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Analysis of Condenser with Composite Material using CFD

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Abstract: ***The main objective of the present work is to increase the performance of the condenser by increasing the heat transfer rate through the condenser and to analyze the cooling rate of the condenser. Heat transfer rate can be increased by the extended surfaces such as fins, design, materials and cooling fluid. For this method we considered to change the material of the condenser, mainly composites. In general, copper is the mainly using material in condensers and heat exchangers. Composites we choosed are Copper-Aluminum combine composite, copper polymer composite, Aluminum alloy, zinc alloy. Major advantage we analyzed are using of composites increases cooling rate and increased life time. We design the condenser in CAD and analyze the working capabilities in CFD.***
Keywords: CFD, Condenser, Heat transfer, pressure, efficiency, composites.

I. INTRODUCTION

A condenser is a system used to convert vapor to liquid. They have been using in enormous industries in mostly all industrial areas for cooling the water vapor from the system and to cool it. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, natural-gas processing. Larger condensers are used in industrial-scale distillation processes to cool distilled vapor into liquid distillate. A composite material is made from two or more constituent materials with significantly different physical or chemical properties when combined, produce a material with characteristics different from the individual components. The new material may be preferred for many reasons include materials which are stronger, lighter, or less expensive when compared to traditional materials. Composites used in condenser to study the heat flow of composite materials and to increase cooling rate of condenser, which can be analyzed in Computerized fluid analysis (CFD) to analyze and study the fluid flow.

II. MATERIAL SELECTION

A. Copper –Nickel Composite

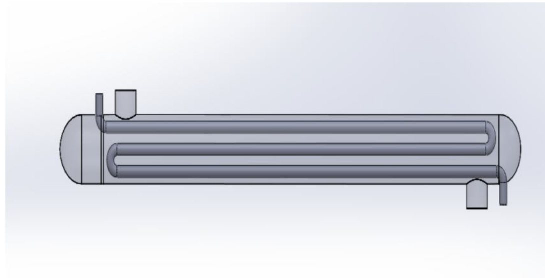
Cupronickel or copper-nickel (Cu-Ni) is an alloy of copper that contains nickel and strengthening elements, such as iron and manganese. The copper content typically varies from 60to90 percent.

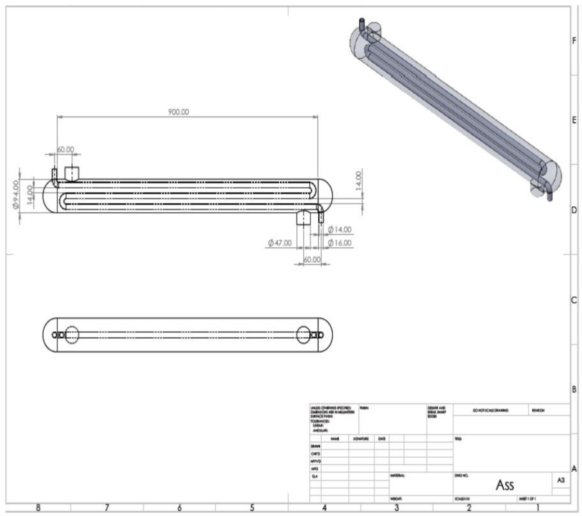
Despite its high copper content, cupronickel is silver in colour. Cupronickel is highly resistant to corrosion by saltwater ,and there fore used for piping, heat exchangers and condensers in sea water systems & for marine hardware . It is sometimes used for the propellers, propeller shafts, and hull so high-quality boats. Other uses include military equipment and chemical, petro chemical, and electrical industries.

Common mode rnust of cupronickel silver-coloured coins. Properties of cupronickel include corrosion resistant, good tensile strength, ductility when annealed, expansion characteristics for heat exchangers and condensers, good thermal conductivity and ductility at cryogenic temperatures and beneficial anti micro bialtouchsurfaceprope

Materials	Density (kg/m3)	Specific heat (J/kgk)	Thermal conductivity (W/mk)
Copper	8978	381	387.6
Cu-Ni	9675	450	457.6

III. DESIGN





The complete model of the solars till is done in SolidWorks 2019. For the geometry to be imported to the FLUENT software ,it has to be doneasper the requirement of the software .The difference for fluent modelling is that the part which has the fluid flow has to be modelled as solid.

This modelling is different fromres to the modelling used for analysis.

1) The modelling is doneasper the requirement of FLUENT software. The model is made as complete solid. Mesh is generated with sizing o f3 mm for all the bodies.
2) Each faceis given names as follows for the meshing process in the software as SteamInlet, SteamOutlet, WaterInlet, WaterOutlet.
3) After the mesh window isc losed the, the geometry along with the mesh is bought into the FLUENT software as file with is developed by the ANSYS mesh.
4) Set up pressur, velocity, time an dinmodels give energy equation.
5) In software inserted cellzone conditions and boundary conditions for simulation.

IV. DIMENSIONS

A. Length of the condenser = 900mm
B. Diameter of the condenser = 94mm
C. Steam pipe inner diameter = 14mm
D. Steam pipe outer diameter = 16mm
E. Water inlet pipe diameter = 47mm

V. TEMPERATURE CALCULATION

1) *Material –Copper,*

steam temperature 320℃
Inlet temperature of the steam, T1= 320℃
Outlet temperature of the steam, T2=26℃
Inlet temperature of water, t1=30℃
Outlet temperature of water, t2=42℃
steam temperature 440℃
Inlet temperature of the steam, T1= 440℃
Outlet temperature of the steam, T2=26.5℃
Inlet temperature of water, t1=30℃
Outlet temperature of water, t2=58℃

2) *Material –Copper Nickel,*

steam temperature 320℃
Inlet temperature of the steam, T1= 320℃
Outlet temperature of the steam, T2=26℃
Inlet temperature of water, t1=30℃
Outlet temperature of water, t2=40℃
steam temperature 440℃
Inlet temperature of the steam, T1= 440℃
Outlet temperature of the steam, T2=26.5℃
Inlet temperature of water, t1=30℃
Outlet temperature of water, t2=55℃
Flow Rate = 25 M/S
Overall Heat Transfer Co-efficient, U = 2300 W/m2K
Specific Heat of Copper = 381 J/ kgk
Specific Heat of Cu-ni = 450 J/ kgk

3) *Cu -Ni at steam inlet temperature 320℃,*

a) Heat load , Q = m.Cp. (T1 –T2) Q = 25 * 450 (320 -26.5)Q = 33.01 x 105J
b) log mean temperature difference ,ΔTm = (T1–t2)–(T2–t1)/ln$T$1–t2(T2–t1)ΔTm = (320−40)–(26.5−30)/ln(320−40)/ (26.5−30)ΔTm = 66.09℃
c) Heat transfer Area, A = Q / (U x ΔTm) A = 33.01 x 105/ (2300 x 66.09)A = 21.7164.Heat transfer coefficient, q= $cpdT.m/t$q = 450∗293.5∗25457.6q = 7.215 KW/ m2k

4) *Copper at Steam Inlet Temperature 320℃,*

a) Heat load , Q = m.Cp. (T1 –T2) Q = 25 * 381 (320 -26)Q = 28.003 x 105J
b) log mean temperature difference ,ΔTm = (T1–t2)–(T2–t1)/ln$T$1–t2(T2–t1)ΔTm = (320−42)–(26−30)/ln(320−42)/ (26−30)ΔTm = 68.38℃
c) Heat transfer Area, A = Q / (U x ΔTm) A = 28.003 x 105/ (2300 x 68.38)A = 17.80
d) Heat transfer coefficient, q= $cpdT.m/t$q = 381∗294∗25387.6q = 7.224 KW/ m2k

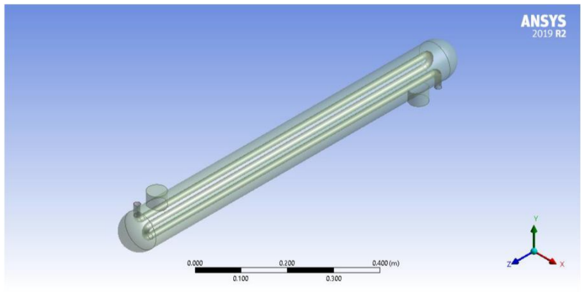
5) *Cu -Ni at steam inlet temperature 440℃,*

6) *`Cu -Ni at steam inlet temperature 320℃,*

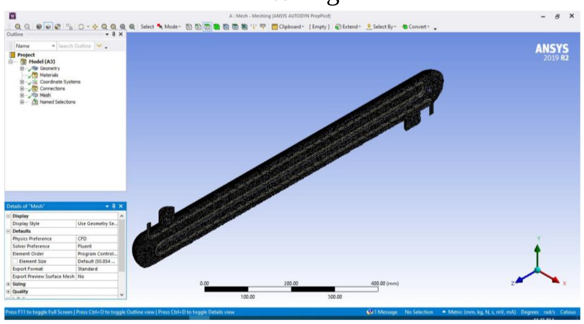
a) Heat load , Q = m.Cp. (T1 –T2) Q = 25 * 450 (320 -26.5)Q = 33.01 x 105J
b) Log mean temperature difference ,ΔTm = (T1–t2)–(T2–t1)/ln$T$1–t2(T2–t1)ΔTm = (320−40)–(26.5−30)/ln(320−40)/ (26.5−30)ΔTm = 66.09℃
c) Heat transfer Area, A = Q / (U x ΔTm) A = 33.01 x 105/ (2300 x 66.09)A = 21.716
d) Heat transfer coefficient, q= $cpdT.m/t$q = 450∗293.5∗25457.6q = 7.215 KW/ m2k

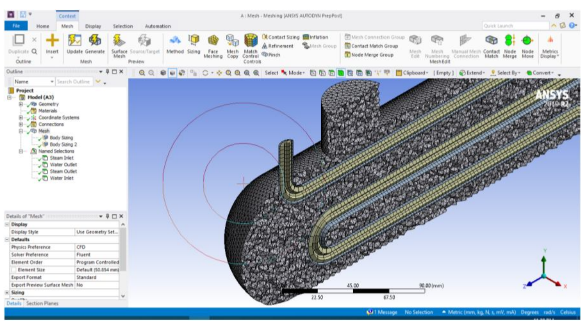
VI. ANLYSIS

Imported Geometry Model In Ansys



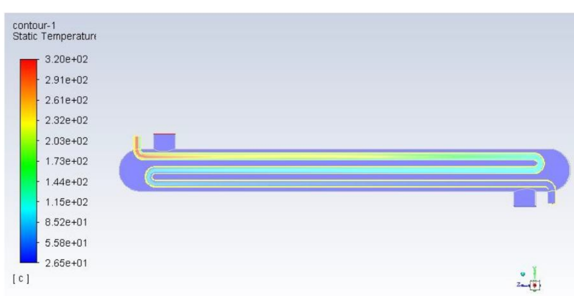
Meshing



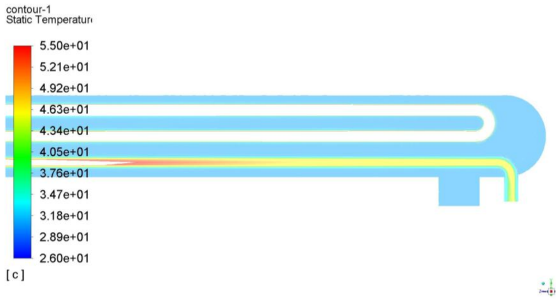


ANALYSIS OF CONDENSER AT DIFFERENT TEMPERATURES

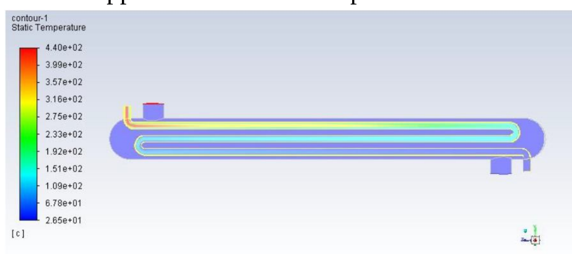
Copper at steam inlet temperature 320°C



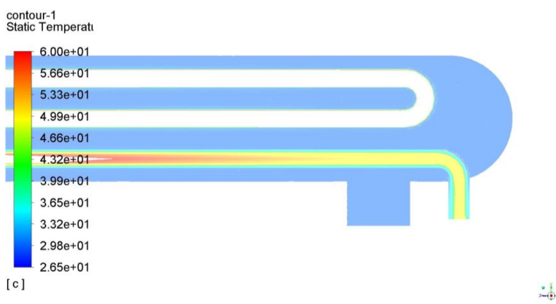
Steam outlet area pointed in the condenser for details at 320°C(Copper)



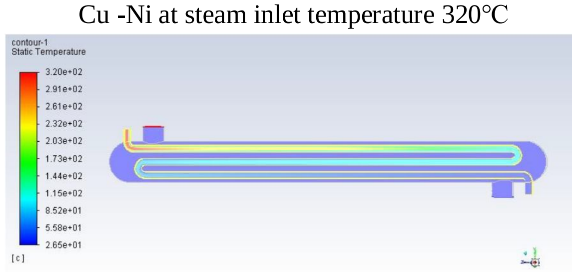
Copper at steam inlet temperature 440°C



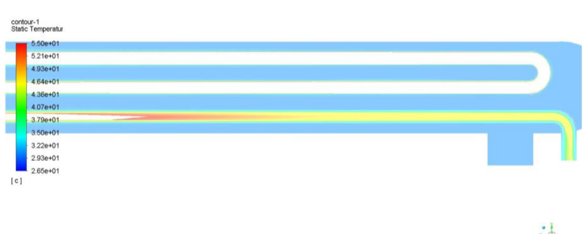
Steam outlet area pointed in the condenser to small deviations at 440°C(Copper)



Cu -Ni at steam inlet temperature 320°C



Steam outlet area pointed in the condenser for details at 320°C(Cu –Ni)



Cu -Ni at steam inlet temperature 440°C

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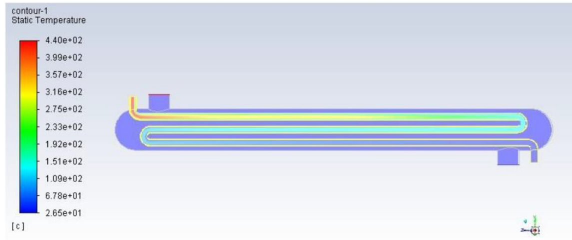
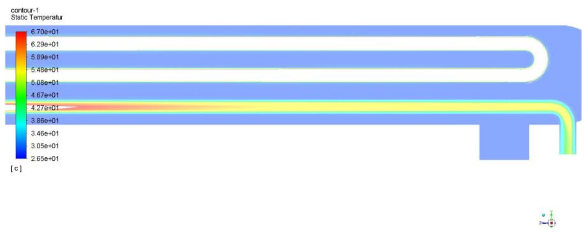


Steam outlet area pointed in the condenser for details at 440°C(Cu –Ni)



VII. RESULT & DISCUSSION

The results shows that the analysed composite and copper material converts the steam to liquid water state at cool water temperature. Thus resulted in the composite Cu-Ni can work similarly as the native condense rmaterial.

VIII. CONCLUSION

In this paper, we have concluded that the using of copper composites, mainly copper-polymer / copper-aluminum composites .These composites have thermal distribution capabilities and increase in cooling rate as evaluated. These composites in the roll- to- roll matrix form, the heat is distributed in a cross flow type . Using certain thermal condenser analyzing equations and CAD models to design the condenser and analyzing using CFD dynamics software for working fluid analyzing.

IX. FUTURE SCOPE

By studying the material properties of composite materials and develop them to use in there altime applications, as a future of efficient and the long life materials composites is a best way in one of them Cu-Ni alloy can use in the salt water and marine condenser and waterpipe lines, thus gives longer life time .Usage of computer models and simulations we can reduces developing and testing costs.

X. ACKNOWLEDGEMENTS

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A. Conflict of Interest

There is no conflict of interest to be described.

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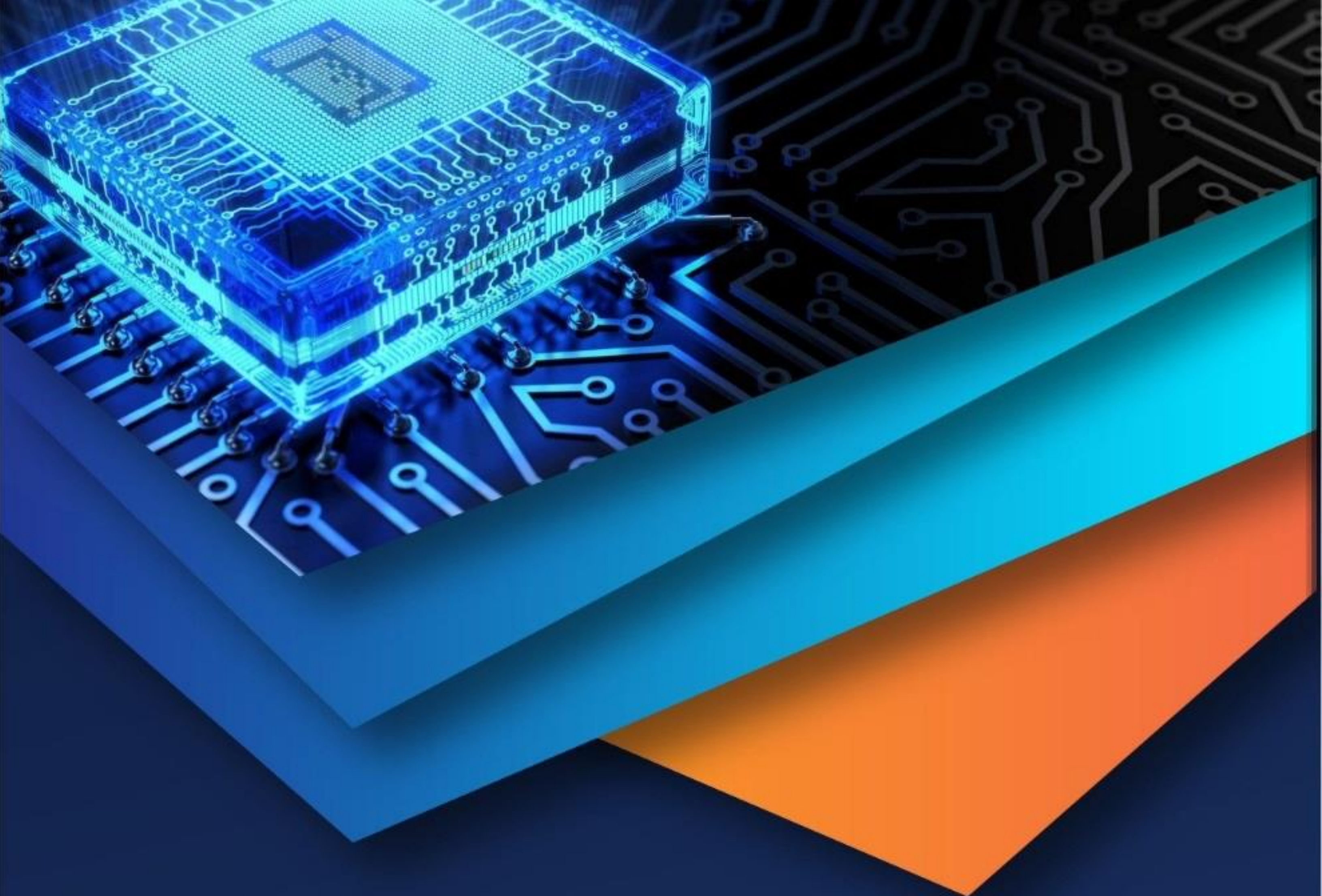

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