

# The Balance of Multi-phase Gathering and Transport Systems

*Cristian Nicolae Eparu*<sup>1,\*</sup>, *Sorin Neacsu*<sup>1</sup>, *Renata Radulescu*<sup>1</sup>, and *Alina Petronela Prundurel*<sup>1</sup>

<sup>1</sup>Petroleum-Gas University of Ploiesti, Faculty of Oil and Gas Engineering, Drilling, Extraction and Transportation of Hydrocarbons Department, Romania

**Abstract.** Natural gases are a mixture of hydrocarbons which are generally in a gaseous state. Due to the variation in transport parameters (pressure, temperature) and gas composition, there may be sectors where those appear in liquid state, the condensate. The paper presents a system for managing the quantities of fluids from a network in which the liquid state appears. Based on a simulator that includes flash computation, a physical balance of the transport or gathering network can be made.

## 1 Introduction

In the natural gas gathering or transport networks due to their composition and transport parameters (pressure, temperature) it is possible that liquid phase, the condensate, will appear. If it were to be separated on the offshore platforms and then sent separately through the pipes, it would be necessary to build a liquid transport network next to the gas gathering network, which would increase the cost. For this reason, it is preferable to transport the gases coming from the wells through a single network even if the liquid phase sometimes occurs.

This paper presents the management of a natural gas gathering network from an offshore field where the groups of wells are connected to the extraction platforms, the gathering network is submarine, and the gas enters the gathering network with parameters close to the wells production.

In order to manage this type of gathering networks we must determine the points in which the liquid phase appears, determine the volume of liquid and gas from separation. Condensation of a volume of gas into liquid phase changes the hydraulic parameters of the transport, but also the quantities of gas supplied [1-5].

From an economic point of view, the production obtained at the outlet points has two components, the gas and the condensate, each with its own price depending on its quality [6-7].

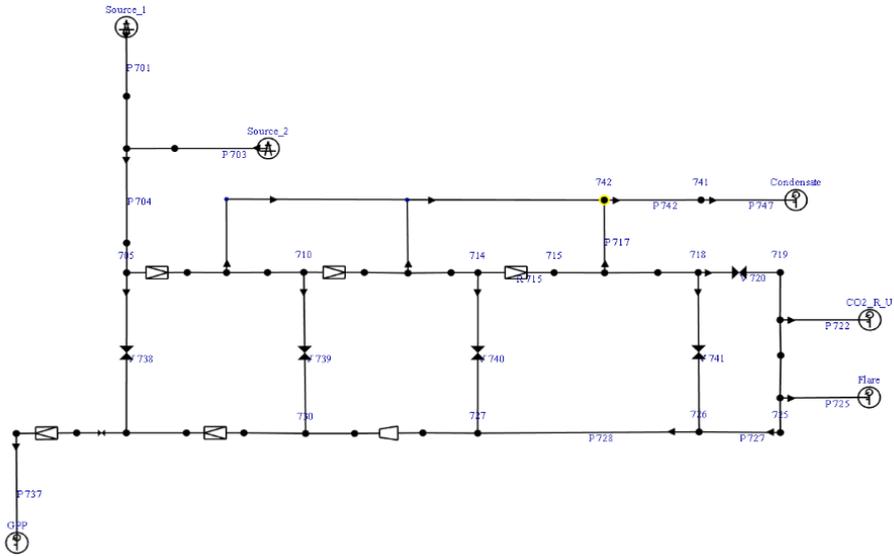
In this paper are presented the modalities of dynamic control of a gas network in which the liquid phase appears, so that, taking into account the production entering the transport network, it is possible to predict production over a certain period of time.

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\* Corresponding author: [cristian.eparu@gmail.com](mailto:cristian.eparu@gmail.com)

## 2 Presentation of the test network

In order to understand the phenomena that appears and to present the results we will use a simple network called test network. The simulations required to obtain the results were performed with the ADMODUNET simulator produced by NetGas R&D, and also with the company's permission to use this simulator.



**Fig. 1.** Test Network Graph.

Even if it is a simple network with a main transport direction, it is provided with command and control elements such as valves, regulators, compressors and separators. Network entries are made through the nodes Source 1 (node 701) and Source 2 (node 703). Figure 2 shows the parameters on the entry nodes.

CONSTRANT	IDDEV	DEVTYPE	TYPE	VAL	TYPE2
	545	NODE	PRESSOUT	74	7
	545	NODE	PRESS	74	
	701	NODE	FLOWIN	5	
	701	NODE	GRATE	268	
	701	NODE	LFRACT	0	
	701	NODE	LRATE	0	
	701	NODE	DENSG	0.8	
	701	NODE	YI	0.626193019	C1
	701	NODE	YI	0.069357025	C2
	701	NODE	YI	0.043045425	C3
	701	NODE	YI	0.011870652	IC4
	701	NODE	YI	0.009604539	NC4
	701	NODE	YI	0.003672484	IC5
	701	NODE	YI	0.002357482	NC5
	701	NODE	YI	0.002282263	C6PLUS
	701	NODE	YI	0.2196285	CO2
	701	NODE	YI	0.011988611	N2
	701	NODE	YI	0	H2O
	701	NODE	YI	0	MRC
	701	NODE	YI	0	HG
	703	NODE	FLOWIN	5	
	703	NODE	GRATE	394	
	703	NODE	LFRACT	0	
	703	NODE	LRATE	0	
	703	NODE	DENSG	0.8	
	703	NODE	YI	0.870579347	C1
	703	NODE	YI	0.04769549	C2
	703	NODE	YI	0.023906333	C3
	703	NODE	YI	0.006802451	IC4
	703	NODE	YI	0.004969027	NC4
	703	NODE	YI	0.001853198	IC5
	703	NODE	YI	0.001071129	NC5
	703	NODE	YI	0.001295267	C6PLUS
	703	NODE	YI	0.027423772	CO2
	703	NODE	YI	0.014403988	N2
	703	NODE	YI	0	H2S
	703	NODE	YI	0	H2O
	703	NODE	YI	0	MRC
	703	NODE	YI	0	HG

**Fig. 2.** Parameter of the entry nodes.

These two nodes represent two gas extraction platforms and data are from the SCADA system. One can noticed that there is no liquid phase at both entry points. The gas from the two platforms blends along the route and travels along a distance of 290km. Upon arrival in the terminal area they are adjusted to a certain pressure, to not damage the equipment. Due to the appearance of the liquid phase the terminal is equipped with 3 liquid separators. Depending on the gas quantities from each source and the totally different compositions, it is possible that condensation does not occur, and then the gas can bypass the entire terminal or parts of it through the four valves available. Also, due to the high CO<sub>2</sub> percentage of one of the sources that leads to damage to equipment and pipelines, there is a CO<sub>2</sub> Removal Unit in the terminal area which has the functionality to bring the CO<sub>2</sub> percentage below a certain limit imposed by the equipment used. Due to the multitude of processes in the terminal area there is also a flare area, where some of the residual gases are burned. The remaining gases, which meet the quality criteria, are then measured to be sent to the Gas Process Plant. On the route, as required, these can be adjusted or compressed. If not, these devices are bypassed.

### 3 Presentation and analysis of results

The ADMODUNET simulator allows you to perform dynamic simulations over various periods of time. For this case, the simulation is done over a 10-day period, but in this paper we will only analyse one day of this in order to be able to balance the incoming and outgoing fluids. Figures 3 and 4 show the flows and pressures for the two inputs.

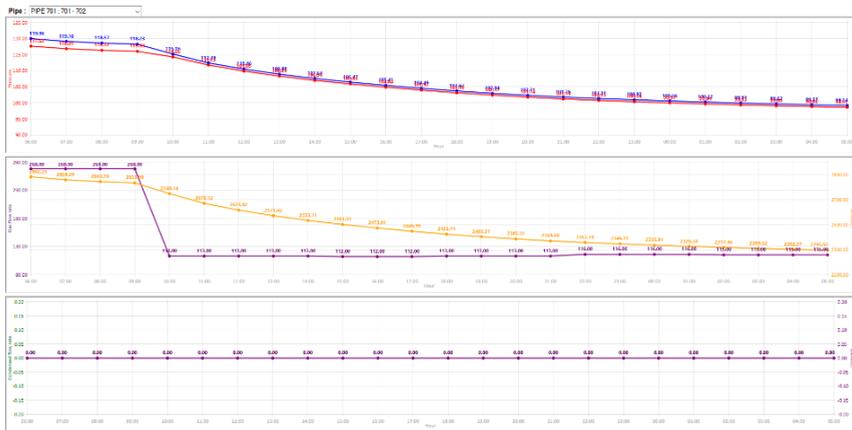


Fig. 3. Flow and pressure for Source 1 (Nod 701).

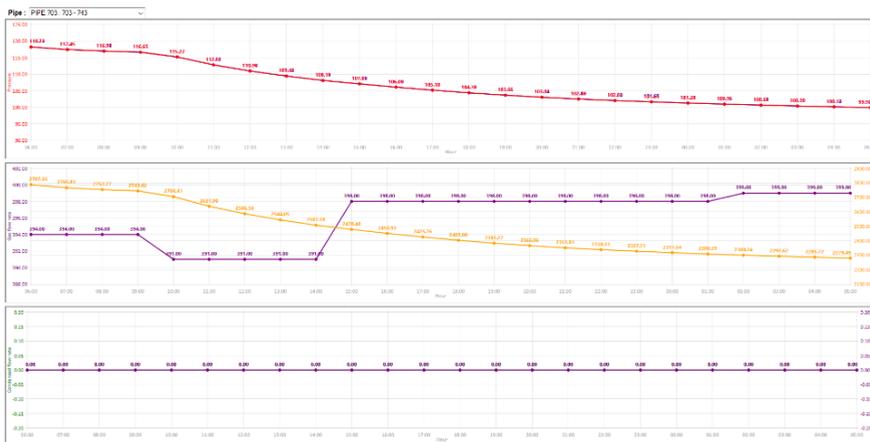
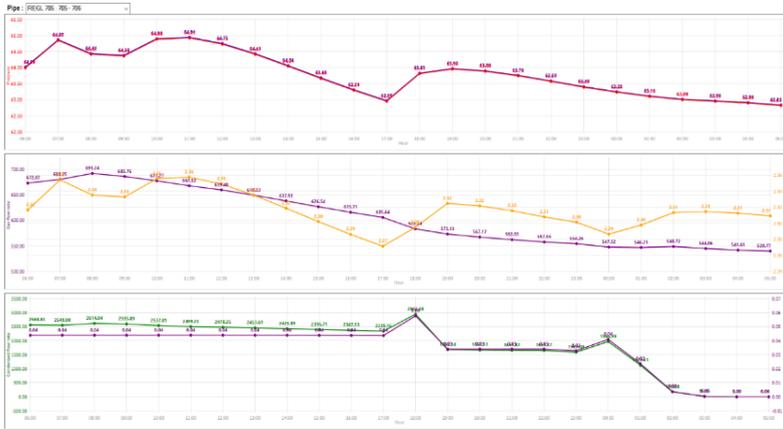


Fig. 4. Flow and pressure for Source 2 (node 703).

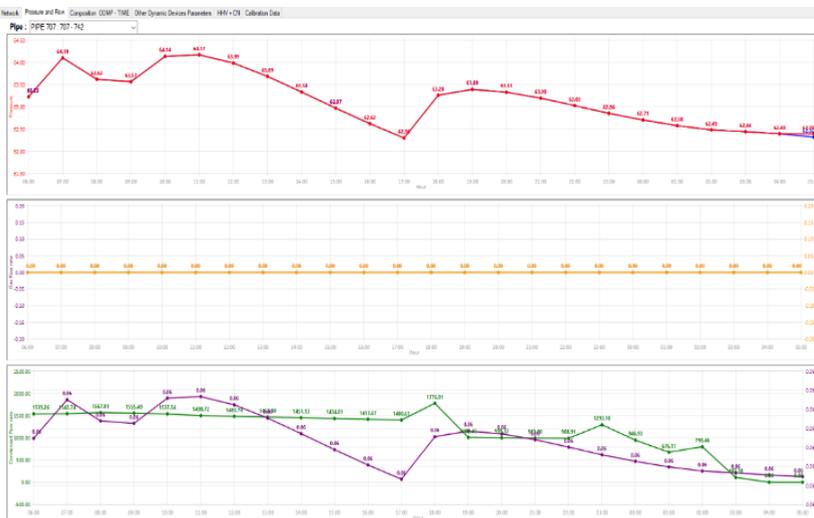
From the production platforms the gases are brought to the land terminal by passing through several hundreds of kilometres of piping which causes the pressure to drop, so that a part of the gas condenses to the inlet in the terminal, Figure 5-the liquid phase appears. The appearance of the liquid phase was deduced from the flash calculation [8-11]. Since the flow measurement is generally performed at the inlet and outlet points, it cannot be determined physically, by measuring the areas where the liquid phase occurs, the quantity and quality of the liquid phase. For this reason, it is necessary to use a dynamic performant simulator [12] which, based on the data from SCADA, can calculate at each point in the network the flow, pressure, composition and, if necessary, flow type - with one phase or several phases. In the test network one can noticed that in the conditions of the network load the gas entering the network condenses in the time, which is determined by online simulation.



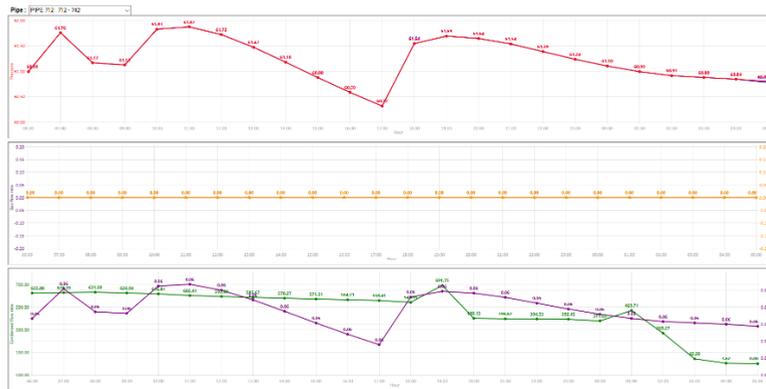
**Fig. 5.** Pressure and gas and condensate flow rate on regulator 705.

In order to deliver the gases, they must be separated from the condensate. In the network there are three cascade separators (slug catchers) in nodes 707, 712 and 716 having various efficiencies. Each separator has a conduit through which the condensate is extracted. These three pipes lead the condensate into a tank from where it is then sent to the refinery for processing.

Figures 6, 7, 8 show the dynamics of the condensate flows from the liquid phase outlets in the separator.



**Fig. 6.** Condensate pressure and flow at first separator (line 707).

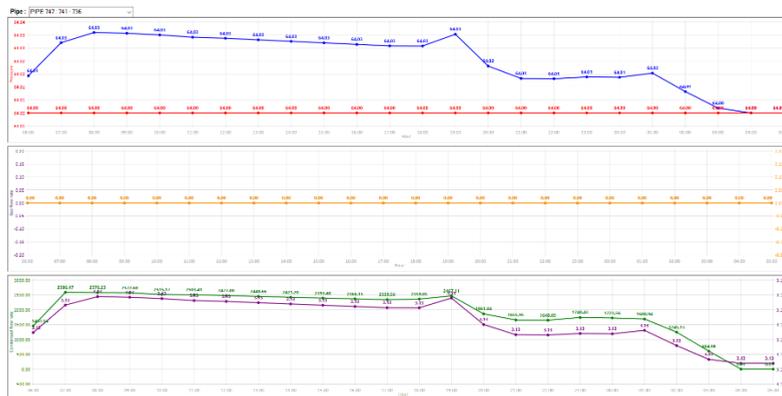


**Fig. 7.** The condensate pressure and flow rate at the second separator (line 712).



**Fig. 8.** The condensate pressure and flow rate at the third separator (line 716).

Due to pressure and temperature conditions in the network and due to the flows and the composition of the gases on the two entry points, from this network, on the day the tests were made, a total volume of condensate (on the 747 pipe) exit the network, in ranges from 2400 to 1600 Bbls/d. Figure 9 shows the condensate flow leaving the tank for processing and its dynamics for 24 hours.

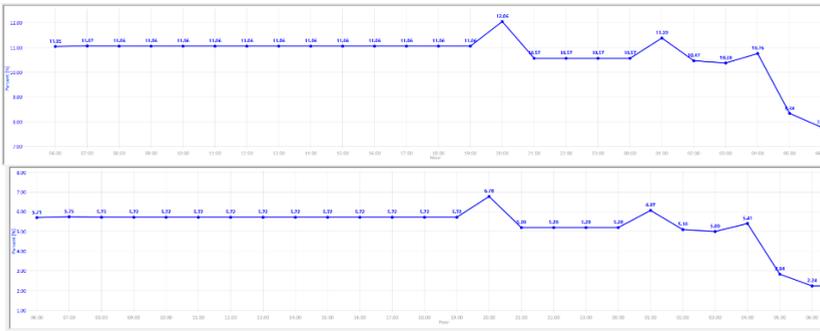


**Fig. 9.** Condensate pressure and flow rate on line 716.

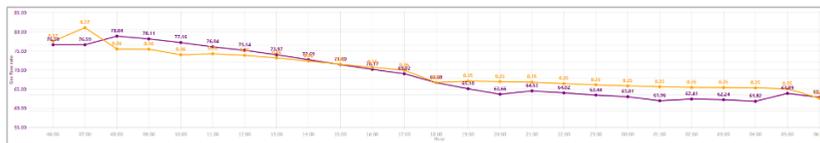
Besides the process of liquid phase separation in the test network, we also have a CO<sub>2</sub> Removal Unit. Its purpose is twofold: to produce CO<sub>2</sub> for use in various industrial processes and to minimize the percentage of CO<sub>2</sub> in the gas going further to the Gas Process Plant. This is because these Gas Process

Plants usually have a limitation for maximum percentage of CO<sub>2</sub> (or H<sub>2</sub>S if applicable) over which they cannot function due to high corrosion. Its purpose is usually to keep the CO<sub>2</sub> percentage below 6%.

Figure 10 shows the variation of the CO<sub>2</sub> component before and after the CO<sub>2</sub> Removal Unit, and Figure 11 shows the amount of CO<sub>2</sub> extracted from the system (purple line), which is the amount of the total fluid flow. In figure 11, besides the amount of CO<sub>2</sub> extracted from the system (purple line), the line pack of the outlet pipe (yellow line) is shown.



**Fig. 10.** The variation of CO<sub>2</sub> percentage before and after the CO<sub>2</sub> Removal Unit.



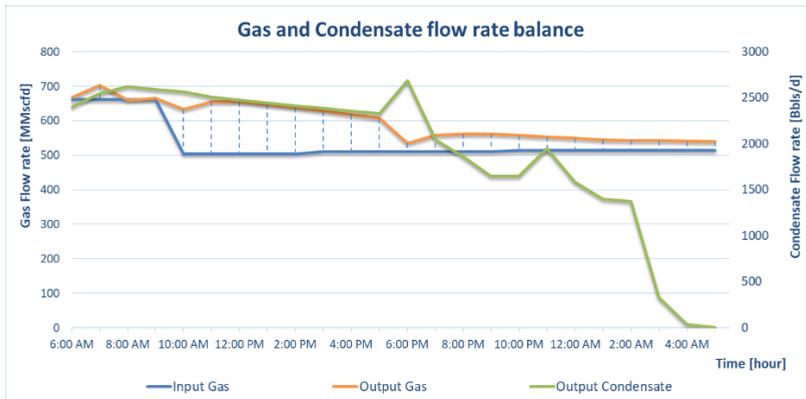
**Fig. 11.** Variation of extracted CO<sub>2</sub> flow rate.

After some further processes (flare, measurement, regulation, compression), the remaining gases are delivered through the 737 pipeline to the Gas Process Plant. Figure 12 shows gas supply pressure and 24-hour gas flow dynamics.



**Fig. 12.** Pipe gas pressure and gas flow 737.

As there are many points of entry and exit the network, some for gas and some for condensate, the dynamic balance of the network is very hard to do. Using the simulator, we can integrate the variation for all entry and exit point for a day in order to see the dynamic. The balance of the network is presented in figure 13.



**Fig. 13.** Entry-/exit points flow rate balance

As one can see the gas entry flow rate are lower than the gas exit flow rate for this day, even though some condensate is also produced. The variation are very different, thus making the balance very hard to complete.

### 3 Conclusions

In the gas gathering networks, and sometimes also in the transport, most often a liquid phase occurs due to the condensation of a quantity of gas. The biphasic composition separates at a time so that the gases can be delivered and the condensate separated.

The operation of collecting networks is based on SCADA data that provides the user with instantaneous values at the monitored points. Between these points, there are often pipes that can also have hundreds of kilometres. Integration of monitoring data is done with a dynamic performant simulator. Based on data from SCADA, it can quickly provide data across all network points along pipelines.

If the simulator contains the phase calculation module, he can predict the points in which the liquid phase appears and its evolution along the pipelines. This is very important because it is possible to predict the amount of condensate and gas that can be delivered by the network for the duration of production tracking (minimum 24 hours).

Due to the delay of the gas movement time to the output points, which depends on the parameters (pressure, flow, composition, adjustments due to operation) at that time, the gas and condensate output values are not synchronized with the inputs, which would make it impossible to balance the network. The use of such software helps to calculate the balance of incoming and outgoing fluids dynamically.

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