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Baker Hughes Drills 60% off Product Development Time With HyperWorks-Driven Simulation

BAKER HUGHES

Key Highlights

Industry
Oil and Gas

Challenge
Validating an advanced oil well liner

Altair Solution
Simulation as an integral part of product development

Benefits
- Reduced prototypes required
- Improved system capability
- Accelerated product development time

Customer Profile

One of the world's leading suppliers of oilfield services, products, technology and systems, Baker Hughes operates globally with nearly 59,000 employees. The company, headquartered in Houston, Texas, recently recorded $21.4 billion in annual revenue from sales of both services and highly innovative products for the world's oil and natural gas industry.

Baker Hughes customers operate in a challenging market, drilling offshore in deep water and arctic regions, perfecting shale and hydraulic fracturing techniques, and consistently complying with strict environmental and safety regulations. At the same time, they must manage such technological challenges as ever-deeper wells, extreme pressures and temperatures, and unconventional geological variations.

Product reliability, safety, speed to market and cost control therefore are all vital to the industry's success. To remain competitive, oil and gas service companies must ensure that the right products are built reliably and meets customer expectations ahead of those from competitors.

"The key to developing optimized products is to design, simulate, test, and verify the product performance in virtual environments and then validate only the final designs with physical prototypes," said Ganesh Nanaware, Senior Project Engineer, Baker Hughes. "In virtual environments, the accuracy and reliability of the virtual simulation model is extremely important to the process of introducing a robust product design with confidence in less time and at a lower cost."

Baker Hughes therefore is committed to integrating finite element analysis simulation with product development, employing simulation at every stage from concept and design development to prototyping, production, field testing, product launch and lifecycle management.

Keywords: Baker Hughes, HyperWorks, HyperMesh, HyperStudy, Oil, FE Model, Drilling

Baker Hughes Success Story

“The simulation process accelerated our product development to 26 months from the previous 65 months, a 60 percent reduction in overall development time. Furthermore, the process reduced overall development costs.”

Ganesh Nanaware,
Staff Engineer
Baker Hughes, C&P, Wellbore Construction

The Challenge: Validating an Advanced Oil Well Liner

One of the most innovative products emerging from the development efforts of Baker Hughes is a tool that attaches a liner string to the bottom of a previously run casing string during wellbore construction operations. The system consists of a setting tool (or running tool) that moves through the liner to expand the hanger body, a slip ring to hang the liner load and a packer to seal the space between the liner and a variable-diameter casing.

The expandable liner hanger thus uses pipe expansion in place of conventional mechanisms for making contact with the casing wall to support the weight of the liner and seal off the space between. This system enables a seamless, one trip, two-stage hanger and packer setting process for cemented liner applications where the packer is set independently. This is the only expandable liner hanger system that is installed and released prior to the cement job, which eliminates the risk of the running tools becoming fixed in place during cementing, requiring fishing or well abandonment.

The challenge of creating a cost-effective, safe and reliable expandable liner hanger required the use of simulation throughout the product development process.

“We were confident that virtual simulation could be effectively integrated in the development of an expandable liner hanger system to improve reliability and robustness of the equipment for challenging wellbore completions while reducing development time and cost,” said Nanaware.

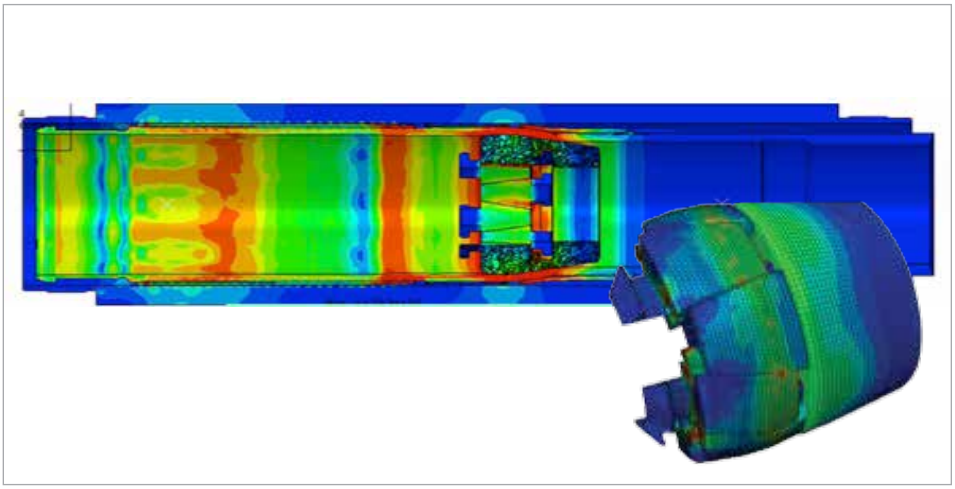
The Solution: Simulation as an Integral Part of Product Development

Baker Hughes turned to FEA simulation that incorporated HyperWorks computer-aided engineering tools from Altair to capitalize on simulation’s many benefits in the product development cycle, including its ability to:

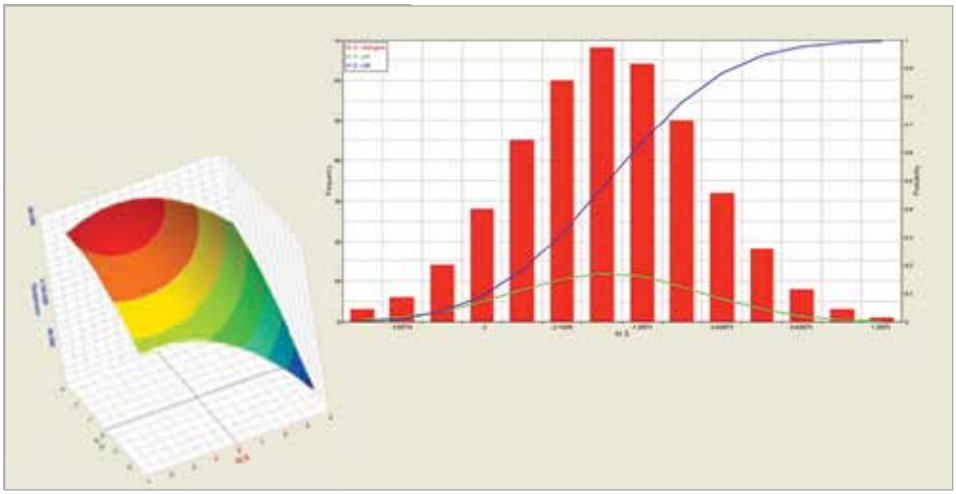
- Accelerate the development of the system’s design
- Predict the hanging capacity and sealing integrity of the liner hanger system
- Optimize the performance of the system’s design
- Improve reliability of the design
- Reduce the development cost and time

The company relied on a seven-step methodology to verify and validate an expandable liner hanger virtual simulation model.

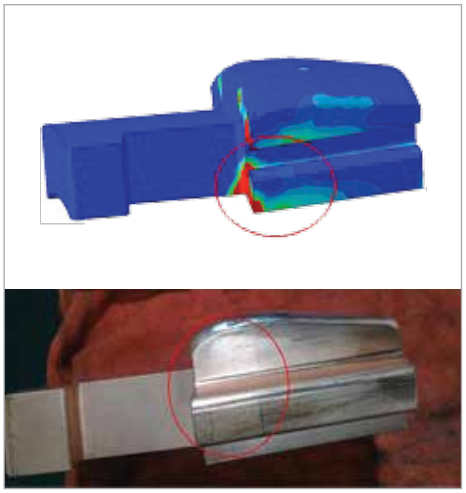
Part of typical mesh of liner hanger assembly



Stresses on hanger packer assembly



Perform stochastic analysis to assess design reliability



Example of validation of swage and backup ring

First, developers built an FEA model, then verified that model against past experience, judgment, hand calculations and test data for similar products. The model was refined, if necessary, and an optional reliability assessment step was executed utilizing design of experiments (DOE) technique, leading to more refinements and optimization that were re-verified. Next, simulation model results were validated against physical prototype test data. Analysts progressed back and forth between steps to build, verify, and validate data until results represented real behavior and produced high-quality correlations with physical prototype tests. Once the validated simulation model was prepared, further design evaluations and performance predictions could be completed with confidence.

Using HyperMesh, the HyperWorks pre-processing tool, Baker Hughes built a 3D FE model of the complete expandable hanger system with six to seven million elements. The model then underwent verification.

"We had some historical performance of other products that were similar in nature and also some calculations we felt were representative of what to expect," Nanaware explained. "When we compared these calculations and historical performance of other products to our simulation results, we felt pretty good about the outcome."

The simulation model then was validated against an actual test part, and the results were very similar, an indication of model validity. Hanging capacity results based on the simulation model, however, were 25 percent higher than those from the prototype test results.

The disparity was determined to be the result of a slight error in friction values. The model was refined with HyperMesh to include different friction values, updates to material models, changes in the model complexity, reevaluation of geometric tolerances and worst-case scenarios.

"After refinements," Nanaware said, "we were able to get our model results much closer than the 25 percent error that we started with."

The baseline hanger slip design obtained 95 percent reliability, which was lower than the required reliability target. In order to meet the reliability target, reliability-based design optimization was performed.

Baker Hughes relied on HyperStudy from the HyperWorks suite for reliability assessment and improvement. The reliability assessment process comprised design variable identification, DOE study, response surface modeling, and a stochastic study using the response surface models to predict reliability. Reliability improvement was performed using reliability-based design optimization.

Results: Far Fewer Prototypes and Faster Time to Market

The seven-step validation process used by Baker Hughes achieved a correlation between the FE model and physical tests within +/- 4 percent. It reduced the number of prototypes required by 60 to 70 percent, while improving capability. For example, the hanging capacity of the system was improved by 40 percent with optimization of the slip ring design, guided by HyperStudy.

"Ultimately, the simulation process, which incorporated HyperMesh for pre-processing and part of post-processing, and HyperStudy for design of experiments, accelerated our product development to 26 months from the previous 65 months, a 60 percent reduction in overall development time," Nanaware reported. "Furthermore, the process reduced overall development costs."

Development of the expandable liner hanger demonstrates the value that simulation brings to innovation, in this instance helping meet the world's energy needs through a virtual process that speeds product to market with higher quality at lower costs.

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About Altair

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From computer-aided engineering to high performance computing, from industrial design to cloud analytics, for the past 30 years Altair has been leading the charge to advance the frontiers of knowledge, delivering innovation to more than 5,000 corporate clients representing the automotive, aerospace, government and defense industries and a growing client presence in the electronics, architecture engineering and construction, and energy markets.

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Performance Simulation Technology

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