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Fabrication and analysis of instantaneous water cooler by using isobutane as refrigerant

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Abstract

This paper studies the instantaneous cooling effect on water using R600a gas as a refrigerant. A refrigerator serves many and useful purposes such as cooling water, storing food items, medicines, beverages, and other such materials. Among all this consumptions of chilled or cold water is more. The household refrigerator that we use in our homes and hotels requires opening and closing the door several times and also we have to fill the bottles or containers each time they are emptied. This reduces the efficiency or performance of the refrigerator. The refrigerant use in our refrigerator has an adverse effect on environment and also the power consumption is huge. So, to solve this problem out making just a water cooler or chillier that will give you chilled and cold water in the minimum time (instantaneous) as compared to our daily refrigerator by using R600a gas as a refrigerant. This system will be atomized with Automatic filling arrangements, Temperature controlling sensors, leakage detecting device. R600a (isobutene gas) as refrigerant used for supportive way to contribute towards our environment, R600a which is easily available, Which contains of pure isobutene. It is cheaper and eco-friendly towards global warming. It works efficiently instead of R134a to obtain good cooling effect and this may be a small step towards power saving, supporting towards environment.

Keywords: *Evaporator Tube, Condenser, Refrigerator, R600a Compressor, Capillary Tube, R600a Gas.*

1. Introduction

Vapour-compression refrigeration is one of the many refrigeration cycles available for use. It has been and is the most widely used method for air-conditioning of large public buildings, offices, private residences, hotels, hospitals, theatres, restaurants and automobiles. It is also used in domestic and commercial refrigerators, large-scale warehouses for chilled or frozen storage of foods and meats, refrigerated trucks and railroad cars, and a host of other commercial and industrial services. Oil refineries, petrochemical and chemical processing plants, and natural gas processing plants are among the many types of industrial plants that often utilize large vapour-compression refrigeration systems. Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere. A device that performs this function may also be called a heat pump. Energy analysis of refrigeration, consider a boundary enclosing a space in which a refrigerator is placed. It is clear that some heat q2 is given out at temperature higher than the surroundings. It is also clear that the foodstuff placed inside the refrigerator is cooled by giving out their heat to the refrigerator which in turn, so to say, absorbs heat q1, of course at lower temperature than the surroundings. Every refrigerator is supplied with energy wither in the form of heat or electricity, that is, some work (w) is provided to it. The refrigerating device, thus is absorbing heat at lower temperature and giving out at higher temperature; this is usually not possible in our day to day life, since heat cannot flow from lower to higher temperature, but in case of a refrigerator this is achieved at the cost of energy supplied to it. For the boundary total heat given out (q2) is equal to the total energy input in the form of heat absorbed (q1) and the work absorbed (w) Balancing them. For a refrigerator device, we are interested in how much heat is extracted from food stuff and how little electrical energy we spend, minimizing our power bill. The ratio of heat absorbed to the work input in the form of electric energy (w) is called coefficient of performance (COP). The ratio should be as high as possible.

$$C.O.P = q1/w = q1/(q2-q1)$$

Theoretical COP is ratio of theoretical refrigerating effect (N), found from pressure heat content chart or temperature -entropy chart to the theoretical compressor work (W) or isentropic compressor work, found from the chart. Actual COP is the ratio of actual cooling effect, to the actual energy supplied to the compressor known from watt-hour reading. Relative COP is the ratio of actual to the theoretical COP. It is a pure number without any unit.

2. Basic Refrigeration Principle

If you were to place a hot cup of coffee on a table and leave it for a while, the heat in the coffee would be transferred to the materials in contact with the coffee, i.e. the cup, the table and the surrounding air. As the heat is transferred, the coffee in time cools. Using the same principle, refrigeration works by removing heat from a product and transferring that heat to the outside air. The principle involves the transfer of heat. We could discuss entropy and the laws of thermodynamics, but we're not going to do that. That isn't really necessary to understand this concept. It is one that we are all familiar with, whether we have any interest in science or not. If you take your supper off the stove but don't eat it right away, it gets cold. If you leave the milk out on the counter, it gets warm. Actually, your supper and your milk would become the same temperature, the temperature of the room. Because your supper is hotter than the room, heat energy moves from it into the room. Because you milk is colder than the room, heat energy moves from the room into the milk. This movement of heat energy affects the objects involved, your supper or milk, changing their temperatures. This concept of moving heat has a direct bearing on our lives. In the winter, we move heat from a fire, or a radiator, or an electric heater into our house, changing its temperature. In summer, we want to do the opposite, move heat from our house to somewhere else (we don't really care where), again changing the temperature of our house.

3. Water Coolers

The purpose of water coolers is to make water available at a constant temperature irrespective of ambient temperature. They are meant to produce cold water at about 7oC to 13oC for quenching the thirst of the people working in hot environment. The warm or normal water can serve the physical requirement of our system for the proper functioning of the body organs but it does not quench the thirst especially in hot summers.

3.1 Types of Water Coolers

The water coolers are two types i.e. the storage type and the instantaneous type. In the storage type water coolers, the evaporator coil is soldered on to the walls of the storage tank of the cooler, generally on outside surface of the walls. The tank may be of galvanized steel or stainless steel sheets. The water level in the tank is maintained by a float valve. In this type of water cooler, the machine will have to run for long time to bring down the temperature of the mass of water in the storage tank. Once the temperature touches the set point of the thermostat, the machine cycle is stopped. When the water is drawn from the cooler and an equal amount of fresh water is allowed in the tank, the temperature will rise up slowly and the machine starts again. As such there is always a reservoir of cold water all the time.

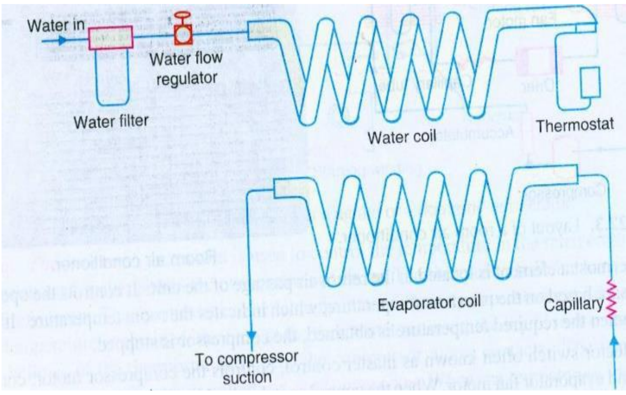

Fig.2cooling coil of instantaneous type cooler

In instantaneous type water coolers, the evaporator consists of two separate cylindrically wound coils made of copper or stainless tube. The evaporating refrigerant is in one of the coils and the water to be cooled is in the other coil. The water is cooled by the refrigerant in evaporator by conduction.
These water coolers are further classified as (a) bottle type, (b) pressure type, and (c) self contained

remote type, these are discussed, in detail, as follows:

(a) Bottle type: As the name suggests, this type of instantaneous water cooler employs a bottle or reservoir for storing water to be cooled. No city main inlet connection is required as it is normally used to cool water supplied in 25 litre glass bottles, which are placed on top of the unit.

(b) Pressure type: In this type of instantaneous water cooler, water is supplied under pressure. The city main water enters the cooler through the inlet connection at the rear of the cooler. It then passes through a pre-cooler. The pre-cooler is cooled by the waste water of the cooler. As the waste water temperature is low, it is made use of cooling the supply water by passing through a pipe coil wrapped around the drainage line. This arrangement helps in reducing the cooling load for the cooler. The amount of cooling depends upon the quantity of waste water and the length of the pipe coil comprising of pre-cooler. The pre-cooled water then enters the storage chamber and loses its heat to the refrigerant. The outlet water pipe is connected at the bottom of the storage tank, which is fitted with a self-closing valve or bubbler. A thermostat controls the temperature of the water in the pipe to set a point.

(c) Self contained remote type cooler: This type of cooler employs a mechanical refrigeration system. The water cooled from the remote cooler is supplied to desired drinking place, away from the system. This type of arrangement does not require extra space near the place of work and is quite useful.

3.2 Types of water flow: a. Parallel flow, b. Counter flow,

a) **Parallel flow:** if a fluid flows in a pipe or device in one direction, another fluid flows in same direction, it's called as parallel flow.

b) **Counter flow:** if a fluid flows in a pipe at the same time another fluid flows in opposite direction to the first one, it's called as counter flow. It is suitable to the instantaneous type water coolers.

3.3 Capacity of Water Coolers

The cooling load for the water cooler (Q) may be obtained from the following relation: Q=mw cp (Ti-To) Where mw= Rate of water consumption cp= Specific heat of water Ti= Inlet temperature of water, and To= Outlet temperature of water. The amount of cold water requirements under various conditions is given. These figures are based on extensive statistical survey. The refrigerants such as ammonia, sulphur dioxide etc. are now-a-days not used because of safety reasons. Generally R-12 is the most common refrigerant up to one tonne refrigeration (1TR) capacity and R-134for two tonne refrigeration (2TR) capacity and appropriate combination for larger size units. The amount of wastage of cold water should be included while estimating the amount of water consumption. Usually heavy insulation around 40mm to 60mm thick glass wool or thermocole is provided rendering insignificant heat transfer through insulation.

4. Experimental setup and methodology

This project focuses about the instantaneous water cooling, it contains R-600a compressor, condenser, thermostat, two ¼ inch diameter copper tubes. One is for carrying the refrigerant (acts like evaporator) another tube for carrying the water.

Actual setup of the model

4.1. Methodology:

This project works on the conduction heat transfer method, in this process copper tubes are winded spiral way, both tubes are

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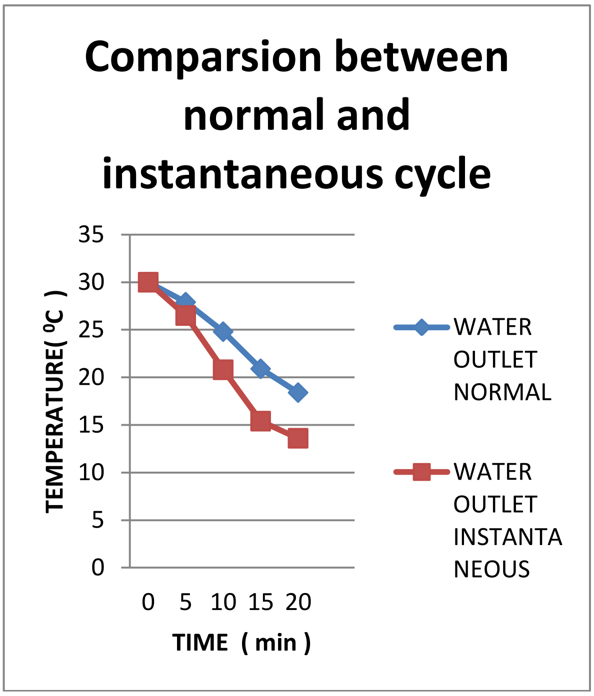
winded parallel to each other and both are joined with spot welding to better contact between each other. By this process thermal conduction between these two tubes will be high. And it follows counter flow method for better cooling effect.

4.2. Experimental Procedure:

a) Take copper tube and making it as evaporator coil, take another copper coil as water coil of same length.
b) Both are joined or attached with each other by the spot welding, for better contact between the tubes, it increases the heat transfer rate by the conduction.
c) This copper tubes equipment is connected to the capillary tube and this capillary tube connected to filter where it is connected to the condenser.
d) Then this condenser connected to the one end of the compressor and other end at inlet of compressor evaporative coil connected.
e) Water tube is connected to water source i.e., in counter flow direction to the evaporator coil, it means where refrigerant in and water out vice verse.
f) After that check all the connections and joints for leakage, by using N_2 gas and soap water. Using the vacuum creating machine to remove air and moist content in the system.
g) After, the process should be filled with isobutene (R-6000a), by using the gas charging unit, Fill the system up to 50_{gr} of refrigerant, and close it by using the valve.
h) At last, the connections and valves of the system, and power connections should be checked.
i) Then run the project for the values.

5. Results and Discussion:

In the case of normal water cooler with R600a as refrigerant, the time taken for water to decreases the temperature from 30^0C to 18.4^0C is 20 minutes; the time taken for instant water cooler is 10 minutes, by



instantaneous water cooler is 10 minutes is saved. So that instantaneous water cooled is the better option to obtain the water at low temperature within short duration.

6. Conclusion:

In this paper the present work serves as the instantaneous water cooler. By fabricating this project of instantaneous water cooler, it conclude that the cooling of water in heat exchanger or evaporator is depend upon,

a) Flow rate of incoming water in heat exchanger.
b) Flow of refrigerant through water tube.
c) Super heating.
d) Quantity of water to be cooled.
e) Capacity, performance and efficiency of overall components.

By comparing other high water cooler with over instantaneous water cooler we observed that water cooler is having excellent performance with good cooling of water and also have better efficiency. The temperature of outlet water obtain is in the range of 13^0C to 15^0C.

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