Heat Pump for Heating and Cooling

An Online Continuing Education Course for Engineers

Course Number: HV-6015

Credit: 6 Hours / 6 PDH / 6 CPD

Heat Pumps for Heating and Cooling

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A heat pump is an electric device used to pull heat out of air, ground or water and transfers it to the building. Heat pumps and air conditioners operate in a very similar way; the difference is that the heat pump cycle can be reversed to either heat or cool a controlled space. Some heat pumps are designed to heat water instead of air. These heat pumps are used in conjunction with spas, pools and hydronic/ radiant heating systems.

Heat pumps also work extremely efficiently, because they simply transfer heat, rather than burn fuel to create it. They work best in moderate climates. If a building doesn't experience extreme heat and cold, then improved energy efficiency can be achieved by using a heat pump instead of a furnace and air conditioner.

This 6-hour course explains the design, types and application of heat-pumps for residential and small commercial buildings. The course is divided into five (5) chapters.

CHAPTER -1: OVERVIEW OF HEAT PUMPS

- Heat Pump Vs an Air Conditioner
- Refrigeration and Heat Pump Cycle
- Function and Operation of Reversing Valve
- Operation of a Heat Pump in Heating and Cooling Mode
- Thermal Performance Terms
- Available Technologies

CHAPTER – 2: AIR SOURCE HEAT PUMPS (ASHP)

- How do Air to Air Heat Pumps Work
- How do Air to Water Heat Pumps Work
- Efficiency and COP of a Heat Pump
- Thermal Balance Point
- Sizing and Service Considerations
- Operating Costs and Payback
- Life Expectancy and Warranties

CHAPTER– 3: GROUND SOURCE HEAT PUMPS (GSHP)

- How do Ground Source Heat Pumps Work?
- Horizontal Loop V/s Vertical Loop Systems
- Series and Parallel Ground Loop Arrangements

- Sizing Considerations and Design Precautions
- Earth Loop Piping Materials and Working Fluids
- Suitability of Site, Commissioning and Decommissioning

CHAPTER– 4: WATER SOURCE HEAT PUMPS (WSHP)

- How do Water Source Heat Pumps Work?
- Open Loop and Closed Loop Systems
- Single Well, Standing Well and Double Well System
- Evaluating Open Loop Ground Water Feasibility
- Site requirements, Commissioning and Decommissioning
- Ground Water, Surface Water and Submerged Systems
- Pros and Cons

CHAPTER– 5: MAJOR COMPONENTS

- Compressors – Reciprocating, Screw, Scroll & Centrifugal
- Heat Exchangers – Condenser & Evaporator
- Receiver, Expansion Device & Refrigerants
- Portable Window Type Heat Pumps
- Ductless Mini-split Type Heat Pumps
- Ducted Split Heat Pumps
- Heated Floor Slab
- Radiant Panels, Panel Radiators & Fin based Baseboard

CHAPTER 1

1. OVERVIEW OF HEAT PUMPS

Heat ALWAYS travels from high temperature to lower temperature.

A heat pump is a device that pumps heat from a lower temperature to a higher temperature. This is opposite to the natural flow of heat, but this applies for all refrigeration machines. However, the label ‘heat pump’ has evolved to define those refrigeration machines, which can be configured to provide both cooling and heating, commonly referred to as “Reverse cycle”.

1.1. Heat Pump Vs Air Conditioner

Simply put, both devices are the same except a heat pump can provide cooling in summer, as well as heating in winter using reversing cycle.... whereas an air conditioner can only cool.

The air conditioners actually remove heat and moisture from the indoor space and transfer it to the air outdoors. This air enters the unit at 80°F and 50% relative humidity and after passing through the indoor coil, it leaves the unit at a temperature of 55°F and a relative humidity of 100%. The heat that has been transferred from this air is carried by a refrigerant (for example R134a) to the outdoor, or condenser coil. The moisture is condensed on the air conditioner evaporator’s coil and is drained outside. Obviously, outdoor ambient temperatures can be quite high during the periods when your space requires air conditioning. The refrigerant must transfer the heat it removed from the air in the indoor space to the outdoor air, but the outdoor air can be at a temperature of 95º F or more. Because we need to transfer this heat to air that is 95°F, the temperature of the refrigerant we are removing the heat from, must be substantially higher than the outdoor ambient temperature. The system is designed to blow outdoor air over tubes containing refrigerant at a temperature that is approximately 25°F warmer than the ambient air, so that the heat within the refrigerant can be transferred to the outdoor air.

The air conditioner is removing heat from area of low temperature (for e.g. your room), and transferring it, or “pumping it” to an area of higher temperature (the air outside). The energy is required in pumping (compressor) because we are forcing heat to be transferred in a direction that is opposite to the way heat will flow naturally.

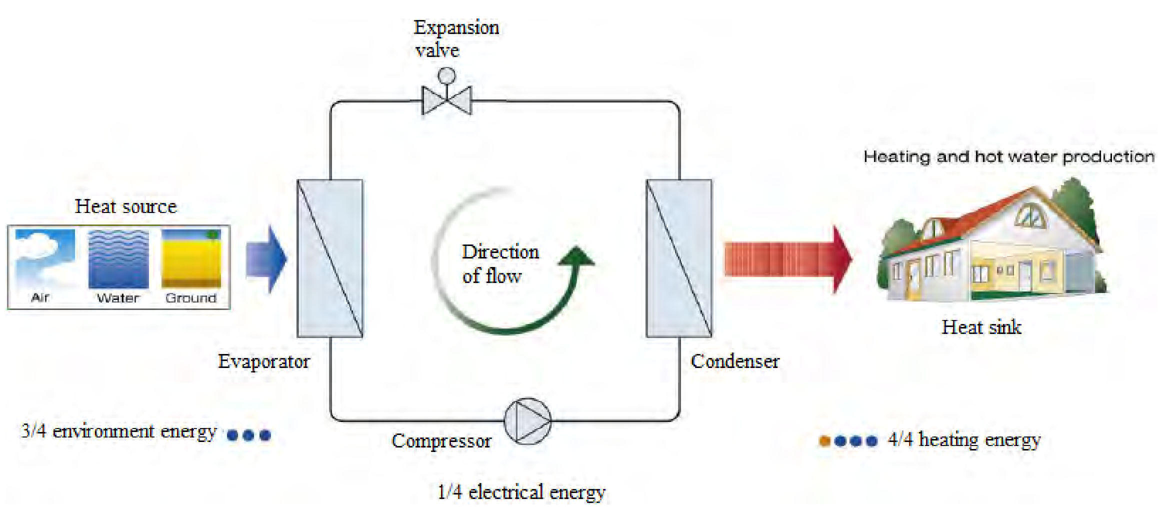
Technically, any air conditioner can be considered a heat pump, but the HVAC industry considers heat pumps, to be air conditioners that have the ability to operate with a “Reverse cycle”.

It you have walked behind a window air conditioner on a summer day, you might have felt the hot air being discharged by these machines. As described above, the temperature of the air leaving these units has increased because the refrigerant in the system picked up heat from the air inside the building, and that heat is being transferred to the air passing over the outdoor coil, thereby raising the temperature of the air.

Think about what would happen if you install the window air conditioner in reverse i.e. turning it 180°. Now, instead of transferring heat from inside the room to the outdoors, the air conditioner would be attempting to cool the great outdoors and transferring heat from the higher temperature outdoor air to the lower temperature air within the room. On a 95°F day, this would be objectionable because we would end up with 125° temperatures inside the conditioned room. However, think about this process on a 45°F day. The air conditioning unit, installed backwards, would be removing heat from the outdoor air at 45°F and transferring it to the air within a room at 70°F. This heating process is called “Reverse cycle air conditioning,” and this is what a heat pump is designed to do. It is designed to cool a space when operating as an air conditioner and it is designed to heat a space when the cycle is reversed. The actual reversal of the cycle is accomplished by reversing the flow of refrigerant and causing the indoor coil and the outdoor coils to switch roles.

What is the Benefit?

The most important characteristic of a heat pump is that the amount of heat that can be transferred is greater than the energy needed to drive the cycle.



The key to the efficiency of a heat pump is the Coefficient of Performance: the “COP”.

In spite of the first law of thermodynamics, which tells us that energy can neither be created nor destroyed, the heat pump can yield up to four units of heat for each unit of electricity consumed. The heat pump is not creating this energy, but simply moves heat from cooler outdoor air into the warmer inside. Even in air that's seems too cold, heat energy is present. When it's cold outside a heat pump extracts this outside heat and transfers it inside. When it’s warm outside, it reverses directions and acts like an air conditioner, removing heat from your indoor space. It pushes heat in a direction counter to its normal flow (cold to hot, rather than hot to cold).

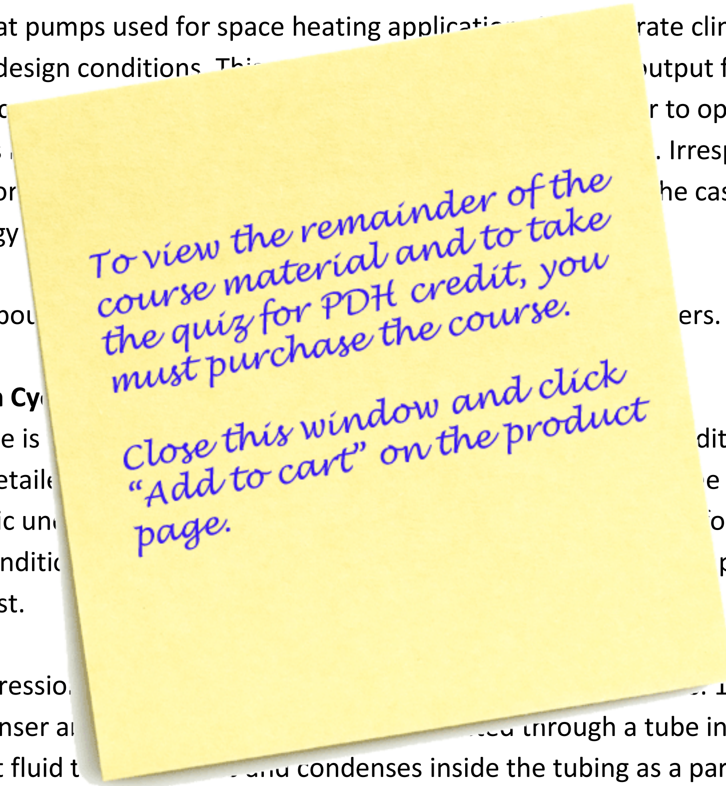
COP is determined by dividing the energy output of the heat pump by the electrical energy needed to run the heat pump, at a specific temperature.

Electrically driven heat pumps used for space heating applicatio rate climates usually have a
COP of a least 3·5 at design conditions. Thi utput for 1 kWh electricity
used to drive the proc r to operate provided that
the electricity price is . Irrespective, even when
the operating costs for he case for heat pumps as a
low carbon technology

We will learn more abou ers.

1.2. Refrigeration Cy

The refrigeration cycle is ditioners and heat
pumps. Although a detaile e practical application
of heat pumps, a basic un or all heating,
ventilation and air conditic por compression
refrigeration cycle first.



A simple vapor compressio 1) compressor, 2)
evaporator, 3) condenser a through a tube in closed circuit. It
contains a refrigerant fluid t condenses inside the tubing as a part of the operation
process.

- The **compressor** is a pump that causes the refrigerant to circulate through the system. The compressor is rated to pump a set volume of vapor, so it will have a set capacity or BTU rating or Tonnage, depending on the refrigerant being used, and the operating temperature in the evaporator. 1 ton of refrigeration is equivalent to 12000 BTU's/hour.
- The **evaporator** is a heat exchanger where the refrigerant vaporizes i.e. it absorbs heat and the surroundings get cold.
- The **condenser** is a heat exchanger where the refrigerant condenses i.e. it releases heat and the surroundings get hot.
- **Expansion valve** is a device used to reduce the pressure and temperature of the refrigerant at the end of the process cycle. Lowering the pressure of the refrigerant allows it to vaporize once heat is added.

The basic arrangement of a refrigeration circuit (cooling mode) is shown below: