Computations of Stress on a Fluid Filled Gun for Survival

UNDERSTANDING FAILURES PROVIDES THE ABILITY TO ENGINEER THEM OUT

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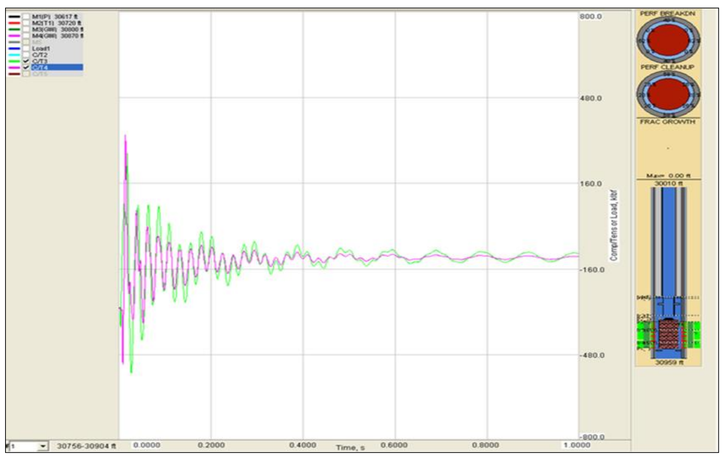
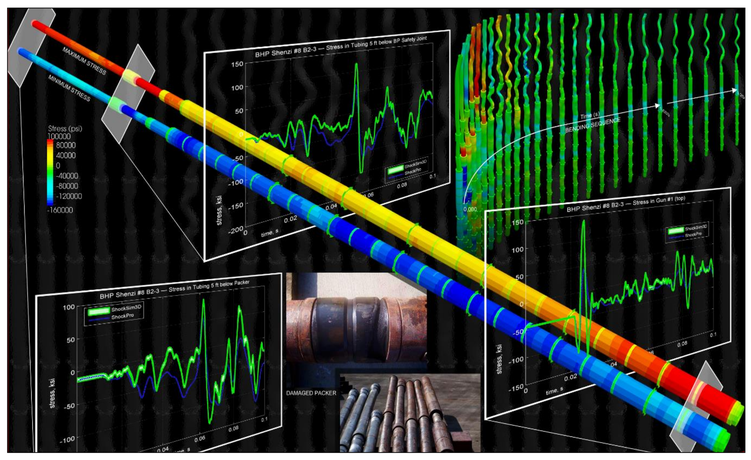
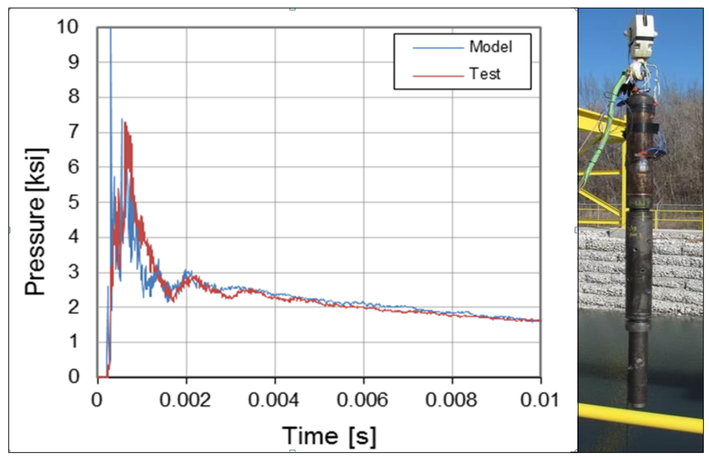


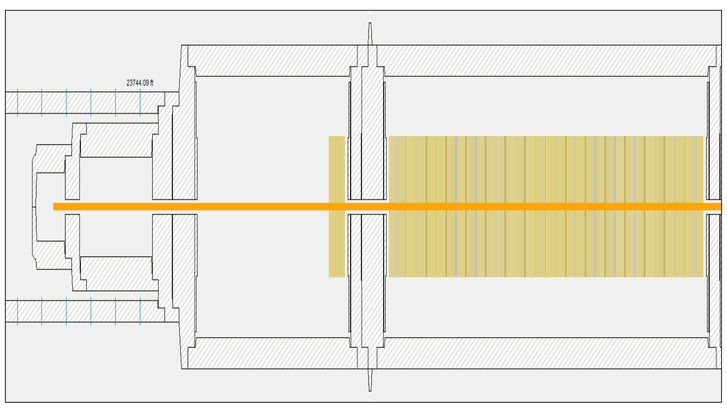


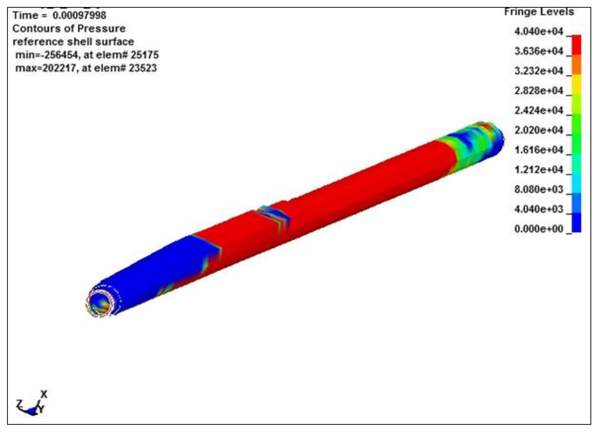


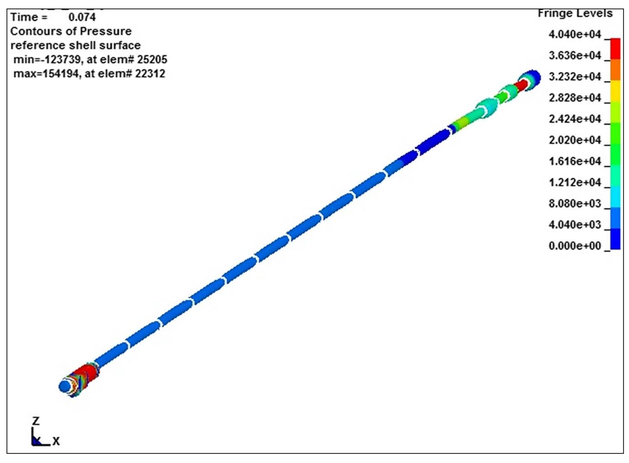
- Computer modeling has become an ever more necessary and critical component in current well completions to help ensure wells are completed without undue risk and associated costs.
- Industry accepted modeling used currently, although typically sufficient, cannot always account for the precise downhole transient behavior of the gun system and wellbore environment during a perforating event.

- To complement existing modeling capabilities, Halliburton developed a new 3D shock simulation suite that provides an additional layer of assurance for successful job execution.
- It provides in-depth analysis capabilities in the event of undesired downhole results.
- 3D graphical representations of the perforating event makes interpretation and analysis intuitive.

- As part of the new software development, systematic testing needed to be performed using a high resolution multi-sensor data collection tool to correlate its outputs to those of instrumented gun systems in a laboratory testing environment.
- Simulated v's actual results for small scale test setups showed excellent correlation.







- A theoretical model of a gun system and associated bottomhole assembly (BHA) was built within the new software and a shock hydro code simulation was executed to provide a baseline for a fluid filled gun.
- Software includes predefined hardware that is user configurable for detailed finite element analysis (FEA).
- A unique feature of the new shock simulation software is the ability to change the fluid inside of each gun, a feature not available with industry known and accepted modeling packages.

- As expected, the shock hydro code model showed immediate gun failure.
- Fluid filled gun shock is able to transverse the structure of the gun and tubing with much higher magnitudes.
- A high order pressure peak is also observed below the packer after approx. 73 m/s, which indicates potential assembly failure.
- A similar effect is experienced when perforating partially loaded guns. Immediately after detonation, fluid enters the gun carrier during the high pressure period. This "water-hammer" will combine with the mass of charge debris inside the carrier and impart a tremendous force on the inner walls of the gun.

- New 3D shock simulation software showed very reasonable correlation with expected failure modes.
- Building on lessons learned from a fluid filled gun will allow overlying fluid based models with structural based models to identify what parameters lead to gun system failures.
- Solutions offered by this new software package will ultimately lead to improved procedures and job designs that will help mitigate the potential risk of future hardware failures.

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