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Heating System Application with Ground Source Heat Pump for Isparta Climate Conditions

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Abstract – This experiments were carried out in a room with measuring 3x3x3 m. The experimental device consists of two cycles: underground cycle and heat pump cycle. Heat pumps cycle; consists of a rotary compressor, condenser, evaporator, expansion valve and four-way valve. The underground cycle consists of the pump and the 1 inch diameter nickel-chrom pipes laid horizontally at 3 m depth were used as ground heat exchanger. In addition, R22 refrigerant is used as the working fluid in the heat pump cycle. The GSHP system for heating purposes is operated at different water-ethylene-glycol mixture ratios such as 5%, 10%, 15%, 20%, 25%, 30% and 10-27 L/ min .The temperature of the GSHP system operated under these conditions, the temperature of the room to be heated (T_{oda}), the condenser and the evaporator capacity, and the effect of the system on the COP parameter was investigated. According to the results of the tests, the best results in terms of the parameters mentioned were obtained with a mixing ratio of 5% and a volumetric flow rate of 21 L/ min and the highest COP is 3.4 and T_{oda} is 27.2°C.

Keywords – Heat Pump, Heating System, Ground Heat Exchanger.

I. Introduction

Lately, the most expended energy sources is fossil-based fuels. While the reserve of these fuels is declining, it continues to be the main cause of environmental pollution. Due to the influence of environmental factors and increases in fuel costs has accelerated the search for new sources of energy, the importance of alternative energy sources as a result of increased even more. At the same time the increasingly severe global warming and energy crisis have made it urgent to explore appropriate renewable energy for building use, particularly for the HVAC systems [1]. At 2030, heat pumps; 50% of new buildings and in 30% of the reinforcing building when used, is expected to decrease CO2 emissions by 40% [2]. Among many forms of renewable energy of renewable energy (solar energy, wind energy, geothermal energy, tide energy bioenergy and hydropower, etc.), Geothermal energy is exemplary for use because of temperature stability and availability throughout the year. The ground source heat pump (GSHP) system is such a device that capitalizes on the geothermal energy to heat up or cool down buildings. During the period of 2010 to 2015, GSHP systems witnessed a 52% deployment augmentation worldwide and had been widely developed in 48 countries globally by the end of 2015 [3]. Corberan et al. [4] investigated the effect of variations in the mass flow rate of the heat-carrier fluid of the external loop on both the thermal capacity and energy efficiency of a heat pump in the cooling mode by means of experimental tests carried out in the laboratory. The authors found that the flow variation on the evaporator side particularly affected its cooling capacity, whereas the flow variation on the condenser side particularly affected energy efficiency. Granryd [5] also investigated the impact of the flow rate of the external heat-carrier fluid (air or liquid) on the condenser and evaporator side. The primary objective of his work was to define simple analytical equations to be used to estimate optimum flow rate. Edwards and Finn [6] developed a control strategy to predict optimal water flow rates for GSHPs under part load operation using some of the results of the study conducted by Granryd [5].The optimal water flow control has usually received little attention for a fixed speed heat pump system under part load conditions. The optimal control strategy proposed was able to increase the seasonal energy performance factor of the heat pump by 20–40% with respect to the same system with a nominal flow rate operation. In this study, ground source heat pump was operated in the heating mode having diverse concentration ratios with several volumetric flow rates. Ground source heat pump (GSHP) heating performance was investigated experimentally. This experiments were carried out in a room with measuring 3x3x3 m. The GSHP system for heating purposes is operated at different water-ethylene-glycol mixture ratios such as 5%, 10%, 15%, 20%, 25%, 30% and 10 to 27 L/ min. The GSHP system operated under these conditions, the temperature of the room to be heated (T_{room}), the condenser and the evaporator capacity, and the effect of the system on the COP parameter was investigated. According to the results of the tests, the best results in terms of the parameters mentioned were obtained with a mixing ratio of 5% and a volumetric flow rate of 21 L/ min and the highest COP is 3.4 and T_{room} is 27.2°C.

II. Materials and Method

The principle work of GSHP system begin from extracts the heat from the ground by using the solution that prepared in the first state and pumping it by centrifugal pump with general Characteristics (Flow rate up to 50 l / min, Head up to

66 m, Diameter: 1") to evaporator brazed plate heat exchanger, then refrigerant entered to the evaporator and will evaporates by absorbing heat from the circulated water - ethylene glycol solution. In the other cycle of the system the working fluid is R-22. After that when the fluid leaves the evaporator towards rotary compressor that compress the fluid until reach to required high pressure, then the fluid go to the condenser and gives its heat to the air room by the fan that exist in front of condenser, then the fluid condense, in the last stage its go to expansion valve. Through the expansion valve the fluid pressure reduce to the evaporator pressure. The volumetric flow rate of the circulated water - ethylene glycol solution through the closed-loop of HGHE and measured by using a rotameter which controlled by a hand. The inlet and outlet temperatures of the R-22 in the condenser, compressor and evaporator were measured with digital thermometer. In addition, the room temperature, inlet and outlet temperatures of the circulated water - ethylene glycol solution through the closed-loop HGHE were measured with digital thermometers. Furthermore, the inlet and outlet pressures of the compressor, evaporator and circulated water - ethylene glycol solution were measured by using Bourdon type manometers. Fig. 1 show a schematic view of the constructed ground source heat pump (GSHP) system.

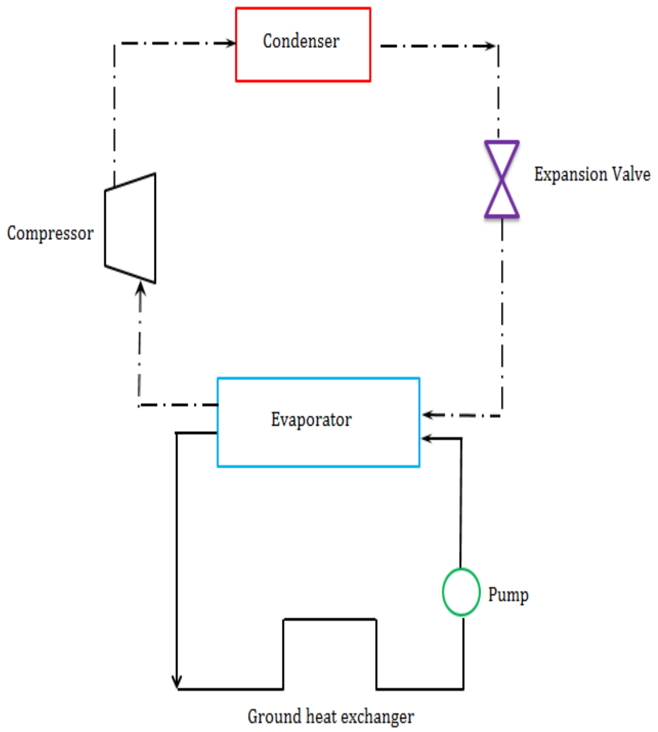

Fig. 1. Schematic diagram of ground source heat pump (GSHP) system.

III. RESULTS

In this study, ground source heat pump was operated in the heating mode having diverse concentration ratios with several volumetric flow rates. Ground source heat pump (GSHP) heating performance was investigated experimentally. This experiments were carried out in a room with measuring 3x3x3 m. The GSHP system for heating purposes is operated at different concentration ratios of water-ethylene glycol mixture (Mr) (5%, 10%, 15%, 20%, 25% and 30%) and different volumetric flowrate $\dot{V}_{mr}$ 10-27 L / min a ground source heat pump (GSHP) has been experimentally investigated. The GSHP system operated under these conditions, the temperature of the room to be heated (T_{room}), the condenser and the evaporator capacity and the effect of the system on the COP parameter was investigated experimentally. According to the results of the tests, the best results in terms of the parameters mentioned were obtained with a mixing ratio of 5% and a volumetric flow rate of 21 L/ min and the highest COP is 3.4 and T_{room} is 27.2°C.

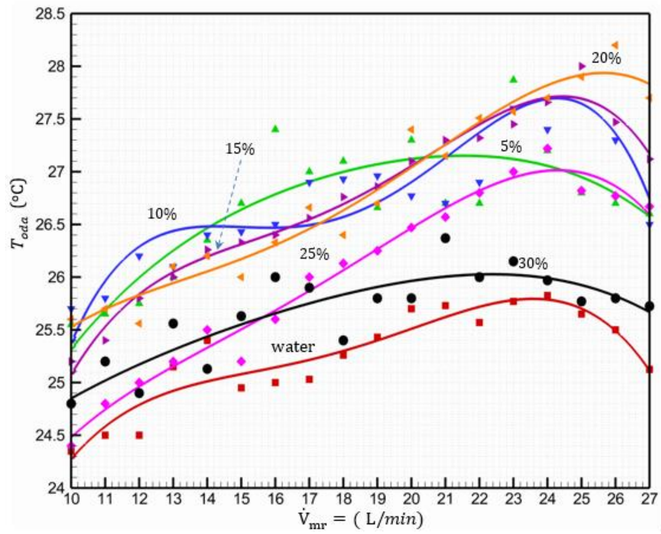

Fig.2 The relation of volumetric flowrate($\dot{V}_{mr}$) and T_{room}.

As can be seen from Figure 2, depending on the change of $\dot{V}_{mr}$ Values, T_{room} takes the minimum values in $\dot{V}_{mr}$ = 10-12 L/ min and maximum values in $\dot{V}_{mr}$ = 24-26 L / min. The maximum of T_{room} = 27.8, Mr(Mixing rate) = 20% and $\dot{V}_{mr}$ = 26 L / min was obtained for the general system. Depending on $\dot{V}_{mr}$ values, T_{room}, values of water is minimum.

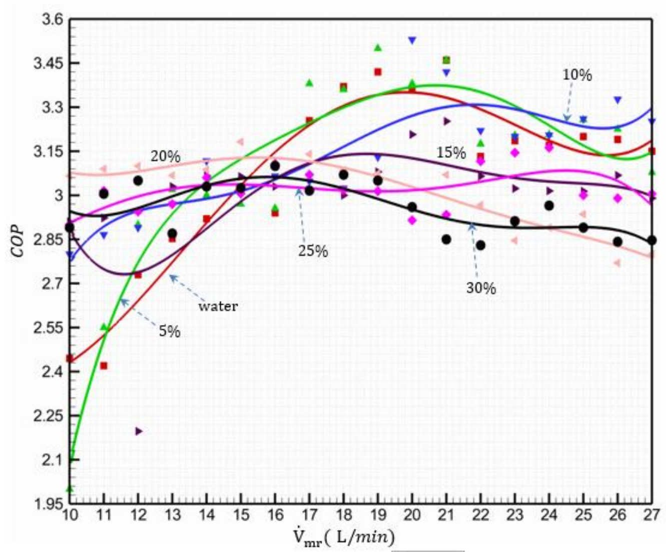

Fig.3 The relation of COP and volumetric flowrate($\dot{V}_{mr}$)

As can be seen from Figure 3, depending on the change of $\dot{V}_{mr}$ Values, the COP generally takes maximum values in the range $\dot{V}_{mr}$ = 20-22 L / min. and minimum values generally takes $\dot{V}_{mr}$ = 10-16 L / min. For the system wide, maximum

COP = 3.4, Mr = 5% and V_{mr} = 21 L / min were obtained. The COP values decrease after $\dot{V}_{mr}$ = 22 L / min.

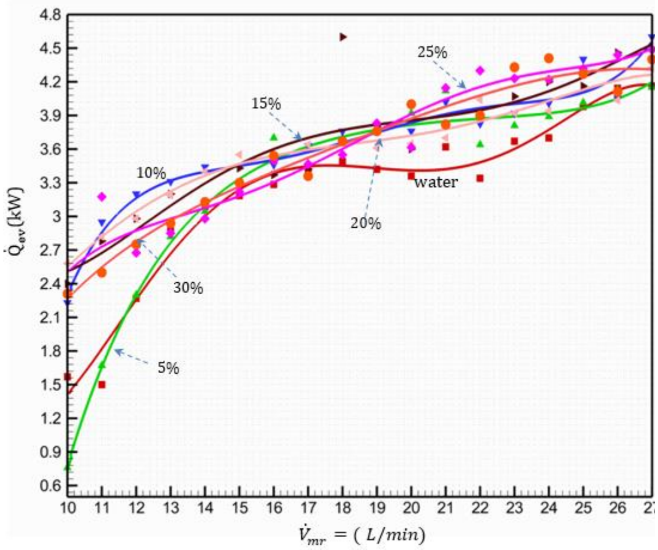

Fig.4 the relation of $\dot{Q}_{ev}$ (Evaporator Heat) and volumetric flowrate.

As can be seen from Figure 3, depending on $\dot{V}_{mr}$, it is seen that $\mathbf{\dot{Q}_{ev}}$ increases as V_m increases. Accordingly, $\mathbf{\dot{Q}_{ev}}$ is the minimum value in the range of $\dot{V}_{mr}$, 10-12 L / min and the maximum value in the range of $\dot{V}_{mr}$, = 25-27 L / min. As $\dot{V}_{mr}$, increases, the value of $\mathbf{\dot{Q}_{ev}}$ of the system increases.

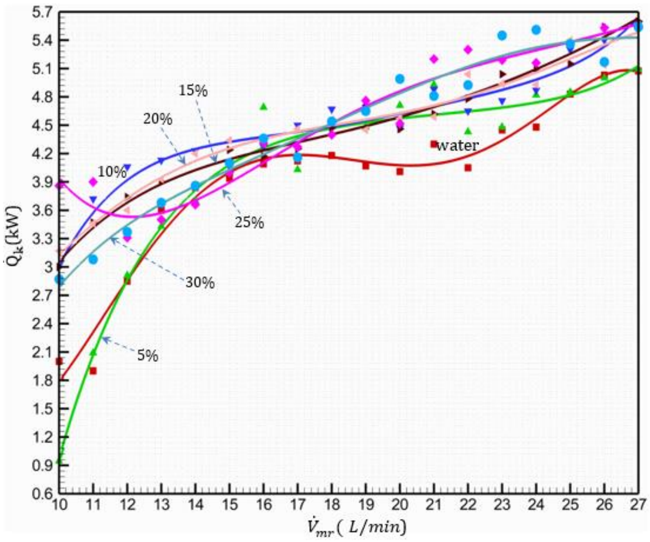

Fig.5. The relation of $\dot{Q}_c$(Condenser heat) and volumetric flowrate

As can be seen from Figure 4, it is seen that $\mathbf{\dot{Q}_C}$ increases as $\dot{V}_{mr}$ increases, depending on$\dot{V}_{mr}$. In general, $\mathbf{\dot{Q}_C}$ takes the maximum values at $\dot{V}_{mr}$= 10-12 L / min and $\dot{V}_{mr}$= 25-27 L / min. As $\dot{V}_{mr}$, increases, the value of $\mathbf{\dot{Q}_C}$ of the system increases.

IV. CONCLUSION

According to the experimental results, the best results are obtained at 21 L/ min volumetric flow rate of the mixture, mixing ratio containing 5% ethylene glycol and the COP is 3.4. For subsequent studies, and to get high rigor measurements, important parameters should be measured before attempting the design of the GHE such as the relevant soil properties, in addition all parts of the system should be regulated in terms of energy efficiency in the design of a GSHP system. Lately, a large number of researchers have been working on different

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