Performing and Testing an Environmentally Friendly Heating System for Viscous Oil Transport

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Nowadays, in order to reduce the viscosity of the oil before pumping it through pipelines which are usually buried in the soil, this is being heated with steam obtained in boilers using fossil fuel as primary energy source. This paper analyzes the possibility of heating viscous oil with a water-water heat pump which uses the soil energy extracted by various systems, the results and the performance of this installation.

Keywords: transport, oil, heat pump, energy balance

The transport of heavy oil with high viscosity has posed specific problems for specialists [1-3]. Among the methods used to transport viscous oil, which have proved valid over time, the most used method is the transport of crude oil in non-isothermal state. To lower the viscosity, crude oil is heated before pumping up to temperatures of 40-70°C and then it is pumped through pipelines which are usually buried in soil.

As crude oil crosses the pipeline, it tends to cool due to heat losses to the ground. If the crude oil is transported on a longer distance than the distance until the temperature of oil drops to a minimum accepted value, then reheat stations are being mounted [3, 9].

Heating oil before pumping is realized in isolated tanks with a coil where steam is circulating. The steam is produced in boilers using fossil fuel as a primary source of energy.

This paper presents a new ecological device based on a water-water heat pump used for heating oil and pumping. In the second part of the paper the results and performance of this plant are being analyzed.

Experimental part

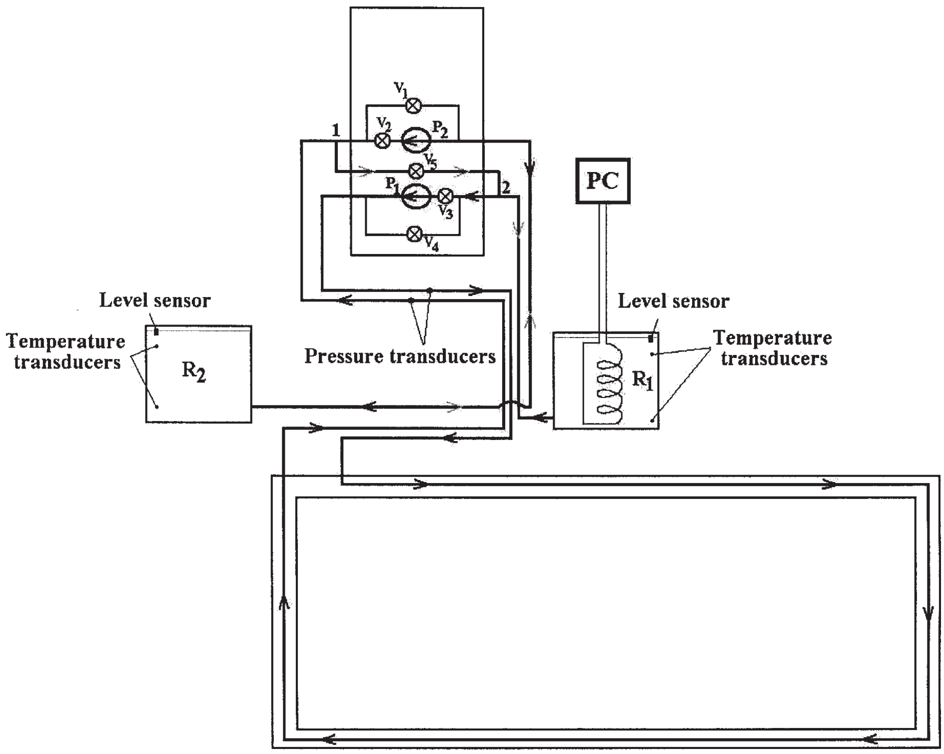
The installation for heating viscous oil for transport was performed in a stand for testing and simulation of viscous oil transport built in the Thermodynamics Laboratory at the University of Petroleum - Gas of Ploiesti (scheme 1).

This installation consists of two storage tanks for crude oil: R1 reservoir, in which the oil is stored before being transported and R2 reservoir tank, the reception tank. The R1 tank is fitted with two copper coils through which warm water from the heat pump circulates. Temperature transducers were mounted in order to control the heat in the reservoir (fig. 1). The transport system also includes an insulated steel pipe, buried at a depth of 1 m. The total length of the pipeline transport is 60 m.

The heating oil process is carried out as follows: the R1 reservoir is filled with oil to be heated, then the heat pump is turned on and thus it produces warm water which is circulated through the coil 2 of the tank.

The heating process is developed until the oil reaches the desired temperature.

A heat pump belonging to the Renewable Energy Sources



Scheme 1

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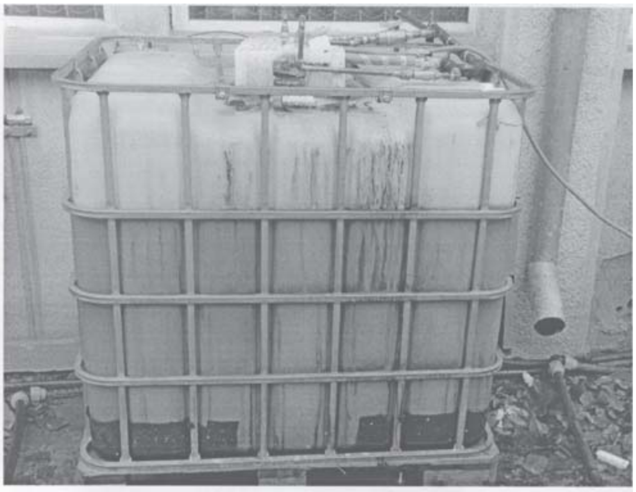

Fig. 1.

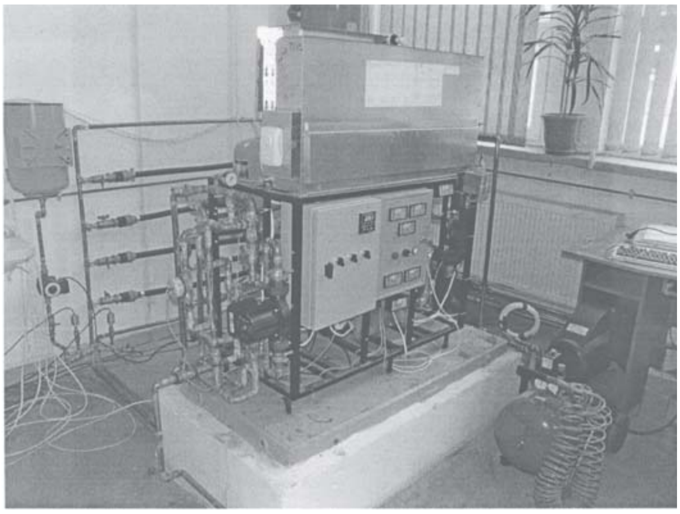

Fig. 2.

laboratory (fig. 2) was used to heat the oil.

The heat pump is a reversible pump with mechanical vapor compression, rotary compressor Hitachi SL-232 CV C7LU and two heat exchangers Alfa Laval AC-30-EQ-40H as a vaporizer and condenser. The laminar air valve is adjustable.

As it is known the heat pump takes heat from a source with lower temperature and gives it back under the form of useful heat at a higher temperature [5]. The thermal equivalent of the consumed electricity by the compressor is added to the process as well.

For the heat taken from the cold source, the heat pump can be coupled to 4 systems to extract heat from the soil:

- a groundwater well with a 300 mm diameter in depth, have a depth of 12 m, with a 4 m hydrostatic level;
- a spiral polyethylene loop with a length of 180 m buried at a depth of 2 m;
- a vertical shaft with a depth of 40m in which a simple polyethylene loop has been inserted;
- a simple polyethylene loop of 60 m buried at a depth of 1m;

The heat taken from the cold source represents the heat necessary to the vaporizer, the process 4-1 in figure 3, which represents the thermodynamic cycle realized in real-time at the stabilized operation of the R 22 freon heat pump.

Following the 1-2 compression process, the thermodynamic agent passes from 0.59 MPa isobar to 2.01 MPa isobar. This makes the process of condensation isobar 2-3 to take place at a temperature of saturation of 51.6°C. The heat transferred in heat 2-3 is useful in adding to the caloric equivalent of the 1-2 compression process.

The analysis of heating oil included several stages in which, in turn, the available systems were coupled to the heat pump.

It has been noticed that the largest thermal power can be extracted from groundwater extracted from a well with a depth of 12 m [1, 2]. Throughout the heating process of the oil, the groundwater had a constant temperature of 17.5°C (December 2008).

The heat extracted by all other systems of water circulation through the soil, coupled to the heat pump, was inferior to the heat of groundwater [4, 6].

Results and discussions

The values of temperature change during the process of heating 800 liters of crude oil are shown in figure 4 for three experiments. Experiment 1 represents the heating oil process as a source with cold water circulating through the loop buried at 2 m depth; in Experiment 2 the heat has as a source of heat the 40m vertical well with a U-shaped loop; Experiment 3 represents the heating having as source groundwater from the 12m well.

During Experiment 1 the temperature of oil tank has remained steady, but at the end of the heating process the temperature inside the tank registered a variation of 2-3°C

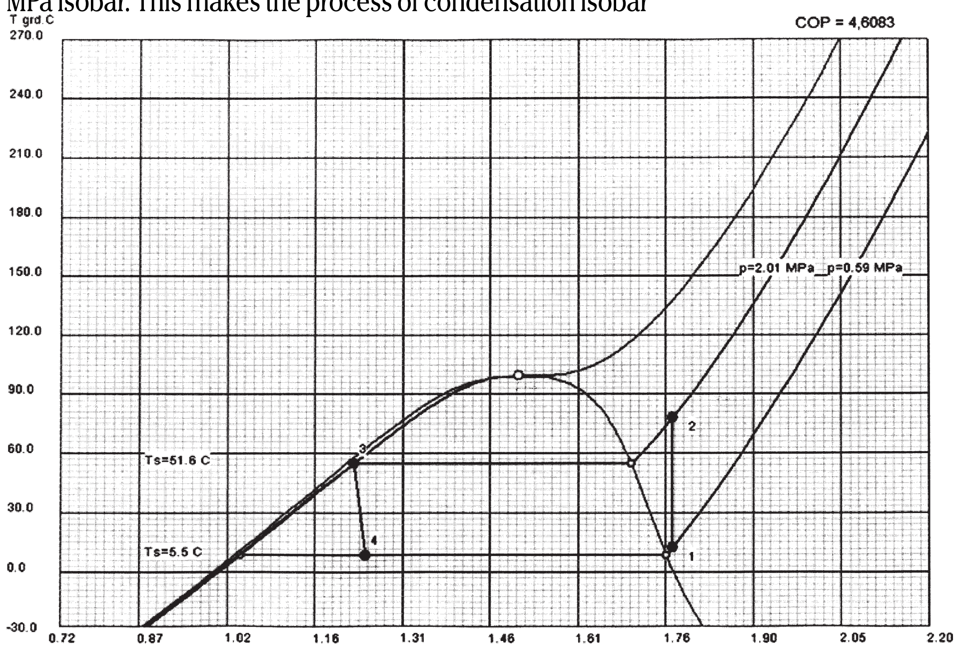

Fig. 3.Therodynamic Agent Cycle R22

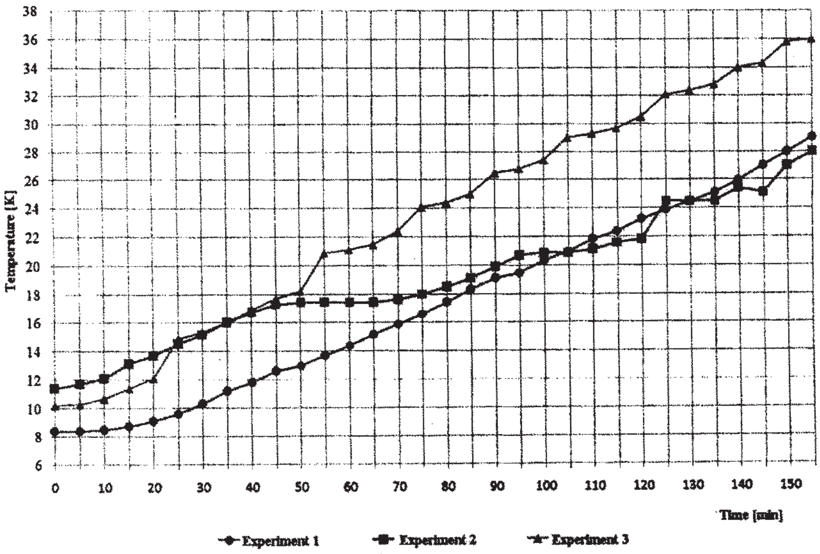

Fig. 4.The variation of oil temperature during the process of heating

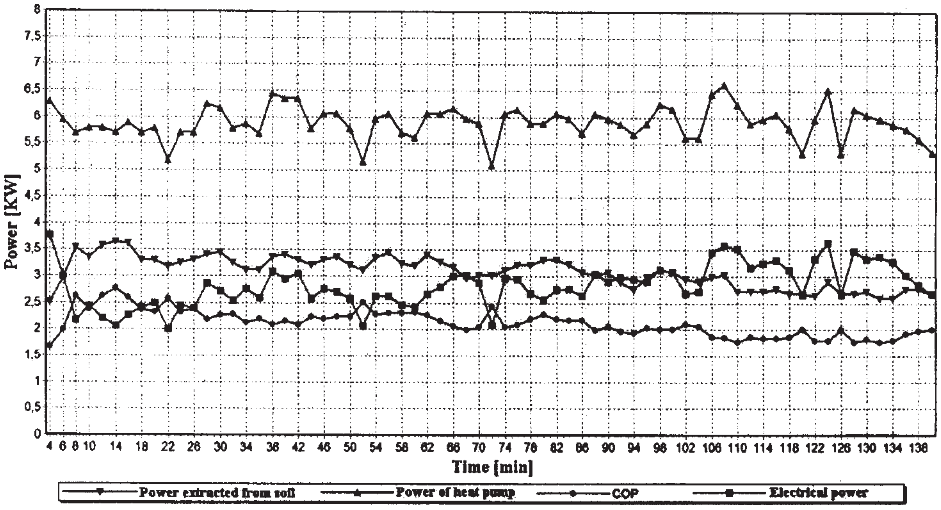

Fig. 5.Heat pump performance

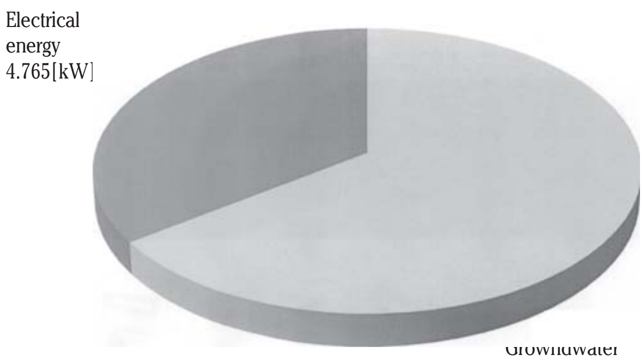

Fig. 6. Energy balance of the heat pump for the entire heating process. Total energy 13.58 kW

between the low and high part. The process of bubbling oil vessel with compressed air was performed during Experiments 2 and 3, which resulted in an uneven growth of temperature.

For the best heating process (Experiment 3) using as a source groundwater, the variation of the energetic parameters of the heat pump is presented in figure **5**, while figure **6** shows the energy balance.

Conclusion

Using Renewable Energy Sources laboratory equipment, it has been shown the possibility of heating viscous oils with a water-water heat pump using soil energy captured by means of various systems.

In order to heat oil from a temperature of 10°C to 36°C, as Experiment 3 has shown, 13.58 KWh were used, produced by the heat pump, out of which 8.815 KWh (65%) represents the heat taken from the cold source and 4.765 KWh (35%) is the consumed electrical power.

Using the heat pump for heating viscous oil is an ecologic process which reduces by 65 % the consumption of fossil fuels. At the same time pollutants and greenhouse gases effect is diminished.

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