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Optimization of An Intercooler Used in Multi Stage Compressor Using with and Without Baffels

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Abstract

Thermal and CFD analysis is done on the intercooler. CFD analysis is done under different boundary conditions. The materials considered for shell and tube intercooler are Aluminum, Titanium and Copper for thermal analysis and compared for better material. The input of heat transfer coefficient for thermal analysis is taken from output of CFD analysis. The intercooler's pressure gradients, temperature distributions, and fluid flow patterns can all be understood using CFD study. Engineers can learn how parameters like input airflow velocity, temperature, and geometry impact the intercooler's performance by modeling various operating and boundary conditions. In order to optimize the design and obtain the required pressure drop and cooling efficiency, this information is essential.

Keywords: CFD analysis, tube intercooler, Gas turbines, shell, Drag Race

INTRODUCTION

An intercooler is a mechanical device used to cool fluids, similar to liquids or feasts, between stages of the multi-stage contraction process. It is an exchanger that is used in gas compressors to eliminate excess heat. Gas turbines, air compressors, air conditioners, freezers, and other colorful devices all employ intercoolers. They are widely used in cars and trucks as air-to-air or air-to-liquid coolers for induction-controlled (supercharged or turbocharged) internal combustion engines. This serves to improve the efficiency of these engines by raising the viscosity of the source air charge through almost isobaric procedure (constant pressure) cooling. Air compressors are employed in different diligence to meet colorful requirements, similar to furnishing process conditions, operating curvaceous tools and outfits, and meeting instrumentation needs. Compressed gas systems account for 10 of the total artificial energy use worldwide.

INTERCOOLER TYPES

Generally, the intercooler's can be divided into 3 types. Type of air-to-air intercooler, air-to-water, and one shot [3].

Air to Air

Air-to-air intercoolers could be a type of the most widely utilized in cars these days. Of explicit interest during this kind of indentation intercoolers and changes in size ought to be as very little as attainable. Additionally, the connections and rubber hoses ought to be of fine quality to be ready to stand up to the pressure Turbo. The erection Turbo additionally has to be thought-about and should be placed in a place where as many as attainable get a breath of recent air once the automotive moves.

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Air to Water

Intercooler air to water at first used for ships. On this kind of water to cool air circulating essentially

works as the radiator water. The foremost necessary component during this sort off or intercooler is the pump. For that's sometimes connected with a pump-mounted 12-volt battery series or parallel.

One-shot Intercooler

Intercooler one shot has the high potential of air cooling and quite cools the turbo and therefore the air in no time. Intercoolers like this are often not appropriate for everyday vehicles, except for vehicles Drag Race. Sometimes the material used for the intercooled one shot is N2 or Esctiveness [5].

ADVANTAGES

Intercooling relies on simple physics the Engine and exhaust produce the majority of heat in your vehicle and intercooling removes that heat.

Intake Gas Temperatures are Drastically Reduced by Intercooling Systems

It is common to net a drop by 85°–200° in intake air temperature (depending on application). This temperature drop ends up in a denser, so a lot of powerful air/fuel ratio, it greatly reduces the probabilities of detonation or pre-ignition, and just about eliminates the decrease in power generally felt in consecutive runs and extended pulls in nonintercooled setups [6].

In Many Cases, Intercooling Allows for Full or Close-to-factory Timing

A reduction in temperature permits your timing to be tuned to factory (or close to factory) timing and avoids substantial H.P. loss created by excessively retarding ignition timing.

An Intercooler Increases Horsepower and the Low-end Boost

The main function of coolers systems is that of a quiet wastegate. This allows more boost to be adjusted for at lower rpm by flattening its boost curve at higher rpm.

The Power Band of your Supercharger is Expanded by Intercooling

Allowing for full timing of your forced induction setup keeps the engine propulsion separate and reduces high rpm fall-off vs. nonintercooled supercharger systems.

Increased Sustained Boost Levels are Safely Allowed by Intercooling

The advantages of Intercooling are felt at any boost level. Actual results of these advantages the flexibility to safely run significantly higher boost levels than non-inter-cooled supercharger systems [7].

Function of Intercooler Used in Air Compressor

Intercooler used in air compressors performs the following functions:

- Atmospheric air contains moisture, and the air could develop oil vapor because it passes through some compressors. Cooling the air right down to or below its initial temperature can take away moisture down to the dew point, improve the standard of the air.
- Another purpose of intercooling is to boost the efficiciency of compression. This is often done by reducing the work of compression (power requirements).
- Since the air comes out from compressor is at higher pressure further as at higher temperature. This higher temperature could produce problems for pneumatic tools, therefore intercoolers are used to scale back the Outlet temperature of compressed gas.
- Each 4°C rise in inlet air temperature ends up in the higher energy consumption by one % to realize Equivalent output. Therefore the intake of cool air improves the energy efficiency of a compressor.

Selection of Shell and Head Types

Shell and heads are determined mechanical cleaning, cost, thermal expansion and leaksge of fluid. The one pass sort E shell is standard. If multiple shell passes are needed, as indicated by LMTD correction issue F (F<0.7) [4, 15], E shell connected serial or a 2 pass shell is used, though the longitudinal baffle is also subjected to leakage. These 2 are primarily used for intercooler [8].

The most necessary consideration with regard to head kind is fixed tube sheets versus floating head. A fixed tube sheet style is cheaper and fewer susceptible to leakage. However, the tube bundle can not be removed to scrub the outside surface of the tubes. So, fixed tube sheet exchangers are sometimes restricted to service with clean shell side fluid. In addition, fixed tubular sheet exchangers require an expansion joint inside the shell to permit thermal expansion between the tubes and shell, which raises the exchanger's cost, if the difference in warmth between the two inlet streams is larger than roughly 100 °F. The entire tube bundle will be driven out of the shell from the front end with floating head and U tube exchangers. This makes it possible to mechanically clean the exterior tube surfaces using hot water or steam jets at high pressure occasionally. Additionally, the tubes are unengaged to expand or contract in relation to the shell due to temperature differences, and only the tube sheets (at the front end) are attached to the outermost layer. The foremost widely utilized floating head design within the process industry is the AES exchange. U-tubes exchangers are less expansive, more cost effective and also are widely used. The arrival of apparatus for cleanup the interiors of U-tubes utilizing high pressure water jets has satisfied the matter of cleanup the return bends, resulting in increased use of those exchangers [9].

LITERATURE REVIEW

A. Sathyaraj [1], the circular cross section pins are inserted normal to the flow direction of air in existing finned tube heat exchanger (intercooler) of 2 stage reciprocating compressor is to extend the convective surface contact area and produce the turbulence leading to a rise in the heat transfer rate. CFD analysis has been done on this intercooler and examining them utilizing FLUENT software. The experimental information are taken as the reference for CFD analysis. From this analysis the heat transfer rate increase and work requirement compared with the prevailing one.

Y. Wu In their work, J. F. Hamilton and W. Shenghong [2] provide the best The design procedure for an intercooler when the goal is to reduce compressor power alone, but also the pumping power needed to cool the water inside of the intercooler and, consequently, the supercharger's original cost. The process allows for a proportional allocation of the intercooler cost in relation to the importance of the combined power decrease. Temperature-related coupling impact is eliminated by optimizing each stage independently of the others in the multiple levels compressor system.

Pawan Kumar Gupta, S.P. Asthana, Neha Gupta [4], presents a study on that the most objective is to intercooling of compressor that is critical for an economical method. During this paper study regarding design consideration should be known before going to design heat exchanger. There are sure parameters that are outlined by the engineers

CFD Analysis of a Shell and Tube Exchanger Without Baffles

The Figure 1 represents the imported file of the assembled file from CATIA to ANSYS. Here to import from Catia we need to save the designed file into stp format and import in the Ansys. This is what needs to be done in Ansys as the first step. Here the fluent module is considered in Ansys to proceed with the CFD analysis. Figures 2 describes the results [10].

CFD Analysis of a Shell and Tube Exchanger with 140Deg Baffles

The Figure 3 represents the imported file of the assembled file from CATIA to ANSYS. Here to import from Catia we need to save the designed file into stp format and import in the Ansys. This is the initial step that needs to be done in Ansys. Here the fluent module is considered in Ansys to proceed with the CFD analysis. Figure 4 describes the results.

RESULTS AND DISCUSSIONS

Here we have analyzed the heat exchanger of an intercooler using two different conditions and using without baffles and even using with 140Deg baffles. So here we are increasing the flow rate for the second condition to see the variations when the flow of velocity is increased.

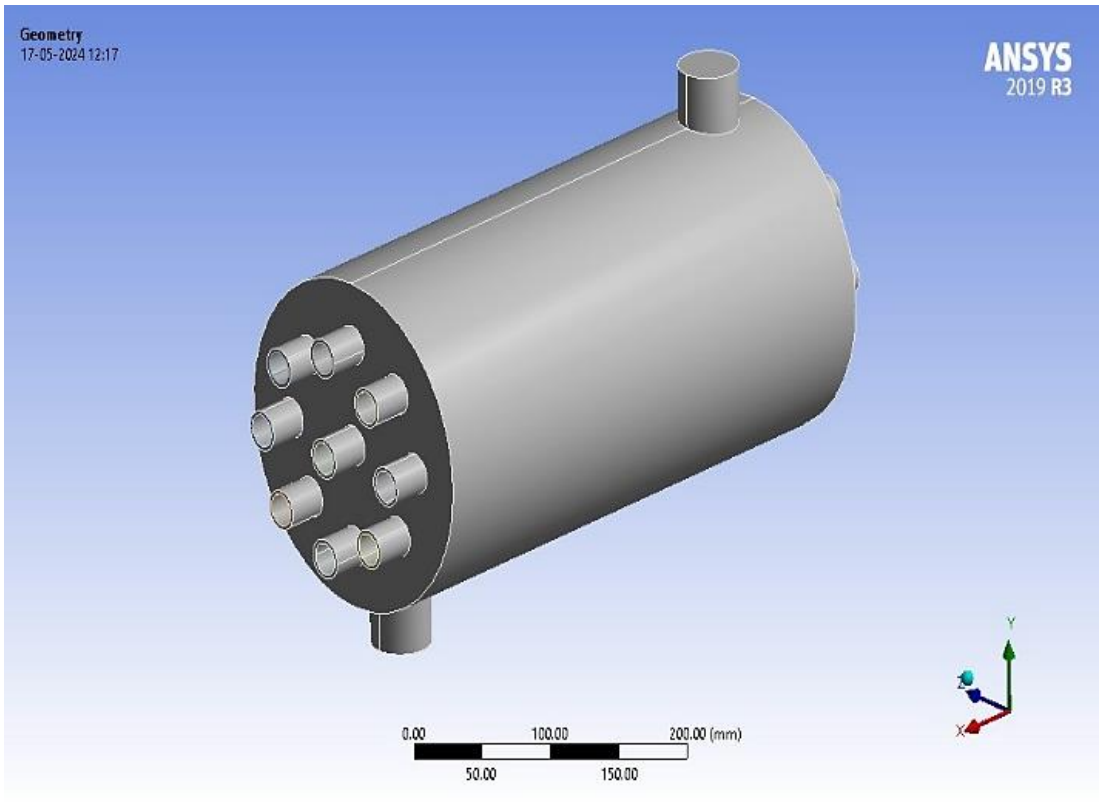
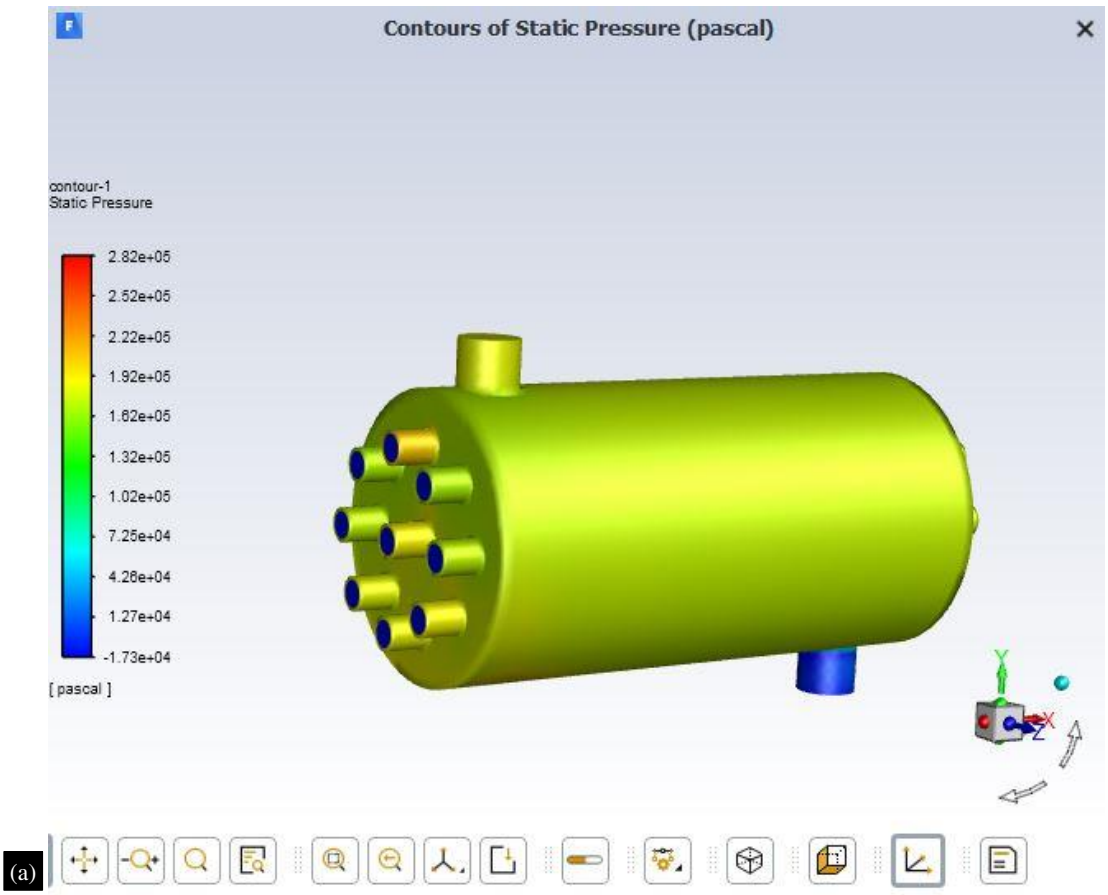


Figure 1. Shell and tube exchanger without baffles.



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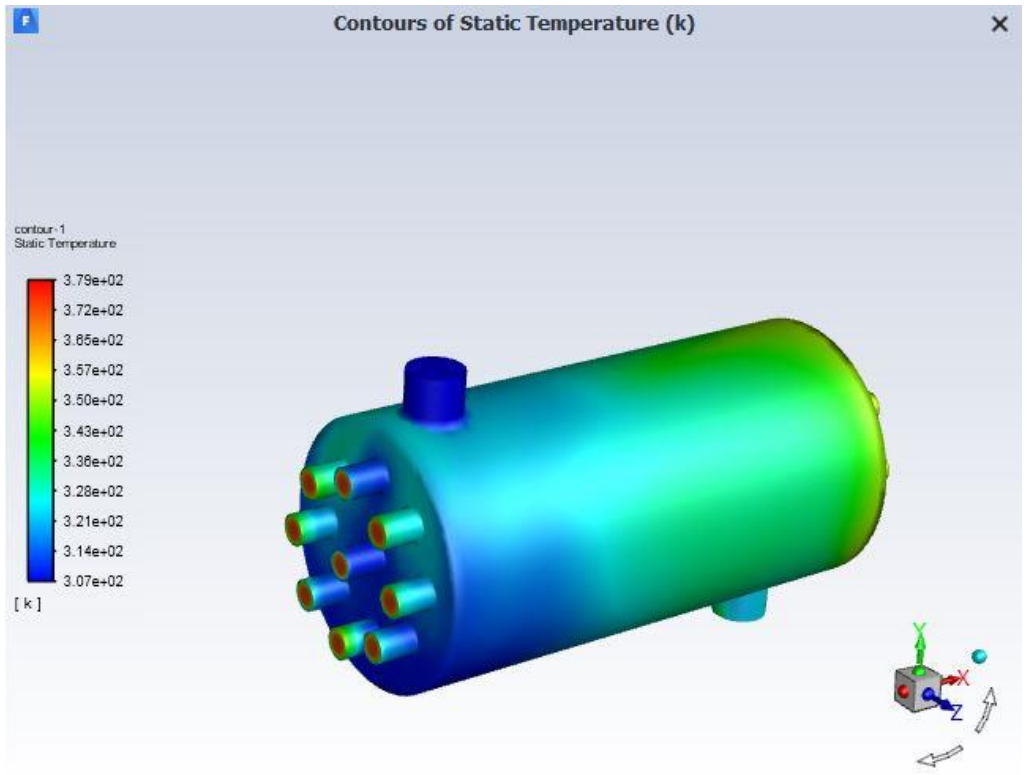

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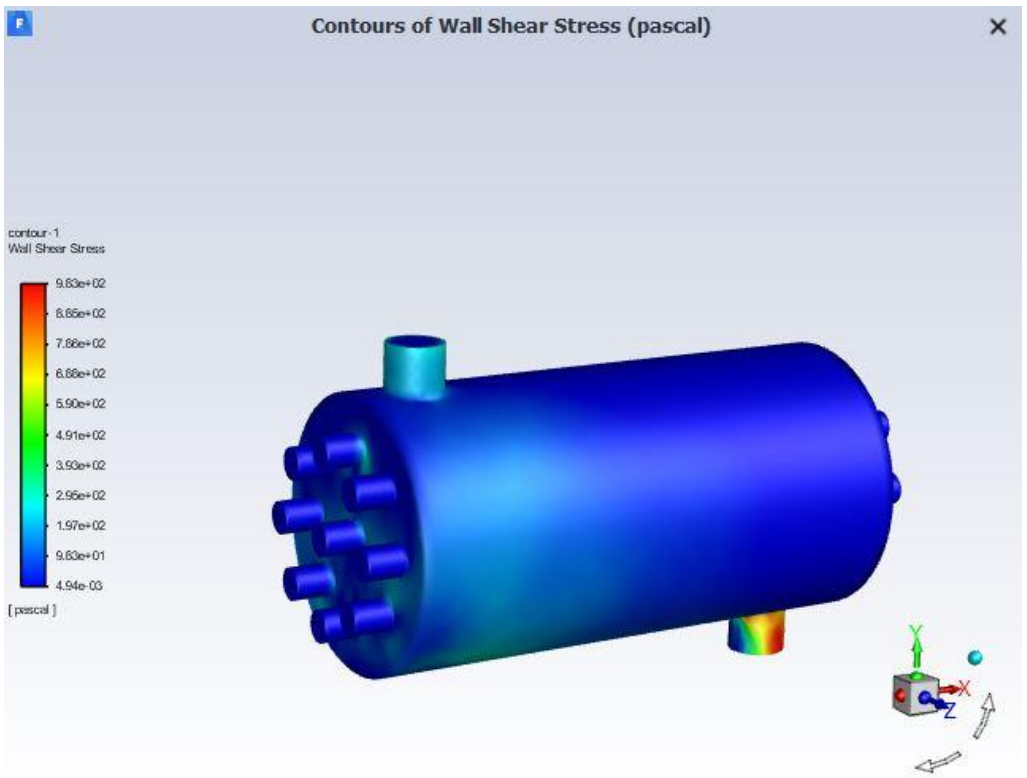


(c)

Figure 2. Representation of pressure and temperature and stress variations.

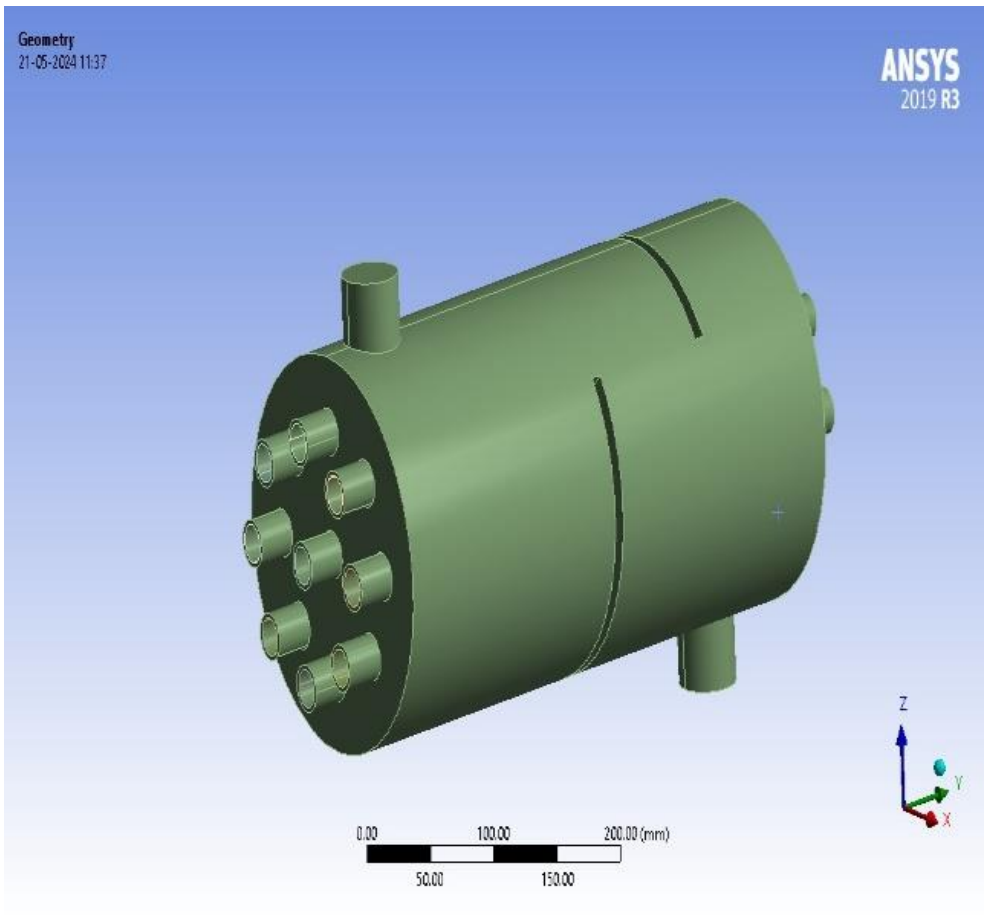
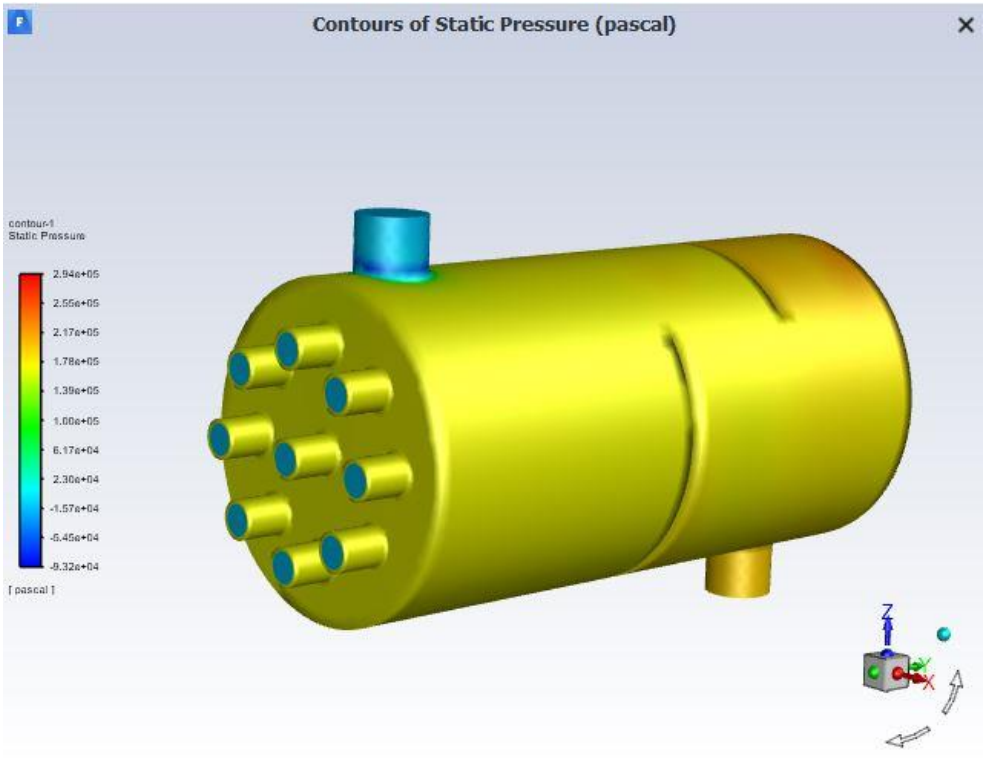


Figure 3. Shell and tube exchanger with 140Deg baffles.



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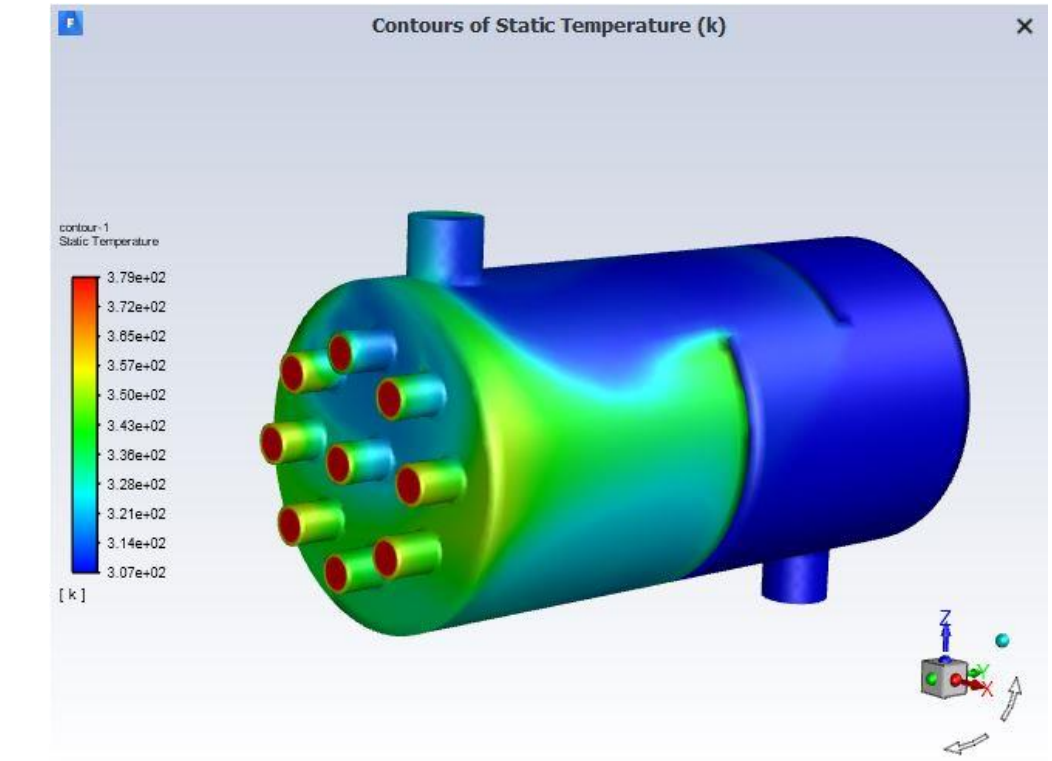

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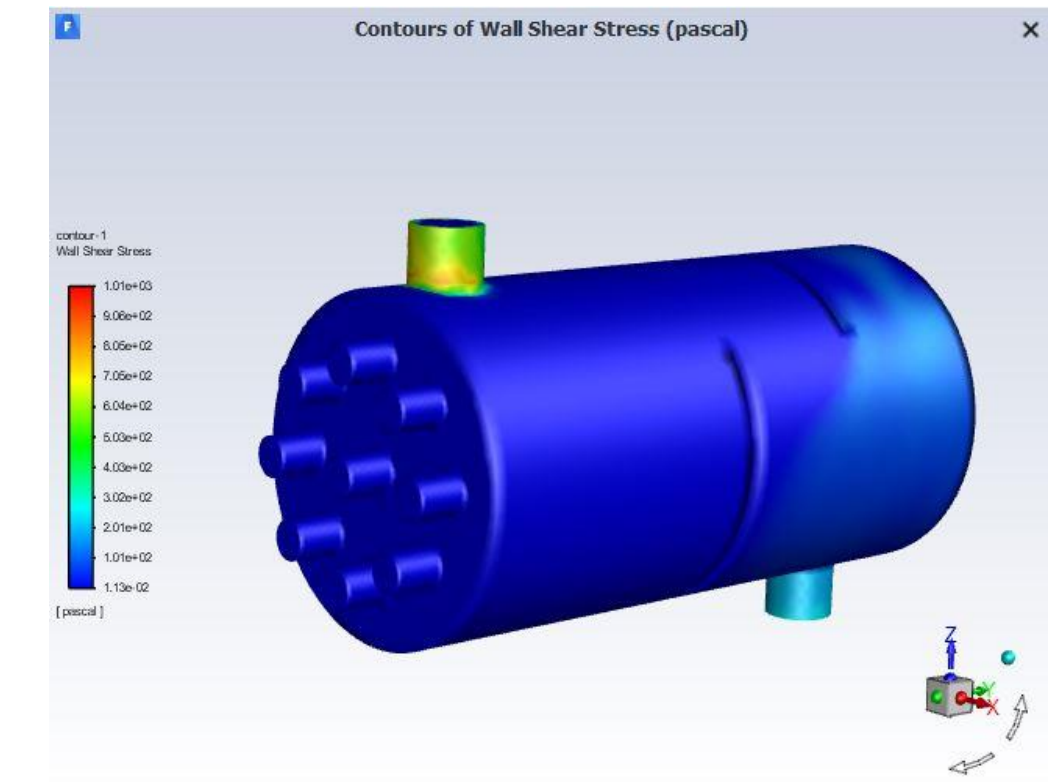

(c)

Figure 4. Representation of pressure and temperature and stress variations in increase the velocity.

CONCLUSION

When we consider the pressure plot for condition using without baffles and when using baffles, here the output pressure is increased from 2.82e+5Pa to 2.94e+5 So from the above results we can consider if baffles are used the pressure is being increased. When we consider the temperature plot for using without baffles and when using baffles, here the output temperature for shell is increased from 336K to 343K when considered for the tubes the temperature, here the temperature is decreased from 336K to 328K and there is no much difference when the flow velocity is increased in the tubes and baffles. So from the above outputs here we can consider that when baffles are used the temperature correction is better rather than using without baffles. As from all the results when compared the heat transfer and the heat transfer coefficient is better when the exchanger using baffles are considered.

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