FLEXIBLE PIPES: END FITTING TECHNOLOGIES

Experience gained at BPP-TECH over recent years in the area of flexible pipe analysis has led to the development of some exciting new capabilities. One of the notable advances this decade is general acceptance in the offshore industry of the increasingly arduous service seen by flexible pipe technology.

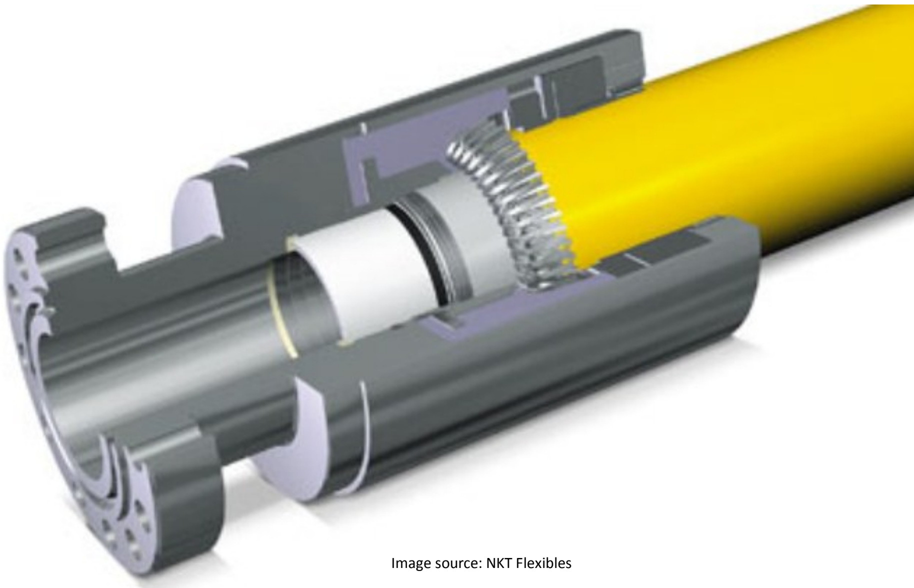

Image source: NKT Flexibles

The application of flexible risers, entwined with the use of subsea developments, encompassing floating production units, is an area of recent rapid growth.

Work has been carried out on an alternative end fitting sealing mechanism, using multiple gasket seal rings as opposed to a crimping seal. The gasket seal ring mechanism is illustrated. The main features are two PTFE gaskets separated by a stainless steel ring. All the rings have a keystone profile that is optimised for seal performance. Tightening the inner casing into the end fitting body energises the seal. It can be seen that the components reacting with the seal forces are the end fitting body and the carcass. The carcass is designed to withstand the radial forces generated by the seal such that it does not collapse.

The geometric and material non-linearities inherent in this sealing mechanism require a non-linear finite element analysis (FEA) based solution. Calculations were carried out using the commercial non-linear finite element code ABAQUS. The full model describes a highly complex problem comprised of sixteen different moving parts, twenty-seven different contacting pairs of surfaces and five different materials, three of which may be deformed into the non-linear regime.

The correlation obtained from the FE model between inner casing axial displacement, maximum carcass radial displacement, and maximum gasket contact pressure, was thoroughly verified by measurements taken during the assembly of several end fittings.

One of the interesting features of the seal mechanism, considered here, is the role played by the radial support of the inner carcass. This support depends on the structural integrity to collapse of the carcass, and this is a particularly relevant concern with deep-water flexible pipe.

This phenomenon may be replicated in a finite element model by careful application of boundary conditions. Use of ABAQUS allows 'mode two' buckling response, to be predicted by constructing a detailed mesh with up to ten turns of carcass, each structurally independent, and accurately replicating, the required helical angle and carcass ovality.

Due to near-symmetry, only one quarter of the circumference needs to be modelled. The polymer sealing layer was also included as it is required for accurate pressure transmission. The observed sequence of events is very much in line with current understanding of the collapse of ovalised homogenous pipe.

A finite element solution has been shown to predict the onset of local plasticity which, when combined with the predicted loss of stiffness, is synonymous with collapse under external pressure. Test results verified the FE predicted value for one particular carcass geometry.

With the increasing importance of water depth and temperature, new approaches will be required if successful and reliable production is to be achieved using this technology. The existing gaps in current knowledge are being filled and by targeting the difficult problems, we hope to continue to generate solutions in pace with industry requirements.