Case Study #3: Improving the Performance of a Seal for a Well Testing Tool

Summary

MindMesh Inc. took the knowledge gained from the calibration of elastomers (refer to Hyperelastic Material Calibration Case Study), to aid in well testing tool development using nonlinear FEA Analysis. Material calibration for deformation and stress relaxation was developed which in turn was used for well testing tool development. The process of well testing is to understand the fluid qualities in the well and well performance so that the production of the well can be measured. Although well testing is done frequently, testing wells downhole accurately needs further improvement, hence, the need for further development of the well testing tool. In this case, the client primarily used a method of well testing called a drawdown test, when the well pressure is measured while the rate is kept constant. Our role was to improve upon the performance of the tool, (Fig. 1) used for drawdown tests that makes a significant pressure differential and in turn improves overall well efficiency.

Challenges:

- Performance of the seal under prolonged operating conditions

Results:

- Evaluated deformations under very high differential pressures
- Provided insight to the failure modes of the seal
- Improved product performance

About the Client:

This project was developed for one of the largest oil and gas service providers in the world. The company provides services and products for nearly every phase of the oil and gas industry, from drilling to production and is represented in over 80 countries. With the company’s’ continuous expansion, the need to stay on the forefront of the most advanced tools is one of their top priorities.

Challenge:

The elastomer portion of this well testing tool would undergo significant deformation due to large pressure differential and would sustain constant pressure differential for extended amounts of time that
will lead to extrusion failures. It was necessary for us to evaluate the performance of this elastomer/seal over prolonged periods of time and to better understand the design limits and enhance the tool's performance. The challenge was looking at the performance of the seal over an extended period of time under a constant state of stress or strain. Large pressure differential between the well bore and the seal will cause potential failure of the seal and extrusion of the seal. Providing guidance and design optimization through our simulation support became essential and critical to the development. Visualizing deformations and failures under high pressure testing environments is very challenging. Our simulation provides better insight of the deformation and failure modes. That helped the client improve the design of the tool.

**How Did We Help?**

Material calibration for hyperelastic materials are critical to the success for modeling tools that are made of rubber-like materials (for more information refer to Hyperelastic Material Calibration Case Study). In addition to standard testing for product life cycle predictions, a more detailed material testing needs to be undertaken. Visco-elastic material models that predict material behavior over time was required. A detailed test procedure for visco-elastic material under constant strain was tested so that stress relaxation and material extrusion could be better understood (Fig. 2 and 3).

The tool was subjected to very high deformation. It initially had a compression load, then 30,000 psi differential pressure was applied. Several scenarios were investigated as a part of this project where direct well pressure and draw down affect were simulated (Fig. 4 and 5). Finally, to better understand elastomer deformation of failure modes, the tool was subjected to axial compression and 30,000 psi differential pressure. Under constant load or strain the stress relaxation of the elastomer pad was evaluated. Under constant state of strain, the elastomers continued to deform which created potential extrusion type of failures. The area of possible extrusion failures were investigated and new design changes were suggested and communicated to the client.

![Fig 2: Visco-elastic test under constant load](image)

![Fig. 3: Stress relaxation under constant load](image)
Results:

By performing this nonlinear FEA Analysis for well testing tool development, this is what was achieved:

- We evaluated deformation modes
- We plotted stresses at critical locations
- We analyzed critical cross sections
- We evaluated modes of failure
- We presented our findings to the client

Value to Client:

- We suggested further design changes that were later implemented
- We provided more reliability for hyperelastic materials
- We helped client develop their tool
- We captured our methodology and that knowledge was communicated to the client