Case Study: **Parker Hannifin**

MSC's Marc Helps Ensure Safe Operation of Subsea Oil Drilling

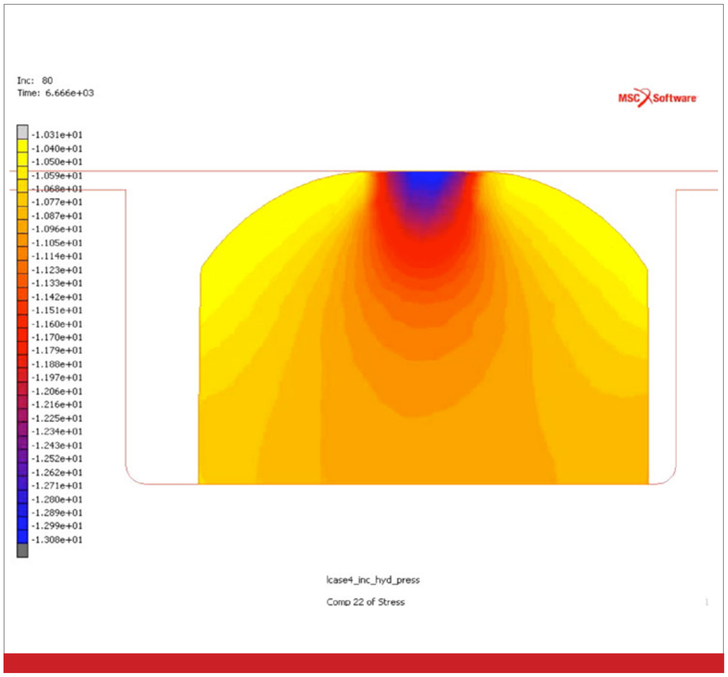
Based on an interview with Stephen Armstrong, FEA Analyst/New Product Development Engineer at Parker Hannifin Corporation

Overview

In designing heavy machinery, such as those on cranes or oil rigs, small plastic components or rubber seals can be vital to the integrity of those large structures. Stephen Armstrong an FEA Analyst/New Product Development Engineer and his team at Parker Hannifin Corporation work on designing just these types of parts.

Parker Hannifin is a trusted leader in motion and control technologies. Stephen's team's main area of focus is on seals that are comprised of hyperelastic materials such as rubber, polyurethane, and other compounds. These seals are used in a variety of applications in heavy machinery, medical devices, military and aerospace industries.

Engineers working with these materials focus on non-linear analysis in most of their projects, because these materials mainly exhibit non-linear behavior. MSC's Marc was their tool of choice for simulating such behaviors.



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“The only way to understand what was happening to the seal was to simulate with FEA. We couldn’t solve the problem with just physical testing. Without FEA, it would have taken many months, to try all the different experimental seal profiles and alternate materials we explored.”

Stephen Armstrong, FEA Analyst/New Product Development Engineer at Parker Hannifin Corporation.

Challenge

The Parker Hannifin team had to re-design and manufacture an entirely new seal design to replace an underperforming D-ring seal for deepwater oil rigs performing drilling at 10,000 feet below sea level. This particular project was of great concern to the customer because the present seal at the time was suspected to be leaking, therefore significantly increasing the time to activate a blowout preventer safety device. Multiple attempts were made to determine the cause of failure via physical testing of the blowout preventer in a land-based lab environment, but were unsuccessful. Stephen’s team needed a powerful simulation tool that had reliable non-linear capabilities. MSC’s Marc proven results over the past 45 years proved to be an extremely valuable resource in this endeavor.

Parker’s client was very frustrated with this project by the time Stephen’s team got their hands on it. To complete one physical test took at least 24 hours to run. The client had already spent six weeks on physical testing trying to resolve the situation, but to no avail. Finally, the customer contacted Parker to investigate the cause of the failure and provide a resolution as soon as possible. The first step was to look at the variety of physical phenomena that the seal would encounter subsea. Stephen and his team had to take into consideration the high subsea hydrostatic pressure being seen by the seal, changes in operational pressures imposed on either side of the seal, and the mechanical properties of the elastomer at near freezing temperatures.

The operational pressures are based on whether the operators are opening or closing the valve that actuates the blowout preventer. Another critical aspect of modeling the seal’s response was the ability to simulate stress relaxation and compression set over an extended period of time. Stephen’s team had to consider all of these physics and incorporate them into the design of the seal.

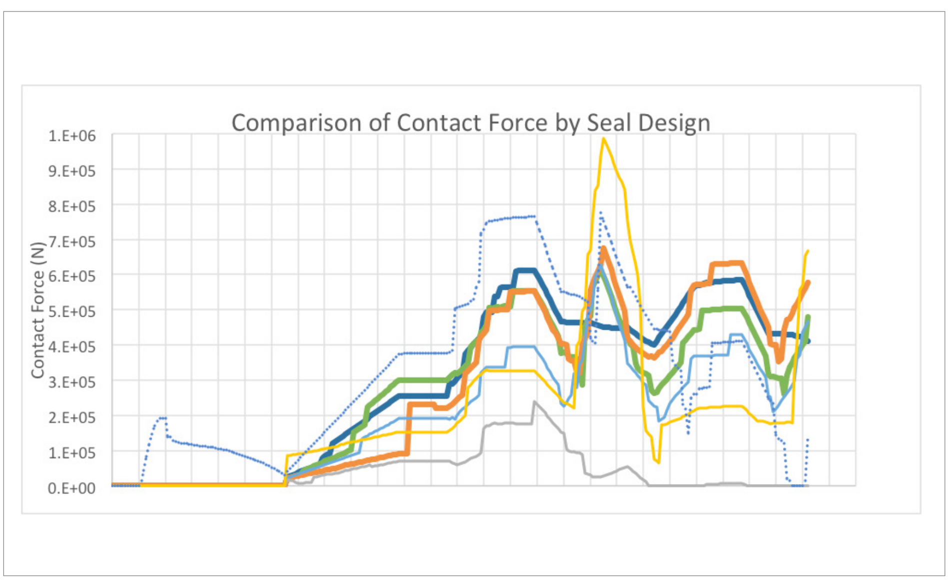
Key Highlights:

Product: Marc

Industry: Oil and Gas

Challenge: Optimize safety equipment design for a subsea environment

Benefits: Enhance the seal design and reduced physical testing

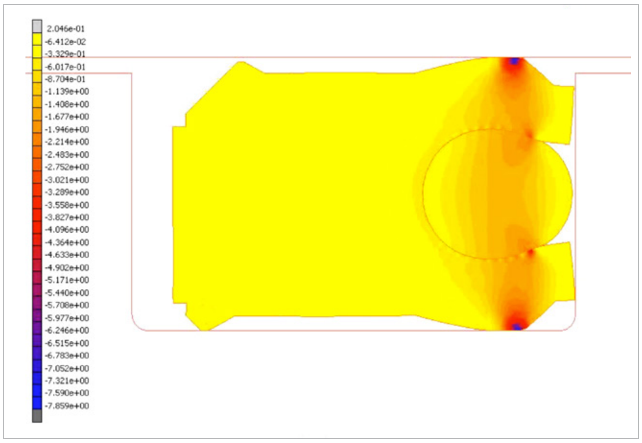


Contact Force Comparison for Different Seal Designs

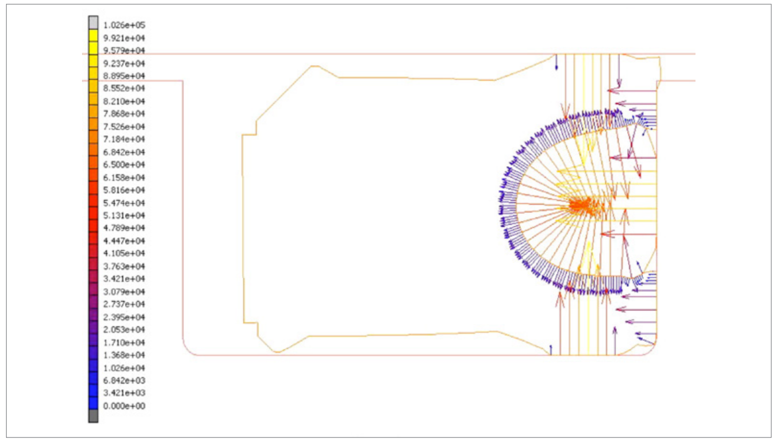
Solution

Stephen’s team used MSC’s Marc to run simulations on the D-ring seal. They found that the D-ring was not able to function properly at the extreme low temperature and high pressure environment created at these new extreme drilling depths. The Parker team knew they needed to run a non-linear Finite Element Analysis (FEA) because there was no other alternative to simulate the failure mode at the bottom of the ocean caused by cold temperatures and high pressures.

“The only way to understand what was happening to the seal was to simulate with FEA. We couldn’t solve the problem with just physical testing.” said Stephen Armstrong, FEA Analyst/New Product Development Engineer at Parker Hannifin Corporation. After some final adjustments to the seal’s



PolyPak Stress Simulation



PolyPak Contact Force Vectors

material characterization file, the Parker team could correlate behavior of the seal material to physical lab testing performed on a dynamic material analyzer (DMA). Stephen and his team used a Mooney model within Marc that considered both time-temperature dependent (viscoelastic) properties and coefficient of thermal expansion to address the change in stiffness and size of the part within the wide range of temperatures found in offshore drilling environments. After finalizing the material data model for the simulation, the Parker team started their failure anlaysis simulations with 3D models and could illustrate why the seal was leaking at the increased sea depths. To reduce computational time, Stephen and his team correlated 2D axisymmetric model results to the original 3D models.

"Our 2D models would only take a few tries to successfully run, if not run on the very first try. This helped save us a lot of time on these complex multi-physics analyses and the development of a solution. Without FEA, it would have taken many months, to try all the different experimental seal profiles and alternate materials we explored" said Stephen Armstrong. Utilizing Marc's deformation analysis capabilities, they found that the D-ring seal was not suitable for the new extreme environmental and increased loading conditions it was being subjected to.

Results

The Parker team analyzed the contact force and seal deformation throughout the entire temperature range and pressure loading conditions that would be encountered at extreme ocean depths to make sure the seal would function properly. Ultimately, Stephen and his team created a custom PolyPak® seal design. In the very last iteration, they took the new design and applied various materials to it to see which one would be most applicable in cold temperature environments, like the kind that the deepwater rig's blowout preventer safety device would experience at the bottom of the ocean.

"By working with all the materials in one user interface, right within Marc, it made the process of dealing with cold temperatures much easier because we didn't have to use an external Fortran subroutine to define the viscoelastic properties of the elastomer. The Marc GUI worked great! The ability to precisely control time, temperature, pressure, and positions of the different rigid and deformable bodies as well as the capability to simulate viscoelastic material properties was a significant improvement in our overall workflow" said Stephen Armstrong.

About Parker Hannifin

Arthur L. Parker founded the Parker Appliance Company on March 13, 1917, in a small loft in Cleveland, Ohio, along with his business partner, Carl Klamm. Parker solutions have enabled countless technology leaps over the past century playing integral roles in supporting war efforts, the exploration of space and the depths of the Earth, as well as advancements in nearly every manmade device that moves.

Today, their technology platforms continue to make a meaningful impact on the world with important innovations driven by their customers. Parker's intellectual property adds unmatched value to their products and systems with over 8,000 patents granted throughout the company's history. To learn more about the company's 100 year history, visit: www.parker.com/centennial.

For more information on Marc and for additional Case Studies, please visit **http://www.mscsoftware.com/product/marc**

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