Parlez-Vous HPC?

French consulting firm EURO/CFD offers clients cost-effective, flexible access to world-class HPC resources.

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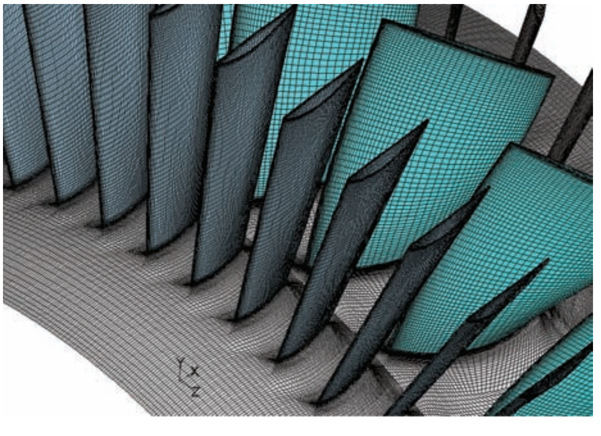
Larger model with a full 3-D view of small turbulent structures

Among innovative product design and engineering companies, there is a natural interest in leveraging the power of high-performance computing (HPC) environments to support their simulation needs. HPC offers a pathway for delivering results in a faster, more cost-effective manner with a greater degree of confidence. However, it is neither easy nor inexpensive to build a world-class computing cluster, and many small and mid-sized businesses simply cannot afford to make this kind of investment. Even larger organizations may not be willing to devote increasingly scarce budgets to this kind of specialized technology.

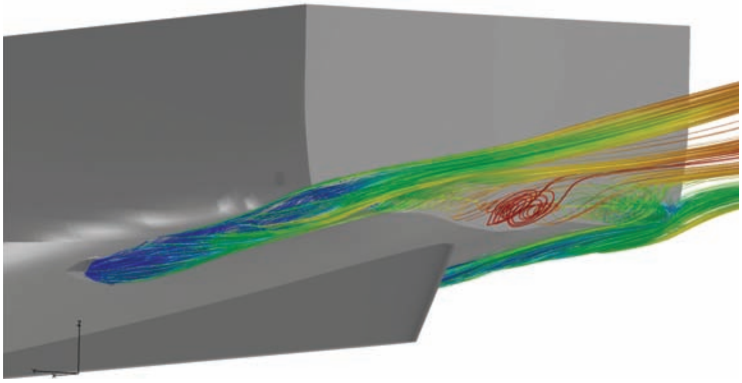
To address such issues, EURO/CFD creates cost-efficient services in computational fluid dynamics (CFD) with flexible HPC resources for companies that rely on simulation to analyze and improve their product and process designs. Headquartered in Belfort, France — a center for energy, automotive and industrial businesses — EURO/CFD is easily accessible to customers throughout Europe. The firm serves a wide range of clients, including companies in the energy, automotive, aeronautics, construction and pharmaceutical industries.



This mesh view of first-stage compressor components was part of a 51-million-cell ANSYS Fluent simulation that EURO/CFD accomplished in just three weeks.

EURO/CFD's mission is to enable customers to focus on their core engineering capabilities while relying on the firm's simulation expertise and robust HPC cluster to produce high-quality results at a minimal investment of time and money. The company employs 15 multilingual engineers and scientists who specialize in fluid mechanics and heat transfer.

Known as “Little BIG,” the HPC system at EURO/CFD is the largest computing resource of its kind among small and medium-sized businesses in France. The cluster consists of more than 700 AMD Opteron™/Intel® Xeon® processors, operated under Windows® HPC 2008 R2 and 64-bit Linux®. A fast InfiniBand® network enables the cluster to perform unsteady calculations on models with more than 200 million cells. Using ANSYS software to run CFD simulations on this powerful cluster, EURO/CFD offers calculation speeds up to 50 times faster than simulations performed on a typical workstation.



EURO/CFD applied ANSYS Fluent in an HPC environment to quickly model back pressure in an underwater exhaust system. In addition, the design needed to direct flue gas away from the propeller. Path lines of flue gas from the exhaust system are shown here.

The outcomes from EURO/CFD's offerings speak for themselves. As illustrated in the examples that follow, the firm has delivered diverse HPC-enabled simulation results to customers across the continent.

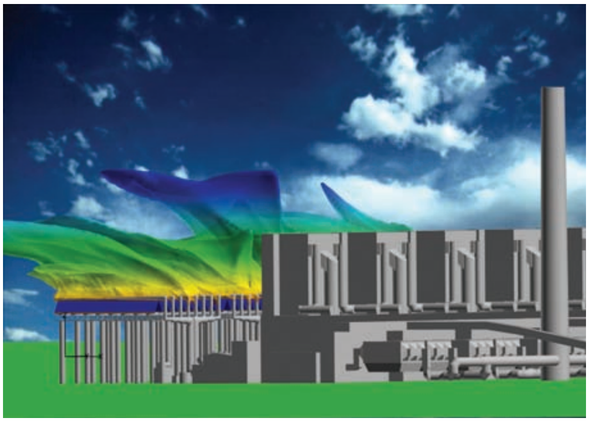
Significantly Compressing Analysis Time

EURO/CFD recently used ANSYS Fluent to study both quantitative and qualitative characteristics of noise generated by a first-stage compressor during normal operations. To analyze the flow impact on noise, the company's CFD analysts modeled both uniform and distorted air velocity fields at the compressor inlet. Because small flow structures were under analysis, the Fluent-enabled simulations would have to consider very small time intervals.

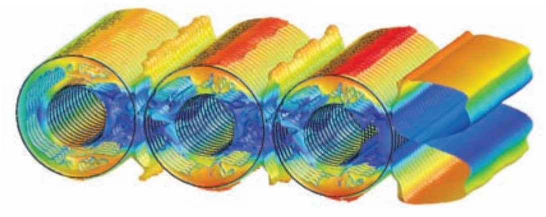
Modeling the compressor in a full 360-degree geometry and using time steps of less than 10^{-6} seconds — as well as accounting for turbulence — resulted in a mesh with 51 million cells, which would require 5,000 CPU-days to solve. A typical company with an in-house 50-core cluster would need about three months to complete the simulation. However, by using 256 cores from the Little BIG cluster, EURO/CFD obtained results in just three weeks.

For MARIN (Netherlands Maritime Research Institute), EURO/CFD was tasked with applying Fluent to analyze the performance of an underwater exhaust system. After calculation of the dynamic trim, sinkage and wave elevation along the vessel with its own potential-flow code (RAPID), MARIN wanted to merge these results with the simulation of multiphase flow exiting the underwater exhaust. EURO/CFD engineers checked the back pressure as a first step and then evaluated different scoop designs to minimize this back pressure at the interface between the exhaust system and seawater. An additional goal of the new design was to direct flue gas away from the propeller so it would not interfere with the operation of this component.

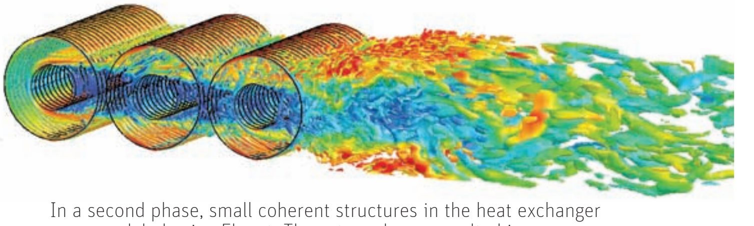
The 3-D symmetrical model contained 6 million cells, and the analysis needed to account for both turbulence and multiphase phenomena. EURO/CFD modeled and assessed many variations of the scoop design and arrived at an answer quickly. Because the CFD model was numerically unstable, many solver iterations were needed. Backed by the power of the ANSYS CFD solution running on its HPC cluster, EURO/CFD was able to apply massive parallelization to achieve a significant time reduction, compared with the use of typical computing resources.



ANSYS Fluent CFD simulation and EURO/CFD's powerful HPC resources allowed ALSTOM Power to better understand the effects of wind on its power plant structures.



In the first simulation phase for a heat exchanger, EURO/CFD used ANSYS Fluent to model large coherent structures of turbulent flow.

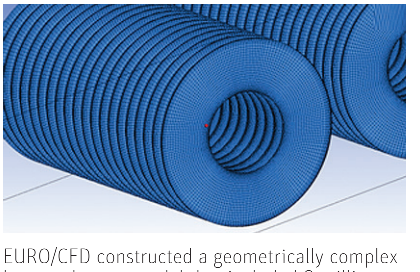


In a second phase, small coherent structures in the heat exchanger were modeled using Fluent. These two phases resulted in a numerically large, high-fidelity simulation challenge.

Streamlining Numerically Large Simulations

EURO/CFD's investment in its Little BIG cluster has not only paid enormous dividends in terms of computing speed, but it has enabled the firm to tackle numerically large simulations that would represent a nearly insurmountable challenge for the typical engineering department.

ALSTOM Power asked EURO/CFD to model the effects of wind on the performance of several hundred air cooler condensers (ACCs) installed at one of its power generation plants. Each ACC is composed of large fans rotating at low frequency, which are extremely sensitive to distortions in air velocity at the inlet. Studying wind effects meant modeling hundreds of individual ACCs as well as all the associated small support structures to determine their impact on performance.



EURO/CFD constructed a geometrically complex heat exchanger model that included 9 million individual hexahedral cells. Detail of the model is shown here in mesh view.

Solving equations for turbulence and energy required about 25,000 iterations for each steady-state case to converge. Furthermore, EURO/CFD was challenged to perform calculations on a large model consisting of 71 million cells while considering several hundred boundary conditions.

Relying on the computing breadth and depth of its HPC cluster, EURO/CFD ran these numerically complex simulations in a time- and cost-effective manner. The result was new insights into both wind effects and temperature variations around the individual ACCs and around the overall power plant geometries.

EURO/CFD also counts several heat exchanger manufacturers among its customers. Recently this opportunity allowed EURO/CFD to launch an internal R&D program. The aim was to determine both quantitative and qualitative characteristics of the noise generated by pipes of a finned-tube heat exchanger.

First, EURO/CFD used a transient Fluent model and employed the k-ε turbulence model to evaluate large coherent structures with low frequencies in the turbulent flow. In the second phase of the simulation, EURO/CFD modeled flow over the fins of the heat exchanger using the Fluent large-eddy simulation (LES) turbulence model to capture small coherent structures and solve the acoustic field.

By using Little BIG in conjunction with Fluent, EURO/CFD constructed detailed models of these complex heat exchanger components while considering very small time increments of approximately 10^{-5} seconds. In all, the EURO/CFD team used a mesh with 9 million hexahedral cells to achieve the high fidelity required by this complex simulation, and calculated both natural frequencies and sound power levels to meet the needs of future clients.

A New World of Simulation Possibilities

As demonstrated by these and other real-world examples, high-performance computing offers substantial benefits for researchers and scientists performing engineering simulations. Technology-intensive HPC environments, along with innovative computing strategies such as massive parallelism, are opening new frontiers by enabling engineers to solve incredibly complex problems with ease — as well as speed up the solution time for virtually every simulation.

One of the biggest hurdles is creating a powerful HPC cluster, which represents an investment that many companies are hesitant to make. By offering a flexible computing resource, EURO/CFD expects to introduce more engineering organizations to the speed and scale benefits of HPC-enabled simulations. Working with strategic software partners like ANSYS — which continues to improve its solutions and tailor them to the needs of HPC environments — EURO/CFD is opening up a new world of simulation possibilities to those businesses that could not otherwise participate in the ongoing HPC revolution. ■