

# Case Study

## Whittaker Engineering

### Gypsy Wheel Structural Analysis

#### Client Profile - Whittaker Engineering

Established in 1983, Whittaker Engineering Ltd ([www.whittakereng.co.uk](http://www.whittakereng.co.uk)) provides quality engineering design to the offshore oil and gas industry. The company's in-house capabilities include manufacturing, engineering design and analysis, alongside CNC machining, water jet profiling and specialized welding/fabrication of ferrous and non-ferrous metals.

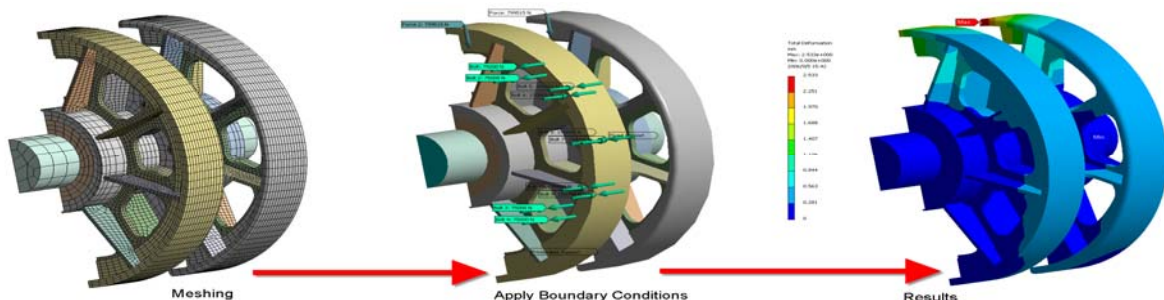
#### Background



IDAC was approached by Whittaker Engineering to validate the structural integrity of a newly designed Gypsy Wheel using Finite Element Analysis. Upon validation of the structural design, the Gypsy Wheel was to be installed on the mooring system on board the FPSO Captain, operated by Chevron Texaco in the North Sea.

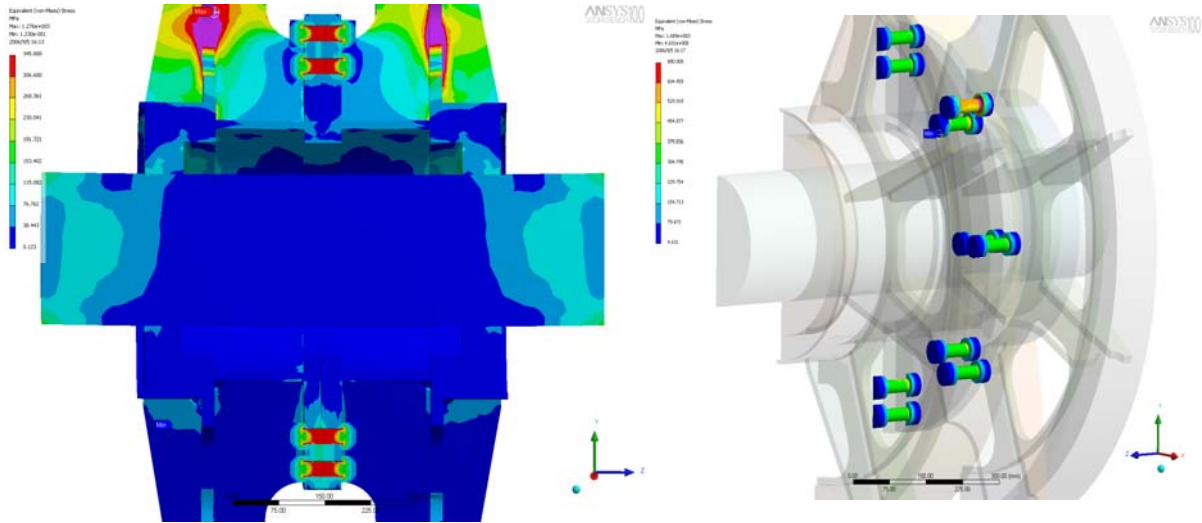
There are a total of eight mooring chains, each of which is provided with its own tensioning system. The system consists of a jack, hawse pipe, chain gypsy and chain locker. The jack consists of a fixed lower stopper with hydraulically setting chocks and a moving upper gripper, complete with hydraulically setting chocks and mounted upon two hydraulic cylinders. In operation (assuming the cycle starts after a lifting stroke), the lower stopper closes onto the chain. Once this is achieved, interlock devices allow the upper gripper to release the chain, which then permits the hydraulic cylinders to retract and lower the upper gripper. When fully retracted the upper gripper closes on the chain. Interlocks then allow the lower stopper to release the chain. The hydraulic cylinders are now extended which has the effect of tensioning the chain. The cycle is then repeated.

The primary reason for developing a new design stemmed from an earlier failure that resulted in one of the mooring chains dislodging from the chain locker and consequently sinking to the ocean bed. IDAC was tasked to perform stress analysis on the Gypsy Wheel, under pre-load and operating load conditions. The cause for the failure is presently undetermined and falls outside the scope of this analysis.



## Analysis

The geometric model of the Gypsy Wheel was meshed using ANSYS Revision 9.0. Non linear contact elements were generated between the shaft and the wheel and bonded contact elements were generated between the bolts and the wheel, in order to simulate the bolt preload. Three separate load cases were studied as part of the investigation. The simplest load case ensured that the assembly did not suffer damage under a pre-loading scenario. The other two cases analysed a normal and angular downward force independently, as well as in combination with an out of plane force.



In each case the results obtained from the simulations suggested that the Gypsy Wheel can undergo the loads witnessed in pretension and during operation. The resultant displacements and stresses fall well within the design parameters.



## Design Benefit

The new design of the Gypsy Wheel, aims to guide the mooring chain into the chain locker, thereby relieving the assembly of any loads during the mooring process. This intrinsically reduces the chances of a failure. As per design mandates, the frame can also withstand transient and impulse loads for a small period of time. In addition, due to the limitations associated with access and mechanical handling, effort was put into keeping the weight and size of the assembly at a minimum. This however did not compromise the structural integrity of the assembly, as shown in the analysis.

## Feedback

*“Our new design had to withstand the same possible failure mode plus another failure mode which had not been previously accounted for. The solution was impossible to load test safely and difficult to analyze precisely by conventional hand calculations but **IDAC**, in their usual friendly and knowledgeable way, worked with us until we were able to produce an engineering package which was acceptable to the Ship's certifying authorities; we manufactured and installed the eight new chain gypsies and they are currently in service in the North Sea.”*

– Ken Whittaker