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Technical solutions for multi-component gas transportation from Shtockman Field by submarine pipeline

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Аннотация. В работе рассматриваются сравнительные проектные решения транспортировки многокомпонентного газа со Штокмановского ГКМ, которые выполнены по отечественным нормам ОНТП и в симуляторе OLGA. Показаны существенные отличия (более чем на 30 %) двух проектных решений для нестационарных режимов работы подводного газопровода для первой фазы освоения названного месторождения.

Abstract. In the paper comparative design solutions of the project concerning the transportation of multi-component gas from the Stockman deposit developed by Russian domestic standards (General Standards for the design of Industrial Projects) and simulator program OLGA have been considered. Existing distinctions (more then 30 %) are demonstrated for the two project solutions for intermittent operating conditions of submarine pipeline for the first stage of field development.

Ключевые слова: подводный трубопровод, многокомпонентный газ, Штокмановское месторождение, пробковый режим, давление, температура

Key words: submarine pipeline, multi-component gas, Shtockman Field, plug flow, pressure, temperature

1. Introduction

The present paper contains comparative results of the calculation of pressure and temperature in case of transportation of multi-component gas from the Stockman deposit by submarine pipeline.

The following design project tools have been used for the analysis:

- Simulator program OLGA
- Simulation program based on Russian domestic standards (General Standards for the design of Industrial Projects)
- Simulation program based on Mathematica data bases.

It is demonstrated that for quasi-steady non-isothermal flows of multi-component gas in a subsea pipeline all project solutions show approximately equivalent values for the process-dependent parameters of the transported flow within the given range of pressure and temperature. The calculation errors for the project solutions do not exceed 3-5 % of the average project values. The differences between the projects solutions are however important at the unsteady regime of the subsea pipeline where hydrate build up can occur.

2. Simulator OLGA and domestic standard

At the moment there are several schemes of industrial pipelines approved, including those from the Stockman deposit, which are designed with the help of various software tools and methodological basis. This, however, poses a question on the comparability of the different project solutions which are in accordance with different methods and with the use of different software, as well as the availability of the software for the Stockman development project.

The simulator program OLGA (*DNV Recommended*…, 2005) is one of such software and methodological complexes, which according to its developers is the most powerful tool for designing the transportation of a multi-component product through subsea pipeline systems.

Scandpower (as a creator of OLGA simulator) is an experienced user of the dynamic multiphase simulator OLGA®, and has applied this tool for a number of different safety and reliability related studies:

- Evaluation of pressure protection of platform inlet arrangements
- Simulation of the dynamic behaviour during process shutdown
- Valve leakage test calibration
- Blow down and flare system capacity calculations
- Water hammer / pressure surge studies
- Pressure transients in shell and tube heat exchangers following tube rupture

- Flow assurance studies, pipeline pressure drop, slugging assessment and heat transfer calculations
- Pipeline and riser leakage calculations.

The software package, however, is presented as a "blackbox" where the mathematic model of the simulator is hidden from the process engineer or the project designer. Such a peculiarity with respect to the knowledge of the model could create difficulties for the engineer when interpreting the final project solutions.

Russian experience with industrial pipeline design for multi-component gases relates to use of the GSPD (*Общесоюзные нормы…*, 1985) standards which correspond to the classic notion of thermobaric flow of the actual gas. As is generally known (*Губин, Губин*, 1982; *Папуша*, 2006), the majority of domestic main pipelines were designed in accordance with the GSPD standards and they appear to be the basic for subsea pipeline projects, including the Stockman pipeline.

Techniques for the calculation of the thermo-baric flow of multi-component gases have lately been proposed (see *Сухарев, Карасевич*, 2000), which specify the effects of various physical parameters, such as the relation between the pressure and physical field that were previously omitted in the GSPD standards. The due regard of pressure – temperature relation inside the pipelines is always necessary when dealing with the issues of protecting industrial pipelines from an undesirable hydrate buildup inside the pipe, especially where it reaches the shore.

3. Designing methods for transportation of multi-component gas

The main aim of the present work is to compare the project solutions for the Stockman industrial pipeline which were acquired according to three different methods:

- Use of the OLGA Simulator
- According to GSPD Standards (*Общесоюзные нормы…*, 1985)
- Implementation of the interconnection of the thermo baric fields in the subsea pipeline by use of a new method through a program prepared in Mathematica.

As will be demonstrated from the given comparative analysis all three project solutions give results close to each other. This means that results found by the OLGA Simulator and by the new implementation of the interconnection of thermo-baric fields in a subsea pipeline are close to the results found by the GSPD Standards. This is also true for the conditions close to shore where the pressure drops and hydrate builds up inside the pipelines. At the same time, the traditional method of designing main pipelines, as based on the GSPD Standards; do not give the answer about the place where hydrates appear inside the Stockman pipeline, although the distributions of pressure and temperature are close to the design values found by OLGA.

Graphics in Fig. 1 and Fig. 2 show us the comparative distributions of pressure and temperature inside the subsea pipeline (1020×23 mm), acquired according to the GSPD standards and the OLGA Simulator.

A given graphics shows us that two design methods are very closed on realizations, except for the locations where the gas reaches the shore. This is the locations where we could expect hydrates to occur.

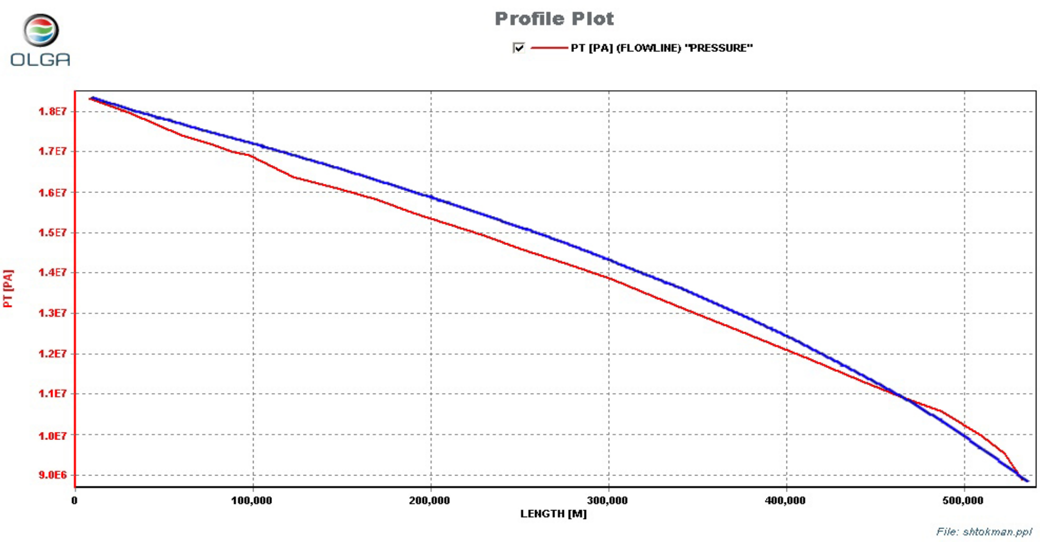

Fig. 1. Pressure distribution (according to GSPD (blue) and OLGA (red))

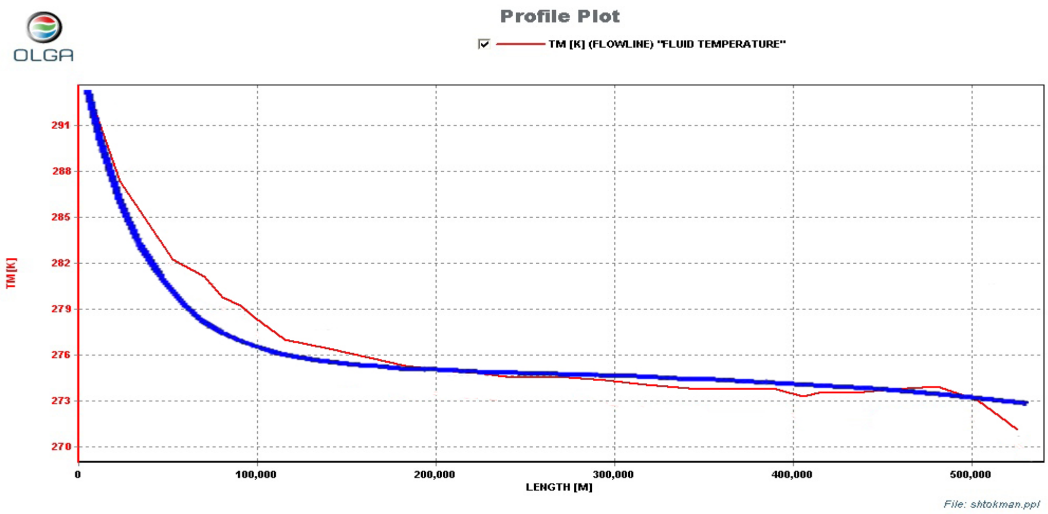

Fig. 2. Temperature distribution (according to GSPD (blue) and OLGA (red))

Fig. 3. Pressure distribution (new method (blue) and OLGA (red))

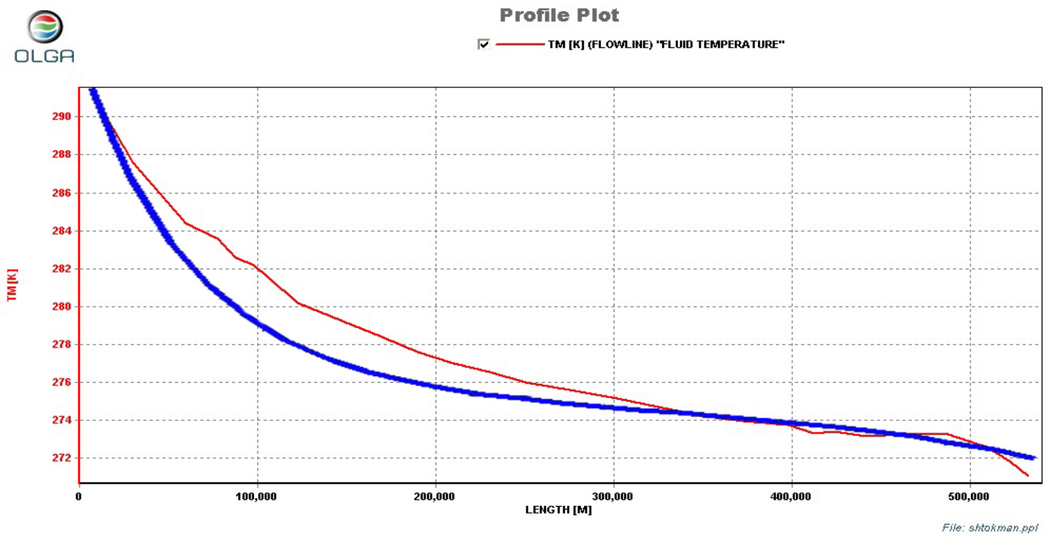

Fig. 4. Temperatures distributions (new method simulation (blue) and OLGA (red))

Then, Fig. 3 and Fig. 4 show the comparative distributions of pressure and temperature inside the subsea pipeline (1020×23 mm), acquired according to *new method* that take into account the mutual influence of physical fields in the pipeline and OLGA. Results obtained by methods involved into consideration are much closed to the solution found by OLGA, except to the shore where small but important distinctions will fail to identify possible hydrate plugs. Both solutions are closed to the results developed by the GSPD Standards, and possibly closer to the OLGA solution near to shore.

Finally, Fig. 5 shows us the momentary distribution of pressure and temperature (acquired with OLGA) at an unsteady flow for the gas-condensate transportation simulated into multiphase regime simulation. A plug flow of multi-phase flow has been simulated and created in the pipeline by OLGA and these solutions for temperature and pressure distributions are shown in Fig. 5 below.

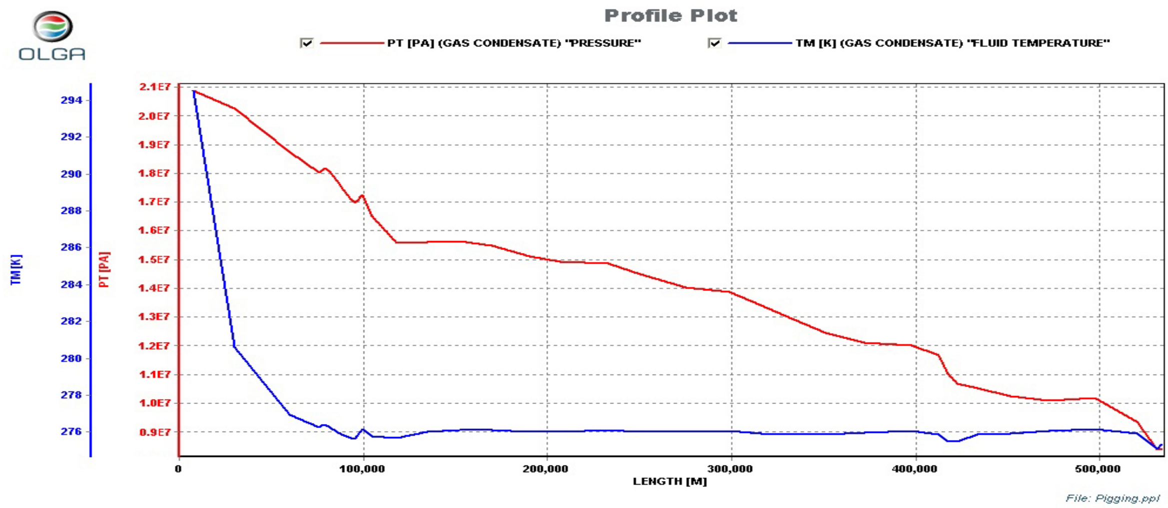

Fig. 5. Distribution of pressure and temperature in a plug flow

As it follows from the graphics, the pressure and temperature drop along the route at the point of the existence of plugs.

This regime is explored in order to reduce or exclude negative influence of plugs when one operates this pipeline transportation of gas and gas-condensate in single and multi-components regime.

4. Conclusions

The comparative analysis of the three project solutions is presented in the paper and shows us that the proximity of their parameters leads to correct project solutions at the initial project designing stages (without taking into account the fact of hydrate buildups and without the plug flow), but in order to make the final design, the OLGA Simulators is absolutely needed. The new updated method developed in the paper would take into account the connection of thermo baric fields inside a submarine pipeline and shows us promises for further development.

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