Case Study #9: Improving Reliability of Mud Motors

Summary:
MindMesh Inc. developed methods to better understand the behavior of mud motor performance under varying operating conditions through analytical and numerical methods. As part of this case study, we developed material calibration methods as discussed in case studies 2 and 3. Further, additional testing and calibration methods were developed to incorporate the effect of temperature variations and hysteresis. Through our modeling process, we improved the reliability of mud motors under downhole operating conditions.

Challenges:
- Understand how the stator and rotor perform under operating conditions

Results:
- Improved material models for stator elastomer
- Conducted failure mode evaluation for mud motors

About the Client(s):
This analysis of mud motors was developed and addressed for several of our clients within the oil and gas industry. The structural behavior of mud motors is essential to nearly all those within the oil and gas industry. From service providers to suppliers and consumers, this analysis was a necessity to improve the reliability and reduce failures of the motors under operating conditions.

Challenge:
There are two main components to mud motors, the lower assembly and the power section. Our primary focus was the power section of the pump where the mud motor stator is located. The mud motor stator is usually lined with an elastomer. Most mud motors fail due to this elastomer part. However, the operating conditions and environment should not cause this mechanical failure of the elastomer part for the life of the equipment. Unfortunately, the industry does not yet have elastomers that can last longer, resist abrasive fluids and solids, and withstand operating temperatures. There is a need for better elastomers to reach areas which are not currently accessible by mud motors and also a
need to improve the life of current products. Our challenge was to understand how the stator and rotor perform under differential pressures, RPM, and torque (operating conditions). The motor under the aforementioned conditions creates dynamic loads which result in motor vibrations, failure of elastomers (chunking), and fatigue failures of the rotors. With this, we studied the dynamics of the power section and evaluated the power section performance under varying degrees of differential pressure.

**How Did We Help?**

The power section of the mud motor uses different rotor and stator configurations to provide optimum performance for the desired drilling operation. Typically increasing the number of lobes and the number of power sections increases the throughput of the motor. In our simulations, we utilized both 2D and 3D models, (Figs. 2 and 3), to better understand physical behavior of the motors.

We developed static and transient dynamic models of the power section and studied the resulting deformations and stress developments under operating conditions (Fig. 4). We also evaluated the dynamic vibrations caused by the eccentric behavior of the rotor and the time varying contacts with the stator. By understanding the peak stress developments and the critical vibrational frequencies, we evaluated the failure modes of the power section. We also studied the effects of heat generation and hystereses on stator elastomer. This, in turn, helped us to evaluate the performance curves of the motors.

![Fig. 2: 3D view of power section](image1)

![Fig. 3: 2D view of power section](image2)

![Fig. 4: Stress in motor](image3)
Results:

By performing this analysis of the power section of mud motors, this is what was achieved:

- We determined material characteristics of the power section assembly and improved material models for the stator elastomer
- We analyzed the static and dynamic behavior of mud motors
- We conducted failure mode evaluation of the motor through simulation including temperature related issues, motor vibration, and fatigue failures
- We studied the effect of pressure drop on the power section under varying degrees of differential pressure (Fig. 5)
- We evaluated the effect of limited LCM in mud motor performance

Fig. 5: Pressure drop across the power section

Value to Client(s):

- We helped improve the understanding of the dynamic behavior of mud motors
- We improved the reliability of the power section and performance of mud motors
- Our analysis methods replicated downhole conditions and thereby improved clients’ understanding