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Multiphase Pumping – a Solution for Managing Pressure in an Offshore Production System

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Abstract

The subsea production systems are obviously installed in the deep and ultra deep water with the difficult temperature and pressure conditions. The host platform is located to a distance of many kilometers, and the elevation between the subsea wells and the host platform has few hundred meters. In this case the wellhead pressure must be maintained high for overcome the backpressure added by the pipeline, and as the consequence the production rate of the well is lowered.
Consequently we analyzing the multiphase pumping and the artificial lift methods applied to the subsea wells for flow boosting, and optimizing the parameters of the well operating regime.

Key words: *subsea production system, multiphase pumping, artificial lift, well.*

Introduction

The subsea production systems are obviously installed in the deep and ultra deep water with the difficult temperature and pressure conditions. Also, these production systems are linked by pipelines to a processing platform located at a distance of many kilometers, and the elevation between these can have few hundred meters. Consequently, the wellhead pressure of the subsea wells must be high in order to assure the transport of the multiphase fluids produced by the wells to the processing platform. In this case the flow rates of the wells are low and the primary recovery factor is low also. With the reservoir depletion the wellhead pressure decreasing and in certain conditions it was necessary to abandon the wells with a high wellhead pressure due the backpressure generated by a long multiphase pipeline.

In this case it is necessary to find the solutions to reduce the wellhead pressure in order to allow the increasing of the flow rate and the recovery factor. Artificial lift and subsea processing are the actual used scenarios for decreasing the wellhead pressure.

Subsea processing is a generically term used for all equipments installed on the sea bottom to separate and boost the fluids produced by the subsea wells. The basic and most simple type of subsea processing is multiphase pumping or the subsea boosting system. In this case the multiphase booster pump is installed close to the wellheads and handles the mixture liquid-gas produced by the wells. At the outlet of the pump this mixture has a pressure of many times higher than the inlet pressure, being sufficient to overcome the backpressure generated by the pipeline. If the subsea wells produce gas it is necessary to install a gas compressor instead a multiphase pump.

Multiphase Pumping

Multiphase pumping is a relative new technology and it is integrated in the offshore and onshore production system for pressure boosting.

The multiphase pumping may be applied to the beginning of the reservoir exploitation which can lead to a recovery factor higher than in the case of natural production, but it is necessary to analyze also a possible unfavorable reservoir response such as excessive water production and sand production.

The few applications of this technology are:
- boosting production from low and medium pressure wells;
- wells start-up;
- subsea, topside or land pipeline boosting;
- tie-back of subsea well to remote infrastructure or to shore;
- automation of marginal production facilities by using of the remotely operated multiphase pumps.

The some advantages of multiphase pumping are:
- flexibility because one pump can serve many wells and also this can be by-passed;
- it has non any interference with the standard equipment of the subsea wells;
- lead to the increasing recovery factor;
- maintain the production plateau for a longer period of time;
- can compensate the production lost due the increasing water cut or decreasing the reservoir pressure;
- handle the multiphase fluid with a high gas volume fraction up to 90%;
- can replace the other artificial lift system used for boosting the fluids pressure.

The figure 1 shows a typical application of a multiphase pumping.

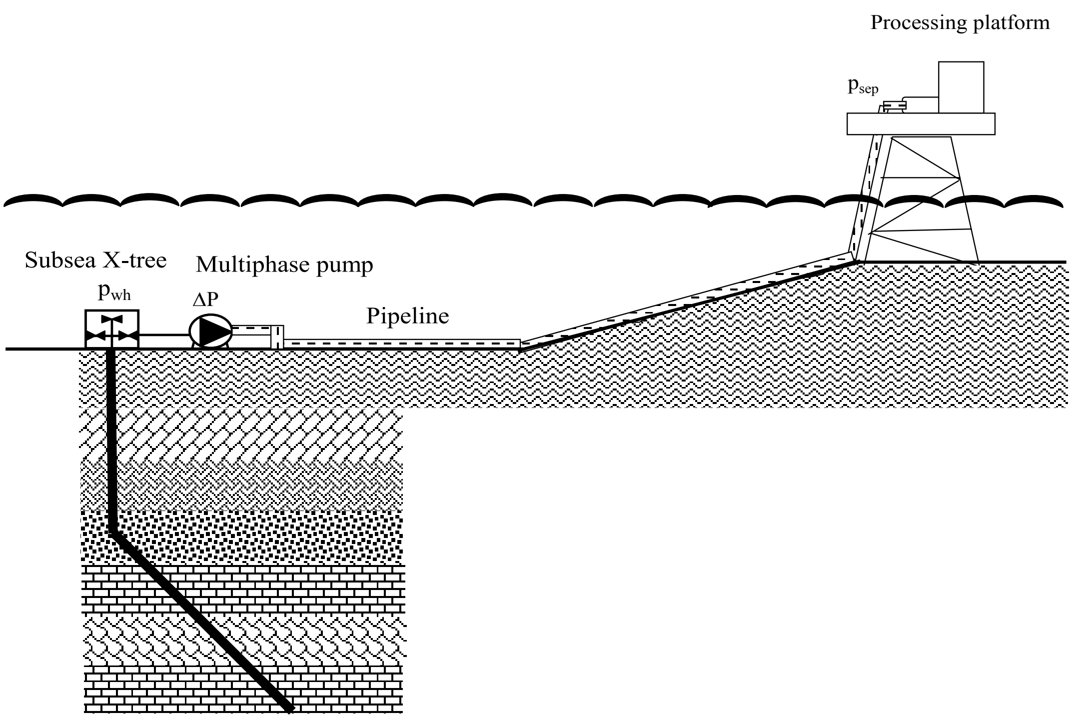

Fig.1 Typical application of a multiphase pumping system.

The most used pumps in multiphase boosting system are helico-axial pump and twin screw pump. These pumps can handle the large volume of fluids with high gas volume fraction.

Currently the multiphase pumping system has been installed in several areas of the world, as the North Sea (Troll Pilot), West Africa (Ceiba), the South China Sea (Lufeng), Western Australia (Exeter and Mutineer). These systems still have the limited capacities relating to the water depth and the pressure boosting.

Case Study

We make an analysis of the natural flow, gas-lift and multiphase pumping applied to a subsea well. Therefore we consider a subsea well which produce by natural flow to a processing platform located at a 5 Km distance. The production system parameters are shown in the table 1.

Table 1. The subsea production system parameters.

Perforations, m	2000
Reservoir pressure, bar	260
Productivity index, m^3/Dxbar	23
Water cut, %	0
Flow rate, m^3/D	149,5
Tubing length , m	2000
Tubing ID , in	4
Casing ID , in	7
Separator pressure , bar	19
Pipeline ID, in	6
Length of pipeline, Km	5
Pipeline elevation, m	0
Riser ID, in	6
Length of riser, m	200

We consider the various development scenarios for this production system as natural flow (base case), gas-lift and multiphase pumping. The two last systems are necessary to maintain the flow rate of the well even the water cut increase and reservoir pressure decrease in the time. Also we want to show the conditions when a subsea natural flow well ceases production in the case of a long tie-back.

First of all we analyze the parameters of the natural flow well for the currently conditions. After that we consider that the reservoir pressure decreases from 260 bar to 100 bar, and the water cut increases from 0% to 60%. The currently conditions for natural flow are simulated with PIPESIM using the Nodal Analysis, and the results are presented in the figure 2.

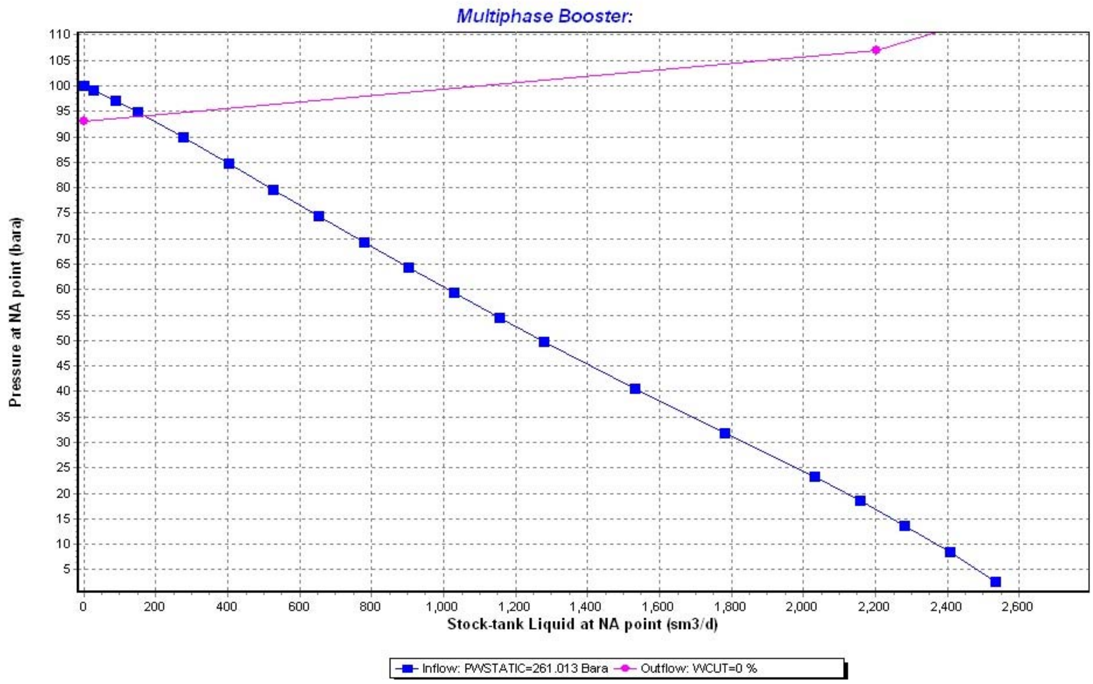

Fig.2. Nodal analysis for natural flow and water cut 0%.

Consequently from the figure 2 results that the wellhead pressure must be about 93 bar for a fluid rate of 149,5 m^3/D, water cut 0% and a separator pressure of 19 bar. Also, figure 3 shows that for water cut of 20% the wellhead pressure is 92 bar and the flow rate becomes null.

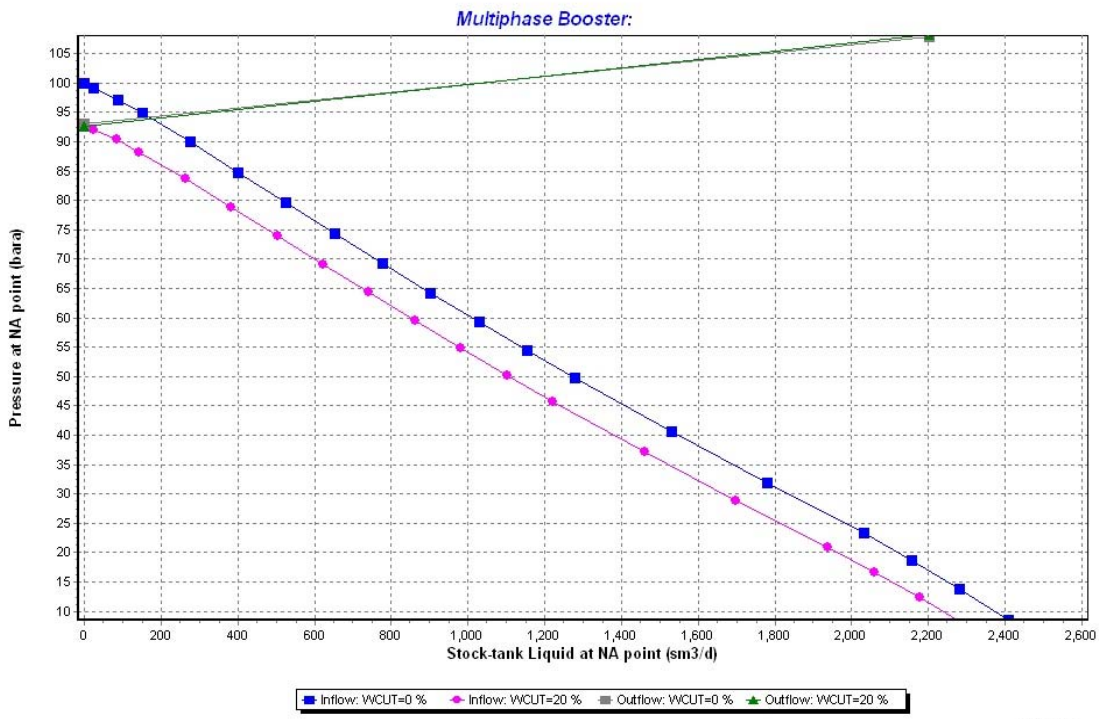

Fig.3. Nodal analysis for natural flow and water cut 0 % and 20%.

Therefore, if the wellhead pressure decrease only with 1 bar because of the water cut increasing, the subsea well ceases to produce.

Further we consider the gas-lift, respectively multiphase pumping to boost the production pressure. In the case of the gas-lift, we make a simulation with PIPESIM for different gas injection rates (2500 Sm^3/D and 2800 Sm^3/D), and for different water cut values (0%, 20%, 30%), the results being presented in figures 4 and 5.

From these figures result that for water cut 0% and a gas injection rate of 2500 Sm^3/D the wellhead pressure is about 98,5 bar and the flow rate is 150 m^3/D. For 2800 Sm^3/D and water cut 0%, the flow rate is 234 m^3/D and the wellhead pressure 94,4 bar. Hence by applying the gas-lift the well start-up and the flow rate has increase. In our case a gas-injection rate of 2500 Sm^3/D is enough to maintain a flow rate about 150 m^3/D.

If the gas injection rate increases, the flow rate increases also. In certain situations the increasing of the gas injection rate is needed to maintain the flow rate when the reservoir pressure declines, water cut increases etc.

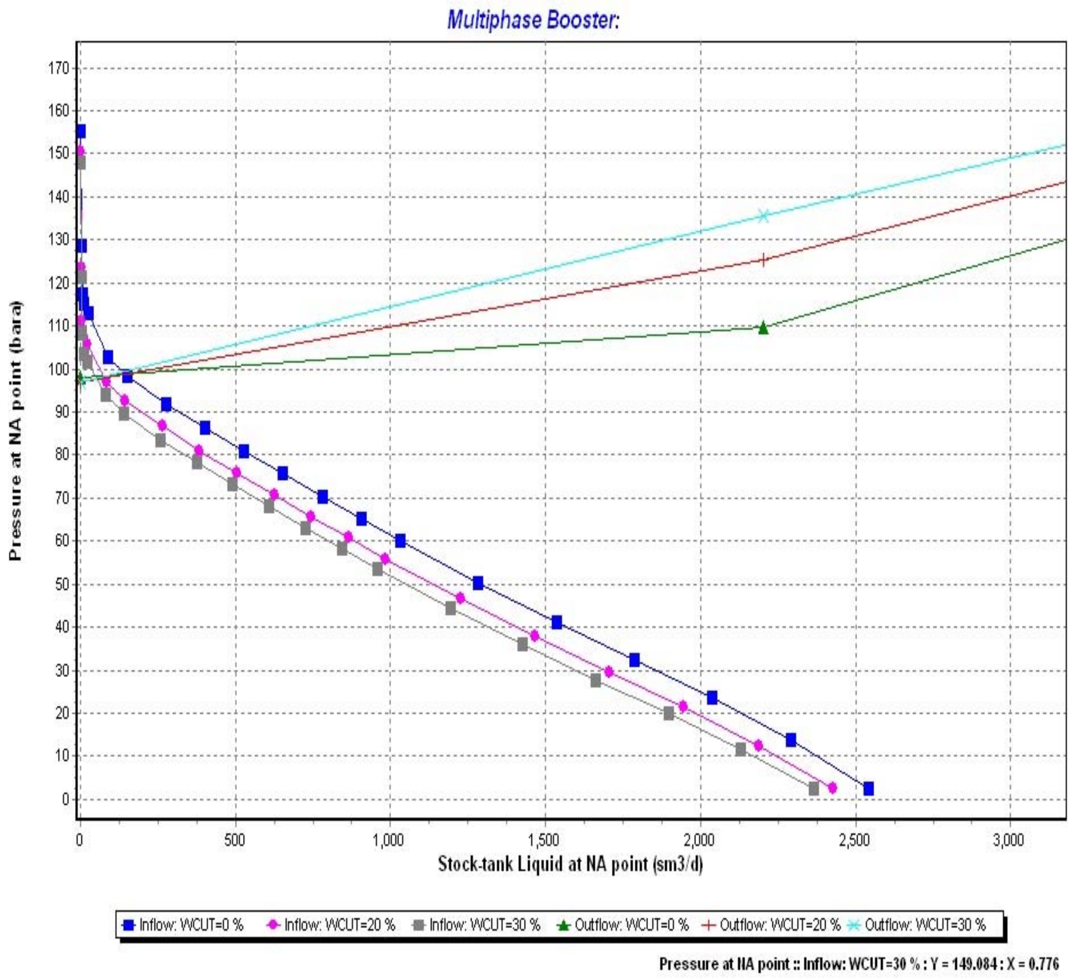

Fig.4. Nodal analysis for gas-lift with Qinj=2500 Sm^3/D, and water cut 0 % , 20% and 30%.

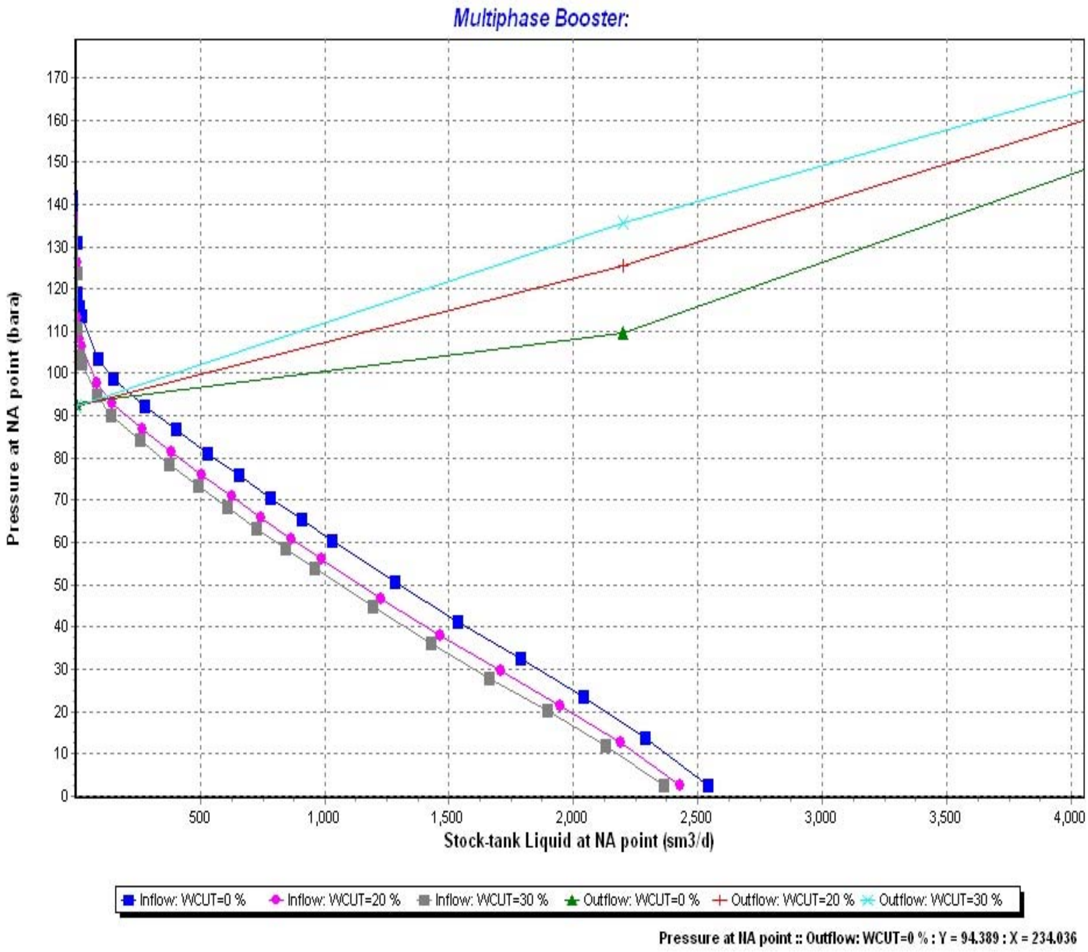

Fig.5. Nodal analysis for gas-lift with Q_{inj}=2800Sm^3/D and water cut 0 % , 20% and 30%.

In the case of the reservoir pressure decreasing below the 220 bar (fig. 6) we observe that the gas injection of 2800 Sm^3/D is too low to sustain the well production. Hence, the gas injection rate must be increased.

We simulate also the multiphase pump installing in the case of the subsea well, the results being presented in the figures 7, 8, 9 and 10.

The figure 7 shows the influence of the water cut increasing on the wellhead pressure and flow rate assuming the multiphase pump installation. From this figure results that the flow rate of the well is null for the differential pressure of 15 bar, the wellhead pressure of 78 bar and a water cut of 60%. In these conditions to maintain the flow rate at certain value it is necessary to increase the differential pressure. The same decision is taked when the reservoir pressure decreases (figures 9 and 10).

In the both figures 9 and 10 we show the results of the reservoir pressure reducing simulation. Also, it is illustrated the compensation of the reservoir depletion by increasing the differential pressure of the multiphase pump, in order to maintain the flow rate. In the studied case for a reservoir pressure of 220 bar, the differential pressure is of 25 bar and, respectively for a reservoir pressure of 200 bar the differential pressure is of 55 bar.

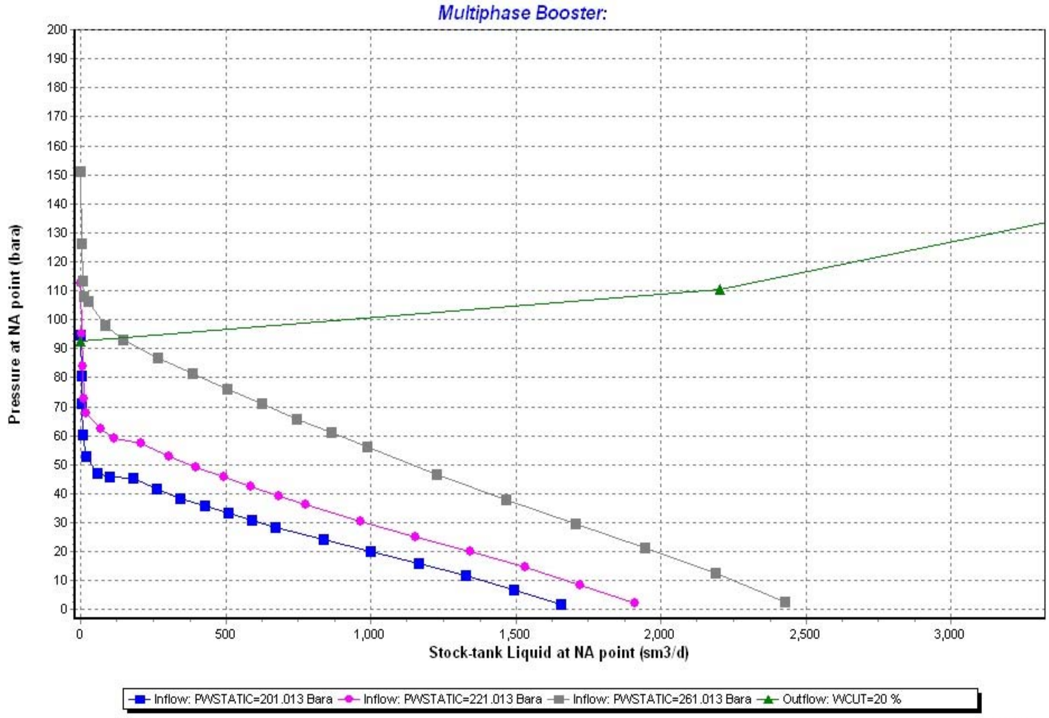

Fig.6. Nodal analysis for gas-lift with Q_{inj} =2800 Sm^3/D

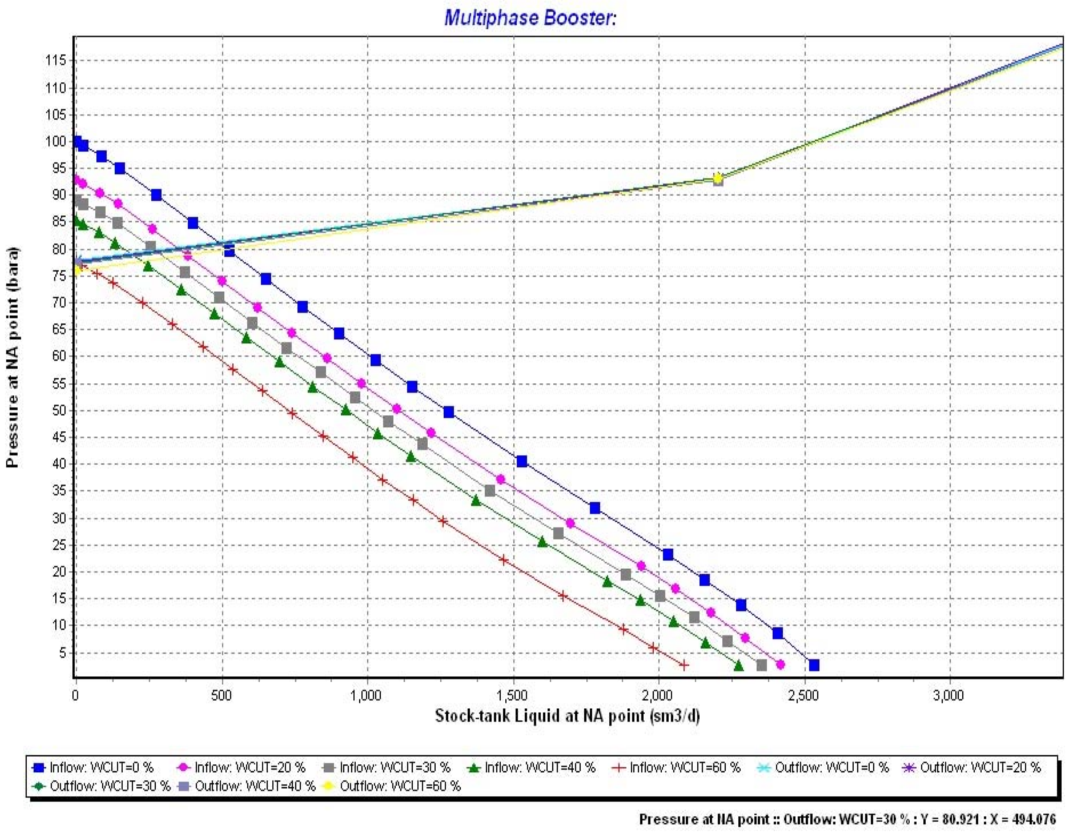

Fig.7. Nodal analysis for multiphase pump and water cut of 0%, 20%, 30%, 40%, 60%.

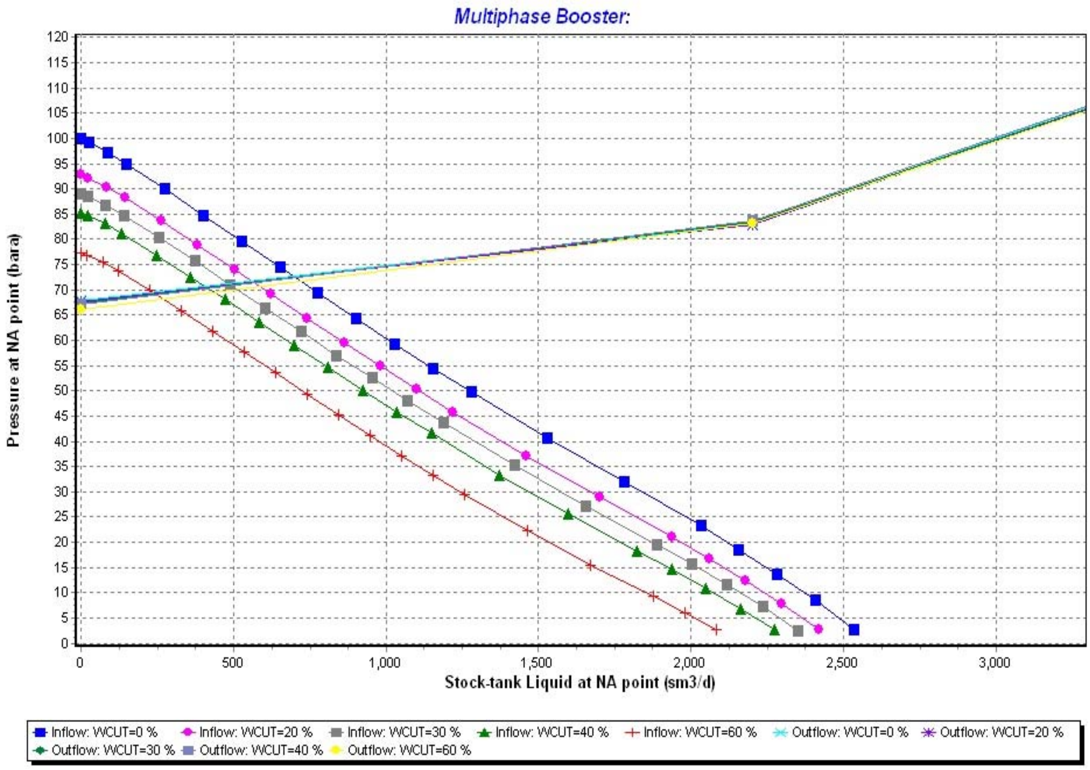

Fig.8. Nodal analysis for multiphase pump with 25 bar pressure differential and watercut of 0,% 20%, 30%,40%,60%.

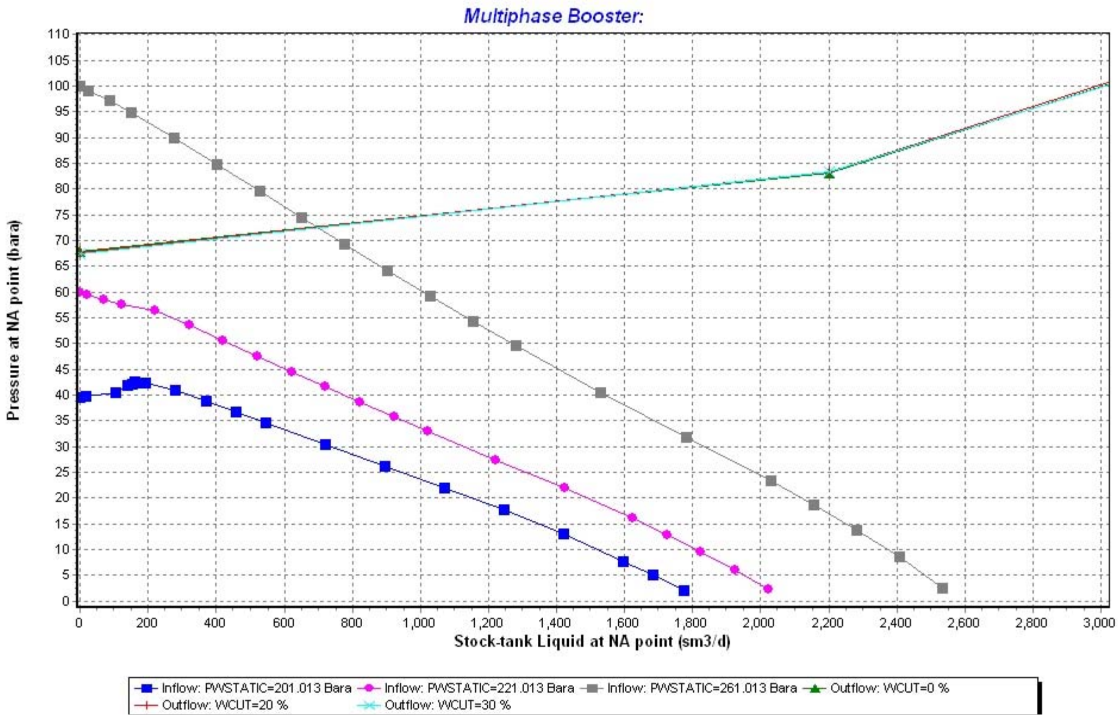

Fig.9. Nodal analysis for multiphase pump with 25 bar pressure differential and reservoir pressure of 200 bar, 220 bar, 260 bar.

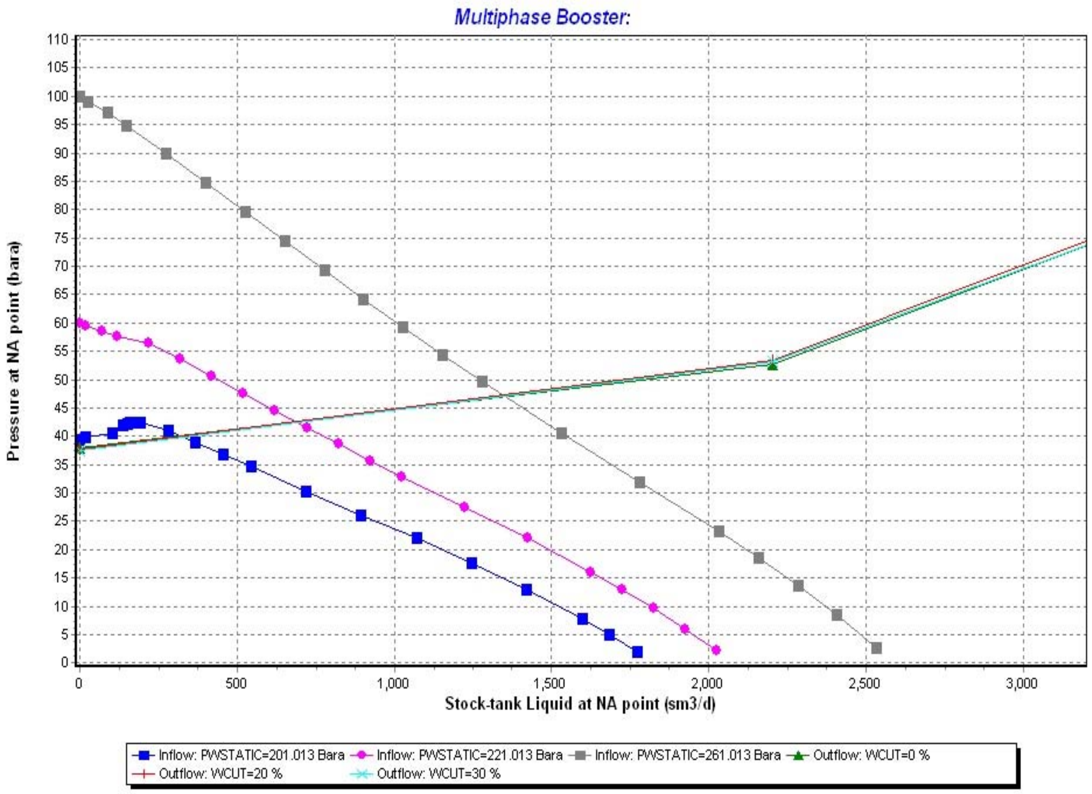

Fig.10. Nodal analysis for multiphase pump with 55 bar pressure differential and reservoir pressure of 200 bar, 220 bar, 260 bar.

Conclusions

The production systems are linked by pipelines to a processing platform located at a distance of many kilometers, and the elevation between these can has few hundred meters. Consequently the wellhead pressure of the subsea wells must be high in order to assure the transport of the multiphase fluids produced by the wells to the processing platform. The solution for this problem is multiphase pumping or other artificial lift methods.

Multiphase pumping is a viable solution for various production scenarios and it is prefered instead any artificial lift method applied for pressure fluid boosting. Wellhead pressure is reduced and consequently the flow rate increases when the water cut increases or/and reservoir pressure decreases.

Gas lift may be also applied to boost the fluid pressure with good results but it requires the more and more gas as far as the reservoir pressure reduces and the water cut increases.

References

1. Beran, W.,T. – *On the Threshold – Subsea Multiphase Pumping*, Journal PT April 1995.
2. Falcimaigne, J., Brac, J., Charron, Y., Pagnier, P., Vilagines, R.- *Multiphase Pumping: Achievements and Perspectives*, Oil &Gas Science and Technology , Vol.57, No.1, 2002.
3. Elde, J.- *Advantages of multiphase boosting*, Gas Revue, 2005.

4. L e p o r c h e r, E., T a i a n i, S.- *Multiphase Pumping-The Lessons of Long- Term Field Testing*, paper SPE 30661 presented at the SPE Annual Technical Conference and Exhibition, Dallas, October, 1995
5. M a r t i n, A.,M., S c o t t, S. – *Modeling Reservoir/Tubing Interaction Identifies Best Candidates for Multiphase Pumping*, paper SPE 77500 presented at the SPE Annual Technical Meeting and Exhibition San Antonio september 2002.
6. S h i p p e n, M., S c o t t, S. – *Multiphase Pumping as an Alternative to Conventional Separation, Pumping and Compression*, Presentation at the 34th Annual PSIG meeting, Portland Oregon , October 2002.
7. W y b o r n, G.- *Multiphase Pumps Offer Alternative for Moving Wellheads Fluids*, Oil and Gas Journal, September 1999.
8. ***Technical Bulletin Framo Engineering , 2007.

Pompajul multifazic- o soluție pentru gestionarea presiunii într-un sistem de producție offshore

Rezumat

Sistemele de producție submarine sunt de obicei instalate în ape adânci şi foarte adânci cu condiții dificile de temperatură şi presiune. De asemenea, platforma de procesare de cele mai multe ori este localizată la o distanță de mai mulți kilometrii, iar elevația dintre sondele submarine şi platforma de procesare poate fi de câteva sute de metrii. În acest caz presiunea în capul de erupție al unei sonde trebuie să fie menținută la valori mari pentru a învinge contrapresiunea statică şi în consecință debitul sondei este scăzut.
Prin urmare, în lucrare se analizează pompajul multifazic şi metodele de liftare artificială aplicate la o sondă submarină pentru mărirea presiunii de curgere a fluidelor produse de aceasta. şi optimizarea parametrilor regimului de funcționare al sondei.