Case Study #1: Bridging the Gap between Standard API Calculations and Tests for Short Casing Collapse through Advanced Modeling

Summary

To increase casing efficiency and reliability, the requirement from a leading service provider was that MindMesh Inc. performed Collapse FEA analysis of the centralizer sub
(shown in Fig. 1), under applied external pressure. This analysis was also to estimate the collapse pressure limit, and compare the collapse pressure limit predicted by API calculations. There were three designs used during this analysis. The designs included nominal material, minimum material and minimum material with ovality/offset conditions.

Fig. 1: *Un-deformed pipe*

Challenges:

- API calculations under predict collapse pressure
- Accurately model short collapse to reduce testing efforts and time to market

Results:

- Improved collapse strength
- Exceeded standard API collapse calculations

About The Client

The service provider is a billion dollar industry leader in cementing and casing products around the globe and continues to expand in terms of innovation and presence in the oil realm. They have several patented inventions and are known for meeting the standards of their clients' oil and gas needs, both onshore and offshore.

The end client has developed some of the world's most multifaceted crude oil fields and continue to do so in countries spanning from Kazakhstan- where the company is the largest private oil producer- to the U.S. Gulf of Mexico where they are the largest lease holder. The client continues to have a powerful presence in all major basins worldwide and is focused on the future growth of the company and improvements within the oil industry.

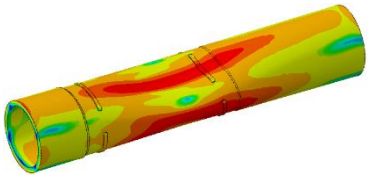
Challenge

The purpose of the centralizer is to help locate the casing in the well during cementing operations. The subs need to maintain collapse pressure equal or greater than casing collapse pressure. This, in turn, improves overall well integrity and ensures good cement distribution. The challenge therefore, is that conventional API calculations under predicts collapse pressure grossly. To reduce testing efforts and improve time to market, a comprehensive process of modeling short collapse of subs has been proposed.

How Did We Help

Collapse is an unstable process that is dependent on applied pressure, casing design, and manufacturing defects. To model the imperfections and design sensitivity, a method of including dimensional variations in the design was proposed. For this, a mode shape analysis to determine Eigen frequencies was performed. A percentage of the Eigen frequencies was used along with dimensional variation to initiate collapse. Pressure was applied over time an deformations, local stresses and plasticity was monitored to predict collapse, Fig. 2.

Fig. 2: *Collapsed pipe from side*



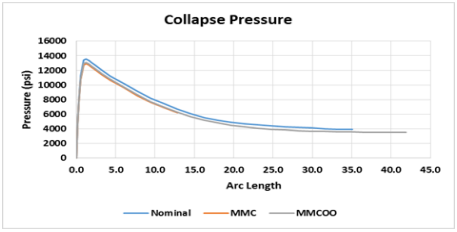


Fig. 3: *Nominal results for collapsed pipe*

Results

By using effective modeling techniques, Fig. 3, and evaluating the collapse pressure limits; this is what was achieved:

- API calculations were exceeded
- Manufactures requirement was met
- Predictions were proven accurate
- Predictions matched reality and met design requirements of the client

Value to Client

- Qualify for higher pressure ratings for centralizer subs
- Potentially qualify for deeper wells
- Meet design requirements
- Improve market reach for clients

The table below shows how our modeling/ simulation compared with real testing. The results are considered good for such collapse analysis.

Casing Size / Grade	Collapse Test Results (psi)	FEA Predicted Collapse (psi)	Difference (FEA – Test) (psi)	Casing Collapse Rating (psi)	Safety Factor Test vs casing
9 7/8" 65.1 # Q125HP	17,904	16,096	1808	13,890	1.29