analysis CFX 3D.

The pressure field calculated by CFX Multiphase analysis was then imported into 3D structural analysis to assess the state of stress on the machine-induced pressure peak.

Results

The maximum pressure inside the cylinder which was obtained from the CFX 3D multiphase analysis is 125 bara, against the nominal 21.2 (see Figure 6)

This value of pressure is certainly likely to cause structural damages of the machine even after a few (3-5) cycles of abnormal operation, which can significantly reduce the operational life of the machine.

The 1 Way FSI analysis have permitted to find that the values of forces on the cranks mechanism can reach levels that would cause irreversible damages.

Model FSI 2Way

The simulation permits to analyze the interaction among the fluid and the structure considering the various aspects related to the elastic deformability and the inertia of the components. The pressure profile on the interface surface fluid / solid defines for each time instant the force field that stresses each valve ring determining the deformation profile and the motion condition.

The valve rings have all the possible degrees of freedom, rotational and translational, and have been added the limit in axial displacement due to the valve seat and counter seat. The analysis has been performed with gas because this is the situation relevant to the normal operation of the machine, and has confirmed, moreover, that the valve rings are a

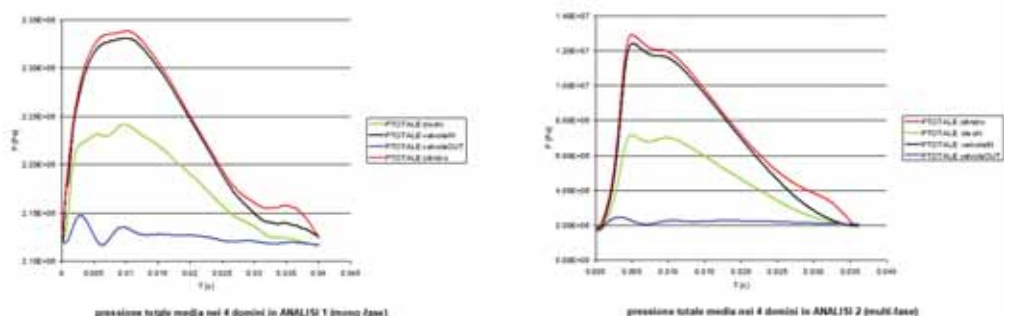


Figure 6



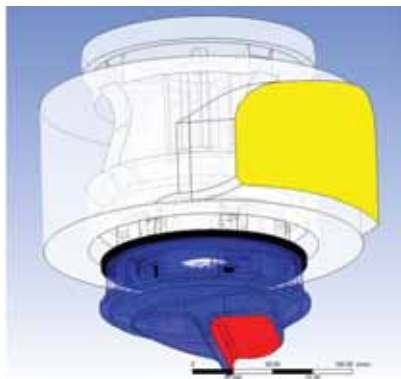


Figure 7

critical component of the machine. Also in normal conditions, the analysis has been limited to a portion of the domains, to the valve portion actually, to reduce the calculating time.

The boundary conditions for inlet and outlet have been

assigned through the profiles of pressure calculated from the CFX 3D mono phase analysis on the surfaces involved (highlighted in red and yellow in figure 7).

For the valve rings, the model "transient structural" has been implemented in ANSYS, and preload springs and gravity have been considered.

Hexahedral mesh has been used for the rings in ANSYS.

To the surfaces of the rings in ANSYS CFX the boundary condition "mesh motion" with the "ANSYS Multifield" option was assigned, while the outer surfaces of the rings have been assigned the "Fluid Solid Interface" status.

Additional considerations: analysis of valve opening and closing transients

At this point, the duration of the transients of the opening and closure of the valve rings in the cycle with gas has been estimated. We could ascertain that they cover a total of about 35% of the length of the discharge (see Figure 8).

The approximation of considering the valve rings as rigid bodies and assign them a movement of pure translation is adequate to evaluate the peak pressure, but it is not acceptable for the evaluation of the opening and closing transient phase.

Given that this is more than 1 / 3 the length of the delivery in which the system cannot be considered in regimen, the phenomenon of transient is analyzed in more detail by means of FSI analysis using 2Way simulation to assess more thoroughly the fluid dynamic (pressure) and mechanical (deformation of the disks, the stress states induced, vibration, shock, etc.) phenomena. Figure 9 shows a short sequence of the transient opening and closure of the valve rings in the cycle with gas, starting from a steady state. The sequence is in an enhanced deformation

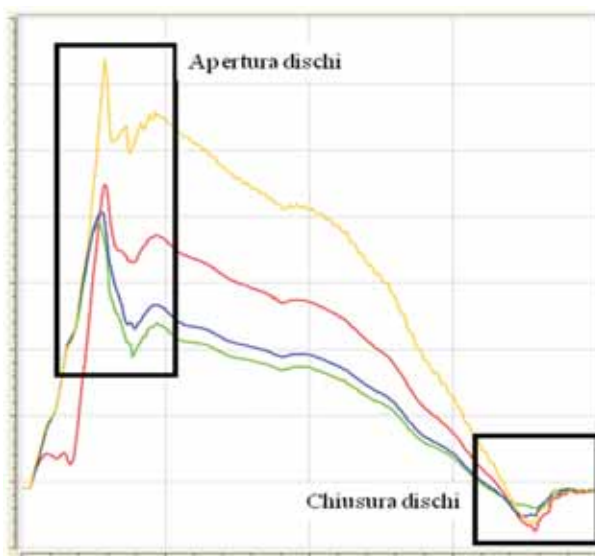


Figure 8

scale (100:1) in order to better evaluate the deformation and vibration affecting the rings and the different dynamic behavior of the single ring with respect to each other. Note that at the end of the whole cycle the rings do not reach a new steady state, however, they are vibrating at the beginning of the following opening cycle.

Conclusions

With the help of the multi-phase analysis in the CFX environment, we could demonstrate the hidden dangers of a gas compressor which operates only a few cycles with ingestion of liquid.

The introduction of approximations utilized in the CFX 3D analysis (such as, for example, the rigid motion of the valve rings or their consideration as rigid bodies) is permitted when the aim is evaluating the overall performance of the plant, but becomes unacceptable when seeking to investigate the functioning of specific organs of the machine.

The subsequent analysis 2Way FSI focused on automatic valves allowed to characterize the actual behavior of the moving parts (valve rings) of the valve itself in the transient opening and closing, highlighting the influence of motion of the valve rings on the progress of local pressures and strains and pressures on the valve rings during each cycle.

We wish to stress that it would be very difficult to demonstrate these elastodynamics phenomena with other analytical methods or experimentally, and that the findings represent accurately the criticality of operating these components.

The validity of the method to analyze transient phenomena characterized by highly dynamic transients has been proved, where traditional experimental techniques or analytical calculation can hardly provide adequate information.

We believe that these models can be effectively extended, providing many benefits, to investigate similar phenomena involving the interaction between fluids and flexible mobile facilities in other areas. In particular, the use of this method may allow the optimization of fluid dynamic profiles of the valve zone of cylinder compressors with a good chance of reducing related energy consumptions.

References

[1] API618 - Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services

Marco Faretra - Barbalab S.r.l.
Giovanni Barbanti - Barbalab S.r.l.
Riccardo Traversari - CST S.r.l.
Massimo Galbiati - EnginSoft S.p.A.



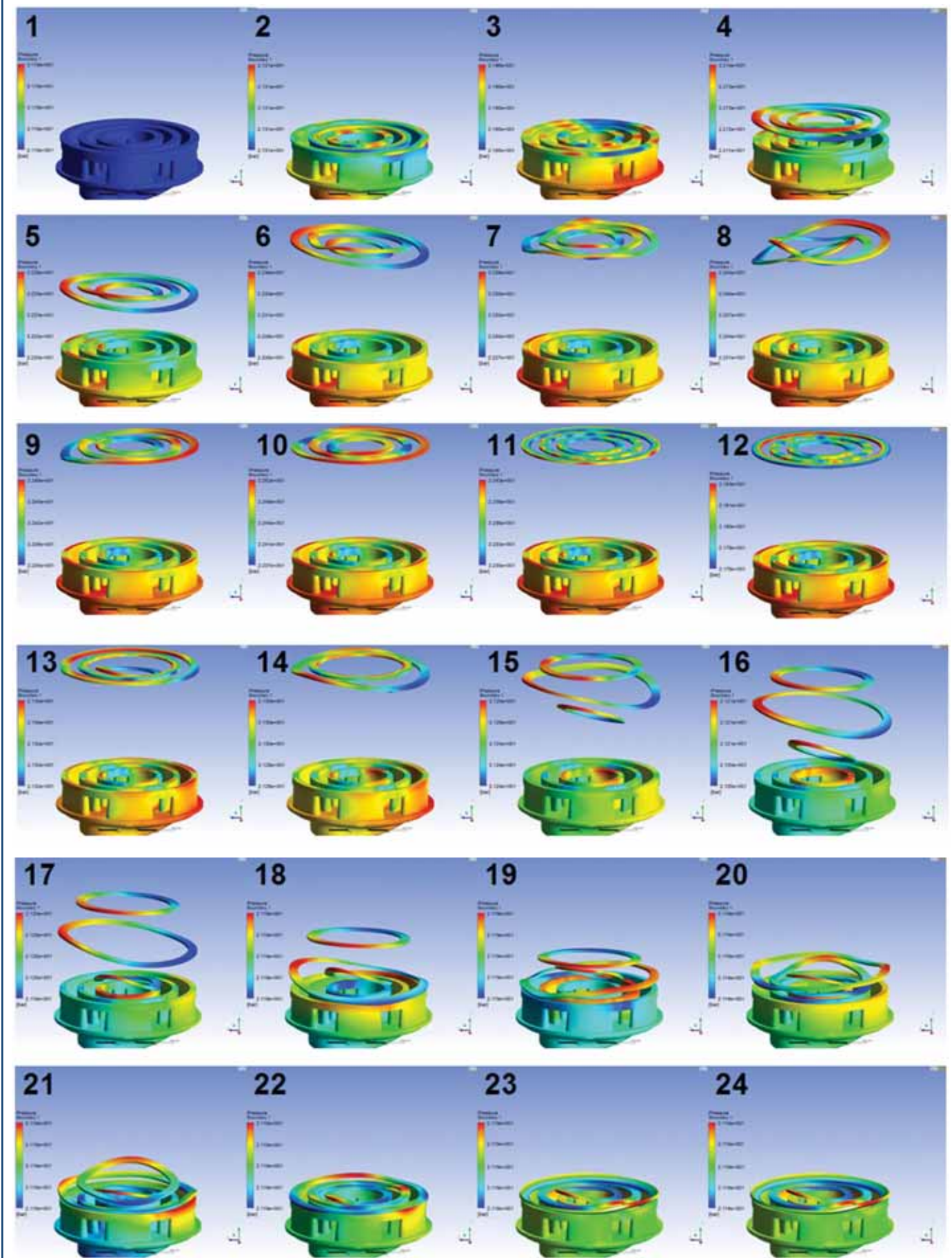


Figure 9



Multi-objective optimization of an aluminium automotive part using modeFRONTIER

In a high-cost country such as Norway it is very important that high volume products, for example automotive parts, are designed and produced in the most cost-efficient way. For aluminium components, the weight is of special interest due to the significant cost of the raw material. Lighter components are also rewarded by a higher price on the market and, in addition, help us to preserve our environment by lower fuel consumption.

Simulation of manufacturing processes still poses challenges and requires experience in order to get reliable results in an efficient way. A good example is forming with springback, especially if the component is formed in multiple operations. With the technology of today, is it possible to automate the search for the best design in this environment, something which would be highly desirable?

Despite many potential problems, a challenging project aiming at automatic search for the optimal design of an automotive wheel suspension component was started. In the project team, SINTEF Raufoss Manufacturing AS added expertise in manufacturing and materials technology, A-Dev brought expertise in nonlinear analysis and automation while EnginSoft Nordic AB focused on optimization methodology.

Motive

The project is part of the Norwegian research program AluPart which aims to "secure future production of aluminium-based automotive components within Norway" by "inventing, developing and industrializing new and radically improved manufacturing technology". The ability to steer

automatic design processes towards the specified goals is recognized as a key technology which will be of great value to the industry, provided it works on real world problems, may be applied to virtually any engineering analysis and is easy to understand and use by the local engineer.

An automotive control arm, made from an extruded aluminium profile, was chosen for the study, cf. figure 1. Simulation models and a baseline design were provided by Raufoss Technology AS who is a leading manufacturer of aluminium control arms. In 2006, their production exceeded 1.4 million complete control arms, delivered to companies like GM, Fiat, Hyundai and Kia. Some examples of their products may be seen in figure 2.

The challenge

The study aimed at finding, through automatic search methods, the best design with respect to cost, performance and manufacturability. The cost value focuses on material cost and takes recycling of cut material into account. The performance is measured by the durability of the component, i.e. the number of loading-unloading cycles it can withstand without fracturing. Also, the deformation of the material during the forming operations is not allowed to exceed a certain limit.

The component is made from an extruded aluminium profile which is cut and formed in multiple steps to its final shape, cf. figure 3. To capture the manufacturing process, a combination of explicit and implicit FE analyses was performed in ABAQUS. While forming used explicit integration, springback and the final fatigue evaluation used implicit integration.

In order to find the best design it was not sufficient just to optimize the shape of the extruded profile, but rather the whole manufacturing process must be optimized, including the shape of the aluminium profile as well as the shape of the cutting and forming tools.



Figure 2. Raufoss Technology AS is an innovative company that designs and produces automotive components in aluminium. The studied control arm is produced according to the patented ExtruForm® process.

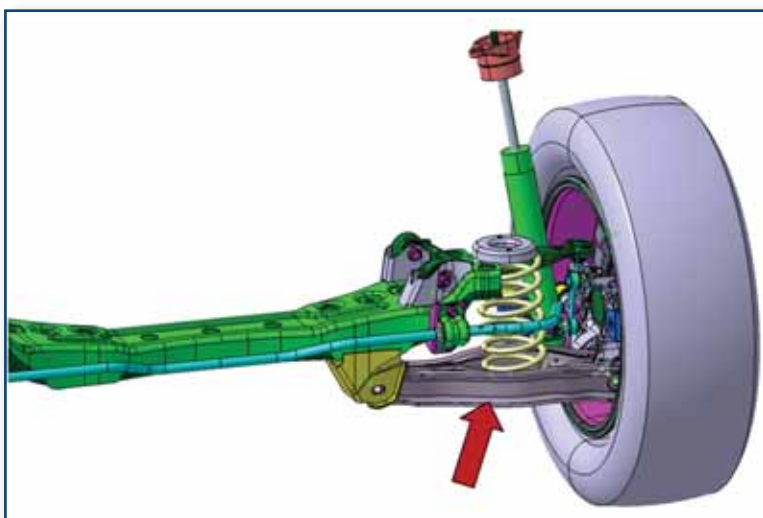


Figure 1. The goal of the project was to find the optimal design of the control arm through an automatic search. The control arm links the wheel to the body of the car.



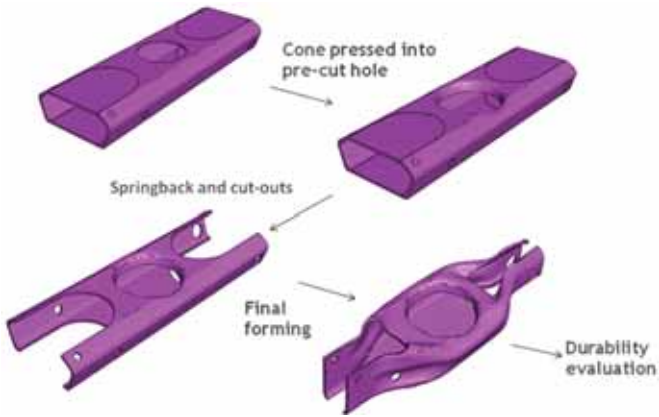


Figure 3. The control arm is formed and cut in multiple operations before the final durability evaluation.

Furthermore, the optimization was performed using "no prior knowledge", meaning that no engineering knowledge of good designs or the base-line design was included in the starting set of the optimization. On the contrary the specified ranges for the input parameters were chosen to be wide on purpose. The aim was to build a methodology independent of prior engineering insight of the problem. This approach, of course, puts the highest demands on the optimization algorithm. Thinking ahead, any prior good design that may be provided as a starting condition for the optimizer may dramatically reduce the number of required design iterations.

The solution

modeFRONTIER was used to link multiple cutting and forming FE simulations into an automatic process and guide it towards the specified objectives. The automated operation included the pre-processing with its geometry change and remeshing, and post-processing including a durability evaluation. Altogether 22 parameters controlled the

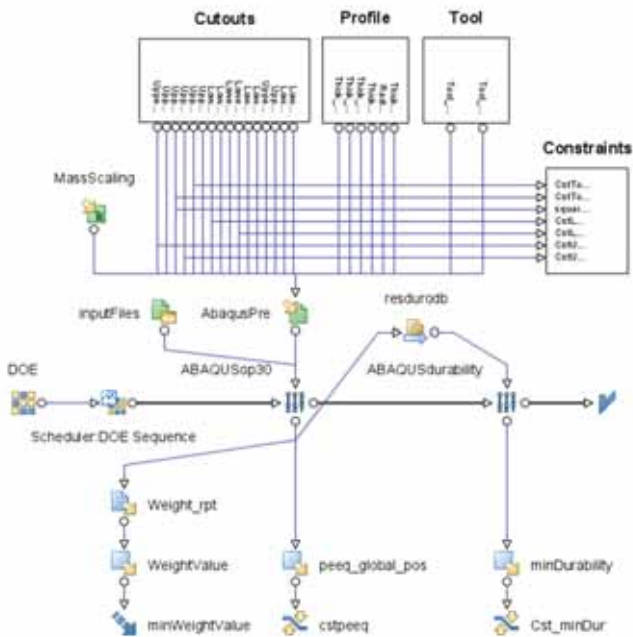


Figure 4. modeFRONTIER was used to automate multiple forming operations in ABAQUS and steer the search for the best design. The 22 input variables are shown at the top.

geometries of the extruded aluminium profile and the tools. The workflow in modeFRONTIER can be seen in figure 4.

An automatic search for the best design requires numerous design evaluations and speeding up each evaluation is often very attractive. As such, modeFRONTIER promotes a trend opposite to the common search for ever more detailed and accurate simulation models. With regards to the automatic process, we only need an accuracy of the results which makes sure the optimizer is guided to the global optimum. Final tuning and validation may be done with high fidelity as part of a hybrid optimization strategy, while the search for the optimum makes use of a faster, approximate model. But what accuracy of the results is good enough for the global search? By sampling the design space and evaluating

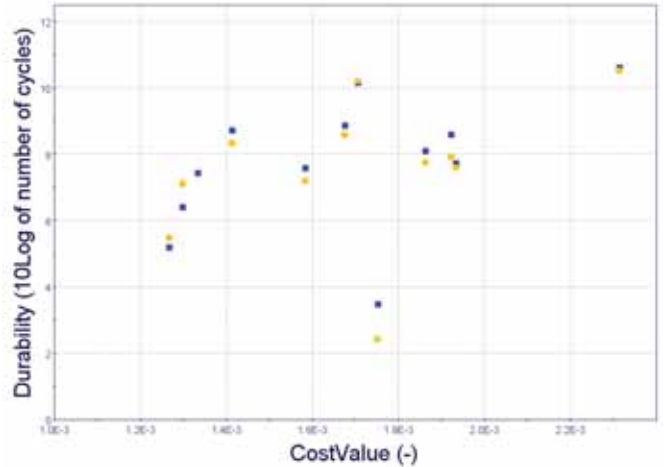


Figure 5. A set of designs are evaluated with two different mass scalings. For each design the cost value is constant and the two points should ideally overlap. The difference in results from the original and the 10 times faster model is small compared to the design space and the Pareto front.

models with different levels of accuracy, it is possible to arrive at an engineering answer. In the forming analysis a significant time saving could be achieved by an increased mass scaling. In figure 5, showing a comparison of calculated durability between two levels of mass scaling, it can be seen that the difference between the two levels are relatively small compared to the size of the results space and the size of the Pareto front, both regarded as relevant relative measures. As the validation has been done on the entire design space rather than a single design, it is likely that the conclusion is valid also for similar components. Being a side effect of this optimization project, the faster approximation may be trusted to help speed up manual design work as well.

Because of the mentioned findings, a multi-level hybrid optimization strategy was selected, including a multi-objective global search, a single-objective local refinement and a final verification. The first two optimization phases used simulation models with significant speed-up due to a higher mass scaling in the explicit forming steps. Following the first two optimization phases a verification phase was performed with the original mass scaling to ensure reliable and comparable results.

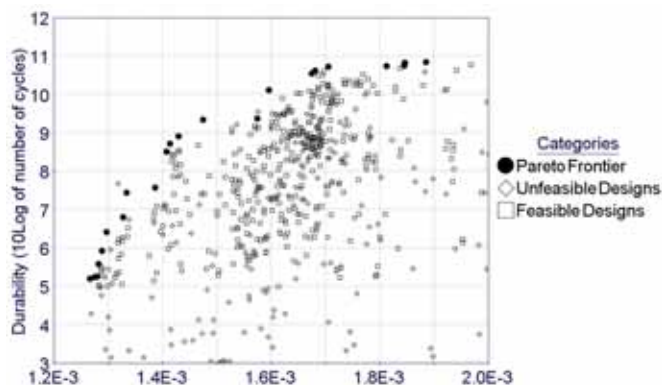


Figure 6. The Pareto front from the initial multi-objective search shows the trade-off between material cost and durability of the control arm.

In the initial study, a multi-objective optimization problem was defined to simultaneously minimize the material cost and maximize the durability while keeping the plastic strain below a specified limit during forming operations. This optimization mapped, in a pedagogical way, the trade-off between the cost and the durability, cf. figure 6.

Once the relationship between the cost and the durability was mapped in the multi-objective optimization, the problem was restated in single-objective form aiming to minimize the material cost while respecting the requirements for durability and maximum allowed plastic strain. In the final phase of the optimization, the designs

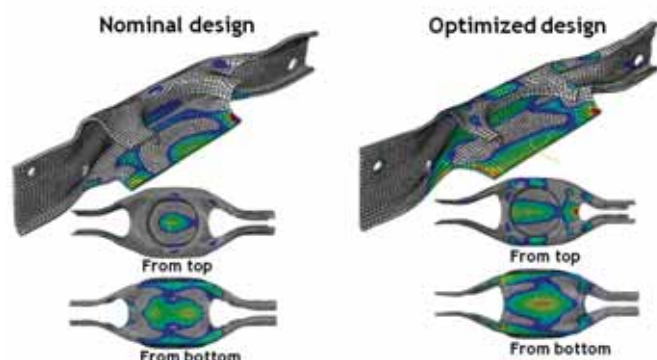


Figure 7. As expected, a larger volume of the material is stressed in the optimized design while the peak value has been decreased. The plot shows expected fatigue life, red being lowest and light grey highest.

from the previous optimization phases were verified with the reference mass scaling, and from this optimization/verification the final design, cf. figure 7, was found.

During the optimization process many designs failed to complete all analysis operations, and thus to deliver a result. A sampling with 650 designs over the full parameter range was performed to investigate this issue. The result, shown in figure 8, reveals that less than 10 percent of the designs managed to succeed. The majority of the designs failed due to geometry build failures, elements exceeding the distortion limits and non-convergence in springback calculations. While a geometry build error may be detected

and recovered from in the order of seconds, errors like non-convergence in the final springback analysis may degrade the performance of the search significantly. Due to the low success rate this optimization task was a real challenge for the search algorithm. Nevertheless, modeFRONTIER was able to run continuously for hundreds of hours on a heavily loaded PC in a persistent search for the best designs.

Results

An automatic process for the forming and cutting operations was created and a hybrid optimization methodology was tested and verified. Besides the best design, several soft values came out of the project such as systematic identification and ranking of simulation error sources.

The optimized design reduced the material cost by 25 percent while fulfilling the constraint on the maximum allowed plastic strain during the forming operations. At the same time, the durability increased from 13 000 to 1 700 000 load cycles.

Conclusions

In the context of product development, the applied multi-level hybrid optimization strategy was well justified and is recommended for future work.

The automatic optimization process managed to:

- find the best design despite many analysis crashes.
- find the best design using a “no prior knowledge”-approach.
- reduce the material cost with 25 percent with increased durability and fulfilled manufacturing constraints.

Some work still remains in order to have a process ready to use in the everyday design work by the manufacturing companies, but the results are promising and modeFRONTIER has proved to be a robust and powerful tool for automating the forming analyses and finding the best design.

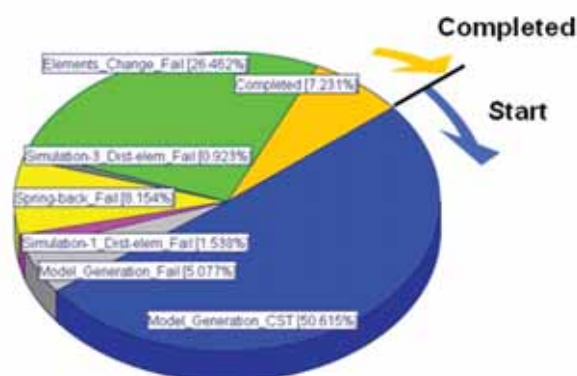


Figure 8. A sampling of 650 designs over the full input parameter space revealed the different simulation error sources. Less than 10 percent of the designs completed successfully.

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Optimization software drives Multi Body simulations in a Circuit Breaker design at ABB

Introduction

In any engineering design process, the final goal is to find a solution that is able to guarantee improved performance while respecting several constraints, despite operational condition uncertainties and manufacturing tolerances. Furthermore, this should be achieved while keeping the design cycle as short as possible, limiting extensive prototyping and experimental campaigns or even more costly product recalls. The solution proposed here enforces the usage of Computer Aided Engineering (CAE) simulation models, by integrating them with design automation and optimization software (modeFRONTIER), in order to introduce the so-called robust design concept from the early stages of the design process.

Let's consider a generic design process, where the product performance index should be maximized ("Performance" in Figure 1). Supposing a vastly simplified case that the performance depends mainly on two design parameters (Variable 1 and 2), the physical behavior of the product can be investigated by means of several CAE simulations. Results can then be plotted as in Figure 1, where designer should pick solutions A and B as optima candidates. While A guarantees absolute peak performance, the surrounding surface area is locally very steep: hence, the solution is prone to fast decay due to small changes of Variable 1 and/or 2. This might easily happen when the variables are affected by manufacturing tolerances or operational uncertainties. B, instead, is called a "robust" optimum: it is much less sensitive to variables' scatter, being located in a more flat (stable) zone of the Performance function. The search for such a design point B is called "robust design optimization", and represents the solution of the design challenge previously described. This paper presents such an innovative robust design optimization for high-voltage circuit breaker components. The available numerical model of such device includes 15 main variable parameters, while 4 performance indexes should be investigated simultaneously and several constraints respected. In this case, even finding a design that meets simultaneously all the constraints and has acceptable performance, represents a long process. In fact, numerical simulation should be

repeated several times following an inefficient and arbitrary "trial-and-error" process. modeFRONTIER greatly speeds up all of these processes, and also encapsulates the search for robust designs, allowing engineers to focus on the result analysis and on the trade-off decision process.

The Challenge

High voltage circuit breakers have to fulfill several functions, such as conduct the nominal current when closed (in the range of several thousand amperes); withstand the maximum rated voltage when fully open (up to megavolts); open and close under short circuit conditions and, above all, interrupt the circuit with current values ranging from very low up to the maximum rated short circuit (effective value up to 80kA). To do so, CAE modeling and simulation techniques are applied starting from the early stages of the design. Still, the difficulty of simultaneously satisfying all the demands and handling many parameters represents a bottleneck in the design process. Moreover, developing a robust configuration in terms of reduced sensitivity to unmanageable external parameters and manufacturing tolerances is mandatory. The solution proposed here integrate the CAE model(s) with an optimization software such as modeFRONTIER, taking advantage of its process automation and robust design optimization capabilities. A crucial component in a circuit breaker is the drive system, that stores the energy required for the circuit breaker operation, including mechanical motion when triggered by an external control system. Essential for any circuit breaker

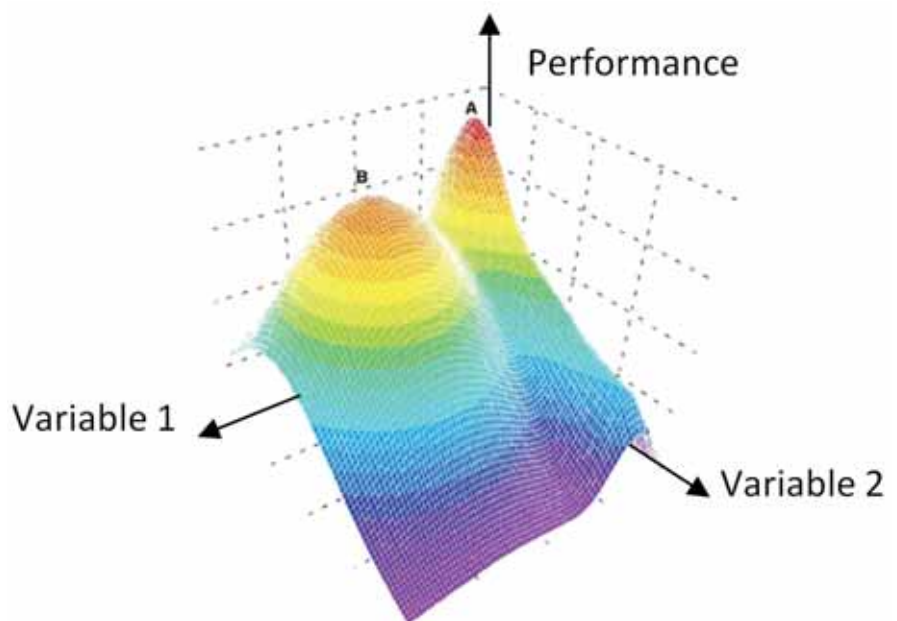


Figure 1: Two variable and one performance index design space: B is the Robust Optimum design



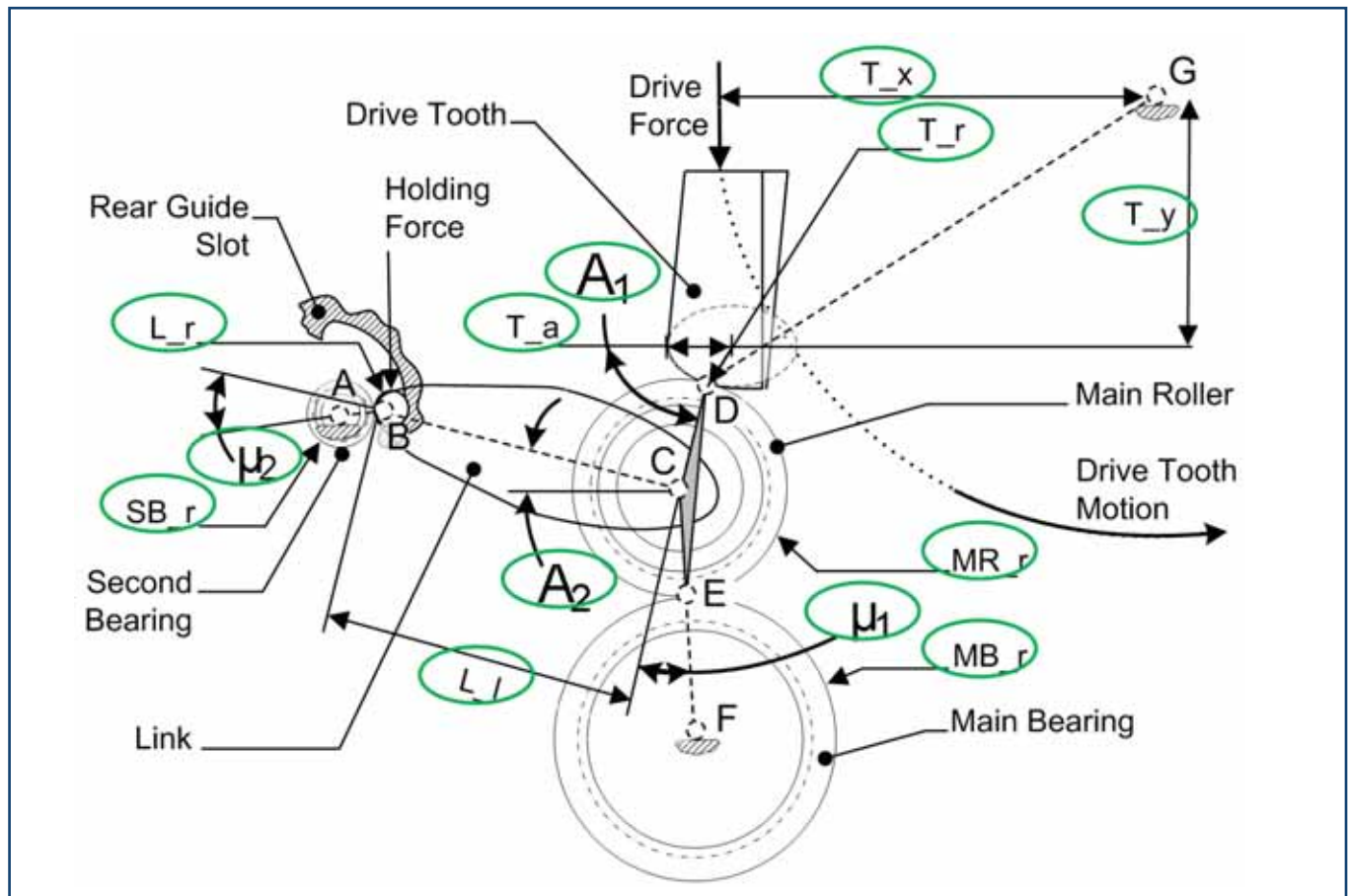


Figure 2: Representations of the parameterized latch mechanism

drive unit is the ability to release the stored energy in a controlled, repeatable and robust way. This is typically done through a specialized latch mechanism (see Figure 2) which serves as an interface between a high speed electromagnetic actuator and a circuit breaker drive element.

This planar mechanism is comprised of five main bodies (plus the ground) consisting of the drive tooth, two rolling bodies that are centrally constrained to the ground (main bearing and second bearing), another rolling body (main roller), that has intermittent contact with the tooth and main bearing, and finally a body (link) which is constrained by a revolute joint to the main roller and surface contact on the second bearing. The mechanism is driven completely by the force of the drive tooth, and released through removal of the holding force. Critical performance criteria for latch mechanisms include response time, response time repeatability, force reduction ratio (driving force / holding force), maximum holding force capacity, and minimum required tripping input (force and displacement). From these, the response time and force reduction ratio are of primary importance. To minimize response time (and contact stress), a tooth with a varying instantaneous contact radius was desired: for the purposes of optimization, the profile was parameterized using an elliptical profile. A parametric Multi-Body numerical model of the latch has been created in the MD Adams simulation

software to predict the mechanism performance, taking into account all the thirteen angle and length variables indicated in Figure 2, plus two parameters that describe the main roller and main bearing lengths. Such model contains also slot constraints, Herzian line contact stress, kinematic collision calculations and the extraction of the performance parameters. In order to simplify the parameterization and expedite the solution time, the interaction between bodies and slot constraints were modeled using curve-to-curve contacts. Additionally, any interaction from the drive was neglected (such as downstream transmission dynamics). Under these conditions, typical simulation time for a single case was less than 7 seconds while running on a standard workstation.

The Solution: latch robust design optimization using modeFRONTIER

The developed MD Adams parametric dynamic simulation model was coupled with the modeFRONTIER software in order to automate the parametric study, and perform the holding force and latch opening time optimization and robustness analysis. The first phase of this process is the "workflow" building. The workflow (Figure 3) represents the operations that should be automated in order to evaluate a parameter combination that represents a design. The considered independent parameters (called also "input variables") define a 15-dimensional variable space search (joint and contact friction parameters were considered



initially constant). Six independent objectives, all to be minimized simultaneously, include: the latch mechanism opening time; holding force; contact stresses between the tooth and main roller; between main roller and main bearing; between second roller and second bearing. Three constraints have been set up, including an upper holding force limit, a maximum allowable response time and an upper contact pressure limits.

Due to the relatively fast simulation cycle time, and to the fact that modeFRONTIER automates completely the MD Adams' simulations and the performance indexes extraction, a 10000-designs study was set up and completed in half a day. Initially wide parameter limits were considered, in order to explore the valid design space, as well as to obtain knowledge about the significance and influence of key input to output relationships. This sampling (referred to as "Design Of Experiments", DOE) has been performed by modeFRONTIER following a quasi-random "Sobol" scheme. These results, collected in a simple table, were post-processed within modeFRONTIER: only 1700 out of the 10000 designs were kinematically feasible. Within this subset, only 15 are also satisfying the relatively strict opening time, holding force and three contact stress constraints. This result in itself confirmed the difficulty in obtaining good designs through simple techniques such as DOE sampling, and the complete

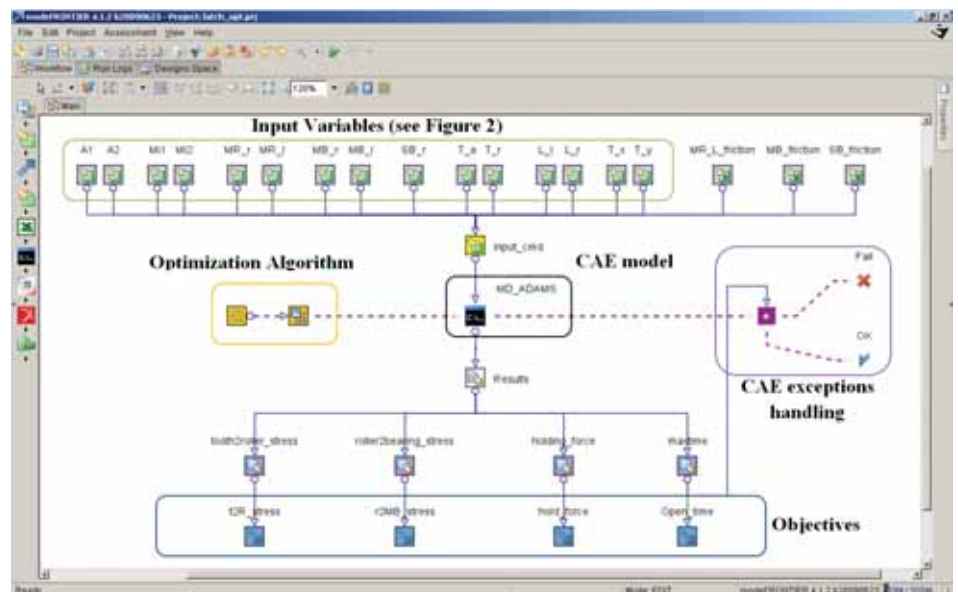


Figure 3: modeFRONTIER's workflow representing the automated design optimization process, with the latch MD Adams multi-body numerical model integrated

impossibility to tackle the problem with a traditional "trial-and-error" approach. Instead, a designer should rather use more sophisticated techniques such as optimization algorithms.

Accordingly to these considerations, the 15 promising configurations found were then used as an initial population to start the modeFRONTIER Genetic Optimization Algorithm (MOGA-II), by simply switching an option in the Figure 3 workflow. MOGA-II mimics evolution in biological species: it is able to focus the search on the most promising species (designs) that better adapts to the environment requests (objectives and constraints). The results of such optimization campaign are represented in Figure 5, where the axis are the two main objectives to be minimized, and each point a CAE solution. The optimization succeeded in finding several promising solutions that respects the constraints (black points), and represent different trade-offs between the four objectives simultaneously. All these points are belonging to the so-called "Pareto Frontier", which represents the set of optima in a truly multi-objective search.

At this stage, the robust design optimization concept comes in. In fact, the standard multi-objective optimization described so far found a large set of optima: that is already a very good result, given the difficulty of finding proper solutions to the challenge. Between this set of optima (trade-offs between the objectives), a designer can easily select the most diverse ones in terms of input variable values, thanks to data clustering capabilities of modeFRONTIER (see green colored designs in Figure 4): they represent the optimal solutions

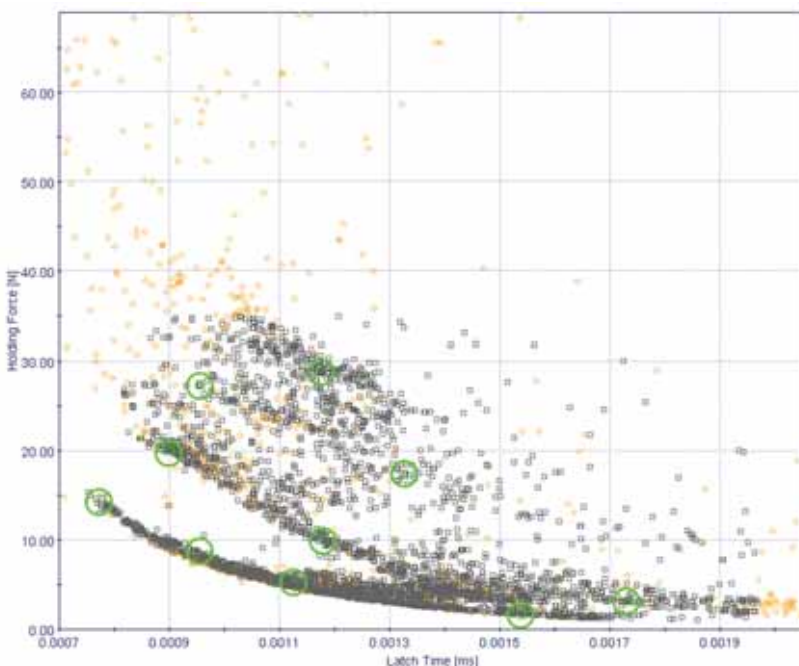


Figure 4: Latch holding force with respect to opening time results from the MOGA-II optimization study. Yellow solutions are not respecting assigned constraints. Highlighted designs indicate those used in robustness analyzes.



of the challenge, without considering the stability of their performances.

The idea is to use these ten solutions as starting points for an other MOGA-II optimization, that now should include the design stability itself as a target: a robust design optimization. In robust design optimization the deterministic values of performance criteria are replaced by their mean and standard deviation values, which can then be separately optimized. The following input parameters (see Figure 2) $A1$, MR_r , L_l , L_r , $\mu1$, $\mu2$, are considered to behave stochastically causing the performance uncertainty, and are assigned normal distributions. Moreover, the three revolute joint frictions were allowed to vary with uniform distributions. All the remaining variables are still considered as deterministic ones.

The size of the stochastic input sampling set should be big enough to guarantee the statistical validity of the conclusions, but should cope with computational time limitation. In fact, robust design optimization requires a non-trivial amount of computational time, even with a short simulation time for a single evaluation, since each individual design needs to be simulated multiple times in order to achieve statistically significant estimates for the outputs. For this reason, a relatively small 50-design sized modeFRONTIER's "Latin Hyper-cube" sampling has been used for the stochastic inputs: it is capable to approximate accurately the prescribed multi-dimensional normal distributions also with few samples.

Conversely, a sophisticated "Polynomial Chaos" expansion scheme is available to improve the accuracy in the esteem of both the mean and the standard deviation of the output distributions (that derives from the small-sized sampling of the stochastic inputs). After 150 deterministic optimization

steps, several designs with reduced latch time and holding force standard deviations were found that are still capable of satisfying all constraints: in Figure 5 bubble chart all the objective standard deviations and means are plotted together.

Designs 1 through 4 are highlighted for their respective minimums of latch time standard deviation, latch time mean, holding force standard deviation and holding force mean. Design 2 was among those selected in the initial MOGA-II population, resulting from the previous deterministic-only optimization. Such four latch designs are the four robust design solutions that have been brought to the further steps of the whole Circuit Breaker mechanism design.

Conclusions

This article demonstrates the process and benefits of adding multi-objective optimization and robustness analysis in the early stages of the product design, by linking available computational models. In this case, even finding a design that simultaneously meets all the constraints while having acceptable performance, represents a challenging process. modeFRONTIER achieved this in a more than reasonable timeframe, allowing ABB engineers to focus on the results analysis and on the trade-off decision process. Moreover, it also encapsulates the search for robust designs: this concept is especially important for the design of devices which are to be incorporated into public safety systems or critical infrastructure, such as high voltage circuit breaker drives. A final remark should be done regarding robust design optimization in all the design processes involving numerical models with longer simulation time. modeFRONTIER offers also Response Surface Models that are able to interpolate accurately available data, and hence replace long simulations with almost instantaneous design performance forecasts. This enables a robust design approach also for longer runtime simulation models.

Acknowledgments

For more information on the article, please contact EnginSoft GmbH:

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modeFRONTIER is a product of ESTECO Srl, EnginSoft Technologie per l'Ottimizzazione (www.esteco.com)

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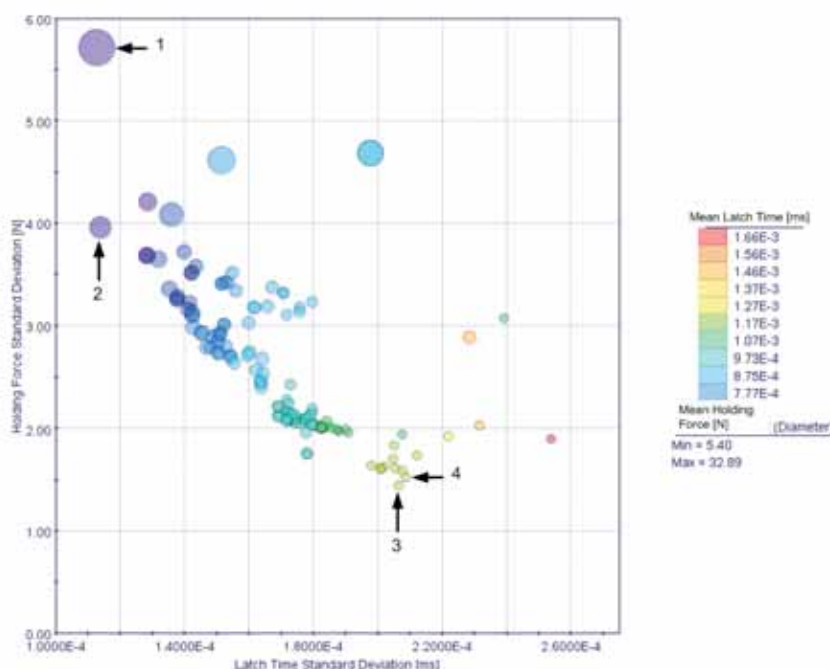


Figure 5: MOGA-II minimization results of holding force and latch response time standard deviations while subject to respective means and stress constraints



The optimal solution of a mixture problem with modeFRONTIER

Have you ever cooked an apple pie? If not, do not worry, also the author of this work has never managed to prepare a good apple pie, despite his many trials... Fortunately, he has a mother with excellent cooking skills. Anyway, it is easy to understand for all of us that a good apple pie needs a good recipe: flour, butter, eggs, salt and all the ingredients have to be mixed and worked together respecting the right proportions and timing, and finally the pie has to be placed in the oven at the right temperature. My mother says that also a bit of love is absolutely mandatory to get a good result...

There are some situations in which good results actually do not depend on the quantity of the ingredients used in the mixture but rather on their proportions.

This is the case with the apple pie, where obviously the same recipe is used when cooking one pie, two pies or hundreds of pies. The mixture used does not contain the same quantity of ingredients (500 gr of flour in the first case, may be some tons in the last) but the ingredients should always be mixed with the same proportion (500 gr of flour needs two eggs, 50 gr of butter...).

The good recipe for an apple pie is a kind of secret that mothers receive from their grandmothers and pass on to their daughters... and this will never change as the greedy author



can be often formulated, and therefore solved, in the same way, as shown hereafter.

The aim of this work is mainly to show how a mixture design can be efficiently solved using modeFRONTIER. Firstly, a relatively simple problem, whose solution however is not so evident, is presented and solved and then some considerations on the stability (robustness) of the solution are suggested.

A simple mixture problem

As explained before, in a simple mixture design problem the final result does not depend on the quantity of the ingredients but rather on their proportions. This means that the problem can be formulated in terms of relative concentrations c_i of the ingredients, which are subjected to the following constraint:

$$\sum_{i=1}^n c_i = 1, \quad c_i = \frac{q_i}{\sum_{i=1}^n q_i}, \quad c_i \in [0,1]$$

where n is the number of the ingredients in the mixture and q_i is the quantity of the i^{th} ingredient. It is clear that the violation of this constraint leads to a physical non-sense, hence it is mandatory that the solution of a mixture problem satisfies this constraint; to this aim, it is recommended to rewrite the above equation in the following form, in order to facilitate the problem solution.

$$c_n = 1 - \sum_{i=1}^{n-1} c_i, \quad c_i \in [0,1]$$

In other words, one ingredient concentration (e.g. the last) is not a free parameter but it can be computed once the

Field	Mixture problem for...
Agricultural	Fertilizers design
Pharmaceutics	Medicine design
Material engineering	Rubber and polymers design
Material engineering	Steel design
Civil engineering	Asphalt design
Civil engineering	Concrete design
Oil and gas	Fuel design

Table 1: The table collects some examples of engineering fields where mixture design problems could arise.

hopes. However, there are many situations where the right recipe is not known or as easy to find as we would like. Several different objectives for the mixture may have to be met (economy, stability, performance and more) and the solution should satisfy many constraints at the same time. In Table 1 some of the possible engineering fields where mixture design problems can arise are collected, together with a simple description of a typical application. Looking at the table, which is absolutely incomplete, it immediately becomes clear that mixture problems can probably appear in many ways, always assuming different aspects; however they



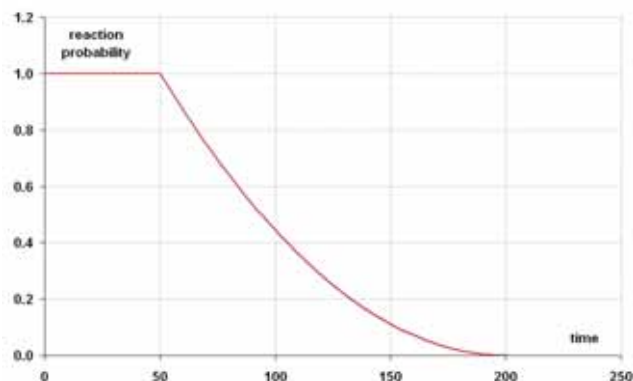


Figure 2: The probability that the reactions between the ingredients described in Table 2 follows the law shown in the picture; a first unitary constant plateau is followed by a quadratic decreasing piece, up to the reaction time. It is clear that other decay laws could be easily adopted.

others are known. It always has to belong to the interval $[0,1]$ to maintain a physical meaning.

The mixture design problem can be described schematically as drawn in Figure 1, where, on the left, the unknown concentrations and, on the right, the results of the mixture are displayed; the central box indicates that a process (chemical, physical or whatever makes sense in the analyzed context) transforms the inputs into outputs.

As mentioned above, the solution of such problems is usually more challenging in the presence of many objectives and constraints involving the mixture results. They can be in contrast to one another and the constraints can seriously restrict the possibilities to find out a proper solution.

A mixture design, as described before, can be regarded as an optimization problem where the ingredients' concentrations are the inputs, the mixture results are the outputs and all the requisites can be transformed into objectives (maximizations or minimizations) and constraints.

In this work the following simple mixture problem has been tackled: five ingredients (let us say A - red, B - green, C - blue, D - deep blue and E - black) have to be mixed together to obtain, within a given time, a solution characterized by the highest concentration possible for E. The ingredients involve different costs (this is quite typical) and therefore, we are also looking for the most economic recipe.

Moreover, the components B and E can be extracted from the final mixture; E will be the product of the mixture process we are looking for, while B can be considered a sub-product and it can be reused in a new production cycle. The other

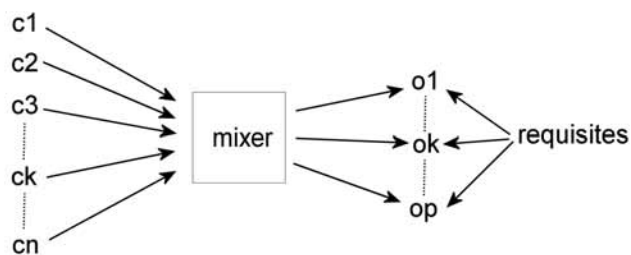


Figure 1: A schematic representation of a simple mixture problem. On the left the unknown ingredients' concentrations are displayed. On the right the products of a mixture process are represented together with the requisites (objectives and constraints) that the mixture should satisfy.

products (if any) cannot be reused and they have to be considered as a discard.

In Table 2 the possible reactions between the ingredients and the costs for a unit quantity of the ingredients are listed. Another issue has to be considered: as the mixing process proceeds, the probability that the reactions described in Table 2 take place decreases up to zero with a quadratic law, as shown in Figure 2. This means that the process tends to a stable point which corresponds to assume an invariable status after a certain time (which we will call "reaction time" from now on).

The mixture process is simulated in this way: an array of 250×250 cells has been considered as a sort of terrain where the mixture process can take place. The ingredients are modeled by means of a given number of particles (computed according to the concentration) which are randomly positioned in the cells array at the beginning of the mixture process (let us say at time zero). The initialization does not allow that more than one particle falls into a single cell. The cells array is not completely filled by the particles, only 25% of it will be occupied during the simulation; this choice is obviously

	A	B	C	D	E	Cost/Unit
A	●	●	●	●	●	1
B	●	●	●	●	●	5
C	●	●	●	●	●	2
D	●	●	●	●	●	4
E	●	●	●	●	●	10

Table 2: The table collects the possible reactions that can take place when two particles reach the same position and the ingredient costs. For example, if a particle B and a particle D reach the same position, they will be transformed into two particles of E. Ingredient E is considered as the main result of the mixture process while B can be extracted from the mixture and reused for a new production cycle.

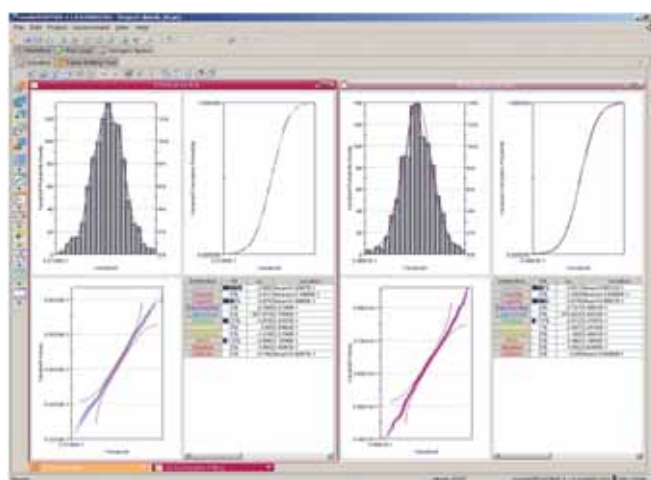


Figure 3: The curve fitting tool has been used to show how the final concentrations of ingredients are distributed. In the picture the concentration of the ingredient E is reported, being the following initial concentrations: A = 0.1, B = 0.3, C = 0.4, D = 0.2 and E = 0 for the first case (left) and A = 0.0, B = 0.2, C = 0.5, D = 0.2 and E = 0.1 for the second case (right). It comes out that in the first case the Gaussian distribution has the highest Kolmogorov-Smirnov test score (83%) while in the second case the logistic distribution seems to be the best one (57%).

arbitrary and it could be easily changed if necessary.

Once the initialization has been concluded, time starts, it increases its value by a unit at a time, and all the particles in the array are randomly moved in one of the eight possible surrounding cells to obtain a new configuration.

It obviously could happen that two particles fall in the same cell: In this case, a reaction could take place. A random number in the interval $[0,1]$ is generated and if it is less than the actual reaction probability (see Figure 2), the reaction starts according to the rules summarized in Table 2 involving two particles at a time. When more than two particles reach the same cell the reactions are performed sequentially starting from the first couple of particles up to the last one.

When the process time has reached a given value (in our case 200) the mixture does not change anymore (no reaction can take place) and therefore the ingredient concentrations are computed simply by considering the number of ingredient particles in the array divided by the total number of particles. As the reader has probably understood by now, the reaction process has been simulated in such a way that the number of particles does not change during the mixture process, preserving in this way the total mass.

The mixture process described above can be simulated using, for example, a Matlab script (other choices are obviously



Figure 4: An example of the cells array during a mixture process at time $t = 50$ (particle colors are the same as used in Table 2). The following initial concentrations have been used: $A = 0.1$, $B = 0.3$, $C = 0.4$, $D = 0.2$, $E = 0$.

possible) or better a compiled routine (Fortran, C, ...) to improve the performance. It is straightforward to note that the computational cost grows quadratically with the array dimensions, which have to be sufficiently large to enable a reliable simulation of the process, and this could lead to prohibitive solution times.

The mixture process variability

As mentioned above the initialization of the array is done using a random criterion: moreover, the particle motion is not given by a deterministic law, but it looks like a random walk in the array. To conclude, also the fact that a reaction can or cannot take place is

PDF	Equation	Location L	Scale S	$P(x < \hat{x})$ $=$ $1 - 0.997300203937$
Gaussian	$f(x) = \frac{1}{S\sqrt{2\pi}} e^{-\frac{(x-L)^2}{2S^2}}$	$L = \mu$	$S = \sigma$	$\hat{x} = L - 3S$
Logistic	$f(x) = \frac{1}{4S^2} \operatorname{sech}^2\left(\frac{x-L}{2S}\right)$	$L = \mu$	$S = \sigma\sqrt{\frac{3}{\pi^2}}$	$\hat{x} = L + S \ln\left(\frac{P}{1-P}\right)$

Table 3: The table collects the equations of the Gaussian and the logistic probability density functions (PDF) and the values of the location and scale parameter as estimated with the method of moments. The empirical mean and standard deviation are μ and σ respectively. The last column collects the equations that allow to compute the variable $\hat{x}$ corresponding to a given value of cumulative distribution function $P(x < \hat{x})$.

governed by chance. This means that a mixture process cannot be exactly reproduced; if two simulations of the same mixture process (with the same initial concentrations) are performed, probably two different final results will be obtained.

These differences are clearly due to the sources of randomness which are present in the model, as mentioned above: however, their effects reduce as the simulation time increases and the mixture process tends in mean to a given final configuration; this is due to the fact that the reaction probability (see Figure 2) decreases up to zero with the process time, leading in this way to an inert mixture.

This makes everything more complicated; actually, an optimal solution could be characterized by important variations in the final concentrations which could be unacceptable.

At this point, it becomes mandatory to identify the probability density function (or the cumulative one) that characterizes the final concentrations, in order to correctly judge the goodness of the recipe. In this way, it is actually possible to estimate the final concentration of the ingredients with a probabilistic approach which appears to be, in this case, more reliable than a simple deterministic

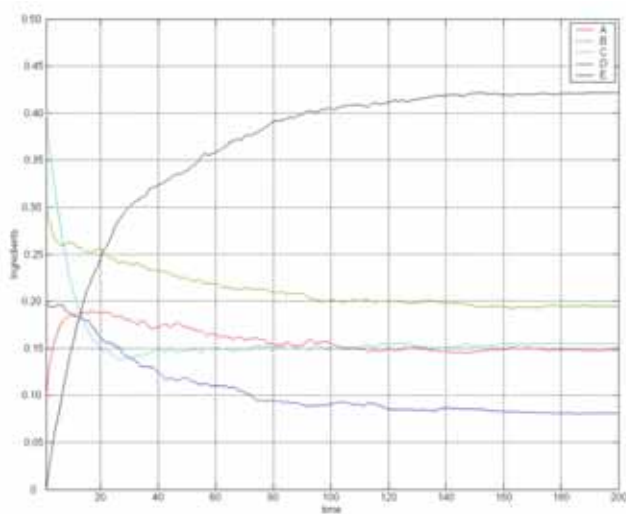


Figure 5: The ingredient concentrations plotted versus the process time. The following initial concentrations have been used: $A = 0.1$, $B = 0.3$, $C = 0.4$, $D = 0.2$ and $E = 0$.



one. To do this, it is necessary to simulate more than once the mixture process and find out a statistical distribution that fits at best the results. This is a distribution fitting problem which is not exactly easy to solve in its more general formulation.

However, if we look at the problem we have described above, it turns out to be quite natural to consider only symmetric probability density functions; all the causes which perturb the solution can actually produce both a positive or negative deviation from the mean and they have the same probability to appear. Following this consideration, and for sake of simplicity, we have decided to consider only the *Gaussian* and the *logistic* probability density functions and to use the *method of moments* for the parameters estimation. In Table 3 the equations of these two probability density functions (PDF), together with the values of the location and the scale parameters, are collected; the table also provides the equations to compute the variable $\hat{x}$ when the value of the cumulative density function $P(x < \hat{x})$ is assigned (specifically, when $P(x < \hat{x}) = 1 - 0.997300203937$).

Once the parameters of both distributions have been computed, a Pearson chi-squared test can be performed to find out which distribution best fits the data.

Finally, the simulation of a given recipe has to include these steps; the mixture process simulation has to be repeated for a certain number of times and a dataset containing the final concentration for each ingredient has to be built. Then, the method of moments can be used to identify the probability density function parameters and a Pearson chi-squared test has to be performed to find out the best theoretical distribution, among the ones that have been considered. To conclude, the value that has a very low probability to overestimate the final ingredient concentration has to be computed.

All the steps described above have to be performed by the simulation software which will pass all the information pertaining to the process to modeFRONTIER.

In order to show that different recipes could lead, in general, to different final concentration distributions we have decided to consider these two different initial conditions; in the first case $A = 0.1$, $B = 0.3$, $C = 0.4$, $D = 0.2$ and $E = 0$ are the initial concentrations, while in the second we have $A = 0.0$, $B = 0.2$, $C = 0.5$, $D = 0.2$ and $E = 0.1$.

The mixture processes have been simulated by means of 100 runs for each recipe and the final concentrations have been stored on a text file; then, these data have been loaded in the Designs Space of modeFRONTIER and some statistics have been done.

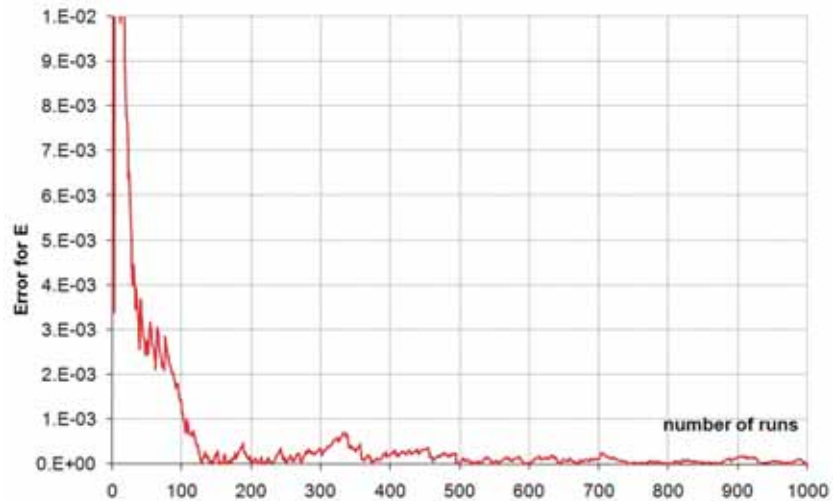


Figure 6: The Error, computed as the absolute difference between the mean and three times the standard deviation and the analogous quantity computed at 1000 runs. After 100 runs this quantity is always less than $1 \cdot 10^{-3}$, which represents the sensibility on the mixture concentration measurements ($A = 0.1$, $B = 0.3$, $C = 0.4$, $D = 0.2$ and $E = 0$ have been set as initial concentrations).

As the Figure 3 shows, the histograms of the ingredient E are well fitted by the Gaussian, in the first case, and by the logistic distribution, in the second case; these distributions actually obtain the highest Kolmogorov-Smirnov scores (83% and 57% respectively).

The estimation of the mean and standard deviation of the final concentrations

As explained in the previous paragraph, the *method of moments* is used to determine the location and scale parameters of the Gaussian and the logistic distributions. Therefore, it becomes mandatory to perform a reliable estimation of the mean μ and the standard deviation σ of the final ingredient concentrations. The simplest approach is to use the definition of the estimated values of these quantities:

$$\mu = \frac{1}{n} \sum_{i=1}^n c_i$$

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (\mu - c_i)^2}$$

where c_i is the concentration of a given ingredient while n is the number of runs which have been performed. The main drawback of this approach is that a large amount of runs n is usually needed to obtain a sufficiently good estimation, especially for the standard deviation, with the consequent deterioration of the computational time. For this reason the choice of an appropriate number of runs n is absolutely crucial.

In order to choose a proper number of runs the following approach has been used: it has been assumed that the estimations corresponding to 1000 runs give the right values of the mean and the standard deviation. Then, the difference between the mean and three times the standard deviation has been computed for all the estimations, supposing, for simplicity, that the output is always normally distributed



(see Table 3); the obtained value represents the worst concentration for ingredient E we would get from the mixture process if the estimations of the mean and the standard deviation were correct. Actually, if we compute the absolute difference between such quantity and the analogous one evaluated with 1000 runs (let us call this quantity: the Error), we obtain an estimation of the absolute error we commit when computing the lowest concentration for the ingredient E we can expect from the mixture process.

Looking at Figure 6, where this Error is plotted against the number of runs, it is clear that after 100 runs the estimated error is always less than $1 \cdot 10^{-3}$, which is the sensibility we have in this problem. For this reason and in view of the introduced approximations, 200 runs can be considered as a good choice for a sufficiently accurate estimation of the mean and the standard deviation for the ingredient E.

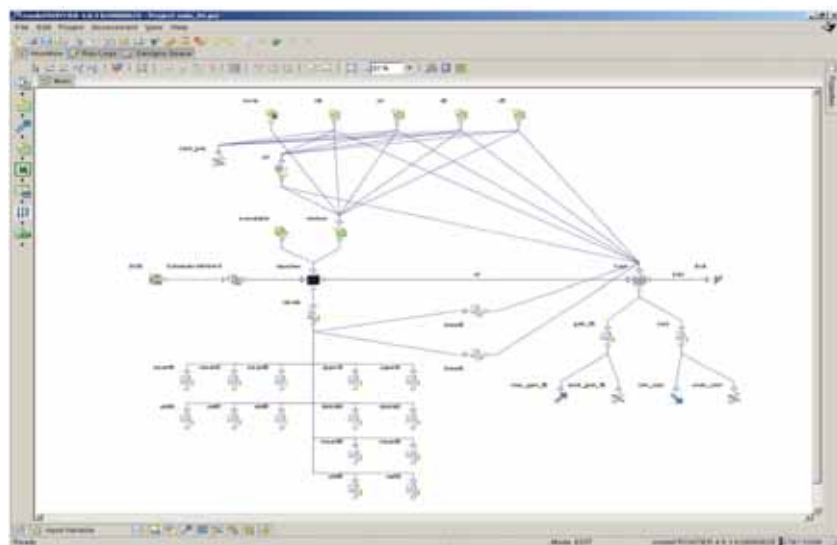


Figure 7: The modeFRONTIER workflow ready to run.

Analogous results can be obtained considering different initial ingredient concentrations.

The modeFRONTIER solution

In order to efficiently solve the mixture design problem a workflow has to be defined following a similar structure of Figure 1.

We decided to use a step of $1 \cdot 10^{-3}$ to discretize the initial concentrations. It is interesting to note that this step represents the smallest possible variation of a concentration which corresponds to a difference of 15 particles (on a total of 15625, with an array filling of 25%) in the cells array. Obviously, it does not make sense to use steps which correspond to a particle variation less than one and, however, it is reasonable to have at least a certain number of particles in the array, in order to have a model too sensitive to randomness.

As explained before, an ingredient concentration can be computed once the other concentrations are known, according to equation [2]. The resulting concentration has to fall in the interval $[0,1]$ and therefore a constraint has to be added.

A calculator can be used to compute the cost of the mixture process taking into account the data in Table 2 and the fact that ingredients B and E can be reused for a future production cycle; to this aim a simple JavaScript can be used.

Two important constraints are given: the first one involves the production cost, which has to be less than 1. The second one states that the gain of ingredient E has to be greater than 0.2: we actually are not interested in a recipe, even a cheap one, which does not produce an interesting gain in ingredient E.

A random DOE of 20 initial mixtures is adopted to feed a MOGA-II optimization with 20 generations: however, one initial design has been modified to include the following initial condition: $A = 0.0$, $B = 0.5$, $C = 0.0$, $D = 0.5$ and $E = 0.0$ (design ID20), because, looking at Table 2, where the possible reactions between ingredients are reported, it turns out that a high initial concentration of B and D should produce a high final concentration for the ingredient E. A second design $A = 0.0$, $B = 0.4$, $C = 0.2$, $D = 0.4$ and $E = 0.0$ (design ID19) is introduced in the DOE table following the same consideration.

The default values in the Scheduler node for the algorithm set up are used. The unfeasible designs (the ones which do not satisfy equation [1]) are not evaluated, because they do not have any physical sense.

After the optimization process it is possible to find out the Pareto front solutions. In Figure 8 the production cost is plotted versus the minimum gain of ingredient E. The DOE designs are the blue points while the red points are the Pareto designs after 30 generations. It is interesting to note that the two initial designs inserted in the DOE table in the attempt to furnish good solutions are both unfeasible; they have a high final concentration of E but they are too expensive.

Moreover, there are some Pareto designs that have a negative cost and a gain in E greater than 0.2; surprisingly, this means that, using some recipes, one can organize a process able to produce a certain quantity of the ingredient E, according to the main objective, and have a production of B sufficient to cover all the other ingredients' cost and more.

The optimal solutions are characterized by low or null values of initial concentration of ingredient E and relatively high of A. Initially, there was the suspect that ingredient B and D should have a high initial concentration; the optimization process gives evidence of the contrary, actually the optimal solutions usually have low initial concentrations of such ingredients.



The robustness of the optimal solution

Once the Pareto front has been found, thanks to the optimization process, it is necessary to choose just one configuration. Obviously, many different criteria can be used to choose the best-for-us configuration. Looking at Figure 8 it immediately becomes clear, that the cost of the process drastically increases when a gain in E greater than 0.29 is reached. For this reason we decided to adopt an optimal solution pertaining to the knee of the Pareto front which provides a reasonable high gain level without being too expensive. The choice falls to design number 462, which has

initial concentrations, with probabilistic density functions that summarize the effects of all the noises.

Then, it is necessary to run a certain number of simulations of the optimal recipe taking into account the effects of noise, as imposed by the stochastic approach, and try to find out the probability density functions that best fit the outputs. Finally, the noise effects can be analyzed and the robustness of the recipe measured and eventually compared with restrictions or requirements that the process has to guarantee.

The problem is very similar to that exposed and solved before, with the important difference that now the recipe is known and that the initial concentrations are affected by small variations whose probability to appear is driven by some given PDFs.

The solution of such problem could be led as before; a certain number of simulations could be run and the final ingredient concentrations stored. Then, another fitting problem should be solved and the robustness of the solution estimated. As shown

Table 4: The estimated means and standard deviations of the gain in E and the mixture cost have been estimated using three different approaches: in (1) equations [3] and [4] have been computed, in (2) the curve fitting tool has been used (the maximization of likelihood is used to determine the pdfs parameters: the normal distribution has been supposed to characterize both the gain and cost), while in (3) the polynomial chaos approach has been adopted. It can be seen that important differences in the estimated values of the standard deviation are present.

the following initial concentrations: A = 0.769, B = 0.000, C = 0.209, D = 0.220 and E = 0.000. It can be further noted that this recipe has the interesting property to have only three initial ingredients with non-zero value concentrations; this is extremely interesting because it allows to enormously simplify the production process. The cost of such recipe (cost = 0.198) is definitely lower than the limit of 1 imposed to the optimization process and the production of ingredient E (gain_{fE} = 0.290) is one of the highest found.

Another interesting issue that could come into play when designing a mixture is the robustness of the recipe. The production process could actually start with a slightly different recipe with respect to the optimal one; the reasons of these variations can arise, for example, from tolerances in machining, in measurements, in the ingredient physical properties and more.

The ingredient final concentrations could be affected in an unacceptable way by these uncertainties: the aim of this paragraph is mainly to show how it is possible to check if the optimal solution is or is not sensitive to the noise factors.

The first step is certainly to characterize the input variables, which represent the ingredients'

before, the most important drawback of this approach is that a large amount of repetitions is needed to have a good estimation of the mean and the standard deviation.

To partially mitigate this aspect one can use the *polynomial chaos method* (see [1]), which is known as a very accurate and relatively cheap approach.

We have supposed that the ingredients' concentrations are all characterized by a Gaussian distribution with a standard deviation of $0.6 \cdot 10^{-2}$; In modeFRONTIER it is easy to set up a robustness analysis; starting from the existing project the user has to change the input variable definitions to provide their correct stochastic definitions, copy in the DOE table the optimal configuration of which robustness has to be measured and finally set up the MORDO panel in the Scheduler node: this last step is probably the most important one, because the number of designs to be generated and evaluated around the nominal configuration and the

Gain E					
Mean			Standard deviation		
Arithmetic ⁽¹⁾	Curve fitting ⁽²⁾	Polynomial chaos ⁽³⁾	Arithmetic ⁽¹⁾	Curve fitting ⁽²⁾	Polynomial chaos ⁽³⁾
3.0338E-1	3.0338E-1	3.0338E-1	1.1972E-3	1.1853E-3	4.3356E-2
Mixture cost					
Mean			Standard deviation		
Arithmetic ⁽¹⁾	Curve fitting ⁽²⁾	Polynomial chaos ⁽³⁾	Arithmetic ⁽¹⁾	Curve fitting ⁽²⁾	Polynomial chaos ⁽³⁾
1.4706E-1	1.4706E-1	1.4706E-1	1.9432E-2	1.9231E-2	2.8618E-2

Worst case for Gain E $mean(gainE) - 3 \cdot std(gainE)$		
Arithmetic	Curve fitting	Polynomial chaos
2.9979E-01	2.9982E-01	1.7331E-01
Worst case for Mixture cost $mean(cost) + 3 \cdot std(cost)$		
Arithmetic	Curve fitting	Polynomial chaos
2.0536E-01	2.0475E-01	2.3291E-01

Table 5: The estimated worst scenarios for the Gain E and the mixture cost using different estimated values of the means and standard deviations. The two outputs have been both supposed to be normally distributed. It can be seen that the worst scenarios strongly depend on the technique (accuracy) used for the estimation of the mean and the standard deviation of the output distributions.



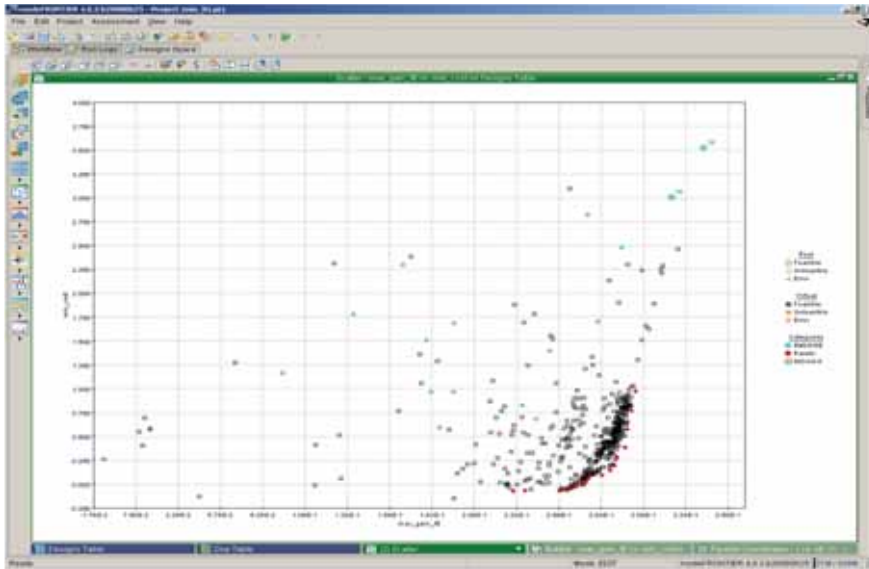


Figure 8: The production cost plotted versus the minimum gain of ingredient E. The DOE designs are the blue points while the red points are the Pareto designs after 30 generations. All the designs (feasible and unfeasible) are reported here. The user defined DOE designs 18 and 19 are highlighted in green and they fall in the upper-right part of the scatter.

polynomial chaos order have to be chosen. In our case we decided to generate 50 designs with a Latin-Hypercube technique and to use a chaos expansion of order 2.

The distribution fitting tool can be used once again to find out the theoretical distribution that best fits the data pertaining to the final concentrations and to understand if the variations around the expected values are acceptable or not.

Table 4 collects some estimations of the mean and the standard deviation of the mixture cost and gain in ingredient E, which can be accessed using different modeFRONTIER tools. It immediately appears that the estimations of the means always provide the same values; unfortunately the same does not happen for the standard deviation. Very different numerical values can be obtained using different approaches. The polynomial chaos approach can be considered the most accurate one and it is strongly recommended to use this approach, when possible.

It can be further noted that the estimated values of the standard deviations computed by the polynomial chaos approach are greater than the analogous ones computed with the other techniques: these differences, which are not negligible in this case, could lead to an uncorrect estimation of the robustness of the recipe.

Actually, if we suppose that both the gain and the cost are normally distributed, it is possible to compute the worst scenario in terms of these two system outputs as summarized in Table 5. It can be easily seen that the worst scenario

strongly depends on the technique (or, in other words, on the accuracy) adopted for the estimation of the mean and the standard deviation of the system outputs.

Conclusions

In this work a mixture design problem has been solved with modeFRONTIER; several aspects that can arise in a typical situation have been considered and some considerations on the process variability and solution robustness have been verified.

We have shown how complicated mixture problems can be tackled involving many ingredients, satisfying both physical and economical objectives and constraints. It is also possible to estimate the robustness of an optimal configuration and to understand in this way if the process noises can affect the final results in an undesired way.

References

- [1] Lovison Alberto (2008), Uncertainty Quantification in modeFRONTIER: Monte Carlo, Latin Hypercube Sampling and Polynomial Chaos, modeFRONTIER Technical Report
- [2] Stefan H. Steiner, Michael Hamada, Bethany J. Giddings White, Vadim Kutsyy, Sofia Mosesova, Geoffrey Salloum, (2007), A Bubble Mixture Experiment Project for Use in an Advanced Design of Experiments Class, Journal of Statistics Education, Volume 15, Number 1

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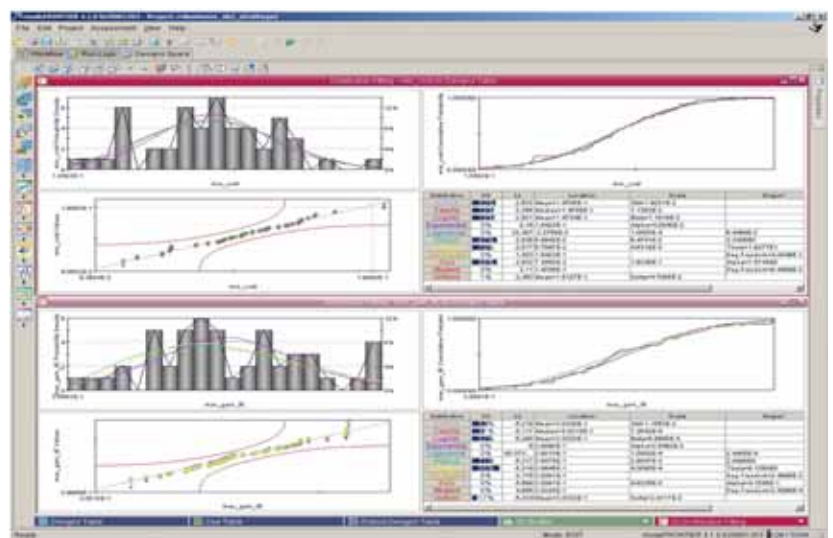


Figure 9: The distribution fitting tool has been used to find out the probability density functions that better fit the mixture cost and gain of ingredient E. It can be seen that the Gaussian, the logistic and the Weibull distributions usually are the ones that have the highest Kolmogorov-Smirnov rates. Also gamma and beta distributions sometimes seem to fit the data in a proper way. Once plotted however, these functions are all very close to one another.

Striving for a better sound environment: FMBEM Solution WAON for acoustic analysis in large scale and high frequency ranges



Computational simulation has extended the range of applications in structural analysis, a domain with a long history which is well-established in various industries and in computational fluid analysis, a well-known simulation that is easy to imagine.

In recent years, one of the analysis areas we focus our attention on more than ever before to create a comfortable, smoothing and ecologically-minded environment, is acoustics analysis.

Acoustics analysis has been generally connected with objectives for solving noise problems in the automotive, aerospace, shipbuilding, construction and electronics industries. There is now a growing need for acoustic analysis as the tool for creating products and services with high added value. In this article, we introduce the Japanese-made acoustic analysis software WAON, the world's first commercial software applying Fast Multipole BEM.

Issues and requirements for acoustics analysis

Generally, what we need to model in acoustic analysis are vibrating planes or forces on the structure, and as for sound sources, the air or structural transmission paths and absorption phenomena on the wall. To achieve our goals, several approaches can be used, such as, for example:

- to solely rely on the experiences of the engineers
- to purchase the sound as an energy flow represented by SEA (statistical energy analysis) or geometrical analysis (e.g. ray tracing method) or
- to follow the method based on the wave nature of the sound.

For the wave based approach, several methods exist, such as FDM (Finite Differential Method), FEM (Finite Element Method) and BEM (Boundary Element Method).

The WAON software actually uses BEM, which provides an effective method for the acoustic analysis as it can handle radiation problems smartly and the creation of the mesh required for the analysis, is extremely easy.

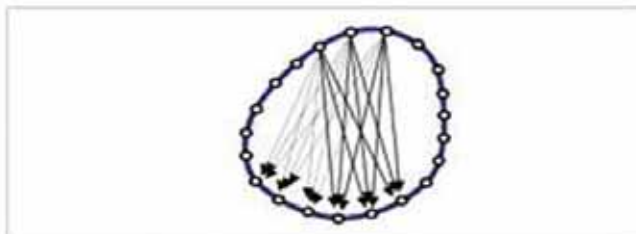
Due to these benefits, the number of applications of acoustic analysis using BEM is now increasing.

However, BEM does have a drawback. The BEM calculation procedure requires to describe the relationship of one specific element with all other elements, for all elements. This entails the generation of the full populated matrix and to keep it or to solve it leads to huge calculation cost.

The recent requirements for acoustic analysis have become more complicated and acoustic engineers are facing challenging expectations and demands, for example: "We want to simulate the problems of a large size model and high frequency ranges" - "We want to apply for environmental noise standards." - "We want to cover all audible levels" or "We want to increase the number of elements and the number of integral points for high-accuracy calculation".

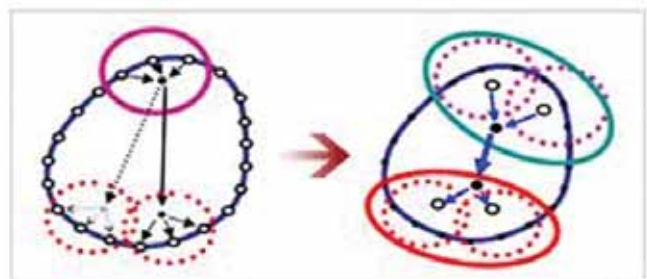
Cybernet Systems Co.,Ltd., one of the biggest CAE solution service providers in Japan, with long and broad experiences in acoustic analysis, had focused on solving these challenging problems, also in cooperation with universities, and finally, released the commercial software

$$G(\mathbf{r}_p, \mathbf{r}_q) = \exp(jk r_{pq}) / 4\pi r_{pq}$$



Conventional BEM

$$G(\mathbf{r}_p, \mathbf{r}_q) = \frac{jk}{16\pi^2} \oint E_{pL}(\mathbf{k}) T_{LM}(\mathbf{k}) E_{Mq}(\mathbf{k}) d\hat{\mathbf{k}}$$



FMBEM

The calculation method comparison between conventional BEM and FMBEM



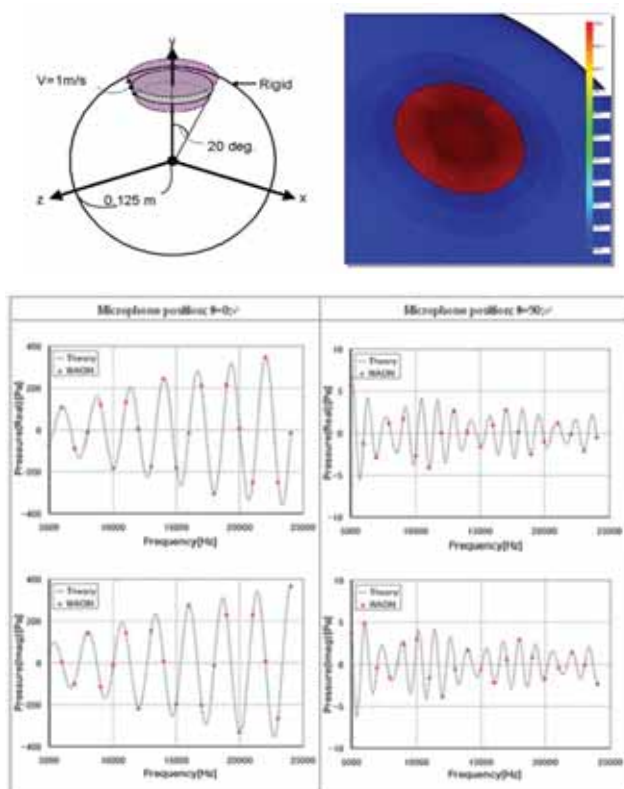
WAON applying FMBEM (the Fast Multipole Boundary Element Method) in January 2006. WAON is regarded widely as a revolutionary and world leading product in the field of acoustic analysis.

Features of WAON

The fast multipole boundary element method (FMBEM) is an analysis method which applies the fast multipole algorithm (FMA) to the boundary element method (BEM). It requires dramatically less memory and fewer calculations than conventional boundary element methods for achieving remarkable performances. By using FMBEM, WAON allows to calculate the analysis of high frequency ranges which used to be very difficult with the conventional wave theoretical analysis approach. Let us describe the case of analyzing problems with 60,000 degrees of freedom. To solve the analysis of this size, parallel processing with a 64-bit system and eight CPUs used to be necessary in the past. However now, if we use WAON for the same problem, it can be calculated within a single process on the 32-bit Windows system. Moreover, when WAON is used on a 64-bit system, analyses with over 200,000 degrees of freedom can be executed with 8-GB memory which used to be impossible with the previous acoustic analysis basic assumption. Besides, WAON provides a sufficient operating environment for such large scale analysis. Its high speed 3D graphics and ease of use GUI are only some of the outstanding features that WAON provides to its users.

WAON Case Studies

Case 1. Sound radiation from sphere with vibrating part (comparison with a theoretical solution)



Model specifications:

Radius	0.125(m)
Angle α	11.5(Deg.)
Velocity	1(m/s)
Distance r	0.25(m)
Angle θ	0.90(Deg.)
Sound speed	340(m/s)
Medium	1.225(kg/m ³)
Elements	79,200
Nodes.	79,202

To investigate the accuracy of WAON, we performed a sound radiation analysis of a spherical object which has a vibrating panel. The outcomes are shown in the table below, which offers a comparison of the theoretical results with the results obtained by WAON.

Case 2. Radiation analysis from vibrating engine of motor cycle

A sound radiation analysis of an engine was done by applying the results of a vibration analysis performed with FEA software. Normally, in this case, we have to prepare a coarse mesh for acoustic analysis because typically, the mesh for FEA is finer than the mesh needed for acoustic analysis. By using WAON, in some cases, there is no need to perform a coarse structural mesh for the analysis.

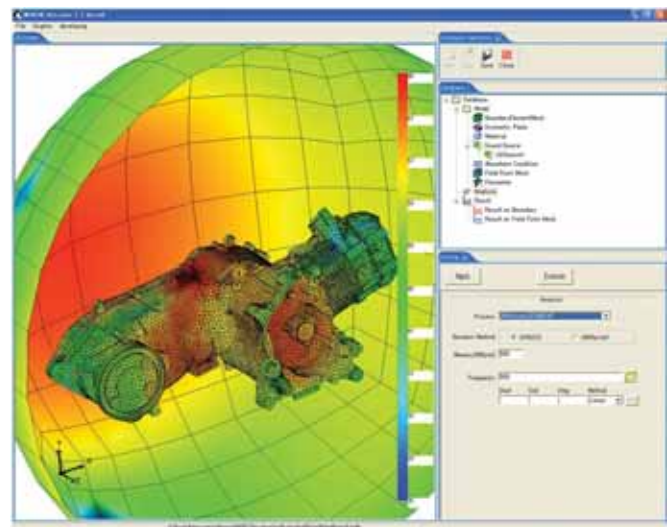


Image and data courtesy Yamaha Motor Co., Ltd.

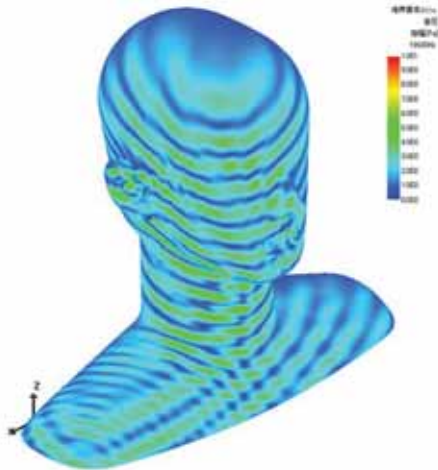
Model specifications:

Elements.	42,512
Nodes.	21,076

Frequency (Hz)	Required Memory(GB)	CPU Time (s)
3,000	2.7	1,504
4,500	3.1	3,474

*When using a conventional BEM approach, 100MB RAM is needed for this analysis

Case 3. Calculation of HRTF (Head Related Transfer Function) in full audible frequency range



Frequency (Hz)	DOFs of analysis model	CPU Time (h)
20,000	200,000	1

Here we show an application for the calculation of the HRTF over 20kHz. At such high frequency ranges, conventional BEM are not suitable as DOFs become huge. All the same, WAON can deal with such a high frequency range efficiently using the FMBEM solver. (DOFs of the analysis model: 200,000 - CPU time: about 1 hour)

Case 4. Acoustic analysis of Car Cabin Environment

This is an application for room acoustics. As the sound source, a loudspeaker was modeled whereas

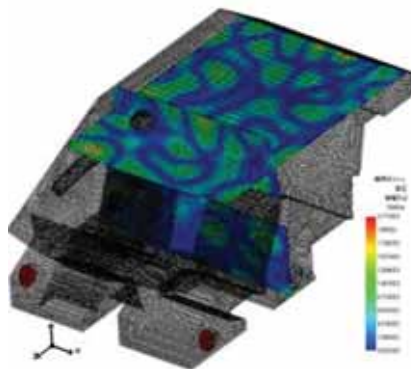


Image and data courtesy Kenwood Corporation

Frequency (Hz)	DOFs of analysis model	CPU Time (h)
1,000	48,586	1.4 Hour

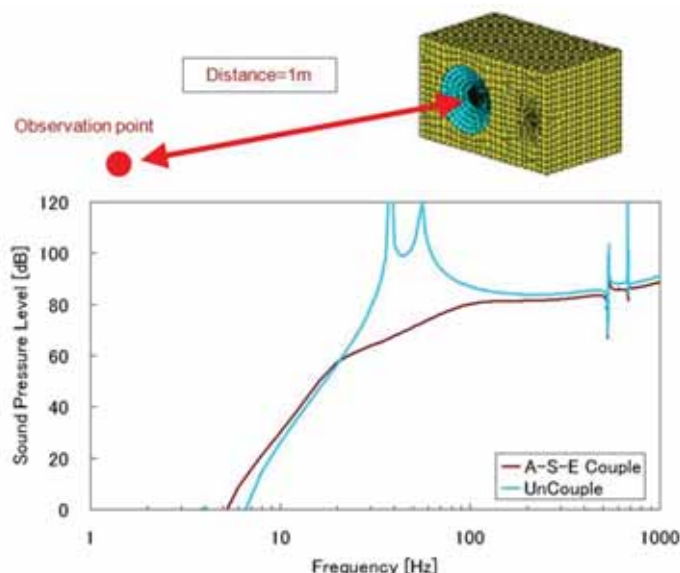
BEM Type	Required Memory	Required specification of PC
Conventional BEM	36.0GB	Not available on 32bit/2GB PC
FMBEM (WAON)	1.1GB	Available on 32bit/2GB PC

Comparison with conventional BEM

the vibration was defined on the panel of the loudspeaker. Conventional BEM proved to be difficult for the calculation of audible frequency ranges as the DOFs of the model are huge. In this example, the DOFs are 48,586, and conventional BEM would need about 36GB memory to solve the problem. By using WAON, we can calculate the same problem with about 1.1 GB memory which is very reasonable.

Acoustic-structural Coupled Analysis Function

Acoustic-structural coupled analysis enables acoustic analysis in a wide variety of applications, including speaker diaphragms, for which acoustic analysis is required to have a highly precise model of the acoustic-structural interaction, and automobile intake manifolds or compressors that require transmitted noise issues to be addressed. Prior to acoustic-structural coupled analysis, it is necessary to separately perform structural eigenvalue analysis using general structural analysis software. With WAON, the results of the analysis may be read via a unique interface, to generate a structural model for the coupled analysis.



Example of acoustic-structural coupled analysis

The following chart shows an example of an analysis of the acoustic-structural interaction on the speaker diaphragm. By taking into consideration both, the acoustic resonance and the resonance of the diaphragm, analysis with higher precision is achieved. (Red: coupled; Pale blue: uncoupled)

Large-Scale Acoustics Analysis with "ANSYS Workbench" and "WAON"

"WBtoWAON" is a specialized interface for ANSYS Workbench, which is included in the standard package of "WAON", the large-scale acoustics simulation software. With this interface, we can easily export geometries and simulation results from ANSYS Workbench to WAON.



Advantages of
"WBtoWAON":

1. Direct interface for ANSYS Workbench: The simulation process is simple because WAON uses the native data of ANSYS Workbench (meshes and simulation results) for acoustic simulation.
2. Highly effective for large-scale acoustic problems: WAON is particularly effective for large-scale and high-frequency problems which we may find difficult to do with FEM tools, such as ANSYS. On a 32-bit Windows machine (memory: 2GB), a model with 60,000 degrees of freedom (DOF) can be solved; and on a 64-bit Windows machine (memory: 8GB), the solvable DOF is 250,000.
3. The surface structure consists of shell meshes: WAON applies the boundary element method (FMBEM or BEM) which models only the surface of a structure, with shell meshes. Therefore, it requires far less elements than FEM, which models the whole of the acoustic medium!

WB to WAON case study: Sound radiation of a speaker

In this example, the results of the Harmonic Response Analysis from ANSYS Workbench represent the Sound Source. The Boundary Element Mesh and Field Point Mesh are the results obtained from the ANSYS Workbench models.

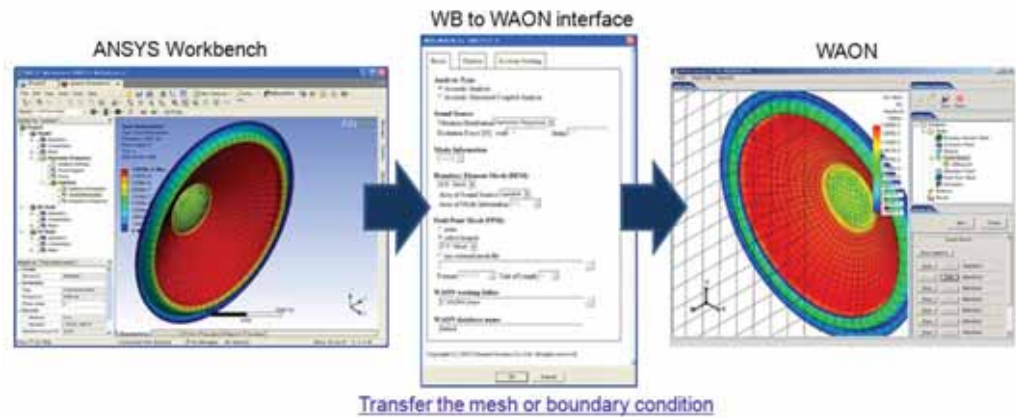
Boundary conditions are as follows:

Geometry; With thin boundary layers

Medium; Air (at RT)

Sound Source; apply the speed to the speaker cone

Frequency; 2000Hz



Solution for low frequency problems

In the FMBEM, elements are divided into some cells and contributions from each element in the cells are accumulated and expressed as a multipole expansion. Then, the expansion coefficients are translated into the value of the other cells. Finally, the values are distributed to each element. Through this procedure, the calculation performance has been improved. However, we need to watch the costs linked to the coefficient translation, in particular because the calculation of this part is quite complex and large. For this reason, Rokhlin's diagonalization is widely used due to its efficiency but at the same time, it is known to be unstable when the calculation frequency is rather low compared to the element length. To avoid this problem, WAON automatically degraded the efficiency and kept the accuracy. With its latest version released in autumn 2009, WAON has completely solved the problem by implementing the other coefficient translation method. Hence now, WAON is able to handle very large BEM models for entire frequency ranges by using conventional FMBEM for high frequency and new FMBEM for low frequency.

For more information, please visit the Cybernet Systems WAON website:

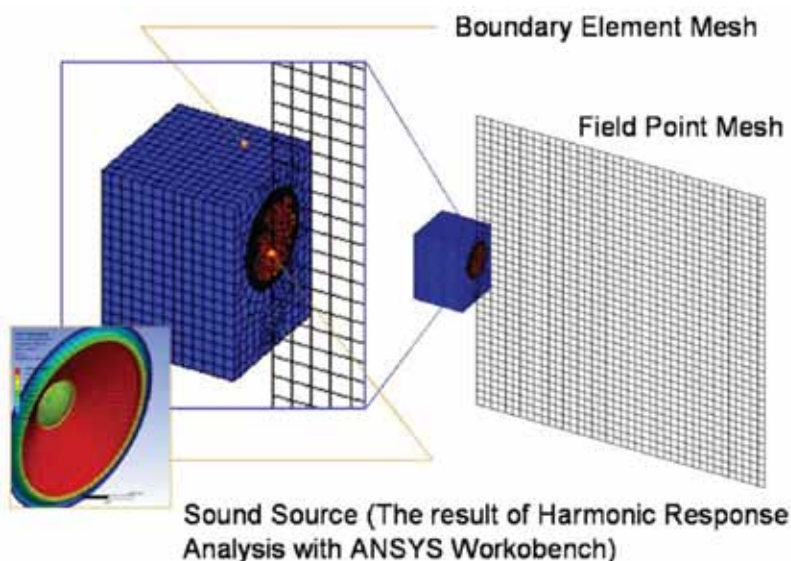
<http://www.cybernet.co.jp/waon/english/>

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EnginSoft partners with Cybernet Systems Co.,Ltd Japan to promote the WAON technology in Italy"



A new encounter with Japanese traditional culture: “書: Sho”

The art of drawing characters



“Sho” is something that we should remember when we discuss Japanese traditional culture. Sho is one of the most approachable arts in our world today. Sho is a unique, artistic way of writing, or more precisely of drawing characters only with a brush and sumi (Indian ink) which attracts a lot of attention, also in Europe. Today, we can see Sho art in many different places. People often say that Sho is profound art work because Sho artists present, in a skilful way, dynamics and/or sensitivity by adjusting the characters' flowing curves and contrasting density. This may sometimes reflect their spirit



Figure 1: “Encounter”

and imagination at first glance, even with drawings that consist of monochromatic characters only. Sho work is one of the origins of MONODUKURI, whereas Sho art is the “design” which evolved and has been polished throughout its long history, but will never be completed in infinity.

MONODUKURI is the Japanese expression for manufacturing. It is not limited to general manufacturing though and used often in discussions about Japanese engineering spirit and traditional manufacturing.

Truly, the Japanese traditional culture of Sho and Japan's similar spiritual culture might be very interesting for the readers of the EnginSoft Newsletter who work in the areas of “Design” and “MONODUKURI”, although both are completely different from virtual prototyping and mechanical design.

This is why we are introducing Japanese Sho in cooperation with Ms. Shizu Usami, one of the most famous contemporary Sho artists, whose fine art work we are pleased to present to our readers in this 2nd Japan Column.

Incidentally, for most readers outside Japan, it may be easier to comprehend if we called the art “Shodo” and not “Sho”. However, in Japan, children in elementary schools enjoy being taught “Shodo” to develop their creative and writing skills. Also, Shodo is broadly interpreted and known as a form of adult education and hobby. Hence, when we speak about the art itself, Sho is the more suitable expression for the final work and the MONODUKURI process. So, in this article, we are discussing Sho.

Japanese Sho

Sho originally came from China, but in Japan, Kanji, the Chinese characters, were combined with the original Japanese characters “Kana” to create a unique art of writing characters. This calligraphy stands as a symbol for Japanese culture and its history of 2000 years. Before talking about Sho, we need to dwell on the derivation of the characters.

The history of mankind dates back to about six hundred thousand years. The art of painting was born fifty thousand years ago, hence about 10% of the time span of humankind, whereas the origins of drawing and writing characters can be traced back to 5.200 years ago, 1% of the entire history of mankind. The latter is based on Egyptian hieroglyphs written in 3.200 B.C., which means 5.200 years ago.

Altogether, the use of “words” and the elements of nature, such as “fire”, characterize and distinguish humanity



Figure 2: “i, ro, ha, ni, ho, he, to”





fundamentally from any other creature. In general, it is also important to note that, to express our words, we use spoken and written language and letters.

Today in Japan, we use 3 kinds of spelling and words: "Kanji", "Hiragana" and "Katakana". Since Kanji came from China at the end of the 4th century, the Japanese had created the unique words of "Hiragana" and "Katakana" based on Kanji. All of this has inspired and guided many of the great works of Japanese literature, including "The Tale of Genji", which are known all over the world.



Figure 3: "The Moon"

Most of the Japanese writings have been handed down through the ages and generations. These works were not only meant to deliver information or literary achievements, indeed not, they should also delight their readers with the beauty of the characters and the finest papers used.

This is the main feature of Sho and what it is all about - in the past and



today! For instance, people who are interested in and study old Japanese writings, consider deeply and enjoy the different subtle expressions of Sho, such as thickness, shading and flow of the characters' curves.

Another role of Sho is to support the growth and reputation of Japanese historical fine arts. For example, Shikki, the craft work coated with lacquer, and ceramics with Sho design, have been highly appreciated, for Sho is not just figurative art, it can express people's spirit delicately through brush writing.

Nowadays, writing letters has become so underrated. While this trend continues, Sho attracts more and more interest as one of the most fundamental means of expressing feelings in Japan and other countries. In this respect, Sho is also regarded and used by many industries as a very effective way to deliver emotional messages linked to company and product names.

"Sho" as a MONODUKURI

The basic tools for Sho consist of the brush, sumi, suzuri (ink stone) and paper called "Four Treasures of the Study". They also have a long history in China, however, Japanese tools have a unique and extra beauty that is highly appreciated. The craftsmen who create these tools, provide some of the fundamentals for the work of the Sho artists, and at the same time, they conserve and pass on traditional Japanese culture to future generations.

Today, such superior skills are highly sought after and in the spotlight in other industries. For example, a certain Japanese Sho brush maker also produces high-grade makeup finishing brushes and its global market share for the same is more than 50%. Sho artists make their choice in accordance with their own taste and expression. They have various tools and select suitable ones for each work, to create the best art. All tools are made from natural materials and each work offers different pleasures. Sho artists are applying and cherishing these living tools every day.

Sho artist Ms Shizu Usami pays close



Figure 4: "Yukata Firefly"



attention to each and every detail of her work, such as the black color of sumi (Indian ink) and the time it was made, to fit her art work. Sometimes, months pass by for what we call "concept design" in CAE, before she takes up her brush. When her real work starts, there is no revision and no second chance. Facing the white paper, soaking the brush with black sumi richly, she "writes" and creates her work with total devotion. The moment we encounter her Sho work, we can feel her Japanese modesty, motherly warmth, unyielding grace and her dynamism that fascinates those around her instantly. Then, only her art work and its monochromatic color starts telling us a story - silently.

To complete our story, we also have to explain the work of the "Hyogu-shi" (Hyogu-professional/paperhanger) who finishes the Sho work. The Hyogu-shi makes scrolls and frames which are made to order for each piece of Sho art. His or her skills transform an entire performance. If the scroll is not of best quality, it may not be tightened enough and warp, especially in the humid climate of Japan.

Thus the beauty of Japanese Sho is supported by the MONODUKURI spirit of the craftsmen and professionals for tools (brush, sumi, suzuri and paper) and the Hyogu-shi. Sho artists spark the fire and enthuse with Sho art which integrates the professional skills of others with their own artistry.

From now on, the message of Japanese Sho will inspire people around the globe giving new values to society.

Figure 1 "Encounter"

Every encounter is unique and has a meaning and so has every farewell. Every day of our life, our entire lives, are full of encounters and farewells. We continue our great journey sometimes holding our breath and sometimes taking a deep breath.... Blue black sumi is used. Expressing our life's love by ink bleed and time with the between of characters.

Figure 2 "i, ro, ha, ni, ho, he, to"

"i, ro, ha, ni, ho, he, to" is the old Japanese poet using Hiragana characters one by one. The first 7 characters describe the scene of a Japanese province. Quietly drifting clouds, small houses and bridges, and the shape of gentle mountains are brought to our minds with Hiragana.....

Sho artist: Ms. Shizu Usami

Ms. Shizu Usami is a famous contemporary Sho artist and Japanese calligrapher who started the traditional study of Sho at the age of 3, established the basis of her expression and is currently looking at new ways of presenting her art. For example, she creates her work by being particular about the black color of sumi, such as blue black, brown black, more intense black.... She also dedicates her work to education and lectures and actively fosters Japanese writing and traditional art. Her art adorns the covers of the official brochures of Japan's "Ministry of Economy, Trade and Industry", the "Wooden House Industry Association", and many other MONODUKURI makers. Moreover, at this time, Ms. Shizu Usami studies textile design at University of the Arts London and produces new art devoted to the integration of European MONODUKURI techniques and Japanese culture. Her art is highly valued, also by embassies, and collectors over the world.

Ms. Shizu Usami URL http://www.shizuusami.com/index_e.html

Ms. Shizu Usami is also the fourth generation president of Usami Honten.co.,Ltd. which produces premium quality soy source and Japanese-style seasonings and boasts a history of 110 years.

Usami Honten. co.,Ltd. URL http://www.usamihonten.com/index_e.html



using brown black sumi made 35 years ago.... hoping it gives you a sweet sense of déjà-vu.

Figure 3 "Moon"

Oriental have loved and written poetry about the moon for a long time. We see ourselves in the moon and miss a loved one or someone who passed away when looking at the moon. The origin of Kanji is linked to the shape of the crescent moon. While the sun is always full and round, the moon waxes and wanes... Expressing the moon silently behind the light cloud.

Figure 4 "Yukata

(Japanese Summer Kimono): "Firefly"

The Kimono is one of the beautiful Japanese traditional garments which is usually worn for formal occasions. In the summer though, we often choose the Yukata which, made from cotton, looks casually stylish. Originally, the Yukata was worn after a bath. Now, it is also something we enjoy to wear in the summer carnival and at events. This Yukata has been designed with fireflies... hoping that every lady shines like a firefly at sundown with the design that stands out at night.

Akiko Kondoh, Consultant for EnginSoft in Japan



SCM GROUP SpA SCM Fonderie

Le fonderie SCM fanno parte dell'importante gruppo internazionale SCM GROUP, leader mondiale nel settore macchine e sistemi per la lavorazione del legno. Inizialmente la produzione delle fonderie SCM era destinata alla componentistica delle macchine per il legno; in seguito la produzione per terzi ha acquistato un'importanza via via crescente, fino a raggiungere attualmente il 90 % del fatturato. Oggi le fonderie SCM, grazie a due stabilimenti, uno a Rimini e l'altro a Villa Verucchio, producono getti in ghisa grigia e sferoidale per tutti i settori industriali.

Le fonderie ed i prodotti

Le fonderie SCM vantano due stabilimenti produttivi dedicati alla produzione di fusioni in ghisa a grafite lamellare e a grafite sferoidale:

- Lo stabilimento di Rimini è caratterizzato da un processo di formatura a verde su due impianti automatici, asserviti da un cubilotto a lunga campagna a vento caldo con capacità produttiva di 13 ton/h ; si presta particolarmente alla produzione di getti di media serie, con un peso da 1 kg a 500 kg.
- Lo stabilimento di Villa Verucchio utilizza un processo di for-

anche ad elevato contenuto tecnologico, tra cui: basamenti motore, teste motore, scatole cambio, coprivolano, carcasse riduttore, portaplanetari, cilindri oleodinamici, corpi pompa, corpi idraulici, coppe olio e contrappesi per carrelli elevatori.

La ghisa ed il controllo continuo del processo fusorio

Il processo di fusione è monitorato e gestito mediante l'uso di software che permettono di ottimizzare la composizione delle cariche, in base ai risultati delle analisi termica e spettrografica della ghisa, secondo un loop di controllo retroattivo che assicura la prontezza di risposta necessaria a garantire sempre un'esatta corrispondenza tra l'analisi chimica cercata ed il risultato reale. La continua interazione, tra le funzioni di collaudo dei getti e di produzione, permette inoltre di adattare, prontamente ed in continuo, il processo alle necessità dei diversi getti, nell'ottica del miglioramento continuo. Il risultato è un'elevata ripetibilità dell'analisi chimica e del processo e quindi una garanzia di conformità del getto alle specifiche richieste dal cliente. La perizia nella realizzazione dei getti permette alle nostre fonderie di realizzare fusioni molto complesse e con spessori molto ridotti, in taluni casi fino a 5 mm per getti in ghisa grigia e fino a 6 mm

per getti in ghisa sferoidale, del tutto esenti da difettosità. Tutto questo permette ai progettisti di avere un elevato grado di fiducia nella rispondenza del materiale alle specifiche normative di riferimento, e quindi di alleggerire i getti, rendendo la ghisa un materiale decisamente competitivo. Le fonderie SCM sono in grado di produrre ghisa grigia e sferoidale conforme alle norme UNI 1561 e UNI 1563 coprendo un vastissimo range di necessità in quanto a caratteristiche meccaniche delle fusioni.



(a) Fonderia di Rimini

(b) Fonderia di Villa Verucchio

Figura 1: Le fonderie SCM

matura chimica con sabbia e resina, e due forni di fusione rotativi a metano da 18 ton/carica grazie ai quali realizza fusioni con pesi fino a 3000 kg, è in grado di realizzare medie e piccole serie, ma anche prototipi.

La produzione delle fonderie è destinata al proprio gruppo per un 10%, mentre il restante 90% è destinato ai clienti terzi, suddivisa per un 85% sul territorio nazionale ed un 15% all'estero. Le fonderie sono in grado di produrre con grande flessibilità getti per le più svariate applicazioni e servono in ogni settore le aziende più prestigiose. Le fonderie SCM sono in grado di produrre per i seguenti settori industriali: Macchine agricole, veicoli industriali, macchine utensili, macchine movimentazione terra, ferroviario, robotica, riduttoristica, fluidodinamica, compressoristica, tessile e artistico. La grande flessibilità produttiva, permette di realizzare un'ampia gamma di prodotti,

La simulazione numerica del processo

Uno dei più grandi punti di forza delle fonderie SCM è rappresentato dalla capacità di affiancare il cliente fin dalle fasi di ideazione del prodotto, progettazione, prototipazione ed ingegnerizzazione della produzione, in un continuo confronto teso al raggiungimento della soddisfazione del cliente.

Questa filosofia permette di ridurre al minimo i tempi di avviamento della produzione e migliorare di conseguenza il rapporto qualità - prezzo del prodotto. Un ruolo fondamentale nella pro-



Figura 2: Due esempi di prodotti SCM (basamento motore 12 cil a V e testa motore 6 cil linea)



gettazione del prodotto e nell'ingegnerizzazione del processo è rappresentato dalla simulazione numerica delle fasi di colata e riempimento delle forme e di solidificazione dei getti, realizzata con il software MAGMASoft. Questo software rappresenta il migliore strumento offerto dal mercato, nell'ambito della analisi numerica dei processi di fonderia. La simulazione permette di valutare in poco tempo alternative produttive, evidenziando eventuali difetti dovuti a cattiva alimentazione o direzionalità del raffreddamento. Attraverso la simulazione 3D è possibile evidenziare le aree della forma sottoposte a maggiori sollecitazioni termiche o meccaniche, il tempo di riempimento, studiare

Integrata Ambientale (AIA), in base al Decreto Legislativo 18 febbraio 2005, n.59 Attuazione integrale della direttiva 96/61/CE relativa alla prevenzione e riduzione integrate dell'inquinamento (IPPC).

Ricerca e sviluppo

Da sempre le Fonderie SCM reinvestono parte del proprio fatturato in Ricerca e Sviluppo al fine di studiare nuove soluzioni progettuali e/o di processo per recuperare efficienza e vantaggio competitivo con interventi per ridurre i costi di produzione migliorando nel contempo le caratteristiche qualitative del prodot-



Figura 3: Il software di simulazione termofluidodinamica MAGMA

l'analisi dei flussi del liquido all'interno della forma e la direzionalità del raffreddamento e studiare di conseguenza il sistema di alimentazione del getto. Questo si traduce nella riduzione drastica del numero di campionamenti effettivi, limitati alle soluzioni migliori ottenute dal software. L'esperienza ha dimostrato ampiamente i vantaggi nell'uso delle tecnologie numeriche di simulazione termofluidodinamica: solo per citare un esempio si è riuscito a realizzare un getto per l'industria oleodinamica avente massa di 1300 kg, del diametro di 1350mm, alto 510mm e con diverse variazioni di sezione circonferenziale, del tutto privo di porosità alla prima campionatura, come dimostrato dal collaudo agli ultrasuoni e dalla lavorazione meccanica finale. In questo caso il software ha permesso di ottimizzare il numero e la disposizione degli alimentatori, dei raffreddatori, degli attacchi e del canale di colata e la posizione del getto sul piano di sformo. La via tradizionale per tentativi avrebbe comportato costi ormai insostenibili e tempi decisamente più lunghi.

Qualità e ambiente

Le fonderie SCM ritengono d'importanza strategica la protezione dell'ambiente e la sua salvaguardia nella realizzazione del prodotto e nel processo produttivo ed ha deciso di operare affinché i processi produttivi, gli impianti, le attività, i servizi non provochino impatti ambientali significativi o generino rischi potenziali/reali. Le fonderie SCM hanno ottenuto con successo la certificazione UNI EN ISO 14001/2004. La certificazione ambientale ISO 14001 certifica che il sistema di gestione dell'azienda rispetta le normative ambientali ed è orientato ad un miglioramento continuo delle proprie performance. Il sistema di Gestione Ambientale adottato da SCM Fonderie ha così integrato il sistema di gestione qualità che opera in conformità alla norma UNI EN ISO 9001/2000. I due siti produttivi delle fonderie SCM hanno ottenuto, tra le prime fonderie in Italia, l'Autorizzazione

to ed il livello di servizio ai clienti. Incrementare la flessibilità/produttività dei processi di produzione, diminuire l'impatto ambientale a fronte di un aumento dell'eco-efficienza e dell'eco-compatibilità, sono must che oggi rappresentano la garanzia di un futuro sostenibile. Non da meno l'importanza della diminuzione del lead time e del time to market (tendenza al JIT) unitamente al miglioramento dei servizi offerti al cliente, rappresentano la possibilità di allineamento delle fonderie con i più alti livelli tecnologici. In ultimo, ma non per importanza c'è l'aspetto sostenibile di tutto il processo. Allo stato dell'arte le fonderie hanno grossi problemi dovuti agli elevati volumi di materiale di scarto con conseguenti problematiche di smaltimento/riciclaggio, generando un onere sia in termini economici sia ambientali per tutto il sistema all'interno del quale sono inserite (ambiente).

Le attività di R&S sono gestite autonomamente all'interno delle Fonderie SCM da personale dedicato ed altamente qualificato che, nei progetti di più ampia portata, viene affiancato dal CSR (Consorzio Studi e Ricerche) centro di ricerca interno ad SCM Group e dalla partnership con importanti istituti di ricerca sia a livello nazionale che internazionale. L'importanza dei risultati raggiunti attraverso le attività di R&S viene poi certificata dalla pubblicazione, diventata ormai una consuetudine, sulle riviste tecniche del settore. È presente all'interno del sito dell'azienda (www.scmfonderie.com) una distinta sezione Articoli redazionali in cui viene dato ampio spazio a tutte le pubblicazioni. Tra i progetti più importanti sviluppati presso le Fonderie SCM occorre segnalare il progetto Eureka! MOD (Moulding On Demand) che ha consentito il raggiungimento di risultati tecnologici d'avanguardia nel settore delle fonderie: tra questi citiamo, a puro titolo di esempio, l'adozione, tra i primi al mondo, di robot antropomorfi per la sbavatura dei getti e per il prelievo e l'analisi della ghisa liquida.



Distretto Aerospaziale Pugliese: EnginSoft membro costituente del nuovo soggetto di riferimento nel campo aeronautico ed aerospaziale



Il 29 luglio 2009 si è costituita la Società Consortile "Distretto Tecnologico Aerospaziale S.c.ar.l." con sede in Brindisi e riconosciuta con legge regionale. Tra i soci privati, oltre la stessa

EnginSoft Spa, compaiono anche Alenia Aeronautica Spa, Avio Spa, Dema Spa, Salver Spa, Cmd Srl, Ias Srl, Gse Srl, Technologycom Srl, Planetek Srl, il Consorzio Cetma e il Consorzio Optel, invece sono presenti l'Università del Salento, l'Università di Bari, il Politecnico di Bari, l'Enea ed il Cnr in qualità di soci pubblici. Il "Distretto Tecnologico Aerospaziale" sarà un moderno strumento di sviluppo per ideare, progettare ed adottare politiche e strategie riconducibili ad una molteplicità di attori: imprese piccole, medie e grandi, università e centri di ricerca, istituzioni locali e regionali, organizzazioni sindacali ed associazioni nazionali dell'aerospazio e della difesa. La società, avrà il compito, inoltre, di sviluppare attività di ricerca industriale e formazione nel settore aerospaziale sia in ambito nazionale sia internazionale. Dotata già di un consistente portafoglio progetti, opererà con un forte orientamento al mercato sviluppando processi e prodotti innovativi occupandosi anche della formazione di eccellenza. La missione del "Distretto Tecnologico Aerospaziale" è quella, quindi, di operare per la competitività delle produzioni aerospaziali pugliesi e per la riconoscibilità delle competenze e



delle specializzazioni di ricerca e formazione nell'intero panorama nazionale ed internazionale. Al fine di massimizzare l'efficienza delle azioni intraprese e da promuovere (i.e. partecipazione congiunta a programmi regionali, nazionali ed europei, sviluppo di nuovi prodotti e processi, ...), il "Distretto Tecnologico Aerospaziale" si fonda su una politica di integrazione e cooperazione tra le grandi imprese e le dinamiche PMI locali. Il neo presidente Giuseppe Acierno afferma che in questo modo si è creato un altro tassello della strategia ideata 4 anni fa per arginare una possibile perdita di competitività delle produzioni aerospaziali pugliesi.

Sul versante della dinamica tra finanza pubblica e PMI, i governi regionali e nazionale preposti a sostenere le attività di R&S, riconoscono il Distretto Aerospaziale Pugliese come interlocutore privilegiato per indirizzare, pianificare e monitorare l'utilizzo delle ingenti risorse comunitarie nel rispetto delle vigenti legislazioni. Il Distretto Aerospaziale Pugliese si configura quindi come uno "strumento" capace di massimizzare le opportunità che i programmi di finanza pubblica offrono (i.e. POR PUGLIA 2007-2013).

Considerando le ragioni che hanno condotto alla costituzione del Distretto, tenendo conto della "mutazione" che le PMI hanno messo in atto per assumere un ruolo sempre più attivo nel campo della R&D (staccandosi quindi da una connotazione prevalentemente manifatturiera), la costituzione di un soggetto unico che rappresentasse le esigenze e gli obiettivi comuni e che mettesse a sistema le singole potenzialità, era divenuta un passo obbligato e quanto mai indispensabile. Il settore aerospaziale pugliese inizia a configurarsi, quindi, come un sistema a rete compiuto, integrato e moderno, ed anche grazie ai numerosi progetti in portafoglio, al loro grado di innovatività, alla loro attualità di mercato il cammino continuerà e seguirà un percorso che valorizzerà ed esalterà le competenze del sistema pubblico della ricerca e permetterà alle piccole e medie imprese del territorio di rafforzare il loro legame commerciale e culturale con i grandi produttori.

Strutturalmente, l'industria aerospaziale pugliese è composta di produttori e fornitori di livello internazionale, e da una dinamica rete di PMI specializzate nella subfornitura. Proprio il dinamismo, la flessibilità, l'innovazione e la dimensione sono elementi caratterizzanti dell'industria aerospaziale pugliese. Nel contesto nazionale, la Puglia rappresenta uno dei poli produttivi più importanti in Italia con oltre 50 Imprese, che generano vendite per circa 1 miliardo di euro e in



cui trovano occupazione oltre 5.000 addetti. Nella visione strategica di andare incontro ed anticipare le richieste del mercato, e tenendo conto delle competenze dei diversi partners, il Distretto si è fatto promotore di progetti di R&D inerenti le seguenti aree tematiche:

- produzione di sensori integrati ai materiali compositi per monitorare lo stato delle strutture;
- produzione di sensori per il controllo della combustione e riduzione dell'inquinamento ambientale; produzione di sensori sulla homeland security;
- Produzione di mini/micro UAV innovativi (Unmanned Aero Vehicles);
- produzione di nuovi motori per aerei ed elicotteri leggeri;
- componenti innovativi per nuovi Aerodine (velivoli leggeri e componenti);
- approfondimento e risoluzione di problematiche;
- sicurezza passiva (crashworthiness) e resistenza termica (thermal resistance) degli elicotteri, anche mediante l'integrazione di sensori e dispositivi nelle strutture;

- Health Management e Repair, con i filoni della manutenzione predittiva, problematiche strutturali di compositi danneggiati o riparati;
- nuove tecnologie di repair per componenti di motori aeronautici;
- Green engines per l'aeronautica;
- tecnologie produttive aeronautiche innovative;
- Enhanced Synthetic Vision Cockpit Display.

EnginSoft si colloca nel Distretto come unico membro di estrazione tipicamente industriale operante nel campo della simulazione virtuale e dell'iDP (intelligent Digital Prototyping), ragione per cui il ruolo è quanto mai complementare e necessario alle attività, non solo di R&D, che verranno di volta in volta promosse.

Per maggiori informazioni:

Link Distretto Aerospaziale pugliese:

<http://www.apulianaerospace.eu/it/ildistretto.html>

Ing. Marco Perillo (info@enginsoft.it)

The Apulian Aerospace District: EnginSoft supports International Aerospace R&D

The company "Distretto Tecnologico Aerospaziale" was founded on 29th July 2009. Headquartered in Brindisi, Apulia – Italy, the "District" will be at the core of international research and development activities in the fields of aerospace and defense.

The District is targeted at a variety of subjects and supported by a number of private and public bodies: from large cooperations to SMEs, from academia to research institutes, from associations to research foundations. Among the private founders and investors are: Alenia Aeronautica, Avio, Dema, Salver, CMD, Ias, Gse, Technologycom, Planetek, the Cetma Consortium and the Optel Consortium. The public founders are: the University of Salento, the University of Bari, the Polytechnic of Bari, Enea and CNR. EnginSoft is the only CAE-related Shareholder and hence has a unique role in a unique context.

The mission of the "Distretto Tecnologico Aerospaziale" is to increase the competitiveness of the Apulian aerospace industry by fostering knowledge transfer in research across the national and international aerospace markets.

As Giuseppe Acierno, the new company President, further explains: "Our ambition is to establish and develop close cooperations between large enterprises and the extremely dynamic local SMEs. For our local and national governments, the "Distretto Tecnologico Aerospaziale" is a project of high importance to address public funding for the support and realization of innovative Research and Development activities".

The "Distretto Tecnologico Aerospaziale" is also a unique opportunity for the Apulian SMEs to represent their needs and

common objectives. In fact, several Apulian SMEs have recently taken on more active roles in various R&D initiatives, in addition to their traditional manufacturing activities. The Apulian aerospace district is constantly evolving and becoming a modern and integrated network which will increase the profitability of public funding for research. It will allow the local SMEs to grow their commercial and cultural partnerships with the world's leading aerospace manufacturers.

Today, the Apulian aerospace industry is structured by some global manufacturers, suppliers and by a dynamic network of SMEs specialized in the sub-supply of aerospace components. Apulia is one of the main industrial hubs of Italy, employing more than 5.000 people, in more than 50 enterprises and a turnover of nearly 1 billion Euros. In this context, the "Distretto Tecnologico Aerospaziale" has already supported various initiatives and developments for specific monitoring sensors, innovative UAVs, new aircraft engines, new Aerodine components and innovative solutions to enhance aircraft safety, eco-sustainability and construction processes.

EnginSoft contributes with its broad experiences in Virtual Simulation and iDP (intelligent Digital Prototyping). EnginSoft is the only Shareholder specialized in these fields and, consequently, will provide complementary services and indispensable expertise to the District.

For further information, please visit, contact:

Apulian Aerospace District:

<http://www.apulianaerospace.eu/it/ildistretto.html>

Ing. Marco Perillo, info@enginsoft.it

EnginSoft Technology Days

Vasta la partecipazione al Technology Day gentilmente ospitato da Magneti Marelli Powertrain nella propria sala Weber di Bologna nel recente periodo estivo.

Il tema del Virtual Prototyping è ormai di grande attualità sia per chi opera a livello tecnico nell'industria, sia per chi ha responsabilità manageriali ed organizzative. Per contribuire alla discussione ed ad una corretta diffusione della relativa cultura, EnginSoft ha organizzato una serie di incontri presso Magneti Marelli, società che già dal 1993 lavora con queste tecnologie utilizzando EnginSoft come partner consolidato nell'ingegneria, nel trasferimento di conoscenze e nella fornitura di software per la ricerca e sviluppo.



Pensato come parte di un più ampio percorso informativo continuo sulle novità nel campo del Virtual Prototyping, il FEA Spring Campus - riservato a Magneti Marelli e ai propri fornitori - ha visto come protagonisti due temi di notevole impatto sul processo di sviluppo prodotto delle aziende più



innovative: le nuove possibilità offerte dalla release V12 della Suite ANSYS Workbench e il vero e proprio salto concettuale nell'uso del CAE permesso dall'ambiente di Multi-objective Design & Optimization, modeFRONTIER.

Come ha efficacemente illustrato l'Ing. Andrea Davitti, R&D Manager di Magneti Marelli Divisione Components, nella sua sessione introduttiva, "l'importanza di disporre di strumenti moderni e di un efficace supporto tecnico multidisciplinare è imprescindibile per rispondere con tempismo alle sempre più sfidanti richieste del mercato automotive. Ormai quest'arma è diventata fondamentale, non solo in fase di progettazione, ma addirittura sin dalle prime e delicate fasi di offerta del componente stesso".

Proprio su questo tema centrale si è sviluppata la sessione mattutina, grazie anche a una serie di esempi pratici, toccando in particolare i seguenti argomenti:

- ANSYS Workbench II - Simulation Framework di ultima generazione
- L'integrazione tra ANSYS Mechanical, ANSYS CFX e ANSYS FLUENT
- Esempi di simulazione parametrica multi-fisica
- L'automazione di procedure CAE e il Design Of Experiment con modeFRONTIER
- Robust Design e CAE Design For Six Sigma

Si è visto quindi come sia possibile non solo affrontare la creazione di modelli fisico-matematici realistici, ma anche snellire ed automatizzare il processo di simulazione e di progettazione stesso. Sono infatti stati evidenziati i fattori comuni alle best practices più recenti di integrazione tra CAD, CAE, strumenti di progettazione trasversali quali MATLAB, e software aziendali proprietari, nonché tabellari e formulari Excel. A corollario si è accennato a come sia oggi possibile, sempre con modeFRONTIER, integrare dati sperimentali e gestire le importanti informazioni in essi contenute per migliorare i modelli stessi e la conoscenza.

Come esempio pratico di uso congiunto di tutte le tecnologie presentate, l'Ing. Facchinetti di EnginSoft ha poi illustrato il paper "Optimization of an automotive door panel acting on injection molding process parameters" recentemente presentato a Detroit.





Nel pomeriggio gli oltre 90 partecipanti hanno potuto seguire sessioni pratiche parallele di approfondimento sulle singole discipline, interagire con il software e parlare delle proprie esigenze specifiche con gli esperti EnginSoft.

Il prossimo evento del Magneti Marelli FEA Spring Campus sarà centrato sul tema della Design Chain Prodotto-Processo, e

focalizzato sul ruolo degli strumenti come MAGMA per prevenire le criticità costruttive, conoscere le reali caratteristiche dei materiali a valle di processi quali quelli di fonderia, trattamenti termici, lavorazioni meccaniche, paragonare pro e contro di vari processi, e illustrando come sia oggi possibile far leva su queste preziose informazioni sin dalle prime fasi di design dei più importanti componenti automotive.

Durante la giornata verrà dato ampio spazio ai risultati derivanti dal progetto NADIA (New Automotive components Designed for and manufactured by Intelligent processing of light Alloys), valutato come uno dei migliori progetti del Framework 6 nel settore automotive in sede europea e di cui EnginSoft è il Project Leader (<http://www.nadiaproject.org/>).

*Si ringrazia Nazario Bellato - Magneti Marelli Powertrain
(CAE Manager Magneti Marelli Powertrain)
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INTERNATIONAL MINI-MASTER Advanced casting design of automotive components



**June 22nd-26th, 2009
DTG - Dipartimento di
Tecnica e Gestione dei
Sistemi Industriali
Università di Padova,
sede di Vicenza**

The latest Mini-Master Course has been held in Vicenza, June 22nd-26th; it was hosted by the Department of Industrial System Management (DTG) – University of Padua.

Thanks to the efforts devoted to the program of lectures, the excellent level of the presentations and the availability of all participants during the 5 days, the Course has become a successful event providing valuable insights and experiences to all students and everybody involved.

The International NADIA Mini-Master has been based on an intensive course which focused on the advanced casting design of automotive components. Every day was dedicated to a specific topic, it was also a kind of “experiment”, trying to achieve different levels of integration and combinations:

- Metallurgy and design & application,
- Theoretical knowledge and experimental features,
- Well-consolidated arguments and “frontier” topics.



Both lectures and students have evaluated the Course by completing a questionnaire. The marks given are between good and excellent and show great satisfaction.

The Mini-Master Course has been organized in the frame of and with the excellent background of the NADIA European Project. The Course is always supported and conducted by several highly qualified lecturers who, this time, came to Vicenza to pass on their knowledge and experiences.

Organized in the frame of the NADIA European Project



New Automotive components Designed for and manufactured by Intelligent processing of light Alloys



6th Framework Program NMP Research Area
Contract 026563-2

with the cooperation of



Associazione Italiana di Metallurgia



Fondazione Studi Universitari di Vicenza



Intelligent Manufacturing Systems



Twenty years in EnginSoft: a reflection (by Livio Furlan)



I arrived in EnginSoft at the beginning of September 1989, when I still was a young chap, even if 7 years had already been spent working in companies operating the Oil&Gas and Offshore sectors and the same number previously passed as industrial designer in a technical office, during

and after my university carrier as Structural Engineer at Civil Engineering.

I joined Stefano Odorizzi (EnginSoft General Manager) ideas and proposal with enthusiasm and I could see them come true and widen their horizons in the following years also (let me say!) thanks to mine and my colleagues daily commitment.

I have decided not to use the little space which I have been given to celebrate my "first" twenty years in EnginSoft, to focus on myself and my professional career but I would rather dedicate a reflection to that time that we all devote to work every day.

I have always been convinced that independently of which (honest, of course!) work we do, our profession is essential not just for our personal but also for our social identity, since it's what we have to shape our own future and change the futures of the people among whom we live.

Working is not just producing but it's the opportunity we have to establish relationships, to grow and become emotionally involved with our dreams, to measure our respect for everybody else, towards colleagues, collaborators and customers; it's the opportunity to face with new technical and social challenges.

I read a nice story some time ago, that I would like to recall for you. It tells about three stonemasons who were using the same cutting-tools to shape stones to build a church. When asked about what they were doing, the replies were very different.

Vent'anni di EnginSoft: una riflessione (di Livio Furlan)

Arrivai in EnginSoft all'inizio del mese di Settembre del 1989, si può dire ancora con i 'pantaloncini' corti, sebbene avessi già trascorso 7 anni in aziende che operavano (ed operano) nel settore Oil&Gas e nell'ambito Offshore ed altrettanti spesi come disegnatore in uno studio tecnico prima, durante e dopo il corso di laurea in Ingegneria Civile (indirizzo strutturista).

Aderii con entusiasmo alle idee e alle proposte di Stefano Odorizzi – Amministratore Unico di EnginSoft – che nel corso degli anni si sono concretizzate in termini ampi e consistenti anche – lasciatemi dire – attraverso il mio, oltre che di tanti altri colleghi, impegno quotidiano.

In questo breve spazio che mi è messo a disposizione in occasione dei miei 'primi' vent'anni di EnginSoft non intendo, però, scrivere di me né dei miei percorsi professionali, quanto voglio dedicare una riflessione a quello spazio temporale che ci accompagna quotidianamente, a quello spazio, cioè, che dedichiamo al lavoro.

È sempre stata mia convinzione che, indipendentemente da quale (purché onesto, evidentemente), il lavoro sia importante per la nostra identità personale e sociale, che sia ciò che possediamo per cambiare, oltre al nostro, anche il futuro delle persone che ci vivono accanto.

Il lavoro, qualunque esso sia, non è solo azione per produrre, è anche opportunità per costruire relazioni, per crescere, per lasciarsi coinvolgere dai sogni, è situazione in cui si misura il nostro rispetto per gli altri, per i colleghi, per i collaboratori, per i clienti, è occasione per affrontare nuove sfide sia in termini tecnici sia in termini sociali.

Letta qualche tempo fa, mi piace ricordare la storia di tre scalpellini che stavano usando gli stessi arnesi (martello e scalpello) per sagomare le pietre che servivano alla costruzione di una chiesa. Ben diverse furono, però, le risposte che diedero alla domanda: cosa stai facendo?

Il primo disse: "Sto scalpellando delle pietre"; il secondo: "Sto guadagnando il pane per sfamare la mia famiglia"; e il terzo, infine, con un grande sorriso, disse: "Sto costruendo una cattedrale".

Tutti e tre faticavano e svolgevano la stessa attività, ma il senso che attribuivano al loro lavoro era ben diverso,

The first answered: "I'm carving stones", the second replied: "I'm earning a living to feed my family" and the third smiled saying: "I'm building a cathedral".

All of them were working hard doing the same activity, but the meaning they attached to it was extremely different, as well as the "falling in love" and enthusiasm they showed towards the fulfillment of a dream.

Many times we have found ourselves in the same situations: superficiality, hurry, fear of getting involved (I'm carving stones), necessity and need (I'm earning a living to feed my family) enthusiasm and passion (I'm building a cathedral).

With regard to anyone's duty, I believe that this last attitude is what contributes to self-fulfilling; that enthusiasm and involvement, difficult to reach and to make real, are necessary to create technical, economic and social projects, where everybody is allowed and supported to give their contribution.

EnginSoft is also that a place where it's possible to join training and technical project with an highly notable profile, where to contribute to meet customers' demand according their specific problems and where to reach and maintain projects' effectiveness and efficiency.

That's because I'm still here; that's what I have experimented and what I have been living since 1989 when I arrived on my own in the brand-new Padova office, and becoming the reference person, after 20 years, for 25 colleagues, grown in expertise and attention to the company objectives which we all share.

Considerable difficulties and alternative perspective have been also part of this long carrier, but my personal conviction and commitment in a stimulating and involving project have always prevailed.

I would like to close my reflection with a remark: we cannot forget our need for certainty and economic stability but we should engage ourselves in conciliating them with the enthusiasm and passion that urge towards renewal and participation.

We are bound to stay in between of fears and dreams. Need is a bad enemy that threatens our way and poisons our hopes. Let's pay attention not to create further useless complications. Above all, let's avoid lust for power which shatters enthusiasm, relationships and human ties.

Instead, let's remember that work combines the hardness of life and the hope of growing. In this way we will be able to embrace the real essence of the "project" that our work brings with it, whatever it may be.

era ben differente lo 'stato di innamoramento' per l'attuazione del loro sogno.

Quante volte ci si trova nelle stesse situazioni: superficialità, fretta, timore di farsi coinvolgere (sto scalpellando pietre), necessità e bisogno (mi guadagno il pane), entusiasmo e passione (sto costruendo).

Con riguardo al proprio lavoro, credo che la situazione che contribuisce a 'realizzare l'essere' sia proprio quest'ultima, quella dell'entusiasmo e del coinvolgimento, difficile da trovare e da concretizzare sempre, ma necessaria se s'intende costruire un progetto, anche sociale e non solo tecnico-economico, in cui ciascuno sia messo nella condizione di dare il proprio contributo.

EnginSoft è anche questo – se ci sono ancora lo debbo anche a questa esperienza 'progettuale' – è luogo in cui si può aderire a progetti di crescita in un contesto tecnico-formativo di assoluto rilievo, si può contribuire alla soluzione di problematiche proprie dei Clienti e al raggiungimento/mantenimento dell'efficacia e dell'efficienza di progetti operativi ai quali si lavora.

L'ho sperimentato e lo sperimento continuamente io, arrivato 'da solo', nel 1989, nella costituenda sede di Padova, e riferimento ora, dopo vent'anni nella stessa sede, di 25 colleghi, cresciuti in competenza, disponibilità, attenzione agli obiettivi aziendali che diventano, alla fine, obiettivi condivisibili da tutti.

Le difficoltà, anche significative (e prospettive alternative), in vent'anni d'azienda si trovano – e ci sono state – ma la personale convinzione di essere partecipe di un progetto che coinvolge ed emoziona ha sempre avuto il sopravvento.

Concludo osservando che, essendo obbligati a guardare, gioco-forza, alle nostre necessità di sicurezza e di stabilità anche economica, dovremmo cercare di conciliarle, per quanto possibile, con i sentimenti che ci spingono verso obiettivi di crescita, di rinnovamento, di partecipazione.

Ciò non è facile, ci troviamo spesso combattuti tra paure ed esigenze che ci opprimono e sogni che ci attirano: è inevitabile.

C'è un nemico che minaccia il nostro cammino e avvelena i pozzi della speranza: è il bisogno. Facciamo attenzione a non crearcene di inutili, soprattutto stiamo lontani da quello del potere che distrugge gli entusiasmi, le relazioni, i legami umani.

Ricordiamoci, invece, che il lavoro fonde sempre insieme fatica di vivere e speranza di crescere. Probabilmente sapremo abbracciare allora, con rinnovato entusiasmo, il progetto del 'costruire' che il nostro lavoro, qualunque esso sia, porta con sé.

Department of Mechanical Engineering Sidebar. Clemson University

The mechanical engineering department at Clemson University is recognized internationally for its excellence in engineering education and scholarship. It is a significant source of engineering graduates for the nation. Faculty members are proud of their contributions to the development of knowledge and educational innovations in mechanical engineering and are a dedicated group of



engineering professionals. The department remains committed to continued improvement in the educational process, excellence in engineering research and service to society. Within the department, there is a balance between the Clemson tradition of excellence, with a spirit of entrepreneurship in both education and research. Funded research activities maintain Clemson mechanical engineering at the cutting edge in various fields including automotive engineering, mechanical and manufacturing systems, engineering mechanics, and thermal/fluid sciences.

Clemson University offers fully accredited academic programs leading to Bachelor of Science (B.S.), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) in mechanical engineering and M.S. and Ph.D. in automotive engineering. Graduates of these programs are highly marketable. Students are prepared to become technical leaders who can function as valuable, productive and responsible members of society. Graduate research programs span a broad and diverse range of topics.

The mechanical engineering department <http://www.clemson.edu/ces/departments/me/> is made up of 34 tenured/tenure track faculty, 3 emeritus faculty, and 5 visiting faculty. The department has 483 (sophomore through senior year) undergraduate students, 204 graduate students, and 12 technical and administrative support staff. In a typical year, 150 B.S., 39 M.S., and 7 Ph.D. engineering degrees are awarded.

Research in the department of mechanical is distributed across nine major research disciplines: automotive engineering; bioengineering and biomaterials; design, dynamics and controls; fluid mechanics; materials and materials processing; manufacturing; solid mechanics; and energy, heat transfer and combustion. The Clemson University International Center for Automotive Research (CU-ICAR) is a 250-acre advanced-technology research campus located in Greenville, S.C., where academia, industry and government organizations collaborate to fill the gap between basic research and commercial application of

automotive technologies. Located on the I-85 corridor between Atlanta and Charlotte, CU-ICAR is in the center of the Southeastern automotive and motorsports economy. With more than \$220 million in commitments from the state of South Carolina and private industry partners such as BMW, Michelin, Timken and others, it is the ultimate in public/private partnership.

<http://www.clemson.edu/centers-institutes/cu-icar/>



The campus houses the Carroll A. Campbell Jr. Graduate Engineering Center, a combination of contemporary architecture, state-of-the-art facilities and staff, faculty and students who are leaders in innovative research. The master's and doctoral programs in automotive engineering focus on systems integration, design and development, manufacturing and vehicle electronics systems. The vision is to bring people from diverse technical backgrounds together to encourage collaboration to solve some of the toughest challenges facing the automotive industry today.



The Campbell Center at CU-ICAR offers cutting-edge laboratory and test cell facilities for private clients and partners as well as for academic research. Four endowed chairs, world-class faculty members who have been recruited to lead key research areas, steer the academic program. They are Paul Venhovens, Ph.D. (Mechanical Engineering) BMW Endowed Chair in Systems Integration; Thomas Kurfess, Ph.D. (Mechanical Engineering) BMW Endowed Chair in Automotive Manufacturing; Todd

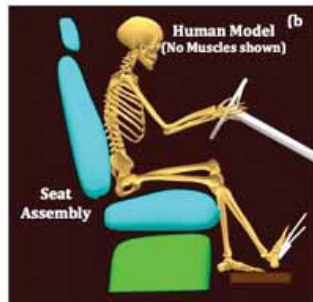
Hubing, Ph.D. (Electrical and Computer Engineering); Michelin Endowed Chair in Vehicular Electronic Systems; and John Ziegert, Ph.D. (Mechanical Engineering); Timken Endowed Chair in Automotive Design and Development.

For more information, please contact Susan Polowczuk, spolowc@clemson.edu and visit: www.clemson.edu/ces/departments/me/

Ozen Engineering Inc. donates human body-modeling software to Clemson

CLEMSON – A gift from California-based Ozen Engineering Inc. to Clemson University is enabling researchers to create detailed computer models of the human body, which can be used to explore a variety of issues, from improving hip replacements to making more comfortable car seating.

Ozen Engineering Inc. has donated a package of software, training and support to researchers in Clemson's department of mechanical engineering. The AnyBody Modeling System allows researchers to create computer models of the human musculoskeletal system that measures internal body forces during daily activities, such as walking, running, standing and sitting. The donation also includes Any2Ans, a software developed by Ozen Engineering Inc. that enables results from the AnyBody System to be streamlined into ANSYS, which can evaluate the stresses and strains on bones and joints during activities.



The software assists research into seating comfort and fatigue, such as long-distance driving fatigue

Mica Grujicic, the Wilfred P. and Helen S. Tiencken Professor of Mechanical Engineering at Clemson, is working with researchers at Ozen to use the software to develop computer-aided tools for the prediction and assessment of the performance and longevity of various implants, such as hip replacements.

"These tools can be used to complement pre-clinical implant evaluation tests so we can determine realistic loading conditions associated with active daily living, conditions that are not generally covered in laboratory pre-clinical evaluation tests," Grujicic said.

Grujicic is also using the software to research seating comfort and fatigue, such as long-distance driving fatigue. This research can be used to design home and office chairs, wheel chairs and car seating for improved comfort and ergonomic quality.

"Currently the development of new, more-comfortable seats is based almost entirely on legacy knowledge and extensive, time-consuming and costly prototyping and experimental/field testing," said Grujicic. "This should speed things up considerably."

Ozen Engineering Inc. works with companies worldwide to optimize product design performance and improve product development processes through simulation and realistic computer modeling. In 2008, Ozen Engineering Inc. became a partner company of the Clemson University International Center for Automotive Research.

"Ozen Engineering Inc. is committed to supporting cutting edge research with industry-leading technologies," said David Wagner, project manager for Ozen Engineering Inc. "We hope this donation will continue to develop the already exemplary capabilities demonstrated by Clemson faculty and researchers."



Ozen Engineering Inc. donated software, training and support that allows researchers to create computer models of the human musculoskeletal system to measure internal body forces during daily activity



The finite element and simulation sector mourns one of its founders, O.C. "Olek" Zienkiewicz.

El sector de los elementos finitos aflige a unos de sus fundadores, el Dr. O.C "Olek" Zienkiewicz.

Olek Zienkiewicz was born in Caterham (England) in 1921 but the very next year the family immigrated to Poland, the country of his father's birth. He excelled in his schooling and university studies which were interrupted by the invasion of Warsaw near the beginning of the Second World War. Days later the family left for Italy, then moved onto France, finally arriving about a year later in England.

Olek finished his university degree at Imperial College of London obtaining his Ph.D in 1945. He worked for some years as an engineer and in 1948 became a professor at the University of Edinburg in Scotland. There he met Helen whom he married in 1952. He then worked for some years at Northwestern University in the United States before taking a position at the University of Swansea in Wales in 1961 where he worked until his retirement in 1988.

Prof. Olek Zienkiewicz became internationally recognized as one of the founders of the methodology of finite elements (FEM). He started research work in the area in 1961 just after the term "finite element" was coined by Ray W. Clough in 1960 when the method was used basically for structural calculations. But Olek was the first who saw its full potential and used it for non-structural applications such as groundwater flow, heat transfer, dynamics, geotechnical engineering, etc.

He gained a great reputation, generating an enormous number of publications, was awarded with some 30 Honorary Doctorates in many countries including China, USA and Germany and was finally appointed a CBE by the Queen of England.

Olek, also known to many as the "father of finite elements", was famous for his book called "The Finite



Olek Zienkiewicz nació en 1921, en Caterham (Inglaterra) pero emigró al año siguiente a Polonia, el país de su padre. Fue un gran estudiante, a pesar de que sus estudios universitarios se vieron interrumpidos por la invasión de Varsovia durante la II Guerra Mundial. Tras el acontecimiento, la familia partió de Varsovia a Italia luego a Francia y casi un año después llegó a Inglaterra para instalarse.

Olek, terminó su carrera de ingeniería en el Imperial College de Londres doctorándose en 1945. Trabajó unos años como ingeniero y en 1948 como profesor de la Universidad de Edinburgo (Escocia), donde conoció a Helen con la que se casaría en 1952. Luego, trabajó en la Universidad de Northwestern, EEUU, y más tarde en la Universidad de Swansea donde ejerció desde 1961 hasta su jubilación.

El doctor Olek Zienkiewicz fue reconocido internacionalmente como uno de los fundadores de la metodología de los elementos finitos (MEF). Empezó su investigación en 1961, justo después de que el término "elemento finito" fuera introducido por Ray W. Clough en el año 1960. Este método era usado básicamente en cálculos estructurales, mientras que Olek fue pionero en utilizarlo en aplicaciones no-estructurales como flujo de fluidos, transmisión de calor, dinámica, ingeniería de geotécnica, etc.

Tras muchas publicaciones alcanzó una gran reputación, hasta el punto de serle otorgados 30 doctorados Honoris Causa en varios países incluyendo China, EEUU o Alemania, e incluso la Reina de Inglaterra le condecoró con el CBE.

"El padre de los elementos finitos" como era conocido por mucha gente, fue y será famoso por su libro "The Finite Element Method" escrito en 1967. Explicó de una manera



Element Method", written in 1967. The text explained the method in a very practical manner and became known as "the book", being published in many languages and terminating in the final sixth edition. Much of the writing for the subsequent versions took place in the small town of Sitges, the town near Barcelona where Aperio Technology is sited, together with Bob Taylor (Professor of the University of California at Berkeley).

After Olek's retirement, he continued collaborating with many universities, one of these being the Technical University of Catalonia (UPC) in Barcelona. It was during his stays here that he installed himself in Sitges and we renewed our friendship after first meeting while I worked at the University of Swansea 10 years previously. During his annual stays in Sitges we met frequently and enjoyed many discussions on the new advances in FEM, related technologies and the future of these methods, on many occasions together with the fantastic knowledge and vision of Bob Taylor.

The finite element analysis and simulation sector mourns the loss of one of its founders and eternal ambassadors, an adventurous person of high intellect, always ready to learn new things and continually in search for new experiences and novelties.

From Aperio Tecnología en Ingeniería we express our enormous respect and gratitude to Prof. Olek Zienkiewicz.

Dr. Gino Duffett
Director of APERIO Tecnología

muy didáctica toda la metodología de los elementos finitos, la obra es conocida como "El Libro" y se publica en varios idiomas, yendo ya por la sexta edición. Con mucho orgullo para nosotros, llevó a cabo el trabajo de varias versiones de "El Libro", junto a Bob Taylor (profesor de la Universidad de California en Berkley), en Sitges la localidad barcelonesa donde se halla la sede de Aperio Tecnología.

Después de su jubilación, colaboró con varias universidades entre ellas la Universidad Politécnica de Catalunya en Barcelona. Durante sus estancias, permanecía en Sitges y fue entonces cuando coincidimos de nuevo tras habernos conocido 10 años antes cuando trabajé en la Universidad de Swansea. Durante esas estancias en Sitges discutimos mucho sobre los nuevos avances con los elementos finitos, tecnologías relacionadas y el futuro de esta metodología, en varias ocasiones, conjuntamente, con el buen conocimiento y visión de Bob Taylor.

Todo el sector de elementos finitos y simulación lamenta la pérdida de un fundador y eterno embajador del MEF, una persona aventurada e intelectualmente rica, ansioso por aprender y siempre en busca de novedades y nuevas experiencias.

Desde Aperio Tecnología en Ingeniería expresamos nuestro respeto y agradecimiento al Prof. Olek Zienkiewicz.

Dr. Gino Duffett
Director de APERIO Tecnología

EnginSoft Germany welcomes Dr. Hans-Uwe Berger to its Technical Sales Team



Dr. Hans-Uwe Berger
Ph.D. (University of Canterbury, NZ)
Dipl.-Ing. (Technical University of Darmstadt, DE)

Dr. Hans-Uwe Berger joined the EnginSoft Team in Frankfurt in July 2009 and will from now on support our clients and prospects in Germany, Switzerland and Austria in all questions pertaining to optimization with modeFRONTIER as well as process simulation including the areas of casting, forging and machining and, hence, the optimization of the design chain in general.

Hans-Uwe has a degree in mechanical engineering from Darmstadt University of Technology where his studies focused primarily on dynamics and numerical mathematics.

Further achievements in his academic career include a PhD from the University of Canterbury, New Zealand, where he acquired in-depth knowledge of numerical analyses in structural mechanics (FEM, BEM) and numerical optimization.

Hans-Uwe's experience abroad includes an internship in New Zealand and engagements as a visiting researcher (New Zealand Postgraduate Study Abroad Award) at the State University of New York (SUNY) at Buffalo. Furthermore, Hans-Uwe supported University of Christchurch as temporary teaching staff.

Given his academic career, his technical and international background, Dr. Hans-Uwe Berger will enhance and diversify the expertise of EnginSoft in Germany and thus help to perfect the response to our customers and the wide range of services we provide in the German-speaking market.

Third International Conference on Multidisciplinary Design Optimization and Applications



Multidisciplinary Design Optimization - MDO - deals with the optimal design of structural elements or systems employed in several engineering fields such as the aerospace industry, where reducing the structural weight is one of the most important tasks.

21-23 June 2010, Paris, France
Co-sponsored by ISSMO, ESTP, EnginSoft, and NAFEMS

Nowadays, use of Structural Optimization is rapidly growing in automotive, aeronautical, mechanical, civil, nuclear, naval, and off-shore engineering. This is due to the increase of technological competition and the development of strong and efficient techniques for several practical applications.

The increase of speed and capacity of computers allows large-scale structures and systems to be optimized. The main scientific challenges of MDO are concerned with the development of strong and efficient numerical techniques and with the computational procedures required for the necessary coupling of software systems.

The efficiency of the optimal result depends on the efficiency of the simulation and the modelling process.

ASMDO 2010 will bring together scientists and practitioners working in different areas of engineering optimization!

To submit your abstract and for more information, please visit:
www.asmdo.com

EnginSoft France – Official Sponsor of Virtual PLM'09

Les Ateliers de l'Ingénierie Numérique et du Travail Collaboratif –Exhibition - Conferences - Workshops on Numerical and Collaborative Engineering. 30 September - 1 October 2009, Charleville-Mézières, l'Institut de Formation Technique Supérieure

EnginSoft France is pleased to announce its presence at one of France's most innovative platforms for numerical engineering: Virtual PLM'09. The numerical design chain experiences a growing interest from small and medium-sized businesses who nowadays can choose from a growing number of different design tools whose implementations may provide significant advantages, but at the same time, highlight limitations in methodologies and technologies. Today, material and software performances provide promising opportunities to test different solutions simultaneously and to consider trials which may not interfere with an existing corporate structure and hence, may be implemented in a more efficient and faster way.

Virtual PLM'09 is organized and hosted by MICADO, an association which fosters and promotes the use of computer technologies for PLM and industrial design processes including CAD CAM, fast prototyping, technical knowledge management, virtual prototyping etc. In challenging times like now, numerical simulation plays a key role as it provides savings in costs and resources while speeding up design and development processes.

Marie Christine Oghly, President of
EnginSoft France, President of
Micado and Vice President of



the "Atelier de simulation numérique de Micado" explains Micado's mission and primary objectives as follows:

- to provide a wide range of competencies
 - to convert experiences into successes in the field of Numerical Simulation
 - to exchange concepts and solutions among its expert network
 - to evaluate and promote the advancements of Laboratories and Universities
 - to collaborate with experts to discuss essential user aspects
- "Virtual PLM'09 is one of the most important gatherings in France for experts from various industrial sectors, research and education who wish to exchange and expand their knowledge in all areas of numerical simulation.

The 2 days will see software and hardware demonstrations in the exhibition. Conference Sessions and Workshops will focus on Design, Simulation, Prototyping, Rapid Prototyping and Collaborative Engineering.

EnginSoft contributes with an expert presentation on the use of modeFRONTIER, the preferred tool for multi-objective optimization and process integration in the French-speaking market, and is looking forward to welcoming delegates at the EnginSoft stand in the exhibition !" – emphasized Marie Christine Oghly. To make an appointment in advance, please contact Marjorie Sexto: info@enginsoft.com

For more information on Virtual PLM'09, please visit:
<http://vplm09.virtual-plm.com>



EnginSoft Event Calendar

ITALY

14-16 October – 3rd European Comsol Conference 2009
Leonardo da Vinci Hotel - Convention Center, Milan
EnginSoft Nordic presenting: Multi-Objective Optimization of a Ball Grid Array Using modeFRONTIER and COMSOL Multiphysics
<http://www.comsol.com/conference2009/europe/>

29-30 October - Aerospace&Defense Meeting 2009, Torino.
EnginSoft will be present with a booth.
<http://www.aerospacemeetings.com/>

27-28 May 2010 - International modeFRONTIER Users' Meeting 2010. Starhotel Savoia Excelsior Palace, Trieste.
Learn how modeFRONTIER is used globally in many industries to better understand product development processes, and achieve higher quality at reduced cost! www.esteco.com

FRANCE

EnginSoft France 2009 Journées porte ouverte
Dans nos locaux à Paris et dans d'autres villes de France et de Belgique, en collaboration avec nos partenaires.
Prochaine événement: Journées de présentation modeFRONTIER 4.1. Veuillez contacter Marjorie Sexto, info@enginsoft.com, pour plus d'information

30 September – 1 October - Virtual PLM 09 organised by MICADO. Pôle de haute technologie de Charleville-Mézières
Le programme prévoit des conférences, des workshops et un espace de démonstrations. The Program will feature a presentation on modeFRONTIER - Don't miss the opportunity to meet the EnginSoft France management and technical experts at our booth in the exhibition!
<http://vplm09.virtual-plm.com>

21 - 23 October - DIGIMAT Users Meeting 2009 - The Material Modeling Conference. Sheraton Elysee Hotel, Nice. Visit the EnginSoft Booth and talk to our experts.
<http://www.e-xstream.com/en/digimat-users-meeting-2009>

29 October – Séminaire Simulation de Process et Optimisation. EnginSoft France Boulogne Billancourt – Paris
A Seminar hosted by EnginSoft France and EnginSoft Italy
www.enginsoft-fr.com

02-03 December – International Conference "The spark ignition engine of the future". Strasbourg – INSA. Arnaud Bussière, EnginSoft France, presenting "Robust Optimization of a high pressure pump flowrate". www.sia.fr
Veuillez contacter Marjorie Sexto, info@enginsoft.com, pour plus d'information

21-23 June – ASMDO 2010 3rd International Conference on Multidisciplinary Design Optimization and Applications - Co-sponsored by ISSMO, ESTP, EnginSoft, and NAFEMS
Paris. ASMDO 2010 will bring together scientists and practitioners working in different areas of engineering optimization! www.asmdo.com

GERMANY

22 September - Seminar Process Product Integration
EnginSoft GmbH, Frankfurt Office
How to innovate and improve your production processes !
A Seminar hosted by EnginSoft Germany and EnginSoft Italy.
For more information, please contact:
info@enginsoft.com
Stay tuned to www.enginsoft-de.com

modeFRONTIER Seminars 2009. EnginSoft GmbH, Frankfurt am Main

- 13 October
- 27 October
- 17 November
- 8 December

For more information, please contact:
info@enginsoft.com
Stay tuned to www.enginsoft-de.com

18-20 November – ANSYS Conference & 27th CADFEM Users' Meeting. Congress Center Leipzig. EnginSoft will be presenting "Validation of Material Models for the Numerical Simulation of Aluminium Foams" on 19th November and welcomes Conference attendees at the EnginSoft Booth.
Please stay tuned to: www.usersmeeting.com

UK

modeFRONTIER Workshops at Warwick Digital Lab on:
20 October - 17 November - 09 December

Technical Seminar on Optimization
Warwick Digital Lab - Dates will be announced shortly -
To register or to express your interest for the above events, please visit: www.enginsoft-uk.com
or contact: info@enginsoft.com

11-13 November - WaPUG Autumn Meeting & Conference
Blackpool. EnginSoft UK presenting their case-study for the Water industry. <http://www.ciwem.org/groups/wapug>

SPAIN

07-09 October - COMATCOMP 2009: V International Conference on Science and Technology of Composite Materials y el 8° Congreso Nacional de Materiales Compuestos San Sebastian. A congress organized by AEMAC (Asociación



Española de Materiales Compuestos) in collaboration with the University of the Basque Country (UPV/EHU) under the auspices of the University of Buenos Aires (UBA, Argentina) and the University of Perugia (UNIPG, Italy).

APERIO Tecnología will present the software ESAComp+ComPolyX at a stand during the congress. <http://www.comatcomp.com>

14-15 October - 1st International Roll Forming Congress Bilbao. Gino Duffett of APERIO Tecnología will present a paper titled "Simulating the Complete Forming Sequence for a Roll Formed Automotive Component Using LS-DYNA" that was written together with Trevor Dutton and Paul Richardson of Dutton Simulation Ltd (England).

www.labein.es/rollform. For more information, please email: g.duffett@aperiotec.es

SWEDEN

EnginSoft Nordic AB have scheduled the next Training Courses: Venue: IDEON Science Park Lund and other 08-09 October 2009. Introduction to modeFRONTIER 24-25 September 2009. Advanced Topics in modeFRONTIER 15th October 2009. Robust Design with modeFRONTIER For further information, please contact Adam: adam.thorp@esteconordic.se

TURKEY

5-6 November - 14th Conference for Computer-Aided Engineering and System Modeling METU Middle East Technical University, Ankara. EnginSoft's presentation will focus on Satellite Technologies – We welcome the audience of this leading CAE event in the Middle East to visit us at the EnginSoft booth in the exhibition! www.figes.com.tr/conference/2009/

USA

25 September, 9:00am PDT, Technical Webinar - BGA Design Optimization using modeFRONTIER Join this webinar and hear experts from OZEN Engineering about BGA Design Optimization using modeFRONTIER Stay tuned to our partner's website for the next events in the USA: www.ozeninc.com

AUSTRALIA

24 November - 2009 Australasian MADYMO Users Meeting The Hotel Charsfield, 478 St Kilda Rd, Melbourne. Meet Ryan Adams of ADVEA Engineering to hear more about modeFRONTIER in Australia! Please contact Ryan at radams@advea.com, for further information. www.advea.com

EUROPE, VARIOUS LOCATIONS

modeFRONTIER Academic Training Please note: These Courses are for Academic users only. The Courses provide Academic Specialists with the fastest route to being fully proficient and productive in the use of

modeFRONTIER for their research activities. The courses combine modeFRONTIER Fundamentals and Advanced Optimization Techniques.

For more information, please contact Rita Podzuna, info@enginsoft.it

To meet with EnginSoft at the above events, please contact us: info@enginsoft.com



European Society of Biomechanics

Call for Abstracts

17th Congress of the European Society of Biomechanics
Edinburgh, Scotland, UK, July 5th – July 8th, 2010

The European Society of Biomechanics cordially invites you to attend the 17th European Society of Biomechanics (ESB) conference in the beautiful, historic city of Edinburgh. The meeting will cover the ESB's traditional core topics while including emerging research areas in which much new and exciting biomechanics research is taking place.

Abstract submission: Abstracts can be submitted for either oral or poster presentation through the online system www.esbiomech2010.org.

14th. Conference for Computer Aided Engineering and System Modeling

Innovation, Design, Engineering

The Conference Theme: Aerospace and Defense Applications focusing on Satellite Technologies

14th ANSYS Users' Meeting
6th MATLAB & Simulink Users' Meeting

FIGES is honored to host the 14th Conference for Computer Aided Engineering and System Modeling at the Cultural and Convention Center of METU (Middle East Technical University), Ankara - Turkey on 05-06 November 2009.

For more information, also on the exhibition/sponsorship opportunities, and to view the Conference Program, visit: <http://www.figes.com.tr/conference/2009/>



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richiedono elaborazioni
sempre più veloci.



E4 Computer Engineering si propone come una realtà italiana di eccellenza nell'integrazione di soluzioni dedicate al calcolo ad alte prestazioni (HPC); l'offerta di E4 si basa su un'estesa gamma di prodotti: workstation grafiche, server, storage, SAN, fino ai sistemi cluster "chiavi in mano" di grandi dimensioni, tutti progettati in base alle esigenze del cliente e testati secondo rigorose procedure per offrire soluzioni scalabili ed affidabili nel tempo garantendo il ritorno degli investimenti sull'hardware.

E4 Computer Engineering excels at integrating solutions for the High Performance Computing (HPC); E4's range includes a broad selection of products: from computer graphics Workstations, to server, storage, SAN, up to powerful custom built cluster systems, each one of them designed following the client's requirements and tested according to strict procedures, in order to provide scalable solutions which are reliable even as time goes by and guarantee a profitable return on hardware investments.

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