A PROJECT REPORT

ON

"HYBRID WATER COOLER"

Submitted by

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In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. JAVED KAZI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

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ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

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CERTIFICATE

This is to certify that the project entitled

“ HYBRID WATER COOLER COOLER ”

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To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

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APPROVAL OF DISSERTATION

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(Internal Examiner) **(External Examiner)**

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Date: ___________

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ABSTRACT

Every year electricity gets more and more expensive. The electric energy is produced by different sources like hydroelectric power plants, thermal energy power plants, nuclear power plants, etc. The application uses the electric energy and does the work. All the work done is not utilized, some of work gets wasted. So the ways to avoid the wastage must be found out. There are different ways to recover from the energy crisis.

In a water cooler, water is cooled with the help of electric energy. Most of the time the cold water gets wasted in varying amounts. So indirectly the electric energy gets wasted. This energy must be saved.

This project deals with designing and developing a working model of heat exchanger. A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another with or without direct contact between the working fluids. This heat exchanger is used to minimize the energy consumption of water coolers. Main objective of the project is pre-cooling of filtered water by using drain water as a cooling medium. This heat exchanger is fitted externally to the water cooler without changing any internal setup of the water cooler. Thus without use of any external work this Heat Exchanger works successfully and required results are obtained.

Keywords: Helically coiled tube, Heat transfer coefficient, Coefficient of performance, Shell and tube.

1. INTRODUCTION

Energy conservation refers to efforts made to reduce energy consumption. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources.

Energy conservation can result in increased financial capital, environmental quality, national security, personal security, and human comfort. Individuals and organizations that are direct consumers of energy choose to conserve energy to reduce energy costs and promote economic security. In colleges, for drinking purposes water coolers are used. Water cooler does the work on water to reduce the temperature. When any person drinks the water about 20 to 25 % get wasted from him. So the work done by the cooler gets wasted. To avoid this wastage, a heat exchanger is fitted to the water cooler.

A heat exchanger is mechanical equipment built for efficient heat transfer from one medium to another. The media may be separated by a solid wall, so that they never mix, or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, and sewage treatment. Heat exchanger can be simply defined as a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions.

Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single or multi component fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distill, concentrate, crystallize, or control a process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact. In most heat exchangers, heat transfer between fluids takes place through a separating wall or into and out of a wall in a transient manner. In many heat exchangers, the fluids are separated by a heat transfer surface, and ideally they do not mix or leak. Such exchangers are referred to as direct transfer types, or simply recuperates.

In contrast, exchangers in which there is intermittent heat exchange between the hot and cold fluids via thermal energy storage and release through the exchanger surface or matrix are referred to as indirect transfer type, or simply regenerators. Such exchangers usually have fluid leakage from one fluid stream to the other, due to pressure differences and matrix rotation valve switching. Common examples of heat exchangers are shell-and tube exchangers, automobile radiators, condensers, evaporators, air pre-heaters, and cooling towers. If no phase change occurs in any of the fluids in the exchanger, it is sometimes referred to as a sensible heat exchanger. There could be internal thermal energy sources in the exchangers, such as in electric heaters and nuclear fuel elements.

Combustion and chemical reaction may take place within the exchanger, such as in boilers, fired heaters, and fluidized-bed exchangers. Mechanical devices may be used in some exchangers such as in scraped surface exchangers, agitated vessels, and stirred tank reactors. Heat transfer in the separating wall of a recuperate generally takes place by conduction. In general, if the fluids are immiscible, the separating wall may be eliminated, and the interface between the fluids replaces a heat transfer surface, as in a direct-contact heat exchanger.

1.1 Problem Statement

To reduce the energy consumption, by using new energy saving technologies and equipment is an important task now-a-days, in order to reduce the energy consumption in refrigeration. Every year electricity gets more and more expensive. Electric energy is produced by different sources like hydroelectric power plants, thermal energy power plants, nuclear power plants, etc. The application uses the electric energy and does the work. All the work done is not utilized, some of work gets wasted. So the ways to avoid the wastage must be found out. There are different ways to recover from the energy crisis.

In a water cooler, water is cooled with the help of electric energy. Most of the time the cold water gets wasted in varying amounts. So indirectly the electric energy gets wasted. This energy must be saved.

1.2 Objectives of Project

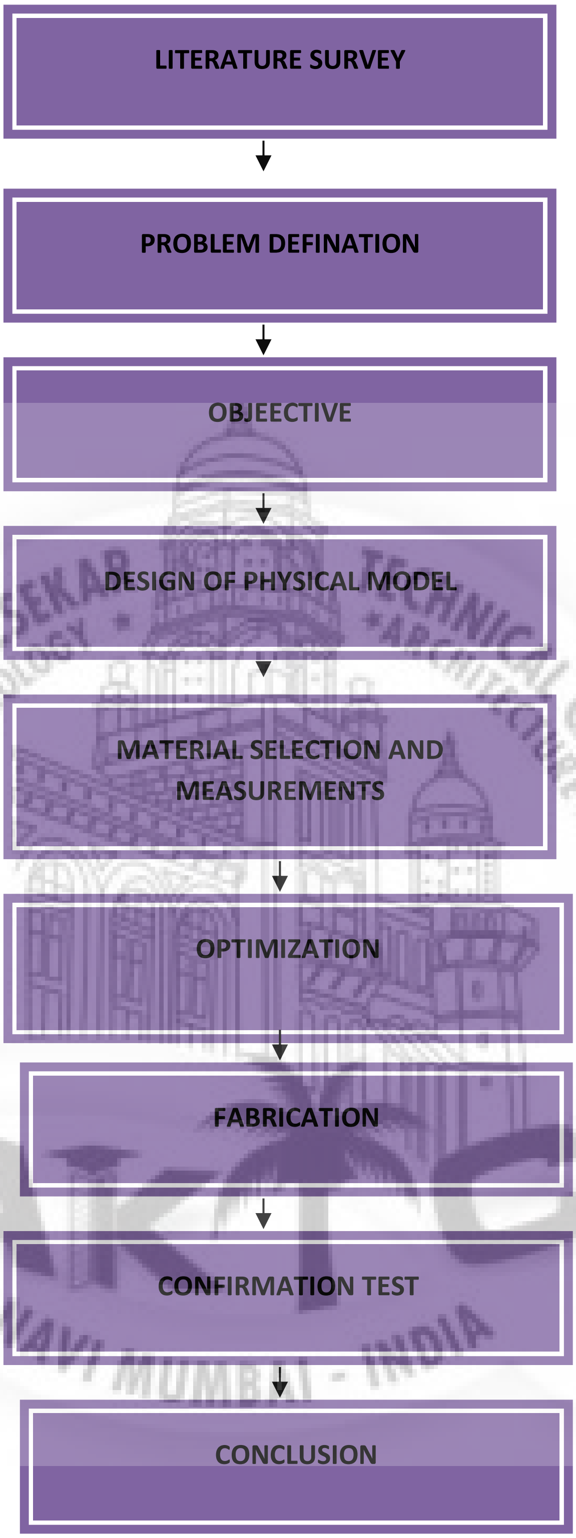
The main objective of this project is to confirm on a well-instrumented prototype the theoretically derived claims of higher efficiency and coefficient of performance. This project deals with designing and developing a working model of heat exchanger. A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another with or without direct contact between the working fluids. This heat exchanger is used to minimize the energy consumption of water coolers. Main objective of the project is pre-cooling of hot refrigerant coming out from the compressor by using drain water as a cooling medium. This heat exchanger is fitted externally to the water cooler without changing any internal setup of the water cooler. Thus without use of any external work this Heat Exchanger works successfully and required results are obtained. Other objectives are to optimize the design parameters and to determine the economic viability of the new technology.

1.3 Scope

Much advancement is taking place to improve the COP of the refrigeration system, to reduce the electricity consumption and to get quick output. About 15% of the world's electricity is used to drive refrigerating and air conditioning systems. Inefficient use of energy is a waste of valuable resources which contributes to global warming. Most of the global warming effect of refrigerating systems comes from generating energy to drive them. Only a small proportion comes from the release of certain refrigerants. This informatory note describes how the efficiency of refrigerating systems can be maximized thereby minimizing their global warming impact. Our project also aims to increase the efficiency of the refrigeration system.

1.4 Methodology

From the flow chart, this project started with the objective of the project. The objective of the project must follow the title. The objective must fulfill the title then follow up with a design review about hybrid water cooler and then study a lot of investigation about hybrid water cooler. This includes study about several types of material which are suitable to make a heat exchanger with maximum efficiency. These tasks have been done through study on the internet, books and other resources. After all information had been collected and gathered, the project continued with the design process. All the knowledge and lessons had been applied to make a suitable design for the project. After several design sketches, design considerations have been made and one of the designs has been chosen by us. The solid modeling and engineering drawing by using solid works software the fabrication process progress use drawing as a reference. The process consists of fabrication to all parts that have been designed by the dimension using various types of manufacturing process. The manufacturing process includes welding, drilling, bending, cutting, etc. During the fabrication process, if there have error occur, such as fabrication errors, so the process need to modification the process need to go back to the previous step and the process flow again, until no error occur the process can been continued smoothly until the final product finished. Then, the draft report needs to be submitted to the supervisor for double checking if there was an error.



METHODOLOGY

1.5 Selection parameter of heat exchanger

The Heat Exchangers are complicated devices, and the results obtained by simplified approaches should be used with care. Due to some uncertainties, it is natural to tend to overdesign the heat exchangers in order to avoid unpleasant surprises.An engineer going through catalogs of heat exchangers manufacturers will be overwhelmed by the type and number of readily available off-the-shelf heat exchangers. The proper selection develops on several factors.

1. Heat transfer rate :This is the most important quantity in heat exchanger for achieving desired temperature change. The heat exchanger should be capable of transferring heat at the specified rate.

2. Size and weight :While designing heat exchanger size and weight are preferentially considered. The smaller and lighter heat exchangers are better to use in various cases such as automobiles, aerospace, etc. The space available for heat exchanger in some cases limits the length of the tube.

3. Type :For selection heat exchanger primary parameters are fluid involved size and weight limitations, phase change process if any. For example heat exchanger in which liquid and gas are used, surface area on gas side is many times that on liquid side. On the other hand, plate or shell and tube heat exchanger is suitable for cooling a liquid by another liquid.

4. Materials :Materials are also a main parameter for construction of heat exchangers. While selecting material parameters considered are thermal and structural stress, temperature difference, differential thermal expansion, and corrosive fluid used, etc. Materials commonly used are copper, stainless steel, etc.

5. Other considerations : The other consideration may or may not be important depending upon the application while selecting a heat exchanger for example in case of toxic or expansive fluid involved, being leak tight is an important consideration. Ease of severing, low maintenance, etc.

2. LITERATURE REVIEW

2.1 Review of Papers

Heat exchangers are widely used in many applications such as heat recovery systems, power plants, nuclear reactors, food industries, chemical processing, refrigeration and air conditioning systems. When the performance of a heat exchanger is enhanced, the heat transfer improvement enables the size of the heat exchanger to be decreased.

The spiral heat exchanger was developed in the twenties for use in the paper industry by the Swedish engineer Mr. Rosenblad. For the first time, a heat exchanger became available that allowed trouble-free heat transfer between particle-loaded process streams. In the beginning of the seventies, Kapp Apparatebau started manufacturing spiral heat exchangers.

[1] Helically coiled tubes are superior to straight tubes when employed in heat transfer applications. In the coiled tubes, the modification of the flow is due to the centrifugal forces caused by the curvature of the tube, which produce a secondary flow field with a circulatory motion pushing the fluid particles toward the core region of the tube. A natural convection shell-and-coil heat exchanger consists of a cylindrical shell with helical coils placed inside it. Helical coils are widely used as heat exchangers due to the high heat transfer coefficients.

[2] Helically coiled exchangers offer certain advantages. Compact size provides a distinct benefit. Higher film coefficients—the rate at which heat is transferred through a wall from one fluid to another— and more effective use of available pressure drop result in efficient and less-expensive designs. True counter-current flow fully utilizes available LMTD (logarithmic mean temperature difference). Helical geometry permits handling of high temperatures and extreme temperature differentials without high induced stresses or costly expansion joints. High-pressure capability and the ability to fully clean the service-fluid flow area add to the exchanger's advantages. Although various configurations are available, the basic and most common design consists of a series of stacked helically coiled tubes. The tube ends are connected to manifolds, which act as fluid entry and exit locations. The tube bundle is constructed of a number of tubes stacked atop each other, and the entire bundle is placed inside a casing.

[3] Due to the curvature of the tubes, as fluid flows through curved tubes, centrifugal force is generated. A secondary flow induced by the centrifugal force has significant ability to enhance the heat transfer rate. Single-phase heat transfer characteristics in the helically coiled tubes have been widely studied by researchers both experimentally and theoretically. There are several advantages of the numerical method, e.g. large volume of the results obtained from the parametric studies, low cost. In addition, due to some complexity of the heat transfer processes in the helically coiled tubes, experimental studies are very difficult to handle. Good agreements were obtained from comparisons between the developing and fully developed velocity profiles, the wall temperature for the case of axially uniform heat flux with an isothermal periphery obtained from calculation and those obtained from experiments. In the model mentioned above, the effects of the torsion and the Prandtl number were not taken into account. The studied laminar flow of the incompressible Newtonian fluid was subjected to be hydro-dynamically and thermally fully developed. The results revealed that the temperature gradient increased on one side of the pipe wall and decreased on the other side with increasing torsion.

[4] A new simplified mathematical model for thermal analysis of a helical heat exchanger for long-term ground thermal energy storage in soil for use in arid zones. The results obtained by solving a finite difference method were validated by experimental data. The various parametric studies such as thermal properties of the soil, cycle period, and height and pitch of the helical coil heat exchanger were studied.

[5] Water flows in the coiled tubes, where air loaded with detergent particles of 43 micrometers in diameter flows within the shell. Four coiled tubes with different coil pitches are used in a counter-current flow configuration. We investigate heat transfer coefficients of inside and outside the heat transfer surfaces through 400 experiments. The correlations between Nusselt number and Reynolds number, Prandtl number, mass flow rate of particulates to mass flow rate of air ratio and coiled tube pitch parameter are proposed. The correlations procured can be used to predict heat transfer between tube and shell of the heat exchanger. From the results of the t study, it was found that the tube-side heat transfer coefficients of the coils with smaller pitches are higher than those of larger pitches but the pitches of coiled tubes slightly affect the shell-side heat transfer coefficients.

[6] Characteristics of heat transfer and pressure drop of a helically coiled corrugated flex tube in a heat exchanger were experimentally investigated in a study. A corrugated flex tube, 13 m long and 0.0254 m in diameter, is helically coiled in the heat exchanger. Water is selected as a working fluid. Hot water flows through the tube, and cold water in the boiler is either stationary or in motion by a pump. Temperatures and pressures are measured at both inlet and outlet of the coiled tube. Flow rates are controlled by a control valve and measured by a flow-meter. The results show that friction coefficients in the present setup are considerably high (by a factor of 2.2 to 3.6) compared to the data available in the literature for a straight corrugated tube. In addition, the ratio of the friction coefficient of the present setup to that of the straight corrugated tube appears to increase as the flow rate decreases. For the case of stationary cold water in the boiler where natural convection takes place outside the tube wall, the overall heat transfer coefficient is measured to be approximately 400 W/m2 K. The overall heat transfer coefficient increases only slightly as the flow rate inside the tube increases. When cold water in the boiler is set to a motion by a pump, on the other hand, the overall heat transfer coefficient is measured to be 800 to 1000 W/m2 K, depending on the flow rate inside the tube. When the surface area of an imaginary smooth tube based on the outer diameter is employed in data analysis, however, the overall heat transfer coefficients are calculated to be much higher. This shows that the corrugated tube considerably enhances heat transfer rate per unit length of the tube, compared to a smooth tube.

2.2 RESEARCH PAPER

- **International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056**

Volume: 07 Issue: 01 | Jan 2020

Enhancement of COP of Vapor Compression Refrigeration Cycle using CFD

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Here the study on Vapor Compression Refrigeration system using diffuser to improve Coefficient of Performance. To Improve the Coefficient of Performance, it is to require that Compressor work should decrease. The purpose of a compressor in vapor compression system is to elevate the pressure of the refrigerant (refrigerant used is TETRA FLUORO ETHANE),but refrigerant leaves the compressor with comparatively high velocity which may cause splashing of liquid refrigerant in the condenser, liquid hump and damage to condenser by erosion. It is needed to convert this kinetic energy to pressure energy, for which diffuser can be used. The diffuser of increasing cross-sectional area profile was designed, fabricated and introduced between Compressor and Condenser.

- **International Research Journal of Current Engineering and Technology (IRJET)**

Performance Evaluation of Water Cooler with Modification of Liquid Suction Heat Exchanger

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The refrigerating effect can be increased by maintaining the condition of the refrigerant in the lower temperature liquid stage, at the entrance of the evaporator. This can be achieved by expanding the refrigerant very close to the liquid line i.e. by sub-cooling the refrigerant and by removing the flashed vapour. The present work describes the design of a VCRS and the design of the liquid suction heat exchanger. A tube in tube type heat exchanger is incorporated in the system, in between the liquid line i.e. pipe joining the condenser and the expansion device and the suction line i.e. pipe joining the evaporator and the compressor. So it is called Liquid Suction Heat Exchanger (LSHX) or Suction line heat exchanger (SLHX). Effect of reduced flashing was found dominant, compared with the effect of sub-cooling on the refrigeration capacity. The effects of different flow rates of refrigerant and initial temperature of water on COP, work of compression, refrigeration effect of the system, heat exchange capacity of the LSHX, effectiveness of the LSHX & refrigeration capacity of the evaporator are calculated and analyzed. On the basis of experimentation and analysis, it is found that, use of liquid suction heat exchanger in the VCRS, increases the COP of the refrigeration unit for different initial temperatures of water. The power consumption by the compressor gets reduced by using the liquid suction heat exchanger. The optimum effect of the LSHX is seen at different flow rates of the refrigerant for lower initial temperature of water (30 to 35 °C).

- **International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-2, July 2019**

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Enhancement of Cop of Vapour Compression Refrigeration System by using Diffusers

This experimental investigation exemplifies the design and testing of four diffusers at compressor inlet and condenser inlet in the vapour compression refrigeration system with the help of R134a refrigerant .The Four diffusers with divergence angle of 10°,12°, 14° and 16° are designed for same inlet and outlet diameters. Diffusers are testing at compressor inlet first. The diffusers are used with inlet diameter equal to discharging tube diameter of evaporator and outlet diameter is equal to suction tube diameter of the compressor. One of the diffuser gives better performance, it will be fixed at the compressor inlet. Then diffusers are testing at condenser inlet, diffuser inlet diameter equal to discharging tube diameter of compressor and outlet diameter equal to condenser inlet diameter The system is analyzed using the first and second laws of thermodynamics, to determine the refrigerating effect, the compressor work input, coefficient of performance(COP). During the experimental test,the coefficient of performance (COP) of the system without diffuser and with diffuser optimized at compressor inlet and condenser inlet are found. At compressor inlet 14° divergence angle of diffuser given the maximum cop (2.46). Percentage of increase in cop is approximately 6%. At condenser inlet 12° divergence angle of diffuser given the maximum cop (2.59).Percentage of increase in cop is approximately 3%.

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- **Improve COP of Water Cooler (Refrigeration System) by Extended Evaporator**

Much advancement is taking place to improve the COP of the refrigeration system, to reduce the electricity consumption and to get quick output. About 15% of the world's electricity is used to drive refrigerating and air-conditioning systems. Inefficient use of energy is a waste of valuable resources which contributes to global warming. Most of the global warming effect of refrigerating systems comes from generating energy to drive them. Only a small proportion comes from the release of certain refrigerants. This informatory note describes how the efficiency of refrigerating systems can be maximized thereby minimizing their global warming impact. Our project also aims to increase the efficiency of the refrigeration system by extending the evaporator coil. Modification in evaporator is meant to increase Evaporator surface area which increases refrigerating effect. Our project is based on this concept.

International Journal of Scientific & Engineering Research, Volume 6, Issue 5, May-2015

- **Improving Performance of vapour compression refrigeration system by using PCM in evaporator Article IRJET· May 2017**

Improving Performance of vapour compression refrigeration system by using PCM in evaporator

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This present study presents the solidification behaviour of water based PCM (Phase Change Material), surrounded in an evaporator coils by using copper. The PCM was prepared by Propane-1, 2-diol and Ethane-1, 2-diol with volume fractions of 22.85% and 25% in deionized (DI) water as the base PCM. The solidification experiments were conducted with and without the PCM at surrounding bath temperature of -11°C and 0°C respectively. The presence of Propane-1, 2-diol and Ethane-1, 2-diol acted as nucleating agents that caused appreciable reduction in the sub cooling. A possible energy saving is 20-25% in the CTES (Cold Thermal Energy Storage) using the PCM. Hence the proposed system will be a new thing for performance improvement of cold storage.

- **Improve the cop of Vapor compression cycle with change in Evaporator and Condenser pressure**

By - Shoyabhussan

The aim is to improve the coefficient of performance of the system which is based on the vapor compression cycle. To improve the coefficient of performance, its requires that the compressor
work should decrease and the refrigeration effect should increase. It means a decrease in condenser pressure and temperature so the refrigeration effect will increase and compressor input work due to this cop will increase. And also increase in pressure and temperature of the evaporator the work input will decrease and refrigeration effect will increase due to this copulation for a vapor-compression refrigeration system in 1834. Perkins built a prototype system and it actually worked. According to the drawing in Perkins patent liquid ether (C4H10O) was contained in an "evaporator vessel" where it was vaporized under a partial vacuum maintained by the suction of a crude hand-operated compressor. The evaporator vessel was submerged in a liquid from which the heat required to vaporize the ether was extracted, thereby cooling the liquid.

2.2 Gap of Research work

By reviewing all research papers, it is found that no one in above research paper have worked on adding the heat exchanger at waste water line after wash basin, hence here we will be working on totally new and different concept the model for increasing the cop of system and reducing the power consumption by using waste heat recovery method.

3. SYSTEM USED

3.1 Theory OfVapour Compression System

There are several types of systems by which we produce cold in the process of refrigeration and air conditioning. We can produce refrigeration effect with absorption type refrigeration,steam jet refrigeration, air refrigeration, non-conventional refrigeration such as Vortex refrigeration, pulse tube refrigeration and Vapour compression refrigeration system.It is roughly estimated that over 80% of the refrigeration and air conditioning system today use the Vapour compression (VC) system

3.2 Vapour Compression Refrigeration System

In a VC system working fluid is a liquid called Refrigerant which involves sensible heat as well as latent heat and thus the COP of the system is more. The refrigerant used does not leave the system, but is circulated throughout the system, alternately condensing and evaporating. In evaporating refrigerant absorbs latent heat from products and in condensing refrigerant rejects heat to the circulating water. Figure shows schematic diagram of VC system.

It consists of 5 essential parts are as -

1.Compressor

2.Condenser

3.Receiver

4.Expansion device

5.Evaporator.

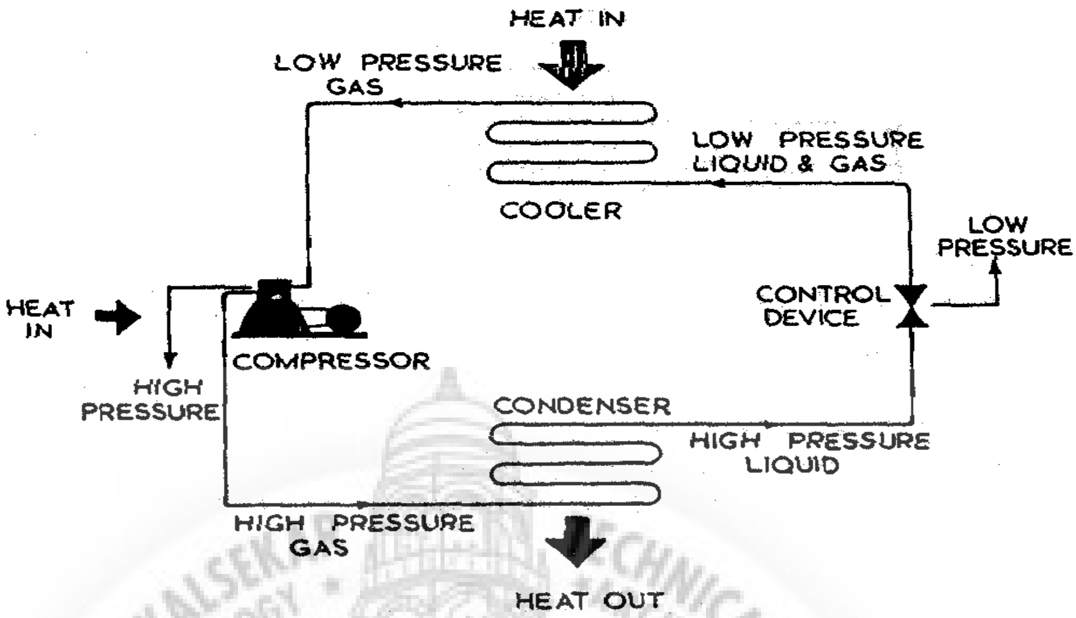
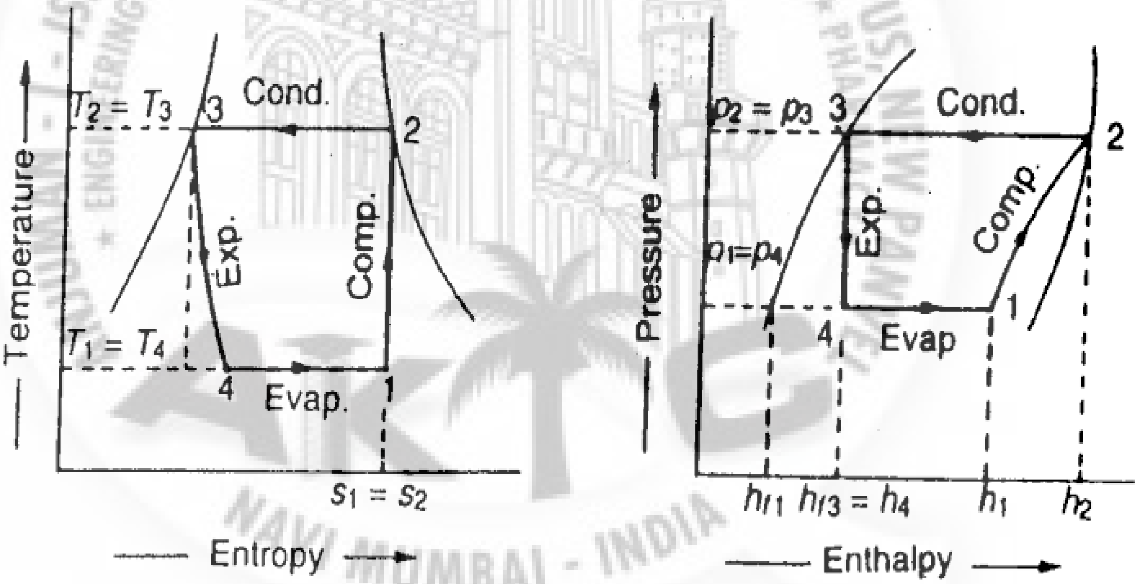


Fig3.1 : Basic Refrigeration Cycle



(*a*) *T-s* diagram. (*b*) *p-h* diagram.

Fig.3.2

The simple cycle is shown on the P-h and T-s diagram-

Compression (1-2) :Low pressure and temperature refrigerant from evaporator is drawn into compressor through suction valve A and is compressed is entropically to high pressure and high temperature. This vapour is discharged to the condenser through the B valve.

Condensation (2-3) : It consists of coils of pipe in which refrigerant is cooled and condensed by air or water. During this process refrigerant rejects heat to air or water. a condensed liquid refrigerant is stored in a vessel known as a receiver from where it is supplied to the evaporator through an expansion valve.

Expansion (3-4) :From the receiver it is passed through an expansion valve where pressure is reduced sufficiently to allow vaporization of liquid at a low temperature of about 10^{o} C.

Evaporation (4-1) :Low pressure refrigerant enters the evaporator where a considerable amount of heat is absorbed by refrigerant and converts into vapour. High pressure side includes the discharge line, condenser, receiver and expansion valve. Whereas low pressure side includes evaporator, piping from expansion valve to evaporator, suction line.

Refrigerant effect, $Q_a = m (h_1 - h_4)$

Compressor power, $W = m (h_2 - h_1)$

$$COP = \frac{\text{Refrigerating effect}}{\text{Compressor power}}$$

$$COP = \frac{Q_a}{W}$$

$$\therefore \quad COP = \frac{(h_1 - h_4)}{(h_2 - h_1)}$$

4. MATERIAL SELECTION

The proper selection of material for the different parts of a machine is the main objective in the fabrication of the machine. For a design engineer it is must that he be familiar with the effect, which the manufacturing process and heat treatment have on the properties of materials.

4.1Choice of material for engineering purposes depends upon the following factors

1. Availability of the materials.
2. Suitability of materials for the working condition in service.
3. The cost of materials.
4. Physical and chemical properties of material.
5. Mechanical properties of material.

The mechanical properties of the metals are those, which are associated with the ability of the material to resist mechanical forces and load.

4.2 Properties as follows

1. **Strength** : It is the ability of a material to resist the externally applied forces .
2. **Stress**: Without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.
3. **Stiffness:** It is the ability of material to resist deformation under stresses. The modulus of elasticity of the measure of stiffness.
4. **Elasticity**: It is the property of a material to regain its original shape after deformation when the external forces are removed. This property is desirable for material used in tools and machines. It may be noted that steel is more elastic than rubber.
5. **Plasticity**: It is the property of a material, which retain the deformation produced under load permanently. This property of material is necessary for forging, in stamping images on coins and in ornamental work.

6. **Ductility:** It is the property of a material enabling it to be drawn into wire with the application of a tensile force. A ductile material must be both strong and plastic. The ductility is usually measured by the terms, percentage elongation and percent reduction in area. The ductile materials commonly used in engineering practice are mild steel, copper, aluminum, nickel, zinc, tin and lead.

7. **Brittleness:** It is the property of material opposite to ductile. It is the property of breaking of a material with little permanent distortion. Brittle materials when subjected to tensile loads snap off without giving any sensible elongation. Cast iron is a brittle material.

8. **Malleability:** It is a special case of ductility, which permits material to be rolled or hammered into thin sheets, a malleable material should be plastic but it is not essential to be so strong. The malleable materials commonly used in engineering practice are lead, soft steel, wrought iron, copper and aluminum.

9. **Toughness:** It is the property of a material to resist the fracture due to high impact loads like hammer blows. The toughness of the material decreases when it is heated. It is measured by the amount of absorbed after being stressed up to the point of fracture. This property is desirable in parts subjected to shock an impact loads.

10. **Resilience:** It is the property of a material to absorb energy and to resist rock and impact loads. It is measured by amount of energy absorbed per unit volume within elastic limit. This property is essential for spring material.

11. **Creep:** When a part is subjected to a constant stress at high temperature for long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing internal combustion engines, boilers and turbines.

12. **Hardness:** It is a very important property of the metals and has a wide verity of meanings. It embraces many different properties such as resistance to wear scratching, deformation and mach inability etc. It also means the ability of the metal to cut another metal. The hardness is usually expressed in numbers, which are dependent on the method of making the test.

4.3 Materials selected in Hybrid Water Cooler Frame and Components Support

Material Used: Mild steel

Reasons:

1. Mild steel is readily available in market.
2. It is economical to use.
3. It is available in standard sizes.
4. It has good mechanical properties i.e. it is easily machinable.
5. It has moderate factor of safety, because factor of safety results in unnecessary wastage of material and heavy selection. Low factor of safety results in unnecessary risk of failure.
6. It has high tensile strength.
7. Low co-efficient of thermal expansion.

4.4 Properties of Mild Steel:

- M.S. has a carbon content from 0.15% to 0.30%. They are easily wieldable thus can be hardened only.
- They are similar to wrought iron in properties. Both ultimate tensile and compressive strength of these steel increases with increasing carbon content. They can be easily gas welded or electric or arc welded. With increase in the carbon percentage weld ability decreases.
- Mild steel serves the purpose and was hence was selected because of the above purpose.

Here we have selected the material as per the following:-

SR NO	PART NAME	MAT	QTY
1	FRAME	MS	15 KG
2	COMPRESSOR	STD	1
3	CONDENSER COIL	CU	1
4	EVAPORATOR TUBE	CU	1
5	WASTE WATER TANK	SS	1
6	CAPILLARY TUBE	CU	1
7	REFRIGERANT	R 134 A	1.5 KG
8	HEAT EXCHANGER	CU	1
9	BASE WATER TANK	SS	1
8	WIRING	STD	3 M
9	TEMP INDICATOR	STD	2
10	TAP	PLASTIC	1
11	FAN	STD	1
12	WASH BASIN	SS	1
13	FILTER, CAPILLARY	CU	1

5. TOOLS & EQUIPMENTS FOR FABRICATION

5.1 REFRIGERATION TOOLS AND MATERIALS

A serviceman must have the knowledge about the refrigeration tools and materials used in the industry. He must also know the selection of tools, the correct use and safe handling of the tools while servicing and repairing refrigeration equipment.

1. **Tube Cutter** :

   A hacksaw or a tube cutter normally cuts the copper tube. Tube cutter is used for the annealed copper tubing only, whereas for hard drawn copper tubing a hacksaw or pipe cutter is used. Tube cutter is made of steel having a single cutter wheel in conjunction with two rollers.

2. **Pipe Cutter :**

   Pipe cutter is almost the same as a tube cutter. The only difference is that it is larger in size. This pipe cutter is used for cutting hard drawn copper tubing and galvanized pipe which is used in refrigeration systems.

3. **Reamer :**

During the cutting operation a burr or fine-feathered edge is raised on the inside of the tubing. Burrs may be removed with a fine cut mill file, a scraping tool or a Reamer. The reamer is a cutting tool with a series of teeth or sharp cutting edges. Some types are made to remove both internal and external burrs.

4. Flaring Tools :

A typical flaring tool is shown below. It consists of two bars held together by a wing nut and bolt; the bars are provided with holes for various sizes of tubing. A yoke containing the forming die is slipped on the bars and the handle is rotated to produce a flare. This tool has been widely used due to its simplicity, ease of performing the flaring operation, and because the flares produced by it are uniformly excellent in producing a tight seal.

5. Pinch off tools:

Most of the larger apparatus is equipped with sufficient valves to enable any portion or section to be closed off and worked on without loss of the refrigerant charge. Some of the smaller and simpler systems have only a few valves. This is an economic measure so that the cost of the apparatus can be kept to a minimum. While the elimination of valves make a simpler, lower priced piece of equipment, it makes servicing somewhat harder for the servicemen. Where there are only a few or no valves in a system, the pinch-off offers a means of closing the copper line so that the defective or worn out parts can be removed and replaced.

6. Swaging Tools :

Swaging is a means of shaping copper tubing so that operation is accomplished with a punch type or screw-type swaging tool. The tubing is clamped into the flaring bar and the specially designed punch is hammered into the tubing, swaging or expanding the end. So that it will fit over the end of another piece of tubing. The screw-type tool produces the same swaged shape by pressure as the punch is forced into the tubing.

7. Bending tools :

A considerable practice is necessary to become competent in bending tubing. For the small size tubing such as is used in domestic models, it is not necessary to use a special tool. A number of tools are available for bending operations. Either internal or external coil-spring bending tools or a lever-type tube bender. The internal spring is designed to be used near the ends of tubes whereas the external spring is best suited for the middle of tubes. A lever-type tube bender is used, to form bends neatly and accurately without buckling the tubing. These tools will form bends up to 180 deg. In one continuous operation. The forming wheel is calibrated to show the degree of bend attained. Each of these tools is used with one size of tubing. Combination lever-type tube benders are also available which are adapted to bending several sizes of tubing by changing the forming wheel and block.

8. Ratchet Wrench :

For all the medium and small compressors, the service valve stems are normally constructed with a square end. This gives the serviceman for rapid control of the slight opening and closing of the valve. A special tool is used for this purpose is called 'RATCHET WRENCH'. It has a square broached ratchet with direction 'on' and 'off' marked at one end and has ¼" square at the other end for convenient openings. When 'cracking' the valves, the fixed end should be used while for opening and closing valves through any appreciable distance within a short time, the ratchet end should be used. These wrenches are also available with reversible ratchet which enables the operator to reverse the tuning of the valve stem without removing the wrench from the stem.

9. Gauges :

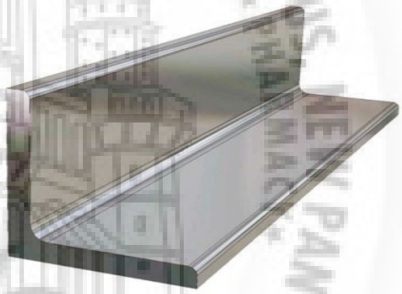
Its operating pressures best judge the correct condition of the machine. To find out the pressures, two types of gauges are generally installed in the machine – High pressure gauge, Compound gauge

- High pressure gauge: It is a gauge whose range is from 0-300 P.S.I. It is installed in the high side of the system to find out the pressure in the high side of the system. This is a very sensitive instrument and should be handled very carefully. A sudden release of pressure may damage the gauge. They are also available with temperature scales for freon – 12 and freon – 22.

- Compound gauge: This is generally installed in the low side of the system having a range of 30" vac-150 P.S.I. They should never be installed in the high side of the system irrespective of the refrigerant used in the system. They are used to note down the low side pressure or vacuum in the system. This is a very sensitive instrument and should be carefully handled. They must be calibrated at least once in every two months. It is also available with temperature scale for freon-12 and freon-22.

5.2 Tools and Equipment's used for constructing Frame

CUTTER WELDING MACHINE



DRILL MACHINE ANGLES

FILING TOOL MEASURING TAPE

5.3 Properties of Refrigeration Tubing

A specially 'annealed' copper tubing is used in most refrigeration work, excepting the absorption system. The term 'annealed' describes the degree of hardness. One peculiar property of copper is that when it is hammered, bent or flexed, it becomes work hardened and brittle. In this condition it cannot be formed or cut without breaking or cracking. This physical condition may be corrected by heating the copper to a dull red temperature or a dark-purple colour. When allowed to cool in air copper again becomes soft and malleable and may be bent or flared. This process of heating the copper with heat is called annealing. The work hardening or aging of copper may cause cracks to form when tubing is flared or it may buckle suddenly and tend to flatten out. Tubing is also 'dehydrated' to free it of moisture. Manufacturers usually dehydrated copper tubing for refrigeration work and then seal the ends by either pinching or closing them with caps to that moisture may not enter. Copper oxidizes easily and turns from its natural brilliance of reddish-bronze to a dull greenish brown colour. This oxide is formed by the action of air or other chemical on the copper. Before copper tubing may be mechanically bonded to another material it is necessary that this oxides coating is removed.

5.4 Tubing sizes

Deoxidized and dehydrated copper tubing is available in common size form 1/8” to ¾” outside diameter (OD) and with all thickness range from 30 to 50 thousands of an inch. The standard dimensions and weights of soft copper tubing are given in the accompanying table. Soft copper tubing is furnished in 50 ft. and 100 ft. rolls and in the larger sizes in lengths up to 25 ft.

- **Type of Tubing :** In addition to soft drawn copper, hard drawn Copper is used in a number of commercial and air-conditioning installations where rigidity is needed and the tube size over ½” are used. The hard-drawn copper comes in straight lengths rather than in rolls. The ends are either copped or plugged to keep the inside of the tubing clean and dry.

OD	Wall Thickness inches	Pounds per ft.
1/8	.030	.0347
3/16	.030	.0575
1/4	.030	.084
5/16	.032	.109
3/8	.032	.134
1/2	.032	.182
5/8	.035	.251
3/4	.035	.305

Standard Soft Copper Tubing Sizes and Weights

5.5 Refrigeration Oil

The moving parts of the compressor must be constantly lubricated with oil in order to have long life and efficient working. Refrigeration oil is specially prepared mineral oil free from Sulphur, moisture and other impurities. It is also specially processed to remove excessive wax. It is available in several viscosities. The lower the viscosity, the thinner the oil. The oil selected for hermetic systems must be of high quality. They must have a minimum of foreign matters, moisture and wax. They must be free of any hydrocarbons that may precipitate on the compressor valves and other parts, otherwise the efficiency of the compressor will go down after a certain time of use. The viscosity of the oil must be followed according to the recommendations of the manufacturers.

Follow the general instructions:

- Buy oil in the smallest sized containers with immediate needs
- Make sure the oil is of proper type and viscosity for the particular jobs as recommended by the compressor manufacturer.
- Do not transfer oil from one container to another.
- Oil will pick up moisture on exposure to air. Air is a leading contaminant.
- Never refill a compressor with used oil. Always put in the new oil.
- The oil should not be exposed to the air for a period of time longer than is necessary to transfer the oil from the container to the compressor crankcase.

5.6 Refrigeration Fitting

There have been many different fitting designs in the market, but the accepted standard for refrigeration fitting is a forged fitting using either pipe thread or Society of Automotive Engineering (S.E.A.), National Fine Thread. The fittings are usually drop forged brass and are accurately machined to form the NF threads; the NP threads, the hexagonal shapes for wrench design and the 45-degree flare for fitting against the tubing flare. This threaded fitting must be carefully handled to prevent injury to the threads or the 45-degree flare. All fittings sizes are based on the tubing size to which the fittings are attached. A ¼ in flare unit, which fastens ¼ in, tubing to a flared fitting has 7/16 NF threads and a ¾ in opening wrench is used to turn it. Whenever annealed copper tubing is attached to a fitting, the flare type of seal is usually used. This practice is conventional throughout the industry in the smaller units. A later trend is a soldered connection between the fitting and tubing. The correct method of installing tubing is to install it in such a way that there is no extra strain on the tubing when installed. Horizontal loops are used to keep vibration from cry stalling the copper tube, which makes it break. Some refrigeration fittings have pipe threads on one end. Pipe threads taper 1/16 in. to one inch.

6.DESIGN OF HYBRID WATER COOLER

The subject of MACHINE DESIGN deals with the art of designing machine of structure. Modifying available design is to create new and better machines or structures and improving the existing ones. In order to design simple component satisfactorily, a sound knowledge of applied science is essential. In addition, strength and properties of materials including some metrological are of prime importance. Condensers and evaporators are basically heat exchangers in which the refrigerant undergoes a phase change. Next to compressors, proper design and selection of condensers and evaporators is very important for satisfactory performance of any refrigeration system. Since both condensers and evaporators are essentially heat exchangers, they have many things in common as far as the design of these components is concerned.

6.1 Concept In Machine Design

When a machine is to be designed the following points to be considered: -

i) Types of load and stresses caused by the load.
ii) Selection of material & factors like strength, durability, weight, corrosion resistant, weld ability, machine ability are considered.
iii) Form and size of the components.
iv) Frictional resistances and ease of lubrication.
v) Convince and economical in operation.
vi) Use of standard parts.
vii) Facilities available for manufacturing.
viii) Cost of making the machine.

6.2 General Procedure In Machine Design

The general steps to be followed in designing the machine are as followed.

i) Preparation of a statement of the problem indicating the purpose of the machine.

ii) Selection of groups of mechanism for the desire motion.

iii) Calculation of the force and energy on each machine member.

iv) Selection of material.

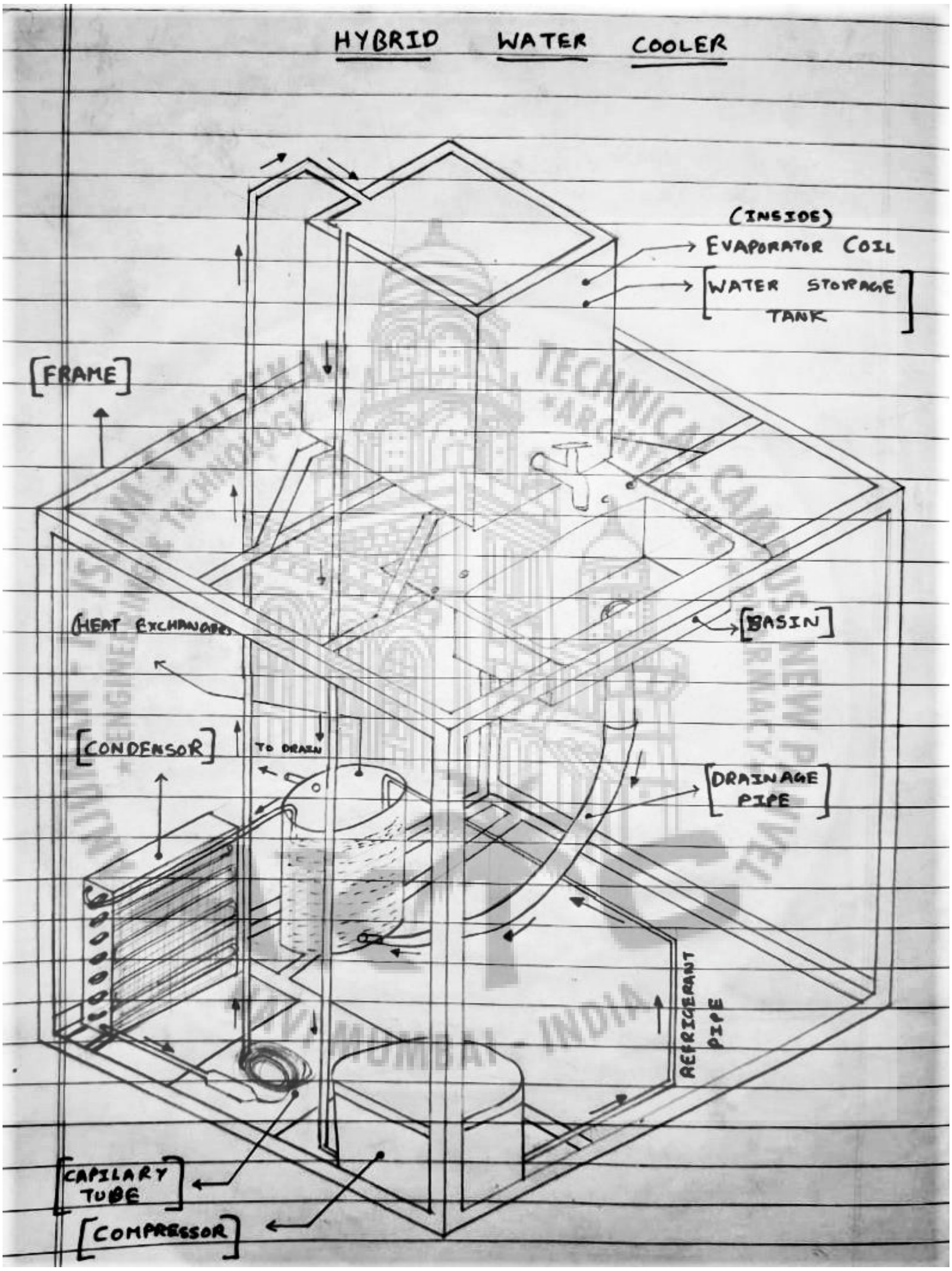
v) Determining the size of component drawing and sending for manufacture.

vi) Preparation of component drawing and sending for manufacture.

vii) Manufacturing and assembling the machine.

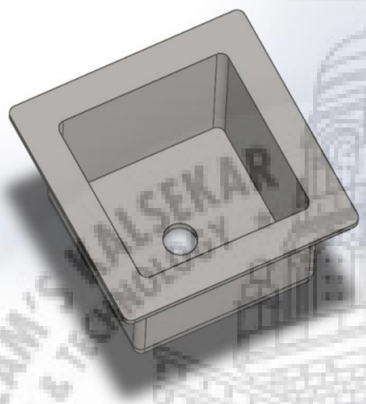
viii) Testing of the machine and for functioning.

6.3 Hand Drawn Design Before Solid Modelling

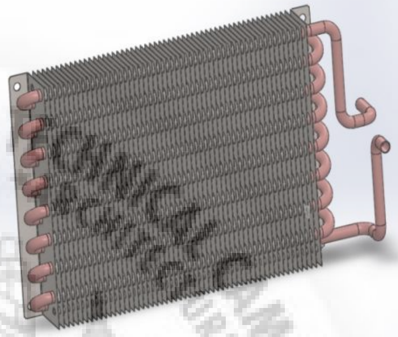


6.4 Solid Modelling

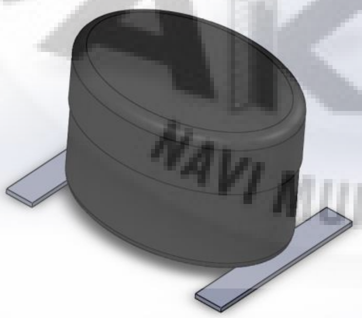
- The entire model has been designed with the help of designing software solid works.
- With the help of colour features the colours are given to the entire model.



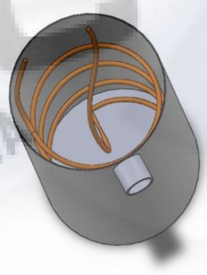
BASIN



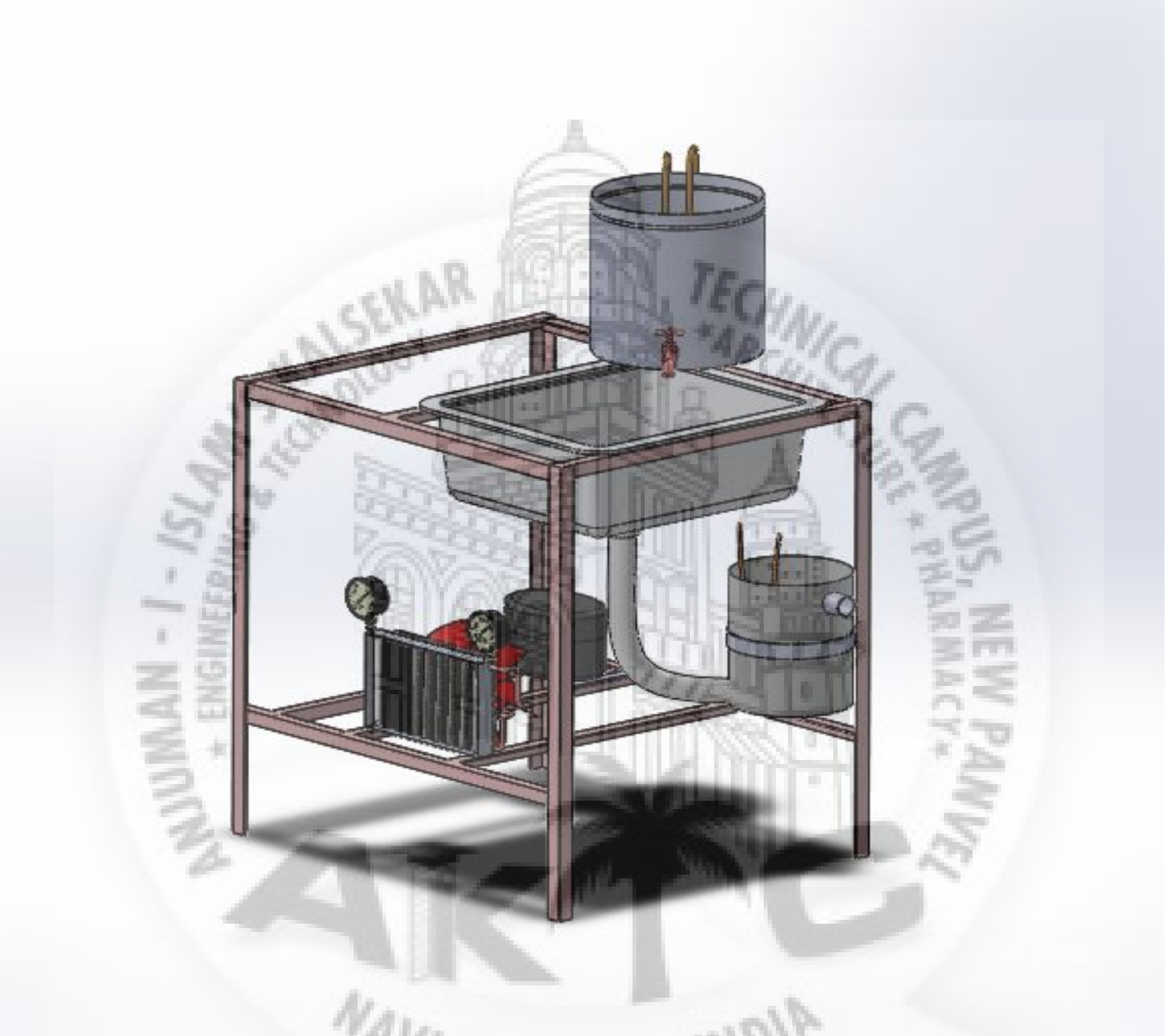
CONDENSER ASSEMBLY



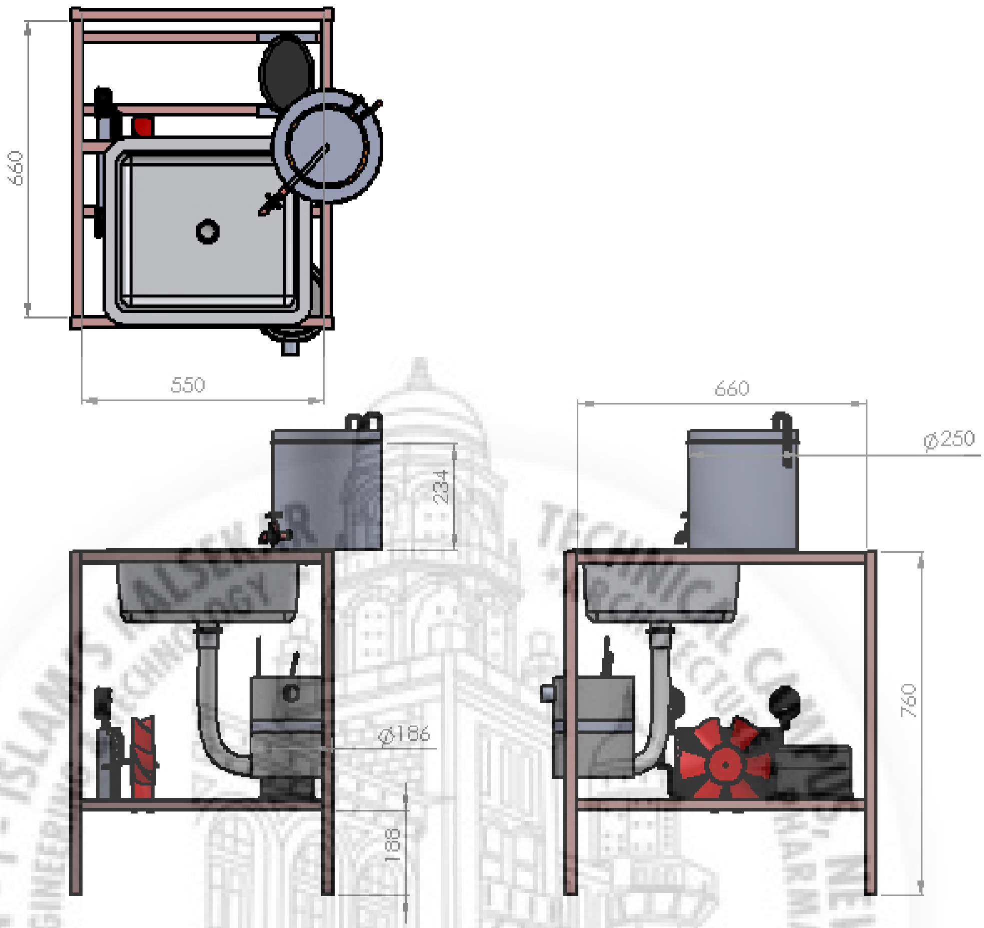
COMPRESSOR



HEAT EXCHANGER



MACHINE ASSEMBLY



DRAFTING

6.5 ACTUAL PICTURE OF PROJECT

6.6 COMPONENTS USED IN THE SYSTEM:

- Compressor - Sealed.
- Condenser - Air cooled.
- Expansion devices - Capillary tube.
- Evaporator - Shell and Tube Type.
- Fan and Gauges- Pressure Gauges (Suction and Discharge).
- Refrigerant - R134A

1. COMPRESSOR :

Hermetic Sealed Compressor

We used Hermetic Sealed Compressors because these types of compressor eliminate the use of crankshaft seal which is necessary in ordinary compressors in order to prevent leakage of refrigerant. The hermetic sealed compressor is widely used for small capacity refrigerating systems such as in domestic refrigerators, home freezers and window air conditioners.

2. CONDENSER :

Air Cooled Condenser

We used air cooled condenser in which the removal of heat is done by air. It consists of steel or copper tubing through which the refrigerant flows. The size of tube usually ranges from 6mm to 18mm outside diameter, depending upon the size of condenser. Copper tubes are used because of its excellent heat transfer ability. The condensers with steel tubes are used in ammonia refrigerating systems. The tubes are usually provided with plate type fins to increase the surface area of heat transfer. The fins are usually made from aluminium because of its light weight. The fins spacing is quite wide to reduce dust clogging.

3. EVAPORATOR:

Evaporator is an important component together with other major components in a refrigeration system such as compressor, condenser and expansion device. The reason for refrigeration is to remove heat from air, water or other substance. It is here that the liquid refrigerant is expanded and evaporated. It acts as a heat exchanger that transfers heat from the substance being cooled to a boiling temperature.

EVAPORATOR TANK

4. CAPILLARY TUBE:

Capillary Tube

Capillary tube is one of the most commonly used throttling devices in the refrigeration and the air conditioning systems. The capillary tube is a copper tube of very small internal diameter. It is of very long length and it is coiled to several turns so that it would occupy less space. The internal diameter of the capillary tube used for the refrigeration and air conditioning applications varies from 0.5 to 2.28 mm (0.020 to 0.09 inches). Capillary tube used as the throttling device in the domestic refrigerators, deep freezers, water coolers and air conditioners.

It is a small diameter copper tube connected between a condenser and an evaporator. The required pressure drop is caused due to heavy frictional resistance offered by a small diameter tube. The resistance is directly proportional to length and inversely proportional to diameter. The flow rate is the function of pressure differential between condenser and evaporator. As the load increases in summer, the tube supplies more quantity of flow as an effect of increased condenser pressure. Similarly, in winter load decreases, the flow rate through the tube also decreases.

5. HEAT EXCHANGER :

Heat Exchanger

It's an equipment that helps distribute heat between two fluids. This way, while one gains heat, the other one loses it and any of them may be used in your production processes. For example, removing heat from a coolant using cold water. These fluids may be of any kind, from water to refrigerant gasses. And can be in direct contact or separated with plates or other solid structures. One of the equipment's most attractive features is that it doesn't need electricity to function, saving considerable resources for the companies that implement it.its implementation is also very simple, since you only need to install one unit to make it work. When integrated with other refrigeration equipment, heat exchangers boost the efficiency of the whole system: for example, feeding the condensers with refrigerating fluids and gasses reduced in temperature, so that the condenser uses much less energy for its processes.

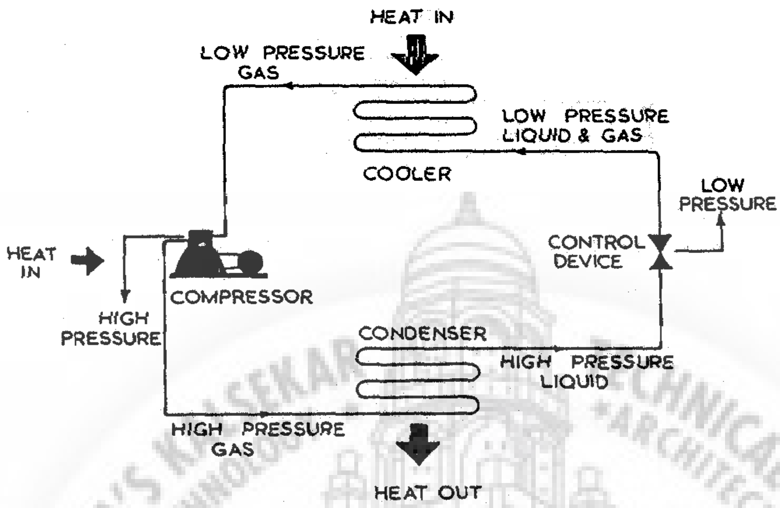
SUCTIONGAUGE **DISCHARGE GAUGE**

6.7 Working Methodology

There are many water coolers available in the market. Branded and local manufactures have flooded the market with their products. The technology commonly used by all of them are the same, Vapor compression cycle with an environmentally friendly refrigerant. The chilled water produced in a water cooler is used for drinking purposes, but some water is wasted by the user for cleaning hands and washing their water bottles. The stopping of wastage is almost impossible. The chilled water is thrown in the washbasin and flows to the gutter. Now this chilled water is not used for anything which means energy is wasted. This wasted energy can be used to increase the copulation of the VCC cycle. Here we will be working on a totally new and different concept: the model for increasing the COP of the system and reducing the power consumption by using waste heat recovery method which will directly reduce the electricity consumption of the water cooler. This project deals with designing and developing a working model of heat exchanger. A heat exchanger is a piece of equipment built for efficient heat transfer from one medium to another with or without direct contact between the working fluids. This heat exchanger is used to minimize the energy consumption of water coolers. Main objective of the project is pre-cooling of filtered water by using drain water as a cooling medium. This heat exchanger is fitted externally to the water cooler without changing any internal setup of the water cooler. Thus without use of any external work this Heat Exchanger works successfully and required results are obtained. The expected energy saved after installing a heat exchanger is around 20-25 %. The result varies due to weather conditions, wastage amount of water, etc. The COP of the total system can be increased by 0.9724. Economically the project cost can be recovered within 9-10 months. Thus we confidently conclude that this project was the most beneficial and enlightening the experience which is bound to help us in the near future.

7. CALCULATION

7.1 Trial



BASIC REFRIGERATION CYCLE

Aim :- To conduct a trial on a water cooler and find COP of system.

Observations Table :-

Water filled in top vessel = 3 liter

Final temp of water = 13^0 C

Normal temperature of water=31^0C

Voltage = 230 V

Current = 1.4 amp

Wattage = V x A = 230 x 1.4 = 125 watt

Theoretical COP = 0.5 (from HMT design data book for 125 compressor pg no…13.5)

Stage 1 :-Observation Without Filling Water In Heat Exchanger

Sr .No	Time (min)	Cond Inlet (^0C)	Cond Outlet (^0C)	Evp Inlet (^0C)	Evp Outlet (^0C)
1.	5	37.2	33.2	-8.4	16.5
2.	10	36.5	32.5	-8.9	16.8
3.	15	35.7	31.7	-9.1	17.1

Calculations :-

Reading No - 1

$$COP = \frac{(T_{Evap\ Exit} - T_{Evap\ Exit})}{(T_{Condenser\ Inlet} - T_{Evap\ Exit})}$$

$$COP = \frac{(16.5 - (-8.4))}{(37.2 - 16.5)}$$

∴ **COP = 1.202**

Reading No - 2

$$COP = \frac{(16.8 - (-8.9))}{(36.5 - 16.8)}$$

∴ **COP = 1.304**

Reading No - 3

$$COP = \frac{(17.1 - (-9.1))}{(35.7 - 17.1)}$$

∴ **COP = 1.408**

$$\text{Mean COP} = \frac{COP\ 1 + COP\ 2 + COP\ 3}{3}$$

$$\text{Mean COP} = \frac{1.202 + 1.304 + 1.408}{3}$$

∴ **Mean COP = 1.3046**

Stage 2 :- Observation With Filling Water In Heat Exchanger

Sr .No	Time (min)	Cond Inlet (^{0}C)	Cond Outlet (^{0}C)	Evp Inlet (^{0}C)	Evp Outlet (^{0}C)
1.	5	35.2	34.3	-18	18
2.	10	36.3	32	-20	19
3.	15	34.5	28.6	-23	18

Calculations :-

Reading No - 1

$$COP = \frac{(T_{Evap\ Exit} - T_{Evap\ Exit})}{(T_{Condenser\ Inlet} - T_{Evap\ Exit})}$$

$$COP = \frac{(18 - (-18))}{(35.2 - 18)}$$

∴ **COP = 2.093**

Reading No - 2

$$COP = \frac{(19 - (-20))}{(36.3 - 19)}$$

∴ **COP = 2.2543**

Reading No - 3

$$COP = \frac{(18 - (-23))}{(34.5 - 18)}$$

∴ **COP = 2.4848**

$$\text{Mean COP} = \frac{COP\ 1 + COP\ 2 + COP\ 3}{3}$$

$$\text{Mean COP} = \frac{2.093 + 2.2543 + 2.4848}{3}$$

∴ **Mean COP = 2.277**

7.2 Testing of water cooler

Time take to cool the water :-

- Ambient temperature = 32.5 ^{0}C
- Water temperature = 30.5 ^{0}C

TIME (min)	SP (PSI)	DP (PSI)	WATER TEMP. (Before fill)	WATER TEMP. (After fill)
5	10	158	27.4^{0}C	26.1^{0}C
10	10	168	21.5^{0}C	18.4^{0}C
15	10	171	16.4^{0}C	13.3^{0}C
20	14	172	13.2^{0}C	10.2^{0}C

7.3 DESIGN OF SYSTEM

7.3.1 Design of Condenser:-

Power of compressor = 125watt

20% of compressor power add due to friction

Heat required to remove from condenser = 1.2 × Power of Compressor

= 1.2 × 125

= 150 watts

Here ,

T_1 = Temp. at inlet of Condenser tube = 59^0 C

T_2 = Temp. at outlet of Condenser tube = 42^0 C

T_{atm} = Temp. of atmosphere =30^0 C

We know that,

$Q = U \times A \times \Delta T$ -{ where U = Overall heat transfer

Then ,

$\Delta T = ((\Theta_i - \Theta_o) / (\ln (\Theta_i / \Theta_o)))$

$\Theta_i = T_1 - T_{atm}$

= 59 - 30

∴ $\boldsymbol{\Theta_i = 29\ ^0C}$

$\Theta_o = T_2 - T_{atm}$

= 42 - 30

∴ $\boldsymbol{\Theta_o = 12\ ^0C}$

Put in above equation,we get,

$\Delta T = (29-12) / \ln (29/12)$

∴$\Delta T = 19.26^0$ C

Taking U = 28 $w/m^{2\,0}C$ will be the best selection (from Heat & Mass transfer handbook)

Now we are try to create such a box which have temperature above atmospheric. That means overall heat transfer increases for 10%

$$U = u \times 1.1$$

$$= 28 \times 1.1$$

∴ U =31 $w/m^{2\,0}C$

Therefore,

$$Q = U \times A \times \Delta T$$

$$150 = 31 \times A \times 19.26$$

∴ $A_{contact} = 0.2512\ m^2$

Now,

$$A_{contact} = \Pi \times D_{tube} \times L_{tube}$$

Take diameter of tube = 6.25 mm

$$0.2512 = \Pi \times 6.25 \times 10^{-3} \times L_{tube}$$

∴ L_{tube} = 12.79 m

For design purpose,

∴ L_{tube} = 13 m

Now since,

L_{tube}= Perimeter× number of tubes

We know,

Box size = 230 × 340

Perimeter = (340 + 230)× 2 = 570 mm

$$13 = 570 \times 10^{-3} \times \text{Number of turns}$$

∴ Number of turns = 22.8 ………….∴ **Number of turns ≅ 23**

7.3.2Design Of Evaporator :-

Here ,

T_3 = Temp. at inlet of evaporator = -11.7^0 c

T_4 = Temp. at outlet of evaporator = 3.4^0 C

T_{atm} = Temp. of atmosphere = 30^0 C

We know that,

Q = U × A × ΔT -{ where U = Overall heat transfer

$\Theta_i = T_{atm} - T_3$

= 30-(-11.7)

∴ **Θ_i = 41.7^0 C**

$\Theta_o = T_{atm}$ - 3.4

= 30 - 3.4

∴ **Θ_o= 26.6^0 c**

Then,

$\Delta T = ((\Theta_i - \Theta_o) / (\ln (\Theta_i / \Theta_o)))$

= 41.7-26.6/(ln (41.7/26.6))

∴ **ΔT = 33.58^0 C**

Taking U=16 w/m$^{2\,0}$C will be the best selection (from Heat & Mass transfer handbook)

Now we are try to create such a box which have temperature above atmospheric .That means overall heat transfer increases for 10%

U= 16 * 1.1

= 18 w/m$^{2\,0}$C

Therefore,

$$Q = U \times A \times \Delta T$$

$$150 = 31 \times A \times 19.26$$

$\therefore$ **$A_{contact}$ = 0.2512 m^2**

Now,

$$A_{contact} = \Pi \times D_{tube} \times L_{tube}$$

Take diameter of tube = 6.25 mm

$$0.2512 = \Pi \times 6.25 \times 10^{-3} \times L_{tube}$$

$\therefore$ **L_{tube} = 12.79 m**

For design purpose,

$\therefore$ **L_{tube} = 13 m**

Now since,

L_{tube}= Perimeter× number of tubes

We know,

Box size = 230 × 340

Perimeter = (340 + 230)× 2 = 570 mm

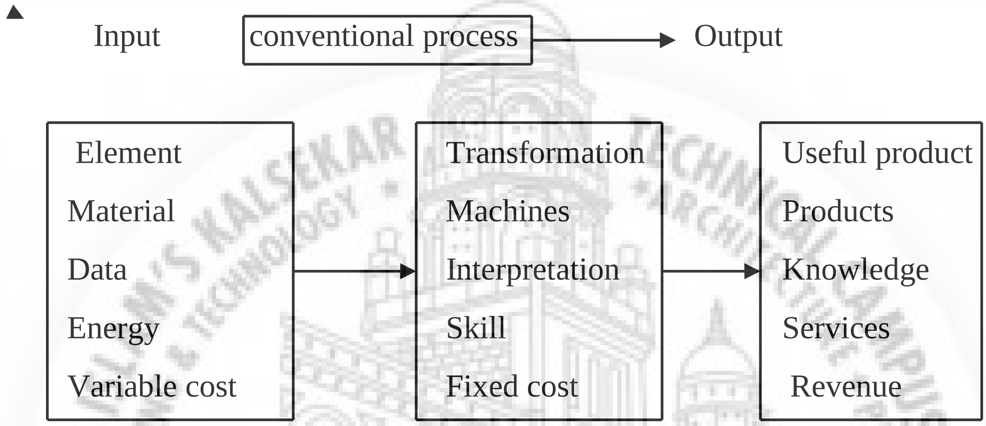
$$13 = 570 \times 10^{-3} \times \text{Number of turns}$$

$\therefore$ **Number of turns = 17.26**

8. MANUFACTURING

The process of conversion of raw material into finished products using the three resources as Man, machine and finished sub-components. Manufacturing is the term by which we transform resource inputs to create Useful goods and services as outputs. Manufacturing can also be said as an intentional act of producing something useful.

The transformation process is Shown below-



It is the phase after the design. Hence referring to the those values we will plan

The various processes using the following machines:-

i) Grinding Machine

ii) Drilling Machine

iii) Electric Arc Welding Machine

iv) Electric Cutting Machine

Component: FRAME (upper frame) :-

SR.NO	ACTIVITIES
1.	Raw Material
2.	Moved to m/c shop
3.	Cutting
4.	Taken to welding m/c
5.	Wedding
6.	Moved to surface grinder
7.	Grinding
8.	Moved to grinding shop
9.	Grinding
10.	Taken to fitting shop
11.	Drilling
12.	Wait
13.	Tapping
14.	Moved to m/c shop
15.	Inspection
16	Send to have other fitting of refrigeration system

FRAME

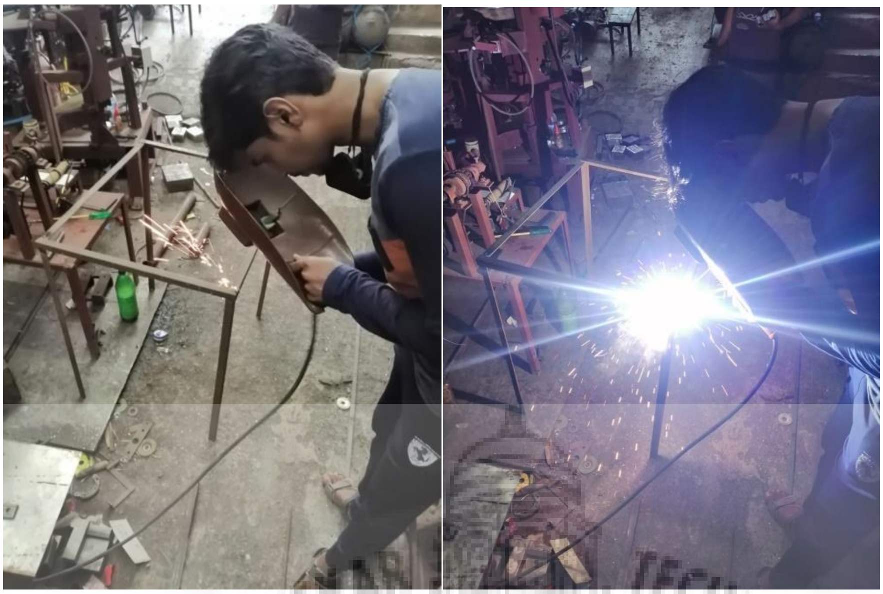
Operation Sheet :-

Name of job : vertical and horizontal angle frame.

Material specifications : ISLC 25x25x5mm .

Quantity :- 1

SR.NO	OPERATION	MACHINE	TOOL/GUAGE
1.	Cutting 25 x 25 x 5 angle for 1200mm length-04 nos.	Power saw	Steel rule
2.	Filling operations can be performed on cutting side and bring it in perpendicular face	file	Tri square
3.	Cutting 25 x 25 x 5 angle for 525mm length-08 nos.	Power saw	Steel rule
4.	File cutting edges and bring it in perpendicular section	file	Tri square
5.	With gas cutting side-slot to accommodate the neighboring angle	Oxy-acetylene gas set	Tri square marker
6.	Drill holes to accommodate other accessories	Hand drill	Twist drill
7.	Weld four angles to form a robust structure	Electric arc welding m/c.	MS. rod chipping hammer



WELDING

9. MAINTENANCE & SAFETY

9.1 Maintenance

No machine in the universe is 100% maintenance Free machine. Due to its continuous use it is undergoing wear and tear of the mating and sliding components. Also due to the chemical reaction that takes place when the material comes in contact with water, it causes corrosion and corrosion. Hence it is required to replace or repair. This process of repairing and replacing is called maintenance work.

9.2 Maintenance Of Water Cooler

As in the water cooler, the main problem was that oil was spread in the system. The reason was wet compression. The oil was passed into the condenser from the compressor. This adversely affected the heat transfer rate from refrigerant to the cooling water. Hence water was not cooled up to desired level. First the water cooler was opened from the back side and cleaned. The suction line and discharge line of the compressor was cut. Then air was pressured into it through a vacuum pump. The process is called air flushing. Due to this the oil, which was spread all over, was forced out of the system. After all oil spread in the system was taken out the system was hushed again to remove moisture and dust out of it. After that brazing operation is done where pipes are cut. Then air was evacuated from the system through a vacuum pump and then charging was done.

Following fault and remedial maintenance is required for keeping the product good working:-

SR N0.	COMPONENT	FAULT	PREVENTIVE MEASURE	BREAK DOWN MAINTENANCE .
1	Tank	Leakage	Colour it periodically	Weld it and apply M-seal
2	Compressor	Not running smoothly	Maintain oil level	Replace thick burnt oil.
3	Side sheets	Eroded	Colour it periodically	Replace worn out sheets.
4	Fan	Not operating smoothly, making noise	Grease it periodically	Replace worn out bearings, Align it.
5	Switch	Not functioning	Use std brand make.	Replace it
6	Evaporator, Heat Exchanger	Not heating and Not cooling	Putt off periodically	Check copper coil and if there is a leakage fix it and fill the refrigerant

9.3 SAFETY

In the present age of crowd and hurry one pays very little attention towards the safety. But due to this attitude one has to pay heavy cost for it by the functional loss or by loss of life. Hence safety has become more and more important in this age.

Following different safety measures operator has to take while operating the ‘**HYBRID WATER COOLER**’ :-

1) Operate ‘the coil for period of at the most12-13hours continuously or it may get damaged.

2) Do not install a coil without a bad conductor or there is a possibility of electrical shock to the operator.

3) Do not change the position of the cooler when it is full of water.

9.4 FAULT FINDINGS AND REMEDIES

SR.NO	PROBLEMS	CAUSES
1.	It does not run and there is no Humming	• Overload cut out tripped or burnt out. • Main overload relay tripped. • Loose connections or broken wire. • Disconnecting switch is open,
2.	The system runs but for a short time	• Refrigerant shortage. • Refrigerant’s control device fault or wrongly adjusted or completely burnt load on evaporator is not correct. • Low suction pressure,high head refrigerant pressure. • Oil entrapped in the coil. • Plugged liquid line. • Refrigerant control device wrongly adjusted or completely burnt out.
3.	The system runs Continuously	• Refrigerant shortage. • Refrigerant pressure reducing device fault or wrongly adjusted or completely burnt out. • Wring not proper. • Load on the evaporator is not proper. • Low ambient temperature. • High head pressure. • Undersized unit. • Oil entrapped in the coil. • Control contacts overload.
4.	The system is Very noisy	• Undersized Refrigerant line. • compressor completely burnt out. • Refrigerant has been overcharged. • Vibration in the system. • High head pressure. • Loading on the evaporator is not proper.
5.	Evaporator Temperature is Very high	• Low head pressure. • Low ambient temperature. • Refrigerant shortage. • Load on the evaporator is not proper. • Oil logged coil. • Undersized unit. • Undersized Refrigerant line.
6.	Evaporator Temperature is Very low	• Refrigerant pressure reducing device wrongly adjusted or completely burnt out.

		• Control contacts overload. • Refrigerant shortage. • Oil logged coil. • Wiring not correct.
7.	System suction Line ices up or Sweats heavily	• Refrigerant pressure reducing device faulty or wrongly adjusted or completely burnt out. • Defective wiring. • Load on the evaporator is not proper. • Refrigerant has been overcharged. • High head pressure.
8.	Cools Occasionally on Switching off the system	• Refrigerant control device leaking. • Compressor is completely burnt out.
9.	Liquid line Freezes	• Clogged liquid line.
10.	Liquid line Extremely hot	• High head pressure. • Refrigerant shortage.

10. COST ESTIMATION

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product. These expenses take into a consideration all expenditure involved in a design and manufacturing with all related services facilities such as pattern making, tool, making as well as a portion of the general administrative and selling costs.

10.1 Purpose Of Cost Estimating

- To determine the selling price of a product for a quotation or contract so as to ensure a reasonable profit to the company.
- Check the quotation supplied by vendors.
- Determine the most economical process or material to manufacture the product.
- To determine standards of production performance that may be used to control the cost.

10.2 Basically The Budget Estimation Is Of Two Types

1. Material cost
2. Machining cost

10.2.1 Material Cost Estimation

Material cost estimation gives the total amount required to collect the raw material which has to be processed or fabricated to desired size and functioning of the components.

These materials are divided into two categories.

1. Material for fabrication :In this the material in obtained in raw condition and is manufactured or processed to finished size for proper functioning of the component.

2. Standard purchased parts : This includes the parts which was readily available in the market like allen screws etc. A list is forecast by the estimation stating the quality, size and standard parts, the weigh of raw material and cost per kg. For the fabricated parts.

10.2.2 Machining Cost Estimation

This cost estimation is an attempt to forecast the total expenses that may include to manufacture apart from material cost. Cost estimation of manufactured parts can be considered as judgment on and after careful consideration which includes labour, material and factory services required to produce the required part.

10.3 Procedure For Calculation Of Material Cost

The general procedure for calculation of material cost estimation is

1. After designing a project a bill of material is prepared which is divided into two categories.

   a. Fabricated components

   b. Standard purchased components

2. The rates of all standard items are taken and added up.

3. Cost of raw material purchased taken and added up.

10.4 Labour Cost

It is the cost of remuneration (wages, salaries, commission, bonus etc.) of the employees of a concern or enterprise.

Labour cost is classified as:

1. Direct labour cost
2. Indirect labour cost

1. Direct labour cost:

The direct labour cost is the cost of labour that can be identified directly with the manufacture of the product and allocated to cost centers or cost units. The direct labour is one who counters the direct material into saleable product; the wages etc. of such employees constitute direct labour cost. Direct labour cost may be apportioned to the unit cost of job or either on the basis of time spend by a worker on the job or as a price for some physical measurement of product.

2. Indirect labour cost:

It is that labour cost which can not be allocated but which can be apportioned to or absorbed by cost centers or cost units. This is the cost of labour that doesn't alters the construction, confirmation, composition or condition of direct material but is necessary for the progressive movement and handling of product to the point of dispatch e.g. maintenance, men, helpers, machine setters, supervisors and foremen etc. The total labour cost is calculated on the basis of wages paid to the labour for 8 hours per day.

Cost estimation is done as under :

Cost of Project = (A) Material cost + (B) Machining cost + (C) Direct/ Indirect cost

A) Material cost:-

Material cost is calculated as under :-

i) Raw material cost

ii) Finished product cost

i) Raw Material And Finished Product Cost:-

It includes the material in the form of the Material supplied by the " Steel authority of India limited" as the round bars, Channels, angles, square rods , plates along with the strip material form.Some of the items are cheaply available in the market and the comparative cost of their manufacturing is more as compared to the market cost, hence we have purchased it directly from the market. We have to search for the suitable available material as per the requirement of designed safe values.

Hence the cost of the raw material is as follows:-

SR NO	PART NAME	MAT	QTY	COST
1	FRAME	MS	15 KG	600
2	COMPRESSOR	STD	1	1600
3	CONDENSER COIL	CU	1	1500
4	EVAPORATOR TUBE	CU	1	2100
5	WATER TANK	SS	1	300
6	CAPILLARY TUBE	CU	1	200
7	REFRIGERANT	R 134 A	1.5 KG	1350
8	HEAT EXCHANGER	CU	1	1600
9	BASE WATER TANK	SS	1	400
8	WIRING	STD	3 M	80
9	TEMP INDICATOR	STD	2 NOS	400
11	TAP	PLASTIC	1	40
12	FAN	STD	1	200
14	WASH BASIN	SS	1	400
15	FILTER, CAPILLARY	CU	1	330
13	MISSILINOUS	-	-	500
			TOTAL	11,600 /-

B) Machining Cost :-

SR . NO	MACHINE	TIME (hours)	RATE (Rs)	OPERATION	RUPEES
1	Oxy-acetylene Brazing-set	2	80	Connecting different components	160/-
2	Flaring tool	1/2	50	Connecting tubes	50/-
3	Welding M/C	1 1/2	80	Fixing the linkages	120/-
4	Drilling M/C and tapping Die set	1/2	30	Making holes and, threads	30/-
5	Charging attachment	1/2	80	Filling refrigerant.	80/-
6	Grinding M/C	2	80	Finishing the comp.	160/-
7	Cutting M/C	2	80	Parting off Objects	160/-
	Total				760/-

Hence the total machining cost = **Rs.760/-**

C) Direct / Indirect Cost :-

Transportation cost = 1000/-

Hence ,Total Direct / Indirect Cost **= Rs.1000/-**

TOTAL COST = Material cost + Machining cost + Direct/ Indirect cost

= 11,600 + 760 + 1000

∴TOTAL COST OF PROJECT = Rs.13,360/-

11. RESULT

11.1 Experimental results

Coefficient of performance of Water Cooler :

1.Before heat exchanger -

$$COP_{\text{Before heat exchanger}} = \frac{COP\ 1 + COP\ 2 + COP\ 3}{3}$$

$$COP_{\text{Before heat exchanger}} = \frac{1.202 + 1.304 + 1.408}{3}$$

$\therefore$ **COP** $_{\text{Before heat exchanger}}$ **= 1.3046**

2.After heat exchanger -

$$COP_{\text{After heat exchanger}} = \frac{COP\ 1 + COP\ 2 + COP\ 3}{3}$$

$$COP_{\text{After heat exchanger}} = \frac{2.093 + 2.2543 + 2.4848}{3}$$

$\therefore$ **COP** $_{\text{After heat exchanger}}$ **= 2.277**

3. Net COP ,

Net COP = $COP_{\text{After heat exchanger}} - COP_{\text{Before heat exchanger}}$
= 2.277 - 1.3046

$\therefore$ **Net COP= 0.9724**

Therefore, the **COP has increased by 0.9724.**

11.2 Energy Saved By The Project

- Power required for compressor = 125 + 20% friction

Fan requires = 30 watt

∴Total energy required to work = 180 watt

Assumption :- Cooler working for 10 hours/day

By observing the readings of testing -

After filling water in heat exchanger Satisfactory temp. reached at 15 mins only instead of 20 mins

5 mins of work saved in every 20 minute of interval.

So every hour 15min of work will be decreased.

i.e. **(5 mins x 3 intervals = 15 mins)**

Therefore the consumption will be reduced to **135 watts**.

And saving / hour will be **45 watts.**

11.3 Power Saving Analysis

- For 10 hrs. per day of working of machine.\-

∴ 45 watt per hour is saved.

- For a day saving:-

∴ 45 x 10 = **450 watts / Day**

- Working days a month:- 26 Days

400 x 26 = 11700 watts OR 11.7 KW

∴ Savings per month:-11.7 units.

11.4 Electricity Billing Calculation

- Electricity per unit rate :- **11 ₹**

(i) 11.7 x 11 = **128.7 ₹** **………………………**(power charges)

(ii) 11.7 x 1.4 = **16.38 ₹** **………….…………..**(carrying charges)

(i) + (ii) = **145.08 ₹**

(iii) 16% of (i + ii) = **23.21 ₹** **…………………..**(electricity charges)

∴TOTAL :- 168.29 ₹ approx per month savings.

12. CONCLUSION & FUTURE SCOPE

12.1 Conclusion

The heat exchanger was designed and manufactured successfully as per the functional requirement and it was tested by us. It was observed that the heat exchanger gave a satisfactory result. It is also completed the aim of the reduction of energy consumption of water cooler.

The expected energy saved after installing a heat exchanger is around 15 - 20 %. The readings were taken in the month of April and the reading showed that after installing a heat exchanger the energy saved is 18.32%. The result varies due to weather conditions, wastage amount of water, etc. The COP of the total system was increased by 0.9724. Economically the project cost can be recovered within 9-10 months.

The results achieved after completion of the projectwere highly appreciable in terms of knowledge, quality and with cost reduction. The project has certainly helped us to know the gap between our theoretical and practical knowledge. It enabled us to see how the knowledge gained through textbooks is implemented in practice.

Thus we confidently conclude that this project was the most beneficial and enlightening the experience which is bound to help us in the near future.

The following are the achievements through our project work

1. **It is the simplest solution to save electricity.**
2. **Economically the project cost can be recovered within 9-10 months.**
3. **Continuous 10 hrs of cost free running per day.**
4. **Low initial and maintenance cost.**

12.2 Future Scope

The future students will benefit from the hands-on study of the helical coil heat exchanger apparatus. This apparatus will be a valuable addition to the thermal engineering laboratory for years to come. It is beneficial to students to think about heat exchanger and its use for various applications such as chilled water systems, industries, etc. it will give a big canvas to go for such pioneering projects.

The copper tube is not having the fins attached with it. Using the fin arrangement to the copper coil the efficiency can be increased. Simultaneously with the help of fin, the length will reduce. So the heat exchanger will become more compact without affecting its efficiency.

The heat exchanger is a separate unit attached to the water cooler. The heat exchanger can be fitted within the water cooler system since it is having space inside it. But while fixing it inside the extra care of insulation must be taken. Because the compressor of the water cooler is continuously working and the heat is continuously emitted from it. So while considering this point, the air ventilation must be provided with it for better efficiency.

Instead of making the coil shape, if we make the coil in the one plane just like the condensing coil of a refrigerator unit. Because of this we can get a more compact shape of heat exchanger. In this case, the shell will be in the form of a hollow rectangular body which has the base and the rectangular lid.

Instead of helical coil heat exchanger we can use different types of heat exchanger like plate type heat exchanger, spiral type heat exchanger, etc. With this type the efficiency will increase and the cost will also increase. Also we can use the stainless steel material, aluminum, etc but according to that the cost will vary.

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