| BULETINUL<br>Universităţii Petrol – Gaze din Ploieşti | Vol. LXVI<br>No. 2/2014 | 47 – 54 | Seria Tehnică |
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# Analysis of a Collecting – Adduction System of an Underground Gas Storage

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## Abstract

*This paper presents the realization of a model for the collecting and adduction network for a natural gas storage, capable of being coupled by boundary conditions to the collector and to the transportation network. The model for the gas collecting network is performed using Simone simulator and has the power of shaping a non-stationary flow through the transportation network. This is necessary because the gas flow rates for each day , vary based on customers' needs. The collecting network model reflects the reality from the ground level and it is built based on GIS data concerning the dimensions of the pipe.*

**Key words:** *gas, collecting, network, model, simulation*

## Introduction

The processes of storage-extraction from a gas field are complex processes involving high energy consumption. The purpose of the gas collector is to allow the accumulation of a large quantity of gas in the hot season, so it can be used in the cold season.

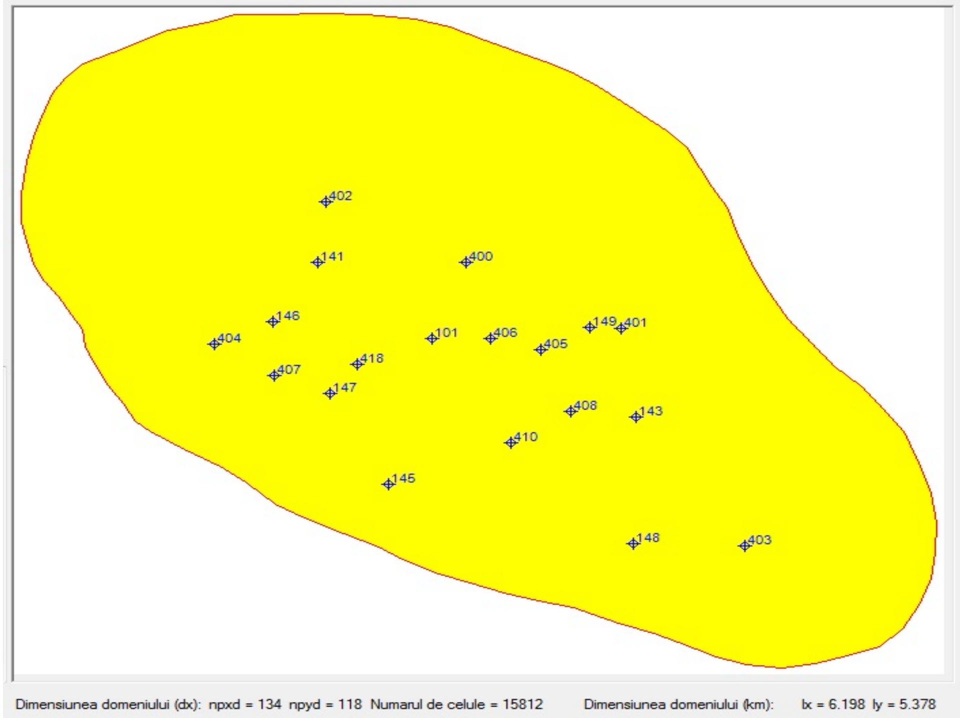
Making a complete numerical model which includes the gas field and the local transportation network is particularly useful because it allows simulation of storage / extraction processes, taking into account all the restrictions. Based on the model the nomination can be checked and the program for injection / extraction for "tomorrow" can be defined.

## Description of the Collecting Network Model for Gas Storage

Using the local collecting network the network was defined as formed by adduction pipes linking the wells to the collecting points (groups) and the collecting pipes to the points of delivery / receipt of gas from the national transport system (NTS). Figure 1 shows the schematic diagram of the gas deposit and well locations, and Figure 2 shows the flow diagram of the local collecting network for gas deposit.

The analyzed network is made up of a compression station, 5 groups of wells, 8 collecting pipes, 19 adduction pipes and 19 wells.

To create a collecting network model it was used a numerical simulator, Simone, which takes into account the network configuration and the dynamic of the storage processes. In the working scenarios defined in the program are listed some constraints due to the unsteady flow of gas in the national transportation system.



Dimensiunea domeniului (dx): npxd = 134 npyd = 118 Numarul de celule = 15812 Dimensiunea domeniului (km): lx = 6.198 ly = 5.378

**Fig. 1.** Location of wells in the gas deposit

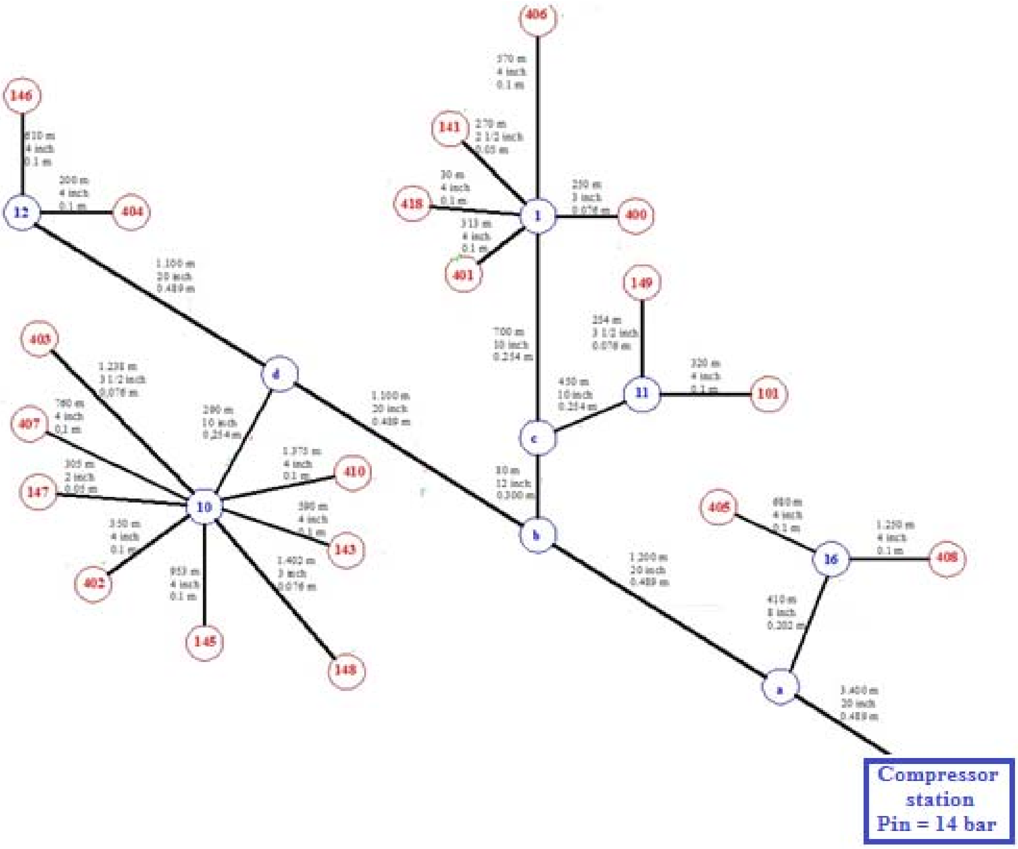


**Fig. 2.** The diagram of collecting pipes in the local network

An important constraint that arises in the operation of the gas deposit is the limited transport capacity of the collecting network. The flow rates injected/extracted into/from the gas deposit/

field should not exceed the transport capacity of the collecting network.

The model created using Simone includes a compression station, 30 pipes, 20 regulators, a gas supply represented by a main transmission line (TNS) and 19 exit points (the wells).

Figure 3 presents the model developed in Simone, similar to the technological scheme presented.

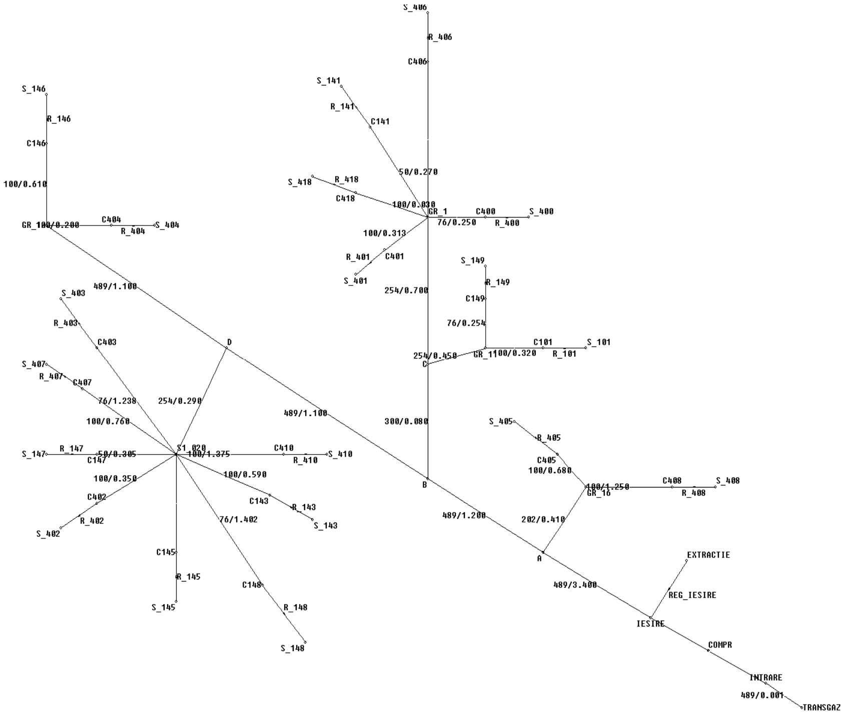


**Fig. 3.** The model of the network for injection into the deposit

The compression station has to raise the pressure of the gas taken from the TRANSGAZ pipes to a pressure which allows its introduction into the gas deposit. Before entering the well, and exit the collecting system, regulators are mounted to allow setting the parameters for injection.

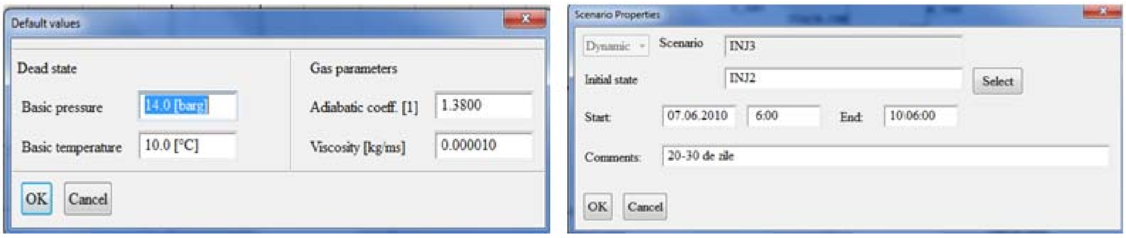
These parameters result after the calculation of the injection of the gas into the gas deposit and depend on the configuration of the well (diameter, length) and on the properties of the reservoir/ deposit in which is injected (permeability, porosity, deposit pressure around the well).

## Creating Injection Scenarios into the Deposit

Transportation processes performed through the collecting network are simulated using scenarios. This is done with specific tools available to the user of the Simone simulator.

After building the network model, the next step is to create simulation scenarios. For gas injection into the deposit, dynamic scenarios are used. Each scenario lasts 10 days, and the following scenario is based on the parameters resulted in the simulation at the end of the previous scenario. A complete injection cycle consists of all the 10-days scenarios of each process. The 10 days limit is given by the multitude of data entered in the scenario and the computing possibilities of the software and of the computer.

When creating scenarios for introducing gas into the storage the first step consists of the initial parameters of the gas in pipelines NTS (fig. 4). The figure also presents a scenario setting mode. It is noted that INJ3 scenario is dynamic, starting from the end of the script INJ2, has the start date 7.06.2010, 6:00 and stretches over 10 days. Because it is a gas day, this begins at 6:00 o' clock. All together one can see that the script INJ3 represents the period between the 20th and the 30th injection day.



Basic pressure 14.0 [barg]
Basic temperature 10.0 [°C]
Adiabatic coeff. [1] 1.3800
Viscosity [kg/ms] 0.000010

Scenario INJ3
Initial state INJ2
Start: 07.06.2010 6:00 End: 10:06:00
Comments: 20-30 de zile

**Fig. 4.** Setting the initial parameters of the gas and injection scenario

The way of setting the boundary conditions for each element is presented in Table 1. Although it is only a part of the scenario, it can be seen the input pressure provided to the well, placed on the regulator and the flow injected through each probe for every day of the simulation and the inlet pressure of the gas from the NTS and the compressed gas pressure for the injection.

**Table 1.** Setting boundary conditions

| | | | | | |
|---|---|---|---|---|---|
| 6:00 | R_402 | CV Control valve | SPO Output pressure setpoint | 43.831 | barg |
| 6:00 | S_147 | NO Node | Q Supply/Offtake | 104078 | Nm³/d |
| 6:00 | TRANSGAZ | NS Supply node | PSET Set pressure | 14 | barg |
| 1\06:00 | R_148 | CV Control valve | SPO Output pressure setpoint | 38.841 | barg |
| 1\06:00 | R_149 | CV Control valve | SPO Output pressure setpoint | 42.724 | barg |
| 2\06:00 | S_145 | NO Node | Q Supply/Offtake | 74322 | Nm³/d |
| 2\06:00 | S_146 | NO Node | Q Supply/Offtake | 131658 | Nm³/d |
| 3\06:00 | COMPR | CS Compressor station | SPO Output pressure setpoint | 58 | barg |
| 3\06:00 | R_101 | CV Control valve | SPO Output pressure setpoint | 56.246 | barg |
| 3\06:00 | S_406 | NO Node | Q Supply/Offtake | 155556 | Nm³/d |
| 3\06:00 | S_407 | NO Node | Q Supply/Offtake | 216865 | Nm³/d |

An important element in this model is the compression station. After running the scenario, one can see in Figure 5, the pressure before the station (from the pipes NTS) - gray color and outlet pressure of the gas station – red color. This variation of the pressure concerning the compression, leads to major variations of short duration of the compressed flow. Thus, in Figure 6 one can see the variation of flow passed through the compression station dictated by pressure variation.

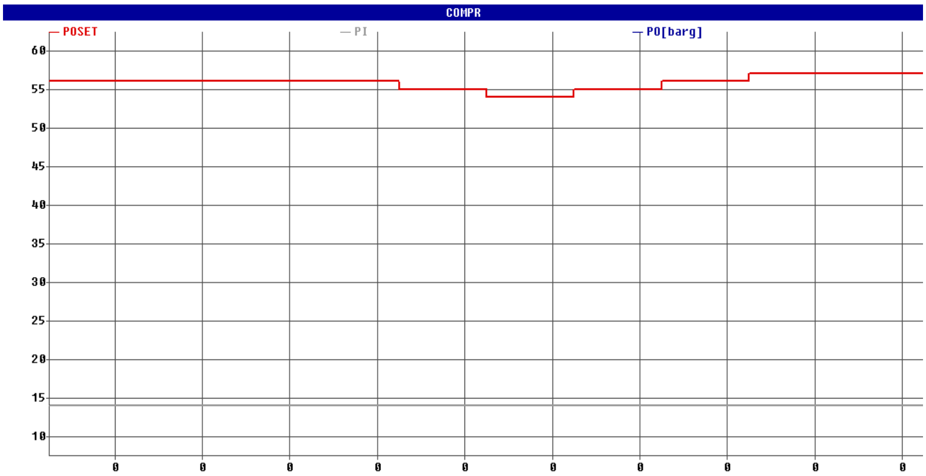


**Fig. 5.** Pressure variation at the compression station

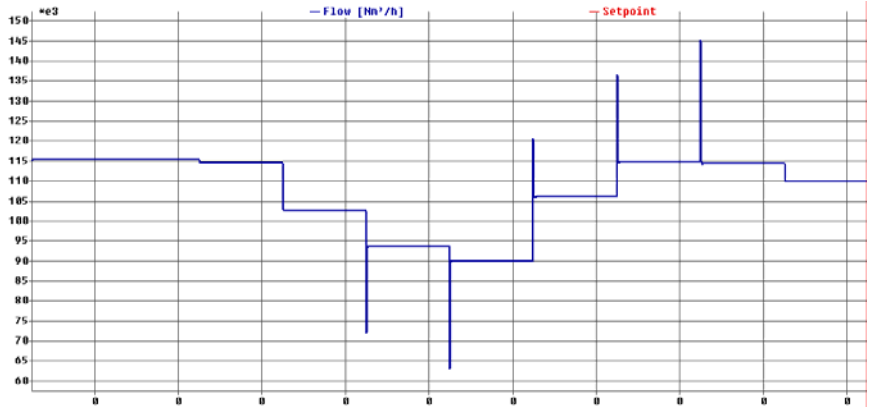


**Fig. 6.** Variation of the compressed flow

For a more complete picture of the phenomena, Figure 7 shows a detail of a pipeline pressure variation (gray – input, blue – output) and Figure 8 shows the equivalent of this variation in terms of flow crossing the pipeline.

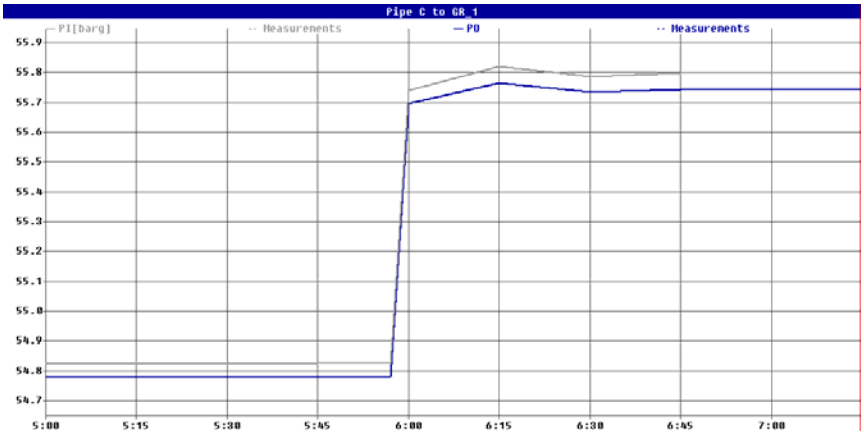


**Fig. 7.** Pipeline pressure variation

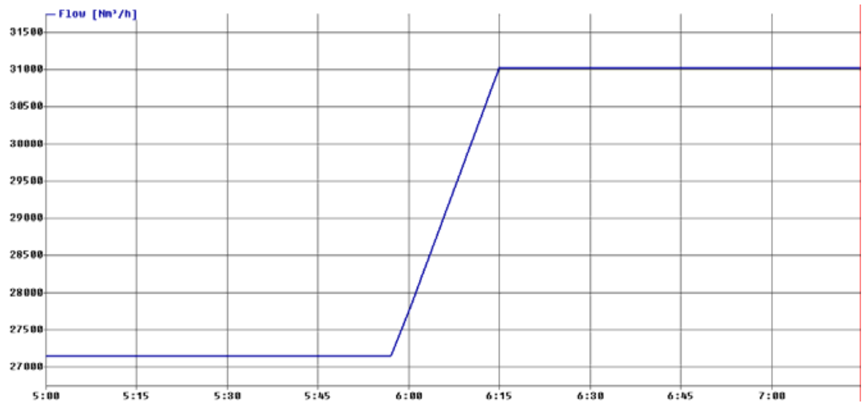


**Fig. 8.** Pipeline flow variation

Before entering the well, the gas pressure is reduced with the regulator until it reaches the injection pressure in the reservoir/ deposit (fig. 9 – red line). The injection pressures in the deposit are taken from the deposit model (fig. 10), which define them on the basis of the flow that has to be injected (fig. 11) and the pressure in the deposit in the area of the well in question.

Flows and pressures injected daily in the wells are boundary conditions for the gas deposit model. It simulates the storage process (gas injection into the reservoir/ deposit) computing for each day the pressure field from the reservoir , the spatial distribution of gas volumes injected and the cumulative injected.

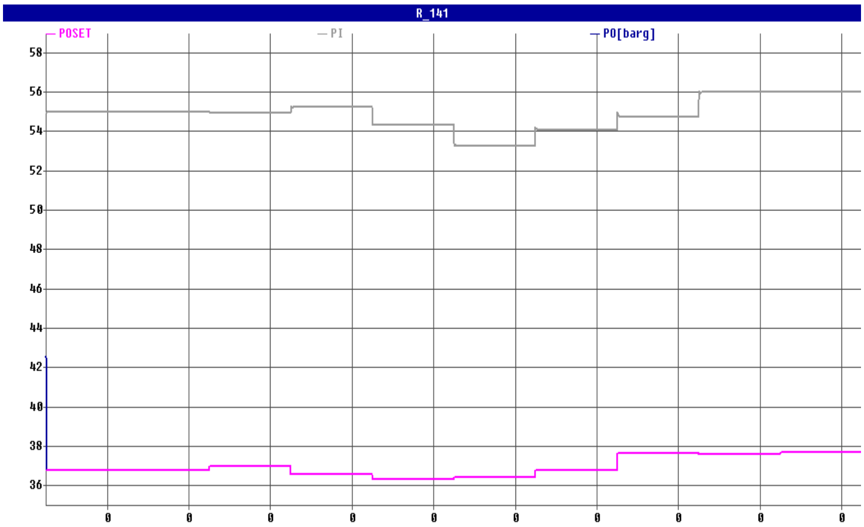


**Fig. 9.** Pressure variation on the well regulator ( nozzle)

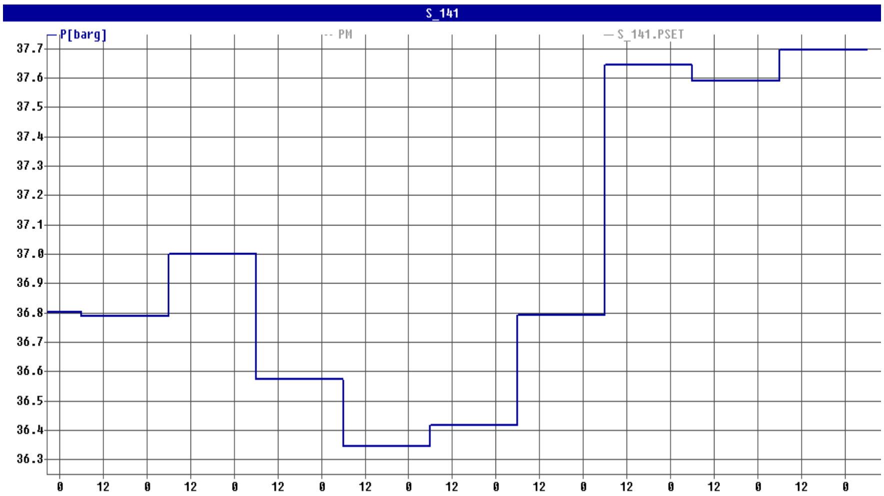


**Fig. 10.** Injection pressure variation into the well

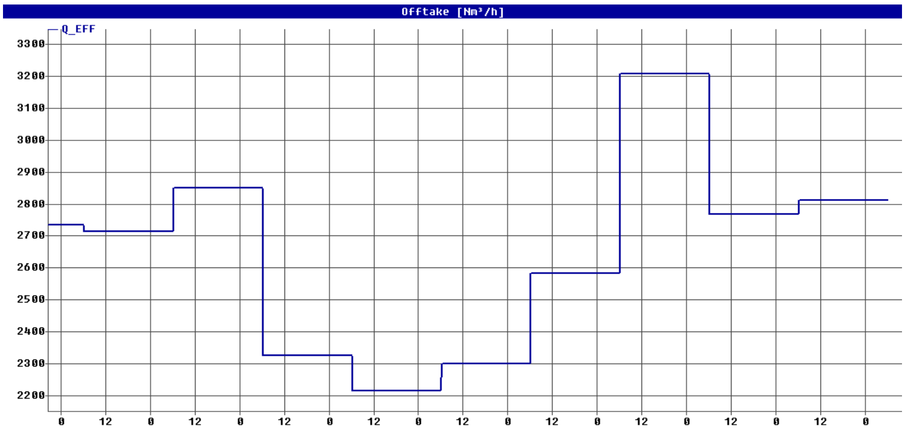


**Fig. 11.** Injected flow variation into the well

It is easy to see from the figures 10 and 11 that the change of injected flow into the well causes the variation of the injection pressure. Daily injected flows are based on nominations accepted by the carrier/ transporter and on the capacity of the collecting network. Figure 12 shows the flows passing through the network at a given time to the storage of gas into the underground storage in color codes.

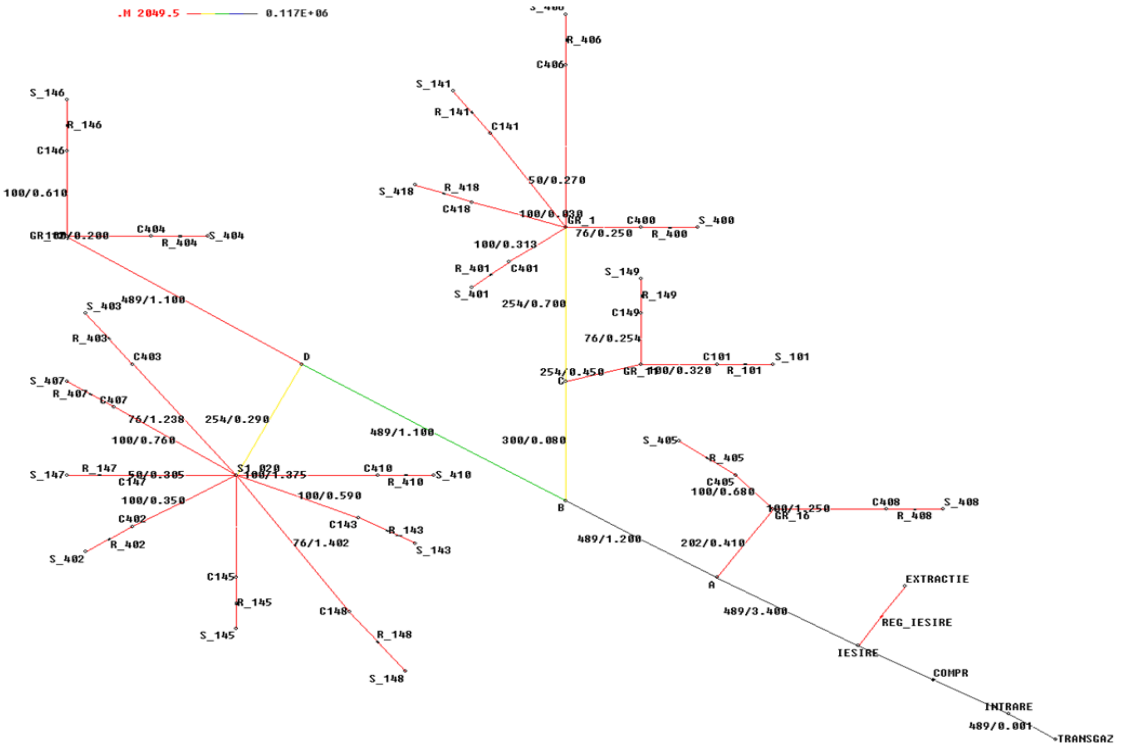


**Fig. 12.** Flow variation into the network after 20 days

## Results

The numerical simulator helped us to define the regulations/ settings used daily for operating elements ( controllers, valves , compression station ) so that the collecting network provide gas transportation from the compression station to the well, with adequate pressure for injection phase and reverse for the extraction phase.

Dynamic collecting network model for field/ deposit gas is able to simulate complete cycles of injection / extraction in real conditions.

The collecting network model is useful for the tracking phase of its behavior. Tracking is done through simulations performed with data from SCADA (Supervisory Control and Data Acquisition) at short intervals (eg. hourly) and comparing the results with the expected values. In case of value differences or trends of development other than those projected, quick simulation are made in order to obtain the corrections needed to be applied to meet the previously defined program.

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# Analiza unui sistem de colectare-aducțiune a unui depozit subteran de gaz

## Rezumat

*Lucrarea prezintă realizarea unui model aferent unei rețele de colectare și aducțiune pentru un depozit de gaze naturale, capabil a fi cuplat prin condițiile la limită cu zăcământul şi cu rețeaua de transport. Modelul rețelei de colectare este realizat cu ajutorul simulatorului Simone şi are capacitatea de a modela curgerea nestaționară prin rețeaua de transport. Acest lucru este necesar deoarece debitele de gaze, pentru fiecare zi, variază în funcție de necesitățile clienților. Modelul rețelei de colectare reflectă realitatea din teren, este construit pe baza datelor GIS privind dimensiunile conductelor.*