Energy efficient cooking pot- Ecopot

add all team members

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1 Introduction

Ecopot is an attempt to make a more fuel-efficient cooking pot for the one billion people who cook on wood gathered by hand from the ground. Making a pot which requires less firewood would decrease the world carbon footprint, but more importantly would save many people, often women, hours of tedious labor and may help reduce gender inequity.

ADD A LITTLE MORE INFO

2 Choosing the right fin shape

Convective heat transfer between a surface and the surrounding has been a major issue and a topic of study for a long time. In this project, the heat transfer performance of fin is analyzed using ANSYS workbench for the design of fin with various design configuration such as cylindrical configuration, square configuration and rectangular configuration. The heat transfer performance of fin with same base temperature having various geometries is compared. In this thermal analysis, Aluminum was used as the base metal for the fin material and for various configurations. Fin of various configuration are designed with the help of Solidworks and analysis of fin performance is done through ANSYS Fluent.

The Fin is a major component used in many systems for increasing the rate of heat transfer. By doing thermal analysis on the fins, it is helpful to know the heat dissipation and rate of heat transfer in different types of fins. Increasing the temperature difference between the fin configuration, slightly increasing the convection heat transfer coefficient or slightly increasing the surface area of the fin increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Therefore we try to compare the performance of fins by changing the surface area i.e the shape of the fins.

2.1 Simulation parameters

1. Rectangular fin: Volume = $4X10^{-5}m^3$, Area = $4X10^{-4}m^2$, Mesh - Fine mesh, Model - Energy (ON), Viscous k-epsilon (Realizable), Boundary conditions - Inlet velocity of 5 m/s, heat transfer coefficient = 210 W/m-K (Aluminum), Solution method - SIMPLE algorithm, Initialisation - Standard, Number of iterations - 500

2. Circular fin: Volume = $4.15X10^{-5}m^3$, Area = $4.15X10^{-4}m^2$, Mesh - Fine mesh, Model - Energy (ON), Viscous k-epsilon (Realizable), Boundary conditions - Inlet velocity of 5 m/s, heat transfer coefficient = 210 W/m-K (Aluminum), Solution method - SIMPLE algorithm, Initialisation - Standard, Number of iterations - 500

3. Triangular fin: Volume = $2X10^{-5}m^3$, Area = $2X10^{-4}m^2$, Mesh - Fine mesh, Model - Energy (ON), Viscous k-epsilon (Realizable), Boundary conditions - Inlet velocity of 5 m/s, heat transfer coefficient = 210 W/m-K (Aluminum), Solution method - SIMPLE algorithm, Initialisation - Standard, Number of iterations - 500

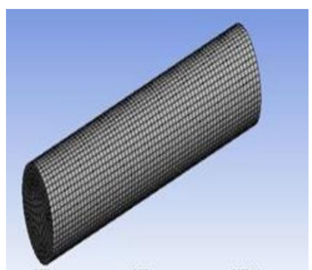

Figure 1: Meshed circular fine

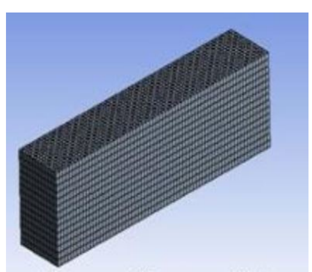

Figure 2: Meshed rectangular fine

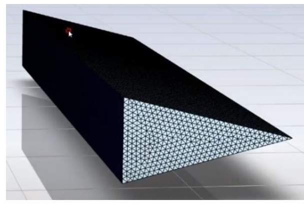

Figure 3: Meshed triangular fine

Simulations were performed for 500 iterations and convergence was observed around 400 iterations.

2.2 Simulation results

The results of the simulation along with the colorscale is shown below. The base temperature of the fin was initialised to 380 K (100 °C). The following assumptions were used for the simulation:

- Steady state
- Constant material properties (independent of temperature)
- No internal heat generation
- One-dimensional conduction
- Uniform cross-sectional area
- Uniform convection across the surface area

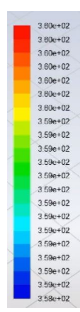

Figure 4: Heat transfer colorscale

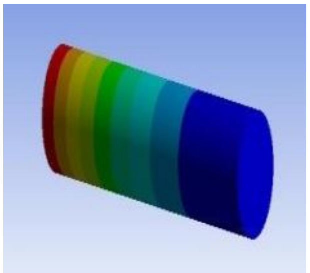

Figure 5: Heat transfer across circular fin

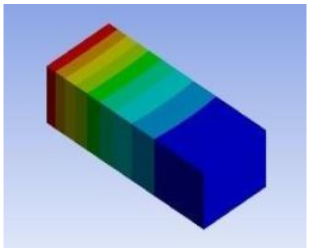

Figure 6: Heat transfer across rectangular fin

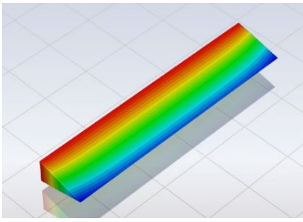

Figure 7: Heat transfer across triangular fin

2.3 Conclusion

The use of fins (extended surface), provide efficient heat transfer. Heat transfer through fin of triangular configuration is higher than that of other fin configurations. Temperature at the end of fin with triangular configuration is minimum, as compare to fins with other types of configurations. The effectiveness (defined as the ratio of the actual heat transfer that takes place from the fin to the heat that would be dissipated from the same surface area without fin) of fin with triangular configuration is also greater than other configurations. Choosing the optimum sized fin of triangular configuration will reduce the cost for heat transfer process and also increase the rate of heat transfer.

3 Designing the top of the pot

As per multiple field surveys, people prefer pots having a rounded top to latch onto rather than having separate handles attached to the top. This requires changing the design of the pot at the top and studying the heat transfer around that region.

3.1 Simulation parameters

Mesh - Fine mesh, Model - Energy (ON), Viscous k-epsilon (Realizable) with Enhanced wall treatment, Boundary conditions- Pressure based, Absolute, Time-Steady, 2D Planar, Wall - No slip, Solution method - SIMPLE algorithm, Initialisation - Standard, Number of iterations - 500

3.2 Simulation results

3.2.1 Simple extended top

Figure 8: Temperature contour at the top of the pot, iteration number 100

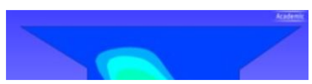

Figure 9: Temperature contour at the top of the pot, iteration number 300

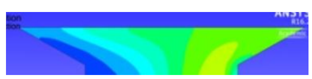

Figure 10: Temperature contour at the top of the pot, iteration number 500

3.2.2 Extended top with a rounded edge

Figure 11: Temperature contour at the top of the pot, iteration number 100

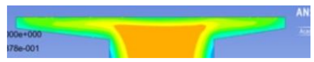

Figure 12: Temperature contour at the top of the pot, iteration number 300

Figure 13: Temperature contour at the top of the pot, iteration number 500

The colorscale is same as the scale used in section 2.2.

3.3 Conclusion

By comparing the temperature contours, we find that the top with rounded edges has a more uniform heat transfer rate across the profile and hence would lead to faster heating time. Also, since more heat is lost along the sides of the top, covering it using a suitable cover would improve the efficiency further.

However, making a rounded edge would increase the production time as it would be a two step process - making a simple extended top and then flattening the sides. However, this is a trade off that's worth making since it would lead to a more efficient pot.

4 References

[1] Knight RW, Goodling JS, Hall DJ. Optimal thermal design of forced convection heat sinks – analytical. J Electron Packag. 1991;113:313–321.

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[3]Kundu B. A closed form solution for ac electro-kinetic driven flow in a microchannel. J Therm Eng. 2015;1:289–294.

[4]Mirapalli S, Kishore PS. Heat transfer analysis on a triangular fin. Int J Eng Trends Technol.. 2015;19:279–284.