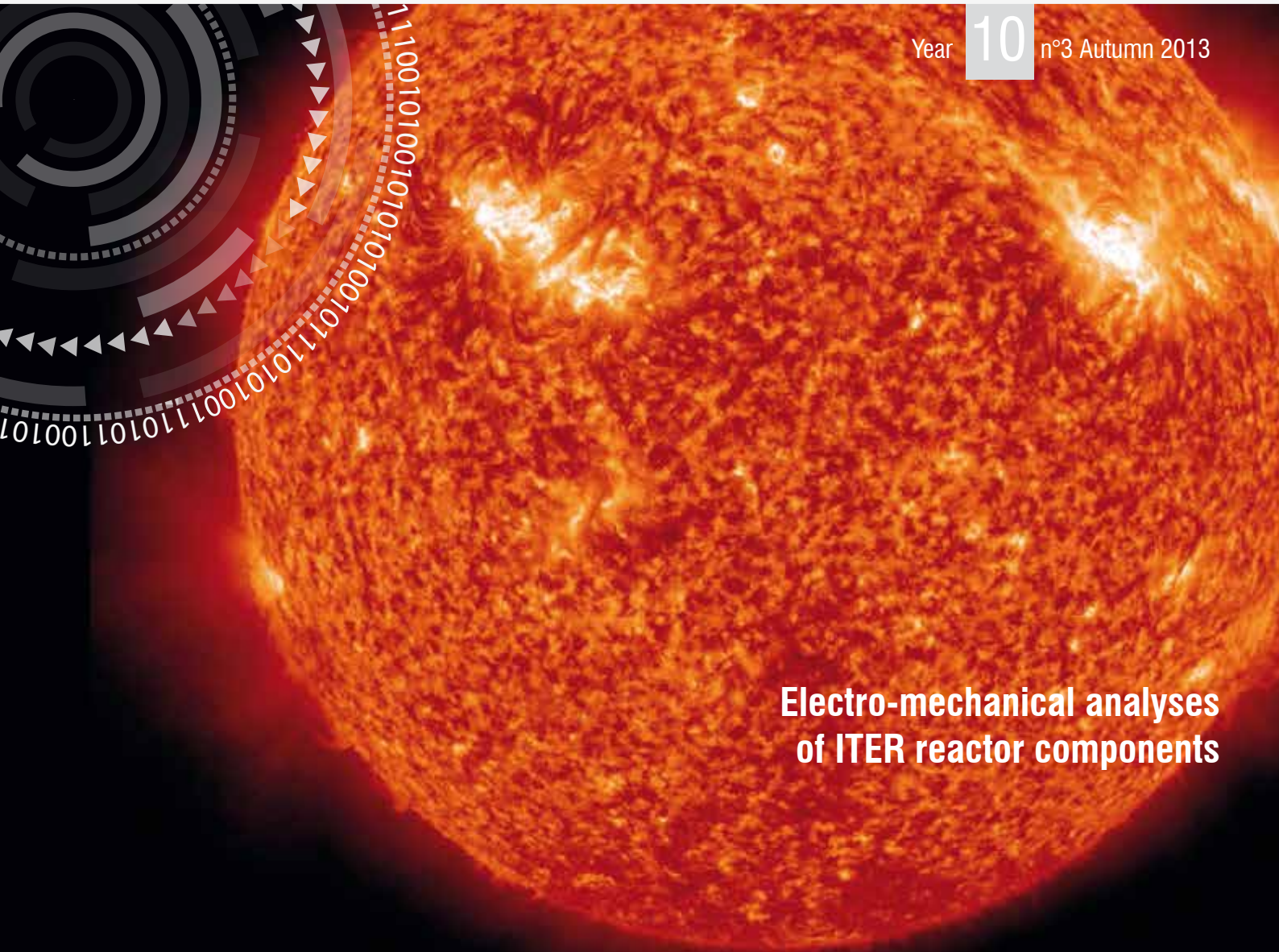




Newsletter

Simulation Based Engineering & Sciences

Year **10** n°3 Autumn 2013

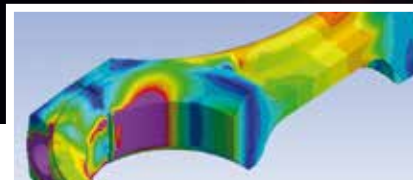


**Electro-mechanical analyses
of ITER reactor components**



Improved Reliability and
Reduced Costs of **Rail
Brakes** Thanks to Simulation

Numerical Models for
Aimable Warhead



Robust Design Optimization
of High Pressure Die Casting
to Produce **Piston Rods**

Process oriented **cooling
optimization** using modeFRONTIER



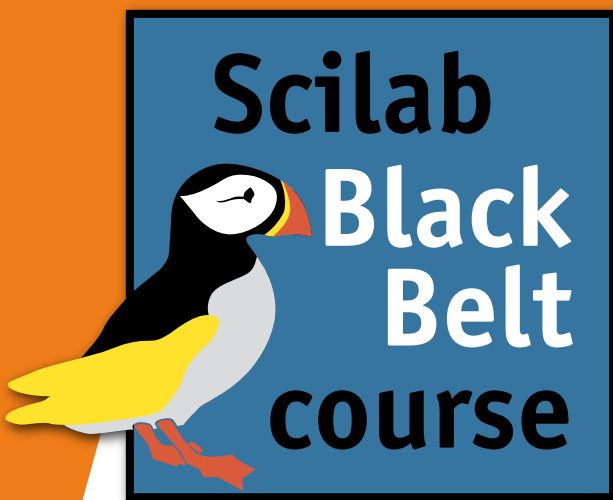
Optimizing clean energy:
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FLASH

By nature, engineers are drivers of new inventions. They are at the forefront of protecting our planet and lives. At the same time, they drive progress in technology and science and enable the transfer of advancements to industrial applications. We believe in creating sustainable solutions for people, for industry, for our environment. An understanding of diversity is key to many aspects of life.

These thoughts have also guided our work for the Newsletter. The year 2013 marks the 10th anniversary of the EnginSoft Magazine. We are delighted to present this Fall Issue that gives a preview of the International CAE Conference which will be held on 21st & 22nd October in Pacengo del Garda (VR).

With the contributions on the following pages, we would like to encourage our readers to actively plan their time at the Conference. Remember that expertise of various domains of engineering simulation will be at your fingertips throughout the 2 days!

In this spirit, we look at the International Thermonuclear Experimental Reactor, a research and engineering project funded by the EU, India, Japan, China, Russia, South Korea and the USA. Poli SpA outlines the advantages of simulation for the design of rail brakes. Simmel Difesa used ANSYS for the AWARD research program whose main numerical results are summarized in this edition. We hear how robust design optimization has been applied for the production of piston rods by A.B.O.R., and how Bottero uses modeFRONTIER for process oriented cooling optimization.

Flowmaster and modeFRONTIER are often coupled to efficiently support hydraulic calculations and the optimization of water supply systems. Veolia Environmental Services and EnginSoft France bring us news on a Biogas collection system. Furthermore, we are updated on circular flange forging processes and on a high precision mobile and airborne survey.

Mr Sawada of Toyota Motor Corporation shares some of his views on process innovation while Prof. Nishinari and Prof. Bandini teach us about crowd dynamics and jamology.

Our software news feature ANSYS Transient Blade Row, ANSYS CFD Professional, aeroacoustic simulations in ANSYS CFD and ACT, an important pillar for the development of the ANSYS code. We introduce modeFRONTIER 4.5 and its many innovative capabilities.

Our article on Wing Box Technology Evaluation addresses the expanding aviation sector. The University of Trento outlines the strengths of Neurobox and its seamless integration for High Performance Computing.

EnginSoft has been appointed by the European Space Agency to coordinate a new strategic line of research as part of the Melissa Framework. We also hear about the SOL2HY2 and the RLW project, the latter supports an EU Partnership dedicated to the optimization of remote laser welding.

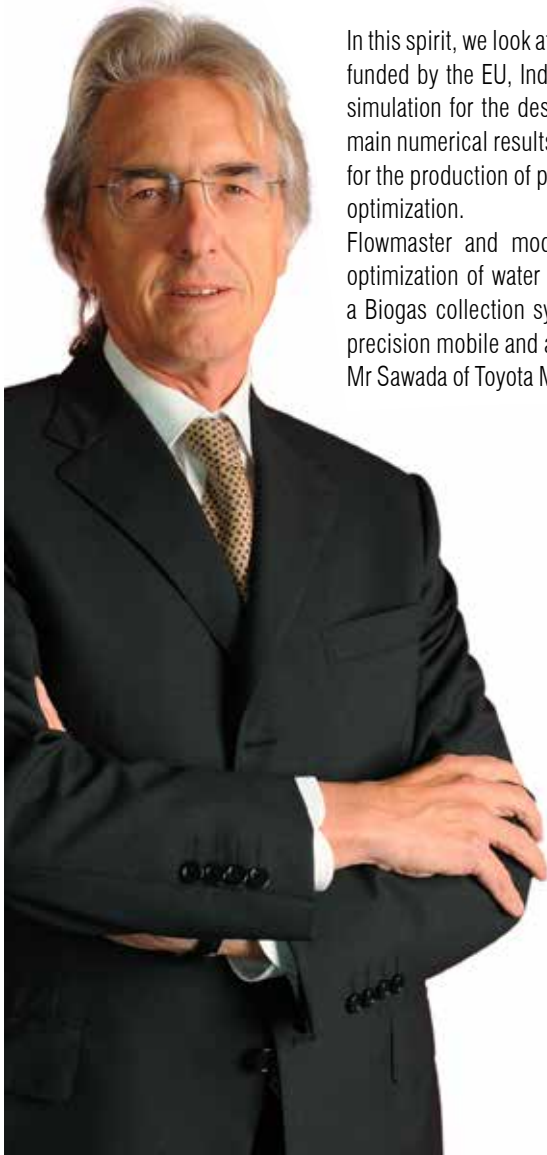
The 50th edition of the Paris Air Show saw EnginSoft as an exhibitor showcasing its capabilities and the synergy of its international team.

In this Newsletter, you will find advertisements and invitations from software and hardware vendors to visit their booth at the International CAE Conference.

A very warm Benvenuto awaits you in Pacengo del Garda. We look forward to welcoming you to a beautiful part of Italy - Let's simulate the world of the future!



Stefano Odorizzi
Editor in chief



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Electro-mechanical analysis of ITER reactor components

ITER (acronym of International Thermonuclear Experimental Reactor) is an international nuclear fusion research and engineering project, which is building the world's largest experimental Tokamak nuclear fusion reactor in the south of France. The ITER project aims to make the long-awaited transition from experimental studies of plasma physics to full-scale electricity-producing fusion power plants. The project is funded and run by seven members: the European Union (EU), India, Japan, China, Russia, South Korea and the United States.

The ITER fusion reactor has been designed to produce 500 megawatts of output power for 50 megawatts of input power, that is to say ten times the amount of energy put in.

The technical difficulties involved in the design and project of this machine are huge. Keep in mind that just few meters separate the 4 kelvin degrees of the superconductive coils cooling liquid and the 150 million degrees of the plasma where the fusion reaction takes place. Between these extreme spots the metallic surface of the reactor is exposed to a heating flux comparable to the one present on the solar surface: obviously the virtual simulation has a key role in the design and project phase of ITER reactor.

EnginSoft is committed to achieve verifications of ITER components

Fusion for Energy (F4E) committed EnginSoft to perform FEM calculations on ITER components. F4E is the European Union's Joint Undertaking for ITER and the Development of Fusion Energy and is responsible for providing Europe's contribution to ITER. In particular EnginSoft has dealt with electro-mechanical analysis of ITER reactor Blanket module number 1. In Figure 1 a cross section of ITER reactor is depicted.

Technical background

ITER is based on the 'Tokamak' concept of magnetic confinement, in which the plasma is contained in a doughnut-shaped vacuum



Fig. 1 - Cross section of ITER. It should be noted the dimension of the white dressed technician placed on the right with regard to ITER reactor

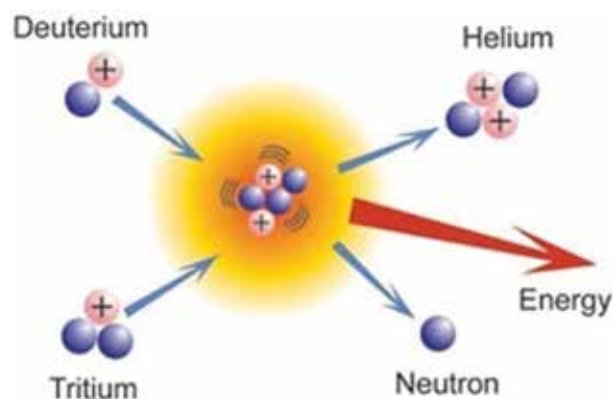


Fig. 2 - The fusion between deuterium and tritium (D-T)

vessel. The fuel, a mixture of deuterium and tritium, two isotopes of hydrogen, is heated to temperatures in excess of 150 million °C, forming a hot plasma. Inside the plasma the nuclear reaction takes place: due to the high kinetic energy the deuterium and tritium nuclei collide, fuse into heavier helium atoms and release tremendous amounts of energy in the process.

In the Figure 2 a simplified reaction scheme is depicted.

Strong magnetic fields are used to keep the plasma away from the walls; these are produced by superconducting coils surrounding the vessel, and by an electrical current driven through the plasma.

The main and inner region of ITER reactor is made by the following components:

- A Vacuum Vessel: an hermetically-sealed steel container inside the cryostat that houses the fusion reaction and acts as a first safety containment barrier.
- The Magnet System: it comprises 18 superconducting toroidal field and 6 poloidal field coils, a central solenoid, and a set of correction coils that magnetically confine, shape and control the plasma inside the vacuum vessel.
- The Divertor: Situated along the bottom of the vacuum vessel, its function is to extract heat and helium ash, both products of the fusion reactions acting like a giant exhaust system.
- The Blankets: they cover the interior surfaces of the vacuum vessel, providing shielding to the vessel and to the superconducting magnets from the heat and neutron fluxes of the fusion reaction.

In the Figure 3 these components are depicted. The ITER Blanket is one of the most critical and technically challenging components in ITER: together with the Divertor, it directly faces the hot plasma.

Aim of the activity

As mention in the previous section the reaction takes place in the hot plasma. For this reason the study and the comprehension of the plasma physics has a crucial role in the ITER targets project.

One of the most important issues concerning the plasma behavior is the plasma disruption phenomenon. A disruption is a violent event that terminates a magnetically confined plasma, usually the consequence of a rapidly growing instability. In a disruption, the

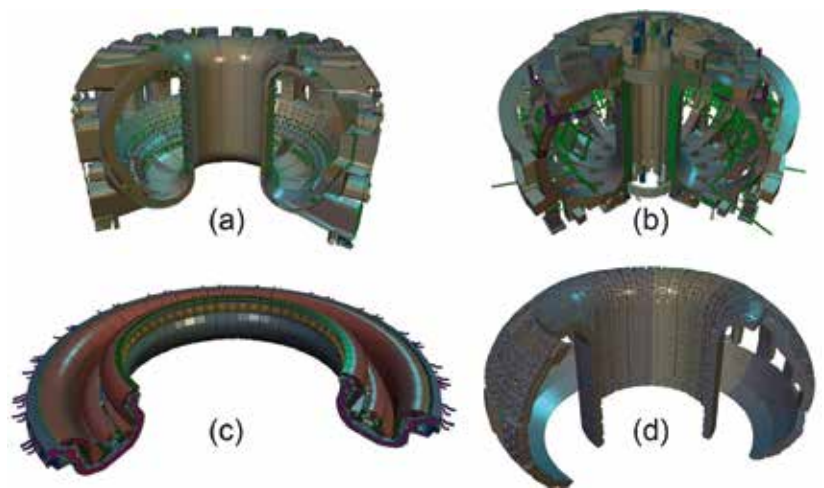


Fig. 3 - The main ITER components: The vacuum vessel (a), the Magnet system (b), the Divertor (c), the Blankets (d)



Fig. 4 – The geometrical model taken into account for the analysis.

temperature drops drastically and heat and particles are released from confinement on a short timescale and dumped on the vessel wall, causing damage in proportion to the stored energy.

Another magnetic effect of a disruption is the generation of large magnetic forces on the metallic structures surrounding the plasma. This phenomenon is associated to the sudden loss and displacement of the net plasma current that induces eddy current in the metallic structures. It's well known that the presence of eddy currents in a magnetic field generates magnetic force densities according to the Lorentz formula: $\mathbf{F} = \mathbf{J} \times \mathbf{B}$

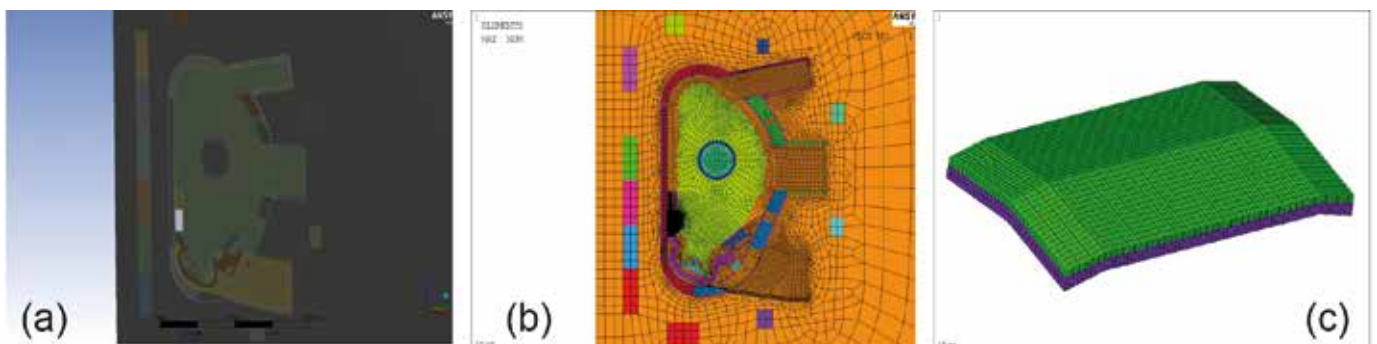


Fig. 5 – Simplified model (a), mesh model details (b), Front wall mesh model details (c)

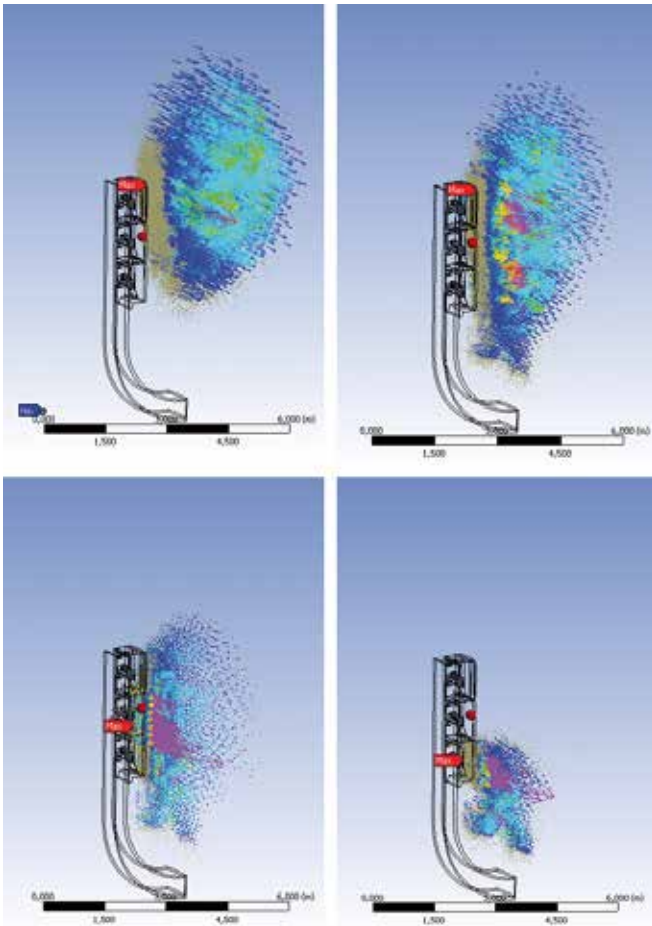


Fig. 6 - Plasma current density at different times during plasma disruption phenomenon.

EnginSoft calculated the time-history signal of torques and net forces on Blanket module 1 during a plasma disruption event. In the present document is taken into account just the poloidal field variation due to the plasma current movement and quench.

Analysis details

F4E provides the geometry and the plasma disruption phenomenon to analyze. The plasma disruption is provided by the dislocation and amplitude of current filaments in a poloidal section of the plasma region versus time.

Due to geometry and load symmetry ten degree of the whole structure is analyzed. In the Figure 4 this geometry is depicted.

The electro-mechanical calculation is performed in ANSYS EMAG environment. A complete HEXA mesh is required.

Since to perform an electromagnetic analysis both conductive and non-conductive regions have to be modeled the difficulties in achieving the mesh model are remarkable.

The geometry model is simplified in ANSYS Design Modeler and the mesh is achieved in ANSYS EMAG.

In the Figure 5 the simplified geometry and the mesh model is depicted. Remarkable is the

mesh achieved to model the front wall of Blanket module 1. The front wall is the Blanket geometry directly exposed to the plasma region. This shield is made of high-strength copper and stainless steel and it's crossed by two rows of cooling piping.

The Plasma disruption is depicted in Figure 6. In different plots the plasma current density is shown during the disruption phenomenon.

The variation of the magnetic induction field leads to the birth of eddy currents in the metallic components of ITER reactor. In Figure 7 the eddy currents on the front wall of Blanket 1 module are depicted.

Conclusions

The calculation of time-history signal of torques and net forces on Blanket module 1, due to a plasma disruption event, has been achieved. The output forces along with the procedures built to calculate them have been validated by F4E.

Due to the achievement of analysis targets, EnginSoft has shown to be a valued partner to perform electromagnetic analysis on ITER reactor components.

Acknowledgment

The activity has been fund by F4E with contract: 1205922.

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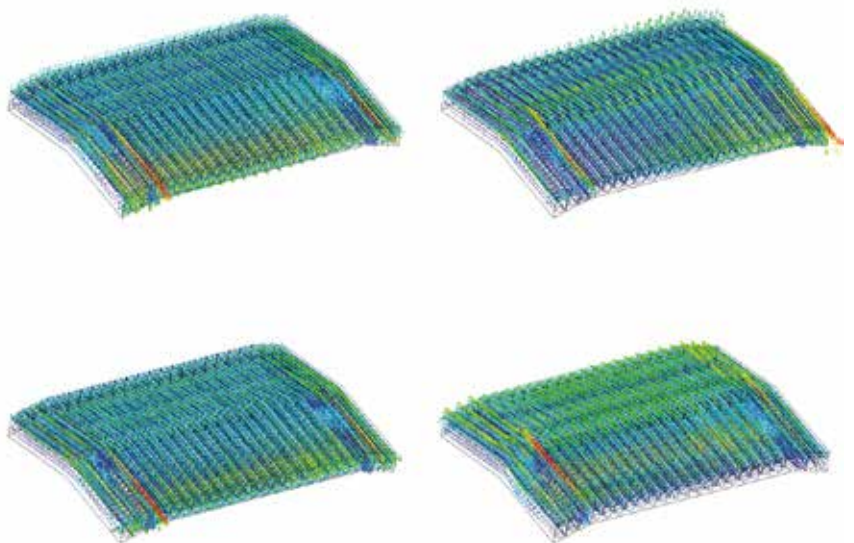


Fig. 7 - Induced currents on front wall Blanket 1 at different time instants during plasma

POLI SpA: Improved Reliability and Reduced Costs of Rail Brakes Thanks to Simulation



Fig. 1 - POLI SpA test bench can simulate any braking condition up to a speed of 450km/h

With 50-years' experience in the railway sector, POLI SpA designs, manufactures and supplies complete brake systems for all types of railway vehicles. Several patents have been registered by POLI SpA thanks to its R&D department, that is specially focused on safety and reliability of brake systems. In addition to this, in recent years weight and cost have become increasingly important factors to deliver efficient and competitive products to the market. Design and innovation at POLI SpA have been strictly connected to the use of ANSYS simulation tools since 2010, when the R&D center started developing Finite Element models to evaluate the thermal and mechanical behavior of brake systems with the support of EnginSoft. Since then a methodology based on ANSYS Mechanical and ANSYS Fatigue has been developed and validated to simulate real track-charts covered by any type of vehicle.

The FE methodology has been developed in agreement with the European standards and with the FKM Guidelines and it has been validated at the POLI R&D center, that is equipped with the most up-to-date dynamometer to test brake discs and friction pads and to simulate braking applications in any load condition up to a speed of 450 km/h. Thermal loads due to friction between pads and disc, together with centrifugal forces and shocks loads, are of paramount importance when evaluating stress and fatigue on brake systems. In particular disc design is mainly driven by the fact that energy dissipation during braking produces high temperature values and gradients, that in turn produce high thermal loads.

With the aim of increasing the accuracy of stress and life predictions and to improve the discs design, in 2012 ANSYS CFD was added to the simulation procedures. The focus of thermo-fluid-dynamics for brake applications is to calculate the heat transfer between the friction pads and the disc, including also the effects of the air flow and of the

disc rotation, aspects that become important above all for high speed cases.

The first CFD application concerned two types of discs, one with internal

blades and the other one with internal pins used to increase heat exchange between disc and air. The advantage of the second solution is a reduced manufacturing cost. The aim of the CFD study was twofold: on one hand the two discs had to be compared in terms of maximum temperature values and gradients, to evaluate if the solution with pins was critical from the thermal point of view; on the other hand the heat transfer coefficients between air and disc could be transferred from the CFD results to the FE models to calculate in a more accurate way the thermal loads and stress in real track-charts. This second point was

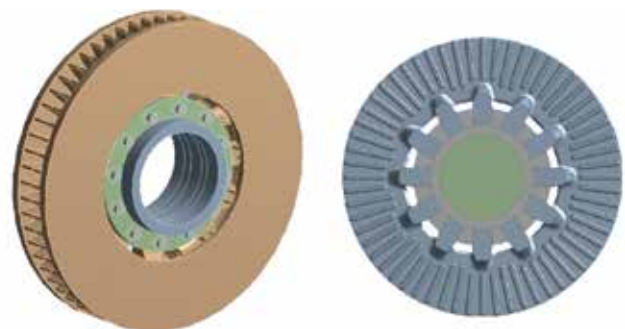


Fig. 2 - railway disc brake with internal blades

a real improvement of the methodology applied by POLI. In fact, before the CFD study, heat transfer coefficients were estimated using formulas from literature and were applied to the FE models.

The CFD geometry reproduced the POLI's test bench with the disc, the friction pad, the shaft and the hub. Particular attention was paid to the geometrical definition of different parts of the system, including contacts between different solid materials. This is essential to appropriately calculate the temperature gradients between disc, hub and bolts.

Three simulations were carried out for each disc, with blades and with pins, considering three different vehicle speeds, 30km/h, 80km/h and 160km/h. Each speed condition corresponds to a different amount of energy that has to be dissipated during "containment braking", that is what happens when a train has to keep a constant speed on a downhill track.

The temperature values calculated by CFD were compared to the available data from the POLI's lab. The delta between numerical and experimental

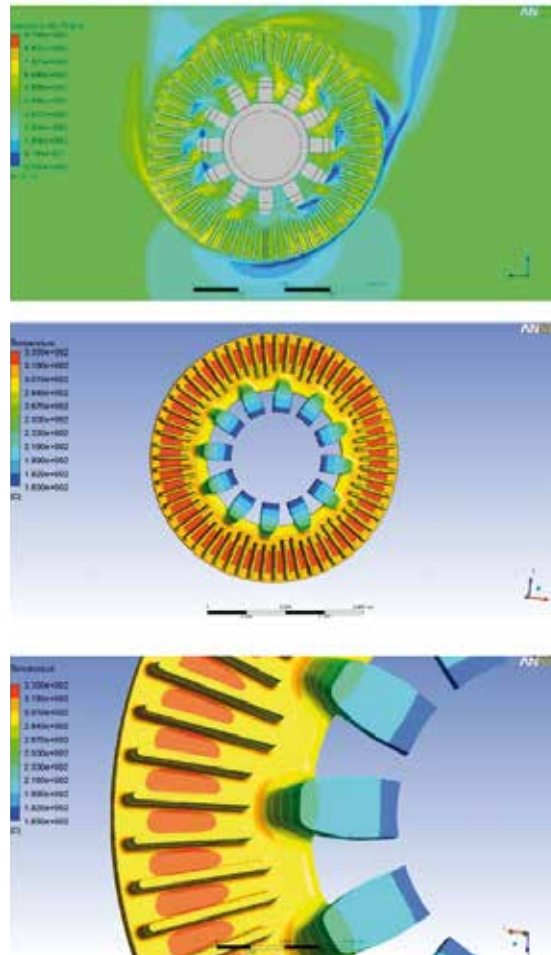


Fig. 3 - CFD model, air velocity and temperature on the disc surface

transfer coefficients and temperature values from the CFD to FE models. Maximum static load and fatigue were checked considering also thermal stress, while shock loads were checked in cold conditions. The FEA results showed that the two discs have a similar behavior and they both comply with European standards requirements and with the FKM Guidelines.

Moreover the CFD analyses allowed to get more general information, that not only were useful for the ongoing project, but were applicable to other brake systems. The heat transfer coefficient distribution (HTC) on the front, back, inner and lateral sides of the discs and the HTC dependency on the vehicle speed have general applicability to any kind of disc. In particular knowing the HTC versus speed law allows to easily define the heat transfer conditions in the FE models also considering the vehicle accelerations and speed history. Indeed the simulation of temperature and stress behavior in particular braking conditions and during long real track-charts has to be done for every project and it is an important part of the results that Poli has to provide to customers.

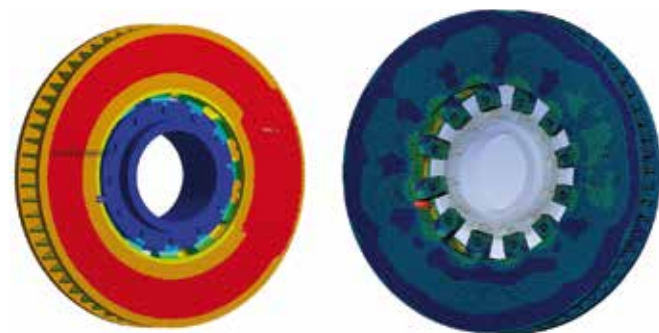


Fig. 4 - FE model, temperature and Von Mises stress

results was between 1°C and 7°C in terms of average temperature on the test bench thermocouples.

The CFD analyses allowed to compare the two discs configurations and to get specific information that were useful for the project. The solution with pins was practicable, because temperature values and gradients were in the allowable range and maximum values were only slightly higher than the bladed disc.

At the end of the CFD study the use of ANSYS Fluid-Structure-Interaction tools allowed to easily and fast map the heat

The conclusions of the simulation process built and carried out by Poli and EnginSoft can be effectively summarized by the words of Ing. Stefano Cappellini of POLI SpA:

"The use of both CFD and FE simulations at the same time allowed to improve the brakes design process and to gain confidence on the methodology that we use for thermal simulations of all our projects. We regard simulation tools as important as our test bench to deliver the best product to our customers."

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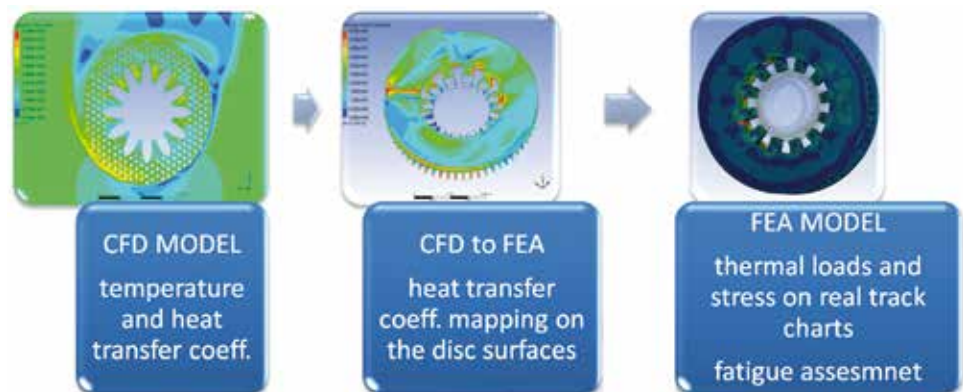


Fig. 5 - fluid-structure-interaction using ANSYS CFD and ANSYS Mechanical



Numerical Models for Aimable Warhead

The objective of this article is to show the main numerical results obtained by Simmel Difesa S.p.A during Phase 1 of AWARD (Aimable WARheadDs) research program which Simmel have been carrying out cooperating with MBDA.IT with the economical support of Italian Minister of Defence.

Simmel Difesa is an Italian company, part of Chemring Group PLC, leader for the design, development, and production of mid-large caliber ammunition (for naval & ground artillery), general

conventional ammunition (mortars, air bombs, rockets, complete rounds), fuzes (mechanical and electronic), missiles components, explosives, powders and propellants and provides services as explosives disposal and ammo refurbishment. For what concerns component missile products Simmel Difesa, designs, develops and produces Warhead, Safe and Arm Device and Motor Ignition Device. For example, Simmel Difesa has developed and currently produces Warheads for Aster Missiles (Conventional and Dual) and Warhead and SAD for Aspide Missile. Both these warheads are axisymmetric and with a different shape of the structure produce a beam of fragment differently focused (Fig. 1).

However, all the warheads considered in Fig. 1 produce a beam of fragments transversely isotropic, being the plane of transverse isotropy the one orthogonal to the axis of axisymmetry (Fig. 2).

AWARD (Aimable WARhead) research program

An increase in lethality against conventional targets (aircraft, ship) or TBM targets (Tactical Ballistic Missile) could be obtained with the use of aimable warheads.

This warhead doesn't produce a transversely isotropic beam of fragments and are capable of conveying the energy contained in the explosive charge in a particular direction, and then are capable of projecting the payload towards the position occupied by the target. Simmel Difesa S.p.A and MBDA.IT S.p.A have been cooperating to AWARD (Aimable WARhead) research program funded by the Italian MoD.

The research program shall be completed in two Phases. Phase 1 is theoretical and consists in choosing the concepts of the aimable warhead and evaluating their feasibility. This phase involves numerical simulations and the issue of a preliminary design of the solutions proposed. Preliminarily, for a number of representative test-cases, numerical models have been validated through the comparison between the numerical results with those available in

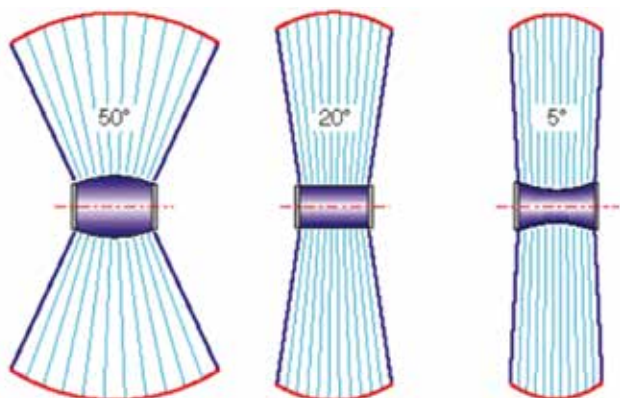


Fig. 1 - Beam of fragments differently focused because of the shape of structure

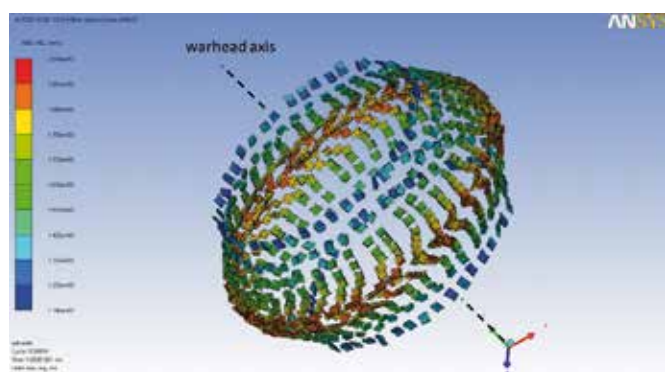


Fig. 2 - Beam of fragments differently focused because of the shape of structure

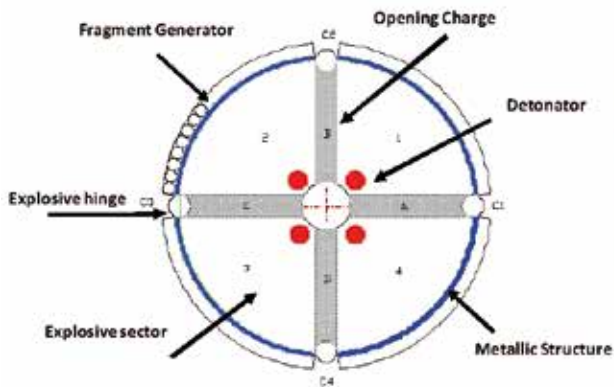


Fig. 3 - Schematic drawing for "Opening Warhead"

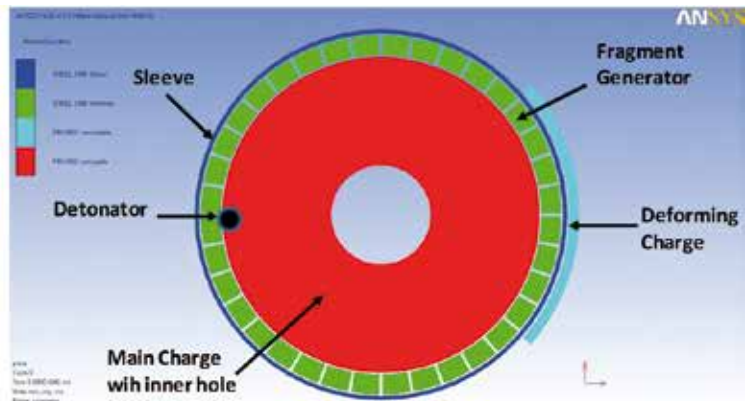


Fig. 4 - Schematic drawing for "Deformable Warhead"

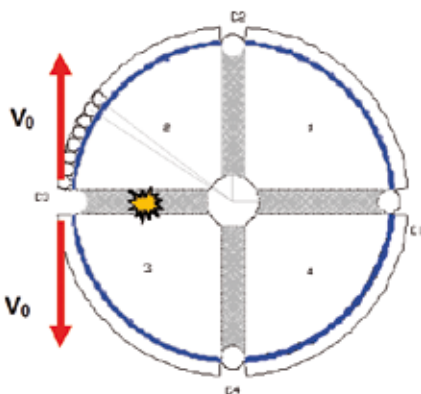


Fig. 5 - Inert Phase OW. Starting of the opening mechanism

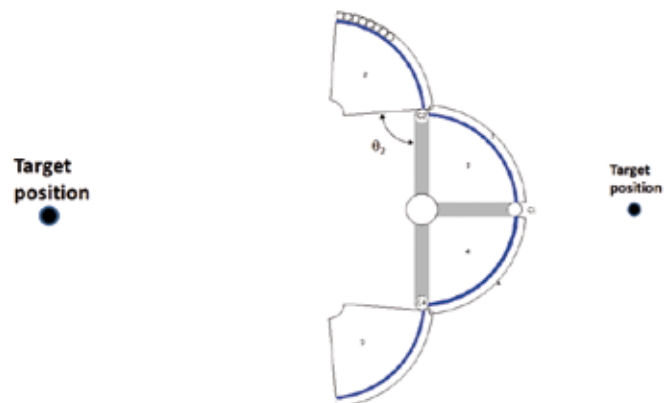


Fig. 6 - Rotation of sector 2 (3) with respect to sector 1 (4) around C2 (C4)

the literature or with those carried out from experimental results. On the basis of the numerical results obtained by the numerical model proposed and validated, in the phase 2 of the AWARD research is provided to continue the study with experimental tests to be performed on the selected configurations. More in detail, Phase 2 provides to build up a demonstrator of aimable warhead and to carry out a firing tests in amphitheater with RX system for measuring the velocity of the fragments and their soft recovery. In the present work two different configurations of aimable warhead called "Opening Warhead" (OW) and "Deformable Warhead" (DW) have been analyzed.

Requirements for this warhead are the following:

- Dimensions: the diameter of the warhead could vary between $\varnothing=80\text{mm}$ (for prototypical applications) to $\varnothing=300\text{mm}$ (for anti-ship warhead). Intermediate size of $\varnothing=200\text{mm}$ can be considered for anti-aircraft applications.
- Set up time of detonation, t_d : In function of the missile velocity V_m ($650 \div 1500\text{m/s}$), target speed V_t (0 to 1500m/s) and

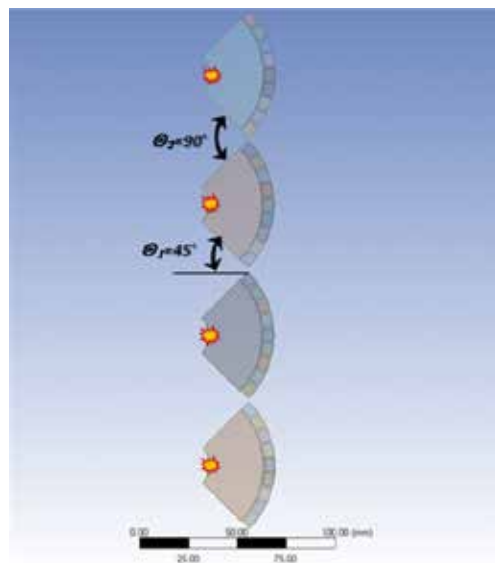


Fig. 7 - Firing Configuration for OW ($\theta_1=45^\circ$ and $\theta_2=90^\circ$)

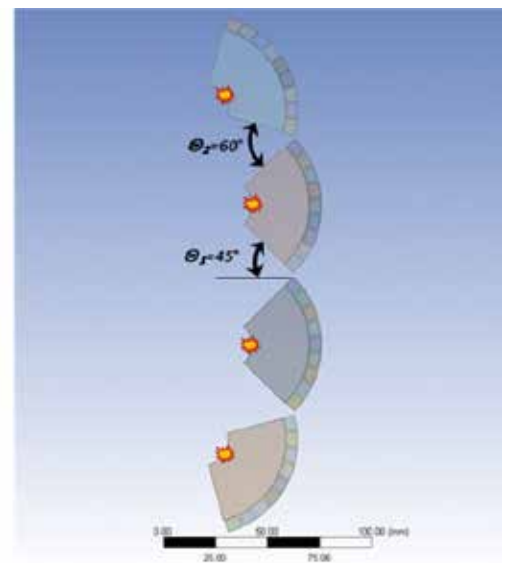


Fig. 8 - Firing Configuration for OW ($\theta_1=45^\circ$ and $\theta_2=60^\circ$)

the miss distance the warhead d (less than 10m) is estimated $t_d < 4\text{ms}$.

- Explosive Mass, C : the explosive mass could vary in function of the dimension of the warhead typical for the different applications:
 - a) warhead prototypical: $C=2.3 \div 2.5\text{Kg}$;
 - b) anti-aircraft warhead: $C=5 \div 6\text{Kg}$;
 - c) anti-ship warhead: $C=25 \div 30\text{Kg}$;
- ratio, C/M (explosive mass/metal mass): could vary from 0.5 to 1.1 .

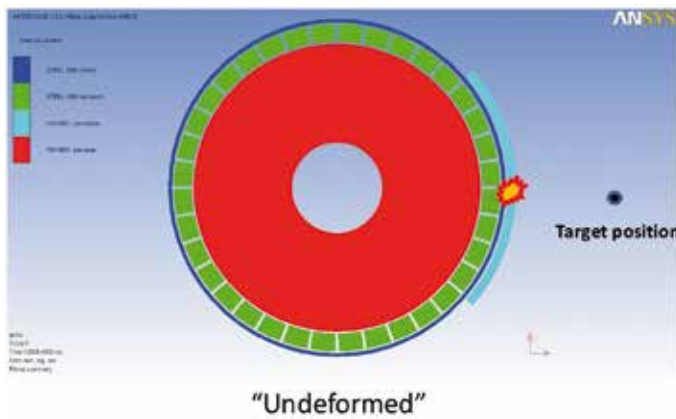


Fig. 9 - Inert Phase of Deformable Warhead

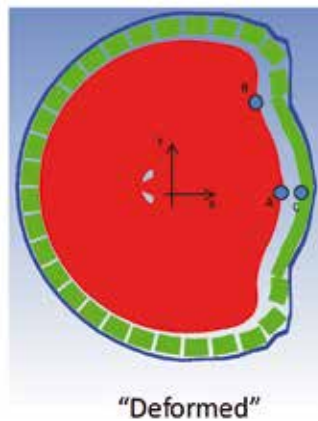


Fig. 10 - Angle of view of the target

“Opening Warhead” and “Deformable Warhead”

A schematic drawing of OW and DW are shown in Fig. 3 and Fig. 4 respectively according to a plan view that is projected on a plane orthogonal to the axis of the warheads.

As to the OW (see Fig. 3), the main components are:

- the structure composed by n° 4 metal cylindrical shells hinged to each other;
- the fragments generator;
- n° 4 hinges with the dual function kinematics and explosive (C1, C2, C3, C4);
- n° 4 opening charges (A, B, C, D);
- the main charge, composed by n° 4 sectors (1,2,3,4);
- n° 4 detonators to trigger the detonation of the main charge.

For what concern DW (see Fig. 4), the main components are:

- main charge with an inner hole;
- fragment Generator;
- a steel sleeve contains the fragments in position;
- a deforming charge (on the side of the target);
- detonator (on the opposite side of the target).

The working principle of OW and DW can be described in two phases called “inert” and “active”. In the “inert” phase, in function of the position of the target, both the warheads move from the initial configuration to the firing configuration. In the “active” phase starts the detonation of the main charge with the result of projecting

fragments (payload) toward the position occupied by the target. Figures from Fig. 5 to Fig. 8 describe the “inert” phase of “Opening Warhead”. In detail, in function of the target position the detonation of an “explosive hinge” and of an “opening charge” start the opening of the warhead as shown in Fig. 5.

Referring to Fig. 6, as a result of the detonation of the “C” “opening charge”, starts a relative rotation of the sector 2 with respect to sector 1 around the hinge C2. At the same time sector 3 rotates with respect to the sector 4 about the hinge C4. The amplitude of this rotation will vary between 0 and 90° and this angle is indicated as ϑ_2 . (See Fig. 6). Over this limit a further rotation is around the hinge C1 with sector 1 and sector 2 integral with sector 3 and 4 respectively. ϑ_1 is the angle of rotation of sector 1 around C1 hinge. In this way the warhead reaches the firing configuration in a time called “opening time”. In Fig. 7 and Fig. 8 two different firing configurations are considered: $\{\Theta_1 = 45^\circ \text{ and } \Theta_2 = 90^\circ\}$ and: $\{\Theta_1 = 45^\circ \text{ and } \Theta_2 = 60^\circ\}$.

As to the Inert Phase of DW, the detonation of the “deforming charge” induces a deformation of the main charge. The deformed geometry of the main charge is shown in Fig. 9 and depends on the diameter of the inner hole of the main charge and from its mechanical properties. If this parameters are properly chosen, the deformed shape of the main charge shall present segment A-B parallel to y when the inner hole of the main charge is closed. In this configuration DW shall be capable to project fragments with high velocity against the target improving the lethality of the warhead with respect to the “undeformed” configuration.

An important functional parameter is the time of deformation which can be assumed equal to the time of closure of the inner hole of the main charge.

Objective of this phase is to evaluate the performances in term of lethality of the OW and DW.

Lethality of the warhead is proportional to the kinetic energy of the fragments which hit the target. More in detail, it is defined “Effective Kinetic Energy” the kinetic energy of the fragments that impact on the target by counting only the velocity component normal to the target surface. The lethality of the aimable warhead shall be measured in term of “Directional Power” that is the ratio between the effective kinetic energy of the warhead in the open/deformed configuration and the effective kinetic energy which is obtained by the detonation the warhead configuration completely closed/undeformed.

Referring to Fig. 10, being H the dimension of the target and D the distance of the target from the warhead axis, it is defined the angle of view of the target as $\alpha = 2\arctan(H/2D)$. In particular,

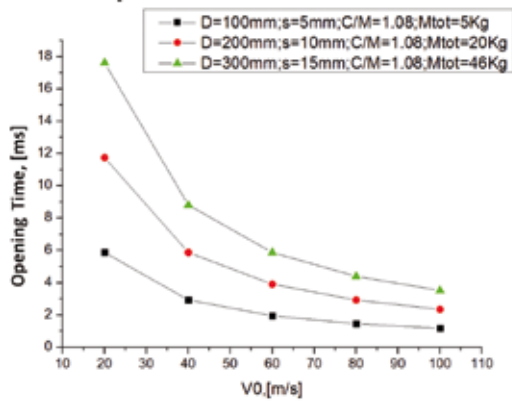


Fig. 14 - "Opening Warhead". Analytical approach

$$\frac{d}{dt} \frac{\partial L}{\partial \dot{\theta}_i} - \frac{\partial L}{\partial \theta_i} = 0 \quad (i = 1, 2)$$

where L is the Lagrangian function of system defined as $L=T-U$, being T the kinetic energy of the system and U the potential energy. The solution of the differential system, expressed in term of the functions $\theta_1(t)$ and $\theta_2(t)$, is obtained by integration under the following initial conditions:

$$\begin{aligned} \theta_1(0) &= 0 \\ \dot{\theta}_1 &= 0 \\ \theta_2(0) &= 0; \\ \dot{\theta}_2 &= \frac{V_0}{R} \end{aligned}$$

A substantial simplification for writing and solving the equations of motion is obtained by considering the hypothesis of decoupled motion illustrated in the working principle of the "Opening Warhead".

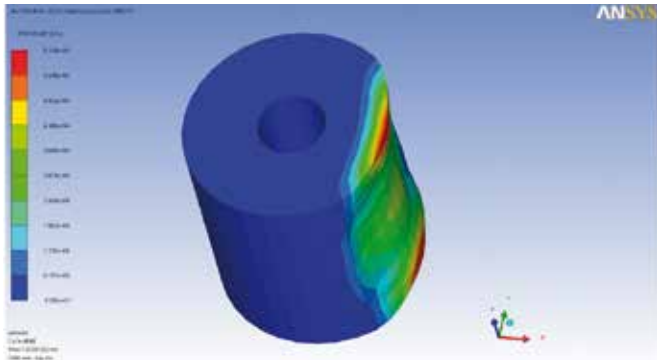


Fig. 15 - Inert Phase of Deformable Warhead. Pressure Map in the for $t=70\mu s$

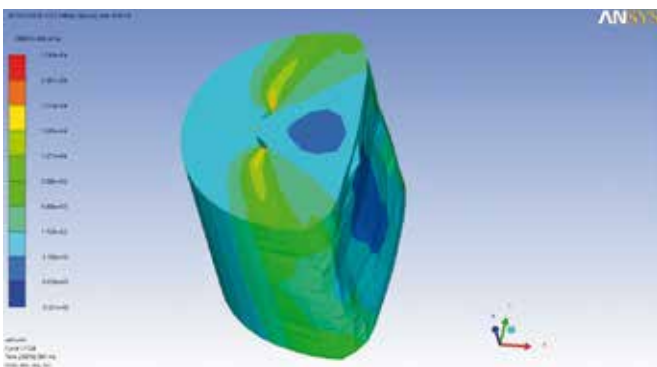


Fig. 16 - Inert Phase of Deformable Warhead. Pressure Map for $t=223\mu s$

The resolution in closed form of the equations of motion it is possible with a linearization with respect to θ_1 and θ_2 . On the other hand, Inert Phase of DW is simulated with 3D and 2D lagrangian models.

Numerical Results and Conclusions

The Inert Phase of "Opening Warhead" has been analyzed to calculate the opening time of the warhead. The calculations were carried out for different diameters of the main charge and different thicknesses of metal in such a way as to maintain constant the ratio C/M of the warhead examined. In detail, assuming a length of the warhead $L_w = 0.2m$, were considered the threecases:

- D=100mm and s=5mm which corresponds to a mass of M=5kg warhead.
- D=200mm and s=10mm which corresponds to a mass of M=20kg warhead.
- D=300mm and s=15mm which corresponds to a mass of M=46kg warhead.

In all cases considered is $C/M = 1.08$; for each case an initial velocity V_0 between 20-100 m/s is considered; the results are shown in figure 14.

An opening time less than 5ms is obtained for all dimension considered if $V_0=100m/s$ is applied on sector 2 and 3 by the detonation of the opening charge.

For what concern Inert Phase of Deformable Warhead, the pressure in the main charge, produced by the detonation of the deforming charge, and the time of deformation have been calculated for three different DW (resumed in Table1). For the smallest case considered ($\varnothing=80mm$), Fig. 15 and Fig. 16 show the pressure contour for different time; the maximum pressure recorded is 0.58kbar very far from the reaction limit of every insensible explosive.

Main charge Diameter [mm]	Time of Deformation [μs]	Max Pressure [kbar]
$\varnothing=80$	223	0.58
$\varnothing=180$	490	0.88
$\varnothing=280$	775	0.93

Table 1 - "Inert Phase" of Deformable Warhead.

For what concern the DW with $\varnothing= 80mm$, it was investigated the role of the mechanical properties of the main charge on the results that are obtained for "inert" phase. For different values of Young's Modulus of the main charge it has been evaluated:

- Time of deformation.
- Maximum pressure in the main charge induced by the detonation of the deforming charge.
- Deformation of the main charge and the coherence with the sleeve distortion.

The results obtained are shown in Tab. 2. For Poisson's ratio equal to 0.4 the increase of the Young's modulus of the main charge produces a reduction of "time of deformation" and an increase of the peak pressure with the onset, with E greater than 200MPa, of a

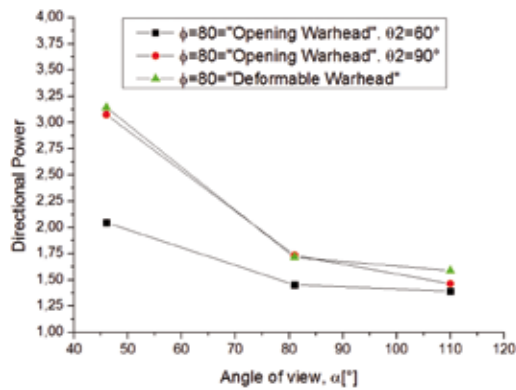


Fig. 17 - Active Phase. Comparison between OW and DW. ($\varnothing=80\text{mm}$).

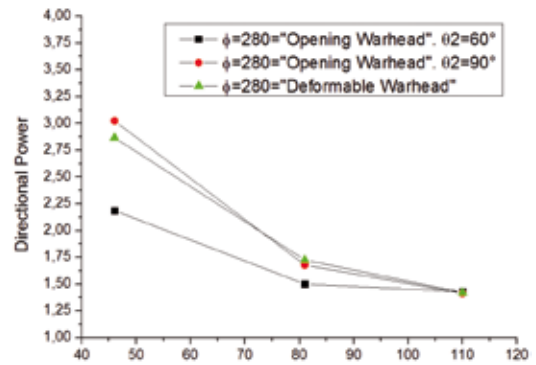


Fig. 19 - Active Phase. Comparison between OW and DW. ($\varnothing=280\text{mm}$).

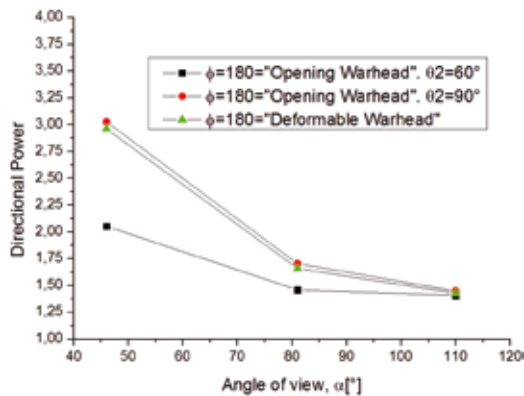


Fig. 18 - Active Phase. Comparison between OW and DW. ($\varnothing=180\text{mm}$).

loss of congruence between the deflection of the main charge and the one of the sleeve.
This value can be considered a limit for the stiffness of the main charge.

As to the active phase, in the graphs of Fig 17, 18 and 19 a comparison between OW and DW in terms of "Directional Power" is shown. The calculations have been carried out for three different dimensions ($\varnothing = 80$; $\varnothing = 180$ and $\varnothing = 280$) comparing "Directional Power" of Opening Warhead in the two firing configuration $\{\theta_1=45^\circ, \theta_2=90^\circ\}$ and $\{\theta_1=45^\circ, \theta_2=60^\circ\}$, and the Deformable Warhead with respect three different angle of view of the target.

For all dimension considered, Directional Power of OW in firing configuration $\{\theta_1=45^\circ, \theta_2=90^\circ\}$ is very close to the one calculated for DW. However, "Opening Warhead" have a greater potential to improve the performances. This can be achieved

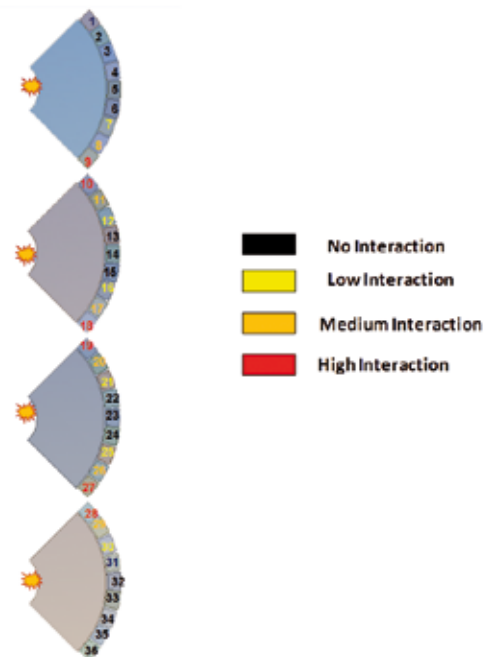


Fig. 20 - Active Phase of OW. Qualitative map of fragments collision

reducing collisions between fragments projected from adjacent sectors.
Fig. 20 show a qualitative map of the collisions of the fragment projected by adjacent sectors.
On the other hand in case of "Opening Warhead" the design appear more critical.

Based on the foregoing considerations, for what concern Phase 2 of the Award research program, a prototype of "Opening Warhead" is proposed as "main solution" and a prototype of "Deformable Warhead" as back-up solution in case the critical design of "opening warhead" becomes incompatible with the time and cost involved in the research program.

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Main Charge Young's modulus [MPa]	Main Charge Poisson coefficient	Time of deformation [μs]	P _{MAX} [kbar]	X _A (y=0) [mm]	X _B (y=23) [mm]	X _C (y=0) [mm]	Gap= X _A -X _C [mm]
23.5	0.4	223	0.88	19	13	13	0
200	0.4	137	1.80	27	21	21	0
600	0.4	118	2.70	27	21	34	13
1000	0.4	116	3.20	28	21	34.6	13.6

Table 2 - Inert Phase of Deformable Warhead. Influence of mechanical properties of the main charge.



Robust Design Optimization of High Pressure Die Casting to Produce Piston Rods

Automotive components are getting more and more complex in shape, with high performance demands, and at the same time less defects and a narrow margin of error; in other words, the design of automotive components requires a combination of acceptable cost, low weight, appropriated mechanical properties, structural integrity and easy production.

To achieve these objectives, the Design Chain approach, for metal casting processes and mechanical properties behaviour, based on optimisation tool, is increasingly used in consideration of the solutions and the process optimisation provided.

One of the most relevant and successful innovations on recent years, and one which this article focuses on, is the CAE application to optimise the well known foundry process, e.g. high pressure die casting (HPDC), in agreement with the mechanical properties requirements.

CAE tools, like MAGMASOFT and its optimisation module MAGMAfrontier, are evolving to support the design during the research of the best engineering solution. The virtual prototype approach is interesting in particular in case of component subjected to high cycle fatigue and sensible level of stress like a aluminium alloy Piston Rod.

In general, the component design comes from the structural FEM simulation, after the mechanical behaviour verification, and it is a geometry input for the manufacturer. The mechanical properties of HPDC components can be affected by gas porosity, shrinkage and other different defects as well as oxides or cold shots. It's means that the HPDC is an attractive process for high level of productivity but its set up and the optimisation the die design are a very complex tasks.

The problem can be divided in sub-tasks:

1. Traditional structural analysis of the designed piston rod to verify which are the critical zones where there are the maximum compressive and tensile stress and to evaluate the stress level compared to the ultimate tensile strength of the material;
2. Optimization of the production process (take advantage of Automatic Optimization technology) for defining the dies and process parameters suitable for the production of Piston Rod maximizing its quality;

3. Advanced structural analysis by exploiting the mechanical properties of the cast from the process analysis to make the final structural verification and validating the production process.

The article aims to show the innovative techniques for the design using the integration of virtual simulation tools to optimize the quality of the finished product, indicating the basic.

Introduction

The applications of light alloys regards engine and also frame parts with a potential weight saving of 40-50 percent compared to traditional materials used in industry, such as steel and cast iron.

It's therefore important to design automotive components, and in general all the components, in combination with the processes in order to minimize costs, scraps and maximize the mechanical performance.

In such scenario, the design activities of the "process-product" is determinant to ensure the maximum reduction of waste and the considerably short-time to finished product as well as to guarantee the casting characteristics required.

Typically the High Pressure Die Casting is the most widely used process for that kind particulars. Similarly to other casting processes, also the High Pressure Die Casting process can introduce defects that can reduce the mechanical qualities of the product determining the scrap. The very high speed of injected metal that govern the process of filling influences the flow dynamics, generating turbulence effects that can lead to the formation of air entrapment or missed fills.

Although HPDC is a highly automated process, the process denotes the multiplicity and variety of parameters with hard identification of the causes that generate a micro or a macro defect in view of corrective actions. For mass production, it is essential to search the optimal solution in terms of quality and production efficiency: the reduction of a few seconds of the cycle time has a positive effect on the number of units produced daily; the alloy mass for the single injection can drastically reduce the cost of raw materials, energy and recycling; the reduction of scrap percentage may result in attractive economic benefits, and finally the extension of the

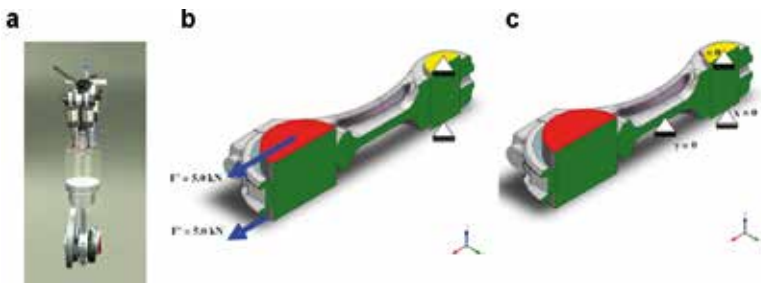


Fig. 1 - (a) Operation scheme of compressor, (b) loads application, (c) constraints application.

dies life time reduces the incidence on the cost of the single cast. The multi-objective optimization techniques, such as those applied in this case, support the determination of optimized and robust solution that has to satisfy all these objectives often conflicting with each other. The high knowledge of the defects and the appropriate interpretation of the virtual results is a prerequisite to the use the numerical simulation and optimization algorithms. The document published on the defects classification by AIM provides an important contribution to the knowledge assessment and it is worth considering as advanced study of scrap production causes.

To obtain the best quality of casting, the Design Chain approach, for metal casting processes and mechanical properties behavior is increasingly used in consideration of the solutions and the process optimization provided.

Preliminary structural analysis

The first phase regards the elasto-plastic structural analysis of the Piston Rod to identify any critical issues for the reference geometry and the nominal and homogeneous mechanical properties of the selected Al

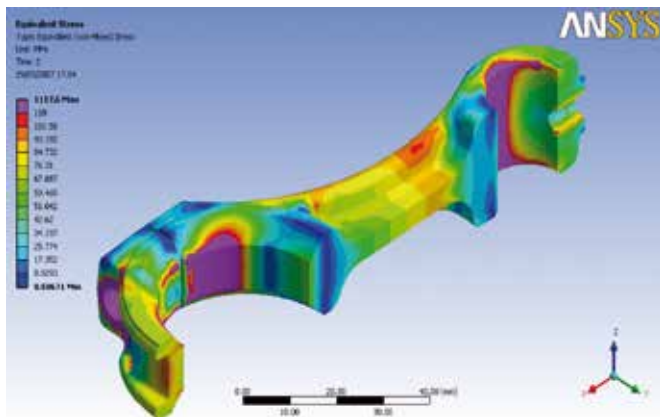


Fig. 2 - Equivalent stress distribution on the Piston rod.

alloy. The aim is to provide information regarding the critical application of the rod and the useful information to the designer of the production process that will define the process ensuring the highest possible quality of the rod and in particular in the areas identified with high stresses.

The work regards the virtual structural analysis of the rod coupled with foot cap to which is applied the constraints, loads and boundary conditions (Fig. 1).

The conclusion of the verification allows to identify a maximum stress concentration in the head and foot part (Fig 2), providing useful information for the design of the production process. In fact it will be necessary to pay the greatest attention in the two areas indicated in

order to avoid introducing defects typical of the production process, responsible for possible reductions of mechanical characteristics of the cast.

Die casting process optimization

The high numbers of variables which define the foundry process of High Pressure Die Casting (HPDC) definitely make it one of the most difficult problems to optimise since, generally speaking, there is no single solution which will satisfy the stated aims in the best possible way. In order to select the best solution, it is necessary to evaluate and compare a large

number of potentially possible solutions. The strategy for searching for the optimal solution characterises the optimisation technique.

In the case of foundry, it is not possible to analyse the entire range of solutions with a high number of variables and goals by means of a

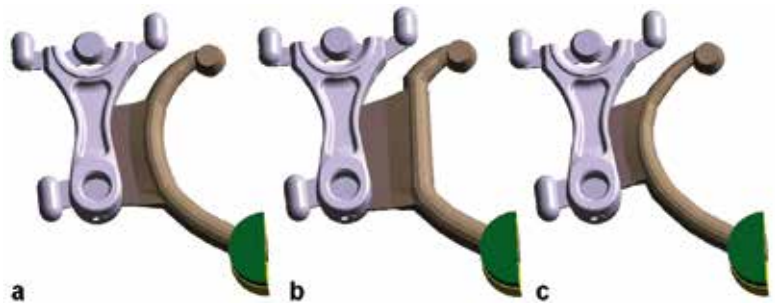


Fig. 3 - Examples of geometries provided by a combination of parametric geometry variables of the casting system

single - objective tool. Despite dividing the problem into sub-problems of a lesser entity (filling, solidification, thermal aspects, residual stress, etc.), the goals are frequently in contrast or interlinked with each other and must therefore be pursued separately without attributing individual degrees of incidence a priori.

The multi-objectives optimisation algorithm (e.g. MOGA) must look for a robust solution which is accurate and respects the design constraints affecting the problem, and establishes the scope of the solutions which can be achieved.

The main objective of the optimization phase is to design, with a fully automatic mode, the best configuration of the process. The aim is pursued using MAGMAfrontier that change the relevant geometric and process parameters to simulate a large number of variants.

The optimization phase is based on an initial population of configurations to simulate (the DOE, Design of Experiment) selected through the use of the algorithm "Reduced Factorial" (this algorithm grounds on two distinct levels of "full factorial" algorithm to cover the extreme of the intervals considered) in combination with the algorithm "Sobol" (this algorithm creates design "quasi random" ensuring that all the factorial design space is covered more uniform as possible). With the combination of these algorithms, it is possible to completely cover the space vector of input variables guaranteeing the representation of the complete design space. Subsequent generations are created by the, above mentioned, genetic algorithm called MOGA (Multi Objective Genetic Algorithm), which allows the user to define new additional designs based on elitism and mutation attributes. Despite the complexity of the topic, the user define only the number of configurations of the first population and the number of successive generations as a function of the available time.

In the case of the die casting process, the design of optimal gating

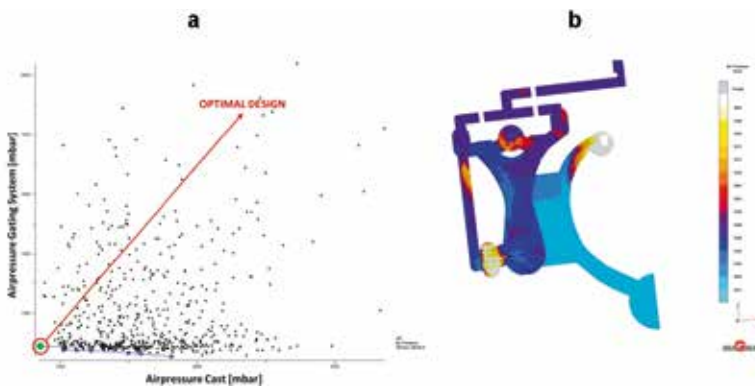


Fig. 4 - Optimization Analysis: a) scatter charts, b) Airpressure results in a section

geometry and the corresponding flux curve, to control the plunger movement during the filling phase, are the goals of the project. Some parametric variables (fig. 3) can define the shape of the gating which connects the shot chamber to the ingates and the ratio between the sections. The main objective is the minimization of the presence of air in the gating system for a re-established ideal injection curve keeping the melt front compact. The output variables, on the basis of which the goals are formulated, are the criterion which represents the pressure of the air entrapped in the gating system (objective 1) and in the cast (objective 2), both to be minimized.

The optimization results, 2840 computed configurations, identify a Pareto frontier representing the best set of solutions that minimize the two objectives. The comparison between the different configurations in a two-dimensional diagram allows to identify the best design (Fig. 4), in terms of principal quality indicators appreciating the improvement in the casting.

The used criterion (Airpressure) is typically used to predict the maximum concentration of air bubbles and their internal pressure. It is also important to reduce the air entrapment in the gating system that can occur during the generation of particularly extreme geometry of gating.

Although the cold shuts is typically another objective of the project, in the case of small Rod the absence of the cooled melt during the cavity can be checked diligently only in the final optimal solution (fig. 5a) as well as for the velocity distribution correlated to turbulence and soldering (fig. 5b). The steady state simulation allows to verify the solidification behavior ensuring the highest quality of the cast in terms of shrinkage and the durability of the dies (fig. 5c).

Mechanical properties prediction stress analysis and advanced structural analysis

The local mechanical properties can be correlated to defects mapping of the casting using the appropriated criteria in a polynomial function [f1].

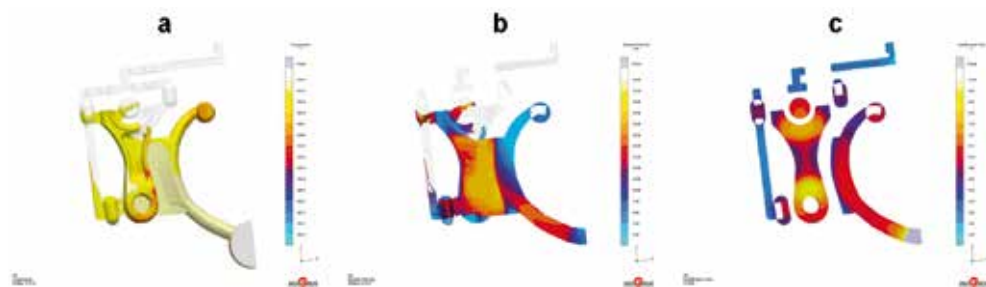


Fig. 5 - Visualization of the detailed results of the optimum design: a) temperature filling, b) velocity filling, c) solidification time distribution

The implementation of the prediction model of the local Ultimate Tensile Stress (UTS) and the relative Elongation to fracture is made possible by exploiting the curve 'Stress-Strain' of the material used for the Piston Rod.

The used formulation considers to calculate UTS as a function of the maximum nominal value provided by the curve (Fig. 6) decreased by a specific amount depending on the presence of defects due to the filling and solidification phases.

The used formulation is represented by the following function:

$$UTS_{final} = UTS_{nominal} - (a * Airpressure)^A - (b * FlowLength)^B - (c * Aircontact)^C - (d * Coolrate)^D \quad [f1]$$

where:

- Airpressure: is the criterion that allows to identify the presence of air bubbles inside the cast as a function of an increase

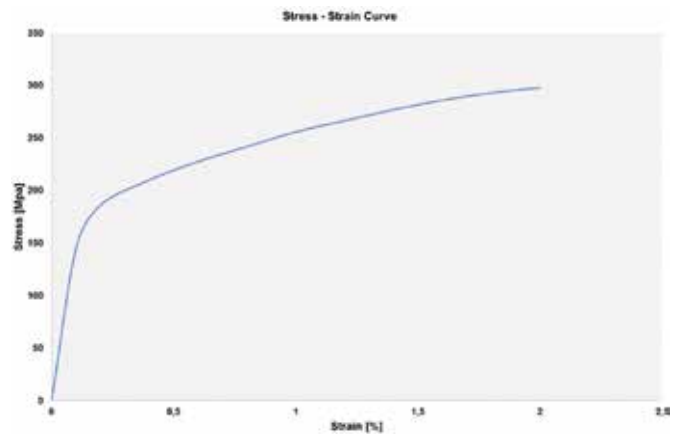


Fig. 6 - Stress-Strain curve of the EN AB 46100 material used for the Piston Rod

in air pressure compared to the value defined by the production conditions;

- Flowlength: is the criteria to identify the distance traveled by the alloy during the filling. This result contains the information concerning the risk of an excessive temperature reduction;
- Aircontact: is the criteria to identify which areas are critical for the oxides formation. This criterion is based on time of alloy contact with the air until the end of the filling.
- Coolrate: is the criteria to identify which areas are critical for any delay during solidification. This criterion is based on the cooling rate of each zone during the solidification phase.
- a, b, c, d, A, B, C, D are constants

The figure 7 and figure 8 illustrates the final local UTS and the corresponding Elongation based on the Al alloy stress-strain curve. The identified values show a lowering of the tensile strength without interfering with the values relating to the Yield Stress.

The end of the process analysis consist of the calculation of residual stresses generated at the end of the production process on the Piston Rod (Fig. 9). The measured values are particularly low, but with the mechanical properties are a good starting point for the final Structural Analysis

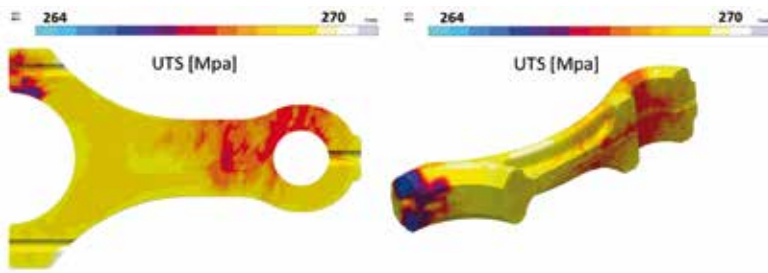


Fig. 7 - Mechanical Properties prediction in terms of local UTS

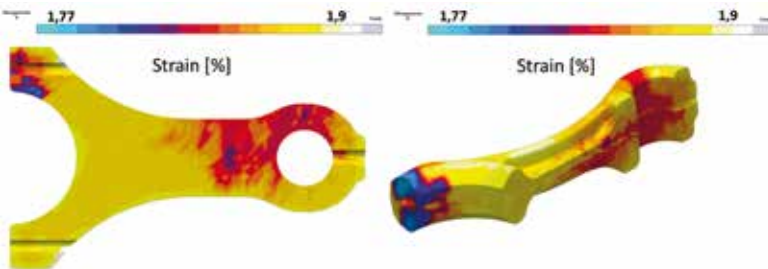


Fig. 8 - Mechanical Properties prediction in terms of local Elongation

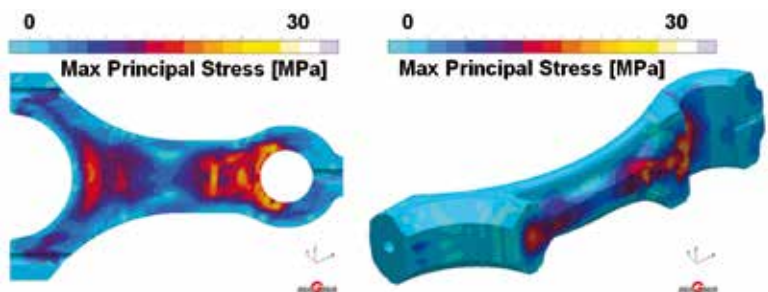


Fig. 9 - Residual stresses at the end of the die casting process

The final interpolation and export of the local mechanical and residual stress results on the FEM mesh is the appreciated linking step from the process to the product to address the mechanical response starting from real-world “daughter” of the manufacturing process (Fig. 10). The final mechanical simulation (Fig. 11), carried out with the innovative process described above, evaluates the realistic performance of the Piston Rod subjected to the operating loads considering the properties deriving from the production process. The process-product approach is based on more accurate method providing the possibility of design the component with the correct admissible stresses and strain reducing the security factor and of course the weight of the body. The final analysis show how the areas previously tested critical, the foot and head of the piston rod, does not reach the values for breaking.

Conclusions

The present work describes an integrated approach between complete process simulation and structural analysis for the Piston Rod component, in order to verify virtually, as realistically as possible, the life of a component from the stage of production until the exercise test. The described methodology is addressed to the High Pressure Die Casting, as shown in its practical application on the component studied and it is aimed at the product design, HPDC foundry and industrial end-users. The innovative aspect of the adopted integrated method does

not lie in the use of computer codes specialized on the process or on the mechanical response, considered as reference in the two areas of application, but it is found in the prediction of mechanical properties as a function of process and product quality as well as in the dialogue between different codes. It offers the ability to view the real mechanical behavior of the cast HPDC produced, and consequently the ability to validate and to correctly predict the response of the service casts.

The design chain method intend to meet the continuing needs and requirements of higher quality, more volume, timeliness, cost-effective production method, especially for the automotive industry. The ability to integrate engineering and manufacturing processes, allowing a more accurate and reliable design of the components, with a view to increasing demand for service performance, can meet the modern requirements of economic efficiency (e.g. reduced energy consumption and recyclability), security (impact, analysis of noise and vibration) and eco-sustainability.

Acknowledgement

The optimization work was carried out in close collaboration with the technicians of the A.B.O.R S.p.A., it is thanked in particular the availability of Luca Bellati.

The technology also has been developed using both experimental and computational tests, carried out in collaboration with the producers of the alloy, university laboratories, foundries, end-users in the automotive sector, in the context of the NADIA European Research Project.

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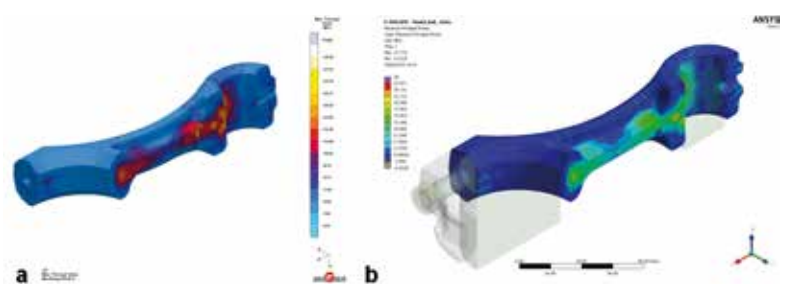


Fig. 10 - Example of Residual stress transfer from MAGMA (a) to ANSYS (b)

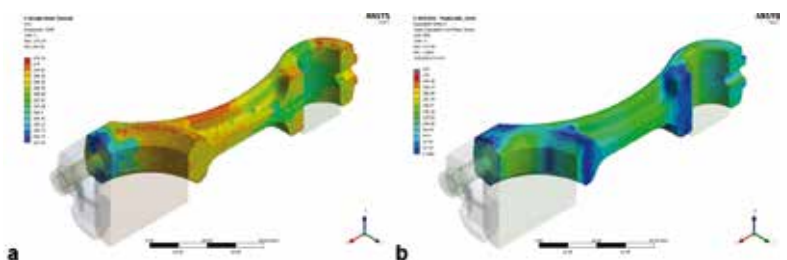


Fig. 11 - Final Structural Analysis: Comparison between a) UTS final distribution and b) Von Mises stresses



Process oriented cooling optimization using modeFRONTIER

At present time CFD Models are widely used to analyze and solve problems that involve fluid flow in the aerospace, railway and automotive industries. Thanks to CFD, the interaction of liquids and gases with surfaces can be modeled for issues such as turbulence in fluids, pressure drops, heat flux and heat exchange in IS (Individual Section) machines.

The Simulation Department at the research center of Bottero S.p.A., since 2007 and first on the market, applied the CFD techniques to optimize the glass forming process. The result is the development of the "E-MOC", a Top-Mounted, Mold-Open-and-Close mechanism currently offered on IS machines.

Meeting design objectives.

The EMOC cooling system, best in class, is based on the completely new idea of the air flow entering into the middle height of the mold; the development process was completely simulation driven.

The main idea behind this project is the deployment of a completely new cooling device in order to increase the heat extraction efficiency and improve the glass distribution on the final container, compared with existing IS machines on the market. This concept leads to a very complex optimization process, developed with ESTECO



modeFRONTIER software associated with CFD capabilities; the objectives were:

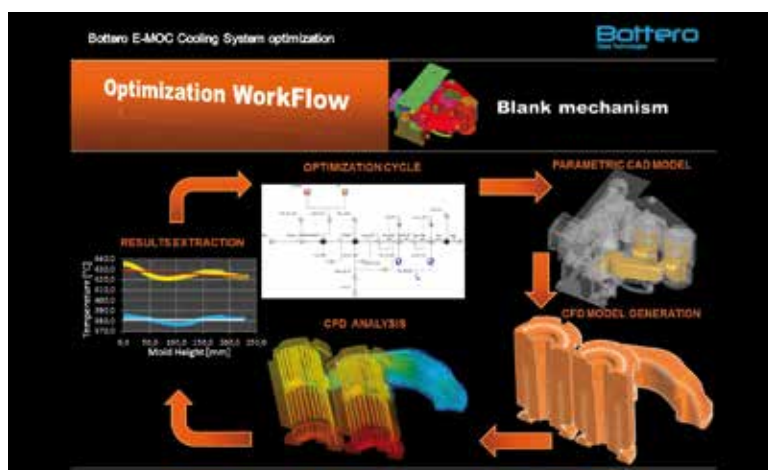
- Increase cooling efficiency, in order to reduce air consumption.
- Control differences in air supply between cavities (double, triple, quadruple gob).
- Augment heat extraction capacity of the system (quantity).
- Improve control on temperature distribution across the molds (quality).

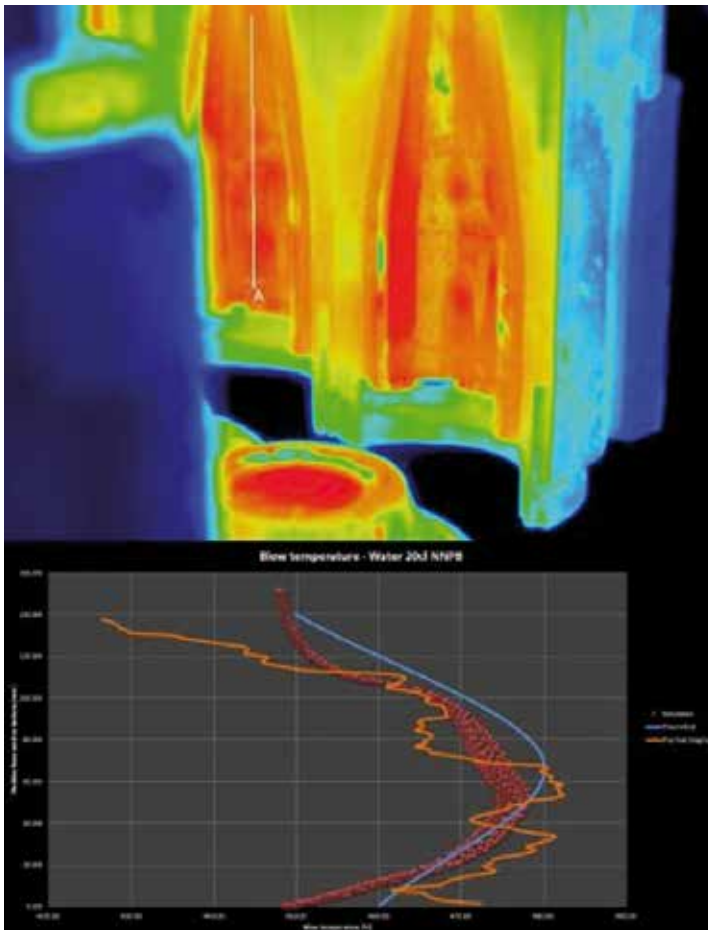
A first milestone was reached with a detailed study and optimization on cooling ducts, starting from the On/Off valves, all the way through the mold holding arms and into the mold, reducing to a minimum possible pressure drops and granting the highest heat extraction capacity in the air/mold contact.

To do this, an optimization cycle driven by MF was implemented: it involved changes in air duct shape, obtained by morphing the original one, presence or absence of deflector, CFD analysis of the configuration and automatic result extraction, as visible in figure 1.

A Conjugate Heat Transfer analysis has been used, to take into account at same time cooling fluidics (pressure, speed, turbulence), mold temperature variations and thermal exchanges (radiation, conduction, convection) as visible in figure 2.

Our main target is to reach a better glass distribution in order to increase the mechanical properties of the container as





well as to explore bottle weight reduction. In this case we used modeFRONTIER to modify the number and the diameter of the mold holes cooling pattern. Tests under glass have been conducted to verify the simulation results, confirming good correlation between simulation and experimental data (obtained with IR camera thermal imaging) as visible in figure 3.

With the E-MOC concept and the service provided by the Simulation Department, BOTTERO can discuss with its Customers the ways and means to optimize mold design, starting with conditions currently running under glass. Through mold design optimization, BOTTERO has been able to achieve for its Customers better temperature distributions while significantly reducing the cooling time. Paying attention to the Carbon Footprint, the higher efficiency of E-MOC allows glass container manufacturers to install smaller cooling fans for IS machines.

CFD analysis coupled with modeFRONTIER optimizer are certainly a way to address some of today's specific needs by the market and customers, offering on-going innovation hence competitiveness to clients, aimed at productivity and efficiency, focusing both on the improvement of the IS machine and its environmental quality.

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Multi-Objective Optimisation of a Water Supply System

The Mono-Objective Problem

In the previous issue of the EnginSoft Newsletter, Trogneux and Soulier presented the mono-objective optimisation of a water supply system performed by coupling Flowmaster and modeFRONTIER. The considered water supply system has eight pipes arranged in two loops and is fed by gravity from a constant head reservoir as shown in Figure 1 and described by Alperovits and Shamir (Alperovits E., Shamir U., 1977, "Design of optimal

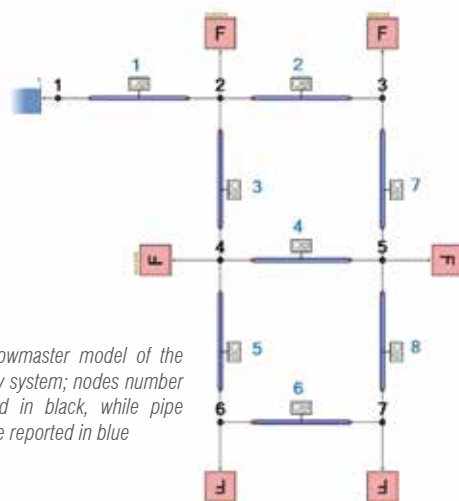


Fig. 1 - Flowmaster model of the water supply system; nodes number are reported in black, while pipe numbers are reported in blue

Nodes	Demand (m3/h)	Elevation (m)	Required Pressure (m)
1	-1120	210	--
2	100	150	30
3	100	160	30
4	120	155	30
5	270	150	30
6	330	165	30
7	200	160	30

Table 1 - Required flow, elevation and required pressure at each node of the water supply system

water distribution systems", Water Resource Research, (13)6: pp. 885-900). Considering the node elevations and the required flow and pressure at each node of the system, as reported in Table 1, the optimal solution was computed by using a FAST method associated with a genetic algorithm (MOGA-II). The optimal solution is represented by the combination of pipe diameters that minimizes the total cost of the system and is reported in Table 2. The allowed pipe diameters and the associated costs are reported

Pipe Number	Diameter (inch)
1	20
2	10
3	16
4	1
5	14
6	10
7	10
8	1
Total Cost (\$)	420 000

Table 2 - Optimal solution of the mono-objective problem

Index	Diameter (inch)	Cost (\$/m)
1	1	2
2	2	5
3	3	8
4	4	11
5	6	16
6	8	23
7	10	32
8	12	50
9	14	60
10	16	90
11	18	130
12	20	170
13	22	300
14	24	550

Table 3 - Allowable diameters and associated cost

in Table 3. To be noted that a mono-objective optimisation problem has a unique optimal solution.

The Multi-Objective Problem

Following Nicolini (Nicolini M., 2005, "A Two-Level Evolutionary Approach to Multi-criterion Optimisation of Water Supply Systems". Evolutionary Multi-Criterion Optimisation, Third International Conference, EMO 2005, Guanajuato, Mexico, March 9-11, pp. 736-751), it is possible to extend the mono-objective problem to a multi-objective problem by relaxing the constraint on

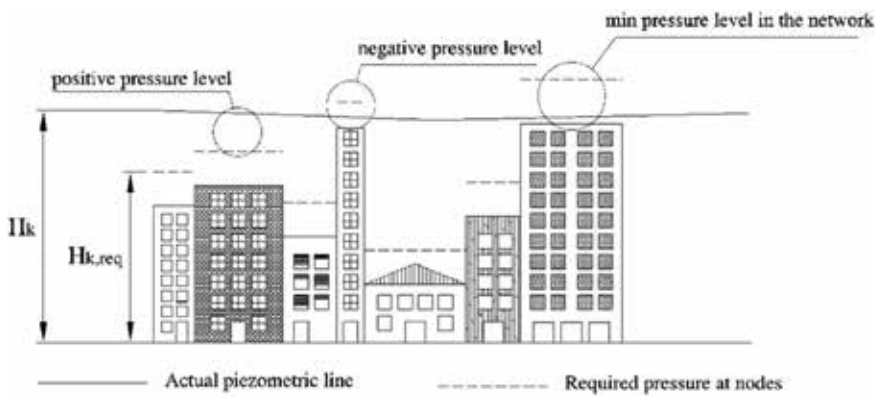


Fig. 2 - Actual piezometric line (H_k) and required pressure at nodes ($H_{k,req}$) – from Nicolini (2005)

the required pressure. In particular, we allow the node pressure to be lower than the required pressure and search for the solutions that minimize the total system cost and maximize the minimum pressure level, i.e. the deviation of the actual piezometric level from the required pressure. A graphical representation of the second optimisation target is provided in Figure 2. We also limit the region of interest for the minimum pressure level between -30m and 0m . It can be noted that the two objectives are conflicting and that this multi-objective optimisation problem has an infinite number of solutions. This extension of the problem allows to exploit all the capabilities of the multi-objective optimisation algorithms of modeFRONTIER.

The optimisation workflow is presented in Figure 3. The input parameters are represented by eight indexes; these are manipulated by a calculator in order to compute the pipe diameters (deep blue box) and the total cost of the system. Once the total cost is computed, the minimisation target can be applied (purple box). Then the pipe diameters are passed to the Flowmaster direct link (light blue box) for hydraulic computations which provides node pressure results (orange box). The pressure values are then passed to another calculator that computes the minimum pressure level. Once the pressure level is computed, the appropriate bounds and the maximisation target can be applied (green box).

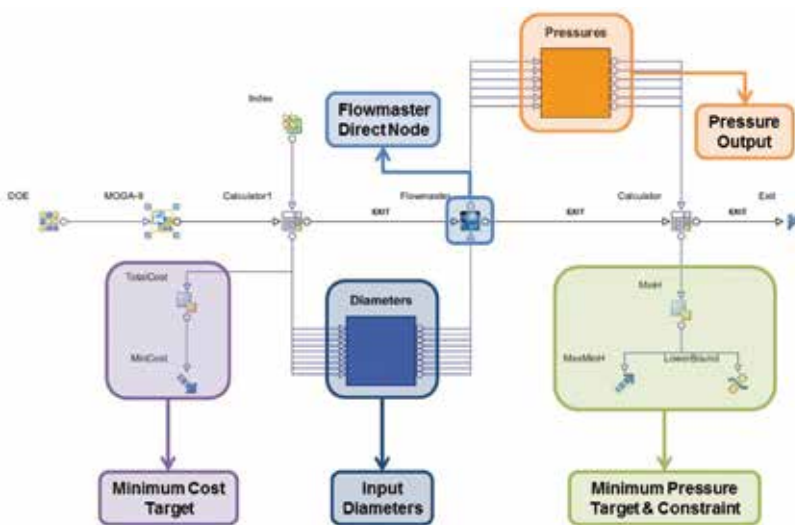


Fig. 3 - modeFRONTIER optimisation workflow.

Sobol algorithm is used for the design of experiment (DOE), then two different genetic algorithms are used to compute the optimal designs, first the MOGA-II algorithm and afterwards the NSGA-II algorithm. This strategy allows for a good exploration of the variable space and to obtain a good definition of the Pareto frontier, i.e. the collection of the optimal solutions.

In Figure 4 a scatter plot representing the total cost and the minimum pressure level of each design is presented; the optimal designs are represented by red bubbles. Among these, the optimal solution of the mono-objective problem can be recognised in the upper-right corner; the total cost of this solution is $420\,000\text{\$}$ and its pressure level is 0 , i.e. the actual piezometric level equals the required pressure head. On the other hand it can be noted that if a deviation from the required pressure head is accepted, then cheaper designs can be implemented. All these designs are optimal in the sense that there is no other design capable to improve both targets at the same time. In Figure 5 a parallel coordinate plot is presented in which

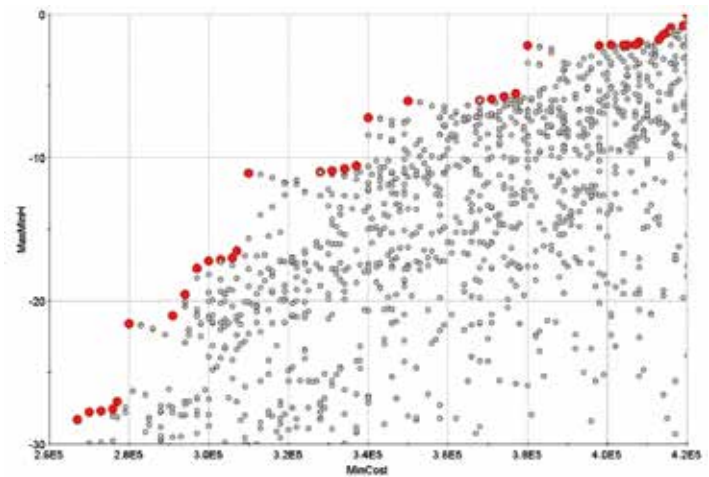


Fig. 4 - Scatter plot representing the total cost and the minimum pressure level of each design; optimal designs are highlighted in red.

only optimal designs are reported. The left coordinate axis represents the total cost of each optimal design while the right coordinate axis represents its pressure level.

This plot is very helpful for decision making because it clearly shows the relations between different targets. For example, a system that costs $377\,000\text{\$}$ will produce a deviation from the required pressure head of 5.53m . A little increase on the cost will produce a large reduction of the deviation, indeed a system that cost $380\,000\text{\$}$ (only $3\,000\text{\$}$ more than the previous one) will produce a deviation of 2.19m . On the other hand a large increase in the cost from this solution will not produce an adequate reduction of the deviation, indeed a system that costs $398\,000\text{\$}$ ($18\,000\text{\$}$ more than the previous one) will produce a deviation of 2.17m .

Conclusions

The simple water supply system considered in this work allowed to investigate all the difficulties related to the optimisation problem and to exploit all the capabilities and opportunities offered by a coupled use of simulation tools such as Flowmaster (the hydraulic simulation tool) and modeFRONTIER (the optimisation tool). In particular, a mono-objective optimisation problem was extended to a multi-objective optimisation problem where two conflicting targets were optimised, namely the total system cost and the deviation between the actual pressure head and the required pressure head. This multi-objective problem has an infinite number of solutions; all the optimal solutions lays on the Pareto frontier. The use of two genetic algorithms provided a good exploration of the variable space and a good definition of the optimal configurations. Finally, the use of adequate charts allowed to clearly visualise all the optimal solutions and to understand the relation between the two different targets. These plot can be very helpful in the decision making process because they are capable to highlight the improvements that can be achieved by changing inputs or by relaxing some requests.

This example showed that a simple mono-objective optimisation problem can be extended to a more complex multi-objective optimisation problem opening a wide range of possibilities. In the same way, this multi-objective optimisation approach can be extended to a more complex real-life water supply system... but optimisation is not limited to water system only; indeed it can be

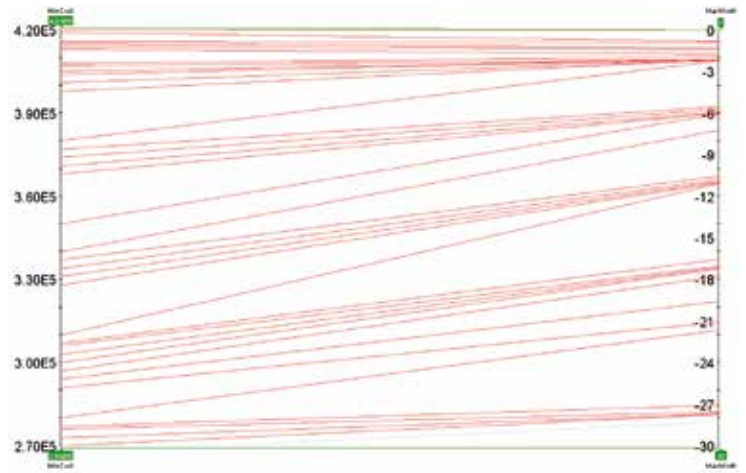
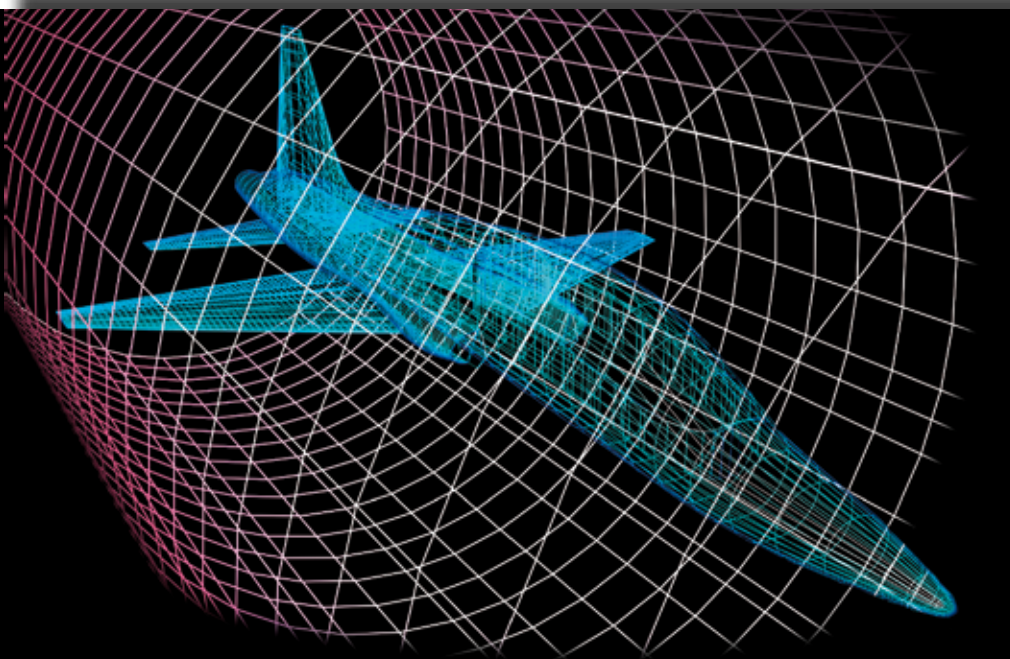


Fig. 5 - Parallel coordinate chart representing the total cost and the minimum pressure level of each design; only optimal designs are shown

applied to any system, regardless of its complexity. The use of multi-objective optimisation during system design process allows for great enhancements in system performances as well as large cost reductions.

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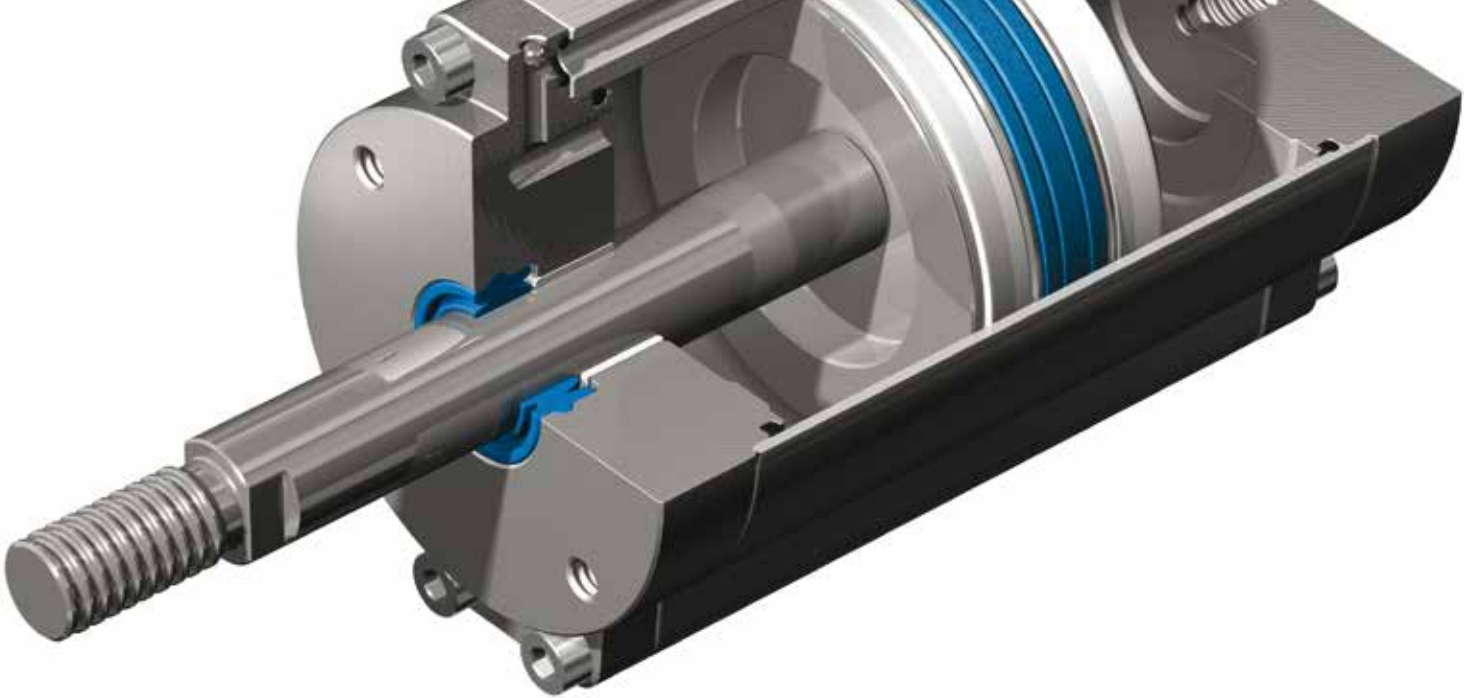
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Creation of a pneumatic component for Flowmaster

Respect of the ISO 6358:2013 standards

A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. It also helps to harmonize technical specifications of products and services making industry more efficient and breaking down barriers to international trade.

ISO 6358:2013 standard

In pneumatic fluid power systems, energy is controlled by a gas under pressure circulating in a circuit. The constitutive elements of such a circuit basically present dispersing characteristics.

Exponent/ Index	Signification
0	Reference conditions
1	Upstream conditions
2	Downstream conditions
*	Conditions during choked flow tests

Table 2 – Index and exponent

Symbol	Description
b	The critical back-pressure ratio representing the boundary between choked and subsonic flow
C	Sonic conductance
m	Subsonic index

Table 1 – Coefficients of the standard



Fig. 1 - Diagram of the component

Consequently it is necessary to carry out experiments to determine this characteristics and the match of the component with the circuit.

The ISO 6358:2013 standard specifies a method for testing components which use gases to enable their flow-characteristics to be compared. It defines three constants described on the table 1 which completely characterize the component.

The downstream mass flow rate \dot{m}_2 of the component shown in figure 1 is calculated with the following equations.

- For $P_2/P_1 \leq b$ (Choked flow):

$$\dot{m}_2 = CP_1 \rho_0 \sqrt{\frac{T_0}{T_1}}$$

- For $P_2/P_1 = 1$ there is no flow:

$$\dot{m}_2 = 0$$

- For $1 > P_2/P_1 > b$ (Subsonic flow):

$$\dot{m}_2 = CP_1 \rho_0 \sqrt{\frac{T_0}{T_1} \left(1 - \left(\frac{P_2 - b}{P_1 - b} \right)^2 \right)^m}$$

With the law of conservation of mass it also gives $\dot{m}_2 = -\dot{m}_1$

Property	Value	Chr
Transmission	Sub Form ...	<input type="checkbox"/>
Critical pressure ratio b	Not Set	<input type="checkbox"/>
Sonic conductance C	Not Set	<input type="checkbox"/>
Compression property s	Not Set	<input type="checkbox"/>
Effective area A	Not Set	<input type="checkbox"/>
Subsonic index m	Not Set	<input type="checkbox"/>
Flow Area	Not Set	<input type="checkbox"/>

Fig. 2 - Table of data (inputs)

Those equations are going to be used in Flowmaster.

$$\begin{cases} \dot{m}_1 = A_1 P_1 + A_2 P_2 + B_1 \\ \dot{m}_2 = A_3 P_1 + A_4 P_2 + B_2 \end{cases}$$

Procedure to create the component

It requires two stages: first the component analytical model (CAM) needs to be created and then it needs to be associated with an actual component.

The CAM is created directly on Flowmaster which creates a stub code asking the user what kind of component is to be created. In this way the name, the number of arms (here 2), the inputs and outputs of the component are chosen.

Figure 2 shows the data sheet of the created CAM. Then Flowmaster creates a « .cs » file which must be modified with the previous equations that the CAM is going to verify.

Flowmaster solves the following type of system:

$$\begin{cases} \dot{m}_1 = A_1 P_1 + A_2 P_2 + B_1 \\ \dot{m}_2 = A_3 P_1 + A_4 P_2 + B_2 \end{cases}$$

The standard equations need to be linearised and then the solution on the code is generated and this will create a « .dll » file that need to be moved in the Flowmaster folder.

Then the component itself is created choosing a symbol and associating the CAM.

Results

The created component has been tested and the model converges in each case with a maximum relative error of 0,1%. Figure 3 shows the evolution of the theoretical and evaluated downstream mass flow rate depending on the upstream pressure.

(With $P_2=1$ bar, $b=0,5$, $C=8.10^{-7}$ s.m⁴/kg and $m=0,5$)

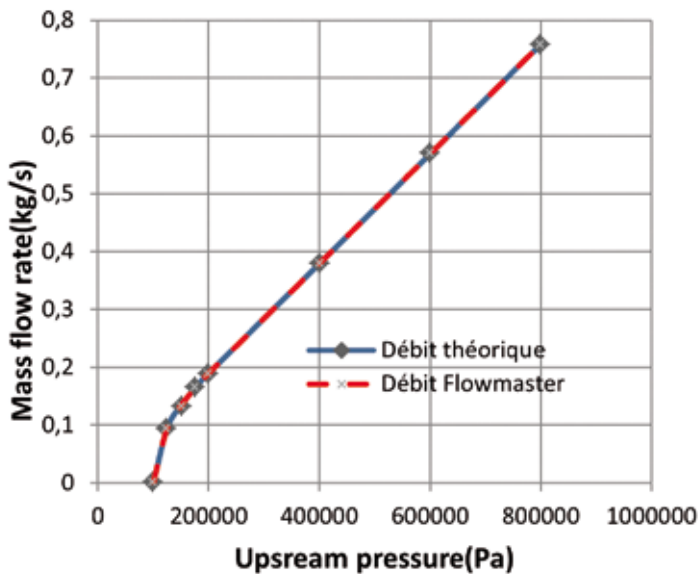


Figure 3 - Mass flow rate depending on the upstream pressure

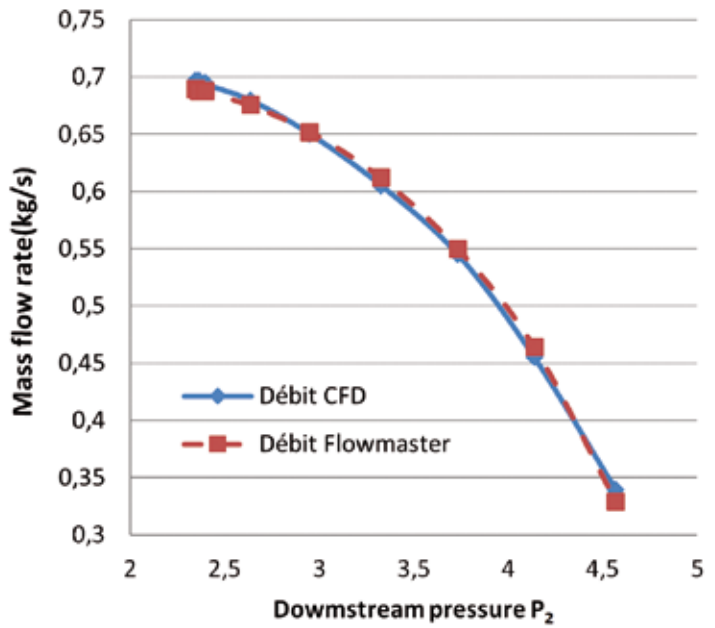


Figure 4 - Mass flow rate depending on the downstream pressure

A parallel with a component created with 3D CFD has also been carried out. The standard coefficients of a 3D piece have been calculated:

$b=0,388$, $C=1,17.10^{-6}$ s.m⁴/kg and $m=0,5585$.

These coefficients have then been set as inputs for the component on Flowmaster and the results found compared with those of the CFD.

Figure 4 shows the obtained mass flow rate results as a function of downstream pressure. The maximum relative error is of 3% which is in accordance with the norm.

Conclusion

A pneumatic component in accordance with the ISO 6358:2013 standard has been created and can be used in Flowmaster networks.

For any real element of a pneumatic system, having its coefficients b , C and m (which should be on the technical data sheet) allows a user to understand the flow through the component with Flowmaster and without the need of doing real experiments on a test bench. This allows the user to do economy of time and money during the study of pneumatic systems.

Furthermore this shows the adaptability of the software regarding the needs of the clients. If in this case a component has been created to be in accordance the last standard, the previous procedure allows any user to create the component he needs and add it to the Flowmaster catalogue.

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Biogas: Biogas collection system study in a waste storage facility

The energy production related to alternative and renewable energies is a major deal with continually increasing energy demands, environmental constraints and ecological constraints. Biogases provide answers to these questions and new technological challenges at the same time. Within the existing solutions which enhance biogases, we present the «skid» case in the present paper which monitors the biogas quality delivered to the engine generating current.

Introduction

Storage facilities receive garbage which are compacted and buried in specific compartments especially designed to contain the biogases produced (cf figure 1).



Fig. 1 – Principles and cross-section of a storage compartment



Fig. 2 – Biogas valorization principles

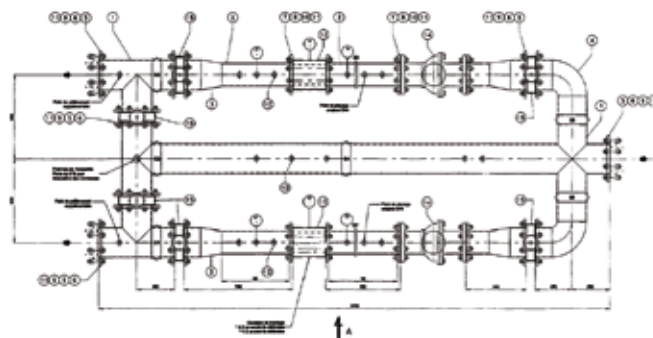


Fig. 3 – Block diagram of the valve "skid"

The biogas caught by the drains is collected and then purified before being used in an engine for producing electrical energy (cf figure 2). The collecting system design whose extension may reach several kilometers with pipes is a complex task. Indeed, biogas production fluctuations with time imply regular and significant modifications of the biogas system and the valorization equipments.

The pressure losses in the biogas collection network are difficult to estimate because of its long branched system. However, the linear pressure loss has to remain very low in order to obtain acceptable ventilated energy consumption. Therefore it is of major interest to optimize the ventilation system design and to assess the impact of the system's modifications.

The software Flowmaster allows rapid and reliable simulation of an existing branched system and a rapid assessment of the modifications' impact projected by the storage facility exploitation. This 1D CFD tool enables the user to optimize a collecting system continuously, i.e. the collecting pipes' diameter and the related ventilation systems.

VALORIZATION PROCESS DESIGN

As part of the biogas energetic valorization study, we present the case of a valve "skid" which regulates the pressure loss of two storage

compartments and collects biogas from these, supplying a suppressor and an engine (cf figure 2).

The “skid” has been designed with Flowmaster from the block diagram provided by Veolia – Propreté (cf figures 3 & 4).

By monitoring the upstream pressure regulation valves, the valve skid has to maintain:

- constant quality of biogas (i.e. at the network exit with Flowmaster);
- The suppressor entrance pressure above a prescribed lowest value

Biogas quality is decreased by parasite air intake in the storage compartment and pressure losses are induced in the system through valves and collectors. The design purpose consists in characterizing all the system pressure losses. This design will be able to identify system areas where pressure losses and parasite air intake risks are the highest.

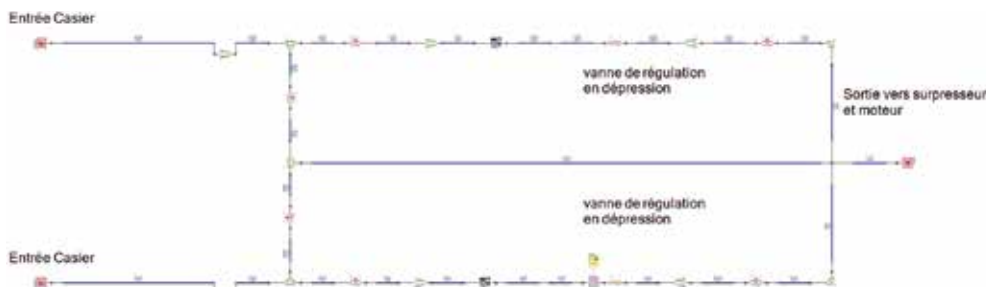


Fig. 4 – Modélisation Flowmaster du «skid» de robinetterie

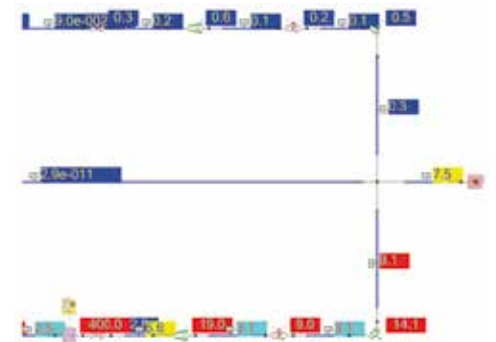


Fig.5 – Pressure losses from valve “skid” at distribution-level towards suppressor and engine

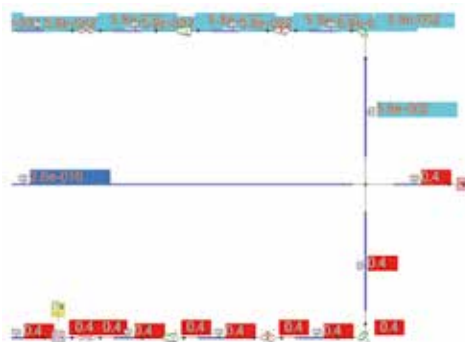


Fig. 6 – Valve “skid” flow at distribution-level towards suppressor and engine

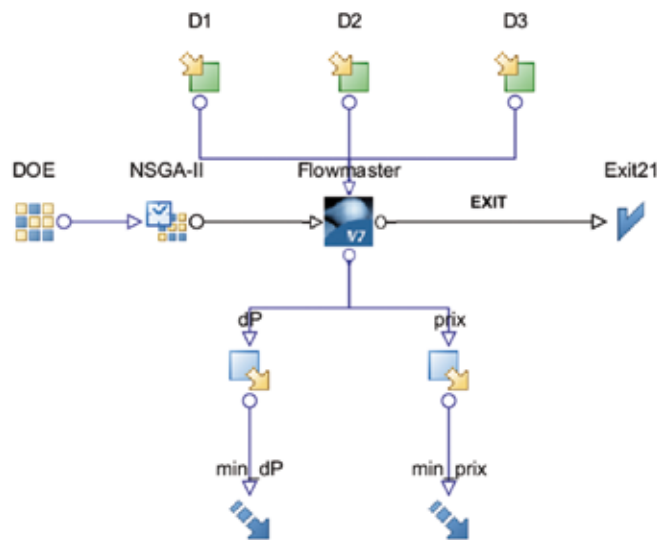


Fig. 7 – Optimization workflow with modeFRONTIER minimizing pressure losses on the “skid” low branch

SIMULATION RESULTS

A compressible steady state calculation has been performed with the Flowmaster model. Pressure losses and distribution flows are both represented in figures 5 and 6.

The highest pressure losses in the low branch “skid” are shown in figure 5. Therefore biogas quality is reduced by dilution with parasite air. This implies the system has to be re-designed biogas quality improvements purposes.

CONCLUSIONS AND PERSPECTIVES

The valve “skid” suggested by Veolia which allows biogas distribution to a suppressor and an engine has been designed with Flowmaster.

Compressible steady state calculations have been done. Calculations have shown the low branch of the valve “skid” is subjected to pressure losses thereby causing possible biogas quality degradation.

As a consequence, a system optimization could be possible by looking for valve designs minimizing the low branch pressure losses on the Flowmaster network. Therefore this optimization has also to minimize the installation price. To make it possible, calculations coupling Flowmaster for the “skid” with the optimization software modeFRONTIER can be done (cf. figure 6) in order to minimize pressure losses and to reach required performance.

In the modeFRONTIER workflow presented in figure 7, three dimensions of the low branch are optimized to reduce installation costs and related pressure losses.

As part of upcoming studies, power production as well as consuming power ventilators will be designed in the skid of Flowmaster network. Two extra objectives will be added to the modeFRONTIER workflow. The energy consumption will be reduced and energy production will be maximized.

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Optimization of a Circular Flange Forging Process

In the conventional forging process, a circular flange was getting forged in 2 stages after heating, i.e. blocker using hammer followed by a combined operation of trimming/piercing/drawing using hydraulic press. This process was having different forging defects at both the stages, viz. under-filling in blocker stage and undesired curvature forming and tearing in combined operation. Additionally reduced tool life was also a problem.

The first step chosen in the methodology was to simulate existing forging process and validate simulation process. Inputs required for simulation were initial billet size, material details, thermal details, die design, forging equipment details, lubrication details, etc. Fig. 1 and Fig. 2 show the simulation results that captured the under-filling during blocker stage and tearing and undesired curvature forming during combined operation similar to actual forging process. This validated the simulation process adopted.

Detailed study was carried out to understand the possible reasons for these defects. Modifying existing forging process was a challenging job, which requires knowledge of die design and understanding of forging process. In blocker stage it was observed that more material

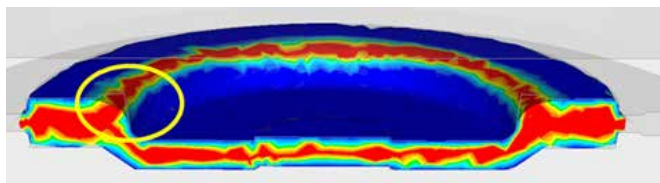


Fig. 1 - Under-filling defect predicted by FORGE 2011

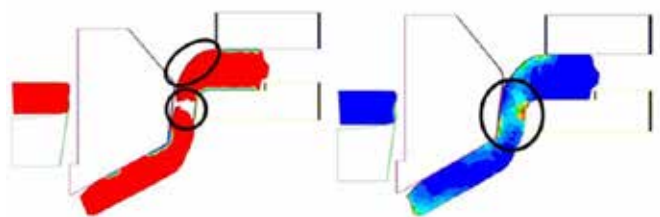


Fig. 2 - Tearing & undesired curvature forming predicted by FORGE 2011

was gathering towards the centre of flange than filling the corners indicating improper design of dies. It was also observed that initial billet size was inadequate for complete filling. Number of iterative simulations were carried out to find the appropriate die shape by changing draft angles, inclinations, fillets, curvatures, etc. and to

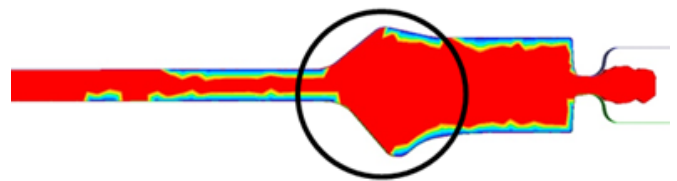


Fig. 3 - No under-filling for modified dies at blocker stage

find optimum billet size for blocker stage to eliminate the defect of under-filling. Billet was changed from rectangular cross section to cylindrical. Fig 3. shows no under-filling after blocker stage by using modified die design. Also no forging defects, viz. folds, cracks, etc. were observed after blocker stage.

In the combined operation (trimming / piercing / drawing), it was observed that less amount of material was getting pierced from central area of component and more amount of diametrical variation was made to get required inner diameter in final component. Due to this die design, more amount of material was flowing outside the area of interest (i.e. waste of material). It was also observed that no proper curvatures were provided on punch causing stress concentration in hub area (as shown in Fig. 2B), which was the cause of initiation of cracks and tearing of component. It also caused die wear and hence less tool life. The punch of combined operation was modified by giving proper fillets and curvatures to minimize the generation of stress concentration and give proper path to material to flow with minimum travel of punch. Fig. 4. shows the forging defects of tearing and undesired curvatures removed after combined operation. As shown in Fig. 5 there was considerable reduction (almost 1/3rd) in the press load requirement because of new die design for combined operation stage which will improve the tool life.

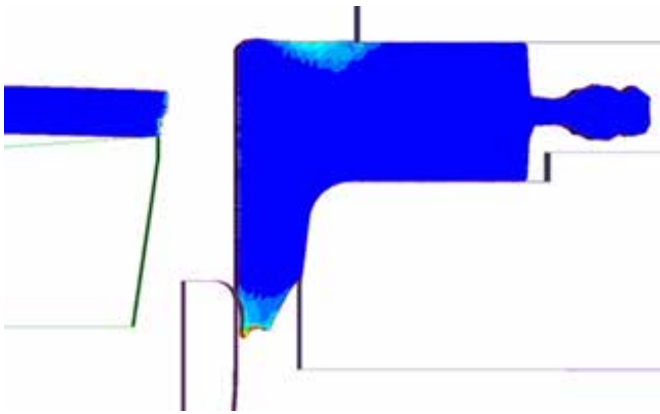


Fig. 4 - No tearing and undesired curvature after combined operation

Shop-floor trials were carried out using modified dies as per the new designs and no defects were observed in the modified process. Machining requirement after combined operation was also reduced considerably.

CONCLUSION:

- Computer simulation could capture the defects in the existing forging process.
- Simulation results gave insight about the forging process and it enabled to find possible reasons for the defects.
- Optimum billet shape and modified die designs were arrived at by iterative computer simulations.
- All the forging defects were removed using the modified forging process.

- Because of modified process, press load was reduced considerably (@ 1/3rd) and hence improved tool life.
- Results of the simulation were validated by shop-floor trials.
- The entire exercise of computer simulation helped to arrive at optimum forging process with no forging defects which gave benefits of reduction in time, cost, energy consumption, waste and improved product quality.

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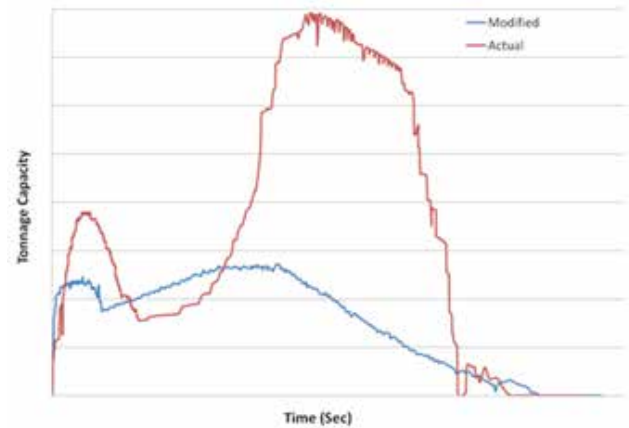
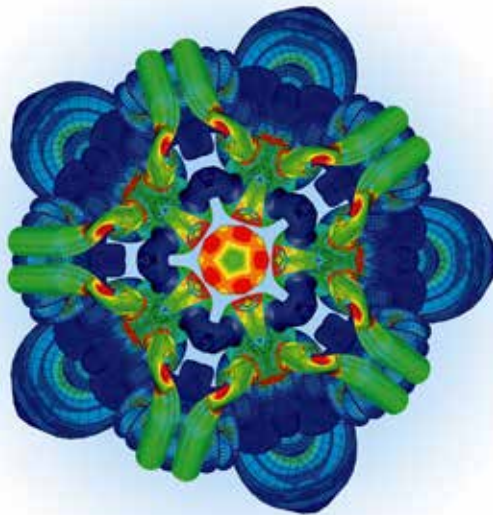


Fig. 5 - Press load for actual and modified die design for combined operation

Case Study - Courtesy of The Automotive Research Association of India (ARAI)



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High-precision mobile and airborne survey



Fig. 1 - The Road-Scanner3 Mobile Mapping System

Relying on a consolidated experience in the field of mapping and surveying, road asset and facility management, and powered by a forward-leaning attitude, Siteco develops and sells world-class technology Mobile Mapping Systems. The Road-Scanner project started with the collaboration of the universities of Parma and Bologna.

Amberg Technologies, an international leading provider of specialized system solutions for the construction and monitoring of civil infrastructures, assigned to Siteco a survey of a stretch of 15 km of the A2 motorway, from Biasca to Faido. The aim of the project was verifying the quality of the data surveyed with Road-Scanner and the creation of a database of the roadside assets. A specific area of investigation of about 2,1 km was prepared within the stretch, in order to

check accuracy and reliability of the MMS survey. In this particular area a topographic high-precision survey was carried out, through a polygonal, by surveying 9 control points for each carriageway. These points made it possible to check the accuracy of the data produced with the mobile survey. In the same area, a Lidar survey was executed with a helicopter, providing a further source of data for the check.

Methodology

The topographic polygonal was obtained by defining the vertices with targets and using some external reattachment points. The topographic targets were installed on the guard-rail and on the border of the motorway pavement so as to be clearly visible, and easy to collimate using the photogrammetric software Road-SIT Survey that allows the operator to intervene directly on the videos and on the point clouds surveyed with Road-Scanner. The equipment used for this survey consisted in 3 Faro Focus 3D laser scanners and 7 high-definition cameras (4 Mpx). With this equipment it was possible to obtain a network of laser points with a maximum distance between the points of about 5 cm and a full high-quality view of the infrastructure.

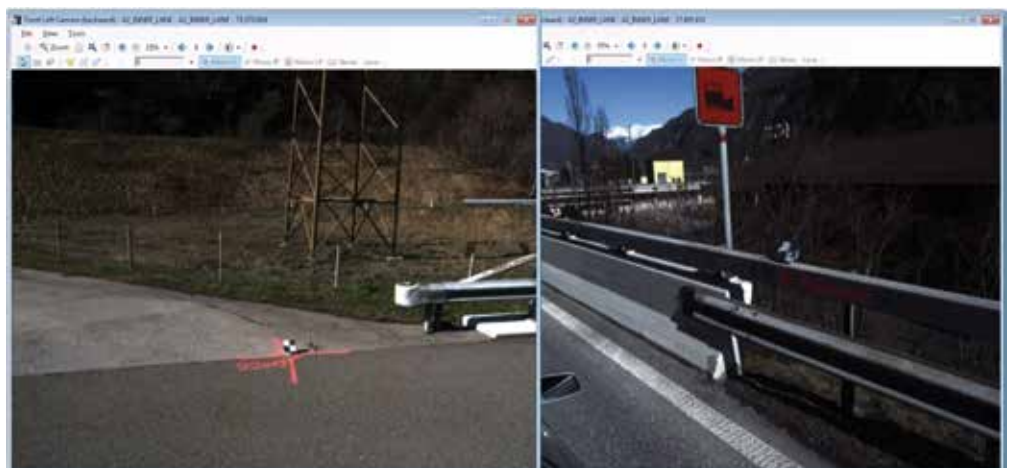


Fig. 2 - Ground control points

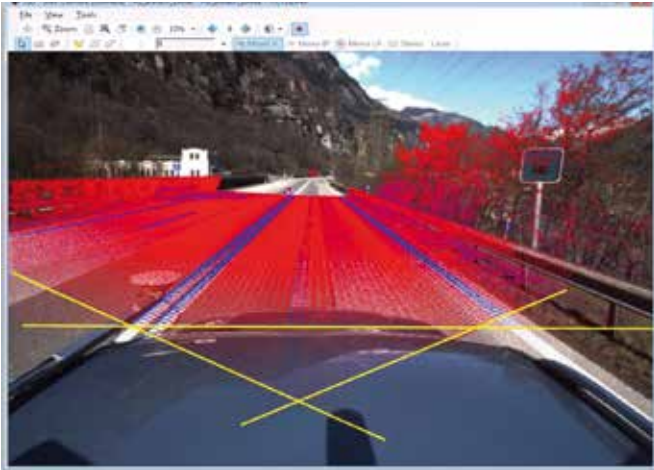


Fig. 3 - The yellow lines in the image above represent the planes of the scans of the 3 laser scanners mounted on the vehicle. The color of the clouds of points, on the basis of the reflectance, allows the highlight of the markings.

Accuracy obtained

The comparison between the coordinates of the targets obtained with the MMS survey and the coordinates defined with the topographic polygonal, showed very limited deviations, within 2.4 cm for most of the points. In 6 cases the deviation was higher, but in any case within 3.4 cm. These values were compatible with the required tolerance, thus no operation of clearing or adaptation of the trajectories was necessary. To be noted that the Road-SIT package contains specific functions for the “rectification” of the trajectory of the vehicle based on the control points. This process uses statistical analyses of the deviations and provides the recalculation of the coordinates of videos and point clouds.

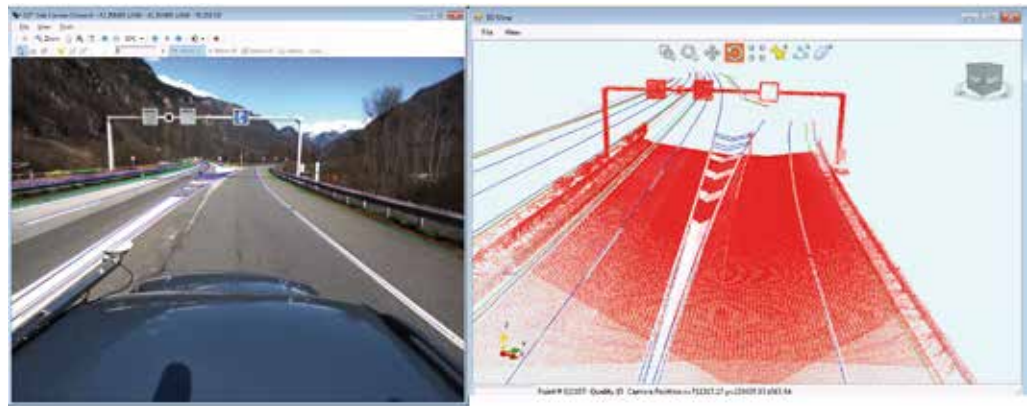


Fig. 4 - The Road-SIT Survey application

Digitization of the survey data

The digitization of the key information that characterizes the motorway was carried out with the tools of the software package Road-SIT Survey. These data were exported to a CAD format and displayed overlapped to the videos. The 3D view made it easier to consult the information collected and get an overview of the infrastructure.

The Road-SIT Survey application allows also the creation of sections based on a line entered by the user, i.e. with a generic (longitudinal, cross, or slant) orientation. These sections are very useful in the process of digitizing the road data.

Overlapping of the MMS survey to the Lidar survey with helicopter

After the mobile survey completion, a Lidar survey with a helicopter was carried out on the same stretch of motorway, obviously keeping the same reference system. The data obtained with the two surveys were exported to the standard LAS format and displayed in overlapping.

The density of the points outside the carriageway is much more reduced because these points were acquired only with the helicopter. On the motorway, instead, both land and airborne surveys are present and perfectly overlapped. To be noted that the MMS scans density is 100 times higher than that of the helicopter. The deviation between the two surveys is very limited, within 2-3 cm for 90% of the points. By analyzing a point cloud section, it is possible to appreciate the level of correspondence between the two surveys. This result had already been found during the testing with the topographic survey of the control points.

The integration of the two surveys provides a complete view of the road infrastructure, combining the benefits of the two different techniques of acquisition:

- The Lidar approach that assures a wide-range survey with a level of details sufficient to recognize the road assets (slopes, embankments, water crossings and pipelines, etc.) and the definition of a digital terrain model.

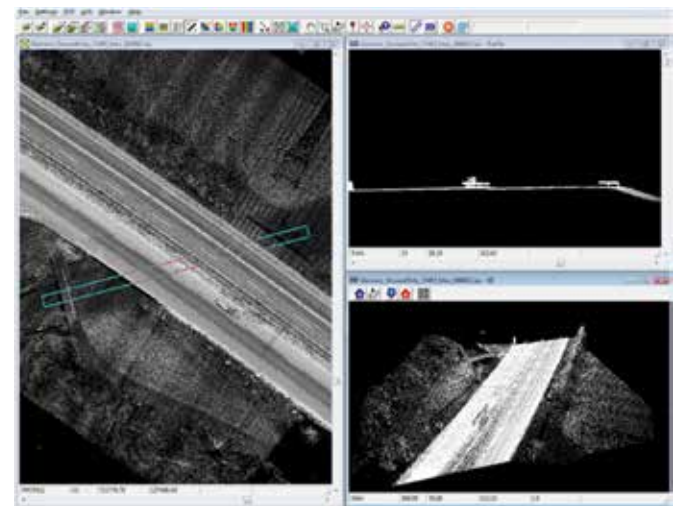


Fig. 5 - overlapping of mobile and airborne survey.

- The MMS survey which provides very detailed information on the road with precision measurements for the single objects. The road survey allows also an optimal view for the acquisition of the information on signage, advertising plants and the overall street furniture.

Augusto Burchi
SITECO Informatica



Interview with TOYOTA MOTOR CORPORATION

The challenges of today's process innovation

TOYOTA is a key representative of the Japanese manufacturing industry and a world leading automaker. Toyota's design and manufacturing practices are always unique and innovative; over the decades, they have also influenced other manufacturers and businesses. In this article, I would like to present an interview that I have had the pleasure to conduct with Mr. Ryusaku Sawada from the Engine Development Innovation Department of TOYOTA.

The history of CAE utilization in TOYOTA

Akiko Kondoh: Can you tell us a bit about when and how you started using CAE technologies in Toyota, your early memories?

Mr Sawada: I joined TOYOTA in 1982. The use of CAE had just commenced around that time. In fact, the car body department began to use CAE to a wide extent in the second half of the '80s, the engine department from the '90s onwards. Hence, we can say

that the first phase of the history of CAE in Toyota was from the mid '80s to the mid '90s. We started with the FEM analysis in the '80s, and we performed analysis calculations by using differential equations. To build the models for the analyses, we created the FEM mesh on the surface models generated from the wireframe CAD models; in the very beginning, we used paper drawings. Then, the engine department adopted a 3D solid CAD, which also changed the analysis process for our 3D solid simulations.

From the beginning, we adopted and relied on 2 different CAE types, "Design CAE" which was to be used by our design engineers, and "Trouble-shooting CAE" to be employed by the CAE experts, as illustrated in Fig.1. At the time, we programmed the original Design CAE which automatically created FEM models by entering the necessary dimensions in the tables. We then offered it to our designers so that they could use the CAE too. Our original Design CAE had customized pre and post processors which performed automatically, with a general-purpose CAE as the solver. It was the Design CAE of the '90s. This special CAE system was adopted for the design of the engine parts, for example for the Crank and Connecting Rod. However, complicated models like the Cylinder Head, required the hexahedral mesh which had to be created manually, and this work required a lot of time. The main purpose was to evaluate the fatigue strength problem. The complicated models were calculated in what we called Trouble-shooting CAE. The simulation work took about 3 months and therefore it could not be applied in the design process. In the car body department, the analysis models were built from the surface mesh. Creating these mesh models required a lot of effort as the mesh size was very large.

Until that time, we had used the original in-house CAD, and as solver, we had applied standard CAE tools like

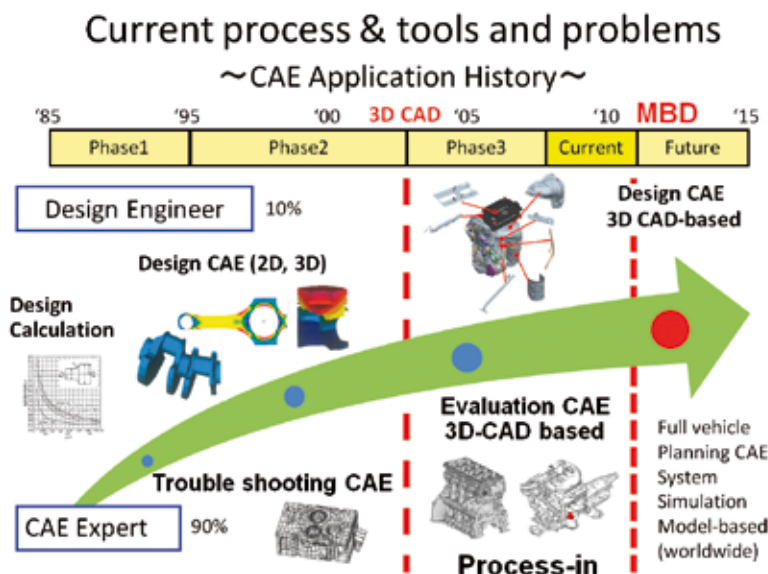


Fig. 1 - CAE application history at TOYOTA

Simulation quality assurance in the car development process ~ meshing requirements ~

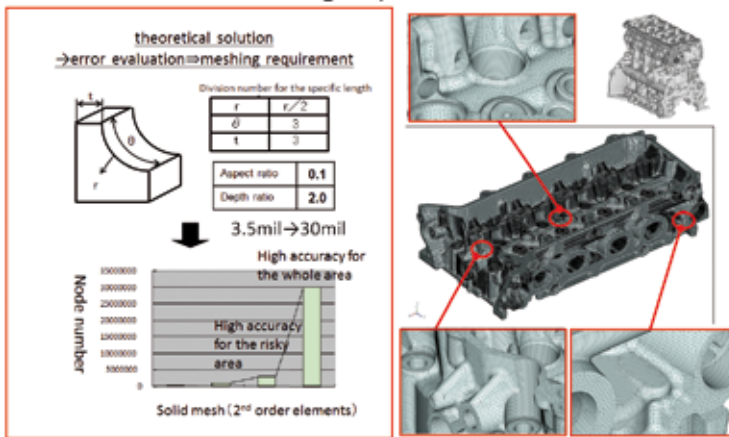


Fig. 2 - Meshing requirements for simulation quality assurance

Nastran and Abaqus. After the year 2000, to fully implement 3D systems, our teams at TOYOTA restructured the engine dept. by introducing Pro/ENGINEER while the car body department now relied on CATIA.

Our expansion for 3D CAD, after what was a major turning point, consequently led to the installation of 3D-based simulation, and we began to manage operations and maintenance accordingly. With our unique strategy, we were able to realize all these new approaches. For example, we developed a function to create the tetra mesh automatically in collaboration with a software vendor. Our aim here was to make efficient use of the 3D CAD. By applying an automatic meshing function, the time for the simulation work could be reduced from about 3 months to approximately 2 weeks.

At the time, the hexahedral mesh was common although it was widely known that the tetra mesh was not accurate enough. TOYOTA began to use the tetra mesh by ensuring its accuracy and implementing the right approaches for such challenges as: what kind of meshing procedures enable the creation of accurate tetra meshes automatically and quickly? TOYOTA was probably the first automaker that put the tetra mesh into practical use. That made it possible for every simulation to be fully embedded in the process. Now we were able to virtually simulate designing models with CAE before the release of the drawing of the prototype and before the process moved forward, rather than simulating after the problems had occurred. We succeeded in using CAE in the design process to reduce the prototype testing instead of simulating it afterwards by following the process. We call it process-in, it was implemented in 2010.

The 3D CAD-based process was a huge step forward. Now, we were able to carry out trouble-shooting CAE in parallel with the design CAE by using the CAD model created by the designers. Moreover, it became possible to consider the requirements for the manufacturing technology because the mold model could be created from the CAD model.

Activities for simulation quality assurance

AK: How do you collaborate today with others involved in CAE, and what are your current challenges and goals?

Mr. Sawada: We at TOYOTA actively promote the technology exchange and encourage regular discussions with other automakers in Europe and in Asia about CAE. We still hear today that meshing automation is the challenge. In the past, each maker used to outsource the meshing work from Japan. Yet recently, we see a change and actually many have now started to perform the meshing inside the companies by automating it. As far as the car body department is concerned, it seems that both options are still being followed, to have the meshing work done internally by automation and to have it outsourced. When we look at the engine department in TOYOTA, the meshing automation is now fully embedded in almost all operations: a great progress indeed from where we began. Since recently and as one of TOYOTA's unique know-how initiatives, we have started to focus on accuracy assurance for the effective use of the simulation process.

To ensure accuracy, the first step has been to build a fine CAD model which can be meshed properly. Now the meshing is successful in almost 100% of the cases thanks to the customization of one of our software tools. As a next step, we have verified the meshing accuracy. At the start, the accuracy of the tetra mesh was lower than the accuracy of the hexahedral mesh. To improve this, we had to use the fine tetra mesh and define the number of divisions in the specific areas or lengths sufficiently, in order to ensure accuracy. All this required a lot of effort really. After accumulating our know-how, we embedded it into our CAD system so that we could define the meshing requirements, e.g. what kind of mesh is necessary for a certain type of model inside the CAD. To be more specific, we could automatically define that the fillet of 90 degrees needed to be divided into 3 and which boundary condition was applied to which group. This meant that we only needed to do the manual work for the grouping at the beginning. In this way, we could eliminate the variation that depends on the engineering

CAE & MBD Vision (Toyota Group)

~How we develop~

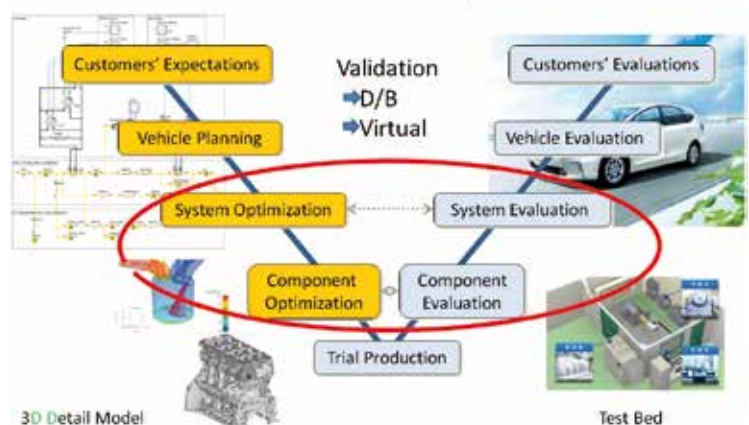


Fig. 3 - The V-process

work, as the CAD system created the mesh automatically by understanding the boundary condition value and the meshing division number from the database.

The topics we discussed at the time for the tetra mesh focused on the structural analysis. Our recent discussions are about the fluid dynamics analysis which requires that we verify the meshing discretization error. Also, we have to consider the fact that hypothetical models are used when we want to improve simulation quality assurance. Moreover, although the structural analysis can be verified relatively easily by using the strain gauge, our fluid dynamics analysis needs to be evaluated by laser measurements, such as PIV (Particle Image Velocimetry). Here we should note that the accuracy of PIV is sometimes obscure, and that we can reduce the error only from a statistical standpoint. For instance, the verification of the turbulence, which involves flow velocity fluctuation is a challenging area.

This is why, since 2012, our simulation quality assurance activities for the car body development also cover these and related topics. For example, we started several efforts to obtain some standard solutions for the flow velocity and the velocity fluctuation which flow into certain primitive shapes, such as flat plates, straight pipes and bent pipes.

We were using the K-Computer for this work. At the time, back in June 2011, the TOP500 Project Committee announced that K had set a LINPACK record with a performance of 8.162 petaflops, making it the fastest supercomputer in the world. Professors from several universities, Japanese automakers and software vendors participated and strongly supported the cooperation that led to these outstanding performances. Back then we applied DNC (Direct Numerical Simulation) which solves the Navier-Stokes equation directly, the analysis model was meshed finely to the utmost limit. The calculations on the K-Computer took an immense amount of time to eliminate the error. We tried to create the physical models by finding the regularity. By using physical models, we could also calculate other analysis problems fast enough on our regular computers. I have always thought that the K-computer will be helpful for such and similar efforts.

Concerning the operation of the K-computer, it is true that the ratio of its industrial use is relatively small in %. The K-computer is a super-massive parallel computer. However, most commercial software programs don't work or don't work on it effectively enough. Therefore, a special program which suits this powerful machine has to be developed and installed if we want to run some engineering simulations on the K-computer. In my role as a member of the working group that discusses the positioning of future super computers, I have had many talks with the government and professors about the implementation and use of these machines which hugely support our industries today.

The model-based development

~Process break down and optimization~ ←model

Process	Objective functions		Design parameters
Product planning (vehicle)	Fuel consumption	Mode/Actual fuel consumption	System capabilities = Target values • Vehicle body size, Weight • Engine mount position, characteristics • Suspension characteristics • Mounting stiffness
	Sound	Acceleration, Sound pressure	
	Driving performance	Acceleration	
System design (powertrain)	Fuel consumption	Fuel consumption, Friction Water/Oil temperature	Component capabilities = Target values • Engine basic data Bore, Stroke, Pressure ratio, Volumetric efficiency • Drive-train basic data torque converter, CVT, gear
	Sound	Acceleration	
	Driving performance	Torque, Torque fluctuations	
Component design	Fuel consumption	Friction, Oil temperature	• Engine combustion chamber, Port Intake/Exhaust system, Cooling/Lubricating system • Engine transfer system • Drive-train transfer system • Component detailed design parameters
	Sound	Combustion pressure, Eigenvalue	
	Driving performance	Combustion pressure, Torque fluctuations	

Fig. 4 The breaking down process for the model-based development

Innovative changes in the engine development process, the “V-process”

AK: Can you give us some general insight into your current product development and the role of CAE and MBD in Toyota today?

Mr. Sawada: Recently, for example, we have entered a phase of changes from the 3D model-based process which was established a number of years ago. In the 3D-based process, we used to create the 3D models at first. When we want to take a look at the engine for instance, the workflow demands that we first concentrate on the layout of the car body. Then, we have to check the financial requirements, such as the costs for the standardization of the parts and the productivity in the manufacturing process. Lastly, we verify reliability, durability and optimization of each function, e.g. noise and vibration. However, as we all know, product development should be based on the expectations and requirements of the customer, the end-user, and not on the constraints that I just mentioned. This is why we are proposing the V-process as a new flow. Our V-process includes 5 steps that are dedicated to the customers' needs regarding fuel consumption and driving performance. We focus on the actual capabilities of the car body, the system and the parts, we design models that satisfy given requirements. We do prototype testing and evaluations of the car body, the system and the components. Eventually, we deliver the final product to our customers. We have our own way of introducing the V-process in TOYOTA, although the idea of this process has not been created solely by TOYOTA, it already exists for a while. To perfect our product development by applying this process also requires that we think carefully about our human resources.

The idea of breaking down the capabilities is a new way of thinking. The breaking down comprises the objectives and capabilities for our customers, and the design parameters are assessed to guarantee these capabilities. The design parameters also contain already the target values for the capabilities of the next step. The capabilities are broken down and the design is considered from

the outline in every single detail. An important aspect for all this are the models, which connect the capabilities and the model design, such as physical models, statistical models, 1D models and 3D discretization models. The 3D discretization models which we have mainly used until now, give us some sort of an answer as they generate 3D models, the meshing, and we can click the simulation button. Yet, during such a process, we tend to lose our ideas and imagination about how we design the model in view of the required capabilities. Therefore, we are convinced that it is important to consider the model design and to do a break down of the capabilities (Fig.5).

When we think about how to develop an idea to consider the capabilities, one possibility is to study the model design of other car makers. This does not mean to just measure and view the design dimensions, but to also look into the mechanism by making models, breaking down the capabilities and activating them. Another way is to experience some trouble shootings. To put it more specifically, it means breaking down the capabilities including troubles, formulating the hypothetical models, recreating

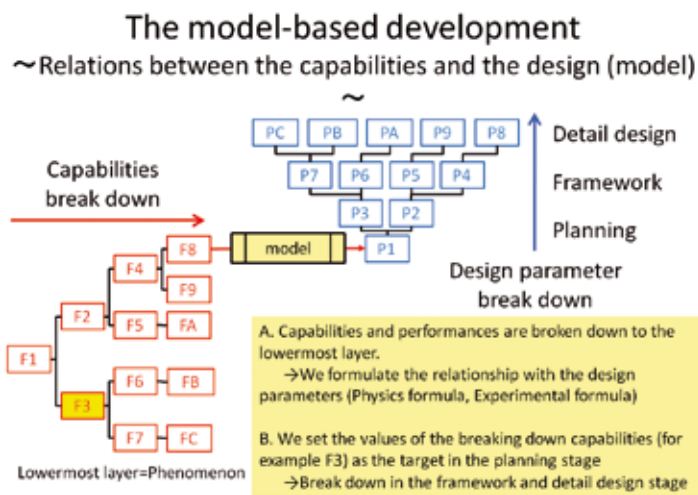


Fig.5 - Relationship between capabilities and design

any specific behavior with the models and considering the robust model design which ensures the capabilities. In the new process, it would be necessary for engineers to acquire the abilities to consider and analyze the capabilities, and to model (formulate) and design (create) them. To be able to do all this, we need the skills to use CAE tools and an understanding of the physical equations. Moreover, what I regard as most important, is to have the engineering mind's eye. I hope to nurture exceptional engineers who have this special gift and who can tackle CAE with a sense of intuition.

Robust product development for companies and society

AK: Can you share some of your thoughts concerning testing, safety and quality engineering?

Mr. Sawada: Auto makers today spend enormous amounts of money and resources for crash tests and other internal evaluations with the aim to increase safety factors, to assure the high quality of the products and to avoid delivering defective products to the market. At the same time, they continue their efforts to maintain and grow the society's interest in their products. When we look

at the nuclear and aerospace industries for example, companies usually increase the safety factors to a much higher extend than the given minimum value. In such situations, they face the challenge how to decrease the safety factor in order to reduce the company's losses. Originally, if we decrease the society's loss, it increases the company's loss. It is a trade-off.

The fundamental idea of quality engineering is: Satisfying the needs of and the functions for society increases the company's loss, and as this is a matter of variations, it is necessary to be robust in order to reduce both the company's and the society's losses. Therefore, we should regard the safety factor as the balance between the company's and the society's loss, and not just define the safety factor as being equal to the durability. To reduce the society's loss, at first an internal evaluation to increase the safety factor is required and then, we should think about the robust design and reduce the variations to decrease the company's loss. If we look at some recent accidents in the national headlines, the causes are often that various different safety factors were not checked thoroughly enough. Capabilities and their impact on safety were not fully applied even if their strengths would have been more than sufficient. This is why we grow and promote our knowledge and plans concerning the safety factors.

Future challenges

AK: What are your visions for networking in our global CAE community and for innovation in the design and manufacturing sectors?

Mr. Sawada: It's important to combine the wisdom of the people from industry, the academia and the government, to make the design and manufacturing in Japan stronger and better. Although the cooperation between our industry, the universities and governmental bodies used to be far behind compared to Europe, the situation is changing rapidly for the good, and we are working more closely together now. For instance, JSCES (the Japan Society for Computational Engineering and Science) established their design and manufacturing study group 4 years ago to obtain ideas and the necessary support from industry, academic institutions and our government (We introduced JSCES in the EnginSoft Newsletter 2010 Winter Issue). These days, we also foster a number of other activities with the same goals; for example we invite different automakers to discuss specific innovative areas, such as model-based design. We collaborate on topics that are important to us and where we do not compete with others. The future goal is that we break all barriers between industry, the academia, the government, different companies and organizations. We should all contribute jointly for the sake of our society by developing several aspects in the country and in industry. To realize all this, to make it happen, I want to work together with all the parties mentioned and in this way support innovation in the design and manufacturing sectors in Japan.

*This article is based on an interview with Mr. Ryusaku Sawada from the Engine Development Innovation Department in TOYOTA.

*Written by Akiko Kondoh,
 Consultant for EnginSoft in Japan*



ANSYS Transient Blade Row, the new method to obtain accurate and fast transient turbomachinery solutions

The influence of unsteady flow on turbomachinery performance has been widely investigated in these years. The interpretation of the unsteady flow effects in turbomachinery is still today a controversial issue for designers. In the past, the common opinion says that unsteadiness always brings a loss in efficiency. By deepening knowledge of the unsteady mechanisms, designers progressively realize that the unsteady flow effects could give some kind of benefit.

Most of the turbomachinery developed up to now are based on the hypothesis of steady-state flow, and designers rely on the use of correlations and their experience to account for unsteady effects. But these aspects cannot reflect the true physical nature of the mechanisms in the unsteady environment.

Flow in turbomachinery is highly unsteady because of the distortions generated by the relative motion of rotor/stator blade rows in a multistage environment.

This unsteadiness has important consequences for the turbomachinery efficiency, blade loading, heat transfer, mechanical and thermal fatigue, and noise generation. It can be computationally expensive to predict the unsteady phenomena that occur as a result of the interaction between adjacent blade rows (as potential interaction, wakes, shock interactions, streamwise vortices, etc.), blade flutter, or boundary disturbances. It can be even more expensive if the designer needs to include more than a few passages per blade row to capture the phenomena more accurately.

In typical turbomachinery applications, it is very common that one or both blade rows have a prime number of blades per wheel. Formerly in such cases, it was necessary to model the whole 360° wheel in order to attain the required level of accuracy. How to obtain the full-wheel transient solution, but at low cost?

Transient Blade Row

The Transient Blade Row (TBR) models available in ANSYS CFX make it possible reducing the computational costs (memory and computational time) by solving the blade row solution for one or two passages per row, while still obtaining reasonably accurate solutions, thus providing a solution to the unequal pitch problem between the blade passages of neighbouring rows. Typical TBR applications involve Single-Stage analysis, Multi-Stage analysis,

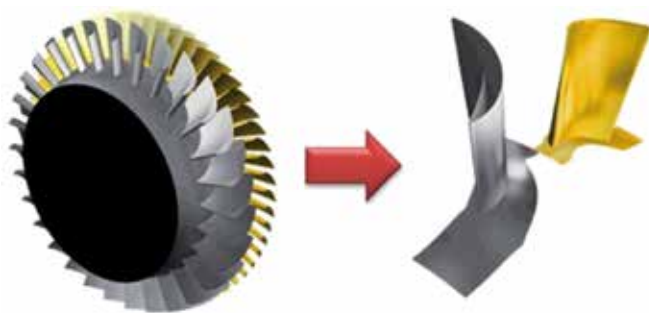


Fig. 1

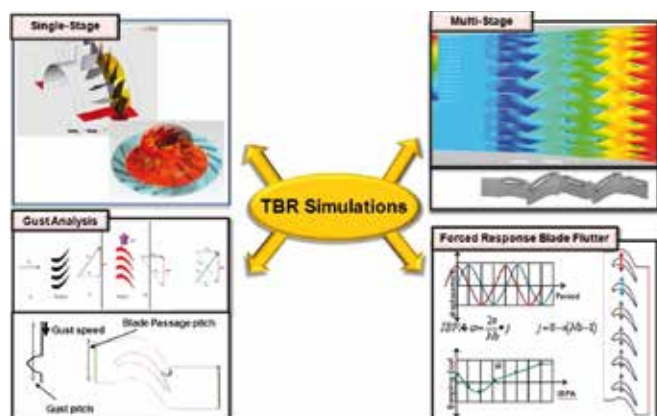


Fig. 2

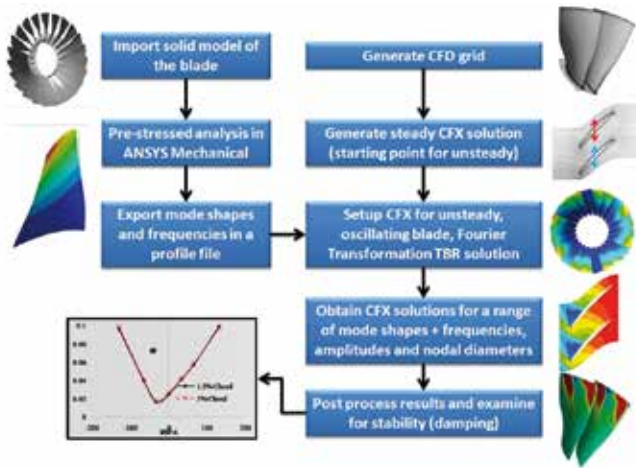


Fig. 3

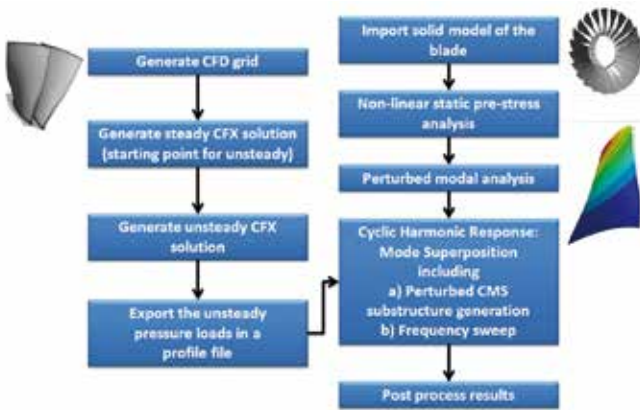


Fig. 4

Gust or Inlet-disturbance analysis, and aeroelasticity (both blade flutter and forced response), as shown in Figure 2.

Three different TBR methods are available in ANSYS CFX 14.5:

- Profile Transformation Method
This method overcomes the unequal pitch problem by scaling the flow profile across the blade row interfaces (full conservation is maintained). It can be applied with single-passage (one blade per row), in Single-Stage and Multi-Stage applications, with small pitch ratio and all-speed flows.

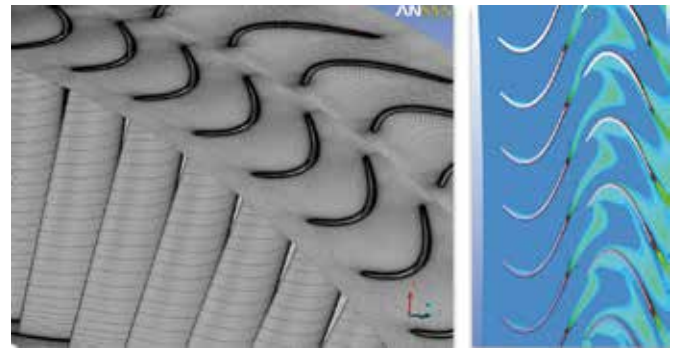


Fig. 5

- Time Transformation Method
In this method the unequal pitch problem is overcome by applying a time transformation (Time-Inclining method, Giles 1988) to the flow equations which allow the use of simple periodic boundary conditions on the pitch-wise boundaries with no approximation. It can be applied with single-passage, in Single-Stage and Inlet-disturbance applications, with moderate pitch-ratio and compressible flows.
- Fourier Transformation Method
In this method, based on the Shape-Correction method of L. He (1989) and Chorochronic interface periodicity of Gerolymos (2002), a phase-shifted boundary condition with Fourier data compression is used to account for the unequal pitch between the blade rows passages. Fourier series are used for reconstruction of solution history on pitch-wise boundary and inter-row interfaces for efficient data storage and convergence. It can be applied with double-passage strategy (faster convergence than single passage), in Single-stage, Multi-stage, and blade-flutter applications, with large-pitch ratios and all-speed flows.

A typical TBR application: Aeroelasticity

Nowadays, one of the most interesting applications is related to aeroelasticity. It is clear that aeromechanics design is essential for machine stability, safety and reliability. The design process requires simulation of both the aerodynamics and the mechanics.

Method	Steady-state	Profile Transformation Transient Rotor Stator	Time Transformation Transient Rotor Stator	¼ Wheel Transient Rotor Stator
Mass flow	122.83	122.95	122.99	122.97
Expansion ratio	1.4912	1.4907	1.4907	1.4907
Work	2.7994	2.805	2.8106	2.8116
Efficiency	91.330	91.784	91.932	91.882

Table 1 - Performance at Design Point

Method	Steady-state	Profile Transformation Transient Rotor Stator	Time Transformation Transient Rotor Stator	¼ Wheel Transient Rotor Stator
Relative Mesh Size	1	1	1	20.2
No. of Timesteps	150	616	616	616
Iter. Per Timestep	1	3	5	4
Estimated Effort	1	12	21	333
Actual Effort	1	10.7	16.3	470.8

Table 2 - Relative CPU Requirement at Design Point

Historically, the aero and the mechanical groups work somewhat independently, exchanging designs in an iterative, sequential manner. Current design directions favour a somewhat more integrated solution, to reduce iteration between the two groups, or at least improve the cycle time. New TBR methods are an enabling technology for this integration. In fact, they supply high-fidelity solutions for lower computational cost and computing resources by simulating only one/two blades per row instead of all or a larger fraction thereof.

A classical approach to the aeromechanics problems leads to a full-coupled FSI analysis, which is sometimes prohibitively expensive. A different, more practical approach is to uncouple the physics and see if blade flutter or structure fail will occur.

If we consider the Blade Flutter problem, we know that it occurs at blade natural frequency and it is dependent on aerodynamic and structural characteristic of the blade. Then, first we perform a modal analysis that provides the natural frequencies and corresponding modal shapes (FEM). From these data, only specific mode shapes are selected to specify the blade motion for CFD simulation with mesh morphing. Computing aeroelastic damping based on work done on the blade by the fluid, we can predict if the blade will or will not flutter. This process is drawn in Figure 3.

If we consider the Forced Response problem, first we estimate blade excitation forces through a CFD analysis. Then we perform a structural analysis (FEM) in order to compute the blade response, predicting the blade motion and when the structure will fail. This process is drawn in Figure 4.

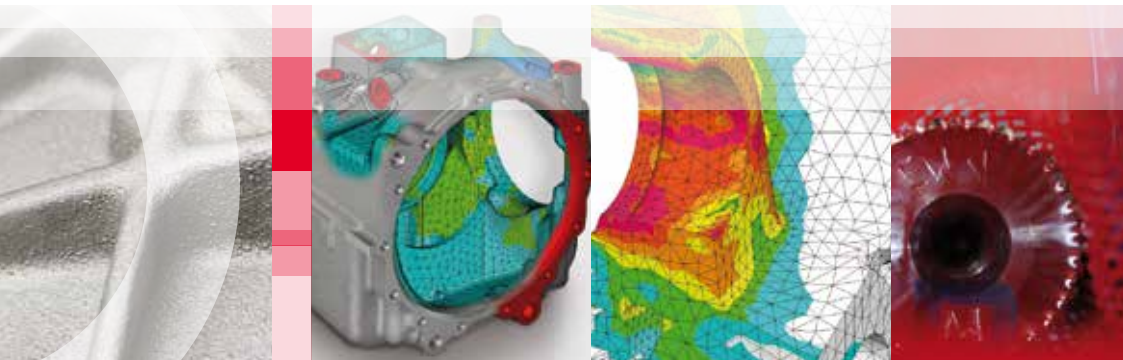
An example of TBR application: Low Pressure Turbine

This low pressure turbine has been designed by PCA Engineers Ltd. It consists of 88 blades on stator and 76 blades on rotor, so the computational domain used as reference comprises $\frac{1}{4}$ wheel (Figure 5).

In this example, Time Transformation method (single passage solution) is compared to true-transient solution (22 passages for stator, 19 passages for rotor). Profile Transformation and Steady-State Stage calculations are also performed.

Results, described in Table 1, show very close performance values by all four methods. It is clear that, if we are interested in unsteady effects, Profile Transformation and Time Transformation give significant advantages respect to the $\frac{1}{4}$ Wheel – TRS solution. In particular, Time Transformation simulation is 30 times less costly than $\frac{1}{4}$ Wheel.

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MAGNA
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FEMFAT (Finite Element Method Fatigue) performs fatigue analyses in combination with all leading finite element pre-processors and solvers.

Fatigue Analysis Software

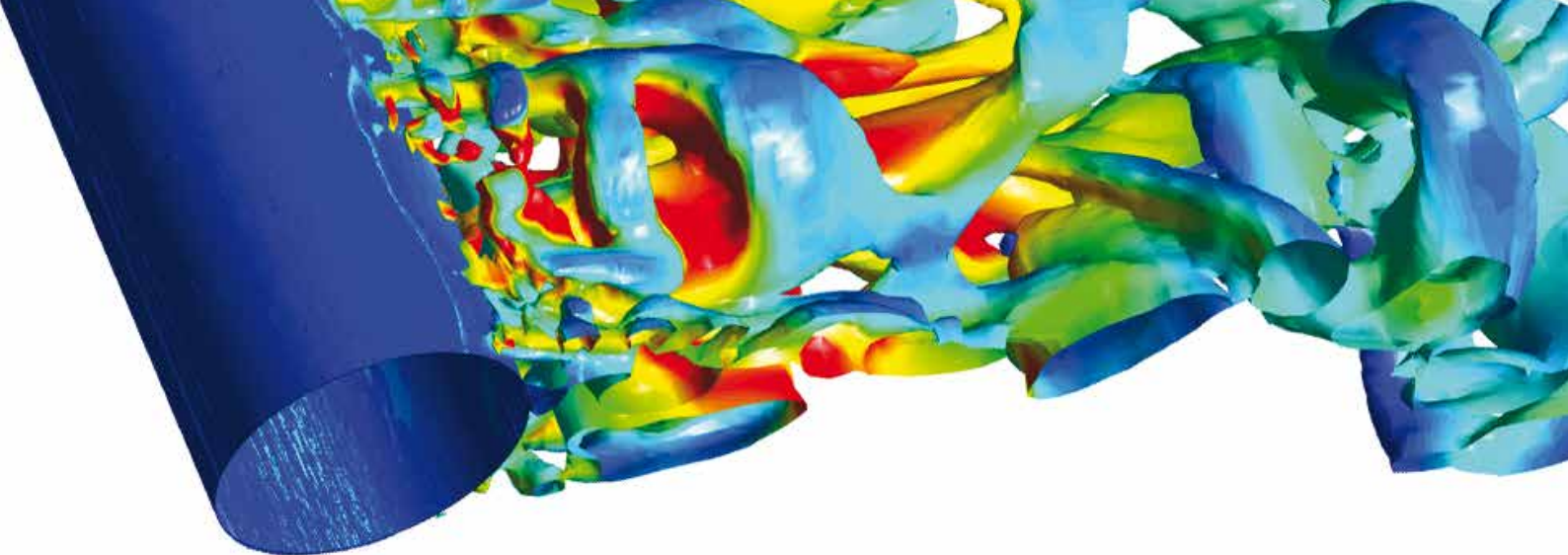
The fatigue software package **FEMFAT** consists of many modules, each for particular use and more powerful if combined.

About 500 fatigue-related projects – analyses and tests performed at Engineering Center Steyr during the last two decades have provided valuable feedback for the technology and software development.

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FEMFAT software
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ANSYS CFD Professional

Dal mese di luglio 2013, la suite CFD di ANSYS, si arricchisce con un nuovo prodotto, ANSYS CFD Professional, che consente agli utenti di approcciare in maniera rapida ed accurata problemi di termo-fluidodinamica di base. Il prodotto è basato sull'interfaccia e la tecnologia di ANSYS CFX e si colloca in una fascia entry-level rispetto agli utenti, alle possibilità offerte da ANSYS e, più in generale, al mercato di riferimento. Il prodotto è disponibile da subito attraverso uno speciale "licensing term".

Di seguito, alcuni dettagli tecnici sul prodotto, nella forma di risposta a tipiche domande di interesse.

Che tipo di analisi cfd si possono affrontare con ANSYS CFD Professional?

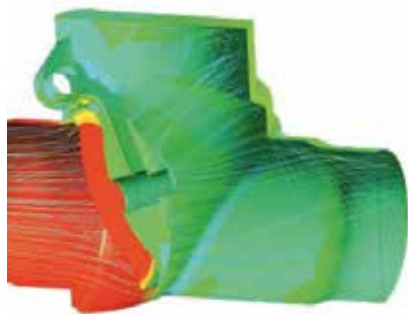
- Analisi stazionarie
- Analisi con fluidi incomprimibili
- Analisi con fluidi mono fase
- Analisi con scambio termico per convezione forzata
- Analisi con scambio termico coniugato

A quali tipi di mercato e applicazioni ANSYS CFD Professional è principalmente riferibile?

- Applicazioni governate da fluidi con comportamento standard e con eventuale trasferimento di calore, ad esempio:
 - o Valvole (senza lo studio di fenomeni multifase)
 - o Piping e connessioni
 - o Scambiatori di calore (senza modellazione di passaggio di fase)
 - o ...

Quali sono le tipi informazioni estraibili da una simulazione svolta con ANSYS CFD Professional?

- Perdite di carico
- Split portate
- Flussi di calore
- Potenze termiche scambiate
- ...



Pressure contour & stream lines (Courtesy of Cameron)

Quali sono le realtà aziendali a cui questo prodotto potrebbe interessare?

- Aziende anche sprovviste di utente CFD e/o con scarsa esperienza nel settore
- Aziende che hanno applicativi per la simulazione in ambito strutturale, ma non cfd
- ...

Qual è la tipologia di utente che può utilizzare questo prodotto?

- Ingegneri, anche senza alcuna (o con scarsa) esperienza nelle simulazioni CFD
- Utenti CAD o che lavorano a contatto con utilizzatori di sistemi CAD
- Ingegneri che lavorano nell'ambito della verifica design, validazione prodotto, progettazione, sia a livello "concept" che di dettaglio
- ...

Quali sono le principali caratteristiche e vantaggi di questo prodotto?

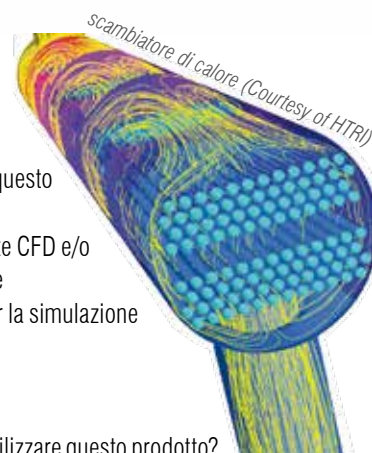
- Estrazione del volume fluido direttamente da CAD
- Meshing automatico (ANSYS Workbench Meshing)
- Interfaccia grafica semplice ed intuitiva
- Di facile utilizzo
- Affidabile e robusto (il core solver è ANSYS CFX, codice validato da diversi utenti nel mondo e tra i leader del settore, nel mercato di riferimento)
- Materiale di training esteso e consolidato, disponibile ai clienti sia on-line che con corsi di formazione, sia calendarizzati che ad-hoc
- ANSYS CFD Professional si può accoppiare con ANSYS Mechanical all'interno di Workbench
- Facile up-grade ai prodotti di livello superiore (ANSYS CFD FLO, ANSYS CFX), ad esempio per
 - o problemi con fisiche più complesse
 - o problemi di ottimizzazione e/o robust design
 - o simulazioni multi-fisiche
- ...

Per ulteriori informazioni sul prodotto e sui relativi corsi:

Contatto: Luca Brugali, EnginSoft

Tel. 035-368711; email: info@enginsoft.it

<http://www.enginsoft.it/formazione/corsi2013/index.html#cfid>



Aeroacoustic simulation in ANSYS CFD

Acoustics is the scientific study of sound. Sound is the result of pressure variations, or oscillations, in an elastic medium (gas, liquid or solid), generated by a vibrating surface or turbulent fluctuations. When a sound wave propagates in air, the oscillations in pressure are above and below the ambient atmospheric pressure. Noise can be defined as unwanted sound. From the acoustics point of view, sound and noise constitute the same phenomenon of pressure fluctuation. Aeroacoustics is a branch of acoustics that studies noise generation via either turbulent fluid motion or aerodynamic forces interacting

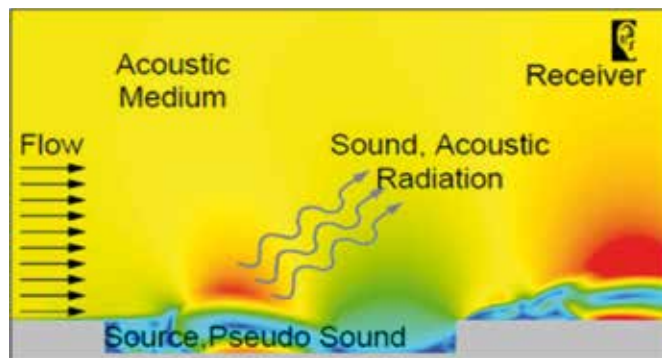


Fig. 1 - Aeroacoustic entities: acoustic medium, sources, sound and receivers

with surfaces. There are four primary entities in the Aeroacoustics problems: the acoustic medium, the source, the sound and the receivers. The acoustic medium is the air and the sound sources are the flow structures that induce pressure fluctuations in air. The sources can be in the form of any unsteady flow structures such as vortices, shear-layers or turbulent eddies. Waves travel inside the medium and the receivers (microphone or human ear) measure the sound level. Pressure and velocity fluctuations generally result in near field noise where the maximum noise levels occur. In contrast, far field noise is the noise level that occurs at some distance from the sources. ANSYS CFD is a powerful tool for Aeroacoustics simulations. Due to

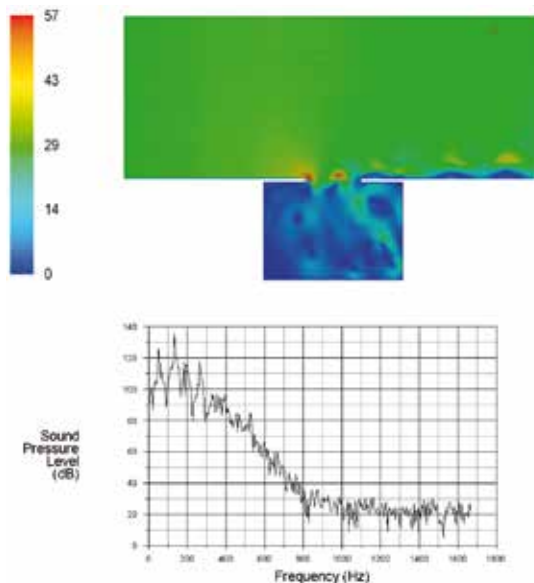


Fig. 2 - ANSYS FLUENT – Direct Method (CAA) and an Helmholtz Resonator: instantaneous velocities [m/s] and SPL computed at the point indicated

the nature of the phenomena, high fidelity simulations need to be performed in order to solve for the noise generation and propagation and ANSYS CFD solvers, with high order discretization schemes and accurate turbulence modelling, fit this requirement.

There are different ways to model sound generation using CFD:

- Computational Aeroacoustics (CAA): sometimes referred to as Direct Noise Computation (DNC), this method directly solves for sound sources and propagation in a single comprehensive model using transient Navier-Stokes equations solved in a domain where sources and receivers are placed.
- Segregated Source-Propagation Methods (SSPM): two different computations are used to solve sound source and propagation. The problem domain can be thought to be composed of a flow field (transient Navier-Stokes equations and sound generation) and an Acoustic field (Wave equations and sound propagation). Different methods can be used to solve the Acoustic field:
 - o Integral Methods (Ffowcs-Williams and Hawkings method, Kirchoff's method)
 - o Boundary Element Methods (BEM)
 - o Variational Methods (FEM, Lighthill's equation)
- Stochastic Noise Generation and Radiation (SNGR): if the sound is broadband, i.e. without any prominent tones characterized

by sharp peaks in spectrum, then source strengths can be evaluated with reasonable accuracy from time-averaged structure of the turbulent flow in the source regions.

These approaches are characterized by different computational effort, order of accuracy and extent of applicability.

ANSYS FLUENT offers three approaches to computing aerodynamically generated noise: a direct method, an integral method based on acoustic analogy and a method that utilizes broadband noise source models. In the direct method, generation and propagation of sound waves are directly computed but the prediction requires time-accurate solutions with very fine computational meshes. Unsteady

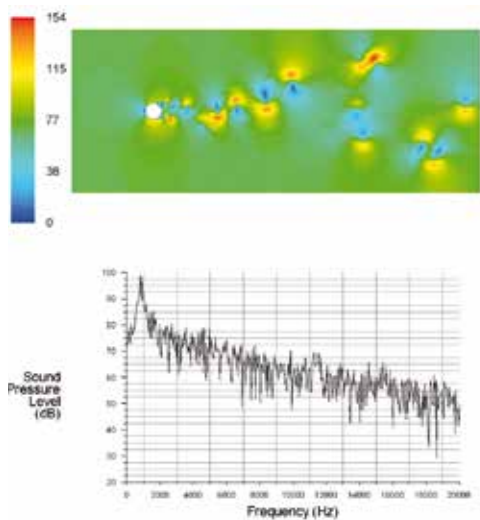


Fig. 3 - ANSYS FLUENT – FW-H Method and Aeroacoustic Noise: instantaneous velocities [m/s] around a cylinder and SPL computed at a distance of 128 diameters vertically using FW-H method.

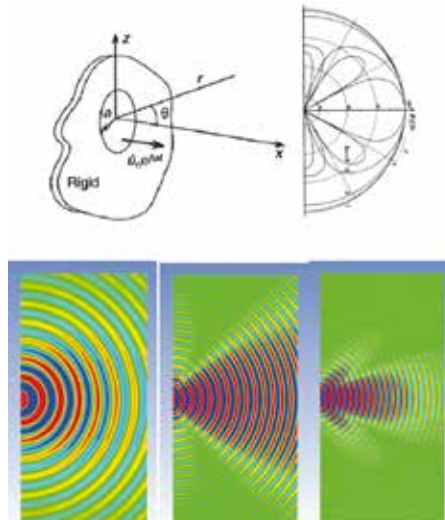


Fig. 5 - ANSYS CFX – Direct method: pressure fluctuations for an oscillating plate (in the middle of the geometry) at different frequency

FLUENT offers several broadband noise source models that enable you to quantify the local contribution to the total acoustic power generated by the flow. Unlike the direct method and the FW-H integral method, these models do not require transient solutions to any governing fluid dynamic equations. All source models require what typical RANS model would provide, such as the mean velocity field, turbulent kinetic energy and the dissipation rate. These statistical turbulence quantities can be used to extract useful diagnostics on the noise source to determine which portion of the flow is primarily responsible for the noise generation.

ANSYS CFX offers two approaches to computing aerodynamically generated noise: a direct method and the strength estimation of noise sources.

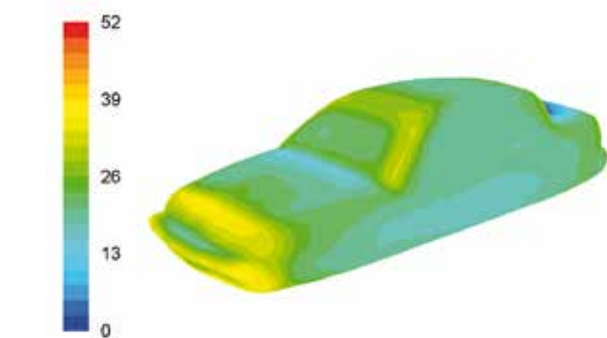


Fig. 4 - ANSYS FLUENT – Broadband Model: acoustic power level [dB] around a car

In the direct method CFX can directly analyze near field noise and its effects upon the flow field but direct prediction of mid to far field noise is made somewhat impractical because of the meshing and timestep requirements. The limits and advantages of this method have already been discussed.

When the far field sound pressure levels must be evaluated, ANSYS CFX offers the possibility to compute the strength of the noise sources without solving the Lighthill equation. In fact, noise sources for the Lighthill equation can arise from several sources. These include displacement of the fluid by a moving boundary, pressure fluctuations on surfaces within the CFD calculation, as well as interior flow features. The first of these sources is called a monopole source. The second is called a dipole source, is the surface is stationary, or it is called a rotating dipole source, if the surface is rotating at a fixed angular velocity about an axis. Finally, interior sources are usually referred to as quadrupole sources. The sources can be post processed and can also be written as transient solution fields from the flow solver on selected boundary conditions. Analysis of various source terms allows comparative evaluations of different design, as well as comparison of the relative strengths of the various types of source terms.

simulations, high order discretization schemes, DES or LES methods and Non Reflective Boundary conditions (NRBC) are mandatory. This method is practical for the prediction of the near field noise.

For the prediction of mid- to far –field noise, an integral method based on Lighthill’s acoustic analogy offer viable alternatives to the direct method. ANSYS FLUENT offers a method based on the Ffowcs-Williams and Hawkins (FW-H) formulation. Time-accurate solutions can be obtained from unsteady RANS, LES or DES, depending on the features that you want to capture and then, the source (emission) surfaces area used from the FW-H method to predict the sound generated not only in the computational domain but also in the free space. The model can be used to predict far-field noise due to external flows, such as the flows around objects, but it cannot be used for predicting the noise propagation inside wall-enclosed space.

When the sound energy is continuously distributed over a broad range of frequencies, ANSYS

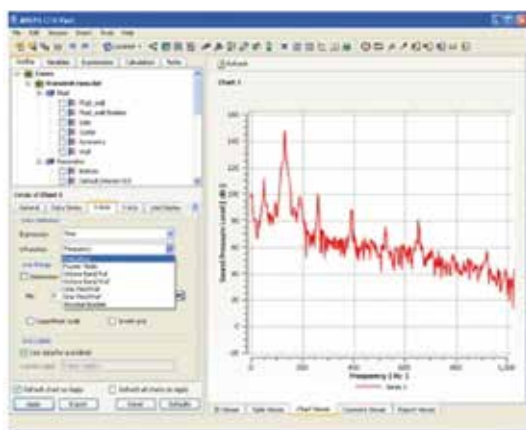


Fig. 6 - ANSYS CFD-POST FFT module

The common post-processor for the ANSYS CFD tools is ANSYS CFD-Post. This provides for advanced, quantitative and visual post-processing capabilities. It is especially suitable to process transient data sets and the CFD-Post FFT module can be used to look at the data’s frequency attributes, especially in Aeroacoustics simulations.

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ACT: 'pillar' dello sviluppo del codice ANSYS

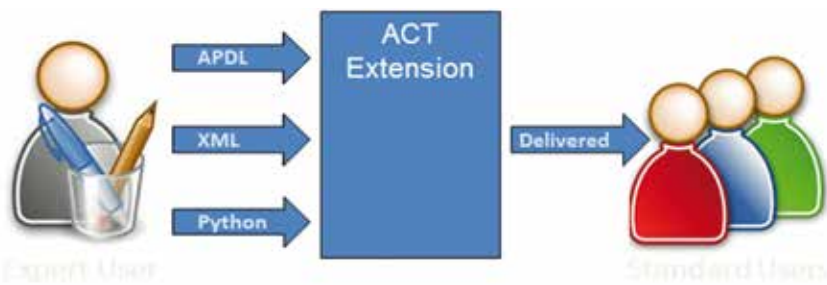


Fig. 1

Fin dalle prime versioni del codice l'attenzione degli sviluppatori del software era rivolta a fornire agli utenti uno strumento elastico e completamente adatto a risolvere virtualmente con il calcolo i diversi scenari progettuali; in altri termini la caratteristica di ANSYS, fin dalla sua nascita, è la elevata capacità di dare la possibilità all'utente di descrivere parametricamente le strutture ed calcolare in fase di post-processor elementi utili alle considerazioni progettuali non marcatamente ortodosse; per esempio non solo tensioni di Von Mises ma anche elementi di stress relazionabili alla singola normativa da applicare; inoltre fin dall'inizio è sempre stato possibile raccogliere in vettori o in matrici elementi non standard dell'output, (per esempio i termini della matrice di rigidità,...). La facilità di manovra in questo tipo di operazioni è nello storico APDL, cioè ANSYS Parametric Design Language.

L'evoluzione di questo approccio è nella recente suite chiamata ACS: ANSYS Customization Suite. Essa è costituita da Act e da SDK (Software Development Kit); SDK consente di operare variazioni della struttura della piattaforma (GUI) attraverso codici di programmazione il cui uso è fortemente

legato ad elevate capacità e competenze dei programmatori stessi; Act invece è pensato per programmatori di competenze medie e nella attuale versione è per ora limitato ad ANSYS Mechanical.

Infatti le conoscenze software richieste all'utente Act sono fondamentalmente una avanzata competenza su ANSYS Apdl e una buona capacità all'utilizzo di Xml e di Python; in realtà tali prerogative tecniche sono diffuse tra i 'nuovi'

ingegneri e qualora non appartenessero alla stessa persona sono perfettamente complementari e reperibili nelle aziende tese ad innovare tecnicamente il proprio prodotto facendo uso di tecniche di simulazione al computer.

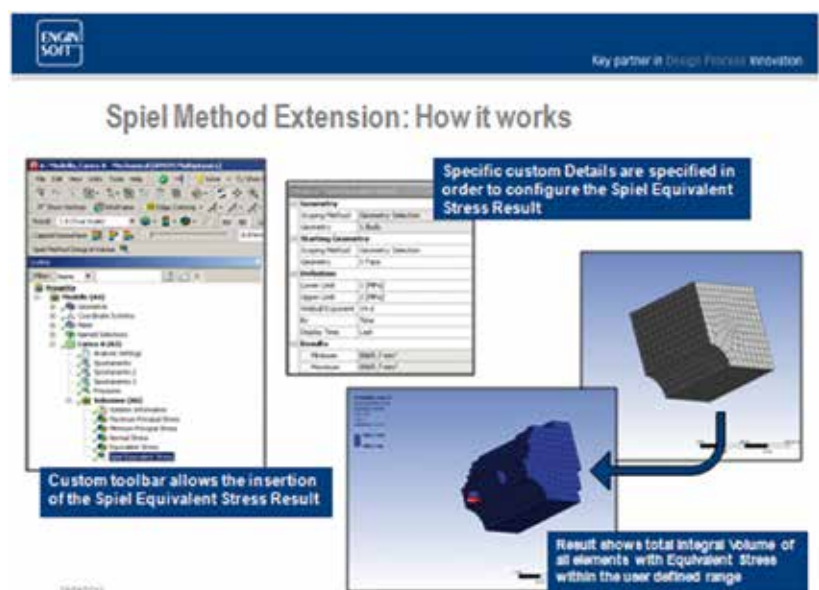


Fig. 2

Nella figura si evidenzia la organizzazione relativa ad un *power user* che è in grado di tradurre via Act le richieste dei singoli utenti dell'azienda. Naturalmente le *extension* generate funzionano sulla singola 'release' e possono essere facilmente riportare in altre installazioni del codice, cioè sono come normali file.db che transitano indipendentemente dalla licenza.

In sintesi è possibile individuare due tipologie di attività Act: l'una Base e la seconda Avanzata. La 'BASE' prevede la traduzione di macro scritte in formato Apdl con il linguaggio di programmazione python, organizzato in formato di icone di Wb realizzate tramite XML; il vantaggio è nel poter con facilità riportare in Wb le proprie macro di utilizzo e conformate alle particolari esigenze tecniche aziendali; inoltre tutte le antiche e consolidate capacità del codice in formato classico sono altresì riportate in ANSYS Wb.

Le normative sono traducibili in Wb e difatto standardizzarle in formato di icona è altra corposa ed importante attività consentita da ACT.

L'uso avanzato della tecnologia Act è in grado di generare un *link* diretto con altri codici, siano essi complementari di ANSYS siano invece codici interni delle singole aziende; oppure addirittura usare altri codici di calcolo all'interno di Wb sfruttando di quest'ultima tecnologia la facilità di generare mesh di qualità e volendo calcolare gli output con solutori non ANSYS (nastran, Is dyna per esempio).

EnginSoft si è attivata sia nel primo tipo di applicazione che nel secondo.

EnginSoft ha infatti implementato con una *extension* Act il modello del Weakest-Link; esso si basa sulle logiche di Weibull al fine di descrivere l'elevata dispersione riscontrata nella misura della resistenza a trazione dei materiali fragili; tale caratteristica è relativa alla disomogeneità del materiale a livelli micro e macro-strutturali.

L'approccio presuppone che tali difetti siano distribuiti statisticamente all'interno del materiale e che il cedimento sia determinato solo dalla porzione di materiale a più piccola resistenza (Weakest Link): la probabilità di cedimento P_f di un corpo omogeneo sollecitato è descritta dalla formula di distribuzione di Weibull:

$$P_f = 1 - \exp \left[- \left(\frac{\sigma}{\sigma_0} \right)^k \right]$$

in cui k è l'esponente di Weibull che tiene conto della dispersione. Tale relazione è valida solo quando la distribuzione di tensione è omogenea; in presenza di zone di intensificazione di stress (intagli o geometrie particolari), la formula si modifica nel seguente modo:

$$P_{f,v}(\sigma_{max}) = 1 - \exp \left[- \frac{1}{V_0} \cdot \left(\frac{\sigma_{max}}{\sigma_0} \right)^k \cdot \int_V g(x,y,z)^k dV \right]$$

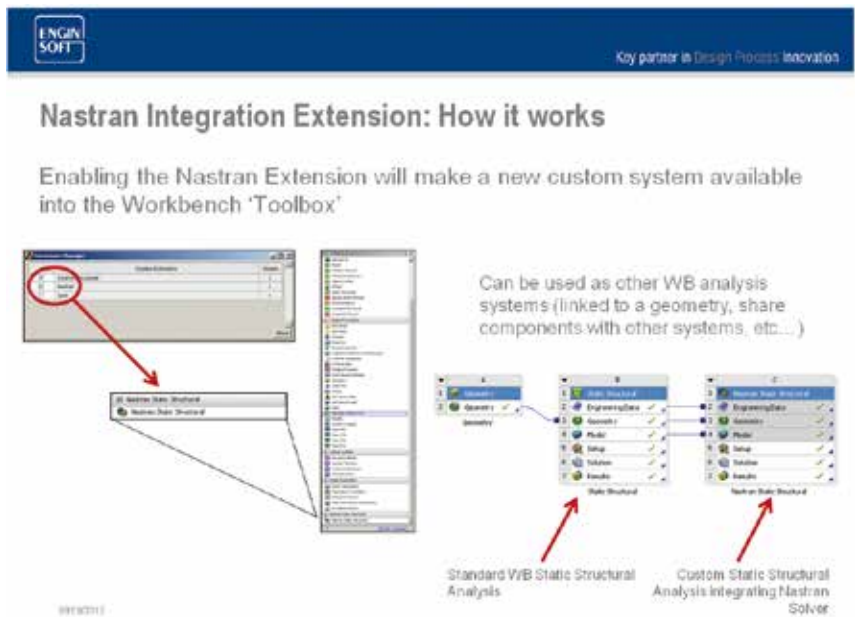


Fig. 3

in cui compare l'integrale di volume dello stress normalizzato rispetto al valore massimo (in corrispondenza dell'intaglio)

$$g(x,y,z) = \frac{\sigma(x,y,z)}{\sigma_{max}}$$

e k è il consueto esponente di Weibull che tiene conto della dispersione.

In sintesi la *extension* riporta la precedente teoria ed è codificata da una icona che si riporta in figura 2.

EnginSoft sta sviluppando una *extension* di tipo AVANZATO; essa ha per obiettivo l'uso di Nastran all'interno di Wb. La *extension* rende possibile sfruttare le capacità di meshing di Wb e all'interno della stessa piattaforma realizzare sia la parte di calcolo che di post in formato Nastran.

Ad oggi la implementazione del software è ristretta ai seguenti punti:

- CQUAD4, CQUAD8, CTRIA3 and CTRIA6 shell elements;
- Fixed Support, Displacements, Force and Pressure boundary conditions;
- Sol 101 (Static Structural);
- Displacements, Stress and Strain results.

In conclusione ad oggi Act lavora su modello di nodi ed elementi ma già dalla versione 15 sarà in grado di raccogliere e gestire le informazioni relative alla parte di modellazione geometrica; in ogni caso esso rappresenterà il viatico con cui continuare in forma estesa l'uso della tecnologia ANSYS non solo come semplice tool di calcolo agli elementi finiti ma di vera integrazione fra discipline diverse accomunate in una robusta piattaforma WB.

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modeFRONTIER | VERSION 4.5

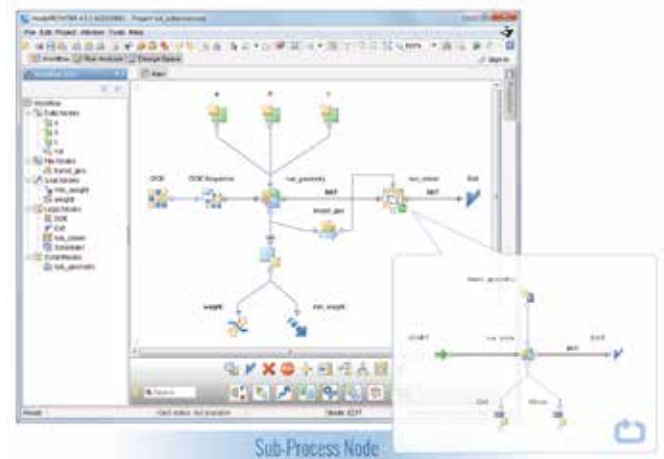
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modeFRONTIER 4.5 A refactored workflow architecture to streamline design complexity

The recently released modeFRONTIER version 4.5, the optimization platform developed by ESTECO, brings to designers many innovative capabilities. Modularity, re-usability, process looping and nested optimization option change the way designers approach and set up trade studies.

This version introduces a refactored workflow architecture allowing engineers to streamline complex projects by using the Sub-Process Node and the Scheduling Project Node. These newly developed powerful tools let easily build complex modular workflows, achieving effective management of design optimization analysis. The Sub-Process Node introduces workflow modularity and re-usability in modeFRONTIER using a brand-new concept - the process: an independent data chain. The Scheduling Project Node helps users tackle nested and sequential optimization tasks by executing multiple modeFRONTIER projects in batch mode from within the same workflow.

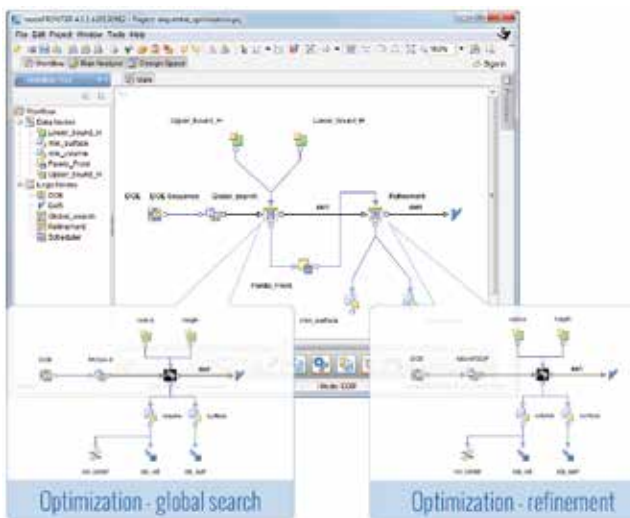


Sub-Process Node

The Sub-Process Node introduces new possibilities for automating the analysis of multifaceted engineering problems by autonomously executing process workflows and simplifies software integration and sharing of different modeFRONTIER projects.

In a typical scenario, the process graphically describes a part of a design problem by mapping input data to output data and returning a logical computational flow. The Sub-Process Node enables the nesting of processes in one or more larger modeFRONTIER projects which then pilot a number of trade studies following different DOE and optimization strategies.

These independent data chains are modular and re-usable and allow users to breakdown complex problems into their constituent parts, each of which can be tackled by a field expert. Additionally, the Sub-Process features a very straightforward definition of loop execution, used for iterated runs of a process until a particular condition is fulfilled.



For example, consider a workflow including two software to be executed in sequence: a CAD tool creates the geometry and transfers it to the second software, a solver that computes stress and deformation. In the event the solver run fails for unknown reasons (network communication, unavailable license, etc.) the Sub-Process Node continues with the execution until the computation is successful. In this way, the entire workflow becomes more robust by automatically solving unpredictable problems that may occur during the run phase, helping engineers save time and identifying failures exactly occur

Processes are created, edited and tested with the dedicated processMODELER tool, which is launched independently from modeFRONTIER and includes its own Workflow Editor and a basic Run Logs environment. This workflow editor helps designers manage multi-level workflows, providing a simple interface for building processes to be incorporated in parent modeFRONTIER projects.

Scheduling Project Node

The new Scheduling Project Node has been developed with the aim of replacing the former Frontier Batch Node, extending and boosting its functionalities. The node can be used to load modeFRONTIER project files and incorporate them into other modeFRONTIER projects, allowing users to run nested optimization projects in batch mode.

The new node supports the complete definition of the optimization strategy of the inner project (i.e. DOE, Scheduler and goals -

objectives and constraints). It also enables the extraction of single design variables as well as entire design databases (e.g. all Pareto designs) and the execution of further optimization of their values. This capability supports designers in addressing intricate engineering projects offering a framework for creating multi-strategy optimization studies.

With the Scheduling Project node users can build complex workflows containing several nested optimization processes. In particular, it enables the run of multiple workflows (modeFRONTIER project files) on different levels from within the same project, exploiting all the benefits of direct integration nodes. For example, users can first perform a global optimization task (e.g. using a genetic algorithm) with a Scheduling Project node then extract the optimal Pareto front and use it as the initial DOE sequence for a refined gradient-based search within a second Scheduling Project node. Another example could be the implementation of a hierarchical optimization by nesting a workflow using the Scheduling Project node with a global optimization defined within and a gradient-based optimization defined in the main workflow and driving the optimization loop.

For more information:

ESTECO website: www.esteco.com

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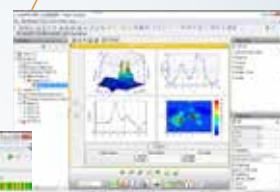


mode FRONTIER VERSION 4.5

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EnginSoft in orbit with HYSSE project

Life support systems

Life support systems (LSS) play a crucial role in manned space missions. Since such missions are becoming longer, requiring expensive shipments of nutritional supplies, the European Space Agency (ESA) has launched a long term research program to study and develop prototypes of bio-regenerative LSS called MELiSSA (Micro Ecological Life Support System Alternative). The program has the objective to develop food production facilities, both for space stations, future Lunar bases and missions to Mars.

Thoughts and discussions about human exploration of the solar system are older than spaceflight itself. Nevertheless, most of today's space programs are limited to human transportation into Low Earth Orbit (LEO). Since humanity has plans to further explore space, including the deployment of habitats on the Moon and Mars, several concepts have been developed to create bases with bio-regenerative LSS. These concepts aim to decrease the (re-)supply mass by (re-)generating essential resources for humans. Humans and their needs are the focal point of each LSS. To cover its task, the LSS must fulfil all necessary functions enabling a sufficient level of living conditions.

The MELiSSA framework is envisioned as a micro-organism and higher plants based ecosystem, which will allow the development of technologies, required for future long-term human space flight. MELiSSA is based on an "aquatic" ecosystem consisting of five distinct sections, or compartments (Figure 1).

The first section, called the liquefying or anoxygenic fermentation compartment, collects the non-edible output from the higher plants and micro-organisms as well as the waste from consumers (i.e., astronauts). Through anaerobic processes this waste is transformed into useful compounds, such as ammonium and volatile fatty acids (Figure 2). Nearly all of the output from compartment 1 is delivered to the second section for further processing by photoheterotrophic organisms. These organisms use fatty acids, alcohols and carbohydrates along with light to produce food for the consumers.

Some of the output from compartment 1, specifically the ammonium and the minerals, are not affected by the processes in compartment 2 and are instead delivered to the third section, the nitrification compartment (Figure 2). Through oxidation processes the ammonium is turned into nitrates. Nitrates are highly favourable sources of nitrogen for higher plants, and are used in section 4, the photosynthesis compartment, along with the minerals produced in compartment 1, to produce the bulk of the edible output for compartment 5 (the consumers).

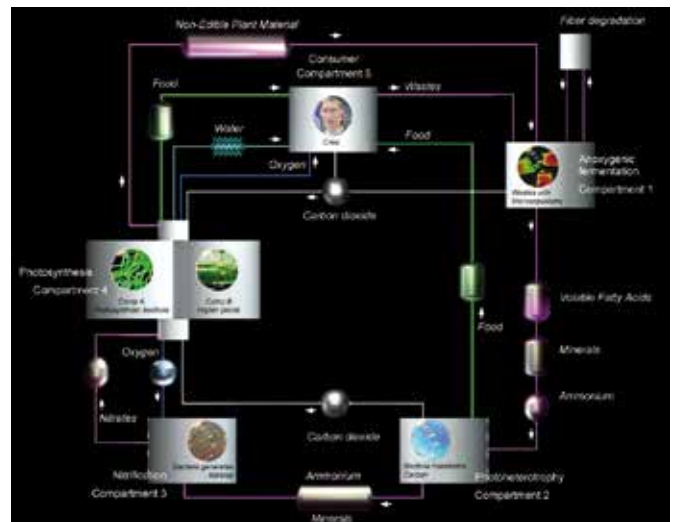


Fig. 1 - Micro-ecological life support system alternative

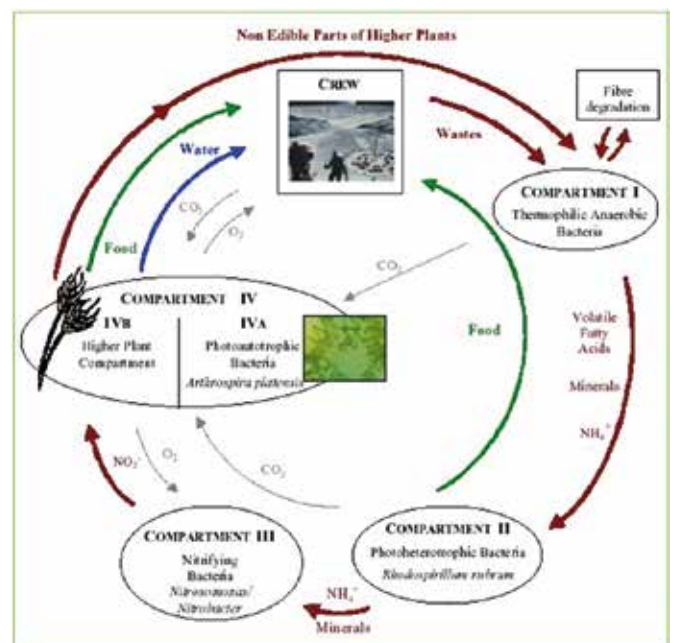


Fig. 2 - MELiSSA compartments: thermophilic anoxygenic bacteria, photoheterotrophic bacteria, nitrifying bacteria, photosynthetic bacteria and higher plants, and the crew. The driving element of MELiSSA is the recovery of edible biomass from waste, carbon dioxide and minerals, using light as source of energy to promote biological photosynthesis

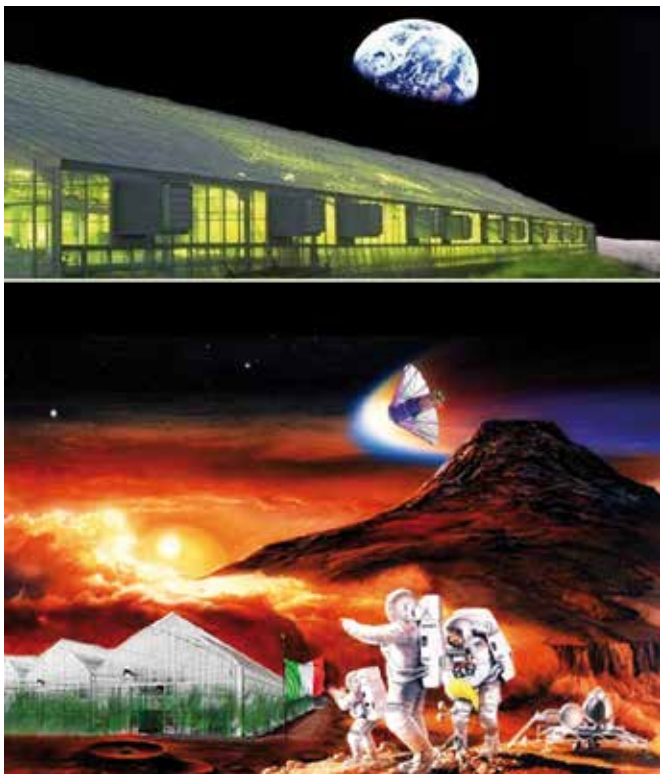


Fig. 3 - Automated greenhouses (top panel) for human exploration of long term crewed missions (bottom panel)

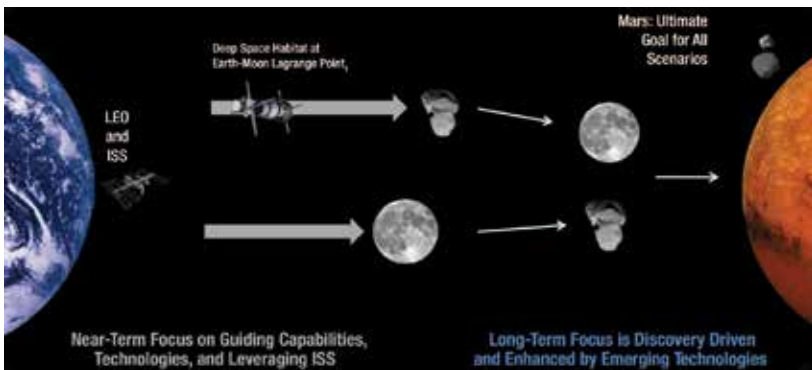


Fig. 4 - Two potential exploration pathways to Mars: the first pathway includes the exploration of a NEO, a return to the Moon and a trip to Mars while the second one includes first a return to the Moon, then a NEO-Mission before a trip to Mars

Hydroponic subsystem engineering project

EnginSoft has been part of the MELISSA program since 5 years, through the participation as a partner in already 4 different lines of research: Food Production Phase 1, ALISSE, GMSS and SCALISS.

Recently, EnginSoft has won a proposal as a coordinator of HYSSE (HYdroponic SubSystem Engineering) project in the MELISSA FOOD CHARACTERISATION PHASE 2 – PLANT CHARACTERISATION UNIT SUB-SYSTEM ENGINEERING and is now leading a team of research composed of University of Gent, Université Libre de Bruxelles, NTNU Samfunnsforskning, University of Guelph, Polytechnique Montreal and Sherpa Engineering.

Hence tank to its team of skilled bio-engineers involved through the years in several projects with a

large know-how of bio space systems, EnginSoft has been appointed directly by ESA (European Space Agency) to coordinate this new strategic line of research.

The main objective of the activities proposed in HYSSE is to study and characterize the hydraulic system of the Plant Characterization Unit (PCU) and its processes related to crop growth.

Within the Melissa project, PCUs have been studied so far addressing several issues regarding air flow, thermal management, visible radiation and evapotranspiration, which are all phenomena present in the environmental air side.

The hydraulic part of the PCU, known as the hydroponic system, has not been adequately addressed with an engineering approach. In fact, the hydroponic system is currently based on experience without a proper knowhow of its performance, and assuming that the plant will manage and compensate any unbalance of the nutrient with different root uptake. In response to the growing need for details of the hydroponic impact on plant health, mandatory investigations concern:

- the piping hydroponic network delivering water, oxygen and nutrients to the roots;
- the shape and air tightness of the gully;
- design for the insertion of young seedlings into the gullies;
- oxygen supply to the gully headspace and CO2 removal.

The understanding of the chemical and microbiological process occurring at gully level in the rhizosphere is another crucial issue.

Research will be conducted in the following areas:

- mineral nutrition supply in accordance with the growth and developmental phase of the plant;
- plant stress due to nutrient overload or deficiencies due to control system malfunctioning;
- evaluation of nitrate uptake rate and measurement of nitrogen accumulation in response to nitrogen supply.

Furthermore, the characterization of the microbiological and chemical contamination scenarios is necessary. Thus, further areas of investigations concern the identification of the main microbial entities at the rhizosphere, the

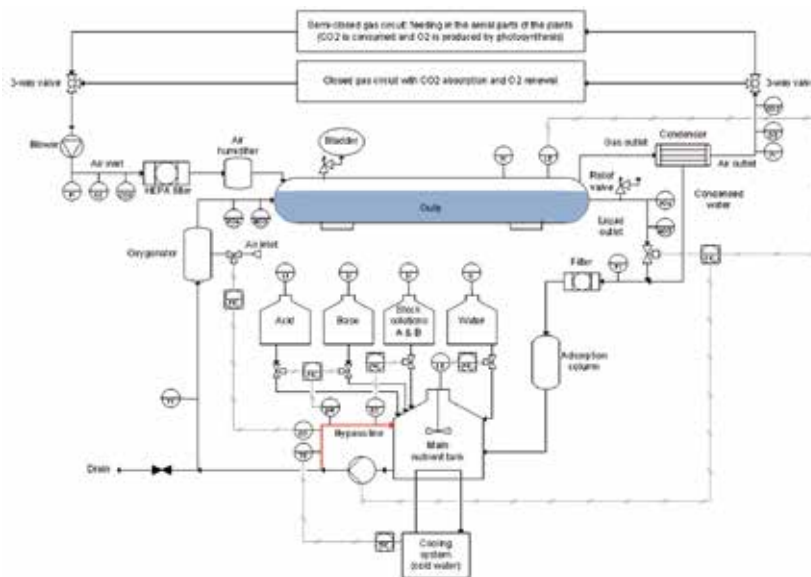


Fig. 5 - Schematic representation of the deep water culture with adjustable liquid height

management of microbial contamination, disinfection methods and germination testing.

The newly engineered hydroponic system will be part of a pilot test plant at a ground facility. The long term goal (not part of HYSSE project) is to generate designs of automated greenhouses (Figure 3 – top panel), which are essential for the accomplishment of extended human exploration of long term crewed missions (Figure 3 – bottom panel).

The roadmap (illustrated in Figure 4) foresees two possible pathways for a successful human exploration to Mars. The first one includes the exploration of a Near Earth Object (NEO), followed by a return to the Moon and eventually a trip to Mars. The second one includes first a return to the moon, then a NEO-Mission before a trip to Mars. Although a greenhouse on a short duration NEO exploration might not be feasible, a long duration Moon exploration and Mars exploration will benefit from space-based farming research done today.

Hence, for such long missions, the LSS (whose PCU with hydroponic is one of the components) need to be automated and efficient in terms of batch cycle production as well as simple in terms of maintenance and operability. The efficiency of batch production needs system balance for the nutrient while the automation of the process needs control system and contamination detection. Currently, several systems are in a development phase on Earth based pilot test facilities. The main features of these system are summarized in Table 1. As previously mentioned, there is a need to develop an engineered approach to the design in order to be able to determine predictive mathematical models for the different scenarios, to test these theoretical models with functional breadboard experiments and to validate them with full life cycle breadboard tests on a few crops selected: durum wheat, soybean and potato. These crops are normally included in the requirements of bio-regenerative LSS for their nutritional value, plant yield, harvest index, processing requirements, palatability and dietary acceptability.

In the first part of the project, the specifications of a hydroponic system suitable for the abovementioned crops have been defined. In particular, throughout a concurrent engineering session, the researchers' team has developed innovative concepts to seal the gully and set the requirements of a sealed air tight gully. Furthermore, different techniques to provide an oxygenated nutrient solution to the plant roots have been analyzed in order to evaluate their feasibility.

Subsequently, throughout a second concurrent engineering, potential designs of the hydroponic system have been developed. A sketch of a preliminary design of the hydroponic system is showed in Figure 5. The use of an deep water culture (DWC) with adjustable liquid height involves a classic DWC with successive (i.e. at desired dry/wet time periods that can be variable with plant

development) and controlled “dry” periods; the dryness level being controllable as well by controlling the gas phase humidity level. During cultivation, roots can be submerged in the circulating nutrient solution for a short period followed by a longer period without nutrient solution, thanks to a control system designed to allow liquid level positioning. In the future activities, mathematical predictive models of the gully fluid dynamics and rhizosphere combined with fundamental tests on crop will lead to the final design of the hydroponic system.

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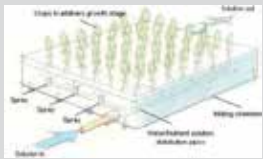

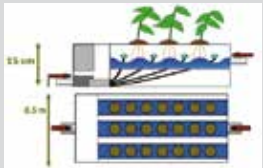

Study Reference	Considered Irrigation System/s	Image
NASA Steckler UA-CEAC Lunar Greenhouse	Cable culture hydroponic system. Washable, low mass, no substrate required. Plants are inserted into a continuous tube that is suspended by aircraft cable attached only the ends of the row. Nutrient water fed into the tube at each end of the row, flowed through the plant root system, discharged and recycled, similar to the Nutrient Film Technique (NFT)	
ESA OGEQU	Considered irrigation systems with medium (flood and drain, dripping irrigation) were discarded for mass and risk. Aeroponics was chosen among NFT, Aeroponics, and Deep Water culture for low mass	
Mc Murdo Greenhouse	NFT system, with EC and pH hand-adjusted. Perlite and vermiculite were used as growing media.	
BIO-Plex	Considered: solid substrate for mechanical support and providing water and nutrient delivery; Sub irrigation, using a solid substrate for only support and water delivery; Hydroponic, using some other approach for mechanical support, and delivering nutrients and water as a nutrient solution. A hydroponic system was assumed.	
Amudsen Scott SPFGC	Recirculating hydroponic system without root zone substrate, except for a 25 mm germination/transplant seedling cube. Dissolved oxygen in the nutrient solution not measured, but oxygenation was provided by air introduced through bubblers (0.01 m ³ min ⁻¹) directly in the nutrient solution storage	
TAS-I SEEDS Lunar FARM	Soil discarded; considered hydroponic, aeroponic and zeoponic cultivation methods. NFT chosen for compromise between mass and needed water buffer	
MELISSA UAB	Nutrient Film Technique was selected and implemented.	

Table 1 - Irrigation system overview

EnginSoft in £3m EU Partnership to Optimise Remote Laser Welding

Vehicle assembly is a complex process involving the joining of many subsystems by a variety of methods. For many years, resistance spot welding has been a key technology. This is far from the only method of body assembly, however. Recent years have seen an increasing use of techniques such as gluing and riveting, for example. In each case, the ability to determine the best joining method for an assembly process is critical to assembly efficiency, and therefore vital to the competitive position of many companies within Europe. Designing an efficient assembly process is frequently far from trivial, in fact each method will have its own limitations as power requirements, cycle times and so forth. So determining the best configuration for an assembly sequence will be a complex procedure.

That is where the “Remote Laser Welding System Navigator for Eco & Resilient Automotive Factories” enters the picture. Remote Laser Welding is a promising and relatively-new joining method which involves an intense laser beam being focused onto the material to be joined from one side only. Local re-melting and fusing to the underlying material then takes place. This can be very rapid, and since the beam can be manoeuvred from place to place with small angular adjustments of the welding head there is a great opportunity for rapid cycle times at the welding stations.

The aim of the RLW project is to provide a software tool that will enable the process designer to develop an optimal configuration for the use of such processes. At the highest level, it will take a series of conventional assembly workstations and consider all the different ways in which they could be combined to make use of RLW techniques. This will propose an RLW-efficient assembly process, leaving parts of the assembly sequence which are unsuitable for RLW unchanged, but introducing RLW where it is most effective. This may involve the introduction of additional workstations or processes that are necessary for the optimum use of RLW, as well as the combining of workstations where RLW is able to perform in place of multiple original locations.

At a deeper level, the project will assist in developing individual workstations. Here, the whole process of gap tolerances at the assembly interfaces must be managed by part-screening and appropriate fixing, as well as defining the process parameters for the laser and the geometrical manipulation of the parts and the welding head. Will also define the control requirements and

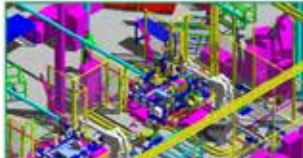


Remote Laser Welding (RLW) System Navigator for Eco & Resilient Automotive Factories



PRODUCTION SYSTEM CONFIGURATION

- Select candidate station to meet KPIs
- Configure Hybrid Assembly System that include RLW & RSW operations
- Synthesize & evaluate Hybrid Assembly System performance



RLW CELL CONFIGURATION

- Optimise cell configuration
- Optimise robot trajectory and welding sequence
- Off-line programming of RLW robot
- Evaluate performance of the RLW Cell



RLW PROCESS DESIGN OPTIMISATION

- Generate error (budget) map
- Optimise fixture layout (Max & Min part-to-part gap control)
- Select and optimise laser parameters



RLW PROCESS CONTROL

- Process monitoring strategies
- Root Cause Analysis (RCA)
- Corrective Action & Preventive Action (CAPA)



VEHICLE DESIGN GUIDELINES & ECO-EFFICIENCY EVALUATION

- Eco-efficiency evaluation
- RLW Navigator software architecture
- Design-for-RLW



Industry-University Research Programme Coordinated by WMG, University of Warwick
 Further information: <http://RLWnavigator.eu/> or <http://tigiPLM.org/> or phone +44 24 765 72681

calculate the process timings and energy requirements necessary to refine the higher-level definition of the assembly system. As the software should assist the designer in developing components that are suitable for efficient laser welding by providing appropriate feedback on the part properties, the project will be an invaluable tool in the development of state-of-the-art assembly processes using RLW technology, and thereby play an important role in maintaining Europe's competitive advantage in systems assembly.

The EU has awarded a £3.35m research grant to a consortium involving EnginSoft to develop a technique for optimizing the use of Remote Laser Welding in assembly processes. The consortium is led by Warwick Manufacturing Group (WMG) at the University of Warwick, and also involves Jaguar Land Rover, Comau, Stadco, Precitec and several important academic institutions including Politecnico Milano, the University of Molise, Ulsan NIST, the University of Patras, Lausanne Polytechnic and SZTAKI Budapest.

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Project website:
www.rlw-navigator.eu



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Optimizing clean energy: solar-to-hydrogen cycles



Hydrogen is today one of the most widely used of the chemical elements. Many different industries and processes utilize hydrogen such as petroleum and chemical businesses and food industry (hydrogenation of fats is the method to make margarine from vegetable oil). Hydrogen is also useful in producing methanol and in reducing metal ores. Other uses for hydrogen may be found in welding, in power generators, and in cryogenics research. Space industry uses liquid hydrogen as a fuel boosting rockets into the orbit.

While about 75% of the universe’s elemental mass is hydrogen, free hydrogen is relatively rare on Earth and is observed mostly in a form of water. In many recent studies, hydrogen is being pointed out as a source for clean fuel because water is the product of its reaction with oxygen. However, hydrogen must be extracted first: although it can be processed artificially from a variety of locally produced sources like methane, coal, water, gasoline, and biomass, there are also some different amounts of pollution. Whether or not hydrogen can help make a greener world for all of us, it will all depend on further research.

This is the intrinsic goal of SOL2HY2 – “Solar-To-Hydrogen Hybrid Cycles” – project: to demonstrate that hydrogen “green” production is possible through the exploitation of solar power. SOL2HY2 is a Research Project co-financed by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU - refer to info box).

The project concept outline

The FCH JU strategy has identified hydrogen production by water decomposition pathways powered by renewables such as solar energy to be a major component for sustainable and carbon-free hydrogen supply. Different solar-powered thermochemical and hybrid cycles are capable to directly transfer concentrated sunlight into chemical energy by a series of chemical and electrochemical reactions.

Despite the many thermochemical cycles have been proven to be theoretically possible, only few of them might be feasible for practical realization. Hybrid-sulphur (HyS) cycle, also known as Westinghouse cycle (Fig. 1), has been ranked by IEA HIA Task 25 “High temperature processes for hydrogen production” and some other parallel studies to be the most promising one. However, the original HyS cycle has been

always associated with nuclear heat and electricity sources as the H₂ production was evaluated to be more economic when combined with nuclear power than using pure solar power. The aim of the SOL2HY2 project is ultimately demonstrate that such cycle is possible to be realized using only renewable energy, like solar one.

The challenges in HyS realization remain mostly in materials (for electrolyser, concentrator, acid decomposer and BOP components) and with the whole process optimisation, which must be tailored to specific solar input and plant site location. The previous research projects have brought some solutions for these challenges, but still did not manage to present the consolidated, optimized plant and process design capable to complain with imposed costs, and operational constrains and the whole process chain objectives. The recent technology options at the large-scale (400-800 MW) hydrogen production plant concepts are unlikely to achieve hydrogen costs below 3.0-3.5 €/kg. For smaller scale plant (which might be more reasonable), the H₂ costs might be substantially higher. Additional associated technical and operational risks do not encourage industries to start such plants construction, which does not allow examination of realistic bottlenecks and make

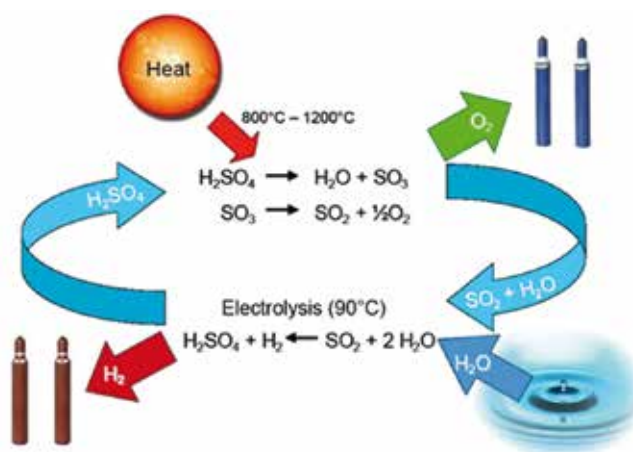


Fig. 1 - The HyS cycle scheme

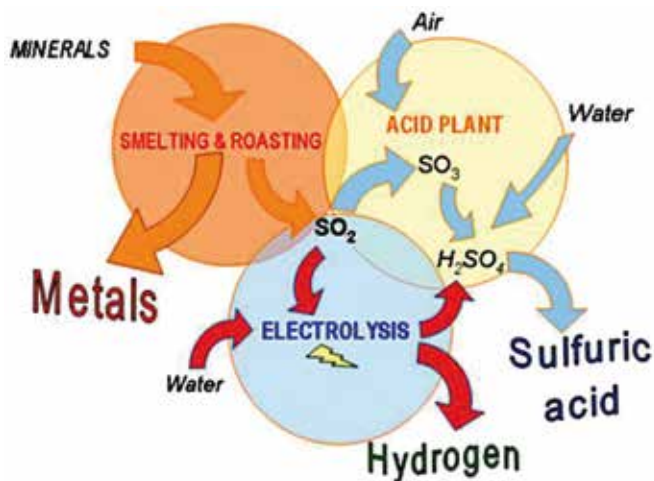


Fig. 2 - The Outotec® Open Cycle scheme



Solar Tower Julich (STJ)

necessary improvements. The SOL2HY2 project focuses on applied bottle-necks solving materials research, development and demonstration of the relevant key components of the solar-powered, CO₂-free hybrid water splitting cycles.

In this project, the consortium provides and develops necessary solutions for solar-powered hybrid cycle in several stages. Whereas the solar HyS cycle remains the best long-term solution, to ensure economic profitability for the short-term opportunities the consortium starts with the integration of solar-power sources with new Outotec® Open Cycle (Fig. 2).

This cycle does produce sulfuric acid together with hydrogen using different sources of SO₂ from chemical and metallurgical plants and allows fast, scalable build-up of smaller scale hydrogen by-production plants without affecting acid production.



The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) is a public private partnership supporting research, technological development and demonstration (RTD) activities in fuel cell and hydrogen energy technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realizing their potential as an instrument in achieving a carbon-lean energy system. The three members of the FCH JU are the European Commission, fuel cell and hydrogen industries represented by the NEW Industry Grouping and the research community represented by Research Grouping N.ERGHY. <http://www.fch-ju.eu>

Simplified structure, extra revenues from acid sales and highly efficient co-use of the existing plants might lead to substantial reduction of H₂ costs vs. traditional HyS process designs. This allows further developments to concentrate in a real-scale size technology, learning from the pilot and smaller scale production and developing key solutions for solar HyS in medium to long term. Besides providing key materials and process solutions, for the first time the whole production chain and flowsheet will be connected with multi-objective design and optimisation (MODAO) and meta-modeling algorithms ultimately leading to hydrogen plants and technology “green concepts” implementation.

The consortium

SOL2HY2, coordinated by EnginSoft, is a medium-sized, multi-disciplinary project with a strong participation of research-intensive university (Aalto University Foundation, Finland) and R&D centres (DLR - German Aerospace Authority, ENEA - Agenzia per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile; Italy), industry (Outotec Corp., Finland) and SMEs (EnginSoft S.p.A., Italy; Erbicol S.A., Switzerland, Oy Woikoski AB, Finland). This is a project in which partners aim at working together to learn the needs of each other and to contribute collectively – with the goal of accelerating the speed at which new breakthroughs might be made to help the European industrial sectors to compete more effectively in world markets.

The role of EnginSoft

EnginSoft will provide to all the partners MODAO (MultiObjective Design and Optimisation) tools and metamodelling methods, including elaboration of DoE strategy, data mining and optimisation. EnginSoft will also help SME and R&D performers in modelling issues, simulation of the relevant processes and elaboration of the models. Moreover, EnginSoft has always employed many resources in R&D activities, at national and international level, with a strong participation at co-funded R&D projects, also with coordination responsibilities. Based on this fruitful experience, EnginSoft has taken the coordination of the project.

The web-based platform EUCOORD, developed by EnginSoft for supporting of the EU projects (www.eucoord.com), will be used in SOL2HY2 as a powerful and reliable project management tool.

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Partners



Wing Box Technology Evaluation

Trade-off Study for the Ranking of New Technologies Best Fitting Wing

The overall strategy of the work plan follows a logical progression, whose objective is to satisfy the call text requests: the projects activities have been divided into 4 Work Packages (WPs) that lead to the production of the expected project results:

- WP1 devoted to the development of a baseline model of the advanced wing box stub, which constitute the necessary reference for the following design activities.

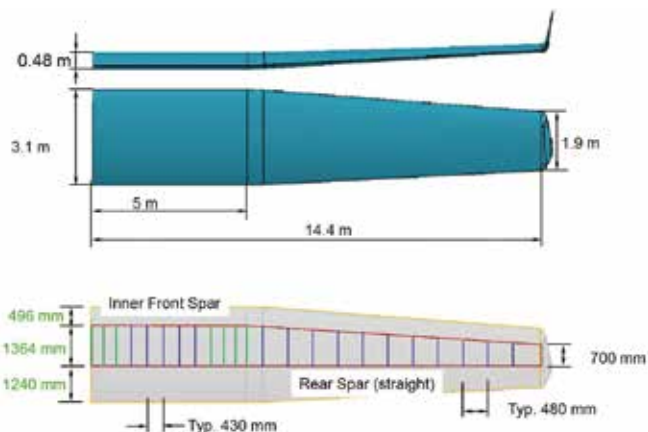


Fig. 1 - General wing box configuration

- In WP2 different variants be developed to analyse the impact of the considered structural modifications on the overall performances of the system: the implementation of Multi-Objective Optimization methodologies is here meant to allow the determination of the best suitable system

	Material	Rib plan (# of bay)	Stringer spacing	Stringer section	Ply definition	Types Load
Baseline	metallic	34	105	J	-	L1 - L7 (1)
Variants	metallic	34, 31, 29	105 - 150 (2)	J, T, Z	-	L1 - L7 (1)
	composite	34, 31, 29	105 - 150 (2)	J, T, Z	P1, P2, P3	L1 - L7 (1)

NOTE: 1) To evaluate figures of merits for different designs, governing load conditions can be reduced to two (L1, and L5).
2) Lower panels have different stringer spacing dependent from spacing in upper panel.

Tab. 1 - WP2 Analyzed Variants

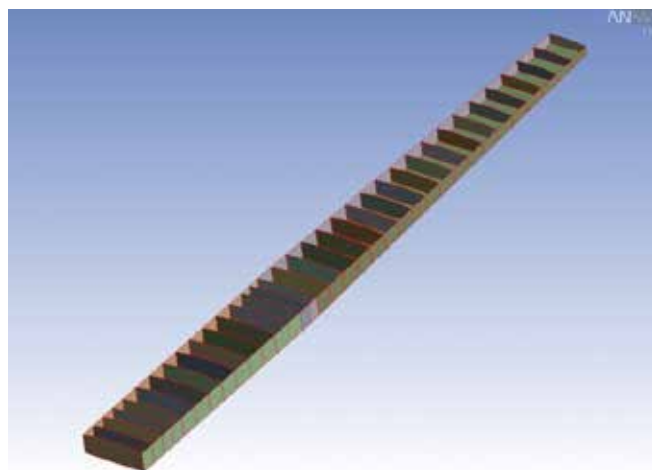


Fig. 2 - Rib geometrical reproduction

- parameters, within the framework of their variability range and of the existing technological constraints (agreed with the Call for Proposal proponent).
- WP3 bring to the completion of the trade-off study, by allowing the individuation of the most promising technical solutions: the usage of Multi Criteria Decision Making techniques support the final evaluation and selection phase.

The completion of the research project also require minor (but still essential) management activities, which have been grouped into WP4: the management of the project allow the project staff to monitor the progression of the research tasks, to efficiently employ the human and economical available resources and to continuously keep in touch with the CfP proponent.

Work Package number 1: Baseline FE Model Definition

A wing box is defined from a general master structure with global configuration reported in Fig. 1.



Fig. 3 - Tip deflection-load1

In Fig. 2 the geometrical model, with removed upper panel, is shown: it is possible to see the result of ribs construction and distribution.

Work Package number 2: Evaluation of the Models Variants

In WP1 different type of possible designs variants were highlighted:

- geometrical variants: rib plan and stringer spacing;
- section definition (typically section of stringer);
- material definition;
- ply definition for composite material;
- applied load.

Variants considered in WP2 are summarized in Tab. 1

Work Package number 3: Selection of the Most Promising Solution

From the global analyses of the results aimed to the identification of the optimal solution, metal configurations have been discarded due to their high weight.

By the ongoing analyses of failure criteria it has been possible to define modification of bays with critical behavior leading to composite configuration form C15 to C26 (having the ply set-up of type "P3") that provide the best structural response; the optimal solutions has then been confined to composite designs C15 to C26.

For all the configurations the set of relevant results to be analyzed has been generated(*):

- Weight,
- Deflection at tip(*),
- Axial force graphs
- Maximum and minimum strain contour maps
- Tsai-Wu criteria maps

An example of generated results in Figure 3 (referring to design C15). (*)All generated results together with corresponding FE input files have been uploaded on the project portal (file C15_C26_results.zip).

From the inspection of the results performed by the Cfd proponent, it has been found that the configuration providing best performances is the C15: it provides the lowest weight and almost lowest tip deflection and satisfy all safety assessments vs. buckling and composite failure.

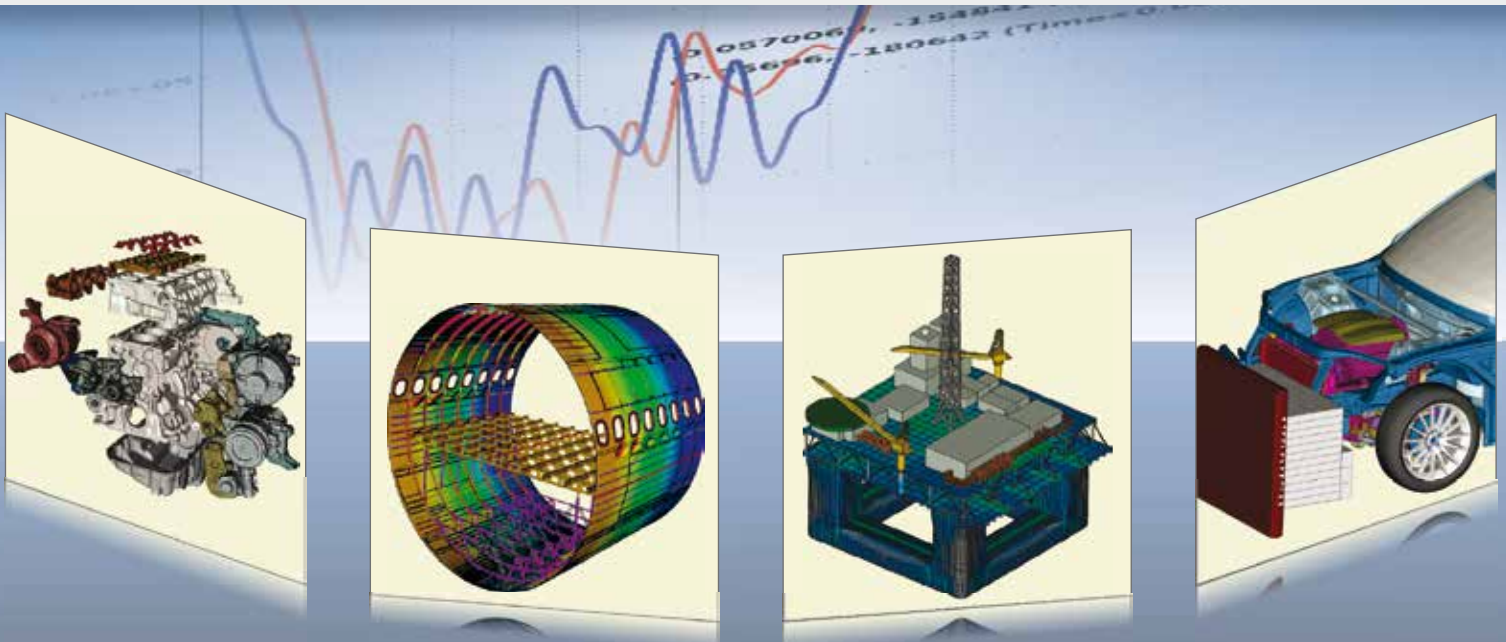
Configuration C15 is actually undergoing the conversion from ANSYS format to Nastran format: this task is covered by the WP3 of the project. A Linear static analysis of the refined model under the given load 1 Condition (1.5 times basic loads) is performed with Nastran to evaluate maximal displacements at tip.

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pioneering software systems
for advanced multidisciplinary
CAE processes





NeuroBox: High Performance Computing Seamless Integration between Data Analysis and Data Management in Neurosciences

Most of the software tools for neuroimaging analysis are released and distributed as standalone desktop applications. Latest trends in neuroimaging studies are focusing more on scalability issues both related to larger data samples and cpu intensive computational methods. The open challenge is how to combine data management and data analysis. LONI, NeuGrid and INCFAWS are considered as the leading solutions to combine large data repositories and scalable computational architecture. However these projects address a particular usecase where data are shared among several institutions and researchers. This kind of scenario doesn't cover the common usecase where data are locally managed by the principal investigator. This contribution is focused on a scenario where a neuroscientist has the following requirements. First, data are managed locally according to the user needs; secondly, the user has access to a remote HPC infrastructure where it is available an execution environment compliant with the required data analysis. The solution currently proposed is based on a seamless integration of the two environments, the local one and the remote one. The main advantage is to avoid metadata annotation coming from external frameworks in data - management. An additional benefit is to preserve the flexibility of pipeline deployment in a user friendly interface to HPC infrastructure.

promoted new research challenges based on large scale datasets such as ADHD and HCP. ADHD provides a collection of fMRI recording for controls and patients affected by Attention-Deficit Hyperactivity Disorder. HCP is an initiative to build a connectivity map of human brain. Both datasets include more than one thousands subjects and their processing requires high computational power. Freesurfer can be considered an example of how as methods become more sophisticated, greater are the requirements of hardware resources.

In addition to the traditional software tools new projects have been developed to address these new challenges. The demand of larger computational power is approached referring to different kind of architectures as High Performance Computing (HPC), Grid Computing and Cloud Computing. The National Institute of Health (NIH) supported LONI Pipeline [3] project, a tool to manage scientific workflows for neuroimaging analysis on a distributed HPC infrastructure. The European Framework Programme funded NeuGrid, a web portal as a gateway to a grid infrastructure for brain data analysis concerned with neurodegenerative diseases. The International Neuroinformatics Coordinating Facility (INCF) promoted a solution based on Elastic Compute Cloud (EC2) and running on Amazon Web Service (AWS) architecture. HPC architectures are usually more

Introduction

Most of the software tools for neuroimaging analysis are released and distributed as standalone desktop applications. One of the major driver has been the need to bring to the end user the latest methods for brain data analysis. For this reason, a requirement as a graphical user interface has been considered mandatory. Latest trends in neuroimaging studies are focusing more on scalability issues both related to larger data samples and cpu intensive computational methods. For example neuroscience community

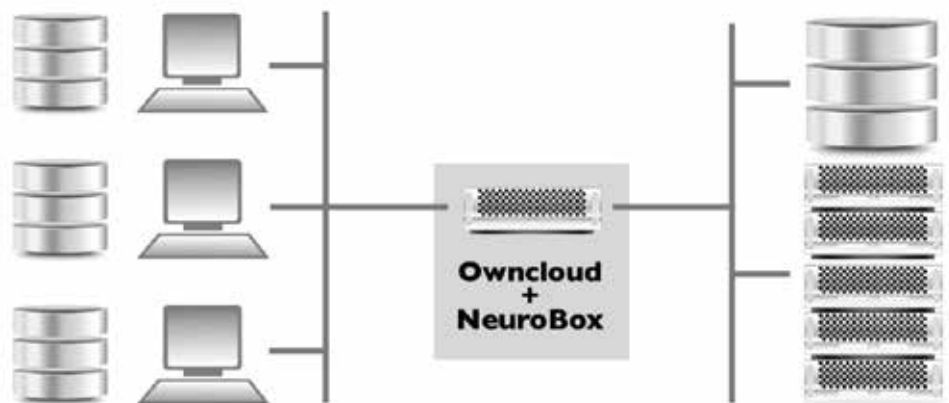


Fig. 1 - An overview of the architecture of the system

performing but less flexible as execution environment, while EC2 allows the setup of custom execution environment at the cost of greater overhead for the virtualization. In this case, the interest is specifically restricted to solutions based on HPC.

The most simple approach to cover the gap between HPC and the neuroimaging analysis is to extend a standalone desktop software. X-batch [11] follows this strategy. It is conceived as toolbox extension of SPM, a popular package to compute statistical parametric brain mapping. The interactive analysis is replaced by a front-end to submit batch of jobs. However this solution is designed for the specific tool of analysis. More recently Nipype was proposed as a general tool to manage pipeline of neuroimaging analyses independently from the specific execution environment (SPM, AFNI, FSL, ...). Not only provides Nipype an abstraction of software tools, but also a plugin for transparent execution of a pipeline on a HPC infrastructure. Despite these appealing features Nipype neglects the need for remote control of data and job management. The working assumption is a smart end user with an interactive terminal session.

The issue of user friendly environment for scientific pipelines of analysis has been addressed by Bisque [6]. The system is designed as web-based server to publish predefined pipeline of analysis that the end user can submit to a HPC infrastructure. The deployment of new pipeline of analysis are mediated by the administrator of the system. Flexibility is considered as a crucial requirement for the end user of deploying his own pipelines. The challenge posed by ADHD was a driver to develop PSOM-CBRAIN a solution that aims to cover the gap between a web-based management of a workflow (PSOM) and a distributed computational architecture (CBRAIN). The assumption of this system is that data are located at server side. In the common scenario data are close to the local host of end user while the computational resources are distributed. XBrain proposes a framework to disentangle the location of data and tools by a middleware to manage queries over distributed databases. To take advantage of this solution it is required to revise how software tools fetch neuroimaging data. The eXtensible Neuroimaging Archive Toolkit (XNAT) adopted a different approach and developed a tool for data management to easily publish data on a remote server. The emphasis of XNAT is on data quality and security since the ultimate goal is to also support data sharing. The overhead for data management using XNAT might have poor payoff if the expectation of data reuse is low.

LONI, NeuGrid and INCF-AWS, as mentioned above, represent the leading solutions to combine data management and data analysis. However these projects address a particular usecase where data are shared among several institutions and researchers. This kind of scenario doesn't cover the common usecase where data are locally managed by the principal investigator. Moreover, the deployment of a system for data management has a twofold drawback: the former is an additional overhead for data storage, the latter is an additional cost for system administration. Since the beginning of the first service of neuroimaging data management, as fMRIDC, the major concern is the sustainability and the lack of a standard for metadata annotation.

Solutions like Globus or XSede provide services to manage in a straightforward way file transfers and job management, but involving no servers. This contribution is focused on a scenario where a neuroscientist has the following requirements. First, data are managed locally according to the user needs; secondly, the user has access to a remote HPC infrastructure where it is available an execution environment compliant with the required data analysis the currently proposed solution based on

a seamless integration of the two environments, the local one and the remote one. From the technical point of view a system has been designed that combines data cloud and job management. The main advantage is not to require the management of data according to some framework for metadata annotation. The additional benefit is to preserve the flexibility of pipeline deployment in a user friendly interface to HPC infrastructure. The implementation is based on the open source software Owncloud and the NeuroBox plugin.

In the next section an overview of the system architecture and the prerequisites are provided. Section 3 illustrates the NeuroBox plugin. A usecase applied to clinical neuroimaging study is reported in Section 4.

System Architecture

The reference scenario that has been addressed in this work is defined as follows: on one side users and the local hosts where are located the storage of data (no restrictive assumption on how data are managed at the local level); on the other side the HPC infrastructure with its own storage area and all the software for data analysis.

No assumptions on any additional web service layer to deploy the pipeline of analysis.

In this scenario the two issues, to be dealt with, are the following ones. The first issue is how to get available data to HPC infrastructure preserving the same organization of data adopted at the level of local host. The requirement is to lower the cost of data management. More powerful solutions may increase the overhead without a clear payoff for the end user. The second issue is how to transfer the control of pipelines of analysis from the HPC environment to the local host.

The proposed architecture aims to achieve a seamless integration between data management and data analysis. The goal is to minimize the impact on the current working setup both at the level of hardware/software and at the level of usual practice of the end user. The solution is based on two software.

components. Both components are deployed on a server that acts as a proxy between the local hosts and the HPC infrastructure (see Figure 1). Data Management: Owncloud. Owncloud is an open source software project that implements a solution to mirror own data according to a cloud architecture. Owncloud comes also with a cross-platform software client enables the synchronization of data between the local hosts and the cloud, namely the storage area of HPC infrastructure. A web interface allows the browsing of the files on the remote storage. This service provides an easy and transparent projection of the data from the local host to HPC but also the reverse. Results computed on HPC are back-projected to local storage area using the same synchronization service. Data Analysis: NeuroBox. NeuroBox has been developed as a web-based software component that is combined with Owncloud services. NeuroBox allows the users to execute their own pipelines, stored on the cloud, on the remote HPC infrastructure. The definition of a new pipeline of analysis doesn't require to be deployed as new web server. Neurobox dynamically provides the access to all pipelines defined by the user. The cloud service supports the synchronization of both data and pipelines. Detailed description of NeuroBox is illustrated in Section 3.

The structure of data is implicitly defined by the organization of the files in directories. The NeuroBox component requires that data on the cloud are organized as follows:

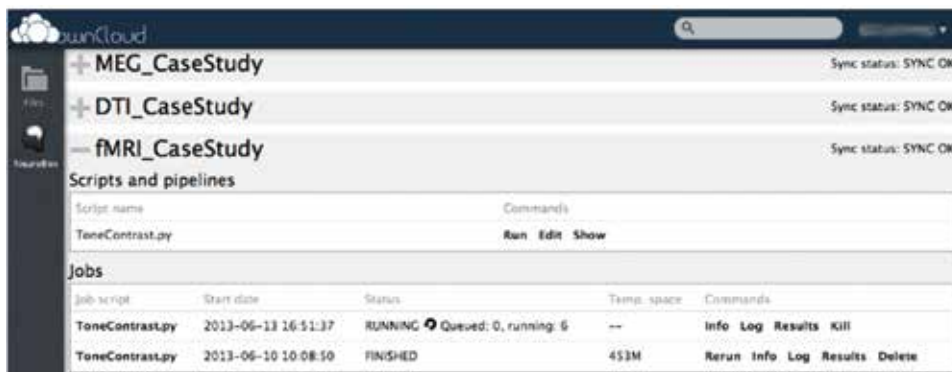


Fig. 2 - An overview of the architecture of the system

```

/<name_of_study>
/<name_of_study>/Data
/<name_of_study>/Pipelines
/<name_of_study>/Results

```

In the storage area every root directory is considered as a distinct study. A user may define many of them. There is no restriction on naming. The files for each study is expected to have at least three subdirectories. The Data directory is devoted to the storage of the source dataset. Nevertheless the synchronization is bilateral, the content of this directory is not affected by NeuroBox on the server side. The purpose of this directory is to manage the pushing of the data to the storage area of HPC infrastructure. The Pipelines directory is the recipient of all the scripts that encode the pipeline of analysis. There is no restriction on the implementation of such scripts. The only requirement is that each script has to be executable on the entry node of HPC and be compliant with the execution environment available on HPC. The deployment of new pipelines of analysis can be easily accomplished by storing on the local storage a new script in this directory. The execution scope of a pipeline is restricted to the recipient study directory. The Results directory collects all the files computed by the execution of the pipelines of analysis. Results are aggregated into subdirectories according to the corresponding job, namely a specific instance of pipeline execution. Files stored in this directory by NeuroBox in the storage area of HPC are synchronized to local storage area by the Owncloud service without requiring an explicit or additional operation.

Neurobox Plugin

Owncloud software architecture is designed to support extensions of functionalities as plugin. Plugins allow the implementation of new commands, to associate actions to data, to define trigger for conditional event-related operations, to extend the graphical user interface. The component of data analysis management and its integration to data management as owncloud plugin have been developed.

The NeuroBox plugin has to be installed on the server. The deployment affects only the behaviour of the front-end web of Owncloud. The functionalities of the software client are not extended by the plugin. For this reason the data analysis management is only supported through the Owncloud web portal.

The standard web-based GUI of Owncloud service provides an interactive view of the storage area. NeuroBox plugin 2 introduces an additional view devoted to the management of data analysis.

The prerequisite for the NeuroBox plugin is that the data are synchronized on the server side and the structure of folders follows the guidelines reported in Section 2. The functionalities of the plugin are temporarily suspended

when there are ongoing synchronization of data or pipeline executions.

The content of the NeuroBox plugin interface is built dynamically according to the threefold structure of the data. Directories in the storage area that don't follow the predefined structure are not processed by the NeuroBox plugin. The interface is based on three elements: Study, Pipelines and Jobs.

Study. For each directory in the root of storage area there is a drop-out box labeled referring to the source directory name. At

the top level the enumeration of studies is the same in the storage area and in the NeuroBox plugin. The former allows the browsing of data while the latter enables the management of data analysis. Each study drop-out box is organized in two areas: Pipelines and Jobs.

Pipelines. For each executable script that occurs in the pipeline directory of the storage area, a new element is created labeled with the same source name. Each element represents the encoding of a possible pipeline of analysis. Operations are associated to each element: Run, to execute the corresponding pipeline of analysis by scheduling the execution to a HPC infrastructure in a transparent way; Edit, to modify on the y the source code of the pipeline taking advantage of the editing facilities of Owncloud; Show, to visualize the source code of the pipeline.

Jobs. The execution of one pipeline, as reported in the previous paragraph, creates a new element in this portion of interface. Each element represents the dynamic execution of a pipeline. The results of the pipeline execution are saved in the corresponding directory of the study in the storage area. Operations are associated to each job: Info, to inspect the execution progress of the pipeline and the status of the jobs on the queue of HPC scheduler; Log, to visualize the default output produced by the pipeline execution; Results, it is a link to the storage area of the corresponding study where the results of the analysis are saved; Kill, to stop the execution of the pipeline of analysis and remove all the pending jobs in the queue of HPC; Delete, to remove all the storage areas where the temporary and final results of the pipeline execution are saved.

A job creates a own temporary storage out of the control of synchronization service. Intermediate results are not synchronized to the local storage of the end user and no overhead is charged on the network bandwidth. The additional benefit is that it is possible to run twice the same pipeline without to wait for the completion of a previous execution.

Neurobox plugin also includes functionalities related to the administration profile. Owncloud users qualified as administrator have access to a specific section of the GUI. The plugin extends the usual operations in charge of the administrator. The user interface is modified to manage the following requirements:

User Management. The usual creation of a new user profile defines the credentials and the disk quota. The NeuroBox plugin extends the standard operations to manage the authentication of the new user with respect to HPC infrastructure that is organized as a third part service. It is worthwhile to remark that Owncloud and HPC have an independent and autonomous management of user profiles.

Storage Management. The management of disk quota supported by Owncloud is concerned only with the portion of storage that is synchronized with the local storage. The NeuroBox plugin relies on a portion of storage

out of sync for job execution purpose. The administrator can extend or reduce the related disk quota.

Job Management. The administrator is enabled to interface the HPC infrastructure and monitoring or kill jobs of the users. The purpose is to support the control of job execution since we assume that the users don't have a direct access to a HPC terminal.

The Neurobox plugin is distributed as open source software. The current version is available as git repository at the following address: <https://github.com/FBK-NILab/NeuroBox>

Usecase

The development and the test of the proposed architecture was driven by a reference usecase concerned with an fMRI clinical study. A neuroscientist and a neurosurgeon were accomplishing a presurgery brain mapping related to language. The neurosurgeon worked at the hospital where he collected data, while the neuroscientist worked at the University where he defined the pipeline of analysis, EnginSoft provided HPC infrastructure based on 1.000+ cores, configured with Scientific Linux Distribution (2.6.32-x86-64) and Sun Grid Engine (8.1.2).

Part of the system was deployed by configuring a server with a virtual host based on Linux distribution, Owncloud (version 5.0.4) and the NeuroBox plugin). The server hosted a threefold network interface: the first with a public IP to internet, the second to the HPC local network, the third to a dedicated high bandwidth connection to the local hosts of end users. The dedicated connection aimed to lower the time required to synchronize the data to the HPC storage area, while the public connection provided the flexibility to access the NeuroBox service from the web and to support anytime job control and monitoring. Speed test on information (1.0 GB) transfer comparing the network paths showed that dedicated connection performed 12.5 times faster (up to about 120 MB/s) than the internet path (up to about 10 MB/S).

The user approaching NeuroBox service should accomplish the following sequence of steps: (i) to register at the front-end web of the service; (ii) to download and install the Owncloud client software (according to own OS platform); (iii) to configure the client according to their current location of storage area; (iv) to enable the synchronization of data and scripts through the client, following the directory convention described in Section 2; (v) to run the analysis jobs using the plugin web interface; (vi) finally, when the job is finished, users may inspect the results on the local storage area. Steps (i-iii) are required only once.

In presented usecase flexibility of the whole architecture has been increased by adopting Nipype as reference method to encode the pipelines of analysis. Nipype python library is a solution that provides a uniform interface to several existing neuroimaging software, it facilitates interaction between these packages within single workflows. In addition, Nipype provides a simple and transparent interface to an HPC infrastructure; a plugin, specific to SGE, manages the mapping of the workflow execution to the distributed parallel environment.

Test study collected two subsequent fMRI recordings for 5 patients according to a predefined protocol of stimuli in the hospital of Trento. After a procedure of anonymization, data have been shared by the neurosurgeon using the cloud service. Referring the same storage area on the cloud, the neuroscientist provided the design of the pipeline of analysis. Some iteration took place to refine the design of the pipeline. After this step, the neurosurgeon is in the position to consult the brain map directly on his

own computer/tablet. Neurosurgeon was not required to annotate the data according to some predefined XML schema while neuroscientist was not limited from the pipelines installed on the website.

In addition to this usecase the system has been tested in laboratory with a pipeline to compute deterministic tractography from diffusion MRI data and a pipeline to compute a multivariate brain activation map from magnetoencephalography (MEG) recordings.

Conclusions

In order to be as user friendly as possible, a common situation, in terms of research environment, has been considered by inserting a layer between end users and high-performance computing services thus hiding all Cluster complexity.

The framework starts from the installation of a Server, acting as a layer between users and HPC services, exploiting features from Owncloud data-synchronization software and those from NeuroBox plugin, a in-house web tool combined with Owncloud. These two pieces of software allow data-management, job management and execution of data analysis scripts through distributed computing frameworks in a transparent way and final collection of the results, potentially from everywhere.

In this way data management and analysis are facilitated: for end users, e.g. those from medical structures, we claim to make them exploiting computing power that is sometimes just ignored; for advanced users, e.g. researchers already dealing with HPC services, several features, previously described, might facilitate the development and testing of new data analysis code directly on the HPC framework, improving the integration of these tools in the everyday research routine.

Future work is needed to improve two features which would complete the picture we described so far. First, to include a visualization tool within the web interface, in order to quickly explore the results. Second, by registering execution time and other information coming from the job submission, the provenance concept has been basically implemented, i.e. to track operation performed on the data from their acquisition to the production of results. Further work is needed to improve this aspect, for example implementing other kind of markers like hardware and software configuration, software version and so on, in order to improve reproducibility of research in an almost free way.

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Crowd Dynamics, emergence of behavior and Jamology

Something which often annoys us and leads to stress are jams. They are part of our daily routine if we live in a big city, and even if not, sometimes we still need to be patient when they spoil our holiday moods. Although we always try to avoid jams, there is no way to consider any measures if we don't understand the mechanisms which produce jams in the first place. In recent years, a very interesting science field has evolved from these and similar considerations, it clarifies jams and researches them as crowd dynamics.

I have had the pleasure to interview 2 leaders in this field, Professor Stefania Bandini and Professor Katsuhiro Nishinari. Prof. Bandini is a professor and the director of the "Complex Systems & Artificial Intelligence" Research Center (CSAI). At the same time, she is the director of the PhD School of Computer Science at the Faculty of Computer Science, University of Milano Bicocca, and a guest professor of the University of Tokyo. Moreover, Prof. Bandini holds the position of president of CROWDYXITY. Part of her research focuses on the crowd dynamics of pedestrians and vehicles from the viewpoint of computer science. Prof. Nishinari is a professor at the Research Center for Advanced Science & Technology (RCAST) of the University of Tokyo. He is a Guru in the science of jam fields and studies them by using a mathematical approach. He has published many books and appears regularly and energetically in different Japanese media to disseminate his research. In his work, he introduces the science of jam as "Jamology". Prof. Bandini and Prof. Katsuhiro

have been collaborating ever since the beginning of their research, they work together very closely. They have also been good friends for many years. Prof. Nishinari loves Italy, he is a tenor and adores Italian opera.

What does your research focus on?

Prof. Bandini: Our research concerns the study of the dynamical behavior of pedestrians and crowds in the scientific framework of Complex Systems. Our collaboration aims to observe and study the dynamical behavior from the viewpoints of mathematics and computer sciences, in order to understand it better and to design computer-based simulation.

The main goals are the development of mathematical and computational models to stimulate a new generation of computer-based simulation systems to support decision makers, crowd managers and designers of public and private spaces.



Is there a particular aspect of the behavior of pedestrians and crowds that you would like to summarize briefly to our readers?

Prof. Bandini: Crowd is a complex phenomenon characterized by self-organizing properties. The study of these properties requires multidisciplinary competencies to be involved in order to take into account anthropological, sociological, psychological and physiological aspects. The development of new computer-based systems to simulate the behavior of crowds will be more realistic and useful in the future only if all these disciplines are considered and provide their contributions.

What originally inspired this research?

Prof. Bandini: The growing need for crowd management, in particular conditions (for instance, evacuation, optimization of queuing) and the opportunities offered by the development of new computational models, that will allow more realistic simulation scenarios. This trend has been seen first about 10 years ago, so the history of the discipline is very young. Moreover, the focus on micro-simulation, the presence of groups in the crowds and the representation of emergent self-organizing behaviors, are the main characteristics of our research.

Could you introduce your company CROWDXITY?

Prof. Bandini: CROWDXITY is a new company (a spin-off from the University of Milano-Bicocca) dedicated to the development of “what-if” scenarios and advanced computer-based solutions to study, according to Complexity Sciences and Artificial Intelligence techniques, pedestrian and crowd dynamics in collective metropolitan spaces. CROWDXITY brings together an international and multidisciplinary team of specialists educated in the research environment and operating in computer science, sociology, mathematics, architecture, anthropology, psychology, arts, and communication.

What kind of crowd dynamics problems do you see?

Prof. Bandini: Each country has its own challenges with crowds. For instance, we sometimes have problems when it comes to football in Italy and England. During the Haji, one of the largest annually

occurring pilgrimages in Saudi Arabia, many people lose their lives every year. We don't see crowd problems in the US often, however, the country, from time to time, faces difficulties when their military forces move to other countries. In Japan, we should consider public transportation scenarios and the optimization of the comfort, both topics are of great importance for the culture of Japanese people. In addition, the challenges linked to evacuation have become a high priority in Japan especially since the Tohoku disaster in 2011.

How are you and Professor Nishinari collaborating?

Prof. Nishinari: We have a lot of experiences in public spaces here in Japan. One example is the project on the queuing at the immigration in Narita International Airport. I'm responsible for the design of the queuing system. We did regular experimental observations and sometimes Prof. Bandini joined the experiments. Narita Airport has 2 terminals. The construction and the design of the new terminal is very good. In contrast, there are always problems with the old terminal building as far as the queuing is concerned. As huge financial investments would be necessary to reconstruct the old building, the airport authorities ask for our advice to improve the situation in the current building.

Prof. Bandini: Among our recent studies, there is also a project with Honda. This is an experiment which concerns the test of a new generation of onboard wireless technologies devoted to fuel saving and pollution reduction through telematics suggestions for drivers. The aim here is to apply and foster virtuous driving behavior. It is important to say that thanks to our collaboration, it was the first experiment by Honda outside Japan, executed in Milano. It was carried out in real traffic in Milano. The most valuable scientific purpose of this experiment concerns the application of Complex Systems Science principles to traffic behavior. Our focus is also on the self-organization of the single driver integrated in traditional means for traffic control.

The design of the experiment on traffic and crowd is very difficult, because we need data about the behavior of the crowd and pedestrians, then we fit it with computational models, and finally, we calibrate and validate these computational models. This is one of the specialties of Prof. Nishinari's Lab, they are outstanding experts in the design of the settings for the experiments to gather the volunteers and to design, in a very precise way, what is the measurement and what is the observation. In fact, they are among the best in the world when it comes to designing this kind of experiment.

Another intense research activity we are developing deals with the Ageing Society and its challenges for our countries. Japan is much more aware of the problem than most European countries. In collaboration with the University of Tokyo, the Tohoku University in Sendai, and the University of Umm Al Qura (Saudi Arabia), we are developing a long-term (5 year) higher educational project to build and support a new generation of scientists and decision makers, to face the technological problems and opportunities associated with the Ageing Society from the different approaches of our specialties. (www.alias.disco.unimib.it)



Prof. Stefania Bandini and Prof. Katsuhiro Nishinari



Prof. Nishinari's experiment to look at the effect of a column in front of the exit



NHK TV "Science ZERO"

Do you often work on projects by relying on such collaborations?

Prof. Nishinari: This field is advanced in Germany as well, and we maintain collaborations with the universities there. Prof. Bandini is also involved in these projects. They are very international and interdisciplinary. We collaborate with scientists in the different fields. Now, we are working with a psychologist in order to see how the influence of musical rhythms affects the pace of the pedestrians. Generally, crowds are very hard to control. But if you apply some music or rhythm, it may influence their mind and psychological rhythm. Sometimes their movement becomes very smooth by applying a constant rhythm. Indeed we can say it is a kind of interdisciplinary and very interesting research work.

Prof. Bandini: It is important that the core of our collaboration is our interest in phenomena like self-organization and emergent behaviors of complex systems, and that we research together from 2 different scientific disciplines, mathematical models and computational models. The crowd and the pedestrians' behavior is considered as self-organizing complex systems. Therefore, it is not possible to model and simulate with traditional mathematics. We need to develop a new form of mathematical computational tools to face this kind of phenomenon. So this is the scientific collaboration. In order to achieve our goal, we need methods for data acquisition and experimental observation. Prof. Nishinari's group are the experts for that. The complexity of science is the umbrella of our collaboration. Hence, the final purpose is to create some kind of a simulation tool by using our mathematical and also the experimental method.

Prof. Nishinari: To solve the real problems such as traffic jams, dangers, risks and many other things in reality, we want to take advantage of mathematical and experimental modeling, computer simulations and so on.

How do you account for the variables, such as age, size of the people and even culture and people's mentality?

Prof. Bandini: We had the opportunity to discuss this issue through the Crystal project. We had to understand the different cultural approaches at the Hajj in Saudi Arabia. It's totally different. One of the topics is that each culture we have differs in proxemics and

relationships. In Japan for instance, people normally don't like to be too close, but they accept it more than in other countries when they are on the subways. In Italy, we don't mind touching, however, if we are on the subway, we are much more nervous to be too close than in Japan. So, we discuss this topic from different perspectives, and how to fit computational modeling to different problems and cultures is and remains a challenge. Yet, if we have good formal mathematical results, through the correction of data in different situations/context, we will be able to apply our method to help people in problematic situations.

Prof. Nishinari: Thinking about the variables, to organize the experiments and to correct the experimental data is very important. Without experiments, we don't know how we can model and whether we will be able to verify if the model is good enough. In addition to that, we must have a sharp eye to capture the essence of the data.

Can you tell us about the current situation of the simulation software for crowd dynamics?

Prof. Bandini: Traditionally, crowd and pedestrian dynamics have been studied by using fluid dynamics, as the case with other traditional mechanical models. In recent years, few software platforms have been developed. We are still at the research stage, and we know about the lack of such software platforms. Although they are becoming standard, it is quite dangerous because the algorithms are not very good sometimes. There is no knowledge about what we are working with, and they don't have enough data. Another disappointing point with this kind of software platform, for example with tools for fire diffusion and pedestrians, is that they are putting together discrete and continuous mathematical models. It is quite easy to launch the software platforms, but they are not perfect. The users should keep this in mind.

Prof. Nishinari: People tend to use such software because the appearance of the post-processing is so attractive and promising. Yet the reality is that we don't know the reliability. No model is perfect. This can be said for mechanical engineering, but it's especially true for pedestrian and vehicle simulations. You know that Newton's law cannot be applied. In fluid dynamics, there are always strict laws. However, as far as pedestrian flow is concerned,

we don't have such documentation and communications. That's a very important point, and we have to brush it up and produce updates.

Prof. Bandini: From a scientific point of view, I can say that for the large mass who wants to see the statistical probability of something, fluid dynamics is quite applicable. But if you want to do micro simulations, you can't do it with fluid dynamics. You can't guarantee that the mathematical model is functioning because of the nature of the model.

There is another discipline which it is the operational research. We discuss intensively in some papers about what is the difference between the traditional operational research and the new approach from complex systems.

Prof. Nishinari: There are so many assumptions in theory, which at times break reality. So the operational research approach is sometimes very good, but there are many assumptions which, at times, contradict with reality. This is why the results can't be applied. We always have to care about the assumptions, and we have to take into account the lack of many things before using the software in a black box way. Sometimes that can be very dangerous. The other point we should mention is that you can't represent important characteristics of crowds from operational research and fluid dynamics in a classical model. That's why our research is distinguished from these disciplines.

How frequently is the crowd simulation applied in our real life?

Prof. Bandini: The knowledge about crowd simulation and study is quite young. It's also relatively recent for public administrations, and there are the constraints of old laws. For instance, traffic engineers and building designers who are not in research, have to take into account the laws. Maybe some laws should be changed following the suggestions from recent research but politicians tend to hesitate to make changes. Hence, it is not easy to have an impact because we have to go against all the mentality using fluid dynamics.

Prof. Nishinari: For example, it's sometimes really strange for us to see certain sentences in the laws. The law for old situations explains that people can evacuate from the room with 1.5 persons per a 1 meter width door. You can see however that there is a clogging phenomenon and people can't go out by pushing each other. Yet in the laws this phenomenon is not considered at all. We did an experiment using computer simulation, and we have found a very simple solution. I put some columns in front of the exit. Someone might think that the exit becomes obstructed but it actually works very well for evacuation. From an additional experiment, we discovered that even a little sign also worked because people are clever, and they are self-organized. People are not just particles but thinking particles!

How do you think are people influenced by the information you provide?

Prof. Nishinari: Information control is a tough problem. For example, using the car navigation system, it is easy to detect which road is

congested and which road is free. But if you broadcast the road is free to all drivers, then they gather at one place without making a selection. So providing information is an interesting research topic.

Prof. Bandini: Let's assume that you have 2 streets to control; in the one street, you push the people or the cars in the right direction and in the second, you let them use self-organization because people are thinking - we are in the second street. It is too psychological and difficult, so we are working on the self-organization part.

Prof. Nishinari: There is a very important keyword "emergence" of the behavior. It arises from our self-organization. Therefore, I think the marriage between mathematics and psychology is very important. Mathematics is sometimes logical but it does not consider "the inside" of people. People are thinking, crying, they are happy, they have strong emotions. Such human factors are not covered in mathematics but in psychology they are studied. Still, the phenomenon has to be examined also using mathematical considerations. For all these reasons, the marriage between the 2 is promising and represents an interesting field.

Can you tell me about your future challenges?

Prof. Bandini: One of our next challenges is the traffic in a social network system like Facebook. The scientific challenge is how to fit in geographical data because there are GPS and virtual spaces. You have people who are connected in a social network but they also have geographical areas. So you can have a crowd situation in the one area but no crowds in the other as we have virtual spaces and physical spaces. We are studying physical spaces and sooner or later, we will look at the problem of the virtual spaces. Another study which is also interesting is about computer vision. This is part of a new collaboration with our partners in the United States. At the moment, high level military computer vision technology is not yet allowed for use for people counting, the detection of groups, and detection of pedestrian behavior. This is also a challenge for surveillance technologies, and they need our data. The data from our experiments is gold for the people who are designing new algorithms for computer vision.

Prof. Nishinari: Automatic detection of what is happening there is very important. Yet it is quite poor compared to our observations because humans can immediately understand the risks and what is going on. Using cameras for automatic detection is very bad for crowds and pedestrians. For individuals, it's okay. But for instance, if you have a trolley and the computer vision sees 2 people, it is not precise. So all in all, collecting data and the ways of collecting data are very important. From a different aspect, we can also say that automatic detection systems and sensors have many ways of collecting data. They can as well be useful for modeling and simulation. So, from a scientific viewpoint, it is very interesting. I like the applications too, they always work when I consult some companies. I am delighted about that, and I know that it is very useful for my future research.

*Akiko Kondoh,
Consultant for EnginSoft in Japan*

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2013-2014 CAE EVENTS

Stay tuned to www.enginsoft.it/eventi for the complete program of the events in 2013 and 2014

EnginSoft at the Paris Air Show 2013

Last June the 50th edition of the Paris Air Show was held at Le Bourget in France. For one week, EnginSoft presented its capabilities in multidisciplinary complex simulation and virtual prototyping from system to component level in the aerospace domain.

A SUCCESSFUL PARTICIPATION

This 50th edition was once again a great success for the exhibitors and for the visitors, in spite of nasty weather ranging from rain and thunderstorms to stifling heat. EnginSoft is pleased with its participation in this new edition and managed to achieve its objectives, as many SMEs were present on the ASTech stands.

THE MAJOR COMPONENT OF OUR STAND

On this occasion, a particular component interested a large number of visitors to our booth. Indeed, our Italian team had brought all the way from Italy an old Turbomeca Marbore engine from a jet which crashed in the 1970's. After the crash, a team of researchers from the University of Padua decided to restore the engine thanks to EnginSoft's knowledge in numerical simulation.

AN IDEAL LOCATION

Thanks to an ideal location on the ASTech competitiveness cluster of Ile-de-France, EnginSoft was able to take part in the different events throughout the week. This show was also the opportunity for Marie-Christine Oghly, CEO EnginSoft France, to share and to exchange with numerous professional relations on the new economic stakes in the sector.

"In collaboration with the International team of EnginSoft, we have shown the synergy of our group and present all of our skills. A great success for this participation in the major airshow"

Marie-Christine OGHLY, CEO EnginSoft France

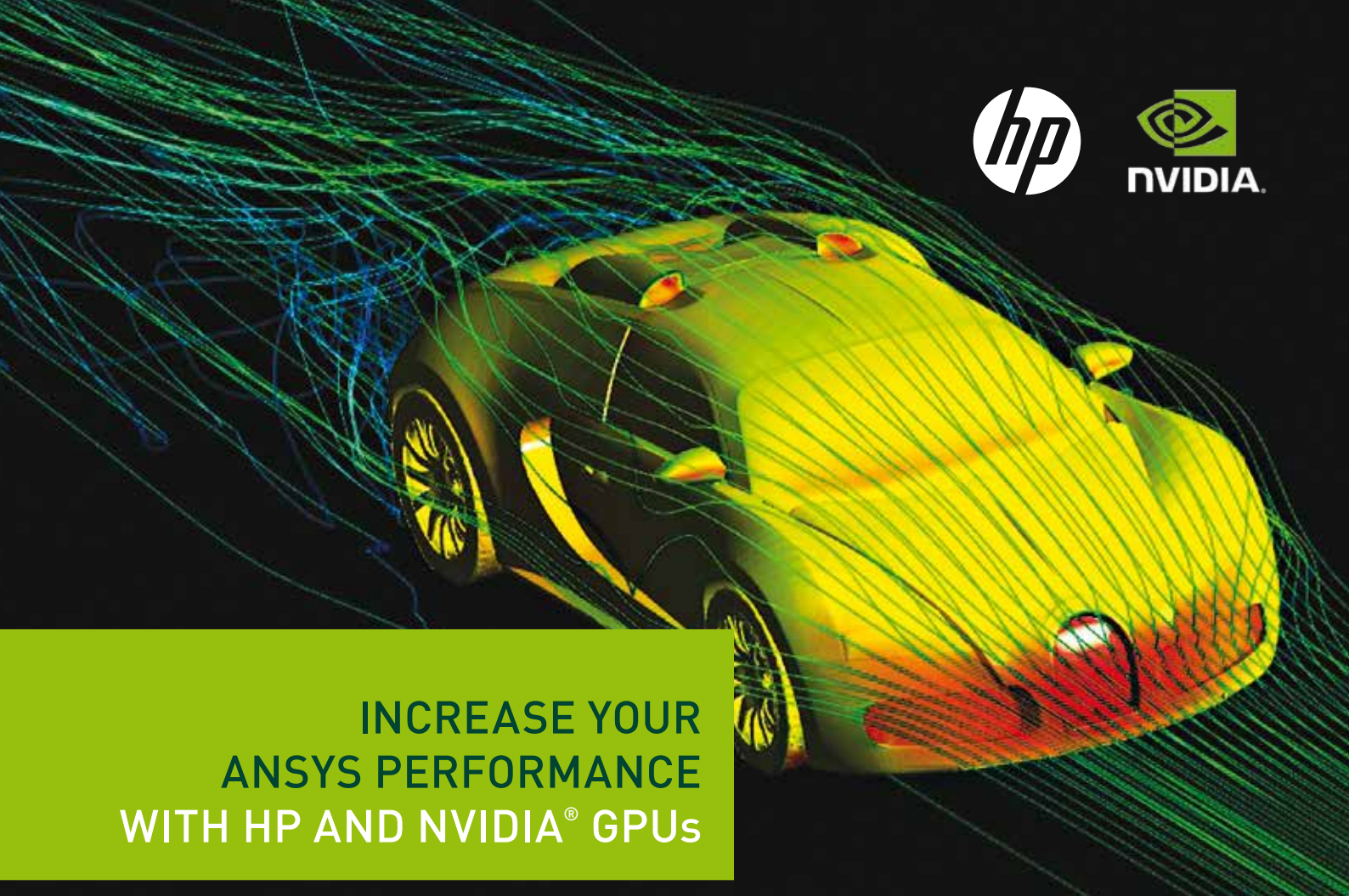
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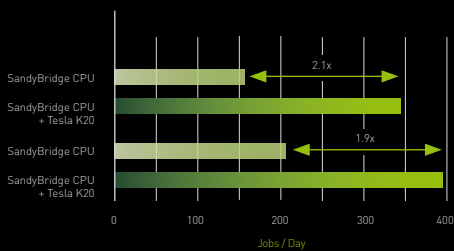
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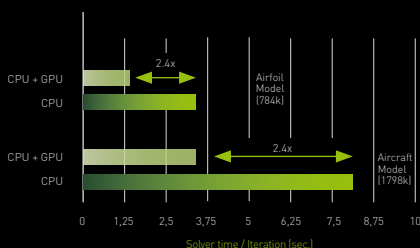
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1) Distributed ANSYS Mechanical 14.5 with 8-core CPUs and single GPUs, V14sp-5 Model, Turbine geometry, 2.1 M DOF, direct sparse solver, Westmere CPU-Xeon X5690 3.47 GHz, SandyBridge CPU-Xeon E5-2687W 3.10 GHz. 2) All results are pressure-based coupled solver times. Airfoil and Aircraft Models with Hexahedral Cells using Intel Core i7-3930K Sandy Bridge-E CPU, 3.2 GHz with 6 cores, Tesla K20X GPU, CPU Fluent Solver F-cycle, agg8, DILU, 0pre, 3post, GPU nvAMG solver-V-cycle, agg8, MC-DILU, 0pre, 3post. © 2013 NVIDIA Corporation. All rights reserved. NVIDIA, the NVIDIA logo, NVIDIA Quadro, Tesla, and CUDA are trademarks and/or registered trademarks of NVIDIA Corporation. All company and product names are trademarks or registered trademarks of the respective owners with which they are associated.



LET'S SIMULATE
THE WORLD
OF THE FUTURE



International CAE Conference 2013

The 2013 edition of the EnginSoft annual flagship event on simulation technologies and technical computing will be held in Pacengo del Garda (Verona, Italy) on October 21st-22nd

Our lives are dominated by the creative outcomes of human design activity. From the raw material of natural processes and our environment, our world is crafted by human ingenuity. And of course, we recognise that our world is sometimes blighted by the unintended consequences of our imperfect understanding of this process. Across all the sectors in which human endeavour seeks to mould its environment, computer simulation has become a central methodology. From its historical home territory of mechanical engineering, pressing out into the domains of life sciences and urban design, and addressing the challenges of the green economy and sustainable growth, "CAE" has become a pervasive paradigm for understanding the complex systems of both our found and designed environment.

The International CAE Conference series has firmly established itself on the world stage as a premier forum for the discussion and development of simulation across all these disciplines. Looking at the topics chosen by our keynote speakers, we can see exactly the multifaceted, multidisciplinary nature encompassed by the term "CAE." We will hear Vincent Cousin's understanding of the city as a planned system expressing one type of complexity, and see it counterpointed by the multiscale, multiphysics simulation of durability in composite systems discussed by Jacob Fish. The massively-interacting systems underlying the simulation of tumour growth described by Bernardo Schrefler seem well-attuned to the capabilities being developed by Gianluca Iaccarino in the realms of exascale computing, and fault-tolerant domain-specific programming languages. If Gianluca's paper is a pointer to the future, it stands on the shoulders of extensive current activities in high-performance computing, exemplified by Alexander Simpson's work at GE, and further illustrated by Catherine Riviere. Acknowledging the role that CAE will play in moving our economies towards a more sustainable basis, Michael Gasik will show how simulation can assist in optimising strategies for hydrogen generation from renewable energy sources.

Drilling down into this rich web of disciplines and examples, we also look forward to a range of truly expert presentations in our sessions

from various industrial sectors (Aerospace and Defence, Transportation, Biomechanics and Biomedical Devices, Civil Engineering, and Energy). These are supported by individual workshops on a range of supporting technologies, covering key software tools and methods.

We are proud to welcome our Italian astronaut, Maurizio Cheli, as one of our keynote speakers. As a test pilot and participant in manned spaceflight, Maurizio has exemplified the human ambition to develop and utilise the most complex and demanding technologies – a great match for the International CAE Conference, and its fascinating and detailed exploration of exactly those tools and technologies required by such an ambition. If you are involved in engineering – as a practitioner, manager or policy maker, there is no better environment for updating your knowledge of the state-of-the-art in this rapidly-evolving and crucial discipline.

www.caeconference.com





21 | 22 OCTOBER 2013

Pacengo del Garda
Verona - Italy

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