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Manuscript submitted 2018.03.26 – revised 2018.03.28,
initially accepted for publication 2018.03.30, published in June 2018

# WORKING PARAMETERS OF GAS HEAT PUMP IN USE WITH LOW-POTENTIAL GEOTHERMAL ENERGY

# PARAMETRY PRACY GAZOWEJ POMPY CIEPŁA WYKORZYSTUJĄCEJ GEOTERMALNĄ NISKIEJ ENTALPII

DOI: 10.30540/sae-2018-018

**Abstract**
*The article presents the operating parameters of the heat pump for gas with low potential geothermal energy. It describes the measurement device and implementations of the experimental measurements resulted in a database of relevant data on the conversion of primary energy to natural gas to GHP heat, using low potential energy from a deep well.*

**Keywords:** technological scheme diagram, heat pumps, heat exchanger, heating system

**Streszczenie**
*W artykule przedstawiono parametry pracy gazowej pompy ciepła, korzystającej z energii geotermalnej niskiej entalpii. Zaprezentowano wykorzystywane stanowisko pomiarowe, a także zastosowanie wyników pomiarów do budowy bazy danych eksperymentalnych na temat konwersji energii pierwotnej gazu ziemnego w ciepło, przy użyciu pompy ciepła współpracującej z pionowym wymiennikiem gruntowym.*

**Słowa kluczowe:** schemat technologiczny, pompa ciepła, wymiennik ciepła, system grzewczy

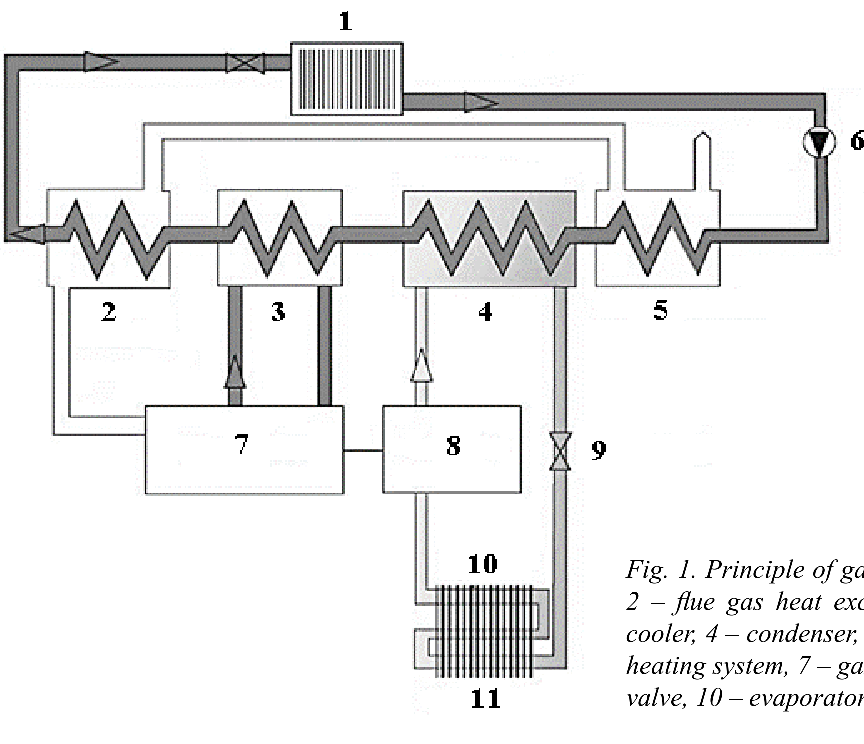


*Fig. 1. Principle of gas heat pumps [1]: 1 – heating element, 2 – flue gas heat exchanger, 3 – heat exchanger – engine cooler, 4 – condenser, 5 – flue gas condenser, 6 – pump of the heating system, 7 – gas engine, 8 – compressor, 9 – expansion valve, 10 – evaporator, 11 – ambient air*

## 1. INTRODUCTION

Frequently used alternative heat sources include heat pumps. Heat pumps are devices that acquire energy from the surrounding environment and use the physical changes of the working fluid (refrigerant) to transform it to a higher level – practically usable for heating. It is a wasteless technology using renewable energy sources that can fully replace conventional heat sources. One of the most promising applications is gas heat pumps. The advantage of gas heat pumps is the ease of their integration into the current energy infrastructure and the reduction of carbon dioxide emissions. The gas heat pump utilizes a plurality of heat sources that derive heat not only from the ambient air but also from the engine cooling circuit and the flue gas produced as shown in Figure 1. For this reason, the gas heat pump is a highly energy-efficient device.

## 2. CHARACTERISTICS AND CONNECTION OF THE GAS HEAT PUMP

As gas heat pumps exist only in air/water systems, a modification of the original type of gas heat pump to the ground/water system was carried out according to the scheme in Figure 2. By implementing experimental equipment with the necessary instrumentation, a unique device has been obtained that can verify different heat sources for a gas heat pump and perform detailed energy balance measurements and thermal performances in real conditions.

The experimental device is installed in the University of Žilina Campus. It is a model AISIN Toyota 10 HP model AXYGP 280 El with a heating output of 33.5 kW. The primary side of the heat pump is connected to a 150 m deep ground bore where the earth probe is built. The earth probe consists of a double U-profile of the PE-Xa pipe system (polyethylene formed under high pressure) which is commonly used in practice for the purpose of high efficiency earth heat collection. The working medium of U-heat exchangers is a 50/50 mixture of ethylene glycol and water. This mixture is anti-freeze, which prevents freezing in the evaporator of the heat pump. The ground probe circuit is connected to a heat exchanger in which the low-potential terrestrial energy is delivered to the refrigerant in the primary circuit of GHP. The gas heat pump consists of an external and an internal unit that are interconnected with the refrigerant circuit (R410a). The outdoor unit also contains the original air-refrigerant evaporators, fans, a gas-fueled combustion engine with a heat exchanger for pre-heating the refrigerant and the compressor shown in Figure 2. The indoor unit of the experimental device is located in the BI 412 laboratory. In it, the thermal energy recovered from the earth is transferred to the heating system using a heat exchanger (condenser). The heating medium at the outlet of the indoor unit serves to heat the NI corridor around the laboratories, through several water heaters, the fan coils. A heat exchanger from the engine cooling is also involved in the heat production, HOTKIT. In this case, HOTKIT was not involved in total heat production.

## 3. RESULTS OF EXPERIMENTAL MEASUREMENT

The experimental measurement took place from 19.3 to 25.3 and the gas heat pump was operating for the entire heating time, with a pre-set heating temperature of 43°C ±2°C. The individual measured parameters needed to evaluate the energy efficiency

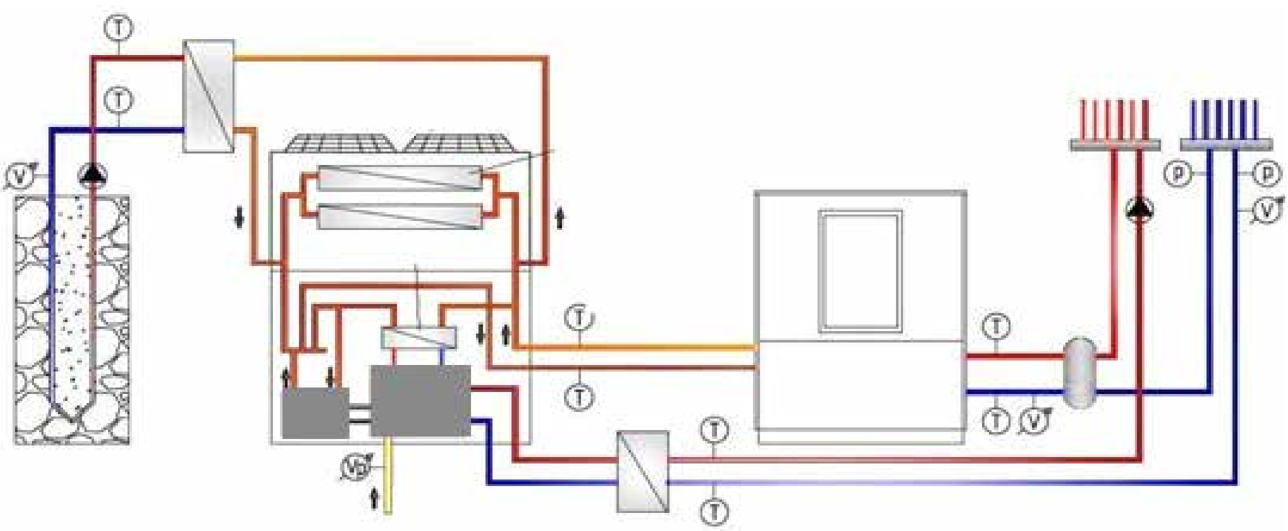


*Fig. 2. Technological scheme diagram of the experimental apparatus*

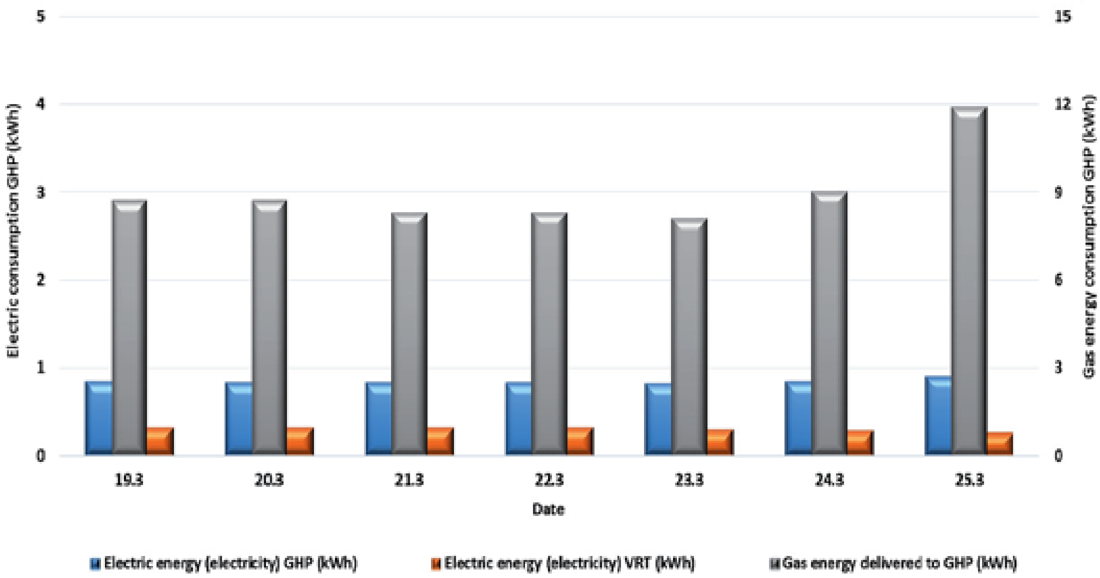


*Fig. 3. The average daily consumption of energy consumed by the gas heat pump*

*Table 1. Average daily temperature and media flow rate for the primary and secondary side*

| Date | Temperature VRT output, °C | Temperature VRT input, °C | Flow VRT, $m^3 \cdot h^{-1}$ | Temperature AWS output, °C | Temperature AWS input , °C | Flow AWS, $m^3 \cdot h^{-1}$ |
|---|---|---|---|---|---|---|
| 19.3 | 9.72 | 3.34 | 5.58 | 45.00 | 41.15 | 4.84 |
| 20.3 | 9.87 | 2.52 | 5.58 | 44.84 | 41.21 | 5.52 |
| 21.3 | 9.98 | 2.53 | 5.58 | 44.87 | 41.22 | 5.24 |
| 22.3 | 10.05 | 2.52 | 5.58 | 44.73 | 41.26 | 5.55 |
| 23.3 | 10.03 | 2.20 | 5.58 | 44.70 | 41.28 | 5.53 |
| 24.3 | 10.00 | 2.26 | 5.58 | 44.77 | 41.28 | 5.55 |
| 25.3 | 9.85 | 2.50 | 5.58 | 44.93 | 41.20 | 5.55 |
| Average | 9.93 | 2.55 | 5.58 | 44.83 | 41.23 | 5.40 |

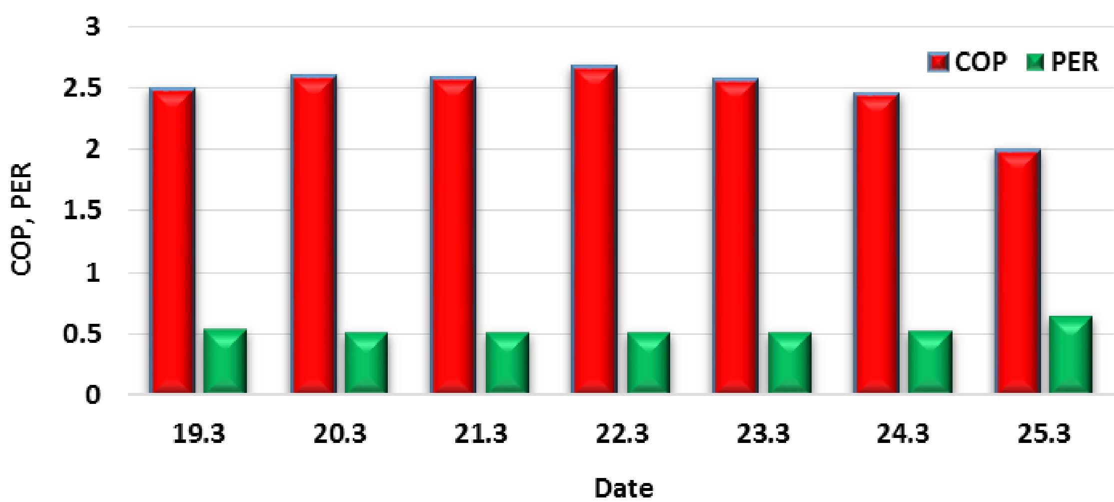


*Fig. 4. COP and PER gas-water heat pump*

of the GHP were recorded at minute intervals and the hourly averages were then calculated. From the measured data, the charts were created for the individual measurement days and the whole measurement time was finally evaluated.

Figure 3 shows the average daily consumption of energy consumed by the gas heat pump. Daily gas consumption averaged 9 kWh/24 h. Electricity consumption for primary pump (0.83 kWh/24 hours) and secondary (0.32 kWh/24 hr) was constant during the measurement period.

The average daily temperatures and flow rates of the working medium on the primary and secondary side are shown in Table. 1. On the primary side (deep borehole) there was the difference in temperature Δt = 7.3°C and the working medium flow 5.58 $m^3 \cdot h^{-1}$. On the secondary side was determined the average difference of the heating water temperatures ~t = 3.6°C and the flow was 5.4 $m^3 \cdot h^{-1}$.

After measuring and evaluating the necessary parameters, the energy efficiency of the experimental device was determined. Energy efficiency Assessed against two Coefficients of Performance (COP) and PER (Primary Energy Ratio).

## 4. CONCLUSION

By modifying the air-to-ground GHP system to the ground-water system, the Earth heat analysis was confirmed as a potential heat source suitable for gas heat pumps. Throughout the measurement period, the heating factor ranged from COP = 2 to 2.68, corresponding to the PER = 0.52 to 0.64. Implementation of the experimental measurements has resulted in a database of relevant data on the conversion of primary energy to natural gas to GHP heat, taking low-potential energy from deep borehole.

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***Acknowledgement***
*This publication is the result of the project implementation: Device for the use of low-potential geotermal heat without forced circulation of the heat carier in deep boreholes, ITMS 26220220057 supported by the Operational Programme Research and development funded by the ERDF.*