International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Development and Analysis of Heat Exchanger for Efficient Heat Transfer for L-Shape Wind Tunnel

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Abstract: ***As automation and mechanical industry growing towards next era, it becoming crucial to design each element of plant with more productive material. Out of many parameters, heat transfer is very important area of study to lower the rate of failure of numerous machines. For heat transfer control there is a need of design of efficient heat exchanger. A heat exchanger can be designed for minimization of heat energy from the wind tunnel. Impact on HE performance is important due to the thermal resistance of wind tunnel. Thermal resistance is the heat property of the tunnel material and dimensions of tunnel. Looking at application level performance, the thermal resistance is crucial element in case of aerodynamic study. The similar study is done for Apolo11 spacecraft which was important in case of landing back to earth as traveling to earth with high speed generated heat which can damage spacecraft body. Such study further leads to various domains like material research, human impact study etc. The most recently, asteroid is passed nearby of earth orbit, where aerodynamic study of NASA evaluated the pre-collision effects where thermal properties are analyzed considering the atmospheric nearby orbit as a tunnel of wind/pressure. Hence, the scenarios must be considered for heat transfer / heat exchanger design specific to the each application domain. This paper discusses about the asteroid bypass which generates heat as a major heat transfer to earth and the automobile specific modeling of heat exchanger for wind tunnel. The focus is kept on heat exchanger design which can be suggested for automobile testing procedure.***

Index Terms**: heat transfer, heat exchanger, asteroid heat, space exploration, heat modeling, C analysis.**

I. INTRODUCTION

Asteroid thermal models is commonly utilized a consistent significance of particular heating capability, even though this kind of variable is a function of heat range. Author analyze either agglomeration of the heat dependence of particular temperature potential is a required processing and so locate that which includes significant variations in temperatures track record. Although the heat influence is revealed in an associated computation meant for an asteroid deterioration as a temperature resource, associated with ultimate result likewise offers ramifications for asteroid heat designs structured with induction heating system or heating systems by means of influence, and in addition for heat designs of the terrestrial planets [1]. In test returning tasks, the acceleration of a test returning capsule is anticipated for being around 18 km/s; nevertheless, the acceleration of the Hayabusa was 12.7 km/s. The solid wind resistant warming triggered by way of an excessive acceleration can potentially harm the capsule at the time of re-entry. To get over this kind of issues, couple of models of excessive-speed re-entry capsules had been recommended. In one particular model, a stiff surface was fastened to reduce the airborne quotient by elevating the entrance forecasted region [2]. Also, reference operation might become an allowing concept which usually can allow for human beings to travelling to and then stay on Mars longer duration. Author explained the heat pattern of the Solid Oxide Electrolysis Assemblage subsystem, which usually functions at 700° C, which includes the mechanical criteria for functioning of a SOXE bunch. Author likewise referred to preliminary assessment and thermal model effects utilized to confirm the model and forecast its efficiency on the surface area of Mars [3]. The NOAA and NASA's earth monitoring satellite captured the asteroid impact shown in figure 1 below. To avoid the impact of asteroid heat, the future study is going on and it falls under special branch of heat transfer study.

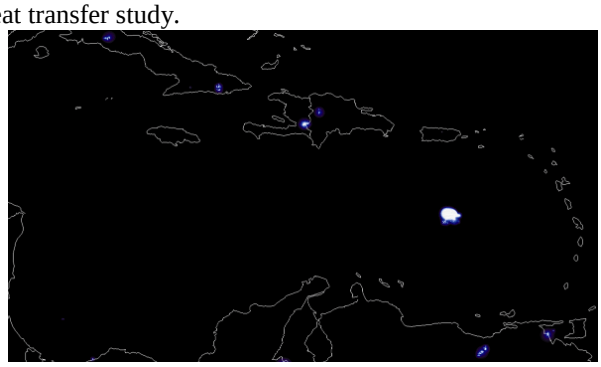

Figure 1- asteroid impacting Earth's atmosphere over the Caribbean Sea on June 22, 2019 (Source: NOAA/NASA)

One of the particular crucial strong elements in temperature transmission of fluids is heat conductivity of substance. The prevalent liquids utilized in industrial sectors possess poor functionality in temperature transmission.

Revised Manuscript Received on October 30, 2019.
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Consequently, by the manufacturing point of view, presently there is a need to have proper heat transfer solution and improvement of liquids with more significant temperature transmission rapport [4]. Heat exchangers are units specially designed intended for the balance transfer of temperature among two liquids, one particular excessive heat fluid to the different poor heat liquid.

These are extensively employed in the petrochemical, automobile and in numerous different functions, just like electrical power plants, exactly where several heat exchanger models have been implemented to fulfill heat criteria with significant heat transfer fields, and demanding requirements of the components utilized in the parts of this kind of devices, including tube joint parts, valve and so welded flanges [5, 6]. By means of raising heat transfer intended for a particular utility, the proportions and expenditures of heat exchanger development are lowered [7]. The lowering in heat transfer exchanger level triggers the decrease in pipe quantity or the quantity of required shells in the exchangers [8]. Mathematical evaluation is an effective application which usually utilized for distinctive research and several areas [9, 10]. The moment working with the heat transfer of compressed heat exchangers, it provides probability to check and replicate a variety of diverse models within several functioning circumstances with no requirement of designing of extremely costly actual proportions representative models [11, 12]. However, mathematical designs with no evidence of abilities can be deceptive [13, 14]. Typical studies on actual proportions designs or with smaller sized satisfactory products are worked to strengthen primary comprehension of corporal patterns, to boost numerical types and so to approximate quality of unit variables [15, 16]. The asteroid is an one particular type of heat transfer entität as it moves with the excessive speed and produce high pressure which impacts earth with unusual vapor generation and high wind blows. As this is natural phenomenon, the impact of heat transfer is unmanageable and ongoing research is going on at NASA.

II. PROPOSED METHODOLOGY

The aim of proposed research is to identify wind tunnel shape and hence further design of heat exchanger to lower the impact of heat on testing subject (i.e. automobile, aerospace etc).The proposed research is a simulation development for identification of heat exchanger design for various wind tunnel shapes. For simulation and CFD analysis we considered three shapes of wind tunnel as rectangular, circular and ‘L’ shaped. Heat transfer is calculated by q=-k(dt/dx) where, ‘q’ is heat transfer coefficient, ‘k’ is constant and (dt/dx) is the thermal difference. The overall process block is depicted in figure 2 below.

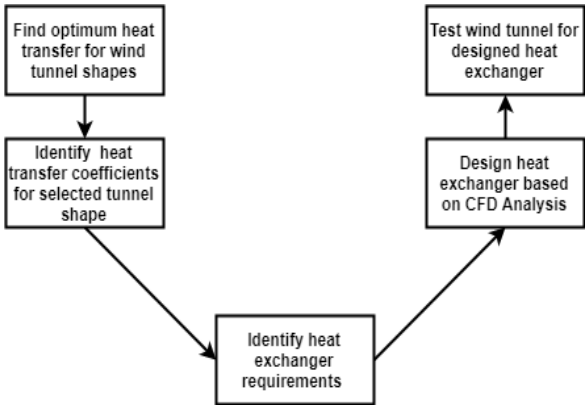

Figure 2 - Proposed heat exchanger identification

To find optimum heat transfer we considered each shape as discussed previously. Further, heat transfer coefficients are calculated and we identified that ‘L’ shaped tunnel design is dissipating more heat as compared to other shapes. Now, considering this ‘L’ shape further we headed to design heat exchanger. Heat exchangers can be fins, pipes or zigzag structure. In our case we conducted CFD analysis for pipe structure and it proved the best. This heat exchanger is discussed further. For analysis of wind tunnel we considered various shapes of tunnel. The core aim of analysis is to identify optimum heat transfer and accordingly design of heat exchanger is tested. Following figure 3 shows the flowchart for proposed analysis.

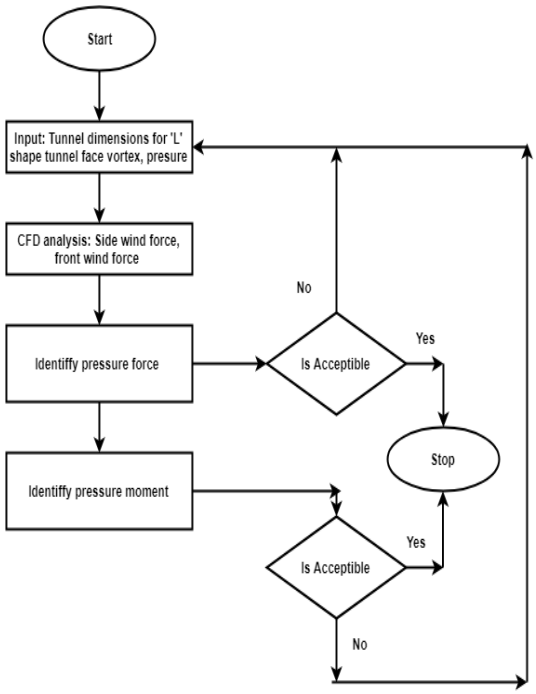

Figure 3 - Proposed CFD Analysis Flowchart

After conduction of CFD analysis for fins, zigzag heat exchangers, finally we carried the analysis for pipe structured heat exchangers which is shown in figure 4 below.

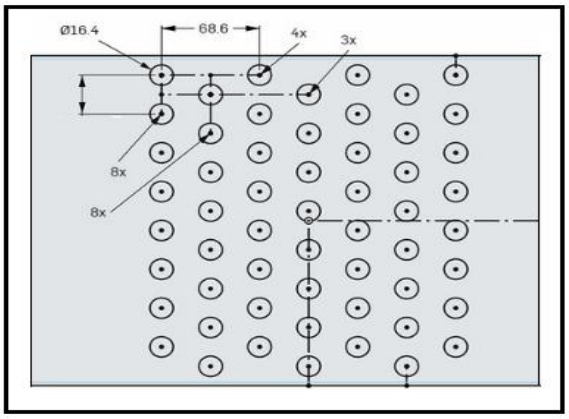

Figure 4 - Proposed Heat Exchanger Pattern for wind tunnel

As per proposed research, the pipe shape heat exchangers are suitable for 'L' shape wind tunnel hence, finally with consideration of variable wind pressure the heat map is identified with CFD analysis.

The proposed research results are discussed in next section.

III. RESULT ANALYSIS

The results are categorized in three sections: first is analysis of 'L' shaped wind tunnel and second is analysis of heat exchanger and last is optimum pressure force and pressure moment identification.L-Shape Tunnel Vortex Position Heat Transfer Mapping is carried out which is shown in figure 5 (a,b,c) . This again shows the optimum position heat generation within wind tunnel. Hence, figure 5(b) is selected for heat exchanger study.

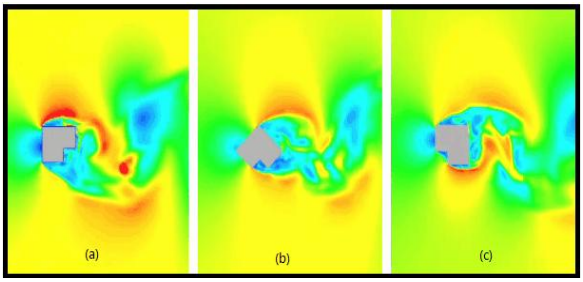

Figure 5- 'L' Shape Tunnel Vortex Position Heat Transfer Mapping

After identification of vortex heat mapping we identified the exact position of heat generation as shown in figure 6 below.

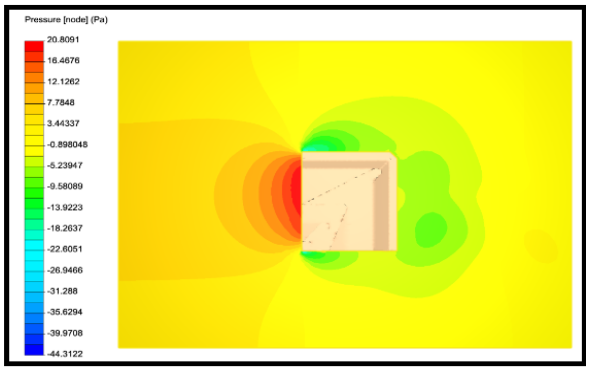

Figure 6- "L" Shape wind tunnel heat transfer position

The most important CFD analysis is about wind entering face of tunnel because maximum heat is generated at face position of tunnel. There is a need of proper heat exchanger implantation.

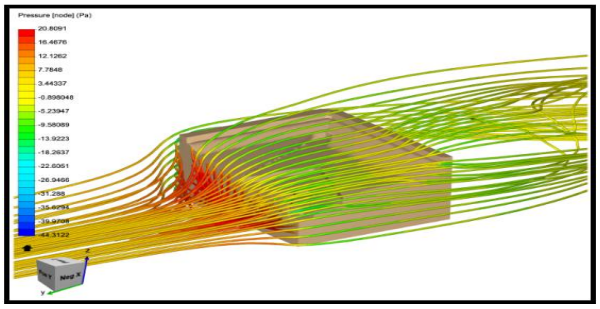

Figure 7- Heat face impact on wind tunnel

As heat dissipation is inversely proportional to traveling distance, face mapping shown in figure 7 above, red color represents that heat is more at face value and must be handled.Hence, as per identified pipe shaped heat exchanger, we conducted CFD analysis and result shown in figure 8. The each pipe structure contributes in hear dissipation by which for L-shaped tunnel heat transfer remains in more controlled manner.

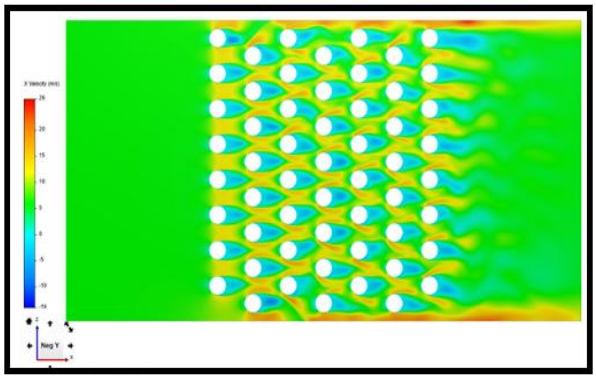

Figure 10- Multi-tube heat exchanger analysis

Finally, with 'L' shaped wind tunnel and pipe structure heat exchanger we conducted analysis to identify impact of pressure force in x,y and z position and pressure moment for x,yand z position as shown in figure 8 and figure 9 respectively.

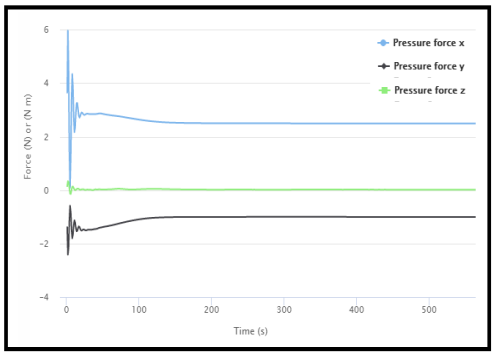

Figure 8- CFD Analysis of pressure force for wind tunnel

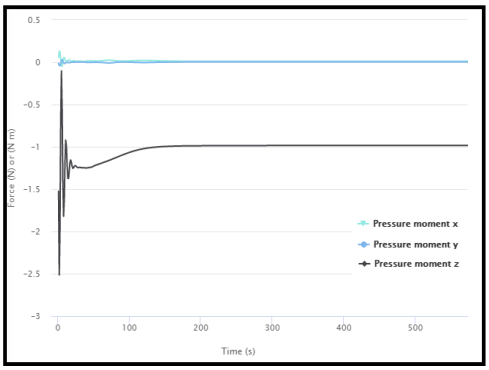

Figure 9- CFD Analysis of pressure moment for wind tunnel

As the aim of proposed research is to design wind tunnel for minimum heat generation and heat exchanger to wipe off the generated heat, following

table 1 shows the results to prove 'L' shape tunnel is best with pipe structure of heat exchanger. The optimum percentage heat transfer for proposed research without heat exchanger is 56.02% and improved with use of proposed heat exchanger design is 79.06% which is considered as a best performance.

Table 1- Comparative Analysis of wind tunnel

Shape of Tunnel	% Heat Transfer without heat exchanger	% Heat transfer with proposed heat exchanger
Rectangle	36.34	52.76
Circular	45.12	61.16
L-shape	56.02	79.06

Thus, at application level, only wind tunnel shape is not sufficient but it also needs optimum design of heat exchanger. Each shape of tunnel can be with different heat exchanger. For conventional applications like automobile or aircraft, only circular or semi-circular wind tunnels are sufficient. But, for applications like spacecraft, asteroid studies we must implement separate design of wind tunnel.

IV. CONCLUSION

Whereas, wind tunnel is with pre-defined dimensions and pressure is generated and it is tested for automobile, aerospace objects etc with similar methodology. Hence, proposed research is focused on identification of optimum shape of tunnel with optimum design of heat exchanger for wind tunnel. This study can further developed as a asteroid modeling for identification of asteroid travel impact on earth and orbit but tunnel design will be different. As a future study, the asteroid tunnel can be a virtual tunnel which can mould in dimensions compatible to shape and size of asteroid. Overall, proposed methodology can be used for any heat transfer study to design optimum performance heat exchanger.

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