

# Correlation of Gas Quality with Hydrodynamic Parameters in Transmission Networks

*Cristian Nicolae Eparu*<sup>1,\*</sup>, *Sorin Neacsu*<sup>1</sup>, and *Adrian Neacsu*<sup>2</sup>

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

<sup>2</sup>Petroleum-Gas University of Ploiesti, Faculty of Mechanical Engineering, Mechanical Engineering Department, Romania

**Abstract.** Natural gases are a mixture of hydrocarbons. Their composition determines the basic variables that need to be taken into account in the calculation of transport or gathering systems. In the daily operation of gas gathering and transport networks, the available composition measured by online systems is reduced. In the usual composition a pseudo-component called C6+ (or C7+) is used. If this component is defined from the complete chromatograph analysis of gas, the properties are established through a lumping procedure. Online chromatographic analysis is done on a small group of basic components, usually for heavy components by introducing a pseudo-component, in this paper called C6+. In this paper we will show how to determine the properties of the pseudo-component according to the measured density of the mixture and its dynamics through the network. Generally, transport networks operators are interested in operating them so as to maximize the benefit and reduce any penalties. For this they have SCADA systems, which provide information on transport parameters and gas quality at the monitored points. The overall picture of the network and its short and medium-term evolution is achieved with a powerful simulator. Managing the gas quality from the entry points to the exit points must be made dynamically by the simulator. In this paper we will present results obtained with the ADMODUNET simulator produced by NetGas R&D based on the company's agreement.

## 1 Introduction

Gas quality is essential in determining the price of gas. As everyone knows, natural gas is a mixture of hydrocarbons containing a small percentage of nitrogen, carbon dioxide, hydrogen sulphide, water vapour [1 - 3], but also other components specific to the reservoir from where the gas is extracted.

The high weight in the mixture is the light hierarchy up to C6, the dominant component being C1 (methane). The composition of natural gas is closely related to the caloric power, the constituent element of the price.

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

In a transport network the gases come from several sources with different compositions, they mix in the network resulting in composition on the output points [4 - 5], compositions that determine the delivery prices. In order to efficiently manage the network, both from the hydraulic point of view (pressures, flows) and from the point of view of the gas quality, the network operation must be based on data from SCADA processed on line with a state of the art network simulator so that it is known in each point of the network the hydrodynamic parameters and the quality of the gas [4, 6].

The quality of the gas in the network is established at the entry points. Their composition is determined by online chromatographs and generally includes light components up to C6 and non-hydrocarbon elements, carbon dioxide, nitrogen, sulphur dioxide, etc [3, 7].

Heavier hydrocarbons (C7, C8, ...) are usually grouped into a pseudo-component called C6+. This makes it easier to manage natural gas composition through the network.

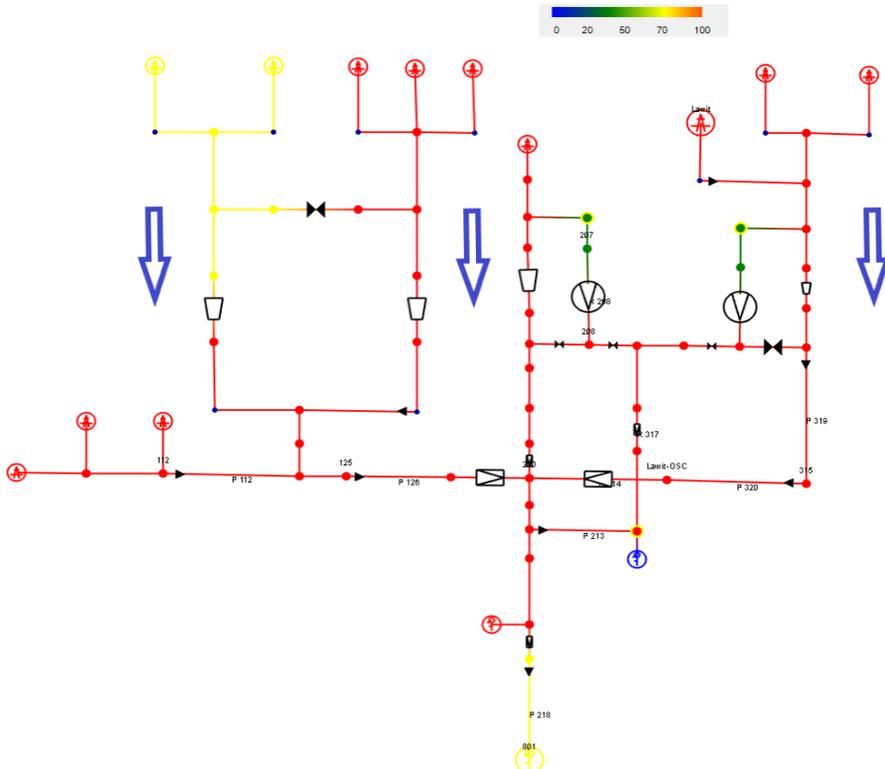
The properties of pseudo-component C6+ are determined at each point of entry based on gas density [1], so we have several pseudo-components C6+, one for each point of entry.

In the nodes of the network, gases mix there resulting in the fact that the properties of these pseudo-components change.

In this paper are presented the steps of managing the C6+ components from the network input to the output nodes.

## 2 Calibration of composition at network entry nodes

The material presented in this paper will be accompanied step by step by edifying examples on a portion of a transport network. Figure 1 shows the network on which calibration and composition dynamics will be presented.



**Fig. 1.** Chart of Test Network.

In the network from Figure 1, input nodes 101, 102, 104, 105, etc. are easily observed. Data on inputs contains values of hydraulic parameters and gas composition on the respective input.

For the "101" entry point, the hourly parameters that come from the SCADA are shown in the Figure 2.

CONSTRAINT				
IDDEV	DEVTYPE	TYPE	VAL	TYPE2
101	NODE	FLOWIN	5	
101	NODE	GRATE	50	
101	NODE	LFRACT	0	
101	NODE	LRATE	0	
101	NODE	DENSG	0.926	
101	NODE	YI	0.767047	C1
101	NODE	YI	0.105196	C2
101	NODE	YI	0.05105	C3
101	NODE	YI	0.012406	IC4
101	NODE	YI	0.012911	NC4
101	NODE	YI	0.004451	IC5
101	NODE	YI	0.002393	NC5
101	NODE	YI	0.003874	C6PLUS
101	NODE	YI	0.032003	CO2
101	NODE	YI	0.008669	N2
101	NODE	YI	0	H2S
101	NODE	YI	0	H2O
101	NODE	YI	7.70E-06	MRC
101	NODE	YI	0	HG

Hydraulic parameters

density

gas composition

**Fig. 2.** Hydraulic parameters and gas composition for the 101 entry point.

C6+ appears in the component list, but its properties must be correlated with the gas density value [3, 5]. We specify that it is the standard density ( $p_s = 1.01325\text{bar}$ ,  $T_s = 288.15\text{K}$ ). Using the composition with the component parameters a standard density of formula (1) can be calculated [2]. Parameters of this formula, density at normal state and molecular weight, are detailed in formulas (2) and (3).

$$\rho_s = \rho_N \frac{T_N}{T_s} \tag{1}$$

$$\rho_N = \frac{Mg}{22.414} \tag{2}$$

$$Mg = \sum_{i=1}^{Nc} y_i M_i \tag{3}$$

The condition that enforce calibration is presented in relation (4), where  $\rho_{\text{measured}}$  represents the value of gas density at the entry point and  $\rho_{\text{calculated}}$  represents the value of the standard density calculated using the molecular weight of the C6 component.

$$\rho_{\text{measured}} > \rho_{\text{calculated}} \tag{4}$$

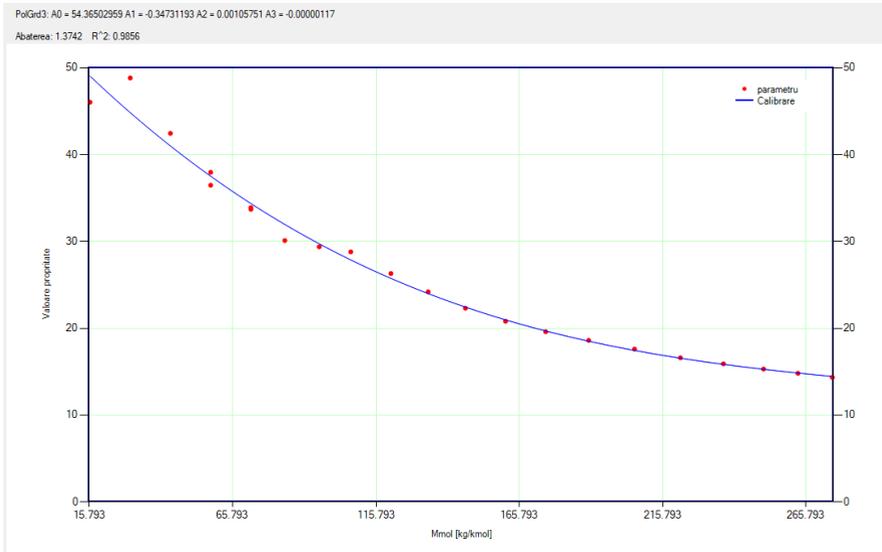
Calibration represents the determination of the molecular mass of the C6+ pseudo-component provided the two densities are equal.

$$\rho_{\text{measured}} = \rho_{\text{calculated}} \tag{5}$$

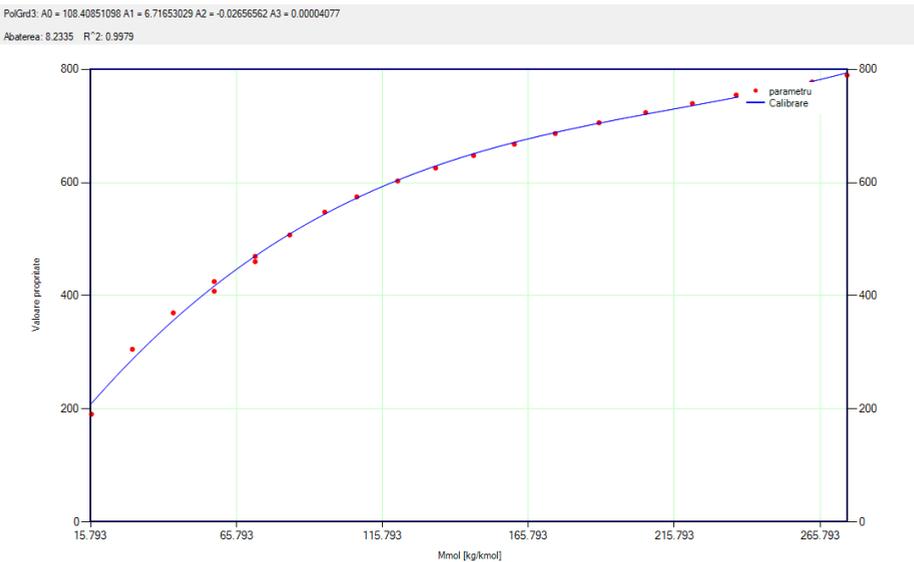
Based on the condition (5) using the relation (6), the molecular weight of the C6+ component can be calculated.

$$M_x = \frac{(\sum_{i=1}^{Nc} y_i M_i - \sum_{i=1, i \neq C6+}^{Nc} y_i M_i)}{y_{iC6+}} \tag{6}$$

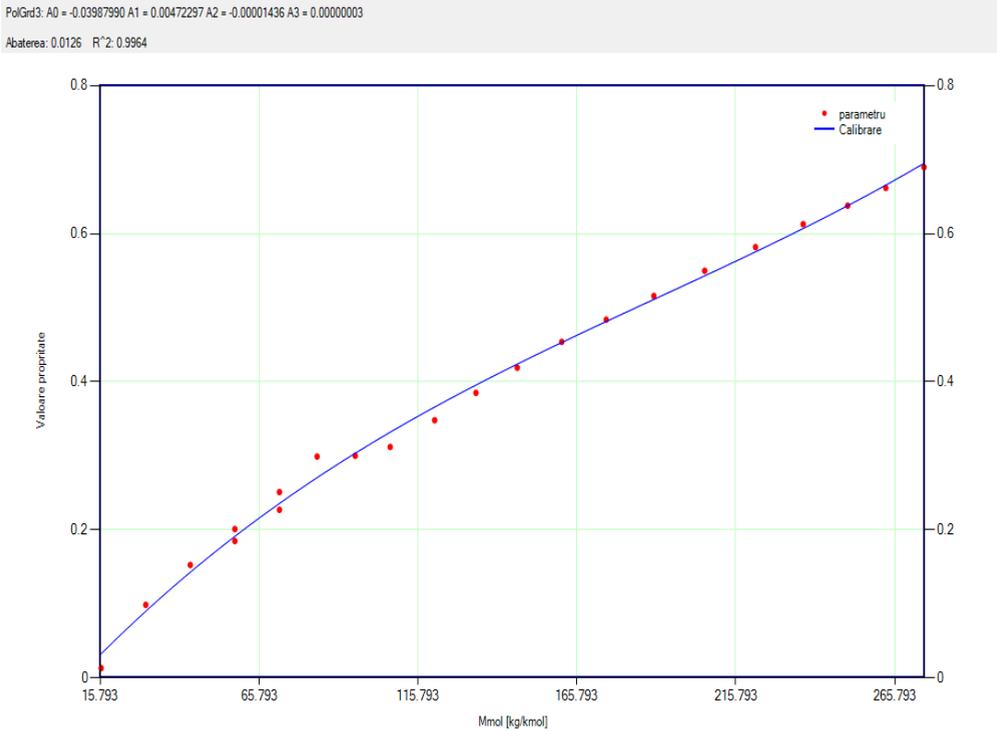
Once the molecular mass of this component has been determined, the properties: critical pressure, critical temperature and acentric factor have to be determined [8]. These properties were determined by numerical methods. For each property one function was generated through regression. Depending on the molecular mass of C6+ at a given moment the property value can be determined.



**Fig. 3.** Function for the critical pressure of the C6+ pseudo-component.



**Fig. 4.** The critical temperature function of pseudo-component C6 +.

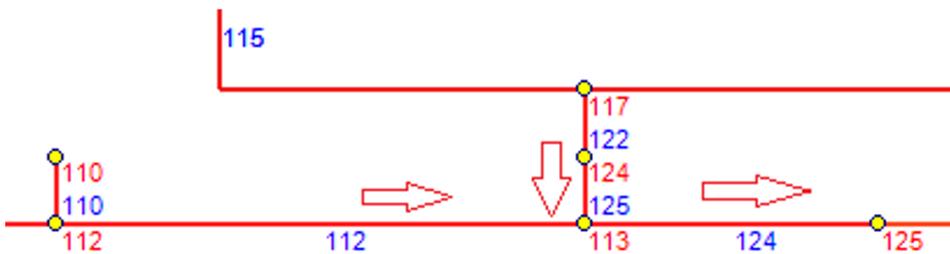


**Fig. 5.** The critical temperature function of pseudo-component C6 +.

### 3 Particularities of the process of blending in nodes

In the nodes of the network, the process of mixing the gas streams takes place. Generally, each gas flow enters the node with a specific composition and a specific C6 + pseudo-component. In the node, the mixing process is calculated based on the mass conservative law [4, 6].

To exemplify the mixing in nodes with the dynamic management of the properties of pseudo-component C6 +, node 113 of Figure 6 has been chosen.



**Fig. 6.** Detail for node 113 (red).

In this node the gas flows are as follows: from the pipes 112 and 125 (with blue) the gases enter the node, mix and leave the node through the pipe 124. The 24 hour evolution of the molecular weight for the C6 + pseudo-component for the inlet and outlet ducts from node are shown in Figures 7, 8 and 9.



Fig. 7. Dynamics of molecular mass of C6+ pseudo-component on line 112.

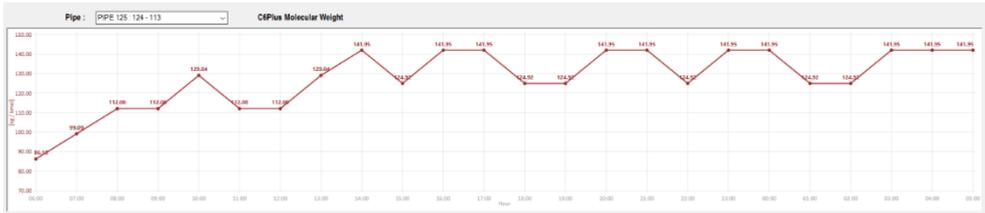


Fig. 8. Dynamics of the molecular mass of the pseudo-constituent C6+ on the conduit 125.



Fig. 9. Dynamics of the molecular mass of pseudo-component C6+ on the line 124.

## 4 Gas quality and management of pseudo-component C6+ on exit nodes

Gas quality has an influence on hydraulic parameters [3, 7], but the most important influence is economic because it directly affects gas prices. Figure 10 shows one of the gas exit point from the test network. It can be seen that on the line 218 the gas flow is constant at 1192 MMscfd at 64.56 bar (Figure 10). However, the quality of the gases varies over time, see Figure 11.

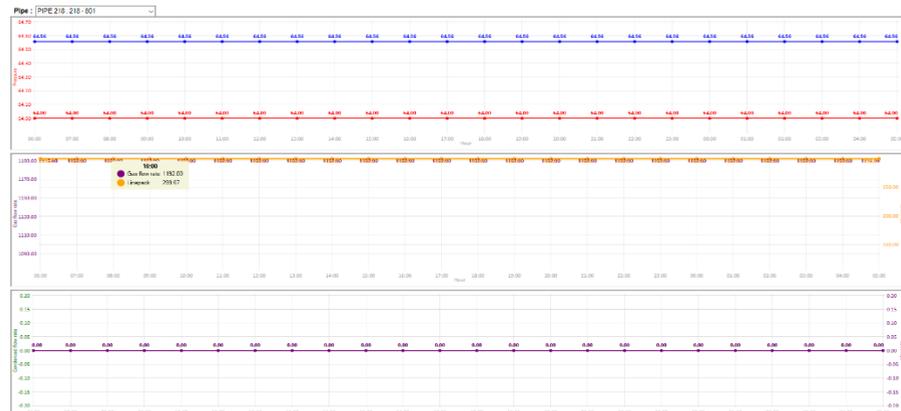
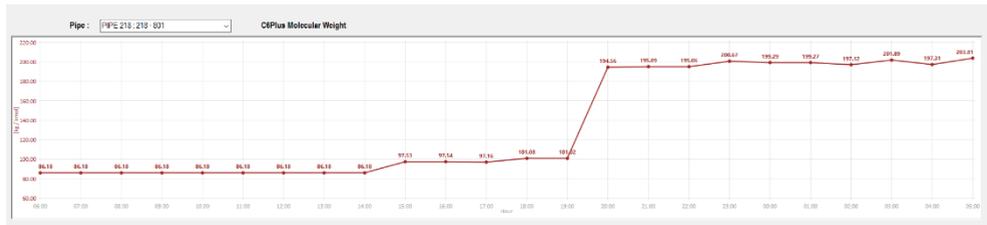


Fig. 10. Gas flow on the outlet pipe 218.



**Fig. 11.** Molecular weight of pseudo-component C6 + on the outlet pipe 218.

The gas flow dynamics on line 218 can be observed. The propagation of the gas from the network entry points to the exit points, depending on the gas velocities on the pipes, causes the molecular mass of the C6 + pseudo-component to reach the calibrated value only at 19 o'clock.

## 5 Conclusions

Permanent tracking of gas quality in transport networks has become a necessity because it is directly related to gas prices. The data required for the operation and monitoring of transport networks come from SCADA and represent momentary values in a limited number of points. In order to have a complete picture of the parameters on the entire network it must be operated with a dynamic performance simulator.

The quality of gas is usually determined when entering the network using online chromatographs. In order to manage real-time gas composition in the network, a limited number of components (the most important) are usually used. Heavy (high molecular mass) components concentrate through a lumping process in a pseudo-component more manageable. In this paper the pseudo-component is C6 +.

The properties of the pseudo-component are determined at the entry points by a calibration process and altered at each node by the gas flow blending. This paper presented a complete flow of dynamic management of gas parameters from a natural gas transmission network.

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