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Experimental Research Regarding the Dynamics of Temperature Field around Buried Pipes for Viscous Oil Transport

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Abstract

In this paper are shown the research regarding the dynamic of temperature field around a buried pipe through is transported a viscous oil. The results are obtained with the experimental stand build in Thermodynamic laboratory of Petroleum and Gas University from Ploieşti.

Key words: *transport, temperature, ground, viscous, oil*

Introduction

In viscous oil transport, mostly in the cold season, various difficulties appear due to the viscosity drop along with the temperature, and the congealing phenomenon can be observed in paraffinic oil.

A solution in use for the transport of viscous oil consists in its heating to 40^{o}C up to 70^{o}C with the purpose of viscosity drop and the transport, in non-isothermal state, through pipes buried in the ground at 1m depth.

In this type of transport, the energy consumption is higher, because of the energy that is consumed for heating the oil beside the necessary pumping energy. During the transport process the temperature of the oil drops due to heat losses in the soil. The heat exchange process between the oil and the soil through the pipe is a complex phenomenon that requires a detailed study.

An experimental stand was built in Thermodynamic Laboratory of Petroleum and Gas University from Ploieşti for the study of this phenomenon.

Description of the Experimental Station for Measuring the Field Temperature

For the study of oil transport process in non-isothermal state an experimental stand was built, whose figure is presented in image 1.

This stand is composed of two tanks of 1m^3 capacity each. One of these tanks is provided with a heating system. The two tanks are bound through a 1” diameter, 60m long steel pipeline.

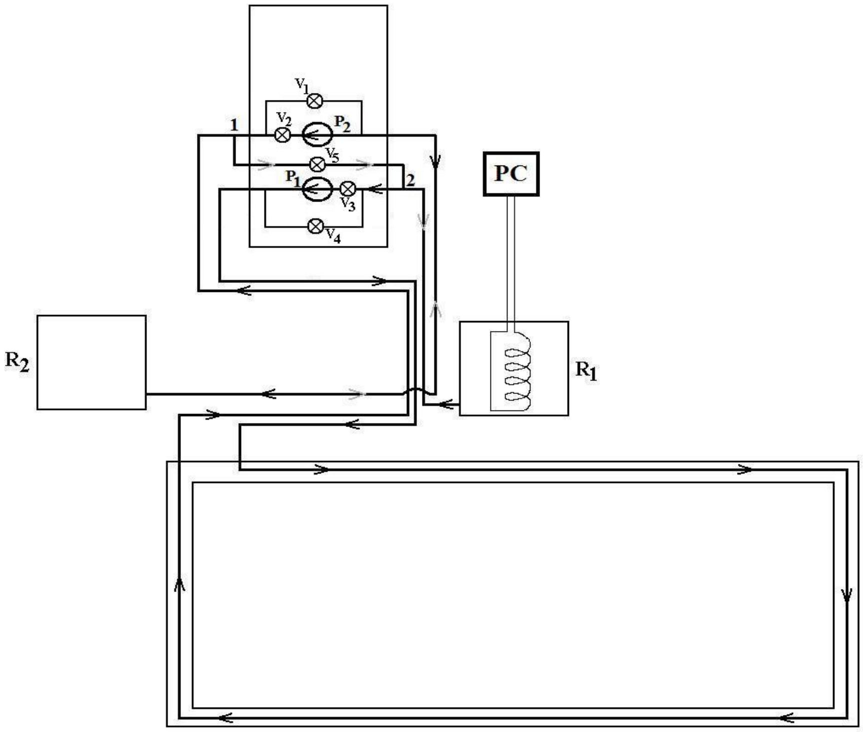

Fig. 1. Experimental stand for oil transport process

Fig. 2. Black insulated pipe buried at 1 meters

The transport pipeline is buried at 1 m depth.

The heat exchange between oil and soil is a complex phenomenon. Thus, the heat crosses by convection from oil to the pipeline wall, then by conduction through the pipeline wall and by insulation to the soil.

In soil, around the pipeline, the heat is dissipating by conduction. According to Fourier law, the heat flow absorbed by soil is proportional with the soil conductivity and the derivative temperature field at the pipeline wall.

Fig. 3. The two tanks of the experimental stand

Since the heat diffusion process around the pipeline is a slow process in time, the local measure of derivative thermal field at the pipeline wall is modified at the same time with the modification of temperature field from the soil.

The direct consequences of this phenomenon consist in the variation of heat quantity, lost by the oil in space, along the pipeline in time.

In order to measure the temperature field, we inserted temperature transducers in the soil. In figure 4 the temperature transducers arrangement around the pipeline are presented.

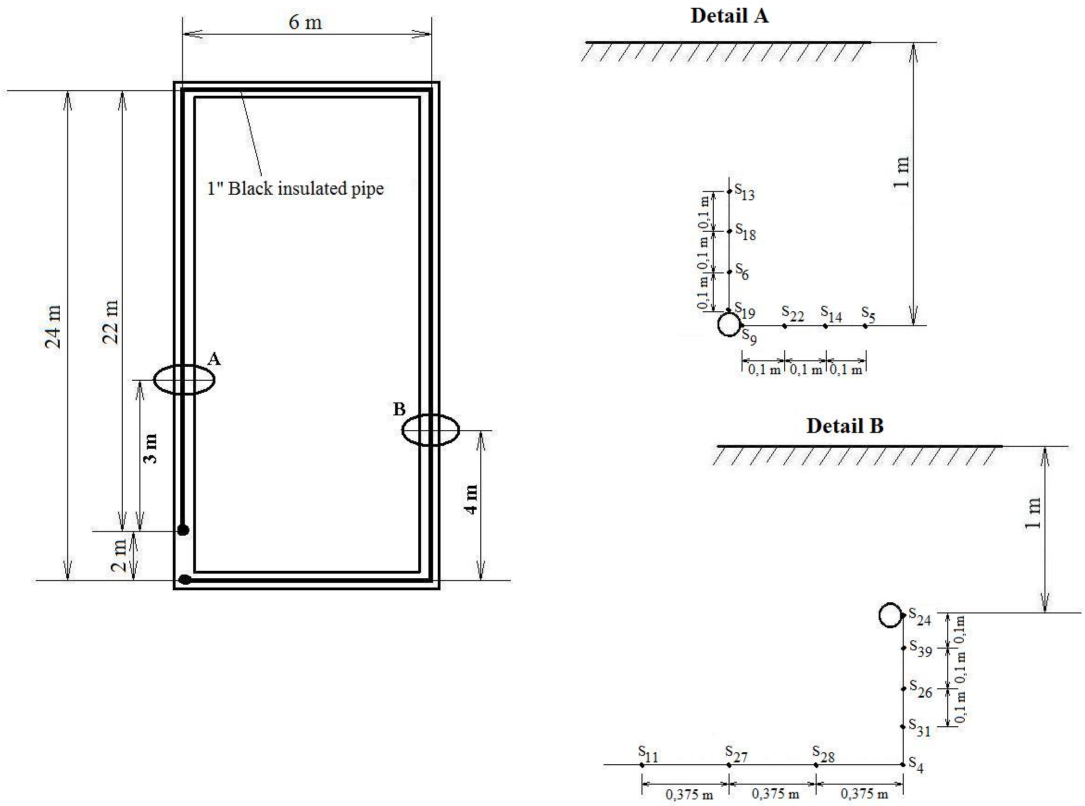

Fig. 4. Temperature transducers arrangement

Temperature transducers of type thermistor (hot conductor), with the range -35…+150°C, precision ± 0,2°C in the range 0 – 70°C and ± 0,5°C in rest, have been used. The information is captured from the transducers by a series of data concentrators (figure 5).

Fig. 5. Data concentrators

Every data concentrator is monitoring 8 temperature transducers. The data acquisition is made every 5 minutes. The concentrator has its own memory, thereby it can store the temperature data for 2 months.

The communication with the PC is made by a RS465 network, where all concentrators can be connected. The data can be accessed via internet with the help of some Ethernet convertors.

Numerical Modeling of Temperature Field around the Pipeline

Due to the complex geometry and non-stationary heat exchange, and for a better interpretation of the data gathered from the field, in parallel with the experimental station, a tridimensional numerical model capable to simulate the thermal exchange phenomenon and the dynamic of temperature field on the experimental pipeline geometry was created.

In the next 3 figures the simulations of the temperature field around the pipeline at the beginning of the transport process are shown.

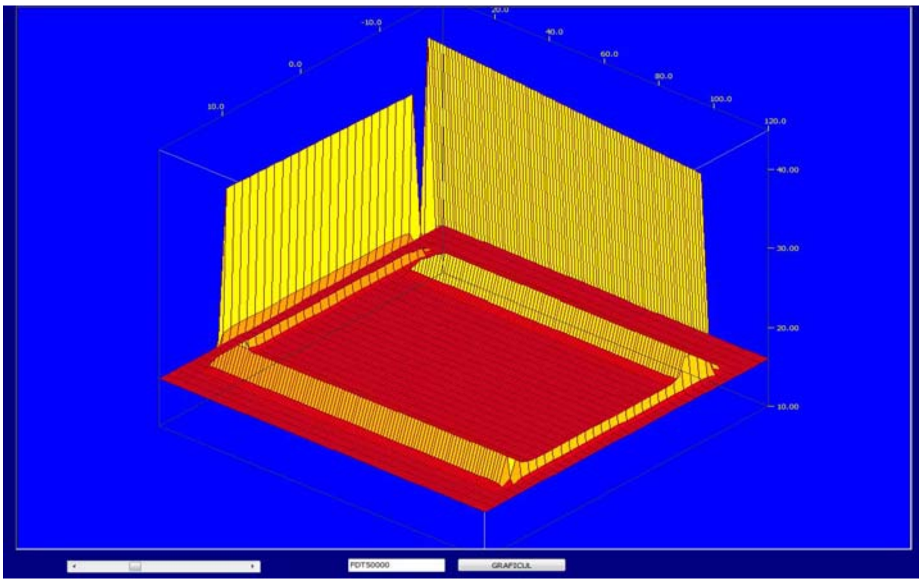

Fig. 6. Temperature field around the pipeline

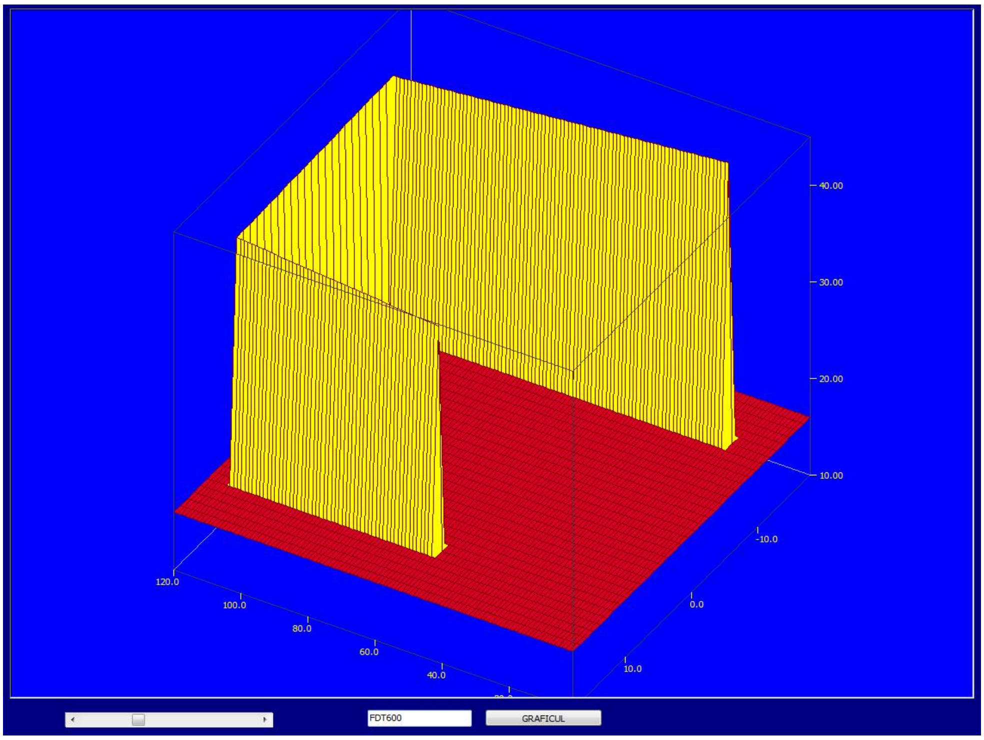

Fig. 7. Temperature field around the pipeline

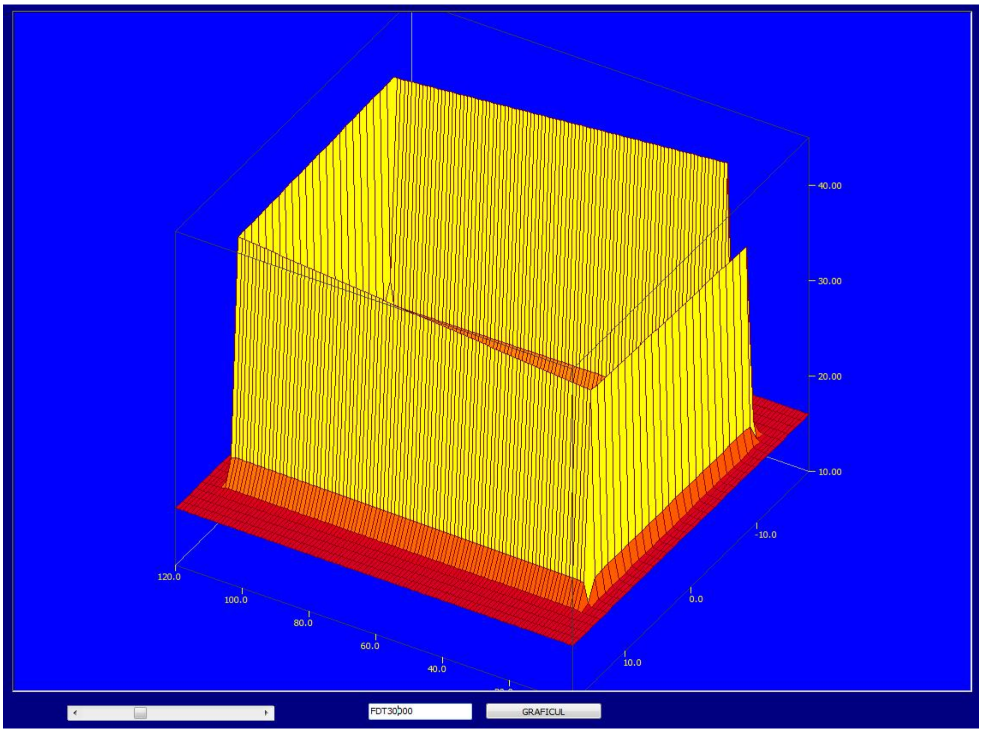

Fig. 8. Temperature field around the pipeline

This figure presents the temperatures from a plan that contains the transport pipeline. The highest values represent the temperature on the exterior pipeline wall.

As it is shown, the numerical model is capable to simulate the dynamic of temperature field around the pipeline.

The model calibration is made based of experimental data.

Conclusions

The experimental station presented in this paper allows specialists to study the process of oil transportation in non-isothermal state and to experimentally reproduce various unfavorable situations that can appear in practice, for example the accidental stopping of pumping.

The data obtained with this experimental station will allow the improvement of transport process projection in non-isothermal state.

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Cercetări experimentale privind dinamica câmpului de temperatură din jurul conductelor îngropate pentru transportul țițeiurilor vâscoase

Rezumat

În această lucrare sunt prezentate cercetările privind dinamica câmpului de temperatură din jurul unei conducte îngropate prin care se transportă un țiței vâscos. Rezultatele sunt obținute cu standul experimental construit în cadrul laboratorului de Termotehnică a Universității Petrol - Gaze din Ploieşti.