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To Increase Efficiency of Air-Cooled Condenser by Using Hollow Cylindrical Fins

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Abstract- In 1970 in the United States of America the concept of Air-cooled Condenser was came into light. But it was recently the last decade when experiments paid their attention to this concept. The reason behind this was to secure the environment for mankind. As the increasing pollution level caused in rise of global temperature thus causing the global warming which in turn creates inconvenience to humans and other living beings. The pollution levels were increasing day by day so this phenomenon created vast requirement to research in the field of innovative technologies in air conditioning. To overthrow such environmental conditions the researchers started to work upon this and propounded different- ideas. They also designed various devices.

In this research work, it is being tried to upgrade the design of air-cooled condenser to raise the efficiency of refrigerator, central, split & window air conditioner, water cooler, Ice plants, freezer.

For this purpose the shape of fins has been changed although the quantity of metal was same as used previously. By this concept the area of fins increases many times. As per the design used the efficiency output increases 2.215 times by taking suitable dimensions and by using the same quantity of metal.

This research work has many advantages as given below-
Primarily this research work is paying attention to enhance the efficiency of air-cooled condenser. Consequently the co-efficient of performance of air condenser is increased.

Secondly it minimize the adverse effect on surroundings by making the air conditioning more environment friendly.

It also curtails the unwanted energy wastage and manages financial loses. This design will also reduce the carbon emission across the world. Further more the maintenance cost of equipment also get reduced. And it becomes also customer friendly.

Keywords- Air cooled condenser, Fins, Efficiency, COP, and Temperature.

I. INTRODUCTION

It is proving very difficult to find the resources of energy and fruitful distribution in our country. To meet our energy requirements we are dependent upon import of fossil fuels and for this the country has to pay a huge amount of budget.

In order to fulfil our power requirements the country has to expend more than 500 crore per year. To get the solution of this problem this research design is being developed so that the raised output of air-cooled condenser may be achieved by using minimal energy by changing it's design. In this way grater output can be accomplished while using lesser assets.

As in this design the less power and equal amount of metal is used so power utilization is decreased. It helps to prevent harm to the atmosphere. In the process of power generation various resources like coal, tree wood, natural gases, kerosene, coke, petroleum etc. are utilized by firing process. This process of power generation produces a huge amount of harmful gases such as carbon mono oxide, carbon dioxide, sulphur dioxide, nitrogen oxide, and vocs. These gases cause damage to the health of mankind, animals, species and all flora-fauna.

AS the decreased amount of power is utilized in this design to raise the refrigeration effect consequently it decreases the financial expenditure of the people that is created due to undesirable power utilization.
As the less amount of power is utilized for getting more work by the movement of moving parts (Compressor) in the air conditioner. In fact, this causes reduction of maintenance cost of ice plants, water coolers, window air conditioners, split air conditioners, central air conditioning.

Due to our research design and the analogous designs which will be manufactured in future on the parallel line of thought the energy generation units will be enable to decrease energy generation in hot areas.

This design will be of great significance in desert. and arid areas of middle east, Saharan sub Saharan African countries and hot areas of Indian sub-continent because in less power consumption our device will yield great human comfort to the natives of these hot areas.

Also the reduced movement of the dynamic parts (as turbine) in energy generation unit causes less damage of the moving parts . It also curtails expenditure of maintenance of power generation unit.

This also rises the income of the workers of power generation unit consequently it will contribute in the growth of G.D.P. This design takes same space and utilizes the equal amount of metal in fins of air conditioner so it is also consumer friendly.

This device is economical in nature. The use of this device (air conditioner) will increase the efficiency of the workers and employees working in industries, govt. offices & private sectors, shops, restaurants etc. and this will contribute to the gross productivity of different sectors.

It is also being observed that the milking animals like cows, buffaloes, goats yield much milk In air conditioned atmosphere. So it proves that milk production increases by using air conditioner that contributes to more profit.

Due to the industrialization and cutting of forests the average global temperature has been raised during last 2 years. The carbon emission & the depletion of ozone layer are responsible factors for rapid raise in temperature.

Due to global warming the use of air conditioning system is increasing rapidly. It causes the huge consumption of electricity so the researchers are doing the efforts so that the use of energy may reduce and output may be increased.

In air conditioning and refrigeration process, the condensate cooled with the help of air used normally. The condenser cool down by atmospheric air is more cost effective than the condenser which

is cool down by using water for same amount of heat rejection. In air cooled condenser the generally round tubes are used with attached fins. To raise the output of the condenser which is cooled down by air various techniques are utilized-

- The area of inner pipe may be increased.
- By changing the tube from round to flat tube.
- By altering the shape of fins which are used outside the tubes.

The flat tubes which are having lesser cross sectional area are good substitutes of cylindrical round tubes. The flat tubes with lesser area of cross section are utilized in heat exchanger. These flat tubes have many separate passages in those cross section. In flat tube heat exchanger the direction of flow is parallel or curvy pattern. The pressure drop is reduced and thermal effectiveness is raised in comparison with round tube which have fin heat exchanger. Various manufacturing companies producing the flat tube heat exchanger due to its good performance.

II. APPROACH

There are three types of heat transfer- conduction, convection, radiation. Conduction is the way of heat transfer in which heat is taken from one end of metal rode and it heats the other end of the same rode.
In this process molecule do not move from one place to another inside the metal. But the molecules vibrate at their own place. The molecules at the end which is being heated vibrate with more amplitude and during vibration it transfers energy to the nearby second molecule by collision.

Due to the collision second molecule begins to vibrate with an amplitude and this second molecule begins to collide with the third molecule. This third molecule begins to vibrate with the certain amplitude. In this way energy is transferred from hot to cool end of the metal rode.

The formula for heat transfer by conduction is –

$$Q = (-KA (T_1-T_2)t)/L$$

Here 'Q' is the heat transferred from hot to cool end.

'K' is the thermal conductivity of the material, it depends on the material used. It is constant for a particular material.

'A' is the cross sectional area of the material.
(T_1-T_2) is the temperature difference between the hot and cool end.

't' indicate time during which period heat- supply exists from hot to cool end.

'L' indicates the length of the rod.

Here the negative sign indicate that the heat is flowing from high temperature end to the lower temperature end.

Another type of heat transfer is CONVECTION. In this process heat transfers from solid surface to the liquid or gases. The liquid and gases are not the better conductor of heat but these are the good medium in heat transfer process. When water or air is heated , fluid particles become lighter due to reduction in density and move upwards. The upper side particles are dense due to lower temperature, move downwards and take the vacant place. Then these particles take heat from source, become lighter and move upwards. Then again the cool particles move downwards and take the vacant place this process continues during the convection heat transfer process. The formula used for convection heat transfer is-

$$q= hA(t_1-t_2)$$

'q' is the rate of heat transfer
'A' is the surface area used in heat transfer
(t1-t2) is the temperature difference between the solid surface area and fluid like liquied & gasses

There are 2 types of convection-

- Nature convection
- Forced convection

The third type of heat transfer is radiation the heat transfer by radiation is very important for all living creatures that is humans, animals and all flora- fauna. The biggest example of energy transfer from the sun to the earth surface is "radiation process".

The heat transfer process by radiation takes place through electromagnetic waves. The conduction and the convection require "medium" to transfer heat but the radiation process does not need any medium for heat transfer. The solar radiation crosses 93- million miles vacuum to heat the planet earth. The radiation process also transfer heat in thermal energy form between two object isolated by a colder medium. The sun rays pass through the mesosphere which is the coolest part of the earth surrounding with minus 173oc.

There are the three part of the thermal radiation spectrum. Infrared, visible and ultraviolet. All these three parts are present in the radiation of the sun. The ultraviolet waves have 900 -3000 angstroms length of the waves of visible light have 4000-8000 angstroms length. The waves of infrared are represented in microns where 1 micron is =10000 angstroms.

The formula used for emissive power is

$$E=qT^4$$

Where E is the radiated energy which is emitted at per unit time by unit area of the surface is proportional by the forth power of its absolute temperature where σ the coefficient of radiation of a body.

In condenser heat transfer takes place by conduction & convection where major part of heat transfer process takes place by the convection. The formula for convection heat transfer process is

$$q= hA(t_1-t_2)$$

Where heat transfer by convection depends on
'h' convection heat transfer coefficient
'A' is the area of surface from which heat is transferred.
't1' is the temperature of the area of surface
't2' is the temperature of the surrounding.

By changing these three or any one of these, heat transfer by convection can be increased.

Here in this work heat transfer is increased by changing the area of surface. For this the shape of the fin is being changed in this work. If the rate of the heat transfer by heat exchanger (Condenser) is improves then the condensation inside the tube will be fast which will proved more refrigerant liquid form in the evaporator. The evaporator will be able to draw the more amount of heat form the object/ space. This will cases to raise the coefficient of performance of air conditioner.

Objective

The aim of this research work is

- To analyses various types of condensers which are cooled by air
- To study the places where energy is unnecessarily wasted.
- To improve the capacity of heat transfer of condenser which is cooled by air.
- To raise the efficiency of the air cooled condenser.
- To increase the refrigeration effect of the refrigerator
- To increase the cooling effect of air conditioner
- To suggest the modification of design which are used nowadays.
- To save energy.
- To reduce maintenance cost of air conditioning plant as well as air conditioner, refrigerator, ice plant etc.
- To minimize the maintenance cost electricity generation unit
- Due to the saving from maintenance cost of the power plants and air conditioning plants. it will be more profitable.
- Since the less power is used so the carbon footprint will be reduced
- To save the earth from global warming
- To make people more efficient, happier and healthier.

III. MATHEMATICAL ANALYSIS

Generally the air cooled condenser used in air conditions, refrigerator, and water cooler use the solid cylindrical Fin.

The convection heat transfer Q1 from Fin to air is proportional to the area of the Fin A1 which is in contact with air.

Initially the diameter of the solid cylindrical Fin is 6mm that is equal to 0.6cm
The length of the solid cylindrical Fin is 60cm
The volume of the metal that is used in the Fin is

$$V_1=\pi\, d_1 X d_1 X L_1/4$$
$$d_1=0.6cm \;\&\; L_1=60cm$$
$$V_1= \pi \text{ X } 0.6 \text{ X } 0.6 \text{ X } 60/4$$
$$= 16.956cu\ cm$$

Lateral area of the solid cylindrical Fin is $= \pi\, d_1 X L_1$

$$A_1 = \pi \text{ X } 0.6 \text{ X } 60$$
$$= 113.04cm^2$$

Now using the same quantity of metal as it calculated above, if the hollow cylindrical Fin is used. Now the new total area of the hollow cylindrical Fin. Suppose the outer diameter of the hollow cylindrical Fin is 08cm

$$So,\ d_2= 0.8cm$$

Since we are using the same quantity of the metal 16.956cucm and the same length of cylindrical Fin

$$So,\ v_1=16.956cucm$$
$$L_1 = 60cm$$
$$d_2 =0.8cm$$

If the inner diameter of the hollow cylindrical Fin is d3
Then by mathematical calculation

$$V_1= \pi\, (d2^2-d3^2)\, XL_1/4$$
$$16.956 = \pi\, [(0.8)^2-d3^2]\ X60/4$$
$$d3^2=0.64-0.36$$
$$d3^2 = 0.28$$
$$d_3=\sqrt{(0.28)}$$
$$d_3=0.529cm$$

Heat Transfer area of the new hollow cylindrical Fin is A2

Than

$$A_2 = \pi\, L_1 d_2 + \pi\, L_1 d_3$$
$$= \pi\, L_1\, (d_2+d_3)$$
$$= \pi \text{ X } 60\ (0.8+0.529)$$
$$= \pi \text{ X } 60 \text{ X } 1.329$$
$$A_2 = 250.3836$$

Ratio of the heat transferring area of the new hollow cylindrical Fin to the solid cylindrical Fin

$$= A_2/A_1$$
$$=250.3836/113.04$$
$$= 2.215$$

By computation the ratio of the heat transferring area of the hollow Cylindrical Fin and Solid Cylindrical Fin

When we are using the equal volume of metal as well as equal length of Fin

$$= 2.215$$

Since convectional heat transfer

$$q=h.A\ (t_1-t_2)$$

Here $q \propto A$

Here q is directly proportional to A as area will increases heat transfer will also increase.

As area of heat transfer of hollow Fin in comparison with solid Fin is raise by 2.215 times, so the heat transferred by the hollow Fin is also raised by 2.215 times.

If we are using hollow Fins which is divided in such a way – so that it is divide in two equal part in longitudinal direction by a section. Then the Fin will divide in equal two parts longitudinally by joining these equally divided Fin on the condenser tube. These Fins will make better contact with air. We will get the 2.215 times approximately raised heat transfer which is computed mathematically, it is also possible due to improved air connect in booth side of newly designed hollow cylindrical Fins.

Assumptions

- Few assumptions have been taken while doing this work.
- The base & top area of the solid cylindrical Fin has been neglected during the calculation.
- During the computation top and basis area of the hollow cylindrical Fin is considered negligible.
- Same amount of metal during the designing of the hollow Fin is being used.
- During the computation of the lateral area and the volume of the cylindrical Fin we have taken appropriate dimension.
- There is no decay in the Fin due to erosion and corrosion.
- The Fin used is clean having no sediment on it.
- Appropriate air flow is available there.

Industrial Application

It can be used in several places such as –

- Process – During processing of fluids the condenser is used in cooling device.
- Automotive – It is used for comfort of passengers inside trains, cars & Planes.
- Building – During the air conditioning of different area of building central air conditioning in used in which condenser is used. Central air conditioning is installed in outdoor either on the ground or on the roof.
- Refrigeration – In refrigeration process the condenser is used during the refrigeration cycle.
- Stem power plant – In the nuclear and stem power plant the condenser is used to condense the steam that comes out from the steam turbine.
- Ware house –It is used in the cooling system installed in ware houses where food grains, vegetables are kept.
- Ice making plants –It is used in ice making plants, producing ice from water and Ice cream.

IV. RESULT & DISCUSSION

The efficiency of the air cooled condenser is raised by 2.215 times. The area of heat transfer of air cooling condenser Fins is also increased by 2.215 times. The amount of the metal used for the hollow cylindrical Fin is same as used for the solid cylindrical Fin. The C.O.P of the air conditioner will be raised. It is the cost effective. It will also save the energy.

As it emits less carbon so it will also help in reducing global warming.

V. CONCLUSION AND FUTURE SCOPE

The main goal of our work is to improve the outcome of the air cooled condenser by using the equal air amount of metal which was initially used. By using ours design the area of heat transfer of the Fins is raised by 2.215 times. Due to that heat transfer is also increased by 2.215 time. The carbon emission will be reduced since the less power is used. The coefficient performance of the air cooled condenser will be raised. The cooling capacity will be raised. The heat transfer by the Fins is raised while using the equal amount of metal which was used initially. It is economical. The time of condensation of the refrigerant or steam will be decreased. As this design Eco friendly and economical its future scope is very wide. This design will be used in various equipment in future.

Refrigerator

- Air conditioner (Both in window, split & central air conditioning.
- Ice Making Plant.
- Water cooler used in various offices, premises like school, colleges, corporates & govt. offices, railway stations, Bus stands, Air ports.
- Food preservation plants.
- Ice cream Plants.
- Chemical plants.
- Power generation unit for steam condensation.
- Processing plants.

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