Studies of Oval Tube and Fin Heat Exchangers

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BACKGROUND

An important part of any Heating Ventilation and Air-conditioning (HVAC) system are the heat exchangers because they exchange heat with the closed loop refrigerant. The tube and fin heat exchangers are used due to the ease of manufacturing and the comparatively low pressure drop across the heat exchanger. There are various types of heat exchangers that are more effective like fin and plate heat exchangers, which are normally used in your car due to compact size compared to fin and tube but more expensive.

PROJECT OBJECTIVES

The main focus of this research was to study how the tube geometry effects the tube and fin heat exchanger with respect to the pressure drop and the overall heat transfer coefficient. The standard circular tube geometry was analyzed first and set as the base model which will be what all the models will be compared to. To analyze the flow characteristics of the different models computational simulations will be used to generate flow fields. These flow fields showed solution data such as temperature distribution and pressure drop across the heat exchanger.

Computational Fluid Dynamics (CFD) Processes

Pre-Processing

- CAD model (SolidWorks)
- Generating Mesh with Initial boundary conditions (Pointwise)

Solving

- Solving general transport equations using finite volume method(ANSYS Fluent)

Post-Processing

- Visualization of the CFD Data (FieldView)
- Data Processing and plotting/curve fits (Python)

Fin and Tube Models

Base Model

- Circular cross-section with a tube spacing of 25mm and tube diameter of 9mm.

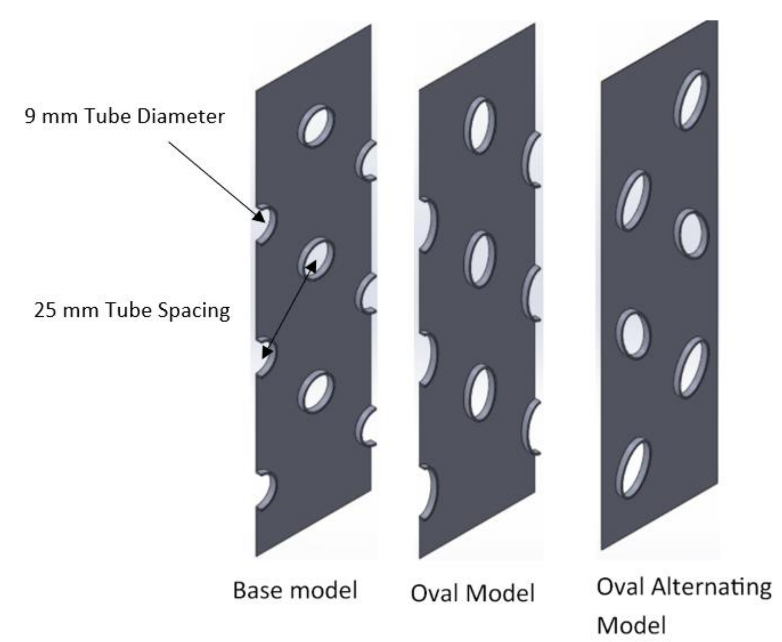
Oval Model

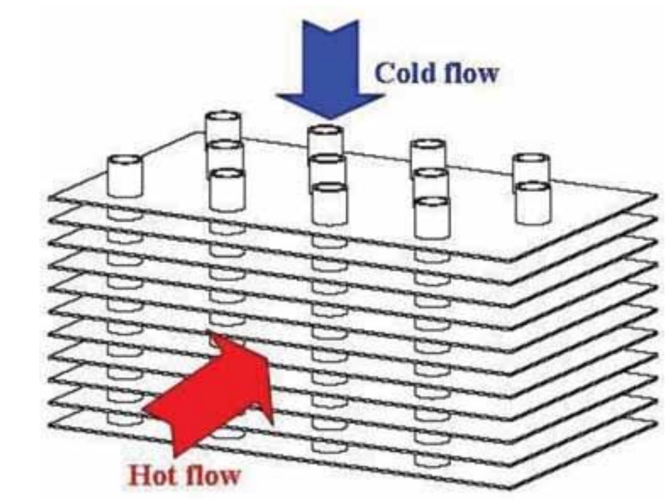
- Oval cross-section with the same tube spacing. The oval shape was derived from compressing a copper tube, this was done to get a more realistic model geometry.

Oval Alternating Model

- This design had the same cross-section but with an alternating angle of attack of 20 degrees.

Fin and Tube Models

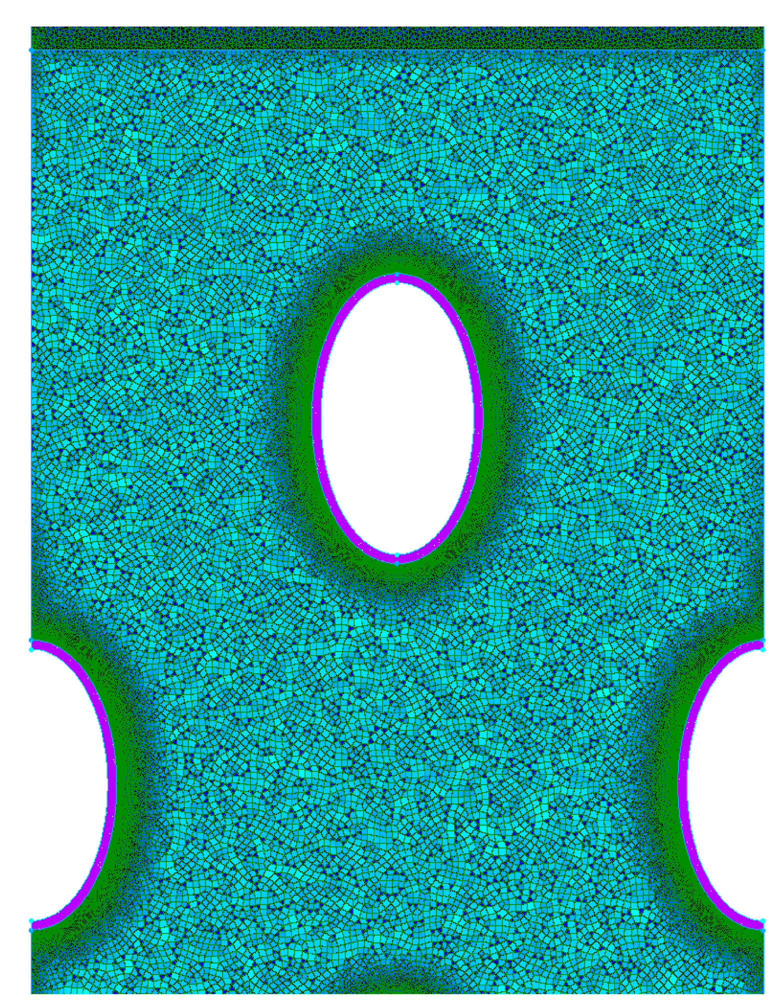




Tube and Fin heat exchanger diagram[1]

Mesh (Discretization)

For the computer to simulate the flow the domain must be split up into finite volume elements (discretization) at which the computer then integrates over this finite volume using Finite Volume Method. The mesh is crucial for simulating the flow with promising results. Therefore the mesh has to be analyzed with parameters like skewness, aspect ratio and volume ratio just to name a few, because these parameters can effect the final result.



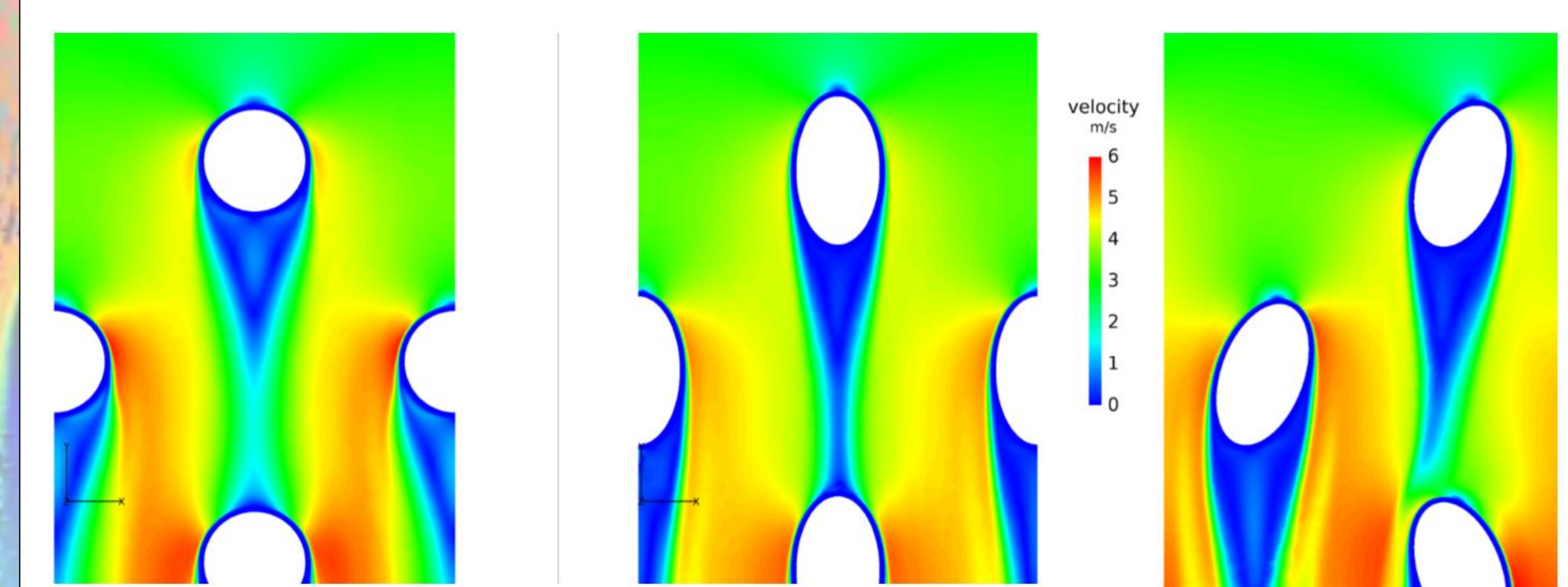
Oval tube and fin model mesh

CFD setup

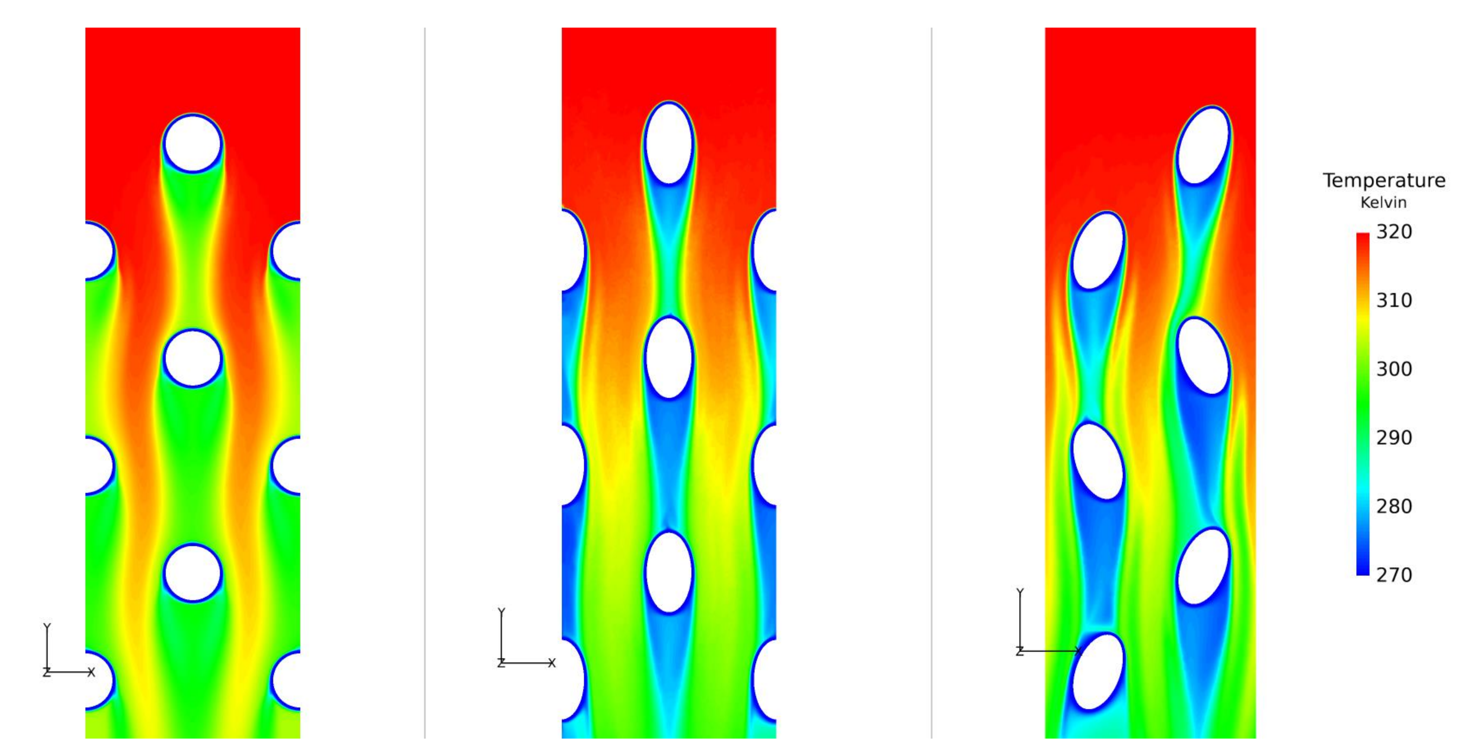
- The inlet flow velocity was 2 m/s and had a temperature of 320K.
- The turbulence model used was K-omega.
- The temperature of the inner tube boundary was set to 270 K, which is assumed to be constant because of phase change at constant pressure.

Outcomes

The outcomes of these three models are shown below and it can be concluded that the base model has the highest pressure drop across the heat exchanger. The oval and alternating oval models had lower pressure drop with greater temperature change.



Velocity Field of Different models



Temperature Distributions of Different Models

MODEL	PRESSURE DROP [Pa]
ORIGINAL	26
OVAL	19
OVAL ALTERNATING	23

CONCLUSION

In conclusion the Oval and Oval Alternating models had lower pressure drop and the temperature difference was higher than the base model when looking at the temperature distribution of the flow through the heat exchanger. These results conclude that there would be positive effects if an oval design was implemented to tube and fin heat exchangers. In the future a full-scale model will be made to validate the CFD if possible.

REFERENCES

1 .Davood Esmaeilpour Ghoochani. (2014, January). Multi-objective Optimization of a Plate-finned Tube Heat Exchanger for Fast Axial Flow CO 2 Lasers Using a Genetic Algorithm. Retrieved from researchgate.net: https://www.researchgate.net/figure/Schematic-diagram-of-the-plate-finned-tube-heat-exchanger_fig1_284338726