Heat Pump

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***Abstract*- Geothermal heat pumps or ground source heat pump (GSHP) are arrangements uniting a heat pump with a high enthalpy geothermal resources (ground heat exchanger in closed loop systems), or provided by ground water from a well in open loop systems. One of world's largest uses of energy is the heating and cooling of buildings. Ground Source Heat Pumps (GSHP) provide a more energy efficient way to meet building energy needs than conventional alternatives. At a relatively shallow depth, the ground temperature is nearly constant year round providing a reliable heat source or sink for the operation of a heat pump. This study deals with reviewing heat pump studies and in the first part of this study, historical development of GSHPs was briefly given, and finally, studies conducted on GSHPs were reviewed.**

Index Terms- Heat Pumps; Sustainability; Ground; Heating; Cooling

I. INTRODUCTION

A heat pump is a device that transfers heat energy from a source of heat to what is called a heat sink. Heat pumps move thermal design of a heat pump involves four main components – a condenser, an expansion valve, an evaporator and a compressor. The heat transfer medium circulated through these components is called refrigerant.

While air conditioners and freezers are familiar examples of heat pumps, the term "heat pump" is more general and applies to many HVAC (heating, ventilating, and air conditioning) devices used for space heating or space cooling. When a heat pump is used for heating, it employs the same basic refrigeration-type cycle used by an air conditioner or a refrigerator, but in the opposite direction – releasing heat into the conditioned space rather than the surrounding environment. In this use, heat pumps generally draw heat from the cooler external air or from the ground.

Technically, a heat pump is a mechanical-compression cycle refrigeration system that can be reversed to either heat or cool a controlled space. Installation for this type of system typically consists of two parts: an indoor unit called an air handler and an outdoor unit similar to a central air conditioner, but referred to as a heat pump.

In heating mode, heat pumps are three to four times more effective at heating than simple electrical resistance heaters using the same amount of electricity. However, the typical cost of installing a heat pump is also higher than that of a resistance heater.

When discussing about and comparing energy efficiency of heat pumping applications some different factors are mainly used, COP (Coefficient of Performance), SCOP (Seasonal Coefficient of Performance) and SPF (Seasonal Performance Factor). The more efficient a heat pump is the less energy consuming it will be and the more cost-effective it can be to operate. There are several factors that will affect the efficiency of a heat pump such as climate, temperature, auxiliary equipment, technology, size and control system.

The ground, therefore, can provide consistently high system efficiency when it is used as the heat source or sink for a ground source heat pump (GSHP).

II. PHYSICAL DESCRIPTION

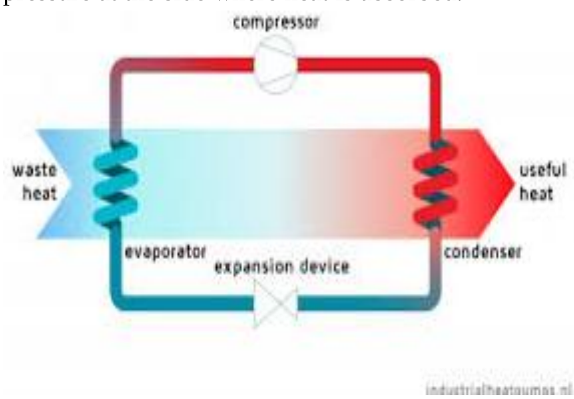
The underlying principle of a heat pump's operation is the reverse of a heat engine: using mechanical work to move heat against its natural gradient from a cold location to a hotter one,

e.g. from outdoors into the home. A refrigerant fluid such as compressed CO_2 or an 'ozone-friendly' hydro fluorocarbon (HFC) is used to transport this heat, exploiting the physical properties of evaporation and condensation.

Most heat pumps are capable of doubling up as air conditioners by reversing the direction of refrigerant flow. This swaps the roles of the two heat exchangers, drawing heat out of the home and expelling it to the atmosphere.

Mechanical heat pump exploits the physical properties of a volatile evaporating and condensing fluid known as a refrigerant.

The heat pump compresses the refrigerant to make it hotter on the side to be warmed, and releases the pressure at the side where heat is absorbed.



III. AIR SOURCE HEAT PUMPS

An air source heat pump (ASHP) is a system which transfers heat from outside to inside a building, or vice versa. Under the principles of vapor compression refrigeration, an ASHP uses a refrigerant system involving a compressor and a condenser to absorb heat at one place and release it at another. They can be used as a space heater or cooler, and are sometimes called "reverse-cycle air conditioners".

In domestic heating use, an ASHP absorbs heat from outside air and releases it inside the building, as hot air, hot water-filled radiators, under floor heating and/or domestic hot water supply. The same system can often do the reverse in summer, cooling the inside of the house. When correctly specified, an ASHP can offer a full central heating solution and domestic hot water up to 80 °C

Air at any temperature above absolute zero contains some energy. An air-source heat pump transfers ('pumps') some of this energy as heat from one place to another, for example between the outside and inside of a building. This can provide space heating and/or hot water. A single system can be designed to transfer heat in either direction, to heat or cool the interior of the building in winter and summer respectively. For simplicity, the description below focuses on use for interior heating.

The technology is similar to a refrigerator or freezer or air conditioning unit: the different effect is due to the physical location of the different system components. Just as the pipes on the back of a refrigerator become warm as the interior cools, so an ASHP warms the inside of a building whilst cooling the outside air.

The main components of an air-source heat pump are:

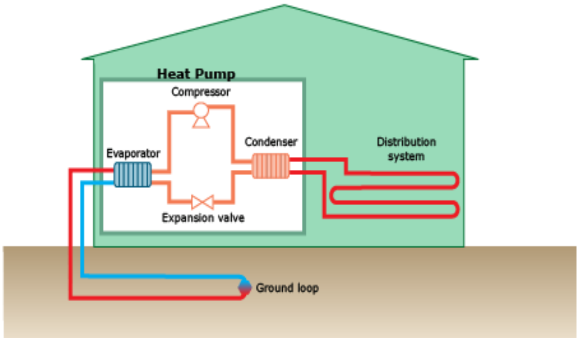
- An outdoor heat exchanger coil, which extracts heat from ambient air
- An indoor heat exchanger coil, which transfers the heat into hot air ducts, an indoor heating system such as water-filled radiators or underfloor circuits and/or a domestic hot water tank

Air source heat pumps can provide fairly low cost space heating. A high efficiency heat pump can provide up to four times as much heat as an electric heater using the same energy.[1] In comparison to gas as a primary heat source, however, the lifetime cost of an air source heat pump may be affected by the price of electricity compared to gas (where available). Use of gas may be associated with higher carbon emissions, depending upon how the electricity is generated.

A "standard" domestic air source heat pump can extract useful heat down to about −15 °C (5 °F).[2] At colder outdoor temperatures the heat pump is less efficient; it could be switched off and the premises heated using only supplemental heat (or emergency heat) if the supplemental heating system is large enough. There are specially designed heat pumps that, while giving up some performance in cooling mode, will provide useful heat extraction to even lower outdoor temperatures.

The first of these directly heats the air of a room using a slim wall-mounted box. Multi-split systems allow more than one indoor unit to be connected to a single compressor, allowing up to four rooms to be heated. This can become an expensive option in larger buildings as an indoor unit is necessary in every room that requires heating. Most air-to-air heat pumps are classed as reversible air conditioning units, as they perform both heating and cooling.

Ground source, or geothermal heat pumps (GSHPs) use copper or plastic tubes buried underground as an external heat exchanger. This allows them to exploit a higher quality source of heat, but makes their installation more disruptive and expensive. Open-loop systems extract water directly from, and reject it back to rivers or groundwater resources such as aquifers and springs.3 These can provide a stable source of moderate temperature heat (5–10 ○C) that is usually inexpensive to harness as only simple wells need to be sunk. However, resource avail- ability is limited, acidity and impurities can lead to corrosion of system components, and in many countries there are complex environmental regulations covering the use of groundwater



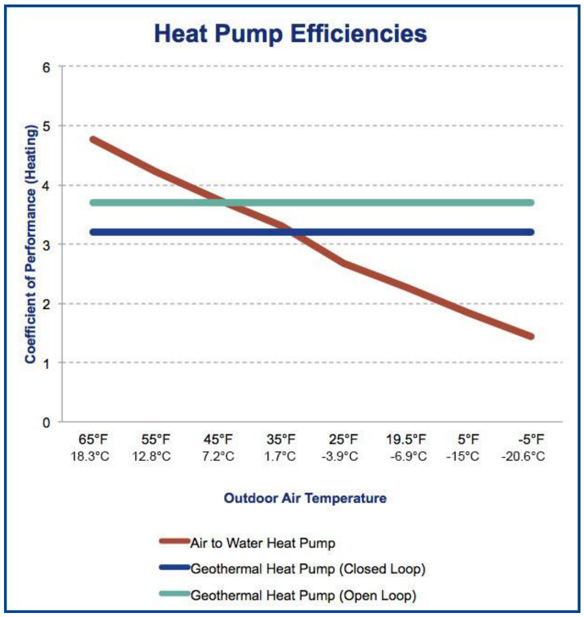
IV. WEATHER VARIATION

The performance of the GSHP is dependent on how much energy is transferred between the working fluid and the ground. As energy is rejected or extracted from the ground, the ground temperature changes; this variation can occur over both a short time period and a long time period. The HyGCHP program calculates the ground temperature based on the building loads for each hour of, in this study, the 20 year simulation. In the standard methodology, the building loads are calculated using a weather file that is based on a Typical Meteorological Year (TMY) which is obtained by constructing an average year based on observations over a 30 year period (NREL, 2009a). This representation of the weather cannot incorporate the year-to-year variation in weather. The design obtained using TMY weather data will therefore be over-sized for particularly mild years and under-sized for severe weather years. Therefore, an optimal GSHP design that is based on weather data that includes year-to-year variations and therefore the impact of unusually severe weather years will be different from a design based on a TMY weather file. The evaluation of the significance of year-to-year weather variation on the optimal design is briefly presented in this section.

Air source heat pumps have a fluctuating COP because their heat source (the air) fluctuates as the season changes. ... As you can see, the warmer the outdoor air, the better the air source heat pump performs. As the outdoor air temperature drops, the heat pump needs to work harder, so it becomes less efficient.

The heat pump is effective by itself down to temperatures around 25 to 30 degrees Fahrenheit. At that point, either a gas furnace or an air handler with supplemental electric heat will kick in and help heat your home.

How heat pumps work in cold weather. ... Because they use outside air, air source heat pumps work especially well in moderate temperatures. But when temperatures drop below 32° F, they lose efficiency, meaning they have to rely on a secondary source of heat to properly heat your home.



V. CONCLUSION

An overview of the work being conducted on GSHPs at the University of Wisconsin – Madison has been presented. Geothermal energy is one of the renewable energy sources that have been employed in many parts of the world for years. The GSHPs are apposite for heating and cooling of constructions and can play a major role in decreasing CO2 emissions. Heat pumps consume satisfactorily less energy to heat a construction than alternative heating methods. This paper affords a specified literature-based review of geo-thermal technology on heat pump applications

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