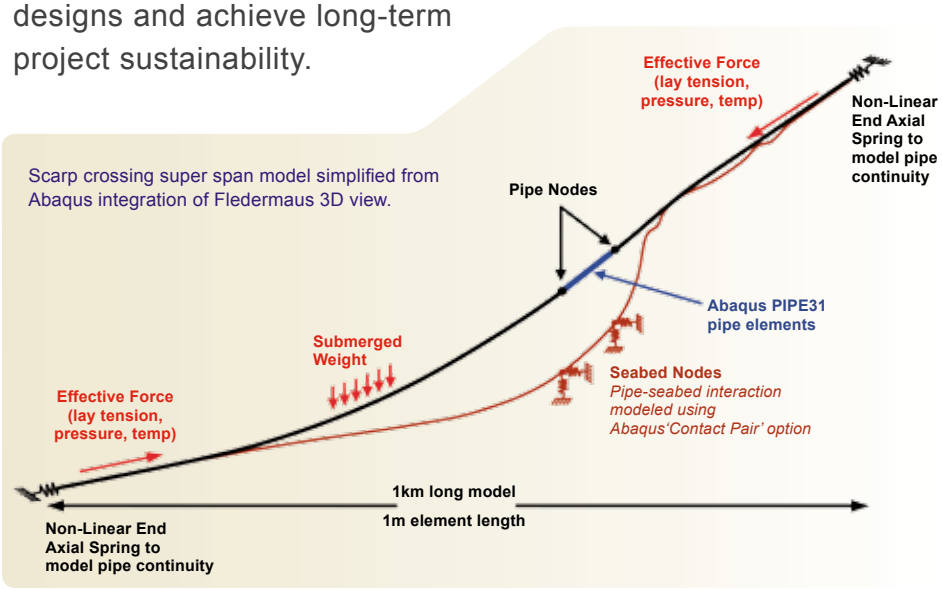
J P Kenny
Pioneers Software Use in Gas Field Projects

In response to increasing demand for oil and gas, energy exploration companies are tackling challenging, deep sea projects that have been commercially and technically impossible until now. Advances in FEA software and growing industry knowledge have been instrumental to the success of these new projects. Companies such as J P Kenny are leveraging the latest technology to evaluate their designs and achieve long-term project sustainability.

Pipeline Design Challenges

In a recent gas project approximately 150 miles off the western coast of Australia, J P Kenny applied state-of-the-art Abaqus FEA technology to evaluate the design performance and route mapping for a large system of subsea pipelines. Many critical issues affect subsea pipeline design including the great length of the pipeline, the depth of the sea bed at up to 1350m, the high temperature of the gas at up to 130°, and relatively high pressure at 360barg.

According to Pipeline Business Leader Dermot O'Brien, the mix of high pressure and high temperature also make pipeline material selection and corrosion management a key design issue. Pipeline wall thickness, corrosion inhibitors, and claddings all impact costs; and FEA is helping in the selection of alternative materials. "The deepwater location of part of the gas field presents clear challenges for the design and installation of large diameter pipeline," said O'Brien. "The pipeline requirements include about 260km of large gas delivery line and some 520km of small diameter pipe connecting the well heads, manifolds, and other equipment."



Other issues being considered in the design of the pipeline are the effects of the local marine environment (which features steep escarpments at the continental shelf), the annual cyclone season, large tidal movements, and strong currents, which impact the seabed and the pipeline itself. A number of design criteria and equations fall outside the current design codes, so specialized engineering assessments are being applied.

Evaluating Subsea Loading

J P Kenny is pioneering the use of Abaqus FEA to evaluate conceptual designs, perform Front End Engineering Design (FEED) studies, and conduct detailed design studies of the pipeline. Abaqus nonlinear and contact capabilities are readily applied to a deep water environment, coupling the analysis of water and seabed movements and pressures with high temperature, high pressure gas products.

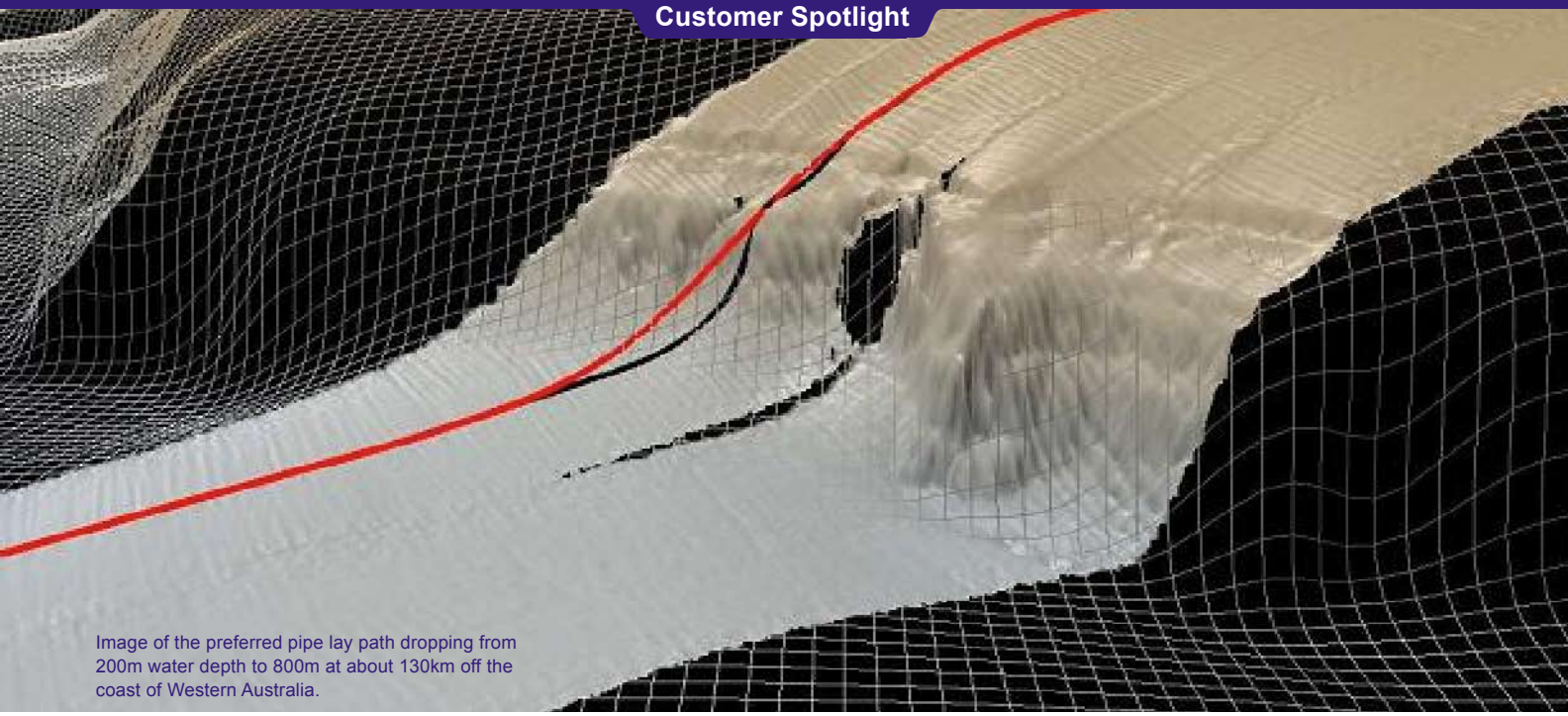


Image of the preferred pipe lay path dropping from 200m water depth to 800m at about 130km off the coast of Western Australia.

It is estimated that the combined characteristics of high pressure/high temperature gas flow and natural seabed behavior could cause a 7m expansion of the main line. The forces associated with this expansion include lateral displacement cycles of the pipe on the seabed of up to 10m. Abaqus is helping engineers develop and test designs to withstand the pipeline dynamics and the forces operating at the continental shelf crossing.

For example, detailed lateral buckling analyses are being done to assess forces, moments, and strains across the full range of behaviors, including ratchetting due to start up and shut down cycles, the cumulative effect that pressure and temperature fluctuations have on the highly stressed apex of the buckle, and the investigation of the potential for pipeline creep or walking.

In addition to helping the pipe lay team understand the loads on the pipeline due to pressure and seabed contact, Abaqus is being used to confirm the location where the pipe line should span the sea floor escarpment at the continental shelf, which drops from 200m to 800m water depth. The pipe lay team successfully integrated the Fledermaus interactive 3-D visualization system from IVS 3D with the Abaqus FEA tool to accurately map the escarpment. At the scarp crossing there is a potential pipeline span of 200 to 300m, so it is crucial that the pipeline has the structural integrity to cross the escarpment. In addition to the usual lay tension, pressure, temperature, submerged pressure, and axial spring tensions to be calculated, there were additional elements defining the local geo-hazards, including mudflows on the scarp face. J P Kenny found that crossing the escarpment at the optimum point will reduce the pipe lay for the project by up to 40km—a significant cost saving.

Finite element analysis is being done for a complete range of conditions, including empty pipelines, those with operating contents, and those containing flushing media. The sensitivity cases being considered are different pipe outer diameters, wall thicknesses, addition of concrete coating, and residual lay tension. Results from the span analysis reveal the bending moment distribution, longitudinal strain profile and spanning pipeline profile along the route, and modal shapes and frequencies.

"To make the subsea infrastructure more secure, we have used Abaqus FEA software to plan for major event scenarios, including the impact of cyclones on pipe line dynamics," explained O'Brien. "Abaqus has reduced simulation times, and improved the efficiency and accuracy of pipeline design and route mapping since the team switched from our former FEA tool."

Meeting Future Demands

J P Kenny, involved in more than half of all subsea projects around the world, is addressing challenging engineering problems on several cutting-edge projects. Paul Jukes, Advanced Engineering Manager for J P Kenny, suggests that key success factors in developing a viable engineering solution for these projects are employing engineers with a high level of experience, encouraging creative problem solving, and leveraging advanced numerical tools. It is the combination of these factors that is enabling J P Kenny to gain a deeper understanding of subsea pipeline performance.

Reference: *Innovative Pipeline and Subsea Engineering Experience* by Dr. Paul Jukes, Ph.D., CEng FIMarEST, J P Kenny. Presented at the International Conference on Subsea Technologies, SubSeaTech' 2007, June 2007, St. Petersburg, Russia.

For More Information

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