Non-linear Stress Analysis of Complex Umbilical Cross-sections

MARINTEK is currently carrying out a project for Nexans Norway AS with the aim of developing a software tool for detailed analysis of the complex cross-sectional designs found in umbilicals. With the ever-increasing water depths of new oil fields, the UFLEX Program System is believed to be a necessary supplement to current design tools and procedures, reducing both technical risk and costs by improving our understanding of the mechanics of umbilical cross-sections.

The software development project combines MARINTEK’s unique know-how in numerical methods and development of marine analysis tools with Nexans’ wide-ranging experience of steel tube umbilical design. Small-scale and full-scale testing of components from a wide variety of umbilical designs, essential for calibration and verification purposes, is also part of the scope of work. Test specimens of dynamic umbilical risers are typically cycled 2-3 million times in full-scale test rigs, such as MARINTEK’s rig at the Marine Structures Laboratory in Trondheim, in order to verify fatigue performance under specified load conditions.

The inaccuracies of today’s commercially available numerical models and analysis tools have led to a growing need for extensive and expensive full-scale tests, which also reflect the increasing design challenges. The UFLEX Program System will offer a new way of improving umbilical design by enabling designers to study the effects of using different materials and varying cross-sectional geometry on a laptop computer, thus also limiting the necessity for expensive full-scale tests.

As shown in Figure 1 a dynamic umbilical is a very complex structure. In addition to having a sophisticated cross-section, each of the components of which the umbilical is built is helically wound in the longitudinal direction. This also implies that the development of a stress analysis tool for such cross-sections, taking into account both geometrical and material non-linearities, is quite a challenge.

The first version of the UFLEX Program System, as illustrated in Figure 2, is due to be completed by the end of 2002.

Analysis Functionality

The UFLEX Numerical Code will include the following functionality:

- Arbitrary geometry modelling including helical elements wound into arbitrary order
- Elastic, hyper-elastic and elastic-plastic material models
- Super-elements
- Initial strain (user-defined or automatic)
- Contact elements, including friction
- Tension, torsion, internal pressure, external pressure, bending and external contact loading (caterpillars, tensioners)

Figures 3 and 4 show the UFLEX geometry model and finite element mesh for a fourth-order umbilical cross-section.

Time Schedule

The first version of the UFLEX Program System, as illustrated in Figure 2, is due to be completed by the end of 2002.

Financing

The UFLEX research and development project, including software development, small-scale materials testing and full-scale model verification, is being financed by Nexans Norway AS.