Development of Condition Monitoring for Subsea Pump

Project	To develop a fibreoptic condition monitoring system for a newly developed deepwater subsea pump
Client	Shell International Exploration & Production Inc.
Project Partners	Shell, Flowserve, SKF, Teledyne ODI, FMC, Smart Fibres
Date	2007-2010
Location	US / NL
Sensors	SmartFBG, SmartTemp, SmartCell, SmartAccel
Attachment	Integration within pump and motor assembly
Interrogator	SmartScan

Pump and Motor Assembly on test stand at Flowserve facilities in Etten-Leur, NL

Requirement

This project was a subtask of a major project carried out by Shell and Flowserve since 2005 to develop a next generation capability for artificial lift from the mud-line that can handle multiphase flow with high boost pressures and a wide range of viscosities. The major project led to the development of a high boost, high power, ultra-deepwater twin screw multiphase pump, and a high power submersible motor. Details of the major project are available in SPE paper 134341 presented in September 2010. The subsea assets that result from this development will be critical to deepwater production, and their continuous health monitoring is highly desirable as part of a managed, condition based operation and maintenance regime. Given the remote location of the assets, perhaps some 10 km or more from the surface FPSO, the key performance benefits of optical sensing make it a very attractive candidate technology for such a condition monitoring system.

The requirement on Smart Fibres under this project was to develop and demonstrate a multi-parameter fiberoptic condition monitoring system for the pump and motor which included the following:

- Multi-point temperature measurement in the motor stator
- Dynamic strain measurements in the main pump rotor bearings
- Acceleration of the motor housing and pump bearing housings
- Pressure and temperature of the lubricating oil system
- Speed and direction of rotation of the main pump rotor shaft

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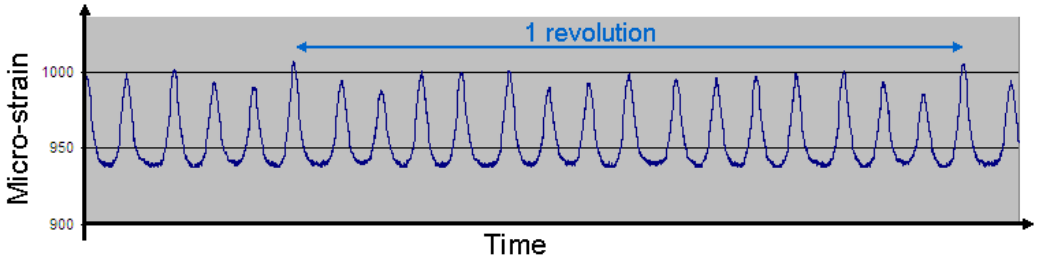
Development

For the motor temperature measurements, fibre Bragg grating (FBG) arrays in polymer tubes were embedded within the stator windings. Measurement in 18 locations was provided to monitor the thermal performance of the motor and to identify hot-spots.

Dynamic strain measurements in the rotor bearing were developed in collaboration with bearing manufacturer and major project partner SKF. By embedding FBG sensors in carefully selected locations in the bearing assembly, and by using SKF's techniques for data reduction and analysis, the strain data was shown to provide early detection of bearing damage, and also to give an indication of the amplitude and alignment of the rotor loads.



Raw data showing the signature of rolling elements passing one of the bearing strain sensors

Acceleration measurements were made in the pump and motor assembly by using third party FBG acceleration transducers, suitably ruggedised for the pressurised oil environment. The project also subcontracted further development activity to increase the upper operating frequency of FBG acceleration measurement, a limitation of currently available products.

Pressure and temperature of the lubricating oil system was measured using SmartCell P/T gauges.

A mechanism for making rotor speed and direction measurements using FBG sensors was also developed and demonstrated using a novel, non-contact technique.

The motor and pump are filled with highly pressurised oil to provide pressure balancing with the external subsea hydrostatic pressure, and also to provide lubrication to the rotating equipment. Therefore, to ensure long-term survivability of the monitoring system in this environment, sensing fibres were protected within metal tubes, and connectorisation was made within pressure chambers. Penetration of the sensing fibres through the pump and motor casings was made via subsea rated optical connectors, developed and implemented by project partner Teledyne ODI.

Testing

The twin screw pump and motor assembly developed under the major project have been commissioned on a test stand at Flowserve's pump division in Etten-Leur, NL. Smart Fibres has instrumented this pump and motor assembly with the various fiberoptic condition monitoring techniques described above. Data from a total of 60 FBG sensors are being collected at various speeds of up to 10 kHz by a 12-channel SmartScan instrument arrangement. This data is then transferred to a SKF managed acquisition, analysis and presentation suite.

Summary

A fiberoptic condition monitoring system has been developed for a subsea pump and motor assembly. A pump and motor system with the fiberoptic CMS installed has been commissioned on a full scale test loop. Operation of the string test will commence in Q1/2011, at which point condition monitoring system data shall start to be collected.

Acknowledgements

The developments described above were made possible with the valued contributions from a large team of engineers and scientists from all parties to the major project: Shell, Flowserve, SKF, Teledyne ODI, FMC and Smart Fibres

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