Maximus

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FEESA
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For fast high fidelity life of field flow assurance modelling

Welcome to the Spring 2014 edition of the Maximus newsletter. Following the release of Maximus 4.14 at the beginning of the year, the new feature development cycle has started again. Already a 64 bit version of Maximus has been developed and is undergoing testing which will effectively remove all model size and result storage constraints which were only due to the 32 bit memory limitation. The team has also started work to extend the Open Interface allowing the creation of models from a blank canvas. This leads to exciting opportunities to automatically build networks of all sizes, for example from GIS data. The current Open Interface has already been used to link Maximus with a third party process simulator, KBC's Petro-SIM™ 5.0, which shares its 'life-of-field analysis' philosophy.

The FlexLM™ licensing system is being extended to allow for a pool of Maximus and its extended features to be licensed with the users selecting which features they wish to 'check-out' at any time. For example a client could have a total of 8 Maximus licenses, 5 KBC Multiflash licenses, 2 Schlumberger OLGAS 2 licenses and 2 Kongsberg Ledaflow Point Model licenses. This also enables users to quickly check who currently has licenses and features checked out from a dialog in Maximus itself.

Please find in this newsletter some examples of systems Maximus has been used to model including CO_2 systems, LNG plants and its use in analysing the benefits of subsea processing. Further information can be found on our new website at www.feesa.net.

IPM Incorporating LNG Plant

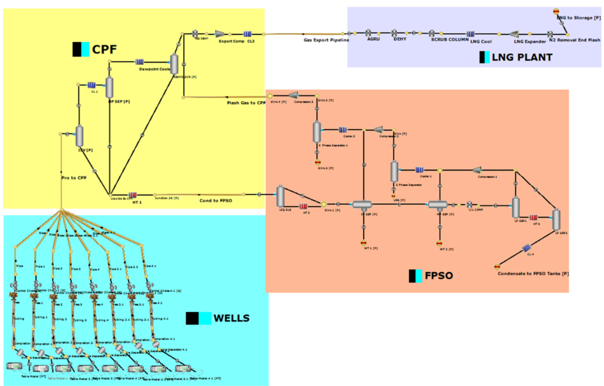
Maximus has been used effectively for developing a conceptual full asset model from reservoir to LNG plant including the process unit operations. The processing operations both offshore and at the LNG plant have been successfully modelled with the use of Maximus objects. Figure 1 shows an example model GUI screenshot. The multiphase fluids produced by the wells are routed to a Central Processing Facility (CPF). The CPF operation separates the gas from the liquid, step cools the gas to remove further condensate and water, and then dehydrates the gas prior to export compression. All liquids collected from the CPF are routed to the FPSO. The FPSO includes multistage flash separation to produce a stabilised condensate that can be stored in the FPSO prior to shuttle export. The FPSO's stabilisation off gas is compressed and recycled back to the CPF via pipeline and tied-in upstream of the CPF's dehydration unit. The CPF's export gas is then transported to the onshore LNG plant via subsea pipeline.

The LNG plant process units are modelled in sequence. For this example, Acid Gas Removal, Dehydration, Scrub Column and N_2 Removal are all modelled with the component separator available in Maximus. The full asset Maximus model can be developed from a very early stage in the project development, and has been known to be completed in parallel with the initial reservoir models. This full asset Maximus model can usefully be applied to the following tasks during early conceptual design:

- Assess various field development options
- Generate/validate production profiles
- Develop high level H&MBs for the CPF, FPSO and LNG facilities
- Generate preliminary equipment data for the purpose of supporting early cost estimating activities
- Assess flow assurance issues

As the project progresses, it is anticipated that responsibility of process modelling will be handed over to a process modelling tool, however the Maximus model continues to be used as the central modelling tool that interfaces via Open Interface with the process modelling tool for the modelling of the CPF, FPSO and LNG processes.

Figure 1 – Full Asset LNG Integrated Production Model GUI



Combined Production and CO_2 Injection Model (with EGR Benefits)

Maximus has been applied on recent projects for modelling of CO_2 injection systems for the purpose of CCS. The majority of large scale CCS projects currently in operation are linked to gas production projects, so FEESA has explored combining gas production, gas sweetening and gas re-injection into a single Maximus model, and also used the same Maximus demonstration model for evaluation of the benefits of Enhanced Gas Recovery (EGR). The model setup evaluates the benefits of injecting the recovered CO_2 to support the pressure in the gas reservoir to prolong gas production and enhance gas recovery, as well as sequestering CO_2.

The system setup, illustrated below in Figure 1, includes representation of the gas reservoir's producing zone using a tank model, which is produced via completion, tubing, choke and flowline to an onshore Acid Gas Removal Unit (AGRU). The AGRU separates the CO_2 from the produced gas, with the sweetened gas sent to the LNG plant whilst the recovered CO_2 is routed to the onshore CO_2 compression/dehydration facility. The CO_2 flow is then compressed, dehydrated and injected via an injection flowline, choke and tubing into a reservoir tank model representing the injection zone of the reservoir. To model the breakthrough of injected CO_2 into the produced gas, the mixing of the injected CO_2 from the reservoir's injection zone into the reservoir's production zone is modelled using a connector between the tanks with the gas transmissibility being specified.

Fig 1. Combined Production and CO_2 Injection Model GUI

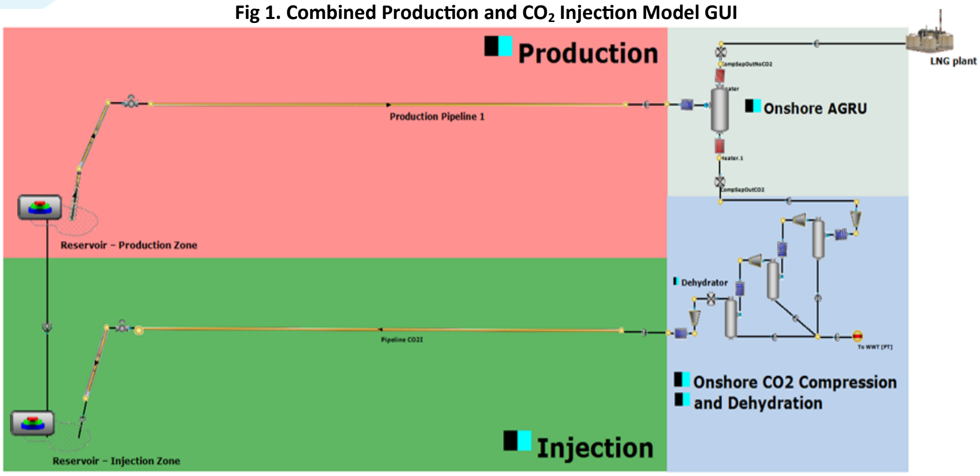
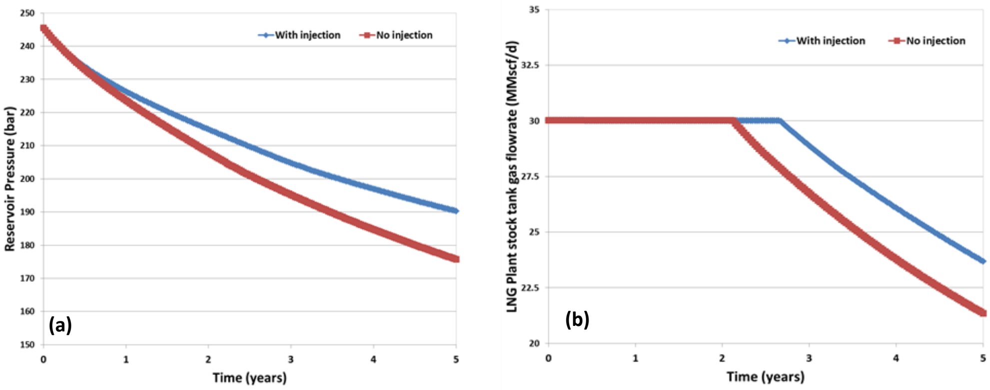


Fig 2. (a) Reservoir pressure change with time for injection and no-injection cases. (b) Comparison of gas production for injection and no-injection cases.



Plots comparing the results for the above production system for cases with and without CO_2 injection are given in Figure 2, providing a comparison of reservoir pressure and gas production rates through life of field. Figure 2 shows the effect that injected CO_2 has on supporting the producing reservoir pressure, and the extended gas production plateau that is achieved. Other key results that can be extracted from the Maximus model include:

- Life of field plot of CO_2 mole fraction in produced gas. This combined with the gas production profile is fundamental for the process design of the AGRU.
- Life of field plots defining dehydration unit duty (in terms of flowrate and water content)
- Life of field plot of CO_2 injection compressor power demand

The modelling of the CO_2 breakthrough is somewhat simplistic in this demonstration model, but the transmissibility can be defined using functions determined by a reservoir engineer. Alternatively, Maximus can interface with an appropriate reservoir modelling tool via the Open Interface. This model demonstrates the versatility of Maximus in being applied to provide a truly integrated production and injection model.

Maximus Application to a Subsea Gas Compression Project

Utilizing the compression curves functionality in Maximus, a subsea compression study (SSC) on behalf of a client has been successfully conducted by FEESA consultants, to support the process suitability and performance of a proposed compression station applied to a field development. The installation of the SSC station at different physical locations, the operation of compression trains both in parallel and serial configuration, and some outlined compressor vendors constraints have been investigated.

The compressors in Maximus have been simulated in two different ways, using the adiabatic control choke compressor, and using polytropic real compressor curves (provided by the compressors suppliers). Different strategies have been implemented in order to control the compressors. For the control choke compressors, the compression ratio (CR) and maximum compression power are specified at a fixed efficiency. Events logic is used in order to increase CR to maintain production target, starting at low value of CR. This approach avoids wasting power because the compressor is only generating a low enough suction pressure such that the potential of the wells meets the gas delivery requirement plus the required surplus margin. When the power limit is reached, the model automatically limits the CR. For the polytropic real compressor curves, the initial compressor speed provided by the vendor is specified to identify the initial operating point. Maximus calculates the power and coupling torque. Events increase speed to match profile demands. If speed or torque are above a limit, a speed increase is not allowed until flow and, therefore, power demand reduces.

Maximus' capabilities have enabled the conceptual model to cover the life of field simulation, including compression, from the reservoir through to the LNG plant. Top of line corrosion and gas velocities have been monitored for this study. The results from this study has allowed identification of the best location for the installation of the SSC train, in terms of maximising the gas production (incremental recovery) from the reservoirs, extending production plateau, and creating a water handling strategy in order to prevent flow assurance issues.

FEESA is enthusiastic about Maximus' application to SSC technology, which is viewed as a potential solution for sustaining gas and condensate production in the face of eventual reservoir-pressure declines. This feasibility study has demonstrated Maximus' powerful ability to successfully modelling the SSC systems.