Catalogue of

Master's Thesis Proposals

By Subsea 7 Norway AS

Contents

Introduction

The following catalogue contains a series of Master Thesis proposals from Subsae7. Subsea7 may have other proposals that are not identified in the catalogue and Subsea7 is also interested to collaborate with students on topics proposed by students. Please find guidance on the last page on the typical process to engage with Subsea7 for a Master Thesis.

Cooling water for pre-commissioning operations of subsea field developments

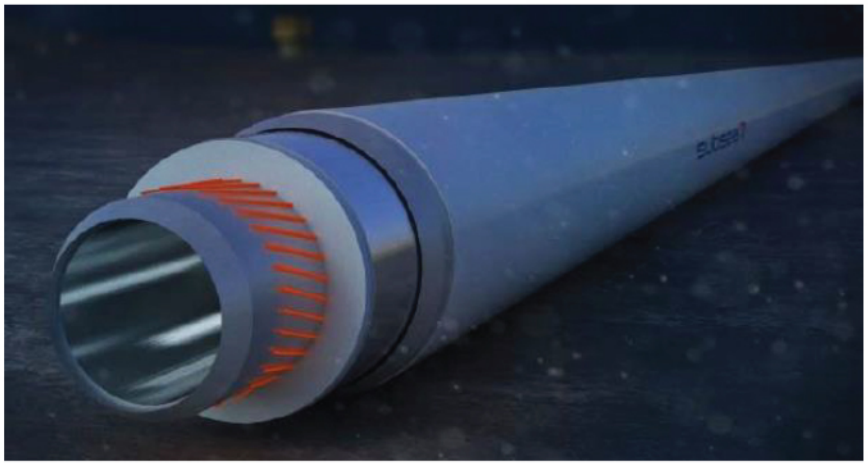
Aimed at: Marine technology, Petroleum technology students.

Purpose: The increasing amount of subsea field developments at deeper water and arctic environment has lead to requirements of higher insulated pipelines with low U-value. High insulated pipelines have resulted in challenges related to achieving stable temperature when performing subsea pressure test of the pipelines.

When a new subsea field development is pre-commissioned prior to start-up of the field, the pipelines are flooded with water and then pressure tested. Due to the temperature difference between the filling water and the seawater at seabed, a temperature stabilization time between the flooding operations and pressure test is required. A pressure test with an acceptable pressure drop within criteria is not possible to achieve if the temperature of the pipeline fluid is not stable.

The acceptance criteria of the pipeline pressure test is highly affected by the temperature of the fluid inside the pipeline. Since reducing time between flooding operations and pressure test is not always an option, a method to cool the pumping medium on the vessel deck during pipeline flooding has been considered.

The purpose of this thesis is to assess the methodology of cooling water on the vessel deck with a cooling device while pumping water into the subsea flowline.



Main activities: The contents for the thesis:

- Thorough review of the theory behind heat transfer of water
- Evaluation of different methodologies to cool water based on theory of water heat transfer
- Evaluation of cooling capacity vs flowrate, energy consumption and number of cooling units required
- Outline of design of the cooling system

Contact Person: Andreas Torstensen – Andreas.Torstensen@Subsea7.com

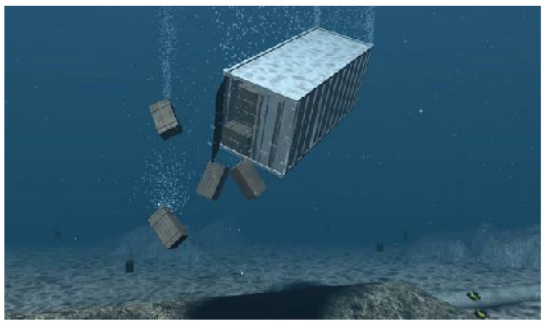
Theory: ☒ ☒☐ Experimental work: ☒ ☒☐ Computer modelling: ☒ ☐☐

An evaluation of the hydrodynamic effect on dropped object impact energy dissipation of subsea protection structures

Aimed at: students from Marine Technology, Ocean Engineering or similar.

Purpose: Recently the industry has seen challenging high dropped object impact energy requirement from offshore platform tie-back projects. The conventional protection cover design simplifies the impact event excluding the hydrodynamic effect from the surrounding water, i.e. added mass and hydrodynamic damping effects. This design approach is assumed to be on the conservative side as the impact energy absorbed by the surrounding seawater is ignored and the GRP or steel material has to absorb the full impact energy. The conventional approach works fine with low impact energy up to around 300kJ. However, for a much higher impact energy requirement around an offshore platform (typically from 500kJ to 1500kJ), this approach may result in unrealistic design with GRP or steel material.

It is believed that the surrounding water will absorb a certain amount of kinetic impact energy during an impact event. As a potential improvement of the protection cover design, the energy transferred to the surrounding water needs to be investigated using both experimental and analytical/computational methodologies. It is expected that with the hydrodynamic effect included in the impact analysis, the protection cover design can be optimized with reasonable proportion and consequently, can be built with a lower cost.



Main activities:
The following tasks are proposed for the Master thesis:

- To perform thorough literature review with regards to underwater dropped object impact related research.
- To establish a test program which can measure the hydrodynamic effects on the dropped object impact energy.
- To perform physical model test.
- To perform analytical/computational analysis to simulate the underwater impact problem.
- To benchmark the analysis results against the test results.
- To propose a practical approach to implement the hydrodynamic effect in the protection cover design.

Due to the complexity involved in this proposal, the activities may be split into two Master thesis with one focusing on the experimental side while the other focusing on the analytical/computational side.

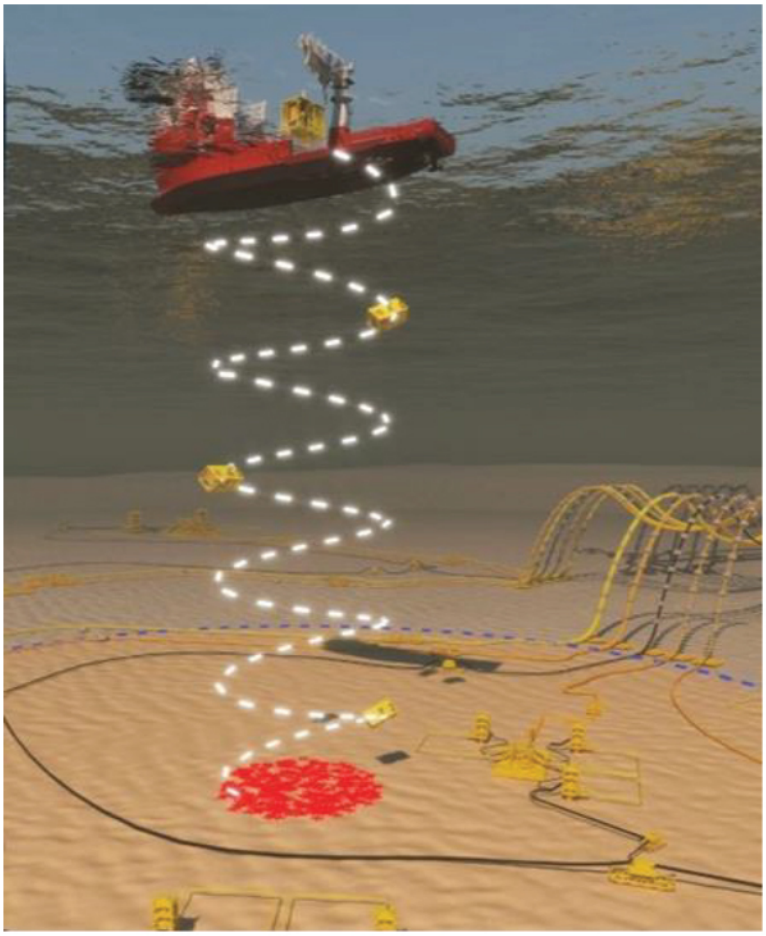
Contact Person: Petter Moen – petter.moen@subsea7.com

Theory: ☒ ☒☒ Experimental work: ☒ ☒☒ Computer modelling: ☒ ☒☒

FE Analysis, Interaction of Container dropped on Steel cover

Aimed at: Civil, structural or mechanical students.

Purpose: Traditionally structural integrity against dropped object impact has been assessed by the protection structure's ability to sustain the impact energy alone. However, the falling object will also deform at impact, as such the impact energy will be shared between the dropped object and the protection structure. In addition, the kinetic energy may be absorbed by object rotational behavior.



FE analysis of dropped object impact is challenging because of the complexity related to material/contact nonlinearity, large deformation and time dependency. In general, there are two different analyses that can be performed for dropped object impact; implicit analysis and explicit analysis. Implicit analysis is normally used for analysis performed over a longer time- interval (typical in seconds) and explicit analysis for very small time-intervals (typical in milliseconds).

Normally explicit analysis would be the safe choice for a dropped object analysis, even though it can be computational expensive. Implicit analysis can be performed using very small time-steps.

Main activities:
The work is proposed split in the following parts:

- Establish a model of a "standard" steel cover
- Perform analysis of an impact on cover
- Include deformable dropped object, and assess energy distribution
- Optional, assess if overutilized (strain based) steel can be removed during analysis as impact is being absorbed
- Provide a detailed explanation of a dropped object FE analysis using explicit or implicit analysis in ANSYS Workbench
- Highlight what is important to inspect in the results and discuss weaknesses and further work for this method.

The Master thesis will evaluate the pros and cons of Explicit and Implicit analysis of a dropped object impact, and eventually propose one analysis type which fits better the nature of the dropped object impact.

Contact Person: Karl Erik Suphellen - Karlerik.suphellen@subsea7.com

Theory: ☒ ☒☐ Experimental work: ☐ ☐☐ Computer modelling: ☒ ☒☒

Development a software for pressure drop calculations of steady flows

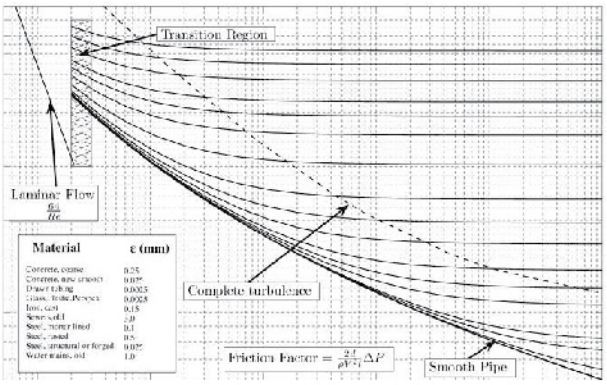
Aimed at: Marine technology, Petroleum technology students.

Purpose: In order to calculate the pressure drop of an overall system, the losses in all the different elements that impacts pressure drops need to be assessed (valves, strainers, flow meters, couplings, fittings, bends, and tubing…)

For systems with relatively long pipeline sections, it is often the case that fitting or other element losses will be minor in relation to the overall pressure loss in the pipeline. However, some local losses such as those produced by a part open valve are often very significant and can never be disregard, and these must always be included.

The loss that a specific pipe fitting or element introduces has been empirical measured and this is then analyzed to determine a local loss coefficient that can be used to calculate the fitting loss as it varies with the velocity of the fluid passing through it.

The purpose of this thesis is to develop and routine/software to make it easy and automatically assess all the local losses in the system to study.



Main activities: The contents for the thesis:

- Thorough review of the theory behind the pressure drops in steady flows
- Develop a routine/interface to identify list all the parameters and system components. Create an internal library with typical elements from a piping system.
- Develop the script implementing the calculation methodology
- Benchmark the results against a commercial software (OLGA/PIPESIM/LEDAFLOW).

Contact Person: Miguel Loira – miguelalvarez.loira@subsea7.com

Theory: ☒ ☒☐ Experimental work: ☐ ☐☐ Computer modelling: ☒ ☒☒

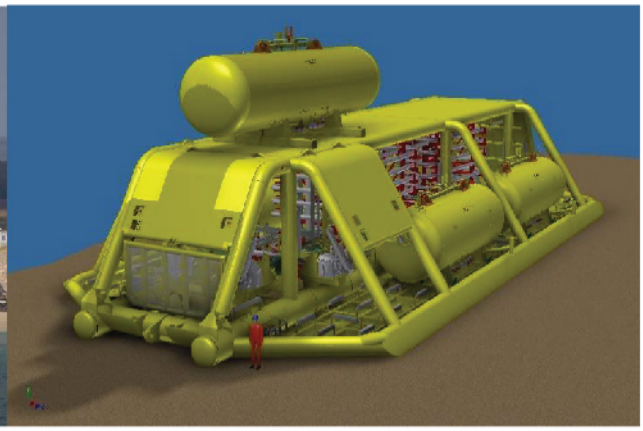
Comparison between PLAXIS 3D and OptumG3

Aimed at: Geotechnical or Civil master students.

Purpose: A new software is available for determination of ultimate capacity of foundations with use of lower and upper bound finite element limit analysis (FELA) in 3D, OptumG3. The conventional approach is the use of finite element analysis where the full load displacement curve is determined to assess the ultimate capacity.

Subsea7 have on some occasions experienced large discrepancies between PLAXIS 3D and OptumG3 for torsional loaded foundations on sand and sand overlaying very soft clay.

The purpose of the thesis is to assess the foundations, understand the numerical background of both PLAXIS 3D and OptumG3 and determine the origin of the differences in ultimate capacity.



Main activities: The project will contribute to the best practice engineering at Subsea 7 to choose the tool with best accuracy to determine ultimate capacity. The contents for the thesis:

- Description of the cases analyzed
- Thorough review of the theory behind PLAXIS 3D and OptumG3.
- Sensitivity study of the cases in PLAXIS 3D and OptumG3
- Determined the origin of the difference between the software packages.

Contact Person: Christian Olsen - Christian.LindeOlsen@Subsea7.com

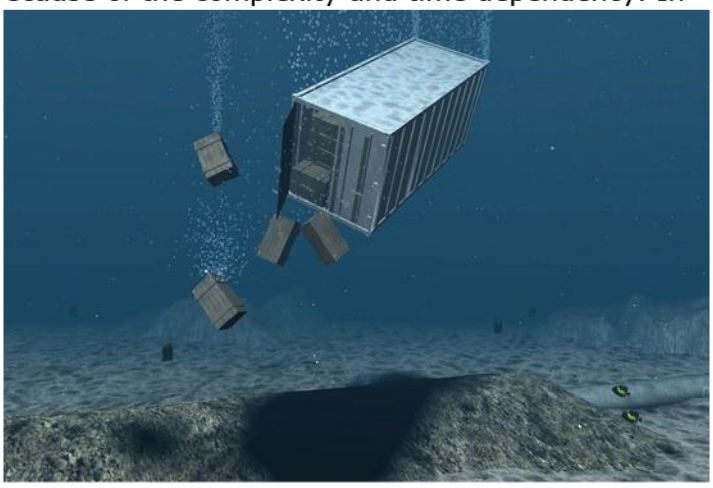
Theory: ☒ ☒☐ Experimental work: ☐ ☐☐ Computer modelling: ☒ ☒☒

Dropped Object FE Analysis Method on GRP using Ansys

Aimed at: Civil, structural or mechanical students.

Purpose: Traditionally structural integrity against dropped object loads have been proven through component testing (dropped object tests). In general, dropped object tests give a very rough conclusion, either the test specimen failed or not failed. It is also challenging to measure deformation and evaluate the severity of the damage (e.g. number of failed layers). In addition the test setup can have a big impact of the final result, like testing with or without water, size of water pool, distance between supports, test specimen geometry, etc.

FE analysis of dropped object is challenging because of the complexity and time dependency. In general, there are two different analyses that can be performed for dropped object; transient analysis and explicit analysis. Transient analysis is normally used for analysis performed over a longer time interval (typical in seconds) and explicit analysis for very small time intervals (typical in milliseconds).



Normally explicit analysis would be the safe choice for a dropped object analysis, even though it can be computational expensive. However, for GRP analyses with shell elements the explicit analysis gives unrealistic poor results when including material damage properties. Instead, transient analysis can be performed using very small time steps.

Structural analysis in Ansys does not have the means to include the water damping effect by itself without combining it with complicated hydrodynamic analysis. However, it is possible to create snippets (scripts) to add this effect by simplified formulas/methods.

Main activities:
The work is proposed split in the following parts:

- Perform material testing to validate GRP behavior/damage during excessive loading
- Establish material model based on the tests
- set up a transient analysis where material damage and water damping effect are included
- provide a detailed explanation of a dropped object FE analysis using transient analysis in ANSYS Workbench
- Perform testing of impact proven numerical compliance
- Description of what is important to inspect in the results and discuss weaknesses and further work for this simplified method.

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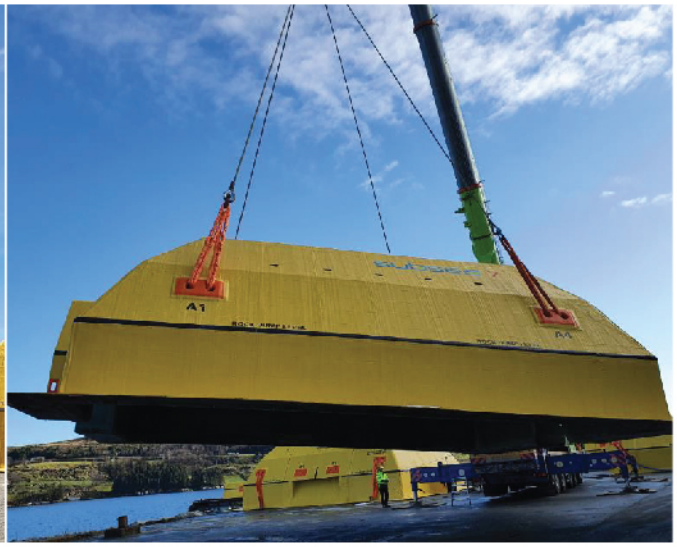
Theory: ☐ ☒☐ Experimental work: ☒ ☐☐ Computer modelling: ☒ ☒☐

Suction effect of skirted mud mat under wave loads

Aimed at: Civil, Geotechnical or Marine technology students.

Purpose:
Glass Fiber Reinforced (GRP) covers are used to protect subsea infrastructure. At water depth in excess of ~120 m, the trawl loads are governing. In water depths shallower than ~100 m, the temporary case before the GRP cover is protected by rock gravel the wave load with a 1 year return period is governing. The shallower the water, the more ballast is required to keep the GRP cover in place in the temporary scenario.

The soil condition is nearly always sand and in the short duration of the wave load, then the "friction" from the water flow through the sand will temporarily create a vacuum. This vacuum will hold the GRP cover in place and help to reduce the ballast.



The purpose of this thesis is to quantify the effect of the suction for the duration of a wave load and what effect will a perimeter skirt have on the suction. How much ballast can be saved when taking the suction forces into account.

It is estimated that this problem is best solved in a wave laboratory. The thesis is considered complex and may need to be broken down into smaller problems.

For the geotechnical engineer, it is possible that some software can determine the short time effect of the wave load if the pore water flow can be accurately assessed.

Main activities:
- Establish the basic theory behind water flow in sand and the wave loads on structures on the seabed
- FE analysis to be used to quantify the anticipated suction force
- Establish a laboratory program to model the problem
- Comparison of results from the FE and laboratory models

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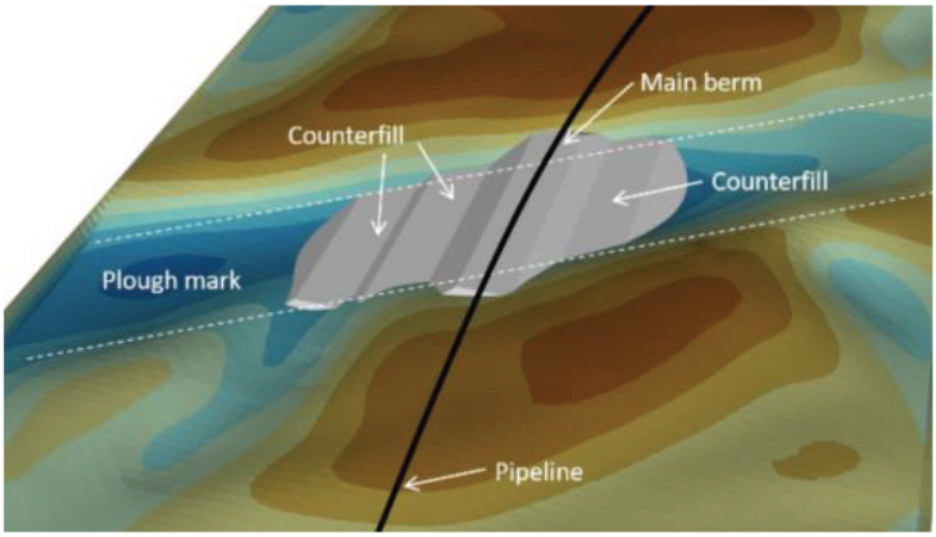
Theory: ☒ ☐☐ Experimental work: ☒ ☒☒ Computer modelling: ☒ ☒☒

Comparison of advanced 2D and 3D slope stability

Aimed at: Geotechnical or Civil master students.

Purpose: Subsea7 install between 250.000 tons – 1.000.000 tons of rock gravel each year to support pipelines, protect structures from trawl and prevent ubheaval buckling of pipelines. Often these rock berms are installed on steep seabed slopes on top of extremely soft clay. To prevent slope failure, large volumes of counterfill may be required to support the "main rock berm", see the Figure below.



The stability of the counterfill is often assessed with a series of 2D cross profiles in limit equilibrium software or FEA. Given that not all possible 2D cross profiles are assessed there is a risk that a governing cross profile is missed. Futher, there may be some 3D effects that decrease or increase the capacity. The purpose of this proposal is to compare a series of rock berm design completed in a 2D cross section approach to a full 3D design. The intent is to determine the accuracy fo the 2D cross profile design.

Main activities:
The work is proposed split in the following parts:

- Complete 2D design of 3 rock berms provided by Subsea7
- Complete a 3D design of the 3 berms
- Compare the results and determine if there are discrepancies

The 2D design may be sovled with use of the Subsea7 and OptumCE developed software Au2Rox, see Stability of seabed slopes - Automated design using OPTUM GX - YouTube.
Theory required for this thesis is limit equilibrium, limit analysis and advance numerical modelling.

Contact Person: Christian Olsen - Christian.LindeOlsen@Subsea7.com

Theory: ☒ ☒☒ Experimental work:☐ ☐☐ Computer modelling: ☒ ☒☒

Increase in strength along suction pile skirts over time

Aimed at: Geotechnical or Civil master students.

Purpose: Subsea7 has recovered a series of suction piles after 6 years in place. On these suction piles, a ~10 cm thick clay layer was recovered on the skirts. This layer increased the weight of the suction pile with 30-50%. This increase in weight could cause the total weight to exceed the vessel crane capacity and the campaign could have to be aborted and a larger vessel sent instead. The cost for a new campaign will easily exceed £1.000.000.

The purpose of this thesis is to make a model that can predict the thickness of the clay layer as a function of time.

Main activities:
The work is proposed split in the following parts:

- Description of the offshore observations
- Thorough review of literature
- Performed analysis in software such as PLAXIS or Optum CE to predict the thickness of the layer. This should be supported with conventional consolidation and thixotropy assessment.
- Determined a method to predict the thickness of clay on suction piles when recovered as a function of time.
- Alternative – the problem could be modelled in the geotechnical laboratory.

For further info, see https://www.youtube.com/watch?v=eh0FFRNOM_s after ~14 min.

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Theory: ☒ ☒☒ Experimental work: ☐ ☐☐ Computer modelling: ☒ ☒☒

Dynamic analysis of a pig train with or without by-pass in a pipeline system under single phase flow conditions.

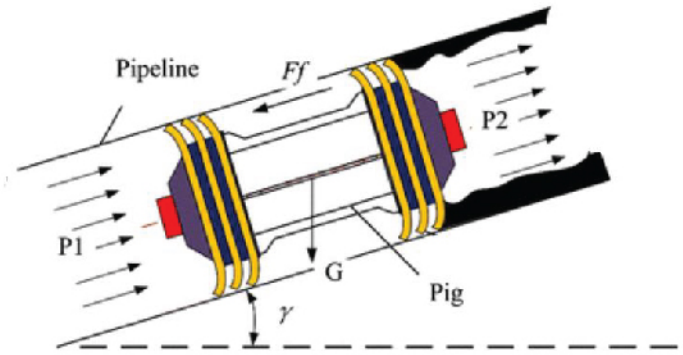
Aimed at: Marine technology, Petroleum technology students.

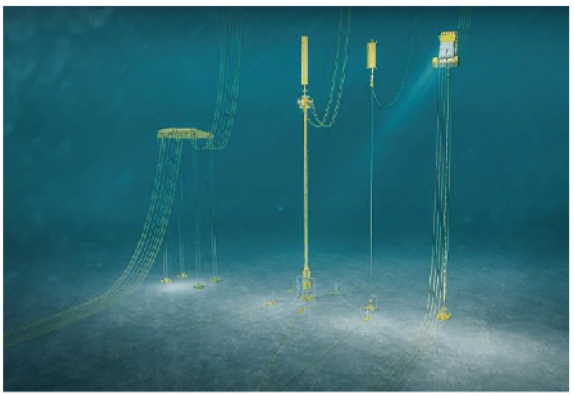
Purpose: The derivation and solution of the equations for a pig train in a pipeline system assuming single phase flow of either oil or gas is the main aim of this work. The solution of the equations should contain pig position, pig velocity and forces acting on a pig at any point of time.

Some additional information:

- Mass, momentum, and possibly energy equations might be required to study pig motion.
- The simulation results comparison with a commercial software show that the derived equations are valid and effective for online estimating of the position, velocity and forces acting on the pigs at any time of its motion.
- Preferable language for coding the equations is Python.

Pig speed control on pig runs is critical. The purpose of this thesis is to develop a script /software to simulate the pig train run and identify forces and accelerations working on the pig train in the system. This will be input for pig design and methodology/operations design of the pre-commissioning and commissioning operations. The simulation of speed controller of a pig by using a bypass port in pig is part of this work.





Main activities: The contents for the thesis:

- Thorough review of the theory behind the mechanics of the pig in the pipeline system and energy equations for fluid. Single phase fluids: liquid or gas. *NOTE1*
- Develop a routine/interface to identify and list all the parameters and system components. Create an internal library with typical elements from a piping system.
- Develop physical-mathematical model of the pig motion. Optionally, the model should be able to handle start/stop events.
- Develop the script to solve the model. Create an internal library for different pigs types.
- Benchmark the results against a commercial software (OLGA/LEDAFLOW).

NOTE1: in some cases, the pipeline system requires to be dewatered with a pig train propelled by gas. The simulation shall account for this type problems.

Contact Persons:
Miguel Loira – miguelalvarez.loira@subsea7.com
Yuri Novoseltsev – yurivladimirovic.novoseltsev@subsea7.com

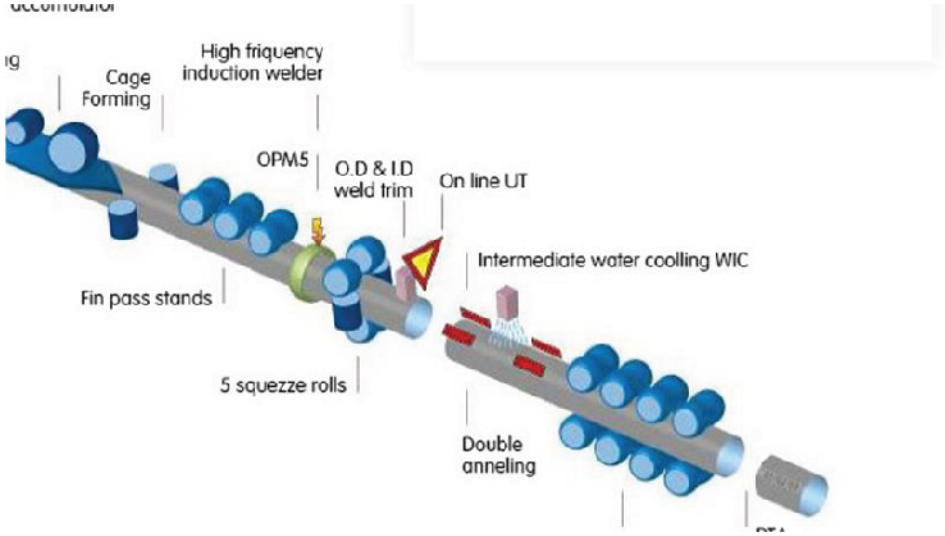
Theory: ☒☒☐ Experimental work: ☒☐☐ Computer modelling: ☒☒☒

Local brittle zones in TMCP pipe

Aimed at: Materials Engineering/Science Students.

Purpose:
For making carbon steel large diameter pipe, the starting material is often thermomechanical rolled accelerated cooled plate (TMCP). The plate may be used to form pipe by bending single plates by the UOE method followed by making a longitudinal submerged arc (SAW) weld to join the plate edges. This method makes single pipes one after the other. The plate may be continuous on a coil used for making High frequency welded pipe (HFI), which is made by rolling steel coil into pipe and making an electrical resistance weld where the edges of the coil material meet. This is a continuous process where the produced pipe is cut at the end of the process in order to make single pipe lengths.

When TMCP material is welded by conventional methods, local brittle zones are sometimes found in the heat affected zone (HAZ), and these zones may cause poor toughness results during fracture mechanics testing (CTOD). This is a potential issue for reeling installation of pipelines where the pipe is plastically deformed during installation.



HFI pipe manufacturing (Corinth pipeworks)

Main activities:

- Literature study on characteristics of LBZ in TMCP pipeline steel.
- Characterization of HAZ microstructures, general and any local brittle zones
- Methods: Light microscope, Scanning Electron Microscope

Contact Person : Inge Andre Omundsen - IngeAndre.Omundsen@subsea7.com

Theory: ☒ ☒☐ Experimental work: ☒☒☒ Computer modelling: ☐☐☐

Effect of uncoated field joints on cathodic disbondment of FBE tails in the water injection pipelines

Aimed at: Materials Engineering/Science Students.

Purpose:
Water injection flowlines are typically constructed with polyolefin liners to prevent internal corrosion of the steel pipe and aid fluid flow.

Factory coating, typically fusion bonded epoxy with solid PP, is applied to pipe joints length of about 12 m, whereas compatible field joint coatings are applied welding the 12m joints together to form pipeline stalks (section of pipelines about 1-1.5 km long).
This is followed by the insertion of the olefin liners in the stalks. The pipeline is then fabricated by welding together (tying-in) the pipeline stalks.
During the latter operation, tie-in field joint coatings are invariably impossible to apply awing to the temperature involved in the process. This temperature is an order of magnitude higher than the heat distortion temperature of the olefinic liner.

The general practice is to leave the tie-ins uncoated and ensure the bare steel is protection against corrosion by installing sacrificial anodes to the pipeline.

There is however strong objections with this practice as the anti-corrosion coating at the tie-in is said to disbond under the influence of cathodic current supplier by the sacrificial anodes.
The purpose of this study is therefore to verify whether such disbondment does indeed take place and if so, to what extent.

Main activities:

- Find definitive proof that coating disbond factory coating as a result of cathodic current
- Establish the extend of such disbondment
- Suggest ways of preventing such disbondment

Contact Person: Papi Mbikay – papi.mbikay@subsea7.com

Theory: ☒ ☒☐ Experimental work: ☒☒☒ Computer modelling: ☐☐☐

Cathodic Disbondment Behaviour of two-parts components epoxy Vs Fusion bonded epoxy used in marine coatings of pipelines

Aimed at: Materials Engineering/Science Students.

Purpose:
Water injection flowlines are typically constructed with polyolefin liners to prevent internal corrosion of the steel pipe and aid fluid flow.

Factory coating typically fusion bonded epoxy with solid PP, is applied to pipe joints length of about 12 m, whereas compatible field joint coatings are applied welding the 12m joints together to form pipeline stalks (section of pipelines about 1-1.5 km long).

This is followed by the insertion of the olefin liners in the stalks. The pipeline is then fabricated by welding together (tying-in) the pipeline stalks.
During the latter operation, tie-in field joint coatings are invariably impossible to apply awing to the temperature involved in the process. This temperature is an order of magnitude higher than the heat distortion temperature of the olefinic liner.

The general practice is to leave the tie-ins uncoated and ensure the bare steel is protection against corrosion by installing sacrificial anodes to the pipeline.

There is however strong objections with this practice as the anti-corrosion coating at the tie-in is said to disbond under the influence of cathodic current supplier by the sacrificial anodes.
The purpose of this study is to investigate the use of 2-components epoxy as substitute for FBE as anti-corrosion coating for stalk tie-ins.

Main activities:

- Collaborate with industry partners to obtain 2-component exposed coated specimen
- Based on industry practice, investigate cathodic disbondment behavior of 2-component epoxy
- Research existing data on cathodic disbondment of FBE as part of 3LPP or 3LPE and compare these to result generated on 2-components epoxy

Contact Person: Papi Mbikay – papi.mbikay@subsea7.com

Theory: ☒ ☒☐ Experimental work: ☒☒☒ Computer modelling: ☐☐☐

Properties of cold deformed Super Duplex bends

Aimed at: Materials Engineering/Science Students.

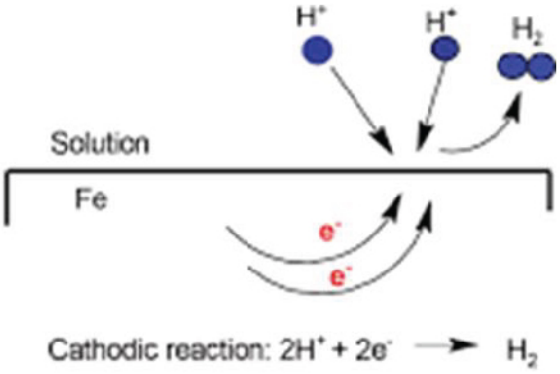
Purpose:
Super Duplex pipe bends are made by induction heating and bending pipe followed by solution annealing heat treatment in a furnace. The solution annealing takes place at a high temperature (~1100°C), and the risk for heat distortion is high if the bend is not supported very thoroughly in the furnace.

This distortion may be corrected by cold deformation of the bend. The effect of this cold deformation on the properties of the material is not fully understood and could potentially affect the suitability of the bend for future service.

The cold deformation may affect the mechanical properties and may as a worst case also affect the resistance to Hydrogen Induced Stress Cracking (HISC).

HISC is a risk for subsea components because they are protected from corrosion by sacrificial anodes. The sacrificial anodes cause a negative potential on the surface of the surface of the protected steel, this causes Hydrogen to be formed on the steel surface and some of this Hydrogen is absorbed into the steel causing embrittlement.

Bend during heat treatment



Cathodic Hydrogen reaction

Main activities:

- Literature study on properties of cold deformed Super Duplex steel and HISC
- Mechanical testing of Super Duplex steel (hardness, tensile, microstructural) before and after cold deformation. A range of cold deformation levels should be tested

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Theory: ☒ ☒☐ Experimental work: ☒☒☒ Computer modelling: ☐☐☐

This catalogue contains descriptions of Master's Thesis ideas proposed by Subsea7. The proposals are aimed at engineering students with various background. The proposals are not meant for any specific university. The structure of each proposal is as follows:

- Student background
- Purpose
- Main activities
- Contact person at Subsea7
- Degree of theory, experimental work and computer modelling.

It is important to note that the student is responsible to find a supervisor at their university who will endorse the contents of the selected master's thesis in this catalogue. The university supervisor will be the day to day contact for the Master's thesis. The Subsea7 point of contact will provide guidance regarding the problem and help when possible, but will not be responsible for the content of the thesis.

It is recommended to contact Subsea7 as early as possible prior to the start of the Master's Thesis o secure availability of a Subsea7 supervisor.