POWER & energy

Offshore engineers, singularly concerned about safety, rely on finite element analysis software to analyze equipment design.

offshoreanalysis

Engineers call upon FEA to design equipment built to withstand the rigors of life in the ocean. By Jean Thilmany, Associate Editor

Say you're designing a huge piece of machinery. Now, imagine that you're creating the machine from scratch; it's never existed before. The expected lifespan is around 40 years. If this thing doesn't function properly, your company will lose vital investment dollars. Or the structure may not qualify for insurance.

The machine will be so big that you can't build just one and test it; the projected lifespan is so long that you can't run physical tests to demonstrate how it will operate across all conditions. Yet the upfront costs are so huge that investors will demand these types of assurances before ponying up the money.

Oh, and a malfunction could imperil human lives and the surrounding environment.

These are the challenges faced, to one degree or another, in many industries. Companies that design and build offshore equipment, in particular, build huge structures that for years must withstand the buffeting of ocean waves and resist corrosion by saltwater.

Equipment called upon by the offshore industries undergoes hard use in the face of nature. Engineers in the offshore industry rely on finite element analysis because of the demands of their business.

Tolpa Technical Services near Houston analyzes piping plant designs for clients in offshore oil and gas industries.

ALGOR INC.

WITHSTANDING THE WAVES

Many engineers, for instance, call upon the analysis technique to ensure that the equipment they design can withstand the unique ocean rigors and the dangers inherent in the offshore environment.

Take Tolpa Technical Services, an engineering consulting company near Houston in Hempstead, Texas. The consultancy specializes in pip-

Tolpa Technical Services calls upon FEA to virtually test and predict how industrial equipment like pressure vessels, rotating machines, structural skids, and oil piping systems will respond in the field.

ing, plant design, and stress analysis for clients involved mainly in offshore oil and gas activities. TTS uses FEA software from Algor Inc. of Pittsburgh to virtually test and predict how industrial equipment such as pressure vessels, rotating machines, structural skids, and piping systems will respond on offshore platforms, said Hubertina Tolpa, principal engineer and TTS owner.

In this, Tolpa is not much different from Algor's other offshore clients, said Bob Williams, the FEA company's product manager. These clients are singularly concerned about safety. When machinery fails, it can imperil human lives and ruin expensive pieces of equipment.

Many offshore companies run FEA analysis to calculate that their equipment will function properly under conditions unique to the industry, like lifting heavy equipment in confined areas, he said.

"If they're designing a crane that will go into a tight space to move things, they'll want to know ahead of time they've built it to withstand the worst-case scenario," Williams said. "Say they have four different cables to lift a load and one of the lifts broke. You may have something that weighs tons swaying around and generating more loads on the other cables. You can quickly run into a situation where you have a catastrophic failure of a lifting device."

Of course, manufacturers call upon FEA for the same reasons that engineers from all industries turn to the analysis method.

"Shorter time to market, shorter response time on a project, and of course one of the primary ones is being able to do the design and verification and validation on the computer instead of having to do physical tests," Williams said.

To round out her company's analysis capabilities, Tolpa looks forward to solving for more than one physical phenomenon at a time.

"In the future, we would like to incorporate two- and three-dimensional fluid flow analysis for prediction of definitive acoustic and flow-induced vibration in piping systems," she said.

A MULTIUSE LIFE

For a look at how offshore engineers call upon FEA to design equipment that may see a variety of use over a 40-year lifespan, consider the case of Aker Yards Marine Inc. in Vancouver, Canada. The company uses NEi Nastran software from Noran Engineering Inc. of Westminster, Calif., to help design foundations for heavy cranes on offshore supply vessels.

The company also designs ship hulls that will withstand a variety of conditions over their lives.

The pedestal-mounted cranes transfer oilfield supplies from a ship's deck to an offshore platform or perhaps to the seabed. They can lift up to 400 tons each and they're designed to withstand the motions of a vessel.

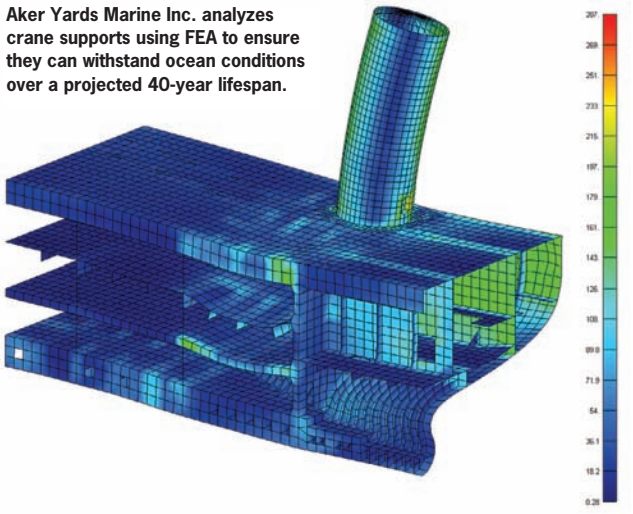
When the crane is added to an existing ship design, or to a vessel under construction, minimizing rework to the existing hull structure is one design objective, said senior engineer Mark Munzel. The foundation may also have to incorporate openings for ventilation, stairs, and machinery access.

Aker Yards Marine provides a foundation to support each crane that doesn't disrupt the vessel's arrangement of tanks and cargo holds below deck. Engineers carry out FEA to minimize the size of the structure. They create an FEA model of the crane pedestal, foundation, and surrounding hull, and use that model to check for potential points of stress and buckling.

FEA comes into play particularly when it comes to hull design. Engineers use the analysis package to ensure that the hull can weather the range of use it'll see, such as the crane mount, Munzel said.

"It's like designing a truck. You design the chassis and then different end users want different things," he said. "So we design the basic hull. Then a company might want a crane or other offshore equipment installed after the hull is in place."

For instance, the owner of a ship designed by Aker Yards may install a crane. Then, upon signing a new offshore contract in which a crane isn't needed, it might remove the crane. That ship needs to be designed to support a heavy piece of equipment, whether or not it's



Aker Yards Marine Inc. analyzes crane supports using FEA to ensure they can withstand ocean conditions over a projected 40-year lifespan.

TOP: ALGOR INC.
BOTTOM: NORAN ENGINEERING INC.

Pelamis Wave Power Ltd. has linked its wave energy converters to form wave farms that generate electricity. That energy is available for purchase.

needed at a particular time, Munzel said.

The ship's owners never know what the future might bring.

"You don't want to have to install additional steel to the ship for every new use," Munzel said.

ELECTRICITY IN WAVES

Meanwhile, Pelamis Wave Power Ltd. of Edinburgh, Scotland, approaches the ocean from a different perspective. The company makes a wave energy converter that generates electricity from ocean waves. The converter is a semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. Hydraulic rams resist the wave-induced motion of these joints. The force of that resistance is used to pump high-pressure fluid through hydraulic motors via smoothing accumulators, to drive electrical generators that produce energy.

Arrays of these interlinked converters are called wave farms. The electricity that they produce is available for utility and electric companies to purchase. A wave farm of 40 converters, covering a square kilometer of ocean surface, can generate enough electricity to power 20,000 homes, said Jon Benzie, a Pelamis senior engineer. The company has three projects under way, two off the coast of the United Kingdom and one near Portugal.

Engineers rely on simulations and analysis to ensure that they have the basis of their design correct and that the equipment they create will function for two decades. They then validate and verify results with small prototype testing in a water tank. This is later backed up with a certain amount of large-scale testing, Benzie said.

Designing the wave energy converter came with its own set of challenges, according to Dale Berry, director of technical marketing at Simulia of Providence, R.I., which provides the Abaqus FEA software that Pelamis uses.

"This type of machine is new, so engineers don't have a lot of past experience to draw on, unlike designing a car where you have the prior generations of design to help you out," he said. "And full-scale testing is quite expensive for these machines, so that's a double whammy. Also, they'll use these machines for 20 years. You can't test for 20 years."

Another issue: simulating waves requires specialized analysis.

SIMULIA

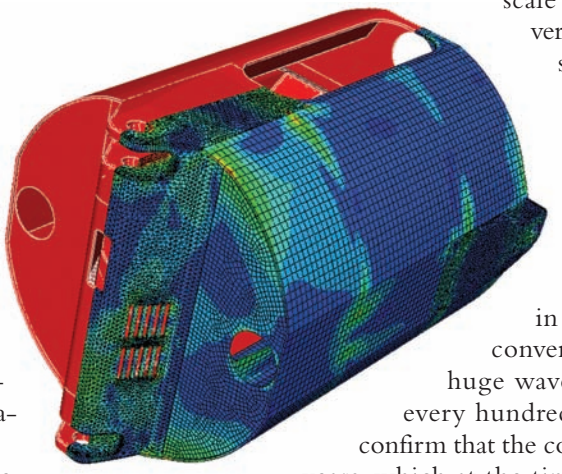
"It's not like they can go out and say, 'I want to buy the market leading software in offshore wave simulation,' " Berry said.

Pelamis engineers have adapted aspects of the Abaqus applications for their needs, to analyze small components and larger assembly simulations, Benzie said. The engineers are now at work marrying Abaqus to their in-house hydrodynamic simulation program, which simulates the machine's motion in the sea. Once integration is complete, engineers won't need to insert results manually from one program into another when generating fatigue calculations for the lifetime of the machine.

While simulation will never totally replace the need to verify results by testing a prototype, analysis is useful in a number of ways. A prototype may run successfully, but actually be very close to failing. Engineers have no way to know that unless they also look at analysis numbers, Berry said.

"Yes, the prototype test was successful, but did it function under the operating parameters or just right at the border?" he said. "Simulation can provide you with the insight into how your structure is really behaving and how good a design you have."

Pelamis engineers adapted their FEA software for their needs—analyzing small components and larger assemblies like this motor.



Five years ago, Pelamis designed a full-scale prototype wave energy converter to complement analysis results as well as to serve as a technology demonstrator. Before building the prototype, Pelamis engineers wanted to double-check their numbers. They brought in Atkins, an offshore consulting company headquartered in England, to verify that their converter design could withstand a huge wave—the type that crests once every hundred years. They also wanted to confirm that the converter would function for 15 years, which at the time was the designed lifespan, Benzie said.

The successful verification of the Pelamis design allowed the company to secure commercial insurance for the prototype and subsequent Pelamis machines, he added.

Which brings Berry to another point.

"If the wave energy converter doesn't function properly, the purchaser or investor in a wave farm would back out," he said. ■

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