Offshore & Dredging Engineering

Technische Universiteit Delft

High pressure dynamic seal development for SOCCS flow-return tube

Over the last couple of years, the Wells R\&D department has developed a new concept for well construction: Shell Open Hole Continuous Casing System (SOCCS). The main characteristic of the concept is that the well design will not consist of a tapered structure, but rather a single diameter in casing used over its entire length. This new technology brings new challenges: one of these is to design a high pressure dynamic seal.

The purpose of is to seal of the space between the moving casing and the flow-return pipe against a kick, which can occur during drilling. It is also necessary to pressure test the longitudinal weld on the SOCCS casing during movement, therefor a fluid is pumped between a set of seals up to 200 bar. The designed seal should be capable of holding the pressure at minimum leakage, whilst also having a low friction force on the SOCCS casing.

This study was conducted to provide insight into different techniques to design a high pressure dynamic seal. Due to the wide range in different technique, this research touches upon many different sciences, ranging from Material Science, Chemistry, Fluid mechanics, System \& Control, Tribology etc. The study presents an overview of the different techniques that are used in the industry for similar problems together with new ideas for sealing concepts. During the research an experiment set-up is designed to subject these concepts to similar conditions as in real life. Finally the data of these tests are analyzed and the solutions are discussed.

A total of four concepts were selected to undergo full-scale experimental testing: Non-Newtonian Yield Stress Plug, Swellable Rubber, Chevron seal and Compression packing. For the first concept a mixture containing water, salts and laponite is chosen, after reacting through a precipitation reaction a very viscous fluid forms. Tests have shown that the shear-thinning effect of the fluid is so dominant that the fluid actually moves as a plug through the gap. The achieved pressure was considerably lower than expected and at high pressure the system becomes unstable. Certain explanations are provided to explain this behavior; furthermore CFD simulations are performed and have shown as a good tool to model the flow. How the CFD simulation does not incorporate the unstable behavior at high pressure, therefore it is advised to first investigate the instability more.

The test with the swellable rubber actually had to be cancelled before it was ready. Due to the bleeding of the SAP out of the rubber, the swell rate of the rubber decreased in comparison with small scale tests. Some beginning research for an oil swellable rubber was also performed; initial small scale test indicated much faster swellrates in comparison with water. Experiments to enhance the rheology properties of the oil have also been conducted and show promising results. Not only is it possible to increase to viscosity to a desired value, but the fluid displays a Newtonian behavior.

The test with Chevron seals was inadequate to say anything about their behavior as a high pressure dynamic seal. Due to a fault in design a not properly working seal was tested. It is recommended to still perform these tests.

Experiments with water in combination with compression packing showed that the concept was able to hold pressure during static conditions up to 48 bar at a flowrate of 50 ml/min, but during movement of the SOCCS casing the packing material got extruded out of the housing, holding almost no pressure. For the testing with wireline fluid, almost Newtonian like fluid with viscosity of 1000 cP, anti-extrusion rings were also added. It was clear that both adaptations increased the performance of the seal; eventually it was able to hold a pressure of 200 bar at a flowrate of approximately 10 ml/min, with a friction force of around 4 kN. This falls well within the set requirements for the design of the seal and out of all concepts is the closest to implementation in the field.

It is recommended to continue on the work concerning oil-based fluid; this would benefit the performance of all concepts. Because is it easier to control the rheology properties of this fluid then with a water-based fluid and it acts more or less as an Newtonian fluid. Furthermore the next steps should be taken in the final design of the seal, the compression packing would be the quickest way to develop a final design.

Student	Sponsor	Thesis committee
Michiel van Arkel	Shell Global Solution International B.V.	Prof.dr. A. Metrikine
April 20th, 2016		Dr.ir. A. Jarquin Laguna
		Dr.ir. R.A.J. van Ostayen
		Ir. P.C. Kriesels