Multi diameter pigging for Åsgard

Commissioning and pigging the 710km 42" x 28" Åsgard Pipeline

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Abstract
Statoil has designed and tested dual diameter pipeline pigs to perform various tasks during operations, precommissioning and commissioning of the 710km 42"x28" Åsgard pipeline. The concepts developed have been put through a major design and testing program to demonstrate that the various functional requirements have been met. The paper describes the development process as well as field experience from the initial pigging runs of the Åsgard Pipeline.

Background

The Åsgard field, currently the world's largest subsea development, comprises of a large number of subsea manifolds connected to two processing facilities. the Asgard A FPSO oil centre and the Åsgard B semisubmersible gas centre.

The Åsgard Transport Pipeline will transport dense phase hydrocarbon gas approx. 710km from Åsgard B to the onshore processing terminal at Kårstø.

The diameter of the pipeline is 42", but the water depth excluded a conventional 42" steel riser. Production will therefore be achieved using a number of 16" flexible risers connected to a subsea Export Riser Base (ERB).

The Åsgard Project and partners initially evaluated a conventional 42" subsea launching facility against a reduced diameter concept. The 42" launcher enabling the use of conventional single diameter pigs, but at a high cost and high-risk development for the subsea structure. The alternative of a 28" sub sea launcher was eventually selected, which required specially designed 28"/42" pigs.

The 28" ERB is connected to the 42" pipeline via a 28" expansion spool with mechanical connectors and a 28" to 42" transition piece.

Operational pigs will be pre-loaded into cassettes, lowered to the seabed and connected to the 28" manifold prior to launching through the 28" section of line and into the 42" pipeline for travel the 710 km to the onshore plant at Kårstø.

During precommissioning and commissioning of the pipeline, pigs have been run the opposite direction, from the landfall site, in order to perform flooding, cleaning, electronic gauging and de-watering of the line. These activities are referred to as the RFO tasks (Ready For Operation).

The Challenge

To develop pipeline pigs that are capable of performing their task in both 42” and 28” pipe. This development involves the largest known change in diameter that a pig has to undertake whilst providing its function.

The pigging tasks for Åsgard Transport can be broken down into four areas:

1. RFO Task 1: Flooding, cleaning and gauging the pipeline after construction Pigging direction from landfall at Kalstø towards the ERB (42”->28”)

2. RFO Task 2: De-watering the pipeline after the hydrotest. Pigging direction from landfall at Kalstø towards the ERB (42”->28”)

3. Operational Pigging: General pigging from the ERB subsea launcher to Kårstø processing terminal (28”->42”).

4. Pipeline Inspection pigging: Running an MFL inspection tool from the ERB subsea launcher to Kårstø processing terminal (28”->42”).

RFO Task 1 combines flooding and cleaning and gauging. The cleaning will mainly comprise of removing ferrous debris from the pipeline and to achieve this magnetic packages was carried by some of the 6 pigs within the train. As the line is dual diameter, conventional gauging plates cannot be used since they would be crushed as they enter the 28” pipeline. A purpose built electronic gauging system was employed to measure and record the deflection of the pig suspension system. The water flooding operation requires a good seal throughout the length of the 42” pipeline, to avoid ingress of air and hence problems during the following hydrotest.

The dewatering operation (RFO Task 2) was achieved by propelling a 6 pig train comprising of 3 batches of glycol with compressed air. This operation is very critical wrt. pig performance, and a high sealing efficiency is required. Also, as the pig train will be propelled using a temporary compressor spread, there is an economic argument to keep the differential pressure for entry of the pig into the 28'' section of pipeline as low as possible. As the 42” to 28” reducer is some 648km away from the pumping station, each additional bar of pressure required to push the pig into the 28'' will take approximately one day to achieve. Dual diameter pigs are notorious for requiring a high differential pressure when entering the smaller size pipeline.

Operational pigging (Task 3) will include liquid condensate removal and possible towing of miscellaneous pig tools. In these instances, the seals must recover from the 28'' diameter sufficiently to provide drive in the 42'' for the long journey back to Kårstø. In addition the discs flip differential pressure, must be high compared with the driving differential pressure, in order that the pig does not stall.

Intelligent pigging (Task 4) represents a highly complicated development where the target was to achieve XHR inspection results of similar quality as for a constant ID line. The tool should be able to inspect both the 28” and the 42” section.

By considering the tasks and operations to be performed, a detailed list of Functional Requirements was drawn up for the various pigs. The development tasks were split, whereas the first three tasks were handled internally in Statoil and the last task, the inspection pig, was to be developed in a joint programme with Pipetronix Gmbh.

Dual Diameter Pigging

- Statoil have extensive experience of dual diameter pigging from previous pipeline projects in diameters ranging from 6” to 42”, but with diameter changes significantly less than the Åsgard challenge.

The technology allows existing J-tubes and risers to be used rather than installing new and more expensive ones. In order to ensure the safe and efficient working of the pipeline and to facilitate commissioning, it is essential that the line can be pigged.

Dual diameter pigs have been in existence for some years now and those designed for changes of between two and four inches in the smaller sizes are now part of most manufacturers’ standard range. However, not many pigs have been designed for larger diameter differences and still fewer have been capable of providing a good seal in both diameters. In fact, in the past when large step sizes were involved and a good seal required, then intermediate pig traps were required.

Over the years, a number of pig types have been developed for the dual diameter challenge. The sealing systems available can be summarised as follows: -

<u>Butterfly discs</u>, try to overcome the hoop stress generated when entering the smaller pipeline, by removing material. Two, out-of-phase discs with V-shaped cut-outs allow the gaps to be filled. The resulting seal is not satisfactory but can be improved to some extent by adding a thin membrane to the rear of each sealing assembly.

<u>Petal flappers</u> comprise of a complete circle of individual blades which overlap each other to form a seal. They are more efficient than the butterfly discs, but still do not form an adequate seal against the wall of the pipe, although again this can be improved by adding a thin membrane to the rear of each sealing assembly.

<u>Standard discs</u>, can be used for small diameter changes. In this approach one seal size is used in the larger pipeline and another suitable for the smaller pipeline. When the pig is in the large diameter pipeline, the smaller seals do not act. Once in the smaller diameter, the large seals are bent back, and the smaller seal size takes over. The large seals are generally worn badly and therefore this arrangement is only useful on pigs travelling from large line sizes to small and for relatively small step changes.

<u>Umbrella discs</u>, feature the use of a thin membrane type material over a mechanical arm which is generally spring loaded. These arms then push the seal into position for the large pipeline or collapse it for the smaller line. The main problems with this arrangement are its complexity and its inherent fragility, both of which are undesirable in a pipeline.

Foam, these pigs are inherently soft and so hoop stress can be overcome simply due to the fact that there are many thousands of voids within the pig itself. In addition, the pig is light and so is self supporting. They are however often unpredictable as they can turn in the pipeline, enter branch connections and they can tear badly or even disintegrate.

Special cups with contoured areas, allowing them to fold down to a smaller diameter, but the maximum change in diameter is generally limited to around four inches and for effective sealing, they generally require relatively small tolerances in each diameter.

There are a number of other ways of producing dual diameter solutions but these are generally limited to small diameter change and/or have poor sealing ability.

A review of work done to date shows that any pig requires two essential functions:

- The seal, which provides drive and performs the pig function such as filling or dewatering the pipeline. In the popular bi-directional pig, this is normally a set of oversized discs, which are both simple to produce and effective in the sealing duty.
- The support system, which centres the pig in the pipeline and allows the seal to perform effectively. In the design of bi-directional pigs, this is commonly two or four strong guide discs.

These essential aspects of a pig design are easily achieved in pigging standard pipelines as the bore is constant and standard components can be used as shown.

It is not so simple with dual diameter pipelines. The problem with pigging such pipelines can be summarised as follows: -

- When negotiating from the large line size to the small size: Here, very large hoop stress results when attempting to fit something large (the seal) into something small (the reduced diameter pipeline). The hoop stress is related to disc hardness, diameter and the ratio of change in diameter to original diameter.
- When negotiating from the small line size to the large size: Here, recovery of the elastomer seals due to time dependent properties of the material is important. The seal may have sufficient "memory" to recover to the original size but it make take time, and a certain amount of permanent set may take place. Thus the seal may be compromised.
- When running in the small line size: In the small line size, wear of the larger diameter seals is a significant problem, especially over long distances.
- Space constraints: Since dual diameter pigs essentially involve designing two pigs on one body, the length to diameter ratio is a difficult issue. Physically fitting the seals and equipment into the smaller pipeline can be a major problem. Bends can also be a problem due to the length to diameter ratio.
- Support of the pig in the larger diameter: Rigid support in the large diameter means that the pig will not easily negotiate the transition into the small diameter. Sealing discs offer little support as they are essentially buckled and therefore

have lost their strength. But an adequately supported pig is essential, as this maximises the flip pressure and the quality of the seal.

Support methods in the larger pipeline are generally achieved using slotted guide discs or mechanical springs such as cantilevers, possibly with brushes attached. It is generally advised that if this approach is to be adopted, then heavy slotted guiders are mounted at the front, the pig is as light as possible (especially at the front) and as long as possible. This reduces the moment on the pig which causes the pig to travel off-centre, but might cause problems in bends.

Given the problems with sealing and support, a new method of supporting the pig and also a method of minimising the hoop stress on the seals when entering the smaller diameter pipeline was developed:

- A wheeled suspension system that ensures that the pig is centred in the pipeline.
- A sealing system, based on a disc seal, but with a method of folding the discs up for entry into the 28".

This is believed to be the first documented use of a pig employing these features to provide a constant high efficiency seal for a long distance dual diameter pipeline.

Basic Principle of Operation

In order to provide the right pig for the Åsgard RFO jobs a set of functional requirements were established:

- Ability to negotiate the 42" and 28" lines and the transition piece.
- Drive differential pressure in 28" line to be less than 2 bar.
- Flip differential pressure in 42" and 28" lines to be at least 3 times the drive differential pressure.
- Forward and reverse leakage past the seals to be minimised.
- Seals and wheels must be capable of existing in glycol for up to 60 days.
- Ability to gauge the 42" diameter pipeline.
- Carry cleaning magnets around the body
- Carry an isotope and a transponder on board

These functional requirements and the means of demonstrating how these requirements would be met were agreed. Some aspects were proven by design, some by calculation, but most by demonstration at Statoil's full scale test facility at Kårstø.

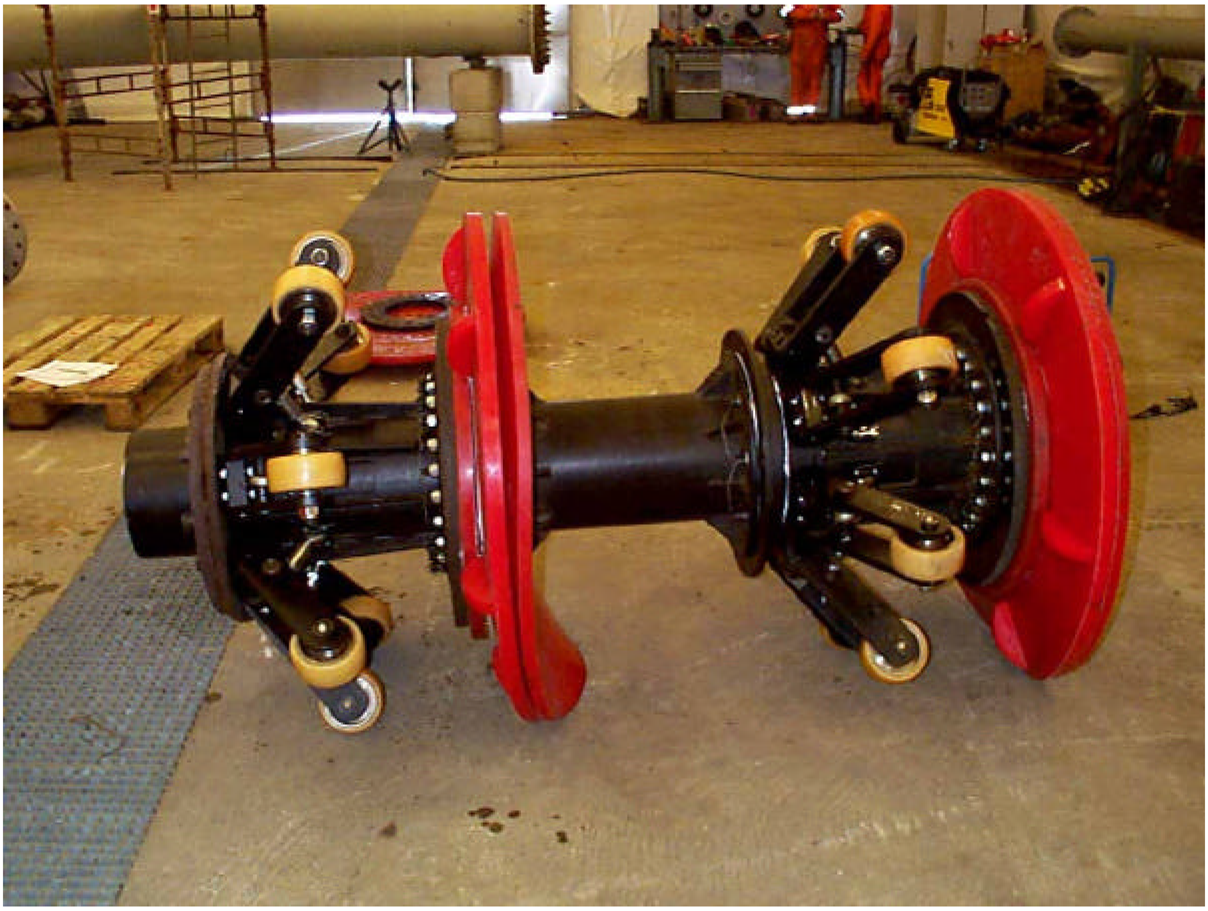

Figure 1

The prototype Åsgard RFO pig is shown in Figure 1. The pig is made up from two basic components:

- The wheel suspension unit capable of supporting and centralising the pig in the 42" pipeline.
- The disc seals with ”Cockle Inducers” for allowing the 42" seals to collapse in a controlled manner in the 28" pipeline. Also a set of conventional ‘sleeper’ discs were added behind the main seals for added sealing efficiency.

The suspension modules consist of 8 suspension arms each of which is linked to a central shaft in such a way that when one wheel arm is deflected, the other seven are also deflected. The shaft resists the deflection using 8 springs.

The basic principle of operation is that the total spring force in the cylinder is greater than the weight acting on the module. The pig rides along the centreline, as the restoring force is greater than the weight. The contribution to pig friction and differential pressure from the wheel module is negligible in both line sizes as it is merely rolling friction from the wheels.

To avoid overloading the wheels however, it is important that the force/deflection curve is as flat as possible, i.e. on entering the 28" pipeline the loading on the wheels does not change significantly. This can be achieved by optimising the linkage geometry.

The final point to note regarding the design of the suspension modules is that there is a slight spiral motion of the vehicle induced by offsetting the wheels by 2^o. This essentially gives each wheel a "holiday" from the maximum load from the weight of the pig. Such a feature is essential if the pipeline was in any way oval.

The seals are essentially standard disc seals as used for bi-directional pigs for many years. However, they also have six ”Cockle Inducers” placed near the edge of the 42" sealing edge. The seals operate as follows:

- Firstly in the 42" pipeline the seals act like standard discs, which are known to be highly efficient seals. The cockle inducers have no effect on the disc at this stage.
- On entry into the 42" x 28" transition piece, each cockle inducer contacts the pipewall and forces the disc to fold controlled inwards in 6 places, reducing the hoop stresses. Without these inducers, the discs would buckle in an arbitrarily pattern which would yield uncontrolled forces
- Separate seals are provided to take up the sealing task in the 28" line.

Figures 2 and 3 show the seals in both the 42" and the 28" pipeline.

Figure 2

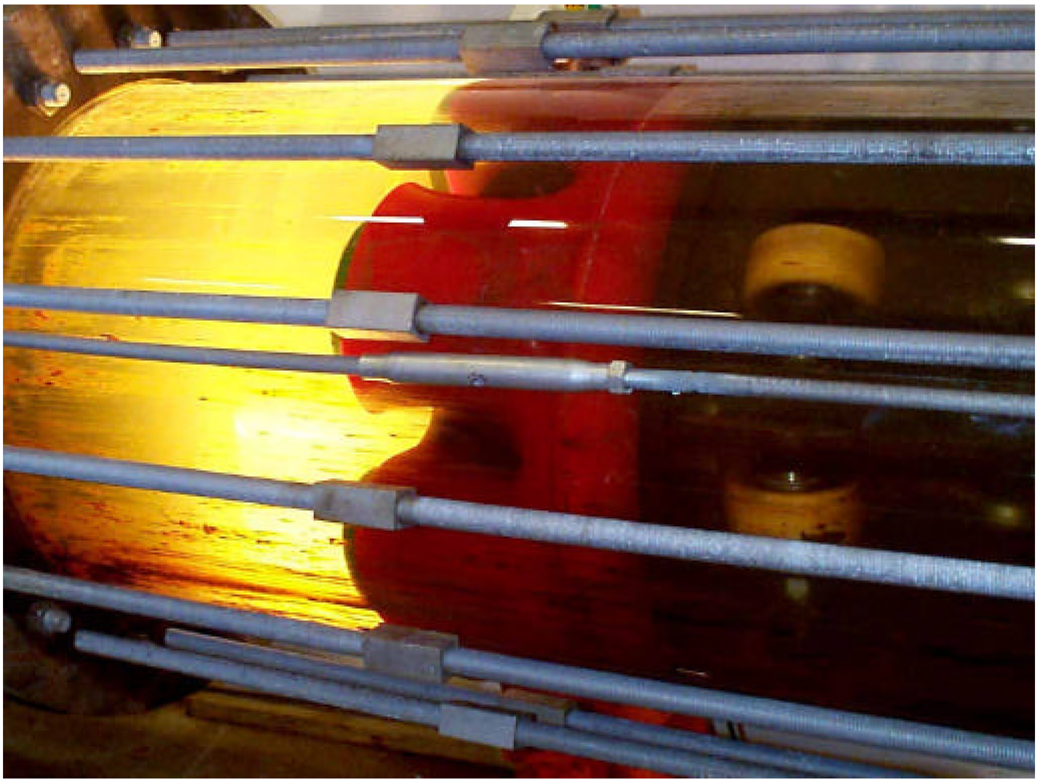

Figure 3

The pig is in effect a carrier vehicle for many different applications. It can be configured to suit different pigging tasks. For example, this tool could be used to aggressively clean the pipeline by using harder discs, and/or magnets for ferrous debris. Another potential use would be to tow an inspection vehicle.

Finally, a basic feature of this pig is its use of standard pig components, which have a proven track record both in terms of reliability and effectiveness:

- The wheel design has been used successfully for many years on inspection pigs.
- Disc seals are considered to be the most efficient for such pigging operations.

The suspension system has also been used on intelligent pigs but not in an interlinked way. This innovation allows the pig to remain on-centre in the 42" pipeline, thus optimising seal performance.

Testing of the Pig

The Statoil team responsible for designing and developing the 28” to 42” dual diameter pig has many years’ experience in dual diameter pig design and operation. This meant that the design phase of the project advanced extremely quickly and a prototype pig was manufactured.

Statoil have always supported the view that specialist pigs are best developed and proven at a full size testing facility, which can replicate the pipeline as far as is practically possible. Such a facility has been established at Kårstø where trials can be carried out in all seasons and weather.

The RFO pig was tested between January and June 1999 and it was successfully demonstrated that the pig would achieve the functional requirements as defined at the beginning of the project. This involved establishing a very fine balance in order that some conflicting aims could be achieved. For example:

- Achieving a low drive pressure in the 28" while maintaining an efficient seal in the 42" line.
- Keeping the 28" drive pressure low, whilst still allowing the pig to be reversed in the 28" pipeline if required.

However, a number of aspects such as the effect of long distance running on the seals and wheels were unproven. The information from the first RFO run was critical to the fine-tuning of the pig for the more important Dewatering run.

Field experience

Flooding, Cleaning and Gauging

The combined flooding, cleaning and gauging of the Åsgard pipeline was performed during October 1999.

Prior to launching the pigs a large slug of water was injected into the pipeline following by compressed air to create a cushion as the pigtrain would run fast down the first steep slopes out of the landfall. A batch of approximately 2km of water was injected between each of the 6 pigs in the train. The train was propelled at a nominal velocity of about 0.6 m/s and after about 18 days the pigtrain was received subsea at the ERB location.

Following retrieval of the subsea pigreciver, the pipeline was tied in to the ERB and the hydrostatic test was performed.

On recovery of the pigs, a detailed examination of the wheel modules and seals was performed:

<u>Seal Performance:</u> The following points were noted:

1. Wear on the seals was greater than predicted and also unevenly distributed along the periphery, with a chamfer of almost 35mm in some places. This was due to the sleeper discs being too close to the sealing discs and causing interference. It was also noted that this caused irregular buckling of the discs into the 28" pipeline.
2. As a result of the very good centralising along the pipeline, any scratching on the sealing surface was continuously renewed by the abrasion action of the seal on the pipe wall. The seal contact length remained at approximately 10mm and smooth. This was a very positive result.

3. It was evident that on some pigs, the sealing discs and sleeper discs had buckled during launch in the 42”. This never occurred during testing, and caused uneven wear as explained above.

Wheel Performance: All 96 wheels on the pig survived the full pipeline distance. However, on closer examination, the following points were noted:

1. 6 out of the 96 wheels had seized. In the others, excessive play in the bearing housing pointed towards a failure of the bearing. The mechanism is thought to have been corrosion of the steel bearings face as the lubricant was washed away. This eventually lead to contact and high wear between the wheel hub and the wheel spindle.
2. Most wheel tires were undamaged. The mould seam was even visible on some wheels! On the wheels that seized only small flats were visible. This was very encouraging.

The pigs were received and the subsequent pressure test showed that they had indeed performed well with a low percentage of air in the water during the test. The challenge to the Statoil pigging team was how to implement changes to the pig seals and wheels, in a short time frame without upsetting the fine balance achieved in the earlier testing. Following further testing the following changes were made:

1. All original sleeper discs were removed from the pig. At the rear, an additional 25mm seal was inserted, with a reduced diameter to avoid buckling and further spaced out behind the sealing disc.
2. Stainless steel bearing housings were used in the wheels in order to avoid the problems encountered previously. Additionally, water resistant grease was used in the wheel bearings.

All refurbishment, retesting and verification were performed in a 6-week window and the pigs were ready on 11th December 1999.

Dewatering

The 6 pig dewatering train was launched between the 13th December 1999 and the 16th December 1999.

Between the first three pigs, batches of approximately 215m of Glycol, (TEG), was injected. The train was launched and maintained at a velocity in the region below 0.2m/s.

After 40 days of the dewatering operation (requiring the injection of approx. 20 MSm3 of compressed air), the train arrived in the ERB pig receiver on 23rd January 2000. Radioactive isotope markers on each pig confirmed pig position as planned. The pig receiver will be recovered during the riser installation phase in May 2000. This will allow additional analysis and examination of the seals to take place.

Glycol samples were taken from each batch in order to evaluate the result of the dewatering operation. The last batch of glycol had a water content of less than 0.4%.

This is considered an excellent result. The normal condition in the pipeline during regular operation is expected to be 3-4% water in the glycol film on the pipewall.

As a conclusion the dewatering operation has been highly successfully and the dual diameter dewatering pigs have performed flawlessly.

Following dewatering, the pipeline air pressure will later be blown down. Nitrogen will be injected from the ERB and remaining air removed from onshore through a vacuum operation in preparation for gas filling.

The inspection pig

Background

In 1993 Statoil embarked on a market study, to determine what was available for corrosion monitoring on Statoil’s pipelines. The market study recommended a development program for an inspection tool that could meet Statoil’s operational requirements for corrosion monitoring. The existing inspection tools available in the market could not comply with this a specification. It was, therefore, decided by Statoil to start a development program, over a two-year period, in collaboration with Pipetronix. The development program resulted in the inspection tool known as the MagneScan XHR. The stringent pre-set specification was achieved in 1996. Statoil as the operator of the Åsgard field has the same requirements for the inspection of the Åsgard Transport pipeline as for on any of its other pipelines.

The challenge

The challenge was to design an inspection tool with the same basic capabilities as a single diameter MagneScan XHR (about 6-meter length and with the weight of about 6 ton) that could still negotiate a 28” 5D bend safely. In addition the tool must be stable enough to travel safely in the 42” main line. The scope of the development was split into several activities with 3 major goals. Firstly the tool had to travel the distance safely and reliably. Secondly, the tool had to produce reliable magnetic signal in order to meet the XHR specification in both diameters, and finally the tool had to collect and store the vast amount of data from the 710 km run.

Driving module

The diameter difference between a 28” and a 42” pipeline is quite significant, and based on the best marked intelligence none of the inspection companies had ever challenged such a diameter large difference. Several companies have run tools with marginally, different diameters, but was usually achieved by modifying existing tools. After evaluating a large amount of innovative ideas, the decision was made to proceed with a concept based upon mechanically sprung-arms, flexible but strong sealing membranes, between the arms, and a central body of the driving unit.
The challenges with the mechanical suspension system included the optimisation of strength, weight and size. Components such as wheels, springs and arms to support the tool all posed there own special problems as they had to be small enough to

travel smoothly through the 28” 5D bend and yet strong enough to provide stability while being able to withstand the forces in the 42” pipe.
The driving function of a standard pig is achieved by the use of a very rigid cup, that encompasses the ability to allow for significant wear, without losing its sealing capability even over very long runs in uncoated pipe. Investigations showed that this concept was not suitable for this project as this type of cups had limited ability to fold down from 42” to 28”. In order to obtain the required folding, of the sealing element, a much thinner disc was investigated, however, this disc would need additional support to ensure expansion as well as provide proper sealing against the pipe wall. The final decision was to mould a specially designed polyurethane support disk that was strong enough to propel the tool, but of such a shape that it was still capable of folding down to fit in the 28”. Figures 4 and 5 shows the driving module in 28” and 42” configuration.

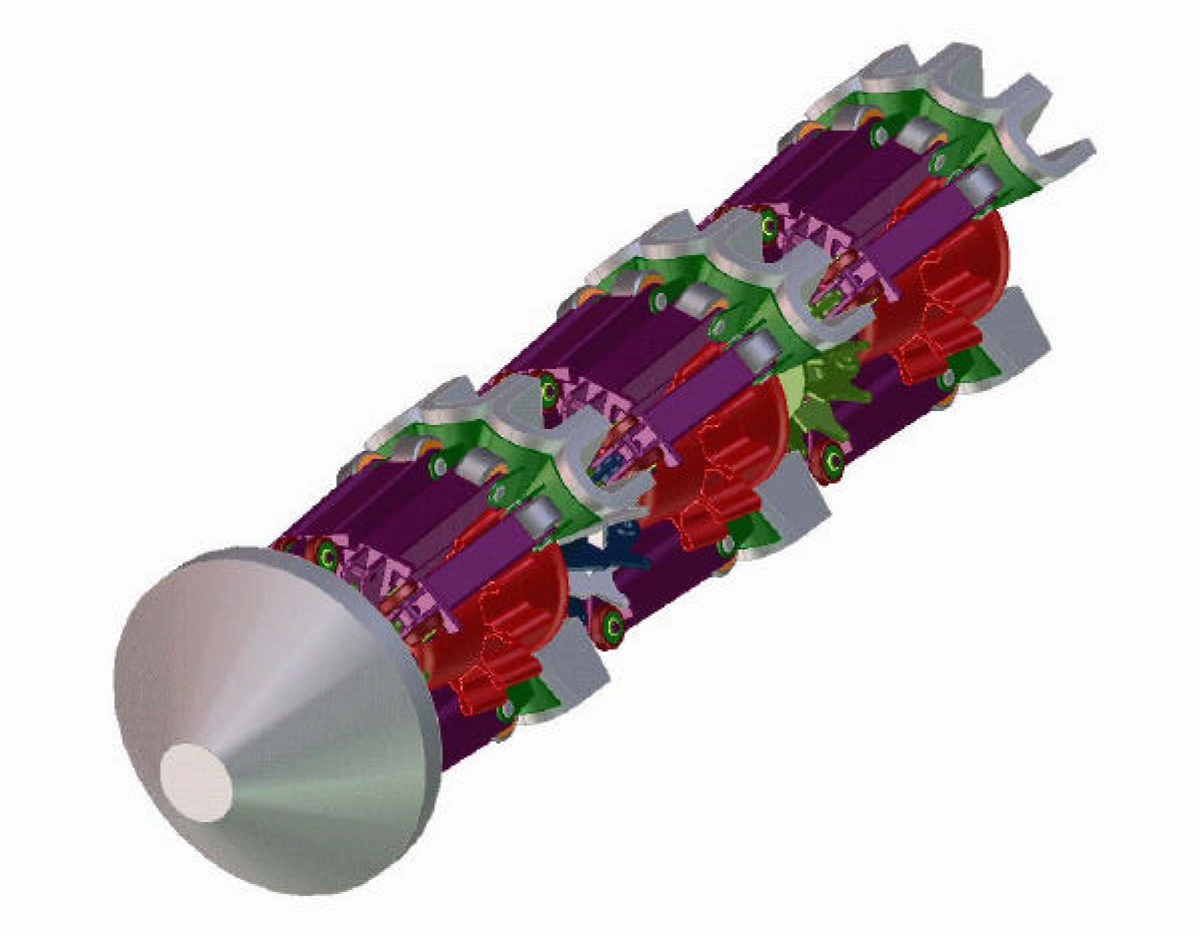

Figure 4

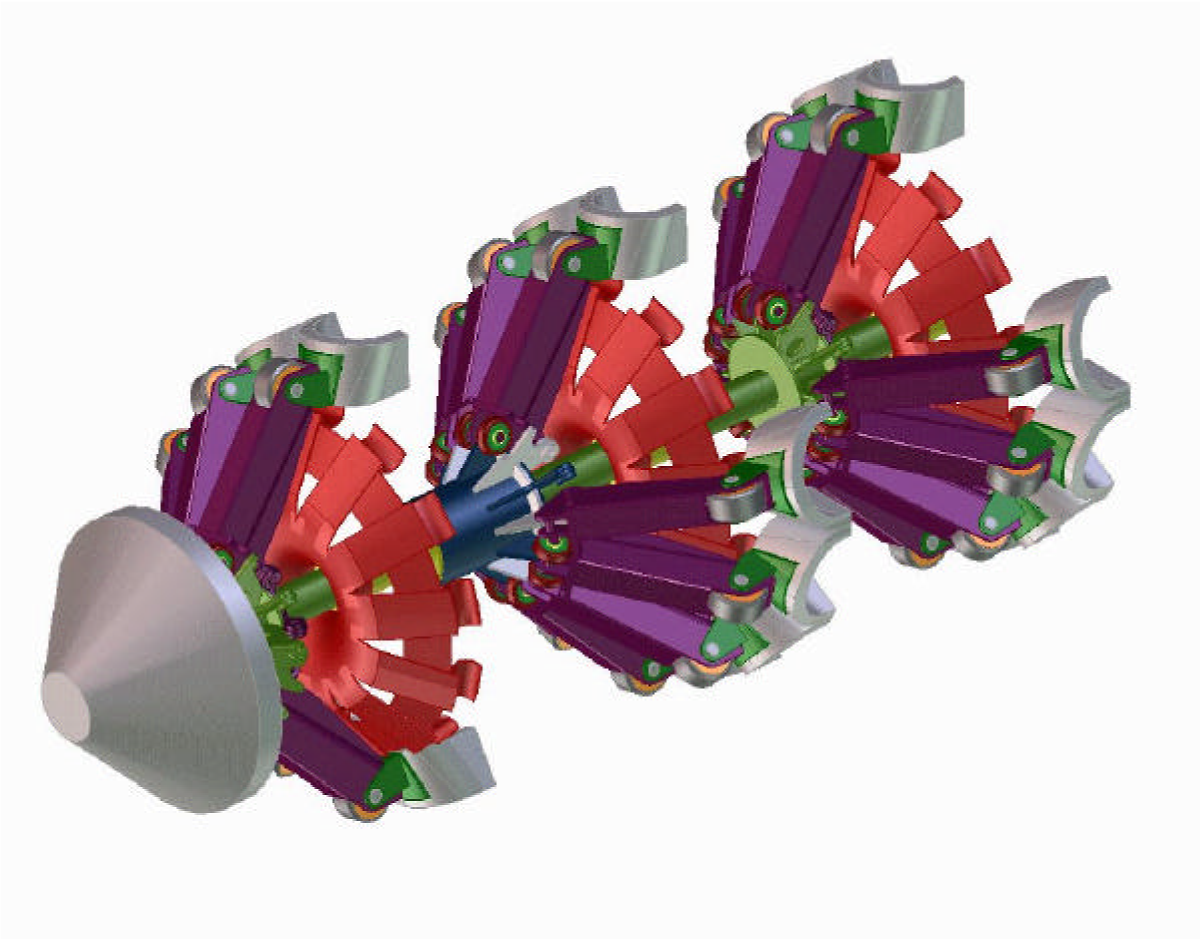

Figure 5

Magnetiser module

During the development of the single diameter MagneScan XHR tool fleet a significant amount of “know-how” was gained in regards to inspection technology. The improvements in terms of detectability and accuracy were achieved by increasing and enhancing the magnetic circuit of the tools combined with higher sensor resolution. The results were by industry standard, a relatively large and heavy tool. To combine the mechanical features with the magnetic in such a way as to enable the tool to travel through both the 28” and the 42” section of the Åsgard Transport and inspect both pipe sizes was a major challenge. The first concept prototype was designed on the basis of having a two unit magnetic section in the 28” mode. The two sections would then come together as one section inside the pipe after passing the transition spool. The coupling process would be accomplished by using a combination of magnetic forces and the towing forces provided by the gas flow. Figures 6 shows the magnetiser module in the 42” configuration.

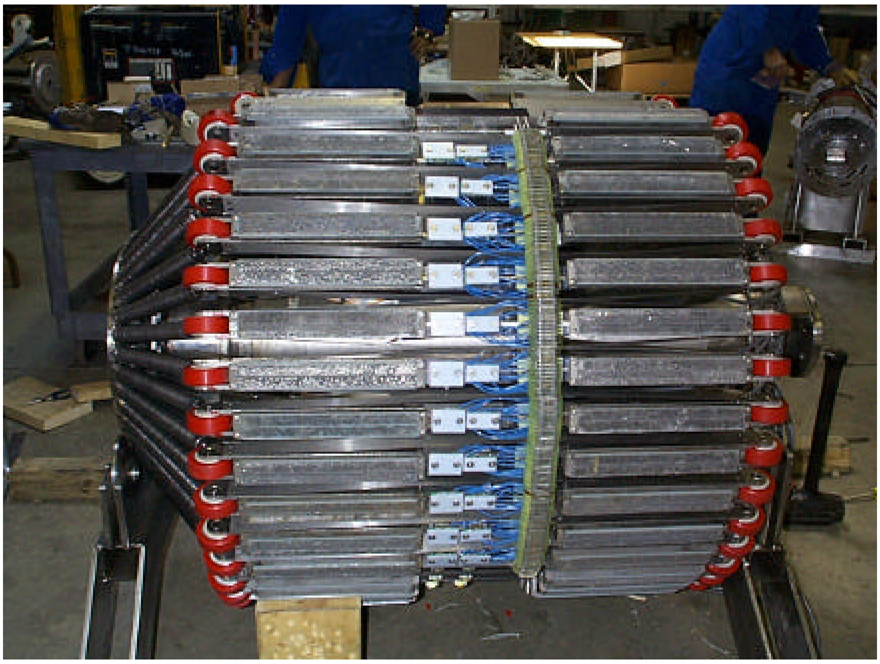

Figure 6.

By using this approach an almost standard magnetic circuit design was maintained as far as mechanical design was concerned. The use of an advanced computer program simulation for the magnetic circuit was a key element allowing an increase the magnetic power and efficiency that far exceeded prior tools. Furthermore, the uses of a high performance magnetic material both the size and mass of the sensing section were subsequently reduced.

The most significant achievement of this development program is the capability to meet the detection and sizing specification of the MagneScan XHR in both the 28" and 42" pipeline and do all this in a single run.

Data acquisition

When designing the data acquisition system for a 28"/42" Multi Diameter Pipeline Inspection Tool, that had to meet the XHR defect specification it presented a unique set of challenges that had to be dealt with.
In order to keep the tool both short and light it was essential to design the electronics in such a way that both power consumption as well as space requirements were minimised.
In addition the data acquisition system had to be fast enough to be able to gather data via more than 1000 Hall sensors, compress the data, add auxiliary data like distance, orientation, pressure all stored on mass storage devices and processed in real-time.
Based on the requirements stated above it was necessary to redesign the existing electronics of the XHR tool and design a new front end electronic. The major requirement for the new front end electronic was to be able to do as much data processing as was possible considering the limited space available on the sensor-carrying magnet bars. Due to the limited space the front-end electronics are therefore housed in the immediate proximity of the sensors. The data on the output of the front-end electronics is in a digital, serial format. this minimises the need for

analogue data transmission over long distances and thus reduces the number of electrical connections required between the different tool modules. The Short analogue data-transfer distances are a major contributing factor a high data quality.
Considering the time and cost for reruns, especially in offshore pipelines, reliability is of high importance. To minimise the risk of data loss during inspection runs due to caused vibration and shock the very latest Solid State drive technology has been utilised for storage of the data.
The combination of the re-design, described above, and the utilisation of a new generation of Hall sensors, the power consumption of the data acquisition system in the 28"/42" Multi Diameter Pipeline Inspection Tool, was reduced by almost 40% compared to the electronics used in the existing XHR tool fleet.
Furthermore it was possible to boost the performance of the electronics to be able to process over 1000 sensors with a sampling rate of 2000 Hz which ultimately will lead to a higher active tool speed.
One major design of the electronics aim was to have it designed in modules which allow for easy adaptation of the electronics for use in other tools with different size ranges and even less space available.

Results

General

The first prototype was a dual diameter tool for 28” / 42” and it was successful tested in Norway during October 1997 for mechanical fitness. The important milestones were the expansion of the magnetiser, the meshing of the two magnetic arrays and the ability to seal in both the straight pipes and within 5D bends. The Åsgard partners approved the concept later in the autumn 1997. Later individual components and details has been designed and undergone extensive qualification tests.

Driving module

All possibilities were explored to determine what design changes were necessary to make the dual diameter-driving unit into a true multidiameter-driving unit. All parties saw the benefit of being able to accommodate more than two different pipe diameters in one run, or being able to both expand and contract in the same run. Several of the parameters of the prototype were changed and the design group came up with a new true multidiameter-driving concept, which is capable of unlimited expansion and contraction between 28” and 42”.

The principles used for the expanding arms on the driving- unit, were implemented on the battery and electronic vessels.

Magnetiser module

The major challenge in the move from dual diameter tool to multi diameter tool was the magnetic unit. The already tested meshing concept was rejected due to major complications in the de-meshing phase the special based on design for only two pipe sizes.

A new concept was introduced. this concept used smaller and stronger magnet bars that did not compromise their magnetic strength due to their reduced size. The magnetic bar had to be strong enough to achieve a satisfactory magnetic flux level in the 42” pipe and yet small enough to compress into a 28” bend. In addition the tool would have to compensate for the effects of over saturation of flux in the 28” pipe wall. A theoretical study was performed as well as tests. Results showed that the chosen principle was feasible. A prototype was therefore built. The test results were so encouraging that based on them the multi diameter magnetiser was built.

Testing

All individual components has been extensively tested and qualified. The complete tool will be assembled during early year 2000, and further tested during precommissioning of the Åsgard onshore pipeline.

Conclusion

Multi diameter pigs for the 28”/42” Åsgard Transport Pipeline has successfully been developed, tested and used during precommissioning of the pipeline.

The Åsgard Pipeline Project is the very first to conceive design based on the multi diameter technology. It is hoped that the pipeline industry, in general, will see the need and the value of this technology, which may enable them to reduce construction and operation cost. With the new technology the operator may reduce the size of his sub sea structures for sub sea launching of a pigs into large diameter pipelines.

A multidiameter tool with the ability to travel through a long flexible riser starting at a floating production facility going down to the seabed, may be the ultimate use of this technology, eliminating complex subsea pigging operations.

Acknowledgement

First of all acknowledgement should go to the partners of the Åsgard Transportation Project for their support to Statoil's proposal for developing this technology.

Secondly to the Statoil pig development team and all external companies and organisations that have contributed to the successful pig development programme.