Designing Modular **Wellheads**

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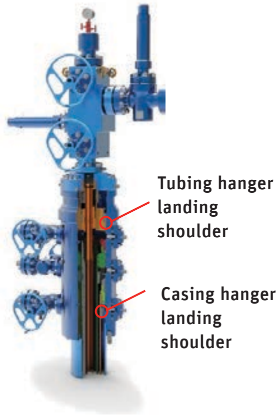
Using the Modular Wellhead System from Singapore WEFIC Ocean Technologies reduces installation time for downhole equipment in the oil and gas industry. Employing a multistage system that accommodates different casing programs and working pressure, the system is easy to operate, safe and efficient. WEFIC engineers used ANSYS Mechanical to evaluate design alternatives for a key system component followed by physical testing to validate the finite element analysis results. This approach greatly reduced the number of test prototypes required, reducing development time by about 60 percent while ensuring reliability.



The wellhead sits at the surface of an oil or gas well and is the suspension point and pressure seal for the drill string, casing line and production tubing that are lowered into the hole at different stages of the well's lifecycle. Two types of equipment are attached to the top of the wellhead to control surface pressure: a blowout preventer during drilling and a Christmas tree (valves, fittings and spools used to control the flow out of the well) once drilling is completed. The wellhead's internal bore contains shoulders upon which the casing and tubing hangers are used to suspend casing strings and production tubing. While these shoulders prevent downward movement of the casing and tubing hanger, a mechanism is also required to resist pressure from downhole that would otherwise force the casing and tubing hanger upward, possibly damaging the wellhead and causing seal leakage, which reduces holding pressure. The most common approach to addressing this issue involves fixing the hanger with tie-down screws. This approach requires considerable installation time because of the need to install and torque up the large quantity of tie-down screws.

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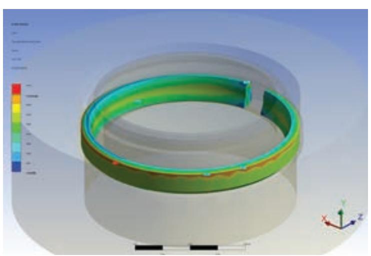
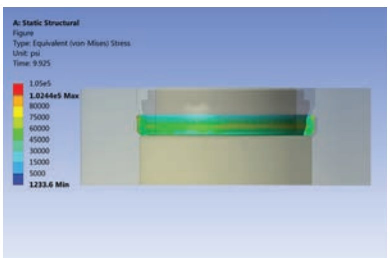
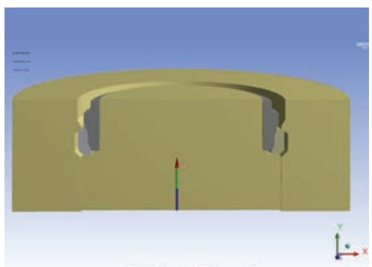


Stress experienced by lock ring under maximum loading



Another view of lock ring stress results

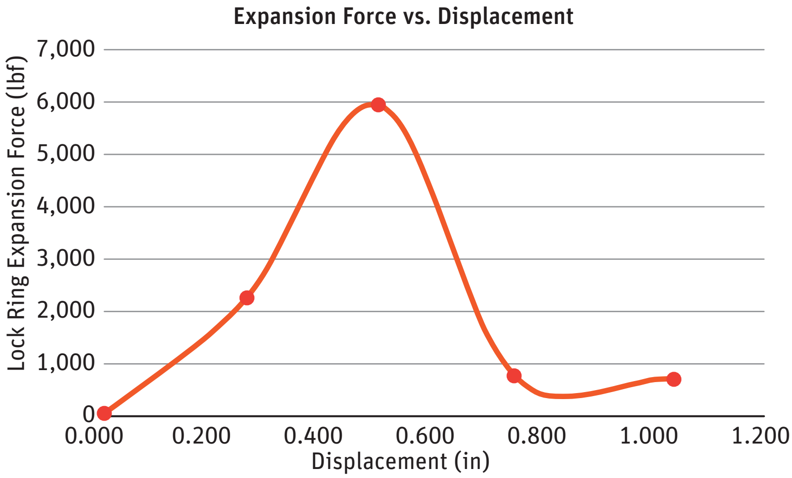


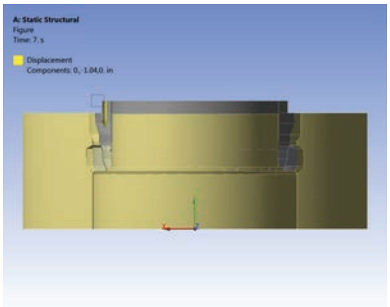
Reaction force to match the pressure rating of the wellhead was generated by applying displacement boundary to move the ring upward.

Singapore WEFIC Ocean Technologies Pte. Ltd. (WEFIC) provides high-tech petroleum equipment and technical services for the oil field engineering industry. The company's Modular Wellhead (MW-I), which can be used for both onshore and offshore application, reduces installation time with a lock ring that can be expanded radially until it sits in a groove in the wellhead. Installation is performed using a tool operated through the wellhead, riser and blowout preventer. This provides a significant reduction in installation time, which reduces drilling expense. Using the company's previous build-and-test methods, designing the lock ring for a new model wellhead would have required building and testing two to three prototypes, with about two months required for each. Engineers estimate that it would have taken about six months to design the lock ring this way. To design the lock ring for the new wellhead, the company used ANSYS Mechanical to get the design very close to the final product in only 10 weeks with only final adjustments required in the prototype phase. This made it possible to bring the product to market much faster.

Lock Ring Design Specifications

The lock ring must support upward forces resulting from pressure of 3,000 to 15,000 pounds per square inch (psi), depending upon the model of wellhead. The rings used on 3,000 and 5,000 psi wellheads interface with a single shoulder on the wellhead, while lock rings on the





Maximum ring expansion force was retrieved by applying displacement boundary condition to expand the ring.

10,000 and 15,000 psi models act against multiple shoulders. Lock rings used in all these models must withstand upward forces equal to the pressure rating of the wellhead while respecting material yield limits within a specified margin of safety. The lock ring is split radially, and a rotating tool is used to expand the lock ring into a groove in the wall of the wellhead bore. The tool is operated by hand, so the amount of force required to expand the ring is limited to approximately 200 foot pounds or less.

In the past, WEFIC engineers built and tested a physical prototype of each design iteration, which took about two months per iteration. The reduction in oil prices in the past few years spurred the company to look for ways to increase the efficiency of its design processes. WEFIC worked with CAD-IT Consultants to create virtual prototypes with ANSYS simulation software that reduce the number of physical prototypes that need to be built and tested. The company leveraged ANSYS Mechanical finite element analysis software to guide the design of a lock ring for a 5,000-psi and 10,000-psi wellhead.

Engineers defined the material of the ring as alloy steel with more than 100,000 psi yield strength. They needed to calculate both the force required to expand the ring and the stress throughout the ring when a force equal to the pressure rating of the wellhead is applied below the ring. They accomplished these goals by displacing the ring so that it expands radially at the start of the simulation. When the ring is fully expanded, radial displacement ends and the maximum force required to expand the ring is recorded. Next, another displacement boundary condition is used to move the ring upward. When the reaction force reaches the pressure rating of the wellhead, the simulation is stopped and the stress and deflection of the ring are evaluated.

Faster Market Deployment

The first design iteration provided acceptable expansion force, but the stress values were above the design objectives. Engineers created additional design iterations by varying the values for the thickness of the ring and the angle of the cross section of the outer diameter of the ring where it contacts the wellhead. Over a series of 10 iterations, they reduced the stress values to below the design specification, while reducing the expansion force and the weight of the locking ring.

Engineers then built and tested a prototype. The test results met all the design specifications and closely matched the simulation results. Using simulation, it took only two weeks to design the lock ring and another two months to build and test the prototype. Using ANSYS technology made it possible to finalize the design in 10 weeks, which is about 40 percent of the time required in the past. Depending on the drilling conditions, well design and casing program, the WEFIC modular wellhead can save a substantial amount of drilling cost per well by reducing installation time.

This is only one example of how ANSYS tools have enabled WEFIC engineers to achieve a leaner product development process and deliver optimized and cost-effective solutions to the company's customers.

WEFIC is supported by ANSYS Channel Partner CAD-IT Consultants.