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Thermal Analysis of an Air Cooled Condenser Using Copper and Aluminium Material for Tubes and Fins of Condenser

Abdullah Kadhim Ali
ME Student,
Department of Mechanical Engineering,
JNTUH College of Engineering,
Hyderabad-India.

Dr. A.Aruna Kumari
Professor,
Department of Mechanical Engineering,
JNTUH College of Engineering,
Hyderabad-India.

ABSTRACT:

Air conditioning systems have condenser that remove heat of the hot vapour refrigerant discharged from the compressor, the hot vapour refrigerant consists of the heat absorbed by the evaporator and the heat of compression added by the mechanical energy of compressor motor, the heat from the hot vapour refrigerant in a condenser is removed first by transferring it to the walls of the condenser tubes and then from the tubes to the condensing or cooling medium. The cooling medium is air. Condenser are typically heat exchangers which have various designs and come in many sizes ranging from rather small to very large industrial-scale units used in plant processes, air cooled condenser are used in small units like household refrigerators , deep freezers, water coolers window air conditioners, split air conditioners, small packager air conditioners ect.

Air cooled condensers to the time not far limited to unit's capacity of 20 T.R or less. But there are now units larger than 100 T.R capabilities. A well designed, highly effective air cooled condenser can help to save energy and material cost. Now days, material cost is one of the important issues that should be condenser during condenser design. The analysis study was carried out on air cooled condenser of air-conditioner by using R-22.this work presents the improvement and development of heat transfer that occurs in the condenser by changing the tube material and also predicts the thermal performance of the condenser. In this work a design optimization technique is established in assessing the best configuration of a finned-tube condenser. The assessment has been carried out on an air-cooled finned-tube condenser of a vapor compression cycle for air conditioning cycle for air conditioning system. Heat transfer analysis is done on the condenser to evaluate the better design and material. The materials considered for tubes are Copper and Aluminum alloy 1050 for fins are Aluminum alloy 1100, 6063 and magnesium alloy for different refrigerants R-12, R-22 and R-134a.3D modeling is done in Pro/Engineer wildfire 5.0 and analysis has been done by using Ansys 14.5 version. The experimental results obtained are validated with computer values using ansys workbench version 14.5 software.

Keywords:

Air cooled condenser, Thermal analysis is done in Ansys 14.5, heat flux,

1.1 Introduction:

Air cooled cross flow fin-tube heat is any device that transfers heat from hot fluid to environment. It includes condenser and evaporator coils are commonly used in industrial fields such as refrigeration, air conditioning and petrochemical industries. There are many different types of geometry for heat exchangers available and being used. The "plat-fin and tube" geometry is one of the most common configurations and consist of copper tube and aluminum fin is generally used. There are different types of plate-fin geometry, the most common being the plain fin, where the fins are parallel plates attached to a hot element with the help of conductive heat transfer and dissipating this absorbed heat onto the outside environment which is at a lower temperature.These heat exchanger are commonly operated with a hot liquid inside the tubes and air on the outside. The heat from the fluid is transferred to the fin by conductive heat transfer. The fins then dissipate the heat onto the environment by convective heat transfer. In order to design better heat exchanger and come up with efficient designs, a thorough understanding of the flow of air and refrigerant in these channels is required. Now days, HVAC&R industry is searching for ways to increase performance, energy efficiency and durability of HVAC&R equipment in a sustainable way, while reducing the cost of manufacturing these, this search has put the spotlight on substituting the copper tubes have been in use for nearly a century with aluminum tubes.

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Fig 3.1 Experimental setup of air cooled condenser

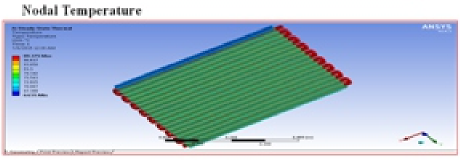
System with required accessories. The setup was equipped with automatic control devices and high precision metrical instruments, as per standards. Thermocouples are fixed at appropriate location to measure air temperature of condenser inlet and outlet.Pressure gauges are attached at the inlet and outlet of the compressor to measure the suction (pressure evaporation) and discharge pressure (condensing pressure) of compressor.

Thermocouples are fixed at appropriate location to measure of air inlet and outlet to condenser. Consist of an unattached air, R22 refrigerant and vapour compression refrigeration system with required accessories. The setup was equipped with automatic control devices and high precision metrical instruments as per standards.

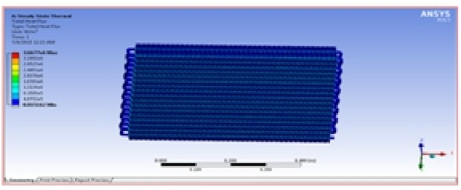
1.3. THERAMAL ANALYSIS BY USING ANYSIS 14.5:

Copper tube and AL-1100 fins with R-12

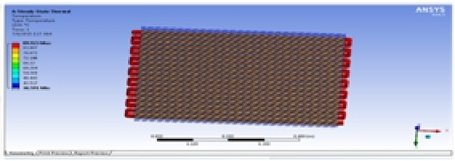
Nodal Temperature



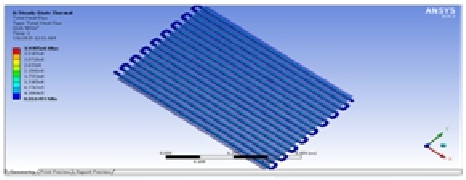
Total Heat Flux



Copper tube and AL-1100 fins with R-22

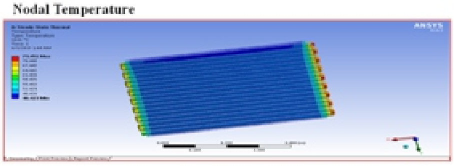


Total Heat Flux

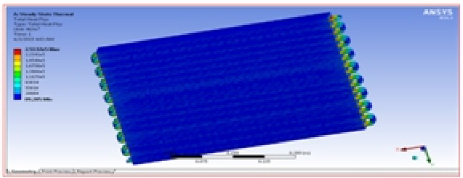


Copper tube and AL-1100 fins with R-134a

Nodal Temperature

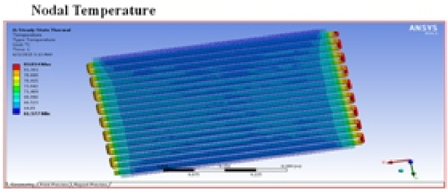


Total Heat Flux

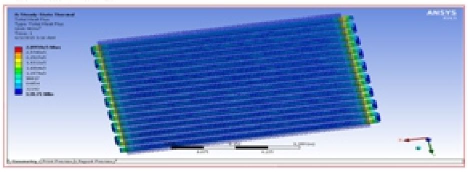


AL-1050 tube and AL-1100 fins with R-12

Nodal Temperature

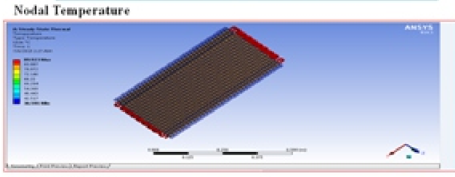


Total Heat Flux

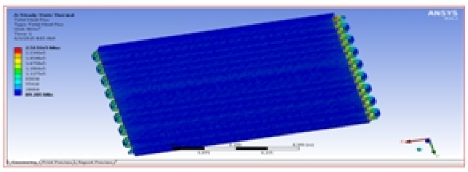


AL-1050 tube and AL-1100 fins with R-22

Nodal Temperature



Total Heat Flux



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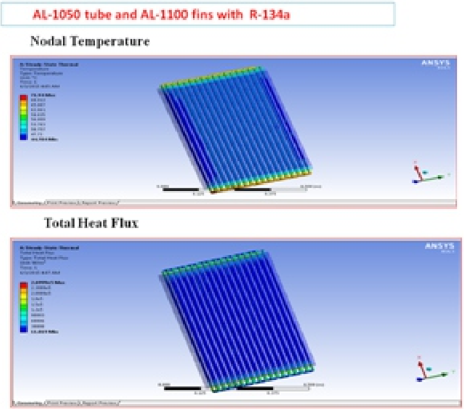
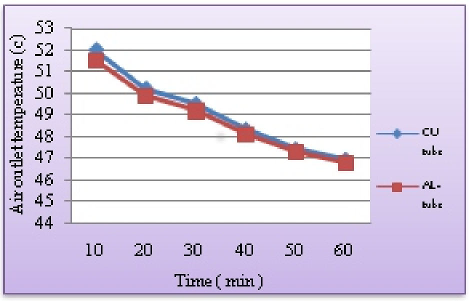
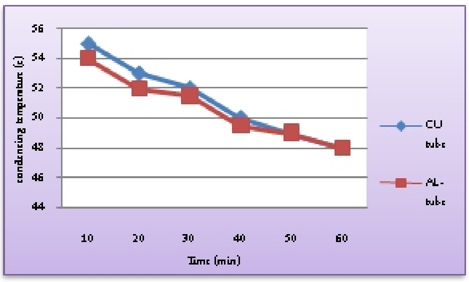


1.4. RESULTS AND DISCUUSSION

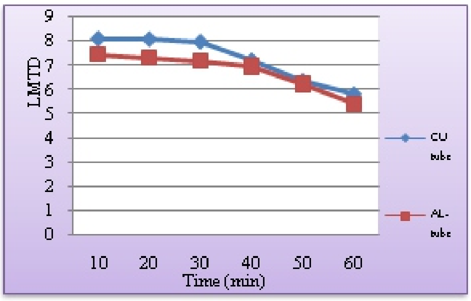
1.4.1.RESULTS AND DISCUUSSION BY EXPERIMENTAL



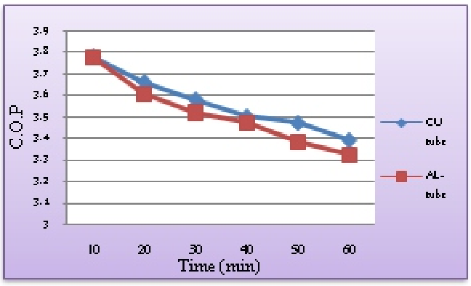
The Figure shows the variation in condenser air outlet temperature. When the refrigeration flows through the circuit and the air flow over the tube, then heat is transferred from refrigerant to air, ultimately the air outlet temperature increases. the heat transfer rate from refrigerant to air is same for both condensers .it seems that , air outlet temperature of copper as well as aluminum tube condenser is same. As the time increases the air outlet temperature decreases because the load on the system decreases.



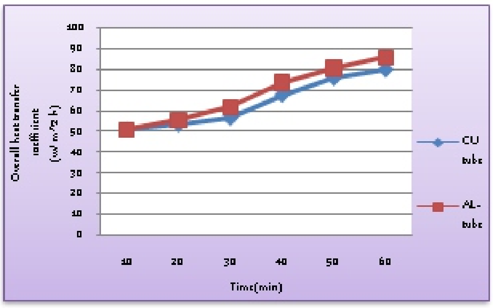
The figure shows the variation in condensing temperature. Condensing outlet temperature is depends on temperature of compressor and it's given at the condenser circuit. when the heat is transferred from refrigerant to air the vapor refrigerant gets condensed up to saturation temperature. It's observed that the condensing outlet temperature of condenser is same for copper as well as aluminum. It means the heat rejection capacity of both the condenser is same.



The figure shows the variation in log mean temperature difference (LMTD). The log mean temperature difference (LMTD) is main important performance parameter to check the performance and to design of air cooled condenser, also shows that (LMTD) of aluminum AL-1050 tube condenser more than the copper tube condenser.



the figure shows that the coefficient of performance (C.O.P) variation of the refrigeration system. The coefficient of performance (C.O.P) of the system is depends on refrigeration effect and work done by the compressor. And its shows that the coefficient of performance (C.O.P) of the refrigeration system is approximate same of both the condenser. At 20 minutes the coefficient of performance (C.O.P) of Copper tubes as well as AL-1050 tubes is same.



The figure shows the variation in overall heat transfer coefficient. The overall heat transfer coefficient is main important performance parameter to check the performance and to design of the air cooled condensers. . And also its shows that the overall heat transfer coefficient of the AL-1050 tube condenser is less than copper tube condenser which is approximately considered as same.

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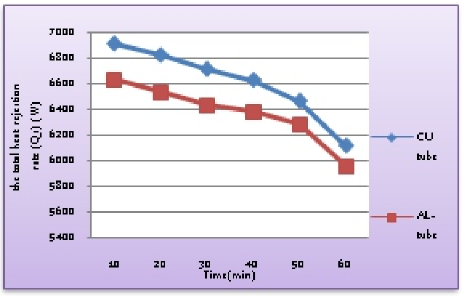
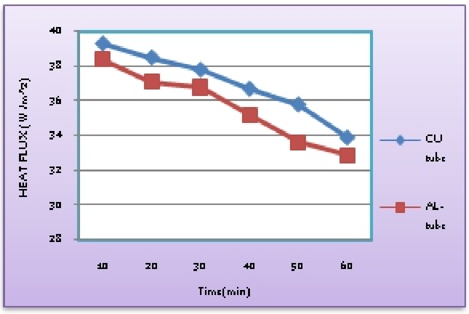
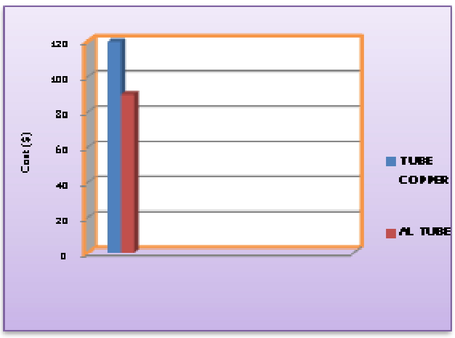
Therefore for same capacity of condenser, area requirement for both copper tubes condenser as well as AL-1050 tubes condenser is same.



The figure shows the variation in overall heat transfer coefficient. The overall heat transfer coefficient is main important performance parameter to check the performance and to design of the air cooled condensers. . And also its shows that the overall heat transfer coefficient of the AL-1050 tube condenser is less than copper tube condenser which is approximately considered as same. Therefore for same capacity of condenser, area requirement for both copper tubes condenser as well as AL-1050 tubes condenser is same.



The figure shows the variation in heat flux (qc), the heat flux (qc) is main important performance parameter to check the performance and to design of air cooled condenser, also the figure is shows heat flux(qc) of copper tub condenser more than the aluminum AL-1050 tube condenser.

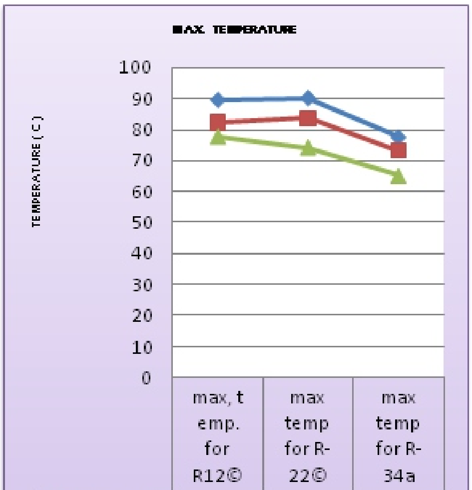


The figure shows the cost variation of copper tube condenser and aluminum AL-1050 tube condenser. By keeping in mind regarding the issue of cost of the condenser and performance comparison of copper tube and aluminum AL-1050 tube condenser, the cost of copper is higher than the aluminum AL-1050. So at same C.O.P, it is possible to replace the copper tubes to aluminum AL-1050 tubs. By tube replacement, the total cost the condenser is reduced.

1.4.2. RESULT AND DISCUSSION BY USING ANSYS WORKBENCH (14.5) Version software.

4.2.1- The Thermal Analysis of the first Model :

The Thermal Analysis of a condenser by tubes copper and with fins aluminum AL-1100, fins aluminum AL-6063 And fins Magnesium materials. With different types from refrigerant likes R12, R22 and R134a, has been carried out by using ANSYS WORKBENCH 14.5 Version software. The results obtained maximum temperature, max heat flux and directional heat flux. The analysis was summarized in the Following Tables: Comparison among the three results obtained from the analysis for R-12, R-22 And R-134a to see the effect of tube material and fins material. The maximum outlet temperature and heat flux. The results obtained the analysis were summarized in the following figures 4.10.



	max, temp. for R12©	max temp for R-22©	max temp for R-34a
cu tube. AL-1100 fins	89.34	89.951	77.451
cu tube . AL-6063 fins	82.268	83.542	73.124
cu tube . Mg fins	77.542	74.086	65.069

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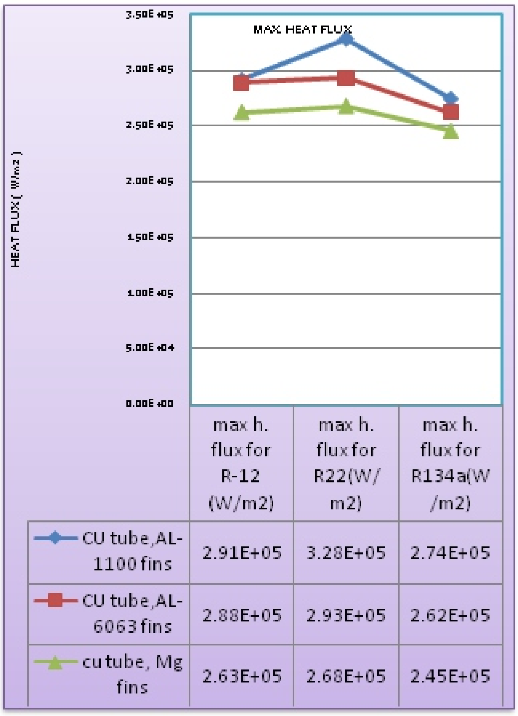
Graph 4.10: Variation of Temperature for copper tube with different Fins materials and Refrigerants



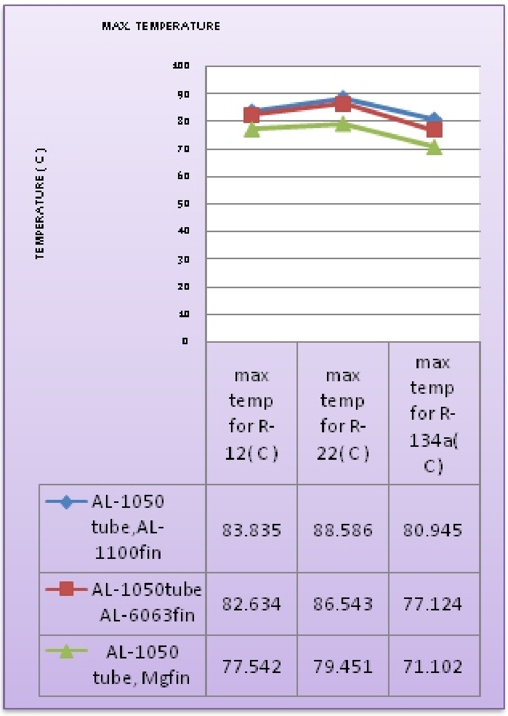
	max h. flux for R-12 (W/m2)	max h. flux for R22(W/m2)	max h. flux for R134a(W/m2)
CU tube,AL-1100 fins	2.91E+05	3.28E+05	2.74E+05
CU tube,AL-6063 fins	2.88E+05	2.93E+05	2.62E+05
cu tube, Mg fins	2.63E+05	2.68E+05	2.45E+05

Graph 4.11. Variation of Heat Flux for Copper Tube with different Fins materials and Refrigerants.

The last Figure shows that the heat flux obtained for copper tube with different fin materials and Refrigerants, so it can be observed from the above figure the maximum heat flux has been obtained for copper tube and fins made up of AL-1100 with R22.

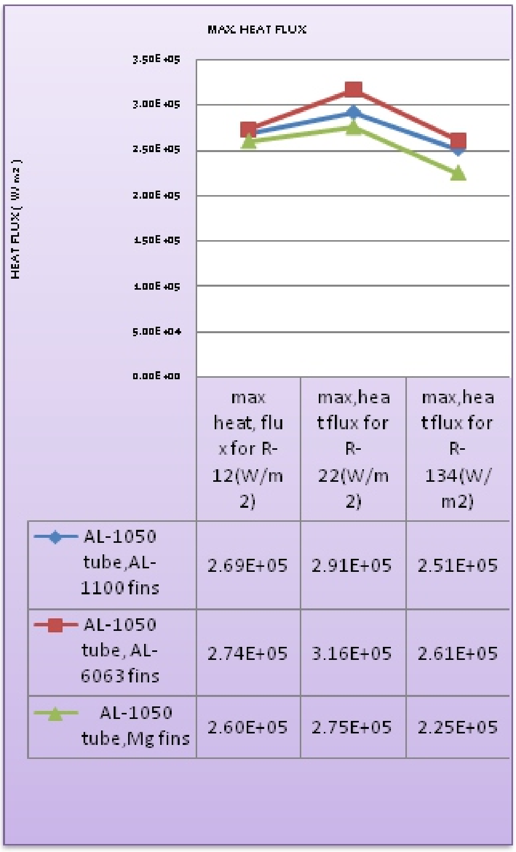
4.2.2- The Thermal Analysis of the Second Model.

An air cooled condenser by using tubes Aluminum AL-1050 with AL-1100, AL-6063 and Magnesium fins materials. With different types from refrigerant likes R12, R22 and R134a, has been carried out by using ANSYS WORKBENCH 14.5 Version software. The results obtained maximum temperature, total heat flux and directional heat flux. The analysis was summarized in the Following Tables:Comparison among the three results obtained from the analysis for R-12, R-22 And R-134a to see the effect of tube material and fins material. The maximum outlet temperature and heat flux. The results obtained the analysis were summarized in the following figures 4.12.



	max temp for R-12(C)	max temp for R-22(C)	max temp for R-134a(C)
AL-1050 tube,AL-1100fin	83.835	88.586	80.945
AL-1050tube AL-6063fin	82.634	86.543	77.124
AL-1050 tube, Mgfin	77.542	79.451	71.102

Graph. 4.12. Variation of Temperature for AL-1050 Tube with different Fins materials and Refrigerants



	max heat, flux for R-12(W/m2)	max,heat flux for R-22(W/m2)	max,heat flux for R-134(W/m2)
AL-1050 tube,AL-1100 fins	2.69E+05	2.91E+05	2.51E+05
AL-1050 tube, AL-6063 fins	2.74E+05	3.16E+05	2.61E+05
AL-1050 tube,Mg fins	2.60E+05	2.75E+05	2.25E+05

Graph. 4.13. Variation of Heat Flux for AL-1050 Tube with different Fins materials and Refrigerants

The last Figure shows that the heat flux obtained for AL-1050 tube with different fin materials and refrigerants, so it can be observed from the above figure the maximum heat flux has been obtained for AL-1050 tube and fins made up of AL-1100 with R22.

5.0 CONCLUSIONS:

From this the following conclusion are drawn. The condenser design optimization has shown a positive result analysed through thermal analysis.

•Air cooled condenser with refrigerant as R22 in copper tube and 1100 Aluminium fins recorded maximum heat flux of 3.241E+05 W/m2 and minimum heat flux of 1.326E+05 W/m2.

•Next, for Aluminum 1050 tube with refrigerant R22 and 1100 Aluminum fins the maximum is 3.146E+05 W/m2 and minimum heat flux is 1.271E+05 W/m2.

•Air cooled condenser using copper tube and 1100 Aluminum fins, the thermal flux recorded is more. It is noted that the heat transfers increases in this case. And by taking refrigerant R-22 is better. The maximum heat flux is about 2.95E+05 w/ m2 and minimum heat flux is 1.326e+05 W/ m2.

•An air cooled condenser using AL- 1050 tube with AL-1100 fins the thermal flux is more than other two materials. So the heat transfer increases, and also by taking refrigerant R-22 is better. The max heat flux is about 2.79E+05 w/ m2.

The maximum error analyzed in the Cu tube with Al 1100 fins is 9.8% when the heat flux is minimum and minimum error is analyzed when maximum heat flux is recorded. Similarly, maximum error analyzed in the Al-1050 tube with AL 1100 fins is 9.5% when heat flux in minimum and minimum error is analyzed at maximum heat flux.

The air cooled condenser by copper tube and Al-1100 fins using R-22 as refrigerant, gives maximum heat flux. This is nearly equal t an air cooled condenser using Al-1050 tube and AL-1100 fins with refrigerant R-22. Air outlet temperature of copper as well as AL-1050 tube condenser is equal. Which follows that from the use of AL-1050 heat exchanger is economical and lower weight.

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Author’s Details:

Abdullah Kadhim Ali
ME Student,
Department of Mechanical Engineering,
JNTUH College of Engineering,
Hyderabad-India.

Dr. A.Aruna Kumari
Professor,
Department of Mechanical Engineering,
JNTUH College of Engineering,
Hyderabad-India.