Multiphysics Maestro

An industry visionary shares insights into the evolution of multiphysics solutions and future challenges to overcome.

EnginSoft S.p.A., headquartered in Italy and established in 1984, focuses on engineering technology and design process innovation. Company founder and CEO Stefano Odorizzi was interviewed by Keith Hanna, ANSYS corporate marketing director in Europe, about the role of multiphysics in engineering simulation.

Dr. Stefano Odorizzi

How did you become focused on engineering simulation, and specifically on multiphysics?

I graduated in 1973 with a civil engineering degree from the University of Padua in Italy. I stayed there to pursue an academic teaching career in construction technologies and mechanics. Research in these fields included work in the fledgling technologies of finite element analysis (FEA), computer-aided engineering (CAE) and intelligent digital prototyping (iDP).

Throughout the 1970s and 1980s, computer power increased dramatically and enabled more complex problems to be handled by engineering analysis codes, such as those available from ANSYS, Inc. A growing number of simulation applications were directed at representing the real-world loads and constraints engineers must always take into account — that is, multiple interacting physics such as structural, fluid dynamics, thermal and electromagnetics.

Capabilities for modeling and analyzing multiphysics problems unleashed a wave of engineering tools that have transformed the way engineers design, develop, retrofit and enhance products in an expanding range of industries. The integration of multiphysics simulation into engineering processes was my vision from the start and remains so today.

You recognized the emerging trends in multiphysics simulation quite early. How did you leverage this technology into a commercial opportunity?

During the 1980s, industrial companies quickly saw the benefits of computer-aided engineering, so in 1984 I founded EnginSoft S.p.A. for technology transfer of these solutions — mostly doing consulting in the Italian market. As a complementary enterprise, in the 1990s we set up ESTECO, a research laboratory for engineering optimization and IT technologies, which these days fall within the field of process integration and design optimization (PIDO).

The concept behind PIDO is to refine designs quickly and effectively by blending simulation into product development processes, rather than performing these studies as a separate function. At ESTECO, we subsequently launched modeFRONTIER™ optimization software for companies to implement PIDO in their particular product development activities. Essentially, the software controls the simulation of a wide range of design variables and quickly converges on a solution that best meets all engineering requirements.

Today EnginSoft has a staff of over 200 and more than 800 clients worldwide. We have been an ANSYS channel partner in Italy since 2003 and have had links to CFX software for computational fluid dynamics (CFD) for over 15 years. The long-standing relationship with ANSYS is one of EnginSoft's major strengths.

In the early years, was multiphysics less of an issue, since individual engineering simulation disciplines such as FEA and CFD were done separately for the most part?

Yes and no. From the outset, EnginSoft applied an approach aimed at multiple disciplines in what we called CAE solutions for the design chain. We developed ancillary software for transferring models and data from one domain to another — for instance, from finite difference-based CFD to FEA-based structural analysis.

This was cumbersome, but it met customer requirements for the physics to be coupled, even though indirectly. So to some extent, what is known today as multiphysics is the approach we used for multiple disciplines two decades ago. Since then, the approach has widened to encompass a range of multiphysics and multi-scale technologies as well as manufacturing process simulation.

How does technology from ANSYS fit into your current range of activities?

The multiphysics approach of software from ANSYS goes hand in hand with our design process optimization concept for multiple disciplines, with ANSYS structural and mechanical modeling software as well as fluid dynamics and meshing technologies performing critical functions in the workflow. We have used this combination with considerable success at many companies, including the auto supplier Mazzucconi and the Piaggio motorcycle and motorbike company. (See accompanying sidebar stories.)

We are currently engaged in two European Union collaborative projects with the aerospace and automotive industries that involve multiphysics and design optimization for all levels of a design process, from component to system level right up to the early production concept phase.

What do you see as the major challenges currently facing the engineering community in making further progress with multiphysics simulation?

As multiphysics and advanced modeling methods become more advanced, simulation-based engineering and science will be indispensable in meeting the technological challenges of the 21st century. The process will not be "simulation as usual" for narrow studies of individual parts and assemblies, but it will be focused on complex, interrelated engineering systems and on analysis results that meet specified standards of precision and reliability. Hence, engineering simulation will develop new methods, technologies, procedures, processes and planning strategies. All these will be key elements for achieving progress in engineering and science. To reap these benefits, however, four significant obstacles must be overcome.

First, we must revolutionize the way we conceive and perform simulation. In this respect, the mass success of computer-based engineering simulation may be its own worst enemy, because the knowledge base, methods and practices that enabled its achievements to date now threaten to stifle its prospects for the future because of organizational inertia and a reluctance to implement new approaches.

Second, we must make significant advances in supporting technologies, including those for structuring the way in which models are built and organized. These technologies have a huge impact on the complexity, solution time and memory capacity required, and, even today, some of the most complex turbulent-flow problems cannot currently be solved on the world's largest and fastest computers. If progress continues at the rate of Moore's law, such solutions may not become practical for decades unless effective multiscale modeling technologies are developed to represent the entire range of complexities, from minute individual component details up to broad system-level characteristics.

Third, meaningful advances in simulation-based engineering and sciences will require dramatic changes in education. Interdisciplinary education in computational science and computing technology must be greatly improved. Interdisciplinary programs in computational science must be encouraged, and the traditional boundaries between disciplines in higher education must be dissolved for information to be exchanged smoothly between scientists and engineers collaborating within teams from multiple disciplines.

Fourth, because of the interdisciplinary character and complexity of simulation, we must change the manner in which research is funded. Incremental, short-term research efforts are inadequate and instead should be replaced by long-term programs of high-risk research. Moreover, progress in such research will require the creation of interdisciplinary teams that work together on leading-edge simulation problems.

If applied mathematics and computer science methodologies are focused on computational science at this broad scale in overcoming the above barriers, there is ample evidence that developments in multiphysics and related new disciplines could significantly impact virtually every aspect of human experience.

Where do you see engineering simulation going in the next 10 to 20 years?

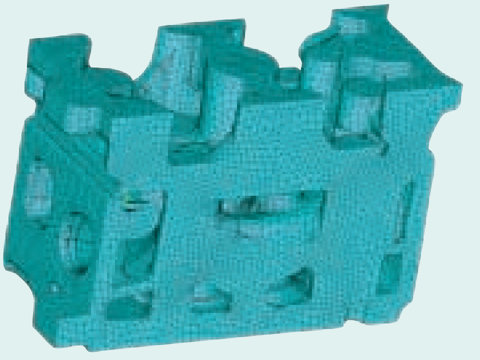
From the perspective of EnginSoft, simulation-based optimization will undoubtedly be used for more realistic decision-making in support of engineering design, product manufacturing and field service activities. Tremendous strides are already being made in technologies and approaches for managing the huge amounts of simulation-based data.

Also, among the world's leading engineering simulation software suppliers, ANSYS, Inc. has the right long-term vision and is making significant investments both in the core disciplines of science and engineering and in the development of algorithms and computational procedures for dynamic multiscale, multiphysics applications.

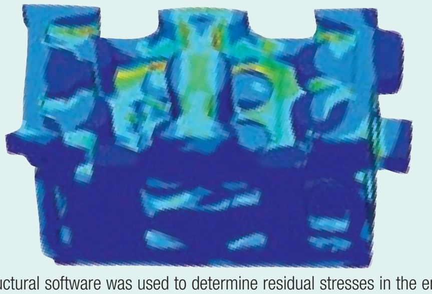
Do I personally think we will get to a point where science fiction becomes science fact within the next decade or two, where design engineers focus most of their efforts on imagining product variants and product innovations while computers churn away in the background spitting out predictions in real time? I really do think these dreams will become reality in my lifetime. ■

Mazzucconi Uses Simulation Throughout the Entire Process

In one recent project, EnginSoft used multiphysics technologies in the study of a 1.3 liter diesel engine cylinder head, made by the casting and pre-machining supplier company Mazzucconi for Italian automaker Fiat. In this study, ANSYS Structural software was used in comparing residual stresses due to casting process, pre-machining and heat treatment. This set of simulations represented leading-edge engineering simulation technology that required a wide range of physical transient values (temperature and deformation, for example) to be computed using control-volume meshing and transferred to the ANSYS Structural model. "To my knowledge, this is the first time that the overall project and production process of such a complex cast component was thoroughly simulated by working in a single environment," noted Luca Pirola, technical manager of Mazzucconi. "It's amazing how powerful the tool is to analyze the logic of the problem, as well as to optimize the entire process and synthesize and document the results for decision-making."



This detailed finite element model contains more than 26,000 solid elements to accurately represent the intricacies of the Mazzucconi engine block casting.

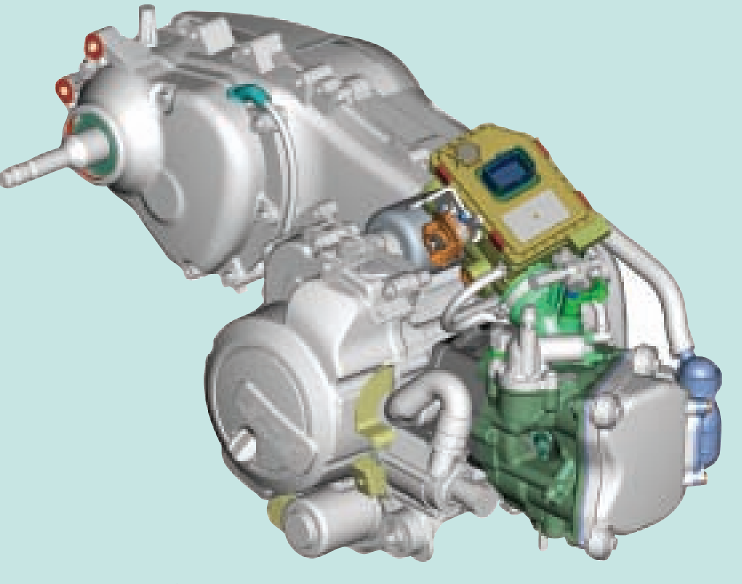


ANSYS Structural software was used to determine residual stresses in the engine block to optimize casting, machining, heat treatment and other production processes.

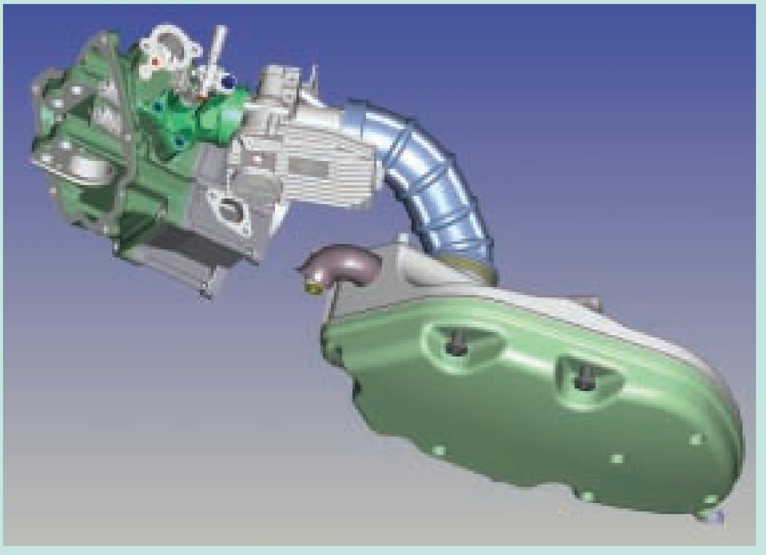
Piaggio Boosts Motorcycle Engine Performance by 15 Percent

The Research and Development Center for Piaggio group approached EnginSoft to perform multiphysics optimization studies on one of their motorcycle engines. The goal was to shorten product development time and reduce costs by refining the design with engineering simulation instead of numerous prototype test cycles. The major challenge was in developing an environmentally friendly engine that conformed to stringent emissions standards while maintaining high performance in terms of low fuel consumption, reduced noise and high reliability.

Piaggio engineers first created a 1-D functional model representing the entire engine system, taking into account the full set of structural and fluid dynamics parameters for meeting all of the engine power, torque and energy requirements. Pressure, velocity and temperature output values from the 1-D model served as an input for ANSYS Structural software to calculate the structural behavior of engine materials. The 1-D results were also used as an input for ANSYS CFX software to calculate the complex fluid mechanics and conjugate heat transfer of the engine cooling system.



This CAD model shows details of the Piaggio engine, for which the structural behavior of parts and materials was determined with ANSYS Structural software.



Geometry of the engine cooling system was imported into ANSYS CFX software to study fluid mechanics and heat transfer of the system.

The modeFRONTIER software managed this multi-variable simulation process providing input to the 1-D code (more than 20 parameters were taken into account), along with the physical and geometrical parameters of the gaskets and cylinder heads for both ANSYS Structural and ANSYS CFX simulation. This design methodology met the project time and cost goals and provided an added benefit of improving engine performance by 15 percent. In this way, ANSYS Multiphysics technology and a collaborative optimization approach helped Piaggio gain a significant advantage in a fiercely competitive global market.