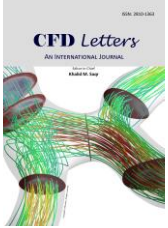

CFD Letters

Journal homepage:
https://semarakilmu.com.my/journals/index.php/CFD_Letters/index
ISSN: 2180-1363

One Dimensional Steady-State Heat Transfer on a Star Fin Shape

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ARTICLE INFO

Article history:
Received 6 October 2022
Received in revised form 27 October 2022
Accepted 24 November 2022
Available online 30 November 2022

Keywords:

cylindrical fin; star fin; heat flow rate; heat transfer coefficient; effectiveness.

ABSTRACT

The convection heat transfers on a surface exposed to the fluid may be enhanced by attaching to the surface, known as the fins. To keep the system stable, heat transmission via solids, boundaries, or walls must be continuously dissipated to the environment or surroundings. A large quantity of heat must be dissipated from a small space in many engineering applications. A fin can boost the surface area's effectiveness; hence, maximize convectional heat. Two shapes of straight aluminum fins have been used, cylindrical and star shape. The result shows that the star fins are appealing due to the same diameter and length; it has a lot more heat transfer than a cylindrical fin. In electronic devices, cylindrical and star fins are provided on the surface of the processor device. The result is done by SolidWorks simulation with 300 ºC on the surface as well as cylindrical and star fin. Input parameters like thermal conductivity, heat transfer coefficient, as well as fin's density and dimensions are measured. The temperature distribution, heat flow, as well as heat flux all resembles output parameters.

1. Introduction

The convection of heat transfer is an important phenomenon in engineering applications such as electronic cooling, thermal system, and heat exchanger. Optimization of heat transfers in these applications is important from the energy-saving industrial and perspective. The fins are used in a variety of engineering applications to improve convective heat transfer. Fins with several geometries and materials can be responsible as the effective emitters of heat for these systems [1]. The cooling performance of a device mostly depends on the surface area and shape of a fin. Therefore, many previous research has been conducted on optimizing fin shapes [2−7]. Also, it is found that heat transfer improvement increases with an increase in Reynolds number and the particle volume concentration [8−12]. Additionally, in the air cooling systems, the volume to surface area ratio and the aerodynamic properties of the shape are significant aspects for performance [13–15].

Ghasmi et al. [16] utilized the Differential Transformation Method (DTM)to assess the nonlinear temperature equations of longitudinal fins in two different instances where thermal conductivity and

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https://doi.org/10.37934/cfdl.14.12.110

heat generation change with temperature. The results showed that this method is very convenient and effective. The authors found that the analytical (DTM) solution exposes efficiency and higher accuracy than the numerical result. Ahmadi et al. [17] employed the FLUENT software to study the free convection heat transfer of a perpendicularly placed rectangular fin experimentally and numerically. They examined 12 various aluminum alloy heat sinks with different dimensions to examine the fin spacing and interruption influence. The outcomes illustrate that providing interruptions to perpendicular fins will increase heat flux from the heat sink, increase the heat transfer rate, and enhance thermal performance. Fluid flow characteristics and heat transfer for the impingement model of single and multi-jets were studied numerically by Chougule et al. [18] for various (Z/d) ratios and Reynolds numbers. They discovered that the single jet impingement demonstrates less cooling performance than the multi-jet impingement on pin fins heat sinks. The multi-jet impingement has a lesser temperature and more uniform temperatures distribution. It is also observed in all ranges of the Re and (Z/d) ratio. AL-Hafidh and AL Zubaidy [19] took the water as the based fluid in an annulus enclosure of a 3D full of silica sand like a porous media in the middle of two horizontal concentric cylinders to numerically study the free convection of heat transfer. The fins were attached to the inner cylinder. They reported that the factors which affected the system were volume fraction, cylinders radius ratio Rr, and modified Rayleigh number. Hyung Do et al. [20] analyzed the temperature and velocity distribution within heat sinks subject to a regularly impinging jet using a similarity transformation and a volume averaging technique. An experimental study is showed to verify the suggested similarity solutions. The results demonstrate that the modified similarity solution is appropriate for calculating the thermal resistance and pressure drops for the heat sinks concerning the regularly impinging jet. Jasim et al. [21-24] used experimental and Computational Fluid Dynamics (CFD) methods to study the influence of multiple circular stenosis on pin fin designing on improve heat transition and decrease pressure drop across the small channel heat sinks [25-28]. The indication of the results that the pin fins heat sink with multiple circular stenosis have lesser pressure drop and high heat transition, difference to regular pin heat sink. This study aims to show the fin shape effect on behavior of heat transfer, the fins are used in a variety of engineering applications such as mechanical and electronic devices [29-32]. Two shapes of straight aluminum fins have been used, cylindrical and star shape, and maintains the base temperature at 300C°.

2. Methodology

2.1 Problem description

In a present paper investigation on a thermal issue from the electronic device, fins were carried out. Investigation yields the heat flux behaviour and temperature of the fins due to high temperature in the electronic devices. Solid works is utilized for analysis. The analysis is done for two different models of fins commercially available nowadays (cylindrical fin), and a comparison is thus established (star fin). A comparison is made between them to know how it will give us a better heat transfer rate.

2.2 Solution methodology

This section deals with the model and the mesh of the cylindrical and star fin using SolidWorks, and its simulation, type of the mesh generation, and boundary conditions are the same for both fins. The design of the fins is done using Solid works with the following as shown in Table 1.

Table 1

Geometrical specifications

Geometrical	Value	Units
Diameter of cylindrical fin	D1 =5	mm
Length of cylindrical fin	L1 =50	mm
Size of the device (source heat)	V1 = (100×50×10)	mm^3
Diameter of star fin	D2 =5	mm
Thick of star fin	t =1	mm
Length of star fin	L2 =50	mm
Size of the device (source heat)	V2 =(100×50×10)	mm^3

2.3 Case 1: Cylindrical fins modelling

The design is done with the help of solid works for a cylindrical fin, Fig. 1, with the above geometrical specifications in Table 1.

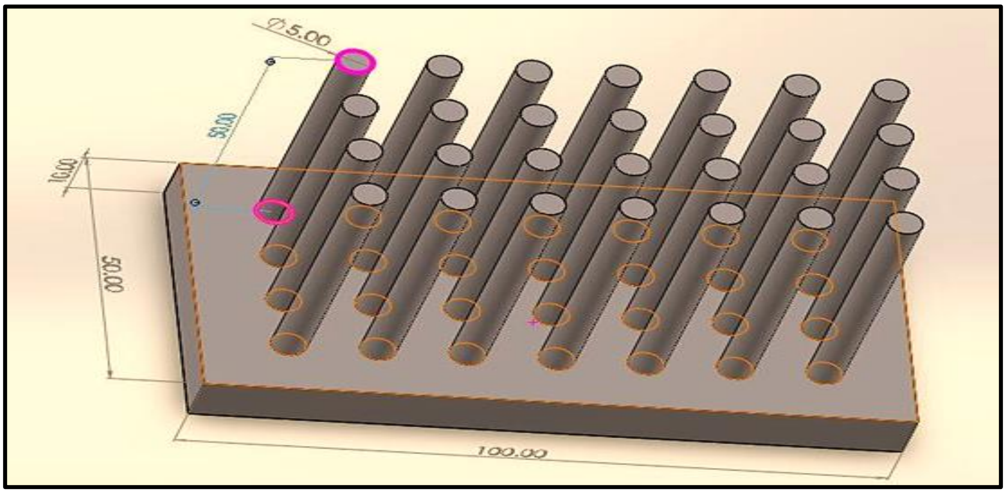

Fig. 1. Top view of cylindrical fin, all dimensions in (mm).

2. 4 Mesh generation

Solid works software was used to grid generation and discretized using the tetrahedral/ triangular mesh. The tetrahedral grid was used to ensure result obtained high accuracy and quality mesh generation along with section view in “Fig. 2”.

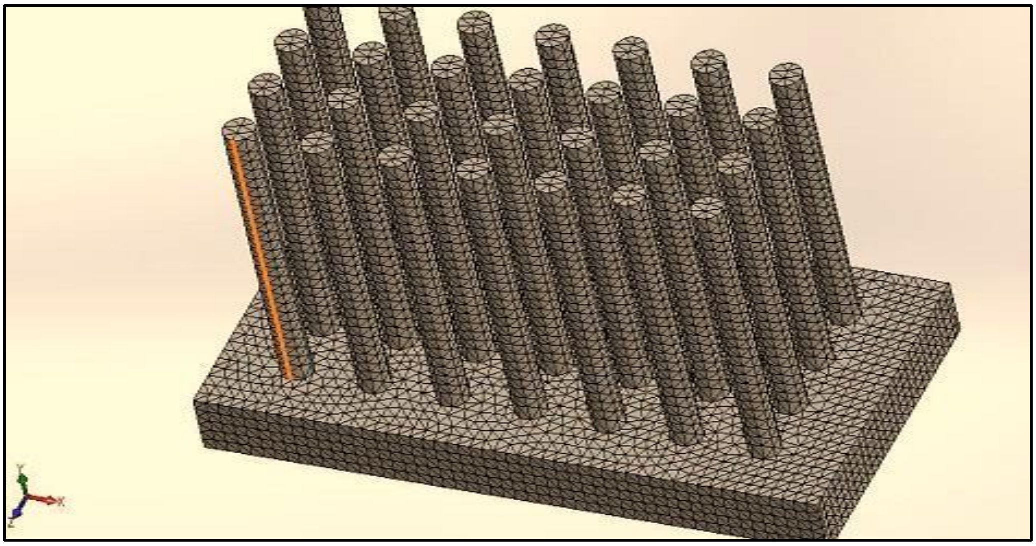

Fig. 2. Cylindrical fin mesh view.

2.5 Boundary conditions

After generating the mesh, it is analysed, and boundary conditions are applied for cylindrical and star fin. The flow and thermal variables on the model’s boundaries are specified by the boundary conditions. Table 2 shows the implemented boundary conditions, the same for cylindrical and star fin. The boundary conditions are considered in solid works. The air is taken as a working fluid, and the inlet and outlet boundary conditions are set at subsonic flow with total uniform pressure of 1atm. The material characteristics are given in Table 2.

Table 2
Material characteristic for the solid

Characteristics	*Value*	*Units*
Elastic modulus	6.9e + 10	N/m^2
Poisson's ratio	0.33	N/A
Shear modulus	2.7e + 10	N/m^2
Mass density	2700	Kg/m^3
Tensile strength	68935600	N/m^2
Yield strength	27574200	N/m^2
Thermal expansion coefficient	2.4e -0.5	1/k
Thermal conductivity	200	W/ (m. K)

2.6 Case 2: Star Fin

2.6.1 Modelling

The design is done with the help of a solid works for star fin, Fig. 3 and 4, with the same geometrical specifications as obvious in Table 1.

2.6.2 Mesh generation

The mesh is used in solid works. Fine tetrahedral meshing is done and mesh generation along with section view in Fig. 5.

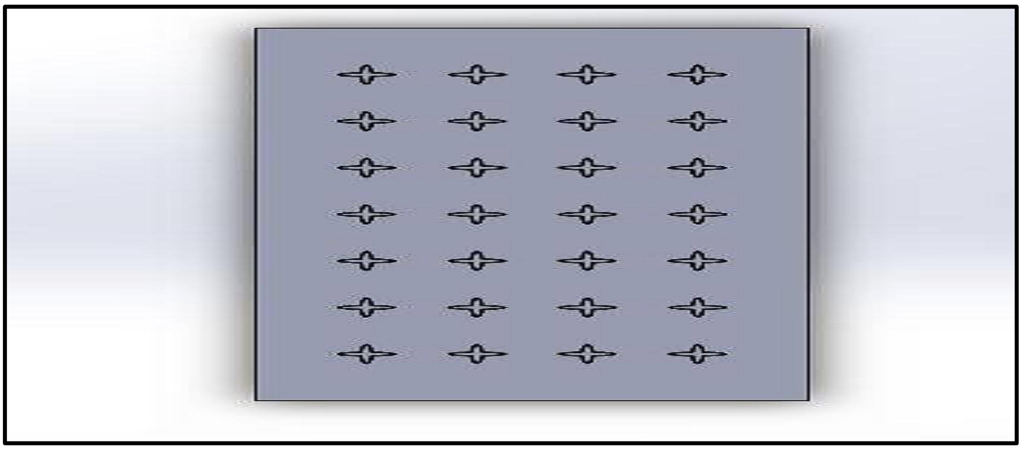

Fig. 3. Top view of star fin.

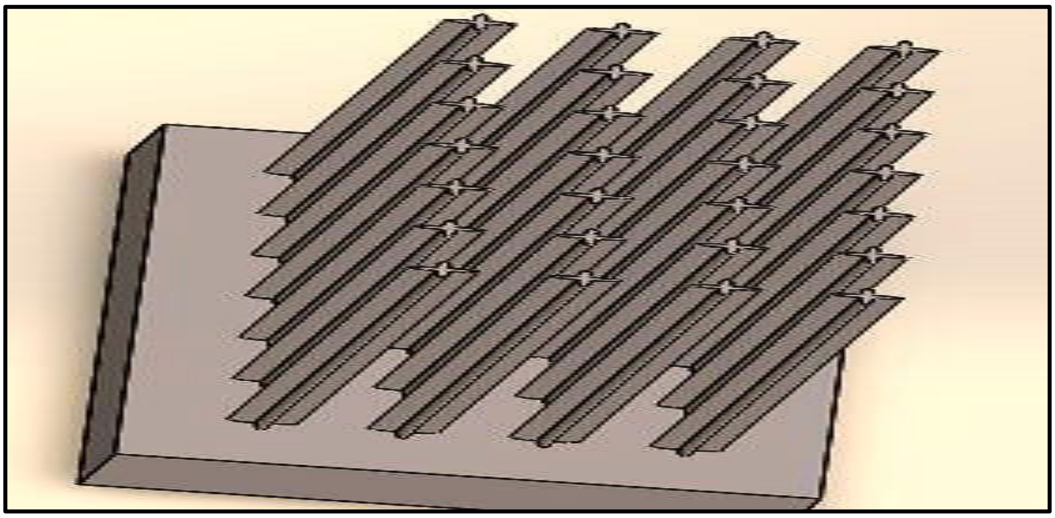

Fig. 4. Isometric star fin.

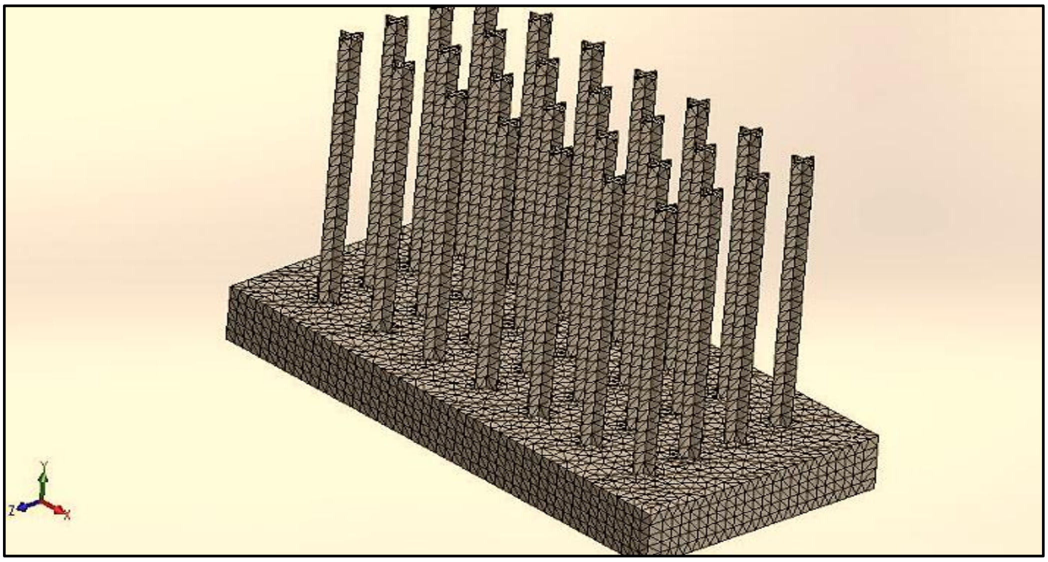

Fig. 5. Star fin mesh view.

3. RESULTS AND DISCUSSION

Fig. 6 demonstrates temperature distribution along the fin which represent the comparison between the current study and the work made by Madhavadas et al. [26-29] for cylindrical fins heat sink. It was illustrated that the present results agree well with Madhavadas et al., for temperature distribution along the cylindrical fins.

Analysis of cylindrical and star fin is done to study heat transfer and heat flux behaviour at natural convection. The discussion of each is outlined as follows:

3.1 Temperature Distribution

3.1.1 Case 1: Cylindrical Fin

In Fig. 7, the line represents the distribution of temperature along the fin, and the fin is at the base of domain red colour represent higher temperature and its equal 300C^0. Along the fins, there are some dark colours represent the temperature variation on the fin [30-34]. There is a variation of the temperature due to heat dispersion along the fin [35, 36], and the blue colour in the line represents the lowest temperature, equal to 287.581C^0 in this case.

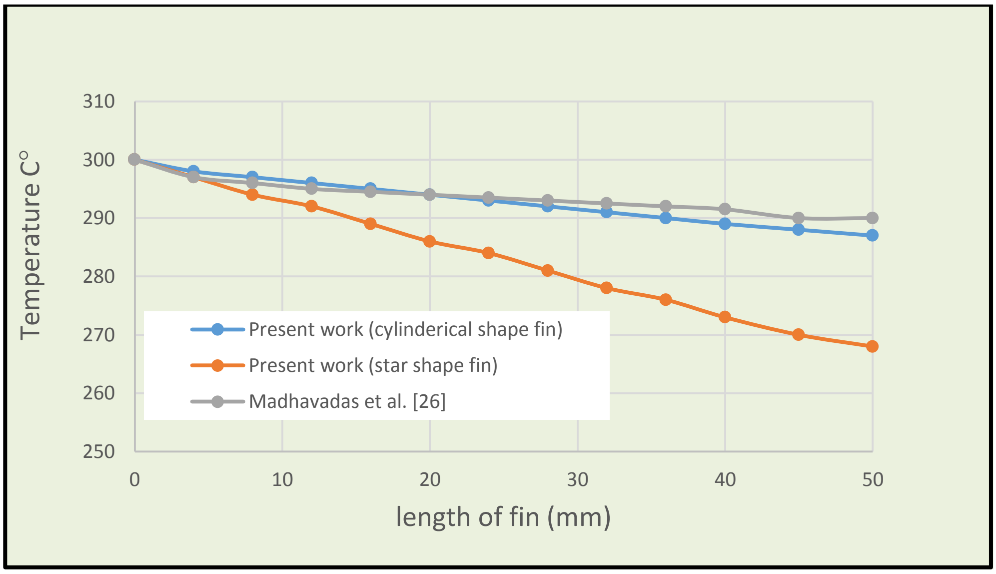

Fig. 6. Comparison between the present study and the work made by Madhavadas et al.[26]

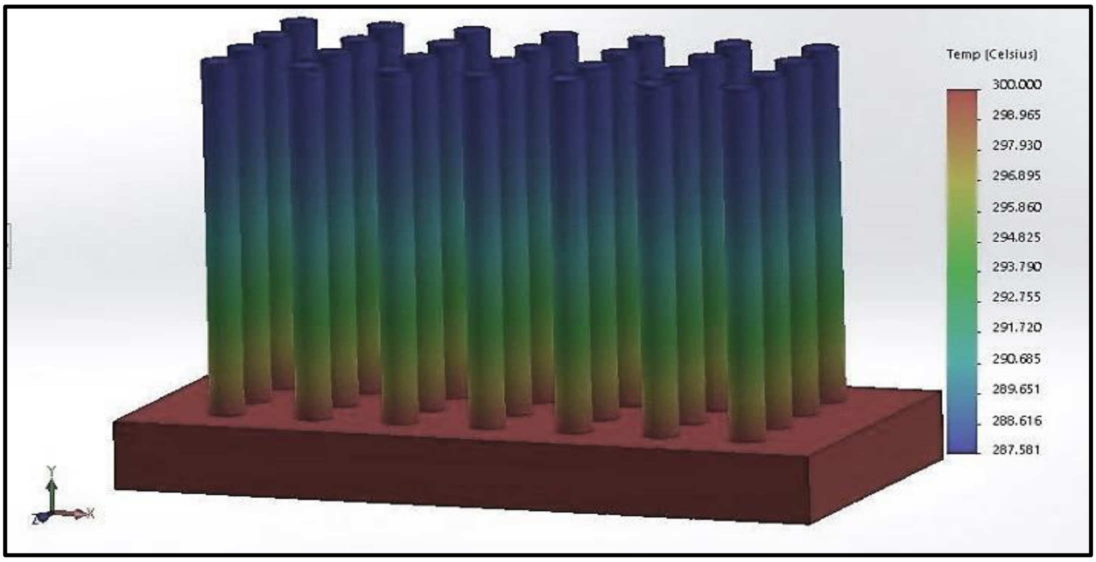

Fig. 7. Temperature distribution along the cylindrical fin have maximum temperature is 300 at fin base and minimum temperature is 287.581C^0 at fin top.

3.1.2 Case 2: Star Fin

In Fig. 8, the line represents the distribution of temperature along the star fin. The fin is at the base of the domain red colour, and it represents higher temperature and equal to 300C^0. Above the y-axis of the fin, some dark colours represent the temperature variation on the fin. There is a variation of the temperature due to heat dispersion along the fin, such as the blue colour in the line represents the lowest temperature, equal to 268.03C° in this case.

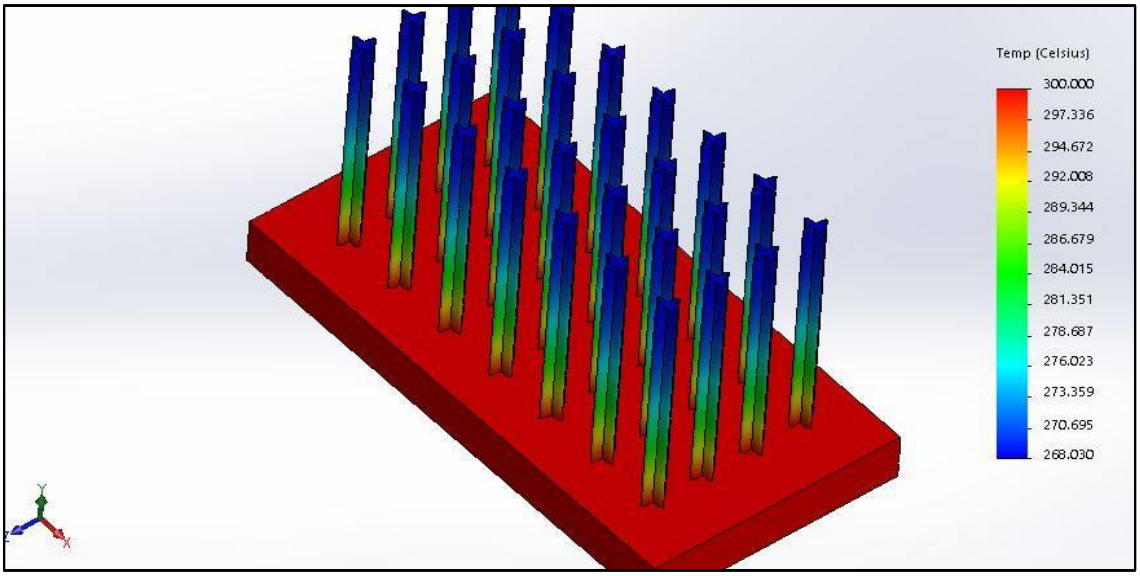

Fig. 8. Temperature distribution along the star fin have maximum temperature is 300 C^0 at fin base and minimum temperature is 268.03C^0 at fin top.

3.2 Heat Flux

Heat flux by the fins is dependent on the shape or form of the fins used. Fig. 9 and 10 showed distribution of heat flux along the cylindrical and star fin. The larger gap between the maximum and minimum heat flux, the larger the quantity of heat transfer. The star fins have a higher heat flux about 60% in comparison to the cylindrical fins due to the profile as the star fin covers further surface area, meanwhile the heat flow from higher to lower temperature.

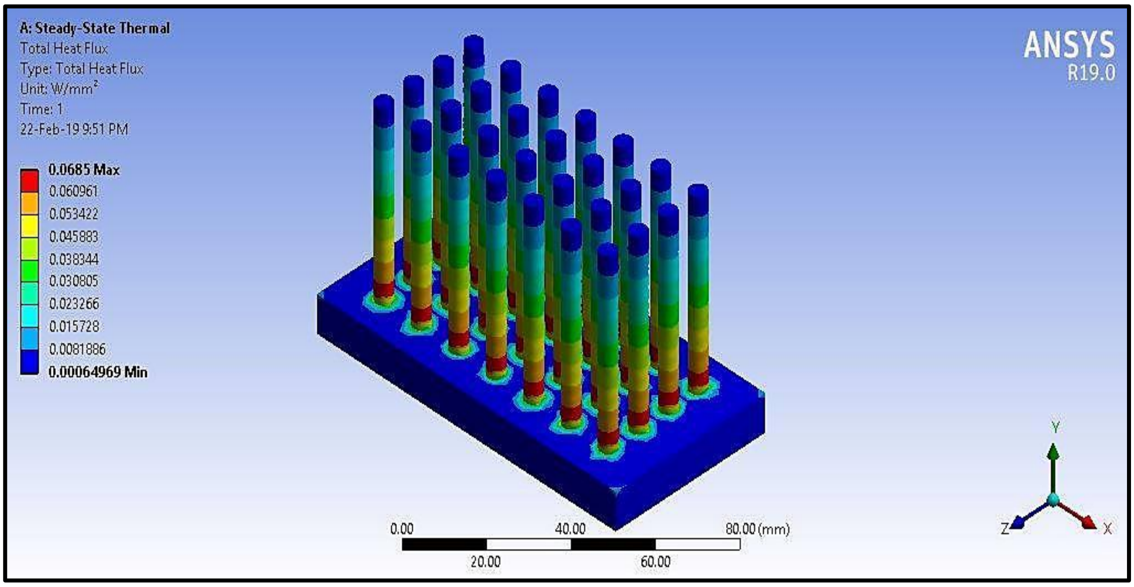

Fig. 9. Distribution of heat flux along the cylindrical fin.

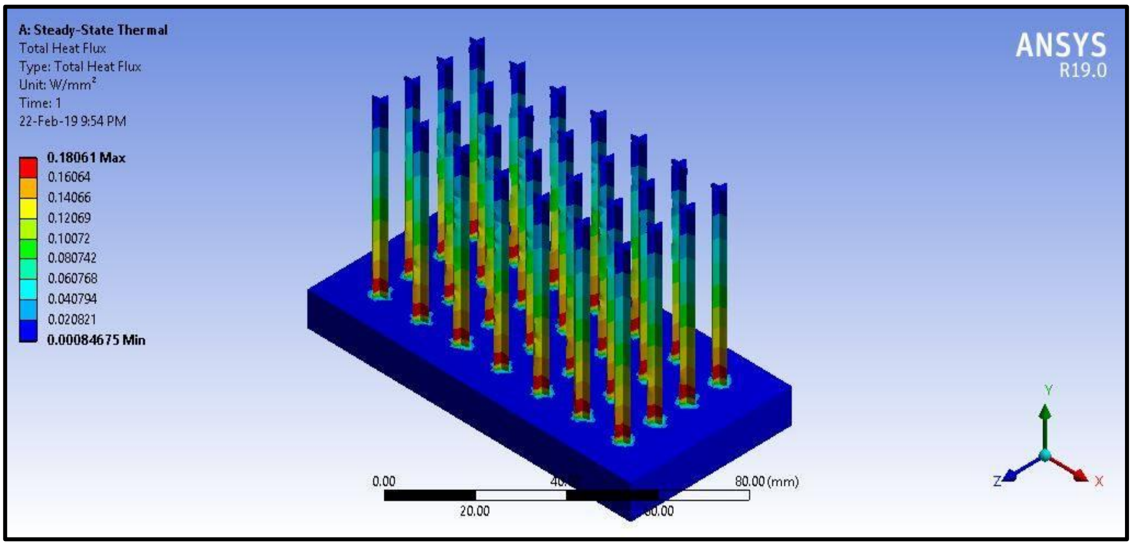

Fig. 10. Distribution of heat flux along the star fin.

4. CONCLUSIONS

The following conclusions arrived when using two types of fins cylindrical and star fin. This aluminium alloy has 50 mm length, 5 mm diameter, and 1 mm thickness for the star fin and maintains the base temperature at 300C°. The result shows that the star fins are fascinating because they transmit far more heat than cylindrical fins of the same diameter and length. In electronic devices, cylindrical and star fins are provided on the surface of the processor device. The result is done by Solid works simulation. The heat transfer coefficient, density, thermal conductivity, and fin dimensions are regarded as input factors. Meanwhile, the output parameters, for instance, temperature distribution, heat flow, and heat flux, are assessed. Therefore, in comparison to the aluminium alloy cylindrical and star fins, we recommend using star fin.

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