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Relative Analysis of Paraffin Wax in Different Geometry using FEA Simulation

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ABSTRACT

In the study of heat transfer, fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object and the environment, increasing the convection heat transfer coefficient, or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options. Thus, adding a fin to an object increases the surface area and can sometimes be an economical solution to heat transfer problems. Industrial experience has shown that for same surface area, the fin array can transfer considerably more energy than single fin. Analysis of single fin is well known. However, when fins are placed in an arrangement, the convective patterns become consistent and the resulting heat transfer coefficient has not been predicted. This paper gives a brief review on the thermal behaviour of different fin profiles. And various conclusions made by different authors are discussed. This study will be helpful for those who work in the field of fin.

Keywords : IC Engine, Fins, Engine Performance, Simulation, fin effectiveness.

I. INTRODUCTION

Equipment that generates heat usually incorporates with fins. Finned surfaces are often employed to improve heat exchanging performance. When fuel is burned in an engine, heat is produced. Additional heat is also generated by friction between the moving parts. Approximately 30-35% of the energy released is converted into useful work and remaining 65-70% heat should be removed from the engine to prevent the parts from melting. On the other hand, for many years of efforts, the reduction of the size and cost of fins are the main targets of fin industries.

Some engineering applications also require lighter fin with higher rate of heat transfer where they use high thermal conductivity metals in applications such as airplane and motorcycle applications.

Heat transfer is classified into three types. The first is conduction, which is defined as transfer of heat occurring through intervening matter without bulk motion of the matter. A solid has one surface at a high temperature and one at a lower temperature. This type of heat conduction can occur, for example, through a turbine blade in a jet engine. The outside surface, which is exposed to gases from the combustor, is at a higher temperature than the inside surface, which has cooling air next to it. The second heat transfer process is convection, or heat transfer due to a flowing fluid. The fluid can be a gas or a liquid; both have applications in aerospace technology. In convection heat transfer, the heat is moved through bulk transfer of a non-uniform temperature fluid. The third process is radiation or transmission of energy through space without the necessary presence of matter. Radiation is the only method for heat transfer in space. Radiation can be important even in situations in which there is an intervening medium; a familiar example is the heat transfer from a glowing piece of metal or from a fire. Convective heat transfer is between the surfaces and surrounding fluid can be increased by providing the thin strips of metal called fins. Fins are also referred as extended surfaces. Whenever the available surfaces are inadequate to transfer the required quantity of heat, fins will be used. Fins are manufactured with different sizes and shape depends on the type of application. Air cooling for an IC Engine is well known example for Air cooling system in which air acting as a medium. Heat generated in the cylinder will be dissipated in to the atmosphere by conduction mode through the fins or extended surfaces are used in this system, which are incorporated around cylinder.

II. LITERATURE REVIEW

Year	Name	Work	Outcomes
2017	Kai Yang, Jing Wang	In this paper, a new boundary element method is developed for solving nonlinear heat conduction problems with temperature dependent thermal conductivity. Radial integration method is used to deal with the domain integral due to the temperature dependence of the thermal conductivity, and the radial basis functions are employed to approximate the unknown appearing in the domain integral.	The Newton–Raphson iteration method is applied to solve the final nonlinear system of algebraic equations. The given numerical examples have demonstrated the correctness of the developed method.
2016	Mohammad A. Bashar	In this work an experimental investigation on the melting process in a PCM and the associated heat transfer in a transient manner. The experiments were conducted in a rectangular chamber filled with paraffin wax used as the PCM and, a cylindrical copper tube with different geometries and orientations as the heat source.	The results show the development of convective motions within the liquid PCM which influenced the local heat transfer coefficient in a transient manner and is believed to have immensely influenced the nature of this distinctive and nonlinear pattern of the solid-liquid interface
2016	Martin Koller, Heimo Walter	Heat exchanger tube design, which consists of a steel tube and an aluminum wire matrix, has been performed. For the numerical analysis, the enthalpy-porosity formulation was used to get quantitative information about the time evolution of the melting front within the phase change material	The numerical results of the solidification process have pointed out that the dominant heat transfer mechanism during solidification is heat conduction. The investigation has also shown that the discharging process has been slower than the charging process
2015	Nasser Mostafavinia	In the Present work, melting of a NePCM in a square cavity with different horizontal angles with two heat source-sink pairs flush-mounted on the horizontal sidewalls is investigated numerically.	The volumetric concentration of nanoparticles of 2% would result in the highest melting rate.
2013	Brian N. Turner	The purpose of this paper is to systematically and critically review the literature related to process design and modeling of fused deposition modeling (FDM) and similar extrusion-based additive manufacturing (AM) or rapid prototyping processes. A systematic review of the literature focusing on process design and mathematical process modeling was carried out.	Approaches to estimating the motor torque and power required to achieve a desired filament feed rate are presented. On leaving the print nozzle, die swelling and bead cooling are considered. Approaches to modeling the spread of a deposited road of material and the bonding of polymer roads to one another are also reviewed.

2010	L. B. Ji	Taking into account temperature-dependent thermal conduction and heat capacity, based on Acrylonitrile Butadiene Styrene (ABS), a three-dimensional transient thermal finite element model has been developed in Fused Deposition Modeling (FDM). The moving material of ABS by the sprayer on the mold equipment is simulated with the employment of ANSYS parametric design language (APDL) and latent heat is considered by using enthalpy.	First of all, the simulation result shows that the temperature field distribution likes an ellipse; secondly, comparing with the previous track, the latter one has larger heat affected region and larger inhomogeneous temperature distribution; the greatest temperature gradient takes place near the edges of deposited part where the sprayer scanning direction changes.
2015	Miqdam T Chaichan	Distillation systems efficiency correlated to solar intensity, and it enhanced with adding PCM. Adding additive to PCM increased thermal conductivity; that enhanced the evaporation and convection energies remarkably. Charging and discharging time for aluminium powder-PCM is reduced, compared with other cases, due to better thermal conductivity.	The study revealed that adding paraffin wax improved the solar distiller productivity with 6.11% in January and 10.38% in February compared to simple solar distiller. While, adding aluminum powder to paraffin wax enhanced its productivity by 21.91% in January and 25.51% in February compared to simple solar distiller productivity.
1983	A. ABHAT	The melting and freezing behaviour of the various substances is investigated using the techniques of Thermal Analysis and Differential Scanning Calorimetry. The importance of thermal cycling tests for establishing the long-term stability of the storage materials is discussed. Finally, some data pertaining to the corrosion compatibility of heat-of-fusion substances with conventional materials of construction is presented.	Incongruent melting salt hydrate may be "modified" to overcome decomposition by adding suspension media, or extra water, or other substances that shift the peritectic point. The use of salt hydrates in hermetically sealed containers is recommended. Moreover, the employment of metallic surfaces to promote heterogeneous nucleation in a salt hydrate is seen to reduce the supercooling of most salt hydrates to a considerable extent.

Problem Identification

By going through the various authors it can be said that is a problem regarding optimizing the geometry for thermal energy storing device. So, there is need of simulation of previously used geometry for validation and any new geometry to get some better result.

III. Methodology

a. Material Used

- **Paraffin wax**

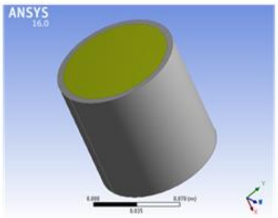
Temperature (^{0}C)	**Density (kg/m^3)**	**Specific Heat (J/kgK)**	**Thermal Conductivity (W/mK)**	**Viscosity (Ns/m^2)**	**Solidus Temperature (^{0}C)**
40	750	28600	0.15	0.005	319

b. Meshing

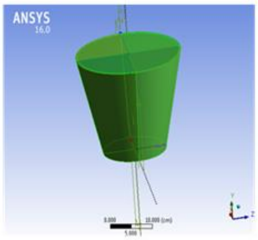
Details of "Mesh"	
Display	
Display Style	Body Color
Defaults	
Physics Preference	CFD
Solver Preference	Fluent
Relevance	0
Sizing	
Use Advanced Size Function	On: Curvature
Relevance Center	Fine
Smoothing	Medium
Curvature Normal Angle	Default (18.0 °)
Min Size	5.0 mm
Max Size	5.0 mm
Growth Rate	Default (1.20)
Minimum Edge Length	157.080 mm
Inflation	
Assembly Meshing	
Advanced	
Statistics	
Nodes	618652
Elements	598208
Mesh Metric	None

c. Model used

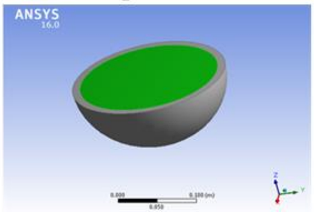
Cylinder



Tapered geometry



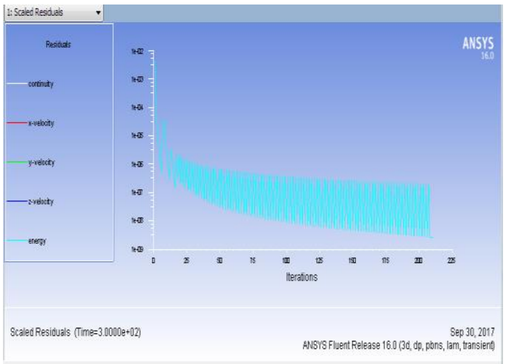
Hemisphere section

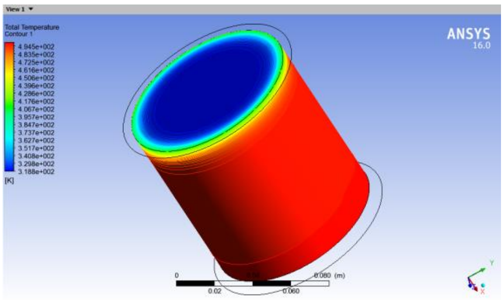


IV. RESULT

Cylinder

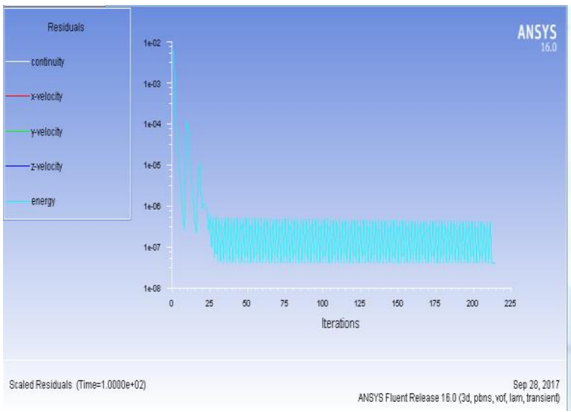
Cylinder			
X (Min)	20° C	19° C	18° C
0	0	0	0
10	60	54	48
20	74	72	66
30	86	80	74
40	92	88	80
48	97	97	88
50	100	98	86
55		100	98
60			100

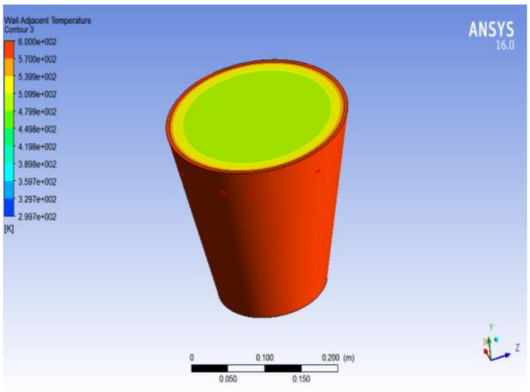




Tapered section

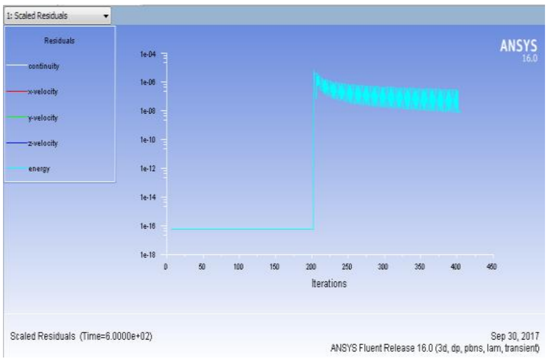
Tapered Body			
X (Min)	**20° C**	**19° C**	**18° C**
0	0	0	0
10	20	18	17
20	35	25	28
30	48	38	32
40	64	50	46
50	80	70	54
60	92	82	62
70	100	98	78
80		100	88
83			100

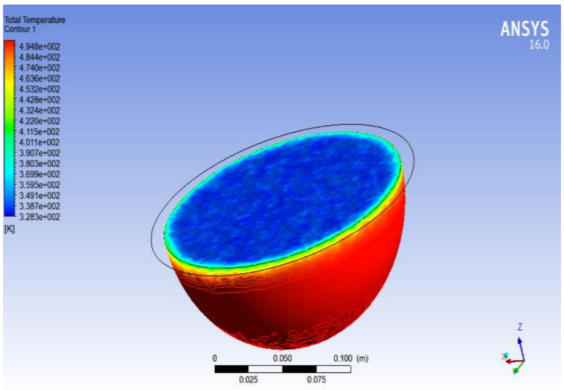




Hemispherical Section

Hemisphere			
X (Min)	**20° C**	**19° C**	**18° C**
0	0	0	0
10	60	54	48
20	74	68	66
30	84	80	74
40	92	88	80
50	97	92	88
60	100	98	95
70		100	98
80			100





Comparison of 100 % melting with respect to time for all three geometry at same temperature difference

Comparison	
Geometry	Minutes
Cylinder	60
Hemisphere	80
Tapered Section	83

V. CONCLUSION

Paraffin wax is an excellent material for storing heat, with a specific heat capacity of 2.14–2.9 J g−1 K−1 (joules per gram kelvin) and a heat of fusion of 200–220 J g−1. This property is exploited in modified drywall for home building material: a certain type of wax (with the right melting point) is infused in the drywall during manufacture so that it melts during the day, absorbing heat, and solidifies again at night, releasing the heat. Paraffin wax phase-change cooling coupled with retractable radiators was used to cool the electronics of the Lunar Rover. Wax expands considerably when it melts and this allows its use in wax thermostatic element thermostats for industrial, domestic and, particularly, automobile purposes.

And the results obtained under boundary conditions taken into consideration are discussed. The results obtained during analysis are shown above, it can be concluded that the paraffin wax has shown better results. The modelling of PCM melting in three dimensional using the cell-cantered finite volume method of a fully implicit time scheme associated with a fixed grid, latent heat source approach is successfully performed. As the melting front should be of a one control volume thickness, this dominating restriction controls both the time interval and the grid sizes. The temperature distributions show that PCM cells heat up faster with a temperature gradient of almost a linear shape. Once a PCM cell is melted, its temperature increase will be slow. This clearly illustrates that the rate of heat transfer is predominantly controlled by the position of the melting front. Temperature measurements and recording the melting processes have been done. The results are analyzed. The results show that the melting process starts from the upper part of the thermal storage.

In 3-dimensional numerical analysis was performed using FLUENT software. Analysis is done in different shape and configurations and find out the suitable configuration for heat storage applications. Various new materials are coming up Now a days and that too with a lot of new properties. In a future lot of new materials will be used in order to improve the melting analysis using FLUENT. Also, this work will be helpful for the person doing work in this field.

Temperature measurements and recording the melting and solidification processes have been done. The results are analyzed. The results show that the melting process starts from the upper part of the thermal storage.
At temperature difference of Δ18°C, results obtained are better. And among three geometries tapered section has shown best result of melting rate. Also it has been observed that melting rate depends upon the wall positioning and its temperature.
Discussion: - By delaying the temperature using Paraffin wax as PCM material, it can be utilized in energy storing devices that need to help industries in an efficient manner.

VI. REFERENCES

[1]. Prof. Arvin S. Sorathiya, Ashishkumar N. Parmar, Prof. (Dr.) Pravin P. Rathod, "Review Paper on Effect of Cylinder Block Fin Geometry on Heat Transfer Rate of Air-Cooled 4S SI Engine", International Journal of Recent Development in Engineering and Technology, Volume 2, Issue 1, January 2014.

[2]. Ashish Dixit, "Review on Heat Transfer Enhancement Through Fins Using Surface Modifications", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 3 Issue III, ISSN: 2321-9653, March 2015.

[3]. Yatendra Singh Tomar, M. M. Sahu, "Review of Performance Analysis of Extended Surfaces (Fins) Under Free and Forced Convection Heat Transfer", Vol 2 Issue 13, ISSN 2278 – 0211, December, 2013.

[4]. Vikash Kumar , Dr. S K Jain , Dr. Sukul Lomash, "A Review Paper on Improving the Efficiency of IC Engine Fins by Varying its Material and Shape", ISSN 2347-6435, Volume 5, Issue 6, June 2016.

[5]. Mahdi Fahiminia, Mohammad Mahdi Naserian , "Experimental investigation of natural convection heat transfer of the fin arrangement on a computer heat sink", Vol. 7(36), pp. 3162-3171, 13 September, 2012.

[6]. Abbas jassem jubear, Ali a. F. Al hamadani, "the effect of fin height on free convection heat transfer from rectangular fin array", International Journal of Recent Scientific Research, Vol. 6, Issue, 7, pp.5318-5323, July, 2015.

[7]. Prof. S. A. Wani, Prof. P. S. Pol, "Experimental investigation of natural Convection heat transfer from a Blackened v-fin array", International conference on science, engineering and management, ISBN - 9788938617116, Page 78-84,

[8]. Yudhishter Saini, Vipin and N.K. Singh, "Free Convection Heat Transfer Augmentation through a Vertical Fin Array: A Review", Journal of Material Science and Mechanical Engineering (JMSME), ISSN: 2393-9109, Volume 2, Number 11, page 43-46, April-June, 2015.

[9]. Mehran Ahmadi, Mohammad Fakoor-Pakdaman, and Majid Bahrami, "Natural Convection from Vertical Parallel Plates: An Integral Method Solution", Journal of thermo physics and heat transfer, Vol. 29, no.1, January 2015.

[10]. Hazim S. Hamad, Dr. Yasin K. Salman, "Laminar Natural Convection Heat Transfer Between Ducted Parallel Plates", Journal of Engineering, Number 3 Volume 14 September 2008.