International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 05 | May -2020 ISSN: 2582-3930

Condenser Algae Cleaner

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Abstract - We analyzed the problem and the solution was to use such a mechanism which can remove the algae so, our group decided to establish one mechanism same as screw and nut mechanism after remarking all the perspectives. In which, we provide slider around the cooling coil and the reciprocating motion provide by help of motion of nut and at the same time, screw rotates with help of electric motor. In addition, this mechanism use once a day and reduce the human effort as well as improve heat transfer rate between hot refrigerant and cooling coil. By applying this mechanism in ice factory we can definitely increase overall efficiency of ice plant compared to without mechanism system.

***Key Words*:** Remove algae from condenser, Cleaning, Screw and nut Mechanism.

Nomenlature:

C.O.P - Co Efficient of Performance
VCRS - Vapour Compression RefrigerationSystem

1. INTRODUCTION

In this paper mainly focus on the improve co-efficient of performance of ice making industry by improving working ability of condenser. The Hare Krishna Ice Factory making ice of 12 tones, to make that ice 48 hours require. This time is definitely much higher than estimating time, so reduce the time rate of ice making is necessary for the company. If they reduce the time than C.O.P also increase and profit also increase in some amount. In this company the ice making cycle is VCRS. For this improvement, regular maintenance of each components of cycle is necessary, specially condenser cleaning and maintenance because continuous flow of water on condenser coil is reason for freezing algae around the condenser fins. Due to that company can not get sufficient cooling effect in the evaporator and it requires more time to make ice. In condenser, usaually company hires workers to remove the algae from condenser, but by applying this mechanism they will get efficient performance of plant with low investment.

1.1 Literature Review

- Llado contijoch francesc(3) had published the information about photobio reactor, process and system for algae growth and also given the process for growing algae in few steps.Photobioreactors for algae growth are known in the state of the art for growing and starting in a tank starting from A small strain in a medium with nutrients until the algae population grows enough to saturate the tank.
- Frederick J. Bobby (4) had given the information about ice which has been manufactured in ice plant by one of two systems the first system generally known as the can system is one in which water to be frozen is placed in suitable sheet iron cans which are then nearly so cold brine. In an improved method of making ice blocks the step of placing water to be frozen in a container immersion said container in a heat absorbing medium allowing a coating of ice to form on the inner walls of said container withdrawing the unfrozen water from within said coating of Ice and replacing said water with Ice and water and retaining said container shell and ice and water mixture in said heat absorbing medium until said shell and said Ice and water have formed a homogenous block of ice.
- David A. Wightman (5) has given information on vapour compression refrigeration system includes evaporator compressor and a condenser interconnected in a closed loop system in one embodiment a multifunctional wall is configured to receive a liquefied heat transfer fluid from the condenser and had also discuss that thereby reducing the amount of time necessary to defrost the system and improving the system performance.
- Sukani sunny (1) has given a paper on improving COP of ice making plant without editing any additional system the factory making an ice of 12 tons to make that ice 48 hours required this time period is somewhat high then the estimated time so reduce the time rate of ice making is necessary for the company if they reduced then time then COP also increase and profit also increase in some amount and also had found that Preventive maintenance conduct routinely and due to that profit is also increased.

2.SYSTEM DESCRIPTION

- Vapour compression refrigeration systems are the most commly used among all refrigeration systems. As the name implies, these system belong to the general class of vapour cycles, where in the working fluid undergoes phase change at least during one process. In a vapour compression refrigeration systems, refrigeration is obtained as the refrigerant evaporaters at low temperatures. The input to the system in the form of mechanical energy required to run compressor.Hence these systems are also called as mechanical refrigeration systems.

- Vapour compression refrigeration systems are available to suit almost all applications with the refrigerant capacities ranging from few Watts to few megawatts.The vapour compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. The below figure depicts a typical, single-stage vapour compression system. All such systems have four components:

(1) Compressor
(2) Condenser
(3)Thermal Expansion Valve
(4) Evaporator

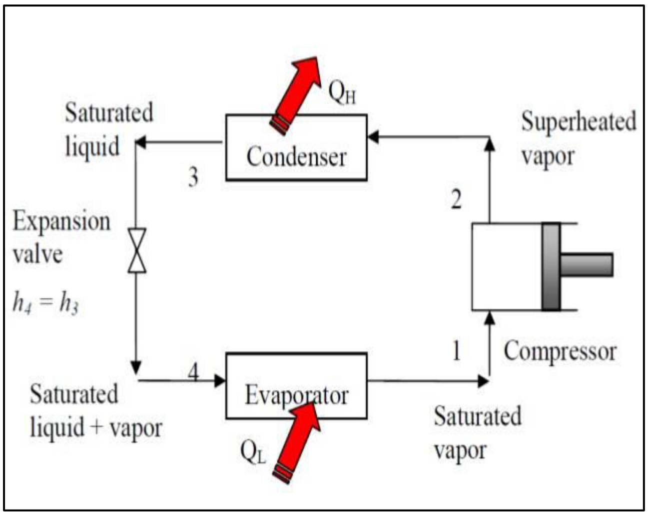

Fig. 1 Schematic diagram of VCRS

- The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid is next routed throgth an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of a liquid refrigerant. The auto-refrigerant effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapour refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.
- The cold mixture is then routed through the coil in the evaporator.A cold water directly contact in the space across the coil or tubes carrying the cold refrigerant liquid and vapour mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to desire temperature. The evaporator is where the circulating refrigerant absorbs And removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water.

2.1 Various components of VCRS

1. Reciprocating Compressor:

- A reciprocating compressor or piston compressor is a positive displacement compressor that uses pistons driven by a crankshaft to deliver gases at high pressure.
- The intake gas enters the suction manifold, then flows into the compression cylinder where it gets compressed by a piston driven in a reciprocating motion via crankshaft, and is then discharged. Applications include oil refineries, gas pipelines, chemical plants and refrigeration plants. One specialty application is that this compressor also used in ice factory.

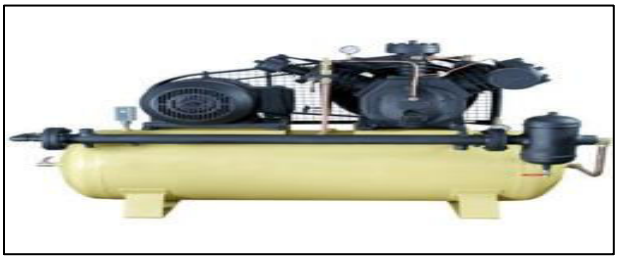

Fig. 2 Reciprocating Compressor

2. Atmospheric Condenser:

- This type of condenser is mainly used in ice factory to change the phase of refrigerant. A condenser is atype of heat exchange used to exchange heats between two fluids to condense stream and gas mixture.A condenser is used mainly with boilers or other gas system such as in refrigeration system.It basically takes out latent heat of vaporization from the gas mixture whether be steam or gas refrigerant to convert it back to liquid.Condenser that works under vacuum such as in boilers are called vacuum condenser while the others working under normal or low vacuum condition are called atmosphere condenser.

Fig. 3 Construction of Atmospheric Condenser

International Journal of Scientific Research in Engineering and Management (IJSREM)
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- An atmosphere condenser is used for extracting hrat out of refrigerant as in refrigerators and air conditioners. Furthermore they are also being used for extracting water directly out of atmosphere.The assembly consists of an air pump,membrane model and two sets of atmosphere condenser.The air is supplied to atmosphere condenser through a blower and membrane modulea vacuum pump take suction from the module while the operation and send output to the other atmosphere condenser.

3. Expansion Valve :

- It controls proper flow of refrigerant in the evaporator as per load inside the evaporator. If the load inside evaporator is higher it allows increase in flow of refrigerant and when load reduces it allows reduction inthe flow of refrigerant.

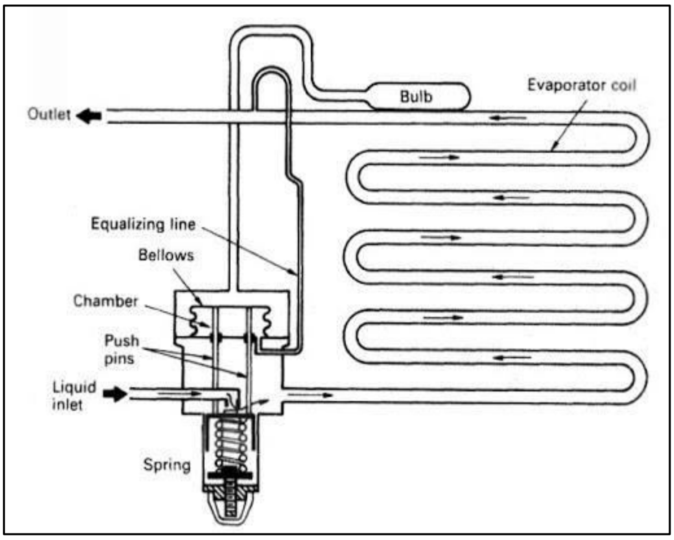

Fig. 4 Thermal expansion valve

- An expansion valve is a component in refrigeration that controls the amount of refrigerant released into the evaporator thereby keeping superheat, that is, the difference between the current refrigerant temperature at the evaporator outlet and its saturation temperature at the current pressure, at a stable value, ensuring that the only phase in which the refrigerant leaves the evaporator is vapor, and, at the same time, supplying the evaporator's coils with the optimal amount of liquid refrigerant to achieve the optimal heat exchange rate allowed by that evaporator. In addition, some thermal expansion valves are also specifically designed to ensure that a certain minimum flow of refrigerant can always flow through the system. Thermal expansion valves are often referred to generically as metering devices"although this may also refer to any other device that releases liquid refrigerant into the low-pressure section but does not react to temperature such as a capillary tube or a pressure-controlled valve.

4. Evaporator :

- The evaporator is placed in the area to be cooled. The refrigerant is let into and measured by a flow control device and eventully released to the compressor.

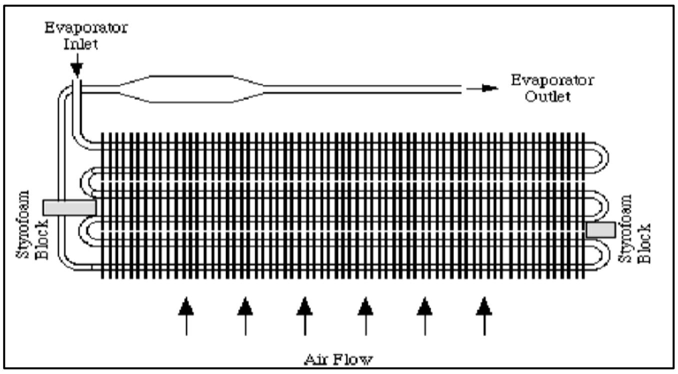

Fig. 5 Arrengement of Evaporator

- Evaporator is a kind of radiator coil used in a closed compressor driven circulation of a liquid coolant. That is called an air-conditioning system or refrigeration system to allow a compressed cooling chemical, such as R-22 or Amonia.

3.ALGAE FORMATION

- An algae bloom is a rapid increase or accumulation in the population of algae in freshwater, and is recognized by the discoloration in the water from their pigments. Cyanobacteria were mistaken for algae in the past,so it blooms are some times also called algae blooms. Blooms can block the sunlight from reaching other organisms, deplete oxygen levels in the water and some algae even secrete toxins into the water.

3.1 Freshwater Algae Bloom

- Freshwater algae blooms are the result of an excess of nutrients, particulary some phosphates. The excess of nutrients may originate around the condenser coil. These nutrients can then enter waersheds through water runoff. Excess carbon and nitrogen have also been suspected as causes. Presence of residual spdium carbonates acts as catalyst for the algae to bloom by providing dissolved carbon dioxide for enhanced photosynthesis in the presence of nutrients.

Fig. 6 Algae Frezzing

- When fresh water are introduced into water systems, higher concentrations cause increased growth of algae. Algae tend to

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 05 | May -2020 ISSN: 2582-3930

grow very quickly under high nutrient availability, but each algae is short-lived. The decay process consumes dissolved oxygen in the water, resulting the hypoxic conditions.

3.2 Effect algae formation on overall performance

Calculation C.O.P Of Before Algae Cleaning:

- Inlet temperature of compressor = -10 C
- Outlet temperature of compressor = 45 C

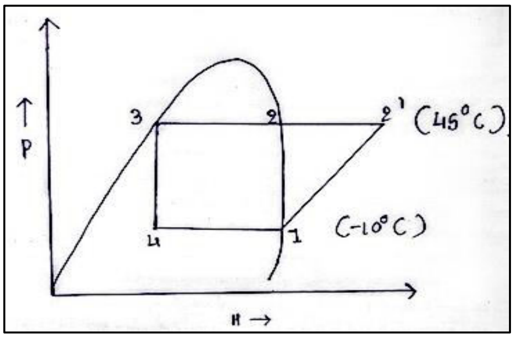

Fig.7 P-V Diagram

- From the refrigerant table;

H1 = 1433.1 kg/KJ
H3 = H4 = 396.8 kg/KJ

- Now, to find T2'

H2'= hg + cp(T2' – T2)
S1 = S2
5.4770 = Sg + cp*ln($\frac{T2'}{T2}$)
5.4770 = 4.8251 + 4.187 ln($\frac{T2'}{318}$)
T2' = 371.57 K
H2' = 1473.3 + 4.187* (371.5-318)
= 1697.5 kg/KJ

C.O.P $=\frac{(H1-H4)}{(H2'-H1)}$
$=\frac{(1433.1-396.8)}{(1697.5-1433.1)}$

C.O.P = 4.01

Calculation C.O.P Of After Algae Cleaning

Inlet temperature of compressor = -10 C

- Outlet temperature of compressor = 40 C

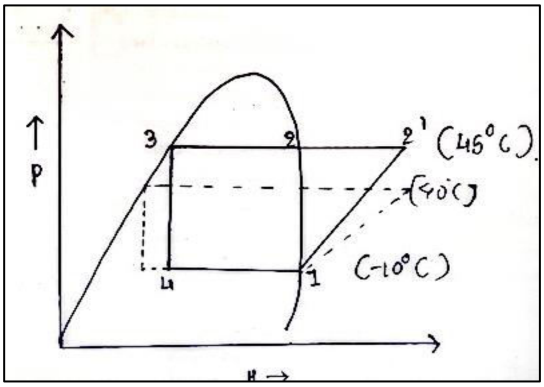

Fig. 8 Modified P-V Diagram

- From the refrigerant table;

H1 = 1433.1 kg/KJ
H3 = h4 = 371.9kg/KJ

- Now, to find T2'

H2'= hg + cp(T2' – T2)
S1 = S2
5.4770 = Sg + cp*ln($\frac{T2'}{T2}$)
5.4770 = 4.8251 + 4.187 ln($\frac{T2'}{313}$)
T2' = 357 K
H2' = 1473.3 + 4.187* (357-318)
= 1657.2kg/KJ

C.O.P $=\frac{(H1-H4)}{(H2'-H1)}$
$=\frac{(1433.1-371.9)}{(1657.5-1433.1)}$

C.O.P = 4.73

3.3 Effect algae formation on various materials

- For chossing approporiate material, we decided to perform one experiment. In which, we collected various materials as per requirement and then put in one tank which filled with purified wster. This task remained for 15 days, afterwards we checked all material texture and corrosion rate.
- In which, we included various materials such as Mild steel, Copper, Aluminium, Rubber, Polyvinyal chloride and Pvc sheet
- From above mentioned figure, we can see that due to water reaction , corrosion frreze on the mild steel and Aluminium.
- But, apart from them, there is too less effect produced on the rubber and polyvinyal chloride, because of higher corrosion resistance ability and flexibility.
- Therefore, after remarking above mentioned reasons, we decided to use Polyvinyl chloride for arranging various slider and support in our mechanism.

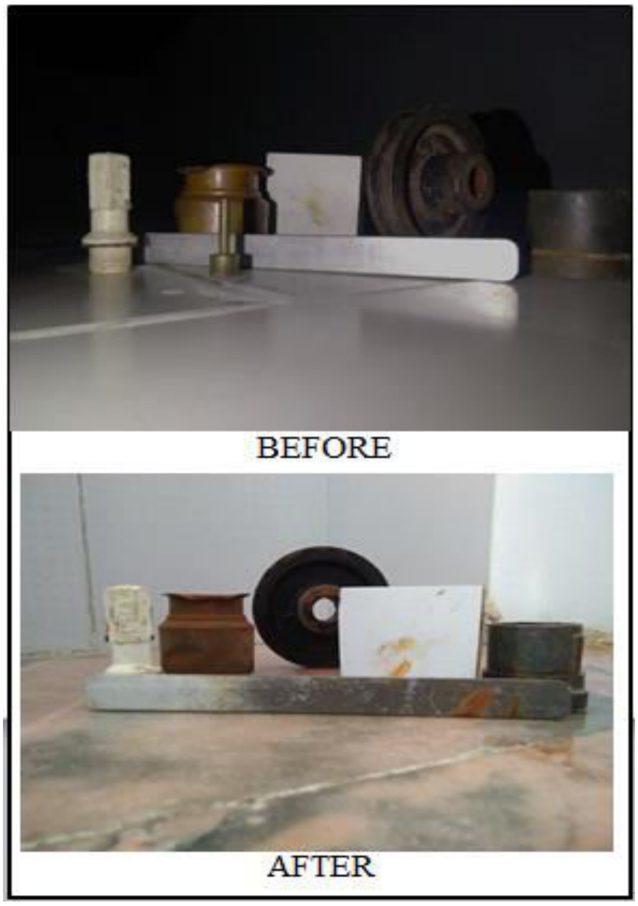

Fig. 9 Material Testing

4. PRODUCT DEVELOPMENT

- The screw one of the last of the simple machines to be invented. It first appeared in Mesopotamin during the Neo-Assyrian period (911-609) BC and then later on appered in Ancient Egypt and Ancient Greece.

4.1 Designed of Screw and Nut Mechanism

- A screw and nut is a mechanism that converts rotational motion to linear motion. The screw passes through a nut with help of thread on the inside of the nut that mesh with the threads of screw. When the shaft of the screw is rotated relative to the stationary threads and the nut moves along its axis of screw rotation.
- In screw and nut mechanism, either screw shaft can rotate through a threaded nut in a stationary objects or nut can rotate around a stationary screw shaft. This mechanism widely used in various mechanical applications such as screw tops for containers, vises, screw jacks and screw presses
- After placing each component at its place the following structure is obtained as shown in figure.

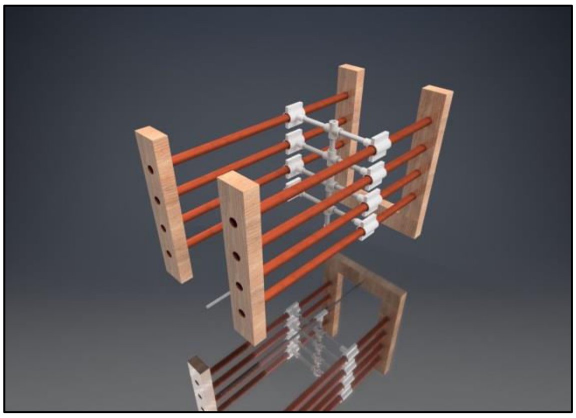

Fig. 10 Arrangement of component

Lead Screw and Nut

- A long screw having a nut mounted on threaded screw give motion to the slider connecting rod, to desire length at constant speed.

Fig. 11 Screw and Nut

Electric Motor

- After the fins were made the main components of the machine we bought is the motor. It is the component which is used to give the motion to the screw and nut mechanism.
- HP - 1/16
- AMPS - 0.6
- WATT - 50
- VOLTS - 220
- RPM -2800

Fig. 12 Electric Motor

Volume: 04 Issue: 05 | May -2020 ISSN: 2582-3930

Slider

- A slider is a components which slides on the surfaces of the fins to keep it clean from algae. In which one end of slider is fixed while another one is removable, due to maintenance of inside material of slider.

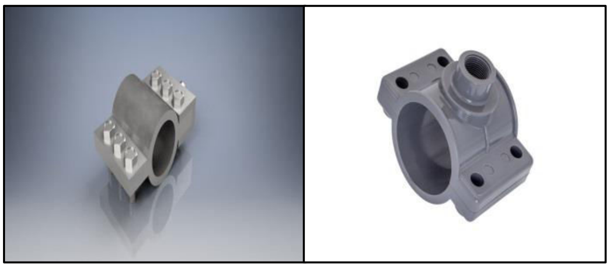

Fig. 13 Slider

Scrubber

- High flexibility with sharp edged steel filaments
- It is used as an abrasive in finishing
- High thermal stability
- Reduced wear rate
- High coeffcient of friction
- Raw material wire diameter (2.81mm to 2.92mm)
- It contains iron(Fe) and carbon (c)

Fig. 14 Steel wool

Cooling coils and Slider support

- Cooling coils used to pass refrigerant to expansion device and PVC support used to remove algae from the condenser coils.

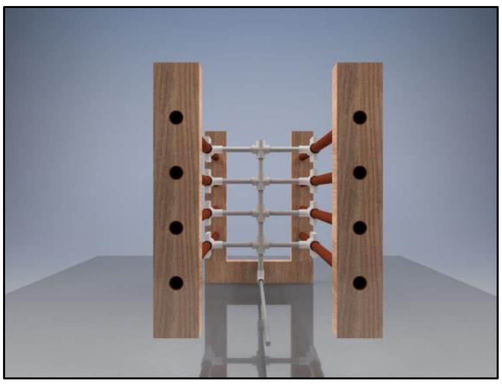

Fig. 15 Cooling coils and Slider arrengement

4.2 Calculation of Linear Speed Of Lead Screw

Theoritical Calculation

- Speed of motor N = 2800 RPM
- Radius of lead screw r = 0.0075 m

$V = \omega * r$

$= \frac{2\pi N}{60} * r$

$= \frac{2\pi 2800}{60} * 0.0075$

$V = 2.19\ {}^{m}/_{s^2}$

- As per experiment reading, nut travels 1000 mm distance within 15 sec.
- Here, pitch of lead screw is 4 mm.
- According to that,
  If pitch of lead screw is 4 mm = 1 revolution by lead screw

For travelling 1000 mm distance = how much revolution?

$= \frac{1000*1}{4}$

= 250 revolution in 15 sec

- For this,

$= \frac{250}{15} * 60$

= 1000 RPM (Without considering any loads and weights)

- Therefore, we are using electric motor with 2800 RPM, because our mechanism can sustain load and run without interference.

Practical Calculation

- As per practical, we can say that in real project, we do not need high speed electric motor but instead of the we require high initial torque.
- As per design, we are putting two nuts at a distance of 1000 mm.
- If we take pitch 4 mm at 1 revolution of lead screw than at 1000mm how much revolution is required ?

$= \frac{1000 * 1}{4}$

= 250 revolution in 5 sec.

- Therefore,

$= \frac{250}{5} * 60$

V = 3000 RPM

This speed can be vary according to the loading condition.

4.3 Calculation of Deflection for Long Span of cooling coil

- Due to long distance between two support of cooling coil, maybe deflection occurred, therefore by this calculation problem can be resolved

Available Data

- Outer diameter of fins = D = 0.07 m
- Inlet diameter of fins = d = 0.06 m
- Density of water = 1000 $Kg/m3$
- Density of condenser fins (stainless steel) = 7850 $kg/m3$
- Modulus of elasticity = 20 * 10^9 $N/m2$

- Weight of liquid can be calculated,

$W_w = \rho_w$ * Ai * g

= 1000 * $\frac{\pi}{4}$ * 0.06^2 * 9.81

= 27.73 N/m

- Weight of condenser fins

$W_c = \rho_c$ * (Ao-Ai) * g

= 7850 * $\frac{\pi}{4}$ *(0.07^2- 0.06^2) * 9.81

= 78.62 N/m

- Total weight,

W = $W_w + W_c$

= 27.73 + 78.62

= 106.35 N/m

- Maximum deflection for simply supported beam under Uniform Distribution Load

$\rho_{maximum} = \frac{5*W*l^4}{384*E*I}$

Here,

I = $\frac{\pi}{64}$ *(D^4- d^4)

= 5.4241 * $10^{-7}m^4$

Length of condenser = l = 5 m

$\rho_{maximum} = \frac{5*W*l^4}{384*E*I}$

$= \frac{5*106.35*5^4}{384*200*10^9*5.4241*10^{-7}}$

= 7.9780 * 10^{-3} m

$\rho_{maximum}$ = 7.9 mm

- By this calculation, we can assume that deflection can be neglected

5. CONCLUSION

- We can conclude that after using this mechanism not only the heat transfer co-efficient between refrigerant and water but also the overall efficiency of the plant increases. The preventive maintenance conduct routinely and to this net profit increases and the time taken by ice to freeze decreases.
- Company definitely saves the money which currently distributes on hiring workers for removing algae around the cooling coils.
- The mechanism can be used with a circuit based system through which the mechanism can be operated in required time period.It can be integrate directly with the computer system with the help of drivers, motors and actuators.

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