A SYSTEMATIC APPROACH

Oil and gas leader FMC Technologies is making a science out of systems-level simulation. Multiphysics Simulation Manager Ed Marotta discusses the company's unique approach — which includes certification for analysts and best-practice sharing that spans the globe.

By *ANSYS Advantage* staff

With a reputation for innovation in the oil and gas industry, FMC Technologies designs, manufactures and services technologically sophisticated systems and products, such as subsea production and processing systems, surface wellhead systems, high-pressure fluid control equipment, measurement solutions, and marine loading systems. The organization was recently named by *Forbes* magazine as one of the Ten Most Innovative Companies in America. With 27 production facilities in 16 countries, FMC has more than 16,000 employees around the world.

In keeping with its strong focus on innovation, FMC operates three tech centers in the United States, Norway and Brazil that leverage corporate knowledge to develop smarter product and systems designs. Based at the U.S. Tech Center in Houston, Ed Marotta directs FMC's Multiphysics Simulation Group. This team was formed in 2010 to maximize the impact of systems-level multiphysics simulations at FMC, enabling the company to more quickly and efficiently advance its products and technologies by rapidly modeling, verifying and introducing industry-changing innovations.

Marotta is eminently qualified to lead this multiphysics effort, with a B.S. degree in chemistry, M.S. and Ph.D. degrees in mechanical engineering, and post-graduate studies in chemical engineering. Prior to joining FMC, he was director of Texas A&M University's thermal conduction laboratory as well as associate research and teaching professor and director of the freshman engineering program there. Marotta spoke with *ANSYS Advantage* about bringing a disciplined approach to engineering simulation at one of the world's leading innovators in oil and gas technologies.

What led FMC to create a team specifically focused on multiphysics studies?

Here at the U.S. Tech Center in Houston, we focus on optimizing energy production technologies for both subsea and ocean-surface environments. Obviously, there are many physical forces at work in these environments. We must consider external factors such as water temperatures, subsea ocean currents, hydrostatic pressures and fluid–structure interactions — as well as internal electromagnetics and fluid dynamics within our equipment. It's not enough to consider just one force; we need to look at the impact of multiple physics and their interactions. So we formed a team of highly skilled analysts to look at very complex problems related specifically to ocean environments.

How has this multiphysics approach helped FMC to emerge as a leader in systems-level simulation?

Just as you cannot optimize overall performance by looking at a single physical force, you need to consider many components to optimize an entire system. One of our most critical systems in recovering oil is the tree — an assembly of valves, piping, spools and fittings that control flows and pressures. The tree incorporates a multitude of components that are subject to a range of structural, thermal and fluidic phenomena. We have to consider varying operating pressures and temperatures. If we looked only at one component in isolation, we would not be able to

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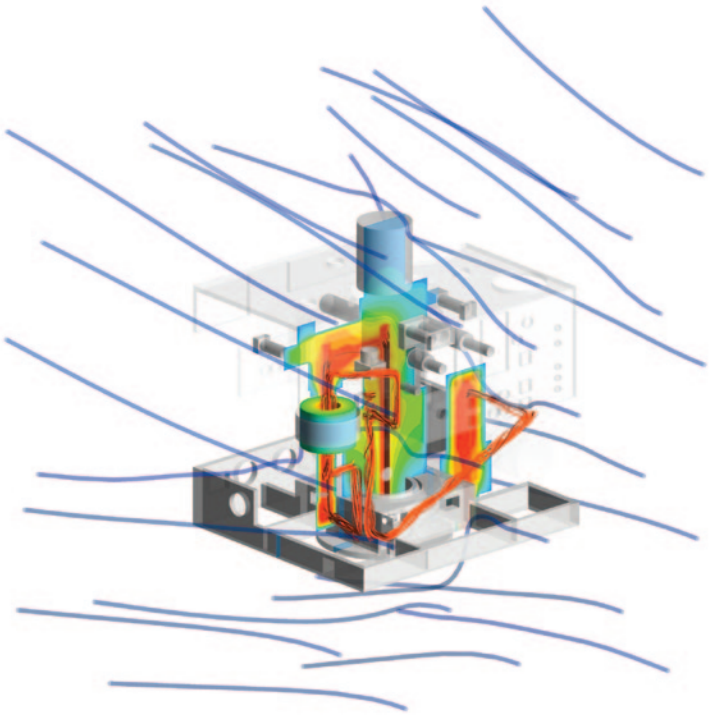

CFD model of tree under full environmental conditions

predict the performance impact of the entire tree as we make design changes. Instead, our analysts have the capability to attach new components to the tree, to make design modifications — for example, to the insulation system — and then to conduct systems-level simulations.

An example of this is simulating an entire production tree to maximize thermal insulation and slow down cooling. When an oil recovery system has to be shut down for a weather event or other contingency, it's critical to maintain a warm internal temperature, despite the fact that the tree is submerged in cold ocean water. By using ANSYS Fluent to conduct computational fluid dynamics (CFD) investigations of our subsea trees and manifolds for cool-down predictions, we can make design changes that help to mitigate hydrate formation, which would compromise operational performance of the equipment. We can look at the thermal contribution of each component in isolation as well as the performance of the entire system. We can customize water currents, boundary conditions and thermophysical properties for customer-specific sites. ANSYS software even enables us to simulate two-phase mixtures.

What are the specific engineering pressures in your industry — and how is FMC responding?

There are three concerns driving the industry right now: safety, quality and innovation. We're addressing the safety and quality issues by focusing on robust design at the systems level, as we've already discussed. By constructing numerically large, complex simulations of entire systems, we are creating a high degree of confidence that our designs will perform as expected in the real world, delivering high levels of quality and safety. Having a clear understanding of functional and performance specifications is paramount to achieving high quality in our simulations.

In terms of innovation, we have a unique initiative called "compact modeling" that attempts to streamline the earliest stages of design, allowing us to move forward very rapidly. We have a strategic agreement with ANSYS that has enabled us to leverage special engineering simulation software that we hope to eventually run on an iPad® or some similar mobile device. These tools will be unique to the Multiphysics Simulation Group; however, expansion to other FMC global engineering groups is our goal. In a fraction of the time, we can arrive at an engineering solution that comes within +/− 20 percent of our high-fidelity models. This allows us to run a what-if scenario very quickly and cost effectively, so we can rule out the bad design possibilities. For the designs that make the cut at the compact-model stage, we then move on to higher-fidelity simulations and higher computational loads. We believe this compact-modeling approach will allow us to introduce groundbreaking new technologies and advanced state-of-the-art products very quickly and efficiently.

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Why is engineering simulation so important to your work at FMC?
Here in Houston, we simply can't build physical prototypes or run systems testing in a water tank. It would be prohibitively expensive to recreate conditions at the depth of 10,000 feet (3,000 meters) of ocean water. So obviously, we have to rely on engineering simulation, and our reliance on simulation keeps growing as innovation becomes more and more critical. The same is true for our other global engineering centers, which are tackling different but just as complex engineering challenges.

Even though global teams are working on different problems, do you also collaborate and share knowledge?
Collaboration is one of our core concepts at FMC. It is important to emphasize that globally we have a very large pool of extremely talented analysts in Norway (Asker and Kongsberg), Brazil (Rio de Janiero), Singapore, India (Hydrabad) and Scotland (Dunfermline) who collaborate on a daily basis on our most complex and pressing engineering problems. FMC has well over 100 analysts with advanced degrees who share knowledge and best practices to ensure that the most accurate analysis is achieved. We share this information globally through an internal online forum called "The Edge," through which our engineers and analysts can ask and answer questions globally. We have specific global design guidelines that make certain everyone is performing analyses and deploying ANSYS software in the same way, no matter where they are or what specific problem they are solving. We believe this is essential to ensuring the integrity of our simulation results.

Here in the Multiphysics Simulation Group, we've created an analyst certification program that ensures that our engineers are well trained in the use of simulation software. Our goal is to work with our global analysis teams to expand that certification program to other sites. Working with ANSYS, we have developed customized internal training classes for our team, and we also seek out external educational opportunities. All of our efforts are focused on making simulation an exact science at FMC, ensuring that our analysts have the right skill set and standardizing our global analysis processes. This allows us to not only arrive at innovations rapidly, but also to have a very high degree of confidence in our results. In addition, the Multiphysics Simulation Group has an internal engineering initiative called the Smarter Design Space, focused on bringing all of our engineers and analysts together to optimize our design in virtual space and improve the accuracy of our results, backed by a high-performance computing cluster and shared software tools.

How would you describe your relationship with ANSYS?
In the past four years, the Multiphysics Simulation Group has grown from two full-time simulation analysts to a team of 11 engineers. ANSYS has been crucial in supporting this growth by providing the required training, technical support and customized tools, such as those for compact modeling. The majority of our engineers have master's and Ph.D. degrees, which means that they have used ANSYS software in academic settings. Most of our customers also use ANSYS software. By collaborating closely with ANSYS, we believe that we are getting the best of both worlds: We are employing the most widely used simulation toolkit in our industry, but we are applying it in a very customized way that sets FMC apart. We work in a very competitive industry, and we have great confidence that ANSYS will help us build and maintain our engineering leadership.

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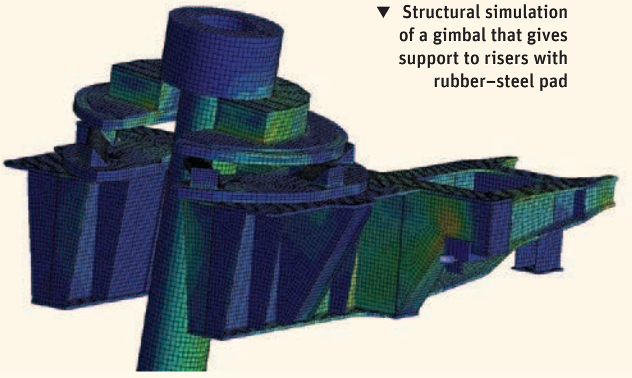
BRAZIL

Identifying Stress Points for Even Load Distribution

FMC engineers in Brazil are conducting structural analyses on a gimbal system — which is used to reduce shock to protect critical sections of piping along with the module that boosts flow, by accommodating the roll of the rig in the marine environment. By using ANSYS Mechanical to conduct structural analysis, the engineers identify areas of stress and ensure that loads are not transferred to piping.



▼ Structural simulation of a gimbal that gives support to risers with rubber–steel pad

NORWAY

Ensuring Pipeline Integrity During Pressure Fluctuations

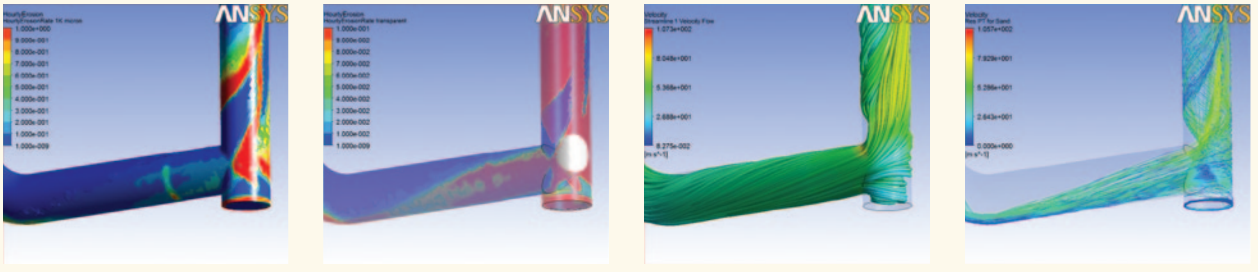
Flow assurance engineers at FMC Norway use ANSYS CFD software to analyze vibration-related issues caused by internal flows inside subsea piping using the Reynolds stress model. To predict fluid forces on the pipe structure, wall pressure fluctuations of high Reynolds number multiphase flows are determined via computational fluid dynamics simulations. For single-phase and multiphase flows, FMC analysts recently used ANSYS to perform simulations with Reynolds numbers up to 1 million, using the SST turbulence model. FMC engineers correctly predicted the frequency of the wall-pressure fluctuations downstream of a single pipe bend. Comparing this input to the natural frequencies of the piping helps FMC to both identify and address potential flow-induced vibration issues for a new subsea production system.

▲ Frequency fluctuations downstream of single pipe bend

SINGAPORE

Defining Erosion Allowances Inside a Recovery Tree

The FMC flow assurance team in Singapore recently conducted a 3-D CFD erosion analysis for a subsea recovery tree for a gas field development. The goal was to predict erosion rates in the tree to verify that proposed erosion allowances in piping and fittings were sufficient. This is vitally important, because insufficient erosion allowances could lead to a breach of containment. This simulation was especially challenging, as the complex geometry of the tree meant that fluid flows were unstable in certain sections. However, by using ANSYS CFX, engineers in Singapore accurately predicted fluid behavior — and identified where increased erosion allowances were required.



▲ Analyzing erosion patterns within recovery tree section

WEB EXCLUSIVES

THE NETHERLANDS

Perfecting Gas–Liquid Phase Separation in Inline Separators

BRAZIL

Optimizing Steady-State and Transient Thermal Performance

UNITED STATES

Predicting Long-Term Fatigue in Piping

These additional examples from FMC Technologies are available at ***www.ansys.com/exclusives/magazine.***