AIR CONDITIONER USING PELTIER MODULE

SMALL SCALE AIR CONDITONING

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ABSTRACT

Present paper gives a picture of a conceptual design of an air conditioner using Peltier modules to achieve desired amount of cooling. The appearance of this thermoelectric type of air conditioner resembles a conventional window air conditioner. This brings the simplicity in construction. The air conditioner is intended to take up the cooling load in volume of space as in conventional automobiles such as cars. If conventional vapour compression type of air conditioner currently used in vehicles is replaced with this one with an arrangement for its placement, it would reduce the total weight of vehicle and increase fuel economy.

EXTRACT

Majot part of my project are closed shell, coiled copper tube and Peltier module.

Closed shell and coiled copper tube : In the present work attempts are made to enhance the heat transfer rate between cooling medium present in closed shell and coiled copper tube . Air at room temperature flows into helical tube and cooling medium is filled in the shell side.

Results indicate that the higher coil diameter, coil pitch and mass flow rate in tube can enhance the heat transfer rate in these types of heat exchangers.

Cooling using Peltier Module: In order to cool the fluid in the close shell, a cooling system is needed which also reduce the total weight, also reduce the size and

more economical. Image attached below gives a picture of a conceptual design of a water-cooling using Peltier modules to achieve desired amount of cooling. The appearance of this thermoelectric type of cooling module resembles a conventional window air conditioner. This brings the simplicity in construction. The air conditioner is intended to take up the cooling load in volume of space as in conventional domestic cooling system such as small room. If conventional vapour compression type of air conditioner currently used in domestic areas is replaced with this one with an arrangement for its placement, it would reduce the total weight of system and more economical.

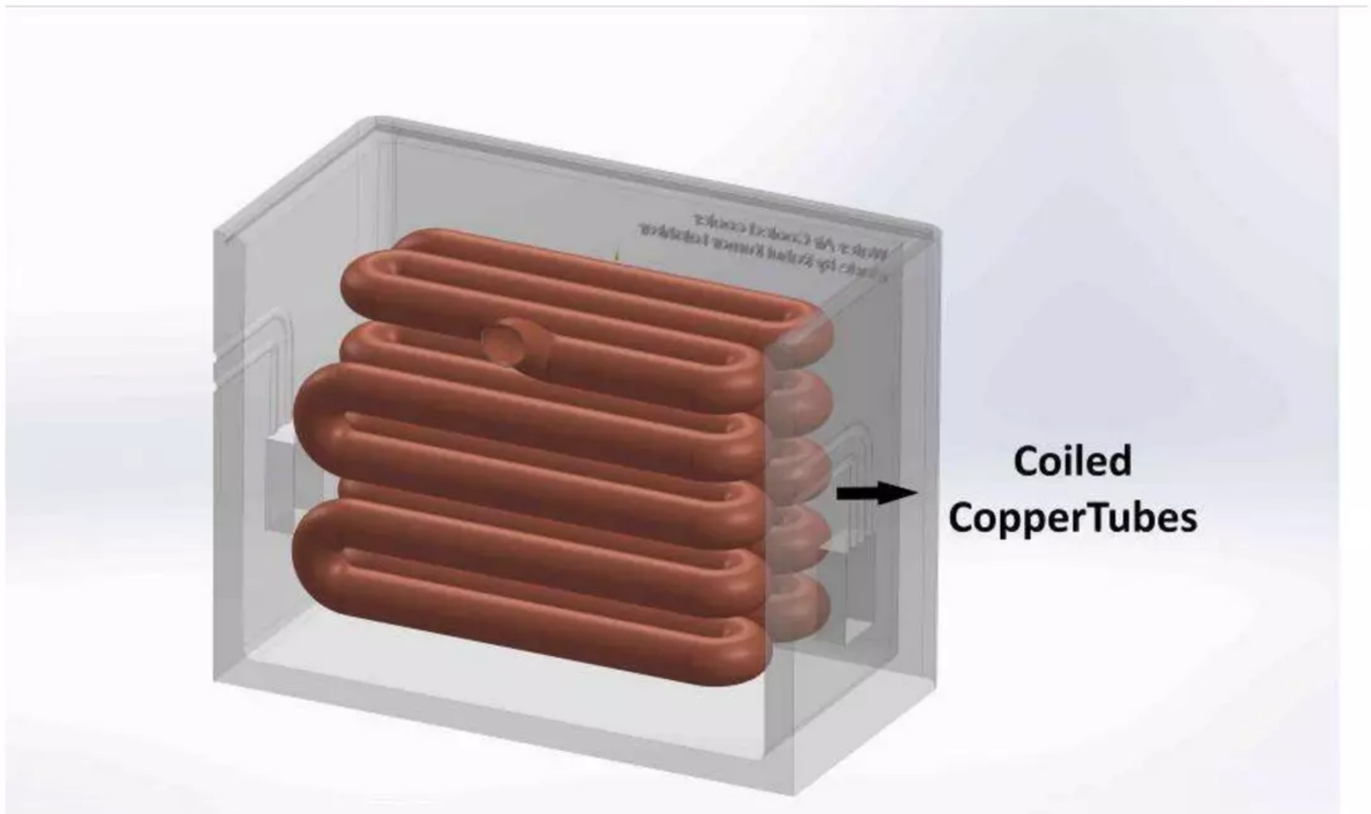
INTRODUCTION

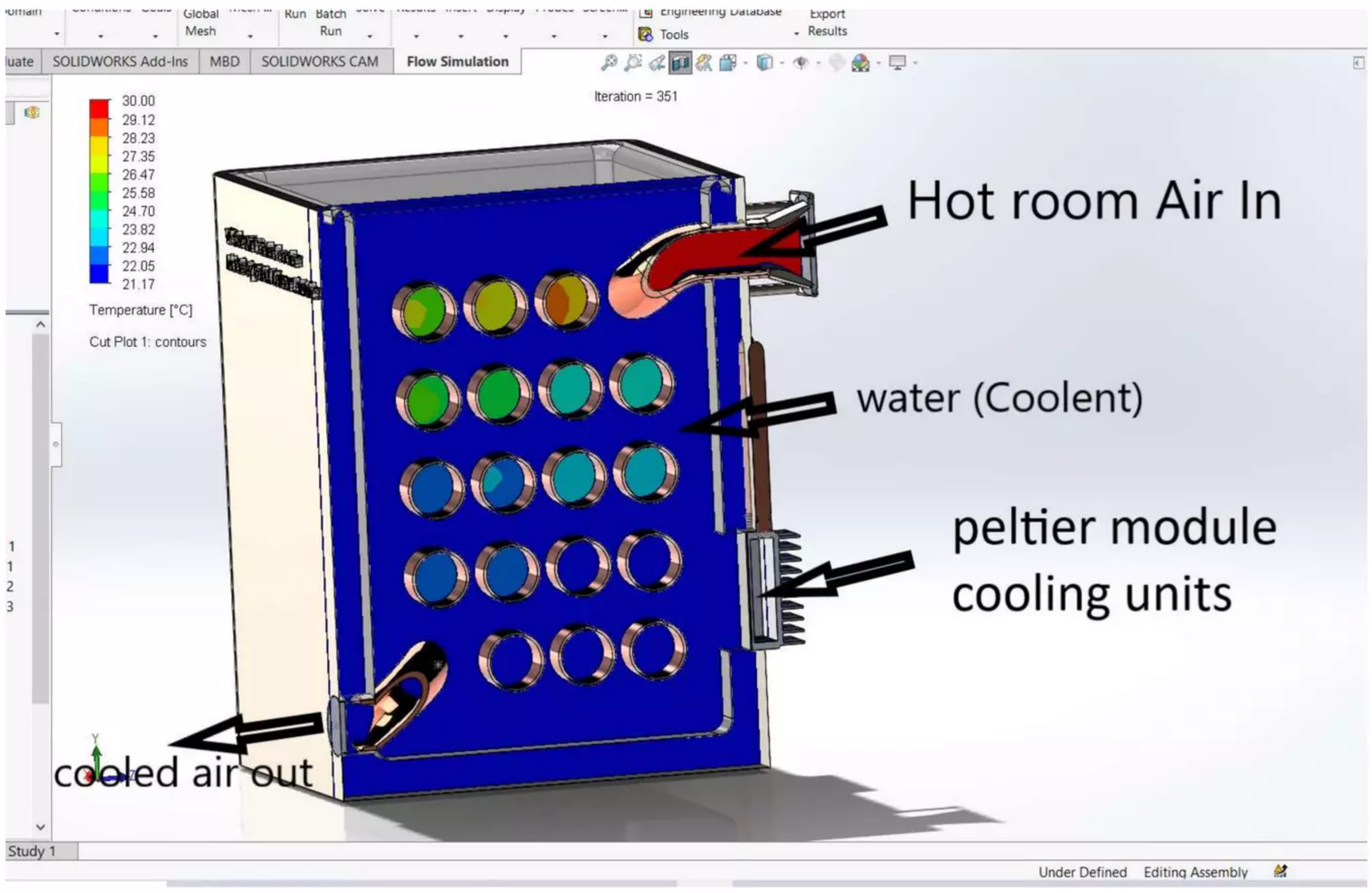
In industrial applications pipelines and tubes are widely used. Coiled tubes are used in compact heat exchangers, condensers and evaporators in the food, pharmaceutical, modern energy conversion and power utility systems, heating ventilating and air conditioning (HVAC) engineering and chemical industries [1e3]. In coiled tubes centrifugal force make a pair of longitudinal vortices and these secondary flow increases the heat transfer coefficient.

Patankar et al. [5] discussed the effect of the Dean number on friction factor and heat transfer in the developing and fully developed regions of helically coiled pipes. Good agreements were obtained in comparison with the experimental data. Kubiar and Kuloor [6] studied experimentally the heat transfer rate and pressure drop of glycerol flowing inside a vertical helical coil at constant wall temperature. The flow regime was laminar and new correlations were proposed. Rahul et al. [7] presented a correlation for outside Nusselt number of a helical tube. Their results indicated that the pitch of coil significantly affects the outside heat transfer coefficient. Helical and straight tubes were compared by Prabhanjan et al. [8]. The results showed that a helical coil heat exchanger increases the heat transfer coefficient and the temperature rise of fluid depends on the coil geometry and the flow rate.

This all researches show that the optimum condition for increasing overall heat transfer coefficient in coiled tube heat exchanger is obtained by highest level of the coil diameter, coil pitch, filled cold water and hot air flow rates.

AIR CONDITIONER USING PELTIER MODULE : SMALL SCALE AIR CONDITONING





Thermoelectric cooling uses the Peltier effect that produces a temperature difference between the junctions of electric conductors two different types of materials, when electricity is made to flow through the circuit. A Peltier cooler used in current work transfers heat from hot region to the comparatively cold region of space with the use of cluster of thermoelectric devices known as Peltier module, a semiconductor based refrigerator resembling flat square plate, where heat is absorbed from one side (cold side) and dissipated on the opposite side (hot side), with consumption of electricity.

This cooling is a solid state method of heat transfer generated using P-type and N-type semiconductor, usually bismuth telluride.

Peltier module consists of a number of thermocouples sandwiched between two layers of ceramic substrates. Thermocouples (thermoelectric legs/pellets) are electrically connected in series but thermally in parallel. A single thermocouple consists of one n and one p-type semiconductor material and is known as a thermo-element. One Peltier module consists of number of such thermo elements.

The ceramic substrates have high thermal conductivity so that there is minimal conduction resistance across the layer of the substrate but very low electrical conductivity to avoid any leakage current flow through the substrate.

At the cold junction, heat is absorbed by electrons as they pass from p-type (low energy) semiconductor, to the n-type semiconductor (high energy) and at the hot junction, heat is expelled as electrons move from an n-type to a p-type, when DC potential difference is applied across two electric wires provided on plate. If the polarity is changed the hot and cold junction, heat absorption and rejection, interchanges.

Peltier modules have specifications in terms of geometry, number of thermocouples, power rating, maximum voltage, current, maximum temperature difference.

Useful features of a Peltier cooler compared to vapour compression system are absence of moving parts such as compressor, no leaks, no use of refrigerant gas. It gains advantages due to above features over a conventional vapour compression such as no noise, long life, high reliability, low maintenance, portable, compact, no ozone depletion potential. Disadvantages of Peltier modules are very high cost and very lower coefficient of performance. Many studies for improvemnent of module carried out are discussed in the section below and in future the limitations would get reduced, so making cooling system based on Peltier modules would surely contribute towards society growth.

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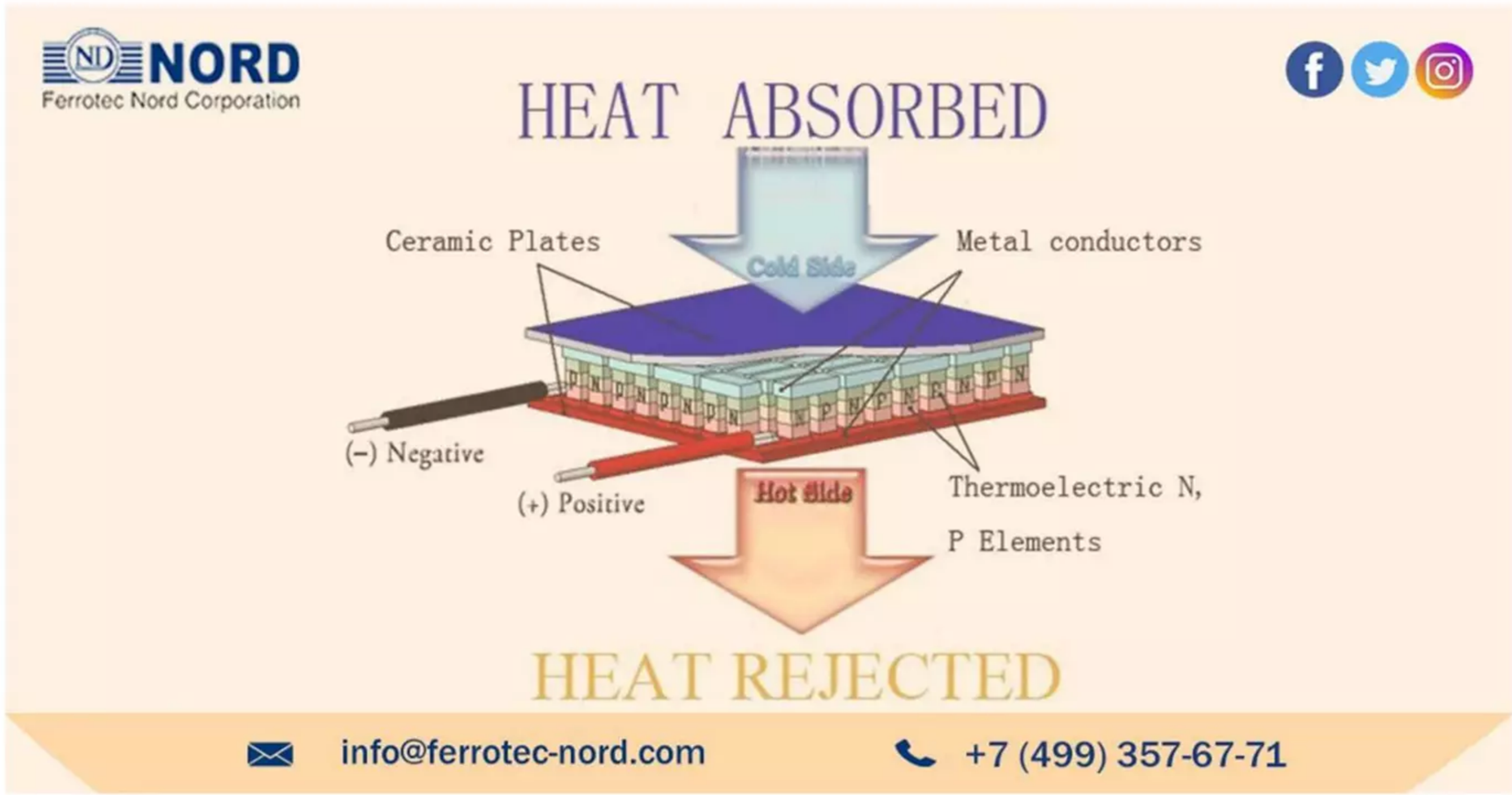

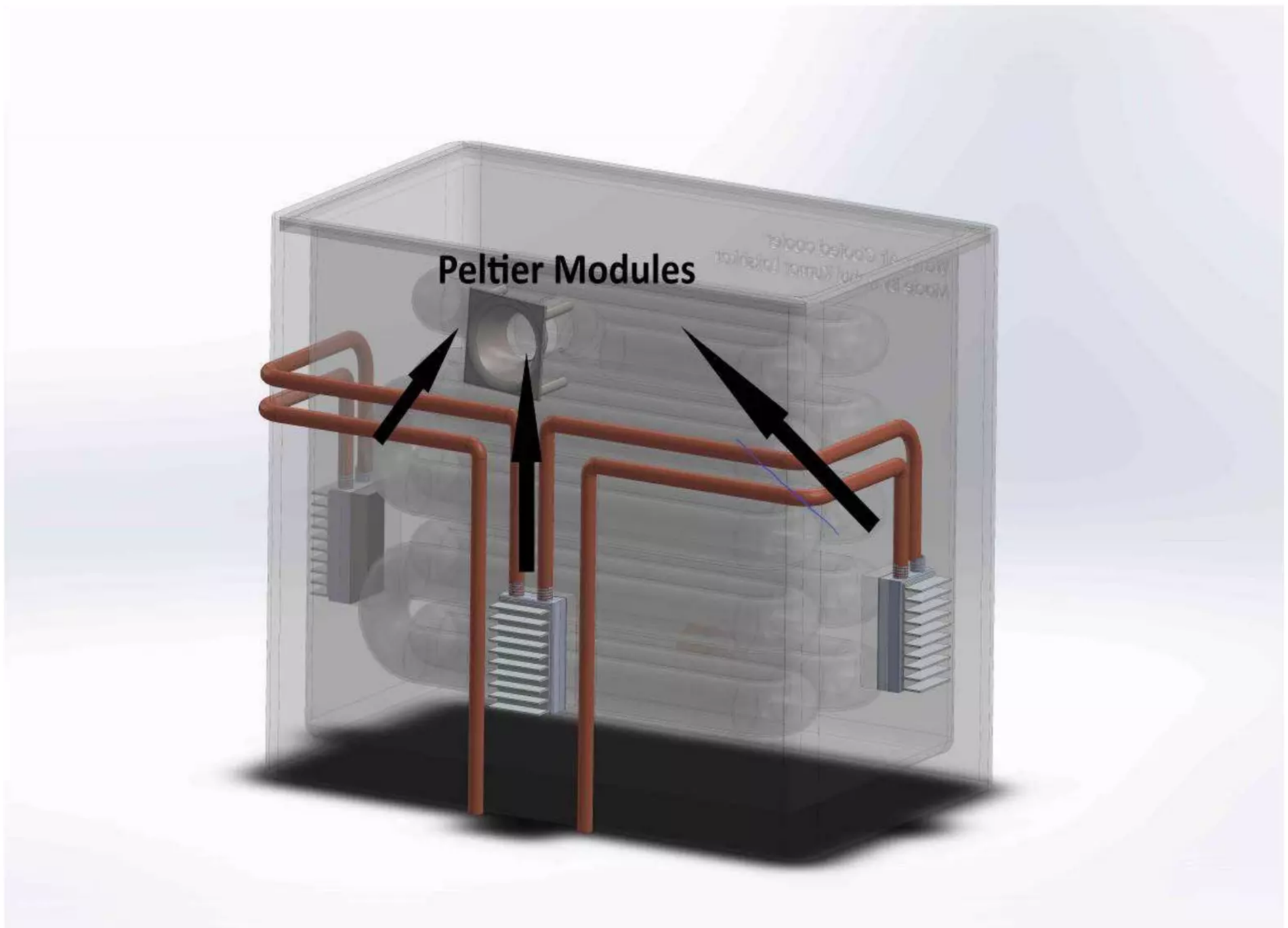

CONSTRUCTIONAL FEATURES OF AIR CONDITIONER

As shown in Fig. air conditioner consists of a casing(shell) in the shape of rectangular box. Casing is of thermal insulated box. contains container filled with water. Shell have one inlet connected with tube inlet side and one outlet connected with outlet side of tube. Cooling tubes is made of cooper for higher thermal conductivity. coiled Tubes is placed in the box for circulating hot air. This coiled pipe is immured in the cooled water which is filled in the shell.

In the wall of the shell attached 4 Aluminium heat sink plates kept submerged in water and each heat sink back side attached one palter module(12V 5A) are attached with cold side absorbing heat from water. Hot side is made to face outside, rejecting heat to external heat rejecting system.

For controlling the temperature inside the space to be cooled, there exists a thermostat. When the temperature inside the space reaches the required condition, the power supply to the Peltier modules will be stopped.

A blower is attached in the inlet of the copper tube, which can circulate the room air inside the tube and cooled air reject exit of the tube.

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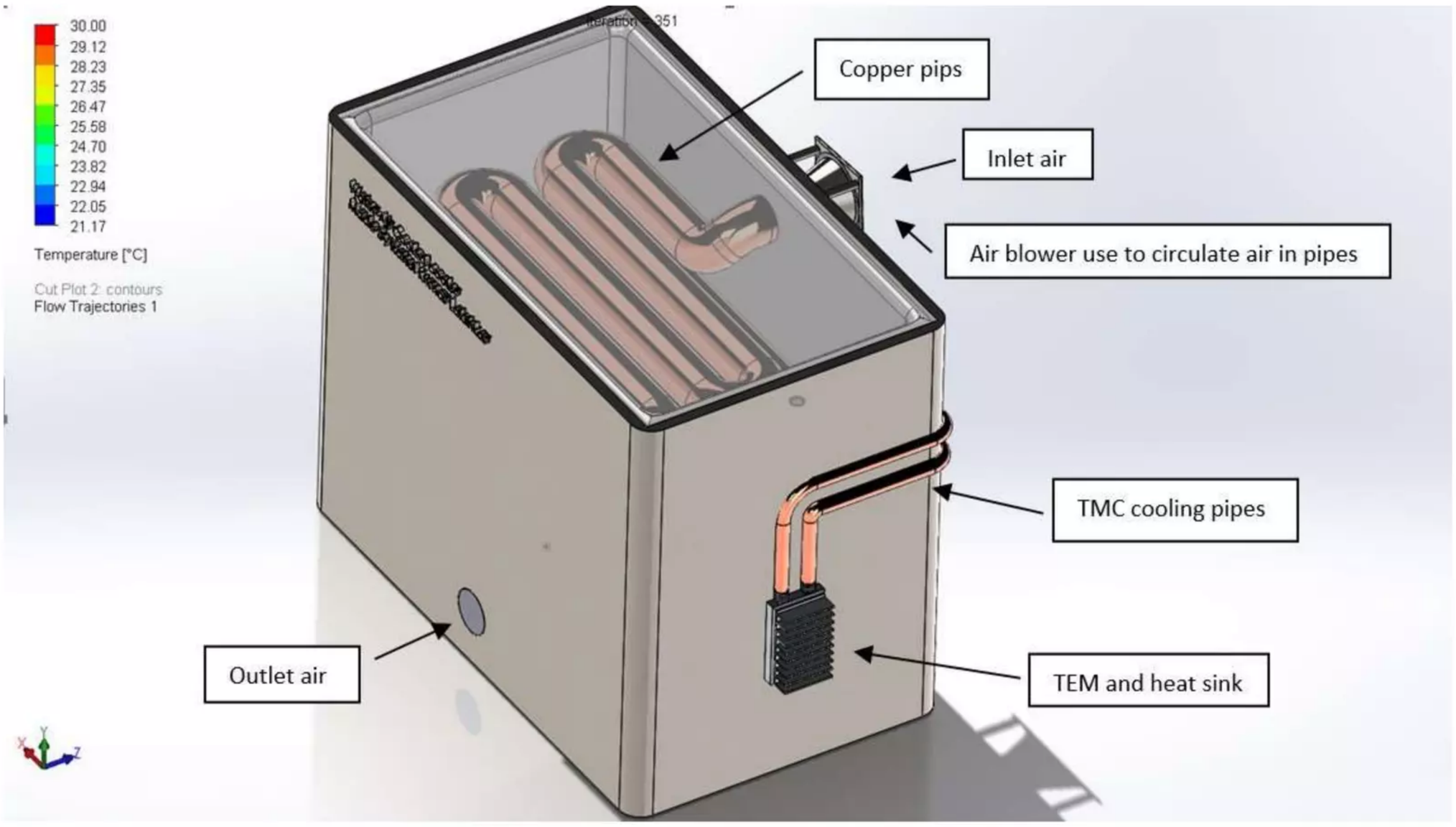

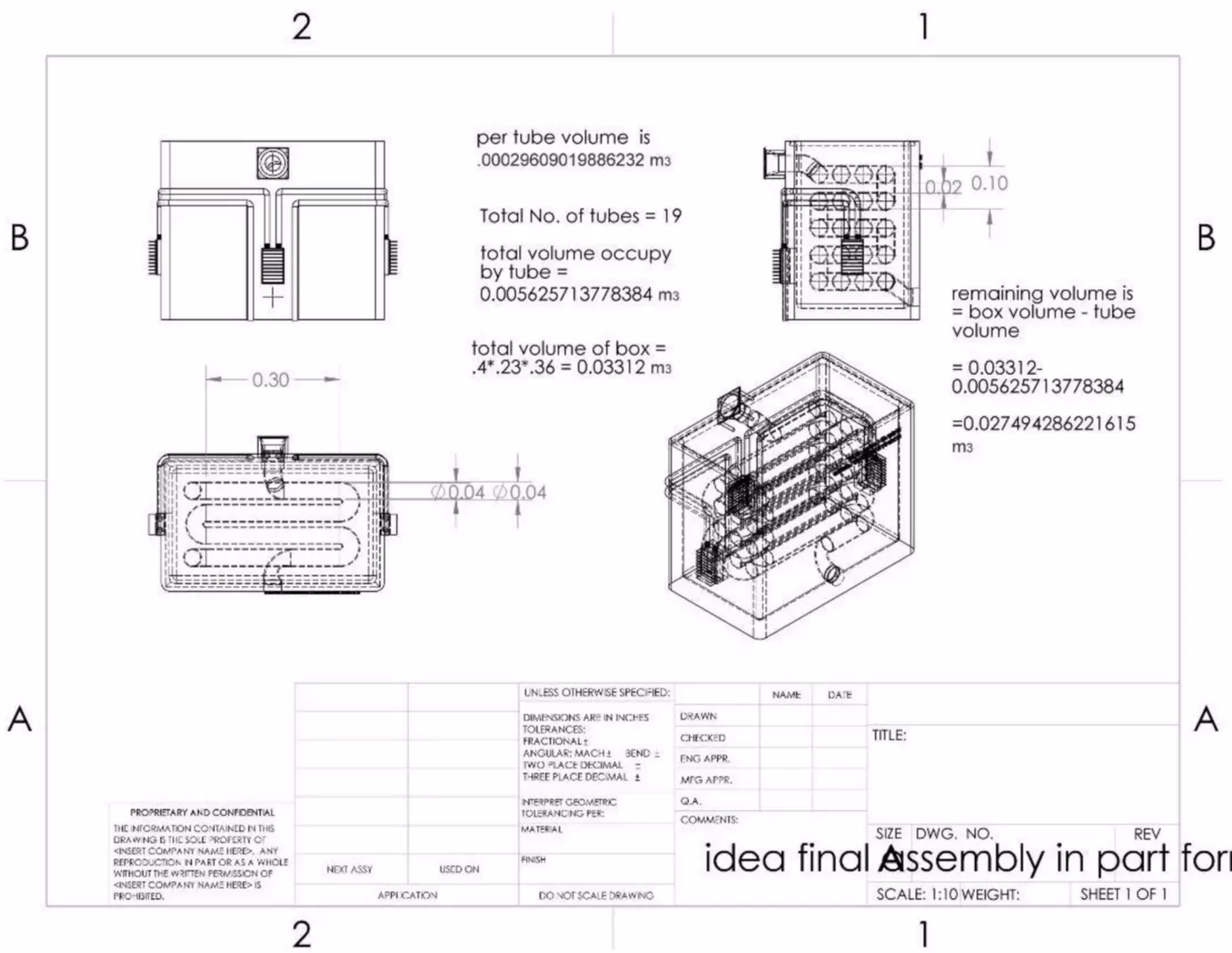

WORKING OF AIR CONDITIONER

There are two circuits; one circuit cools water directly through contact with Peltier plate and second circuit cools air to be circulated in the pipes to be conditioned.

The Peltier plates attached on water container box's one face absorbs the heat from water with consumption of electricity. This heat transfer is enhanced by the use of fins. Also the cold side of Peltier plate does not contact directly with water. Cold side makes contact with thin highly conductive wall of container and on that wall fins are attached. On hot side of Peltier plate heat is rejected outside of the space by external heat rejecting system, to be cooled and again heat flow rate is enhanced by use of a fan (forced circulation) and highly conductive finned plate.

Water cooled by the 4 palter module at the desire temperature and room air now enters cooling pipes of highly conductive material, in which the cooled water absorb heat at an enhanced rate from surrounding air. Air moves in zig zag manner until it reaches at its outlet. During this journey it gets good contact with filled shell water due to increased area because of zigzag arrangement made in the space available and fins.

Because of heat transfer hot side to cooled side, the temperature will increase which feather cooled by palter module.

The blower forces air pump from space to cooling pipes. Which gets cooled after flowing inside the pipe. (forced circulation for higher heat transfer rate).

PROPOSED CALCULATIONS FOR DESIGN

To Calculate coefficient of performance of single Peltier module following procedure is adopted [7].

Some known amount of water is poured inside a beaker. Water initial temperature is measured. Then beaker is kept on cold side of Peltier plate. Now plate and fan is supplied safe amount of electricity its wattage is measured. Certain temperature difference is set and accordingly final temperature is measured with amount of time taken and above recorded data is substituted in following equations. The current Peltier module has following observed data.

Initial Temperature = 33°C

Final Temperature = 10°C

Temperature Difference (dt) = 23° C

Volume of water (m) = 20 litres

Time (t) = 60 minutes = 3600 seconds

Power Utilized = Power utilized by air blower fan + Power utilized by Peltier Module = (.5 x 12) + (2 x 12) = 30 watts = 30 x 10-3 kW

Heat absorbed (Q) = m Cp dt = 20 x 4.18 x 23 = 1922.8 kJ

Work consumed (W) = Power Utilized x Time Duration = 30 x 10-3 x 3600 = 108 kJ

COP = Heat absorbed / Work consumed = Q / W = 1922.8 / 108 = 17.80

Average refrigeration effect = Q/t =1922.8 /3600 =0.53411 kW= 534.11 W

Accordingly, number of modules required for required refrigeration effect can be calculated considering some losses due to resistance of conduction (fined wall), resistance of convection from wall to water, water to cooling coiled copper pipe and cooling coiled copper pipe to air. Number of modules determines container wall and the casing dimension by knowing module geometry and spacing between modules.

According to flow rate of air desired and refrigeration effect needed one can find flow rate of Air required. By this blower could be selected. However, pressure drop

considerations also will be important for selection of these two. Mass of water desired will also decide size of container. Blower area for air flow rate desired will also determine size of casing and grid sizing.

COST ESTIMATION

Total estimated cost reaches in over-all project up to 8000-9000

CONCLUSION

Conceptual design and a different kind of construction of environment friendly, portable Peltier air conditioner are elaborated.

An arrangement for fresh air entry could be made by providing another inlet communicating outside atmosphere to air duct with adjustable dampers to control required amount of fresh air.

This whole unit with casing could be placed anywhere in the room.

The optimum condition for increasing overall heat transfer coefficient in coiled tube heat exchanger is obtained by highest level of the coil diameter, coil pitch, hot and cold-water flow rates.

This air conditioner could be coupled (provided the required electric power) with solar photoelectric panels, generating electricity from solar energy.

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