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Enhancement of rate of heat transfer of fin made by aluminium alloy 1060

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Abstract
The following paper examines the heat transfer performance of fins with several projections along the length of fins. The projections are cylindrical in shape with same dimensions. The heat transfer performance without projection and with projection is compared. There is about 2% increment in the heat transfer rate when the length of the projection is increased to 1mm. The modelling and simulation software Solidworks is used for analysis. The material used for fin is 1060 Aluminum Alloy having conductive heat transfer coefficient of 200 W/mK. Different parameter values of alloy 1060 are used during solid works simulation.

Keywords: fin, projections, solidworks simulation, thermal conductivity

1. Introduction

Fins: Fins are nothing but the extended area to increase the convective heat transfer rate. By Newton's law of cooling the convective heat transfer rate is directly proportional to normal area to flow of fluid. Hence by increasing area heat transfer rate increases.

Fin Effectiveness: Fins are used to enhance heat transfer, and the use of fins on a surface cannot be recommended unless the enhancement in heat transfer justifies the added cost and complexity associated with the fins. In fact, there is no assurance that adding fins on a surface will enhance heat transfer. The performance of the fins is judged on the basis of the enhancement in heat transfer relative to the no-fin case. The performance of fins expressed in terms of the fin effectiveness defined as, represents the rate of heat transfer from this area if no fins are attached to the surface. Indicates that the addition of fins to the surface does not affect heat transfer at all. That is, heat conducted to the fin through the base area is equal to the heat transferred from the same area to the surrounding medium. An effectiveness of fin indicates that the fin actually acts as insulation, slowing down the heat transfer from the surface. This situation can occur when fins made of low thermal conductivity materials are used. An effectiveness of indicates that fins are enhancing heat transfer from the surface, as they should.

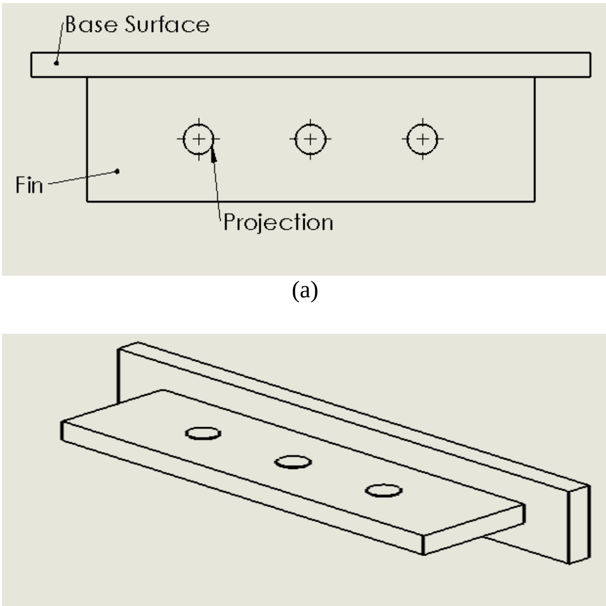
The rate of Heat Transfer

Considering all the assumptions, the rate of heat transfer is calculated by using the heat transfer governing differential equation for the fin of finite length and loses heat by convection [4],

$$Q_{fin} = \sqrt{hPkA_{cs}}(t_o - t_a)\cdot\frac{\left(\tanh(m\cdot L) + \frac{h}{m\cdot k}\right)}{\left(1 + \frac{h}{m\cdot k}\cdot\tanh(m\cdot L)\right)}$$

Where, length of fin (L in m), thermal conductivity of fin (kin W/m K), coefficient of convective heat transfer (h in W/m^{2}K), temperature at base of fin (t_o in K), temperature of the ambient fluid (t_a in K).

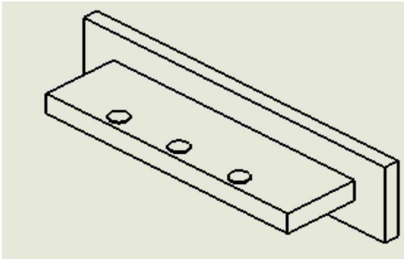
Fins are popularly known as heat transfer element which transfers heat from a heated source in the form of conduction, within the fin material, and in the form of convection, from the surface area of fin. Projections are made on the surface of fin for increasing the surface area of heat transfer. For the projection of same dimension, temperature drop changes as the position of the projections changes along the surface of the fin.



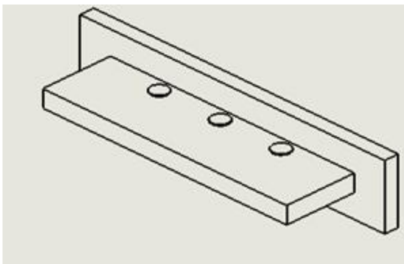
(a)

(b)

Fig 1: (a) and (b) fins with projection at the center.



(c)



(d)

Fig 2: Fin with projection (c) at the far end from base surface, (d) near base surface.

2. Literature survey

Pardeep Singh, Harvinder lal, Baljit Singh Ubhi *et al.* [1]. In this paper, the heat transfer performance and effectiveness of fin with various extensions such as rectangular extension, trapezium extension, triangular extensions and circular segmental extensions are analyzed and compared with each other.It is found that there is about 5% to 12% increase in heat transfer rate with these various extensions on fin as compare to same geometry of fin without these extensions.

Abdullah, H. Alessa *et al.* [2]. had studied the natural convection heat transfer enhancement from a horizontal rectangular fin embedded with equilateral triangular perforations. The heat dissipation rate from the perforated fin is compared to that of the equivalent solid one. The effect of geometrical dimensions of the perforated fin and thermal properties of the fin was studied in detail. They concluded that, For certain values of triangular dimensions, theperforated fin can result in heat transfer enhancement. The magnitude of enhancement is proportional to the fin thickness and its thermal conductivity. The perforation of fins enhances heat dissipation rates and at the same time decreases the expenditure of the fin material.

B. Ramdas Pradip *et al.* [3]. had studied the many industries that are utilizing thermal systems wherein overheating can damage the system components and lead to failure of the system. In order to overcome this problem, thermal systems with effective emitters such as ribs, fins, baffles etc. are desirable. The need to increase the thermal performance of the systems, thereby affecting energy, material and cost savings has led to development and use of many techniques termed as “Heat transfer Augmentation”. This technique is also termed as “Heat transfer Enhancement” or “Intensification”. Augmentation techniques increase convective heat transfer by reducing the thermal resistance in a heat exchanger. Many heat augmentation techniques have been reviewed, these are (a) surface roughness, (b) plate baffle and wave baffle, (c) perforated baffle, (d) inclined baffle, (e) porous baffle, (f) corrugated channel, (g) twisted tape inserts, (h) discontinuous Crossed Ribs and Grooves. Most of these enhancement techniques are based on the baffle arrangement. Use of Heat transfer enhancement techniques lead to increase in heat transfer coefficient but at the cost of increase in pressure drop.

Methodology to increase the heat transfer rate:

The rate of heat transfer can increase by

1. Increasing the surface area in contact with fluid or providingfins.
2. Increasing the convective heat transfer coefficient.
3. Increasing the temperature of the hot surface or by increasing the temperature difference between hot and cold bodies.

Increase in the heat transfer rate by increasing the surface area-

3. Designing of fins with projections

The fins with projections are design using Solidworks. Several projections of similar dimension are given on both sides of the fin along thelength of fins

Steps involved in designing of fins

Firstly, the base surface is created and extruded using Solidworks as shown in figure 2.1.

Secondly, the fin is created on the suitable plane and with the appropriate dimensions as shown in fig 2.2.

The projections are created on fins with diameter, d = 12 mm and having length, l = 1mm. (Arbitrary value initially) as shown in figure 2.3.

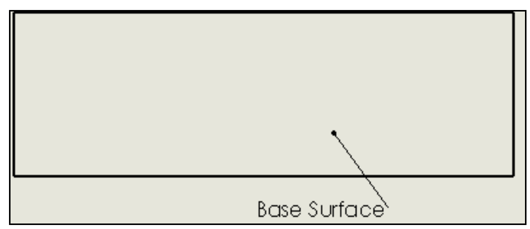


Fig 2.1: solid extruded base surface (front view)

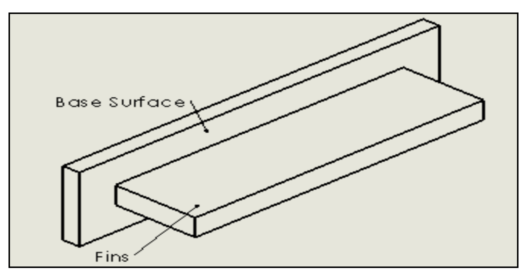


Fig 2.2: solid extruded surface with fin without projection (isometric view)

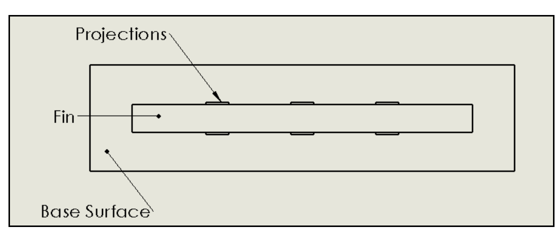


Fig 2.3 solid extruded surface fin with projections.

4. Constraints allocation to fins with projections

The fins are analyzed under the Solidworks Simulation. The constraints assign for analysis of fins are:

Ambient Temperature, T_a = 298.15 k (25 °C).

Surface Temperature, T_0 = 498.15 k (225 °C).

Coefficient of convective Heat Transfer, h= 75 w/m^2 k.

Thermal Conductivity, K= 200 w/mK.

4.1 Analysis of fins

After designing of fins with projections, the fins are meshed and run in the Solidworks simulation with the above constraints. The results obtain from the analysis are as follows:

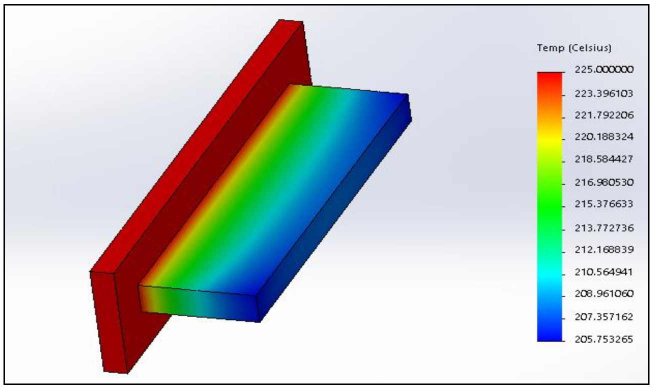


Fig 3: Fin with no projection.

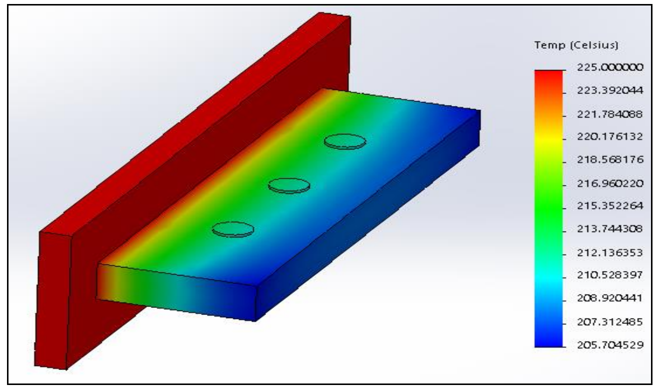


Fig 4: Fins with projection at the center

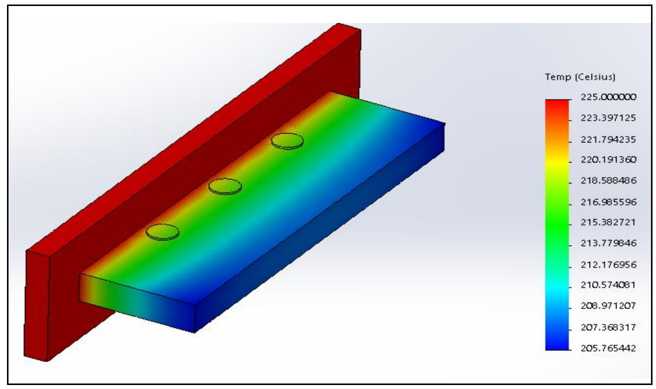


Fig 5: Fins with projection near base surface

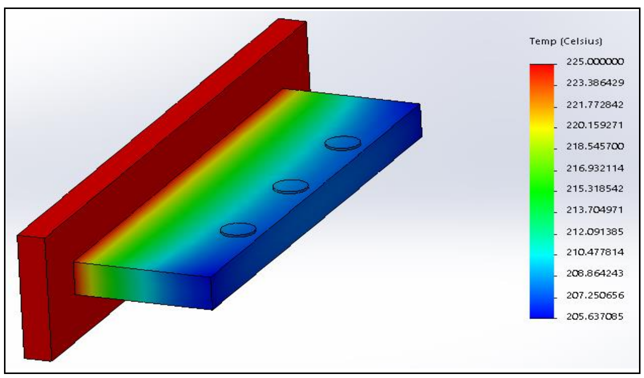


Fig 6: Fins with projection at the far end.

The above figures show the variation in temperature along the length of the fins for various positions of projections. The results are tabulated below in table 1.

Table 1: Comparison between temperatures at different places of projections

Length of fin (mm)	Fins with projections at different places (temp °C)			
	No projection	Center	Near base	Far end
0	225	225	225	225
6.25	219.668274	219.672455	219.736664	219.643036
12.5	216.237152	216.224884	216.245361	216.190826
18.75	213.387878	213.363281	213.395538	213.321747
25	211.037445	211.003448	211.046509	210.954254
31.25	209.142242	209.101196	209.152588	209.0448
37.5	207.679657	207.634033	207.69101	207.571625
43.75	206.637085	206.58902	206.649078	206.522705
50	206.007538	205.95871	206.041809	205.875214

5. Results

The following graph is plotted on the basis of the table 1, showing different a comparison between variations of temperature for the fins having projection at different places along the length.

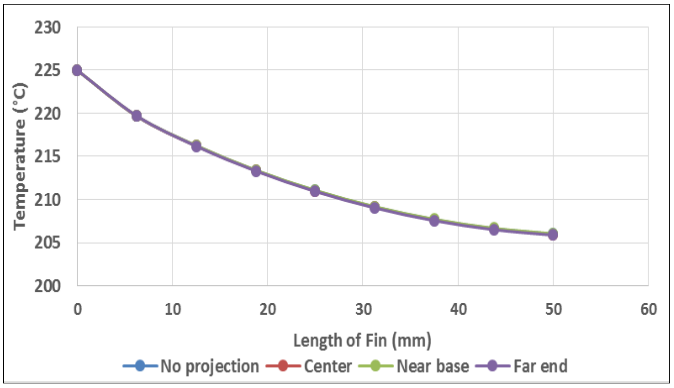


Fig 7: Graph shows comparison between fins places at the different positions along the length of the fin. After calculating the rate of heat transfer for fins with and without projections, they are compared in the table given below.

Table 2: Comparison between heat transfer rates of fins with different thickness.

Heat transfer rate (W)		Change in Heat transfer (W)	percentage change (%)
Without Projection	116.20203	--------------	--------------
Projection with thickness 1 mm	118.53204	2.33001	2.00%
Projection with thickness 2 mm	120.74170	4.53967	3.75%

The above table compares the heat transfer rate for the fins without projections and projections of thickness 1 mm and 2 mm.

6. Conclusion

1. There is about 2% increase in heat transfer rate when the projections made are of 1 mm thickness.
2. The rate of heat transfer increase about 1.5% on increasing thickness by 1mm.
3. The temperature drop reduces as the projections move towards base surface
4. When the projections are at the base surface the temperature drop is less as compared to fin without projections.

7. Future work

1. By providing perforates over the fins of engines vehicles to increase the rate of heat transfer.
2. Incorporating the perforates in radiators so that faster cooling rate can be achieved.
3. Perforates can reduce the quantity of material required and can reduce weight of fin.

8. Reference

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