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Original article

Development and application of an innovative tool to automate the process of results extraction from the thermo-hydraulic simulator Olga

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A B S T R A C T

This paper presents the development and application of an innovative code to extract in an automated way data from the thermo-hydraulic simulator Olga. The results show that the tool can significantly reduce the time needed for the data extraction procedure and increase the reliability of results due to the fact that there is no more the need of the human operator. Moreover, during the data extraction phase, the Olga code is available for running different simulations allowing to optimize the use of this resource.

1. Introduction

The Flow Assurance engineer has to guarantee the correct production and transportation of oil, gas, and produced water products through pipelines facing issues and challenges such as erosion, wax, hydrates, asphaltenes, foam, corrosion, erosion, and sand.

A typical Flow Assurance analysis process is the sensitivity analysis which, from the thermodynamic analysis of multiphase flows, using Olga (the dynamic multiphase flow simulator), broads to the sizing of a gathering system. Using Olga to perform the analysis means that you first have to set up all the aspects of the scenario you want to simulate, lunch the simulation and finally extract the results.

Olga doesn't provide, as default, a way to automatically extract data from the analysis in a structured way. The result extraction is an operation that, at present, has to be carried out by the user “manually” using trend and profile plots from inside Olga. This “manual procedure” is slow, repetitive and requires a lot of time and effort.

In this paper the development, implementation and validation of a code (written using visual basic for application as a language) to extract results from Olga, called OtoEx is presented. The main characteristic of the code is that it automates the process of data extraction allowing a faster, more accurate and independent from Olga, recovering of the information.

2. Relevant literature

Several authors presented flow assurance studies performed by Olga code, there are a wide range of case studies in literature in which multiphase flow issues have been addressed by simulating the behavior of the systems.

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Ref. [1] used OLGA software to simulate pigging transient flow characteristic of a 79 km dual flowlines system of a deepwater gas field.

In many flow assurance designs for subsea production systems, a single assumed rock-layer thickness surrounding the subsea wellbore is used to simulate wellbore thermal performance over the well's entire projection life. This assumption may lead to significant errors in flowing wellhead temperature calculations and potential failure of the flow assurance thermal design.

Ref. [2], demonstrated a new generalized equivalent rock-layer thickness (ERT) model with a time-dependent impact zone of the formation rock-layer surrounding the wellbore. Various drill-stem-test (DST) data, field production data, and OLGA simulation results have verified the validity of the proposed model.

Ref. [3] presented a general Flow Assurance study mainly using OLGA software by performing a detailed flow and thermal analyses, using dedicated CFD simulations, to identify local cold or hot spot in a large offshore/subsea development. Hot spots could lead to an accelerated aging of some of the equipment materials, whereas cold spot could lead to a quicker cooldown time than required creating a local risk of wax or hydrate plug formation.

Ref. [4] have studied gas injection as an effective method to mitigate hydrodynamic slug using OLGA simulation.

Ref. [5] presented a new way to face flow assurance challenges developed by CD-adapco and SPT that have partnered to couple their industry leading analysis solutions – STAR-CCM+ and OLGA – to provide a multi-fidelity, multiphysics simulation tool for flow assurance applications.

Ref. [6], discussed the flow assurance design and operating strategies for the high pressure high temperature Blind Faith development located in deepwater Gulf of Mexico. An OLGA model based Flow Management Tool (FMT) was developed prior to field start-up to provide asset team engineers and operators with live information on calculated well production rates, steady state thermal performance of the flowlines with forward looking projections on cooldown times for hydrate management.

Ref. [7] in their paper described different operational scenarios where hydrate plugging might occur and how a hydrate plug formation prediction tool would be beneficial. They demonstrated the effectiveness of the implementation of an existing hydrate plug formation model, called CSMHyK (The Colorado School of Mines Hydrate Kinetic Model) that have been implemented in the transient multiphase flow simulator OLGA as a separate module.

Ref. [8], summarized some of the experiences from modeling and operation of gas/condensate pipelines based on analysis performed using the multiphase pipeline simulation tool OLGA.

Ref. [9] demonstrated how transient models such as OLGA are used to predict and alleviate the flow assurance problems associated with deepwater production of a gas condensate subsea system. The paper addresses the importance of flow modeling before and during production.

Despite the wide amount of papers dealing with the application of the thermohydraulic simulator Olga in flow assurance problems, there is no evidence in literature of codes developed for simplifying, speeding up and reducing errors of the data extraction process.

3. Material and methods

This chapter is structured in three parts. The first one is dedicated to the sensitivity analysis in flow assurance, describing why it is important and how it is performed using Olga as an analysis platform. Then two different data extraction procedures: the old "manual procedure" and the one that has been proposed through the development of OtoEx are described.

3.1. Sensitivity analysis in flow assurance

In flow assurance the sensitivity analysis approach is used to find the optimum condition for setting different parameters of a gathering system: the optimum pipeline's route that minimize the costs of the plant; the lowest number of pipes that allows to process safely the entire mass flow rate that comes from the wells; the diameter of the pipeline's system that allows the safe transportation of the mass flow. The best configuration is the one that allows costs minimization, to meet the required specification from the standards or the customer and to ensure the safety of the plant.

In order to successfully complete a sensitivity analysis, the first action to carry out is to perform a thermo-fluid dynamic simulation of the gathering system under analysis. Olga is a dynamic one-dimensional modified two fluid model, used to simulate two phase hydrocarbon flow in pipeline networks. It was first developed by IFE in 1983 for the Norwegian state oil company, Statoil. Since then has been improved thanks to the increasing of the experimental database and all the numerical testing in the oil companies involved. Olga can simulate pipeline networks with its full suite of equipments such as compressors, pumps, heat exchangers, separators, check valves, controllers and mass sources/sinks.

To simulate a flow scenario with Olga three major steps have to be carried out:

- Setup preparation
- Launch of the simulation
- Data extraction

This paper focus on the procedure and optimization related to data extraction.

3.2. Manual procedure for the extraction of data

At present, data extraction is carried out using a manual procedure which follows a simple algorithm:

1. Visualize the plot of a certain variable of interest with the trend/profile plot tool
2. Collect the information directly from the plot, activating an Olga's tool that reads the value of the function displayed at any specific selected point
3. Elaborate the information if needed
4. Process data

This procedure is time consuming and repetitive, and it can represent a significant issue when the number of scenario to analyze increases: it takes a lot of time and effort and could lead to errors due to the repetitive work. Moreover if Olga is fully dedicated to data analysis, it cannot be used efficiently to run other simulations.

3.3. Otoex software development

When one analysis is launched, Olga automatically produces a total of 6 files with different extensions (GENKEY, H5, TPL, PPL, RSW, OUT), inside each file are stored different kind of variables and parameters related to the scenario being simulated. The file of interest for the developed procedure are the .tpl and .ppl,