Drilling Simulations Enhance **Well Planning and Drilling Decisions**

MSC Software Partners with Pioneer Natural Resources to create Adams Drill Platform

By **Fred Harvey, MSC Software**

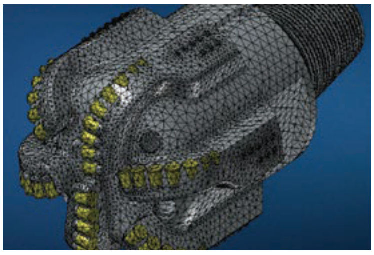
Exploration for oil and gas involves drilling a well with a length of drill pipe attached to a Bottom Hole Assembly (BHA) that includes a variety of specialized drilling tools for boring through rock, taking measurements, managing vibrations, and steering control. The drill string follows a trajectory intended to reach a particular oil rich target zone, often exceeding 15,000 feet from the drill rig itself. Since each well is unique, and the drilling process is incredibly expensive, it is impractical to physically test the design as with traditional prototype testing.

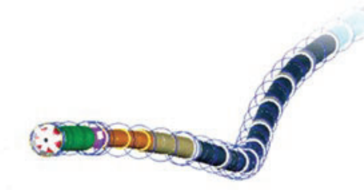
The drilling system is complex and includes fluid systems, electrical systems, advanced control systems, mechanical drives, rig structure, and drill string in addition to Mother Nature, who contributes to the environment with high temperatures and pressures and a wide range of geology considerations. The drill string is immersed in drilling fluid and remains in contact with the wellbore through many layers of formations, each with different physical properties. Rotation and axial motion is controlled at the surface by electric top drive and cable systems; each with their own mechanical, hydraulic, and control systems. Drilling fluid is pumped through the drill pipe and up the wellbore to provide lubrication, cooling, and evacuation of rock cuttings from the bit. This fluid provides viscous damping and buoyancy effects to the drill string, but also has a tendency to cake when left static. Mud motors convert hydraulic energy into mechanical energy that provides torque and additional RPM to the drill bit. Other devices with varying degrees of sophistication are used to take measurements, manage vibrations, and stabilize and maintain directional control of the BHA. All of these devices must be accounted for in the model in order to capture the correct system behavior. As one can imagine, the drilling system as a whole is very complex, comprised of numerous nonlinear subsystems that interact with fluids, geology, control systems, and mechanical structure of the string itself. With such a complicated system, it is no surprise that damaging vibrations can occur downhole with little or no indication at the surface. Physical testing is not only prohibitively expensive, but the test data are often not available until after the drilling is completed and downhole data is made available. Even with downhole test data, it is very difficult to comprehend what is actually happening from the

limited information available. Modeling provides an opportunity to study the drilling system, make sense of available physical data, and estimate behavior of future designs.

Many approaches have been used to model drilling with various degrees of success. Finite elements are most common. On one end of the spectrum, very simple linear structural dynamics models have proven to be a very useful representation of the string for basic planning purposes. Advanced nonlinear FEA models used by the major service companies have been used to study the nonlinear drilling dysfunctions. Although FEA is appropriate for capturing nonlinear behaviors, such models tend to be cumbersome, computationally expensive, and are not commercially available. Systems of equations are on the other end of the spectrum. Fast enough to be used in real time analytics, but difficult to capture enough fidelity to account for individual designs or the complex coupled physics.

A Multi Body Dynamics (MBD) approach with MSC Adams strikes a nice balance between fidelity and computational efficiency while capturing the coupled three dimensional nonlinear behaviors of the drilling system and various subsystems. MSC Software has partnered with Pioneer Natural Resources to tailor fit Adams to this unique industry vertical application. “We’re very excited about the potential for Adams Drill,” said Chris Cheatwood, Chief Technology Officer at Pioneer. “This software allows us to simulate drilling an entire well from start to finish, monitoring a range of





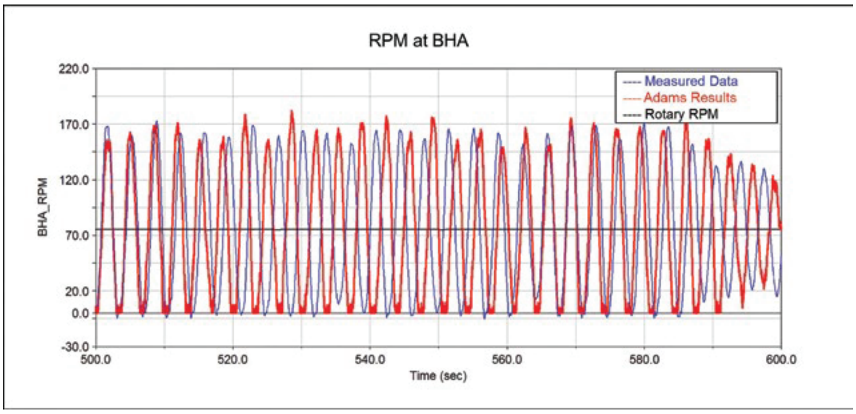


Figure 1: Comparison of measured and simulated RPM at the Bottom Hole Assembly.

new parameters we've never had access to before." Pioneer is helping MSC validate the models by collecting physical drilling data with special measurement subs that are designed to withstand the extreme vibrations and downhole operating environment during drilling. The team is using the measured data for comparison with simulation data to verify accuracy of the models and improve them as necessary. Figure 1 shows a high level of correlation between the measured and simulated RPM recorded just above the motor in the Bottom Hole Assembly.

These recording subs are capable of measuring torque, rpm, axial load, and bending moments at various locations in the BHA at 50 Hz for long periods of time. Such downhole data is critical to calibrate and gain trust in a comprehensive drilling model such as this. Similarly, the model is critical to rationalize the nonlinearities observed in the physical data and understand how changes to the BHA design, wellbore trajectory, lithology, operating parameters, and control systems, will impact drilling system dynamics.

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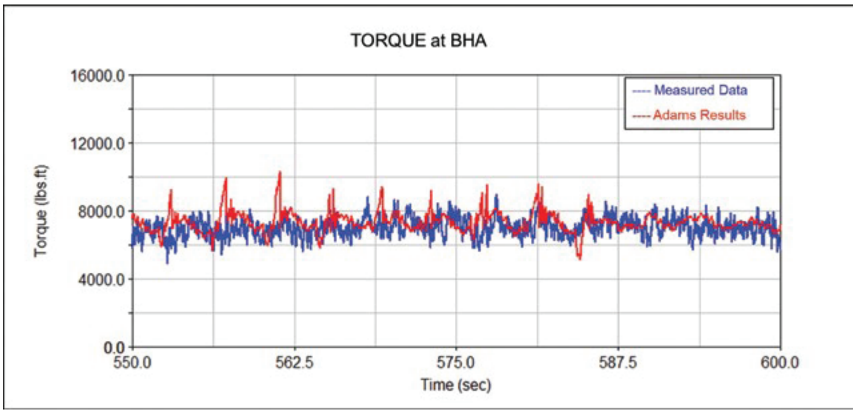

Figure 2: Comparison of measured and simulated torue at the Bottom Hole Assembly.