JOINT

DTU - DONG E&P

RESEARCH PROJECT CATALOGUE

DONG energy

DTU | CERE
Center for Energy Resources Engineering

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Introduction

The main intention for the continued collaboration between DONG E&P and the Center for Energy Resources Engineering (CERE) at DTU is to intensify and to enhance the energy-related research activities. Please therefore find in this catalogue an updated list of mutual interests and possible projects.

Both DONG E&P and DTU share the challenge of attracting the right young people to work with E&P related topics, - from theoretical modelling to construction and engineering of installations. It is our hope that a more rigorous and explicit collaboration between academia and industry will demonstrate to the students the fact that the E&P area is a vibrant, dynamic and interesting area to be engaged in. The present list of projects is a practical instrument by which the student can choose relevant topics to work with, and after graduating the student will have knowledge of the industry as well as to DONG E&P.

By the end of the period, it is DONG E&P's intention to have supported a number of PhD projects, to be involved in a series of projects, to have formed the basis of enhanced collaboration between DTU and DONG E&P, and last but not least: to have helped educating young people within the area of E&P where the demand for skilled engineers continues to increase.

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Improved Seismic Imaging: Frequency and Energy Loss Reduction

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In some regions hydrocarbon accumulations are capped by depositional sequences including volcanics, e.g. the West of Shetland and Faroe areas. Hydrocarbon reservoirs may also be interbedded with volcanic.
This project is rock physics based: aim is to develop a method to enhance seismic resolution in areas with volcanic rocks present in overburden and intra-reservoir sequences.

How do seismic velocities change through different rock packages and how is the energy dispersed; with focus on volcanic packages. A part of the project may incorporate an evaluation of and possible the inclusion of a new petrophysical interpretation methodology for volcanic facies, which has been developed for the North Atlantic Ignous Province (NAIP), based on detailed interpretation of wireline logs.

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Geological models - Down scaling

A classical, but still unresolved challenge in seismic exploration and reservoir characterization, is high-resolution, seismic interpolation between wells. Many methods have been proposed, but no satisfactory model for deriving the required horizontal correlations of fine-scale structure has been developed.

The objective of this project is to use probabilistic inverse methods and modern geostatistical ideas to develop reliable, high-resolution methods for seismic well interpolation. An important ingredient of the method will be a model for uncertainty analysis.

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Stress configuration in wellbore with flow

The stresses around a borehole are relatively simple to calculate. However, the calculations become much more complicated in poro-elastic formations in the presence of fluid flow. The project aims at constructing a 2D (or 3D) FEM model, which can predict borehole collapse or tensile failure at various production and injection scenarios for different well orientations.

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Real time mud monitoring system – for HPHT application

Changes in lithology and hydrocarbon traces that could indicate gas, is hugely important to pick up quickly in HPHT drilling operations, to avoid blow-outs, cave-ins or other issues that could compromise the well or the drilling operation. We are looking for the development of a real time mud monitoring system that can help us get the information we need as quickly as possible. The system should ideally be measuring mud properties down hole, so we do not have to wait for the mud to be circulated out before we can make the measurements.

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Numerical modeling -compositional/ thermal effects

Compositional modelling of flow and thermodynamic processes in oil and gas reservoirs has become increasingly important as more and more complex production processes are being used to increase recovery from mature fields. The primary objective of this project is to continue and strengthen the development of new techniques to model compositional effects and advanced recovery process.

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Development options for thin oil rims underlain by water

Many of the discoveries found in the North Sea has a very thin oil column with water underneath. Developing these finds is often uneconomical – not because the reserves are small, but because water quickly starts coning into the wells. The water then bypasses the oil and causes a very high water cut and a very low recovery factor. We are looking for solutions to manage the well inflow such that the oil is swept by the water, rather than bypassed. We imagine that some kind of autonomous inflow control in the well completion could be a solution to this (shutting off water whilst allowing oil to enter the well).

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Production system optimization for mature fields

The Siri area is a very mature field that suffers a number of constraints, such as high water cuts, not enough gas available for gas lift on all wells, failed equipment, corroded wells and pipelines, etc. We are looking for a way to optimise the production system such that we get the most out of what we have, optimising the production and minimizing the costs. There is already an on-going study into how we can optimize the production facilities, so this study would focus more on the reservoir management side than on the production facilities side.

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Nanotechnology in oil and gas reservoirs

Nanotechnology is still in its infancy in the oil industry. We believe that nanotechnology can resolve a multitude of problems in reservoir management, for example as fluid modifiers, for data gathering, for matrix manipulation, or for fluid flow control. We believe that nanotechnology could revolutionize the oil industry if someone is able to think out of the box and come up with game changing solutions. We would encourage some truly creative thinking in this area.

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Gas injection optimization

Injection of gas into oil reservoirs to increase oil production is one of the most widely used techniques to improved recovery from many oil fields. The objective of this project is to optimize the gas injection process under a variety of conditions.

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PVT and Delumping. Reservoir and processes

Numerical models of fluid flow in oil and gas reservoirs are commonly used to predict hydrocarbon recovery. The quality of such predictions is dependent upon how accurately the reservoir hydrocarbon composition (mixture of oil and gas) is described in the numerical flow model. Often the description of the geological structures and the flow of the fluids in these structures requires so much computer power and memory that the description of the oil and gas mixture requires that a compromise is made with respect to how many components that can be included to calculate the phase split process in the reservoir. A compositional description of oil and gas may by simplified by lumping components and again "delump" the lumped components in the production phase, when a more detailed description is needed for the process simulations. The objective of this project is to describe procedures for these lumping and delumping processes and adjust existing techniques to reflect the properties of light oils found in reservoirs in the Danish and Norwegian sectors of the North Sea.

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HPHT PVT

Oil and gas is being produced from still deeper reservoirs in order to meet energy demands. At depths of 5000 to 10000 m the pressures and temperatures in such, so called, high-pressure-high temperature (HPHT) fields are outside of the range of the traditional models that are used to calculate the properties of the fluids in the reservoir. As such, these models are not considered to be accurate in predicting the performance of HPHT reservoirs. This project will aim at developing and testing PVT models to more accurately describe and calculate the thermodynamic properties of hydrocarbons in HPHT fields. The project may include the experimental verification of existing models, the development of improved models and the assessment of available field data including the development of a HPHT fluid data base. DONG Energy will supply the project with data from HPHT fields.

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Water shut-off by polymers

Water production is almost always associated with oil production, and it usually increases throughout the lifetime of the reservoir. In very mature fields the water cut (relative water production) may exceed 90%. High rates of water production increase the load factor of the process equipment on the platforms and may require expensive extension of existing process installations. Eventually, production wells may have to be shut-in due to high water production rates. However, the inflow of water to production wells can be reduced by injecting polymers into the reservoir, which alter the water viscosity and the mobility of the water phase relative to that of the oil phase.

In this project the effect of polymers on water production in reservoirs in the Danish sector of the North Sea will be studied using numerical flow models. The viscosity and the relative mobility of the water can be varied in flow models representing different reservoir types and well configurations. The results of the study can be used to identify the required properties of the polymers to be used under specific conditions. The results may also be used in combination with experimental studies where polymer properties are measured.

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Streamline-based Reservoir Simulation

Streamline simulation is a technique different from the conventional finite difference (FD) based reservoir simulation. In streamline simulation, the 3D transport problem is decoupled to a set of 1D problems, which can be solved along the 1D streamlines in a faster manner. In addition, the streamlines provide direct visualization as well as quantitative description of the flow from sources to sinks, which is invaluable to decision makers. The state-of-the-art streamline based reservoir simulation is mainly for simplified PVT models. A comparative study between the streamline-based and the conventional FD simulators is useful to reveal the differences between two techniques and determine the adequate scopes for their applications. In addition, for the streamline-based simulation, several fundamental issues like compressibility effects, compositional effects, gravity effects, and mass balance errors should deserve dedicated study.

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Modelling of inverse Joule-Thomsen effect

Reservoir fluids under high pressure may undergo significant pressure decrease during production. It is well known that adiabatic expansion of a fluid leads to so-called Joule-Thomsen effect, which is usually a decrease in temperature for most fluids at a wide range of temperature and pressure conditions. The temperature change, however, can reverse for reservoir fluids at high pressure and high temperature conditions, which is known as the inverse Joule-Thomsen effect. The purpose of this project is to model the Joule-Thomsen effect for real reservoir fluids at relevant high pressure and high temperature conditions with different rigorous thermodynamic models. Though the study, it is expected to establish a comprehensive knowledge about Joule-Thomsen effect for reservoir fluids especially at high pressure/high temperature conditions. The project requires an integrated effort of EoS modelling, PVT study and oil characterization.

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Smart wells/Optimal control

Smart wells are wells that are completed with downhole equipment, which can be operated at the surface in order to control flow rates in sections of the well. This allows for the optimisation of oil production by, for example, shutting-in well sections in which the water production rates are too high. This project will use models to simulate smart wells in one of DONG's producing fields in order to estimate how the use of smart wells could potentially increase oil production.

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HP/HT production

DONG E&P are currently developing a high pressure and high temperature oil field, and we have several more potential developments on the horizon. HPHT poses a number of challenges, and we continuously look for solutions to these challenges, for example:

- Heavy scaling issues
- Critical fluids handling in wells and in facilities
- Down-hole chemical injection
- Reduce intervention frequencies to enable subsea developments rather than dry production well-trees
- Enhanced oil recovery/well stimulation in HPHT fields
- Well integrity issues when pressure is reduced
- Safety issues related to prevention of blow-out, ensuring well integrity, etc.

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Gas lift optimization (system)

The pressure in reservoirs typically decreases as oil is produced. This drop in reservoir pressure can make it increasingly difficult for oil to flow up the well to the platform, as the driving force (difference between the pressure at the bottom of the well and the platform facilities) becomes less and less. Gas lift is a method that enhances the flow of oil in a well by injecting gas near the bottom of the well, which reduces the density of the oil column in the well thus making it easier for the oil to flow up the well as the reservoir pressure decreases.

Models exist for calculating the flow rates of oil and gas in wells in which gas lift is used to enhance flow. The objective of this project is to review these models and propose improved calculations for optimizing the gas injection depths and propose improved and optimized procedures. Examples of improved processes could be to utilize the multi-stage compressors to take gas out the gas at several pressure stages and inject the gas at depths associated with the respective compressor pressures. This may greatly reduce the energy consumption used in such processes. Optimization will take into account both energy and environmental considerations, including the minimization of CO_2 emissions.

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Nanotechnology in oil processing

Nanotechnology is still in its infancy in the oil industry. We believe that nanotechnology can resolve a multitude of problems in oil and gas processing and transport, for example as fluid modifiers (drag reducers, foam/emulsion control, liquid separation enhancers, liquid/gas separation enhancers, etc.), for leak detection and leak remediation, to replace dirty chemicals or behave more efficiently than traditional production chemicals, for data gathering, etc. etc. Only the fantasy is a limit in this area. Nanotechnology could revolutionize the oil industry if someone is able to think out of the box and come up with game changing solutions. We would encourage some truly creative thinking in this area.

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Concept study: Gas transport from marginal fields

Production of solution and free gas from small marginal fields often presents a huge challenge as the gas volumes are in many cases so small that a pipeline infrastructure for the exporting the gas is not economical. The only alternative in such cases is often to re-inject the gas back into the oil field. This is in some cases both a waste of energy resources and an energy consuming process.

Alternatively the gas may be exported from the field as anon-gas liquid (NGL). The project will aim at optimizing the NGL concept for especially smaller fields and to determine the critical volumes that will make the NGL solution economical.

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Gas Hydrates – Low Dosage Inhibitors

Experimental and theoretical studies of gas hydrate inhibition – both kinetic inhibition and anti-agglomeration will be considered. Two main thrusts could be:

1. Novel (biodegradable) synthetic polymeric kinetic inhibitors will be synthesised and tested.

2. Anti-agglomeration studies

Several old and new rigs will be employed in the testing (three existing cells, new HP microcalorimeter, rocker rig) as well as advanced synthesis and characterization of polymers.

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Chemicals in gas/oil/water processing and production

Chemicals are used in oil production to reduce flow resistance or energy requirements in transport processes, and to prevent precipitation in the reservoir, pipelines and/or process equipment. The use of chemicals is costly and may in some cases also cause an increased environmental load.

The objectives of the project are to map the effect of the different chemicals used in oil production and to provide an overview of alternatives methods or chemicals, which have a lower cost and environmental impact. The project can be a combination of literatures and experimental studies.

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Energy optimization of off-shore platforms

The energy use associated with production of oil and gas is substantial. The energy consumption of a medium size off-shore production platform is of the order of 25 to 50 MW corresponding to the energy consumption of a city with a population of 25,000 to 50,000 people.
The use of more advanced production techniques requires the injection of fluids (e.g. water or gas) into the reservoir to sweep more oil out the reservoir. This increases the energy consumption on the platform. In many cases, a large percentage of the injected fluids are reproduced. On the Siri platform for example, the production steam from the reservoir contains more than 90% water in some of the wells. At such high relative water production rates the well will not flow naturally, but will require the use of submerged pumps or injection of gas into the well to ”lift” water and oil out of the well. This also requires extra energy. Energy optimization will therefore in many cases be the precondition for introducing enhanced oil recovery.
Energy optimisation on platforms, resulting in a lowering of the energy consumption and thus also the environmental impact, by reducing the energy requirement and/or increasing the efficiency of power generation at the platform.
Energy consumption may be reduced by optimising components such as pumps, compressors and other energy consuming equipment at the platform, and also looking at the processes the equipment is used for. For example, is the use of gas the most energy efficient way to produce wells with a high relative water production? Gas or diesel is usually used

to generate the power required. But are power generating components up to date and is power generation at the platform most efficient way to generate power? Could external power generation using, for example, windmills be an option?

Energy optimization is not only required from an economical and environmental point of view. For advanced production methods to be economical it is also a requirement that the platforms can be used in their present form without any major re-design and extension (i.e., within the present space limitations). This imposes severe restrictions on the components to be used.

This project will investigate different energy supply concepts on off-shore platforms with the objective of identifying innovative solutions to the challenges listed above.

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Storage of Natural Gas in Aquifers

DONG Energy owns and operates the Stenlille Gas Storage, where natural gas has been stored since 1989. The storage is located on Sjælland, a few km North of Sorø. The gas is stored in a sandstone aquifer of Triassic age. The depth of the aquifer is about 1500 m. The thickness of the aquifer is about 140 m. The initial aquifer pressure and temperature was 155 bar and 50 deg. C, respectively.The storage reservoir is overlain by a 300 m thick caprock consisting of claystone. Large volumes of gas is injected into the storage every summer and withdrawn during the winter.

The Stenlille storage is a vital part of the Danish Gas Transmission System. The importance of the storage is expected to increase in the future, because the distance to the sources of natural gas supply for Denmark is expected to increase as the gas resources in the North Sea are being depleted.

Potential research subjects could be:

1. Water coning in a gas storage zone with an underlying water zone (ways to reduce coning: polymers, operational modes etc ?)

2. Effect on sand production of cyclic operation of gas storage wells (will the rock weaken after many cycles ?)

3. Effect on sand production of injection of dry gas into the gas storage wells (will cyclic drying of the rock make the rock weaken with time ?)

4. Effects of storing biogas in the aquifer storage (could storage of biogas imply souring of the stored gas ?)

5. Injection of dry gas may cause precipitation of salt in the pores near the wellbore due to the drying effect. (will the precipitation increase or decrease with time ? will this effect well injectivity, productivity, etc ? should the injection gas be saturated with water before injection in order to prevent salt precipitation ?)

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