# Analysis of Heat Sink with different Pin Configuration to Predict Thermal Effect

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*Abstract* — the model has been simulated using ANSYS software on fluent domain 15.0 workbench in order to observe various parameters affecting the thermal and hydraulic performance of heat sink channel. Four types of configurations of rounded pin fin heat sink have been used with different pin profile i.e. type-1 pin dia. 10 mm, type-2 pin dia. 12 mm, type-3 pin dia. 14 mm, type-4 pin dia. 15 mm. An optimized model of heat sink has been developed with pin of different round headed diameters. The simulations have been performed at a constant heat input 1481W/m$^2$ that is the heat flux of fin base of heat sink with Reynolds number ranging between 3450 - 7970. The simulation of the optimized model gives higher value of pressure drop, less thermal resistance and increased Nusselt number. It has also been observed that profit factor was improved at moderate pumping power. The results are validated with previous research work. The configuration of type-4 i.e. 15mm round headed pin fin heat sink gives maximum convergence on all parameters amongst all the configurations used.

Keywords— *Plate Fin Heat Sink, Nusselt Number, Reynolds Number, Profit Factor, Pressure Drop, Thermal Resistance, rounded pin fin heat sink.*

## I INTRODUCTION

Excessive amount of heat generation in electronic devices is detrimental to their safer operation. In a computer, the excess amount of heat generation on processor of CPU, damages of the device may happen that many harm the system, to protect the processor from excess amount of heat, so that the temperature should not exceed the given limit, a device heat sink is used. A heat sink is a device that absorbs heat generated on the processor and dissipates it into the atmosphere by the process of forced convection to protect processor from excess amount of temperature. Heat sink acts as in a semi conductor device to transfer maximum of heat. Hence the thermal conductivity of heat sink should high, so that maximum amount of the heat must be dissipated into atmosphere. The thermal conductivity of heat sink depends on material properties. For example aluminium has better thermal conductivity, so commonly heat sinks are made up of aluminium. It has good manufacturing and economical to assemble or to optimized for better heat transfer during the work of processor to dissipate the heat in maximum amount to atmosphere.

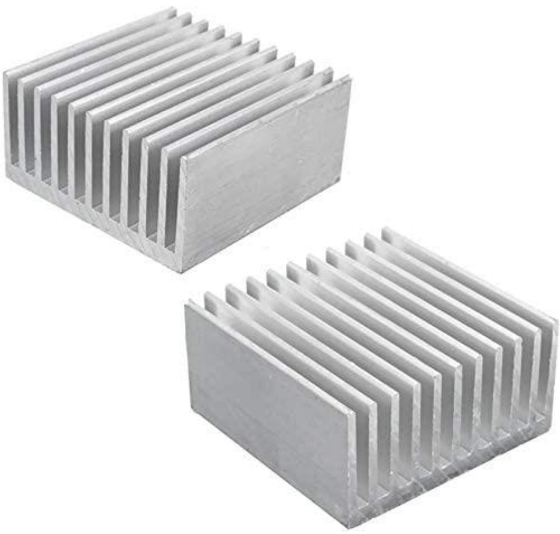

**Figure 1:** Heat Sink

According to the configuration of heat sink, it is classified as follows

- Rectangular channel heat sink
- Circular fin heat sink

- Stamped heat sink
- Annular fin shaped heat sink
- Zigzag shaped heat sink

- RECTANGULAR CHANNEL HEAT SINK

These heat sinks are commonly used on CPU for their better heat transfer rate and good thermal conductivity. These shaped heat sinks are made up of aluminium.

- CIRCULAR FIN HEAT SINK

These heat sinks are basically used in complex type of geometry. The fin shape is in the form of circle which is fabricated on circular platform to absorb excess amount of heat flux. Due to the circularity, the surface area of heat sink is increased. Design of circular heat sink leads to increase in heat transfer rate and decrease in the temperature of system. These types of heat sinks are basically made of silicon alloy.

- STAMPED HEAT SINK

These heat sinks are directly interfaced into a heat generated device. These heat sinks consist of a rectangular channel type configuration with edge, fillet to resist the concentration of heat for maximum heat dissipation. They are also in the form of circular type configuration for maximum heat transfer rate and also used for complex structured shaped.

- ANNULAR FIN SHAPED HEAT SINK

These heat sinks are configured in shape of annulus. The one end of annular shaped configuration is interfaced with heat generating device and another side of annular shaped is exposed to the atmosphere. The side of annulus which is exposing to the atmosphere could be optimized in the form of rectangular shaped, circular shaped tip for better heat transfer rate.

- ZIGZAG SHAPED HEAT SINK

These heat sinks are configured in zigzag shaped to increase the surface area, which increase Nusselt number and decrease the thermal boundary layer effect for better heat dissipation.

## II OBJECTIVES

- The main objective of the proposed research work is to validate the CFD analysis of simulations result of different configurations of plate pin fin heat sink models by comparing the results of simulations models of this research with research reported in the literature.
- To optimized the different configurations of plate pin fin heat sink models with drafted pins by $2^0$, and artificial roughened i.e. rectangular shape (shape of the roughness) on fin wall with different profile i.e. type-1 pin dia. 1,1,1 mm, type-2 pin dia. 1,1,2 mm, type-3 pin dia. 1,2,2 mm, and type-4 pin dia. 2,2,2 mm at different air velocities of 6.5 m/s, 8 m/s, 10 m/s, 12.2 m/s, 15 m/s for constant heating power 10 W that is the heat flux of 3665 W/m$^2$.
- To analysis of the performance parameters pressure drop, thermal resistance, profit factor, surface nusselt number, and convective heat transfer coefficient on different configurations of plate pin fin heat sink models.
- To predict the temperature distribution on optimized heat sinks along the influences of different velocities 6.5 m/s, 8 m/s, 10 m/s, 12.2 m/s, 15 m/s.
- To improve the hydraulic and thermal performance of heat sink, and comparing the best configuration of optimized heat sink model under the analysis of influencing parameters.

- DESIGN PARAMETERS OF HEAT SINK MODELS

**Table 5.1:** Basic geometric parameters of plate fin heat sink

| Fin Length, L (mm) | Fin Height, H (mm) | Pin Height, H1 (mm) | Fin Number, N | Fin thickness, t (mm) | Fin Spacing, δ (mm) |
|---|---|---|---|---|---|
| 51 | 10 | 10 | 03 | 1.5 | 5 |

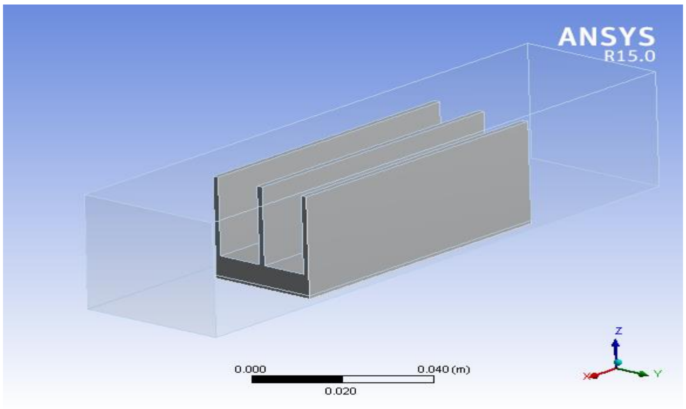


**Figure 2:** 3D Model of plate fin heat sink (PFHS).

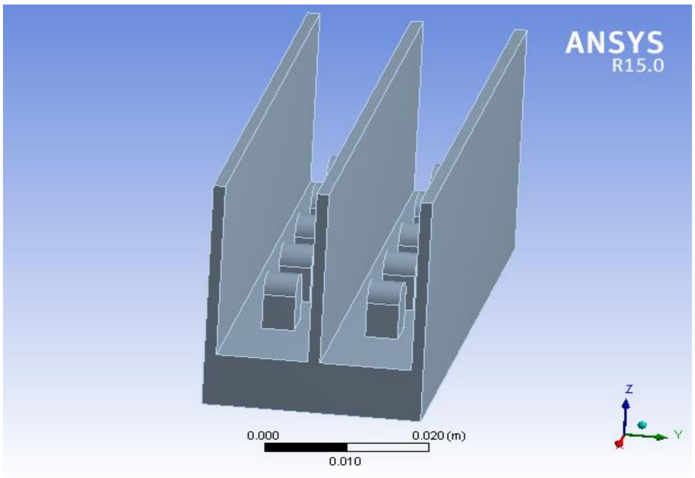


**Figure 3:** 3D Model of rounded pin fin heat sink (RPFHS).

- DESIGN PARAMETERS OF OPTIMIZED HEAT SINK MODELS

**Table 5.2:** Four types of rounded pin fin heat sink (RPFHS)

| Fin type | Round headed pin diameter (mm) |
|---|---|
| **Type – 1** | 10 |
| **Type – 2** | 12 |
| **Type – 3** | 14 |
| **Type – 4** | 15 |

- PARAMETERS CONSIDERED IN BOUNDARY CONDITIONS

- Definition of various surfaces (ids) i.e. inlet, outlet, heat wall, and wall on heat sink model.
- Applying governing equation on fluent i.e. continuity equation, momentum equation, and energy equation.
- Defining values of velocity, turbulent intensity and hydraulic diameter on heat sink model.

**Table 5.5:** Boundary conditions

| Fin Profile | Fin types | Reynolds No. | Heating power (W/m$^2$) | Periodic boundary condition |
|---|---|---|---|---|
| | Type – 1 | | 1481 | Translate in X direction |
| | Type – 2 | | 1481 | Translate in X direction |
| | Type – 3 | | 1481 | Translate in X direction |
| | Type – 4 | | 1481 | Translate in X direction |

## III RESULTS

The Existing simulation results are obtained for pressure drops (ΔP) and thermal resistances (Rth) w.r.t. Reynolds number (Re) ranging from 3450 to 7970. The results are in graphs show less than 5% deviations between existing simulation results and experimental results. But the deviations are not so large, and thus the existing simulation results of different configurations of plate pin fin heat sink models in the research work can be regarded as reasonable.

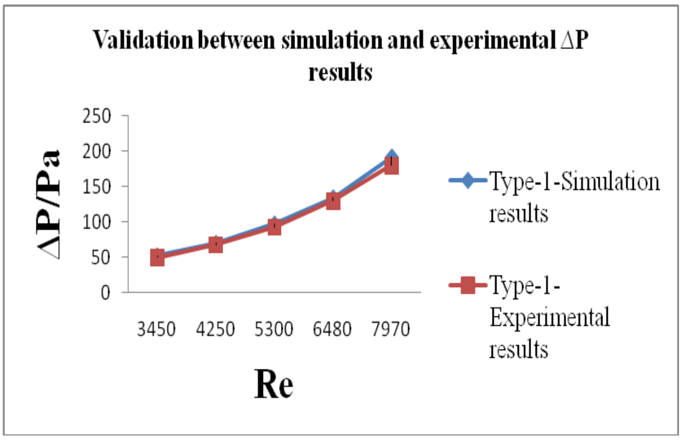


**Figure 4:** variation in pressure drop w.r.t. Reynolds number of type-1 configuration

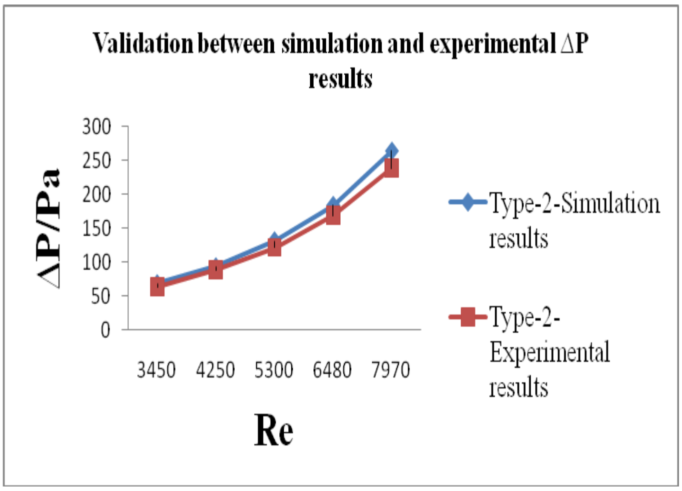


**Figure 5:** variation in pressure drop w.r.t. Reynolds number of type-2 configuration

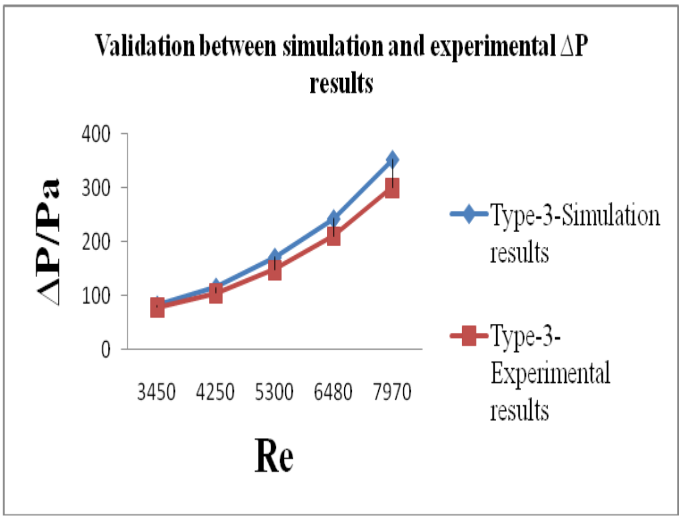


**Figure 6:** variation in pressure drop w.r.t. Reynolds number of type-3 configuration

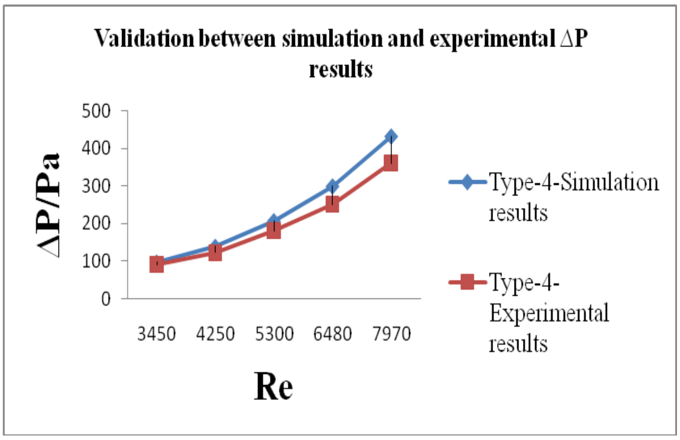


**Figure 7:** variation in pressure drop w.r.t. Reynolds number of type-4 configuration

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- COMPARATIVE RESULTS ANALYSIS OF PRESSURE DROP WITH REYNOLDS NUMBER

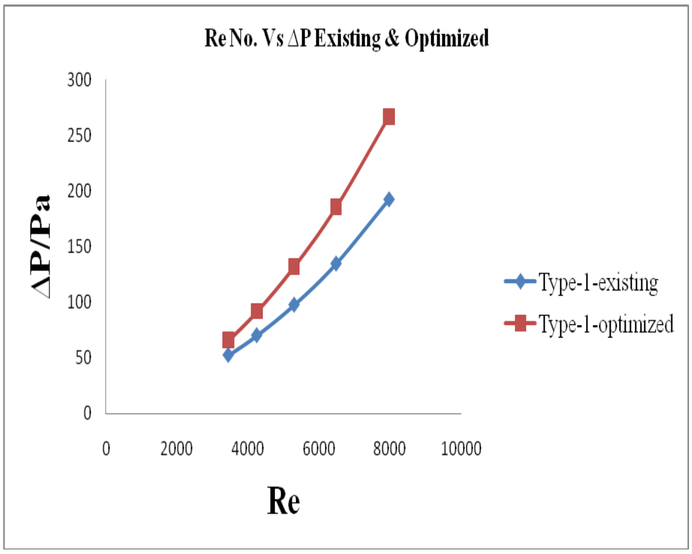


**Figure 8:** Existing & Optimized comparative results of pressure drop for type -1 configuration of heat sink

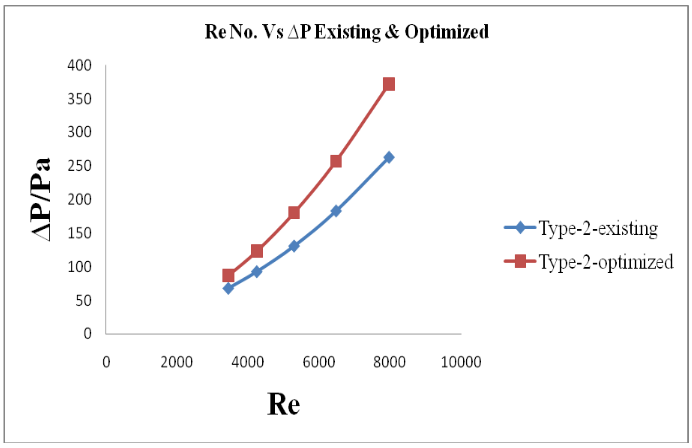


**Figure 9:** Existing & Optimized comparative results of pressure drop for type -2 configuration of heat sink

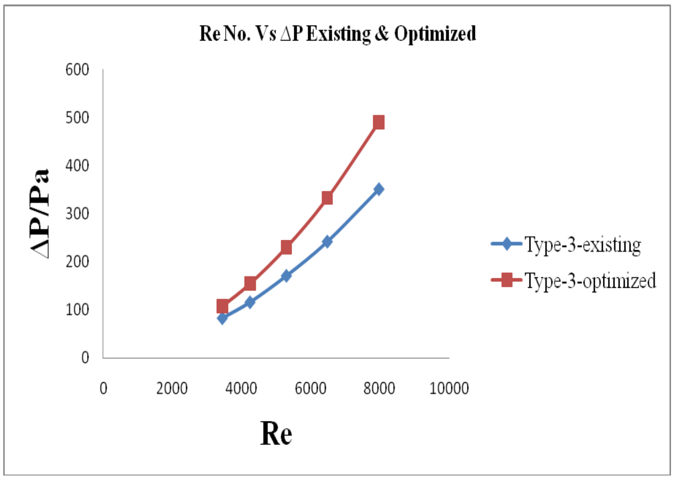


**Figure 10:** Existing & Optimized comparative results of pressure drop for type -3 configuration of heat sink

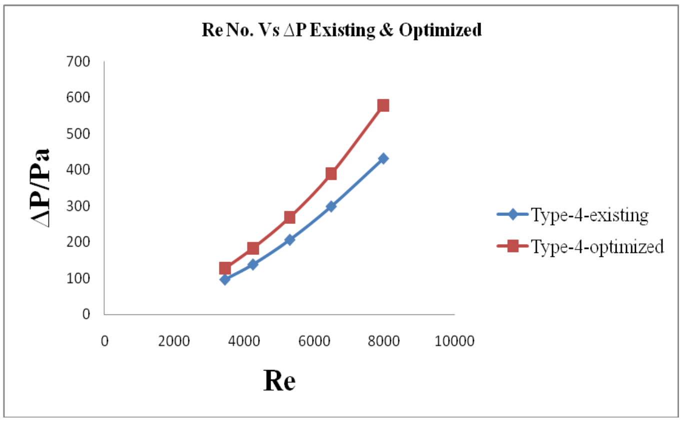


**Figure 11:** Existing & Optimized comparative results of pressure drop for type -4 configuration of heat sink

- COMPARATIVE RESULTS ANALYSIS OF THERMAL RESISTANCE WITH REYNOLDS NUMBER

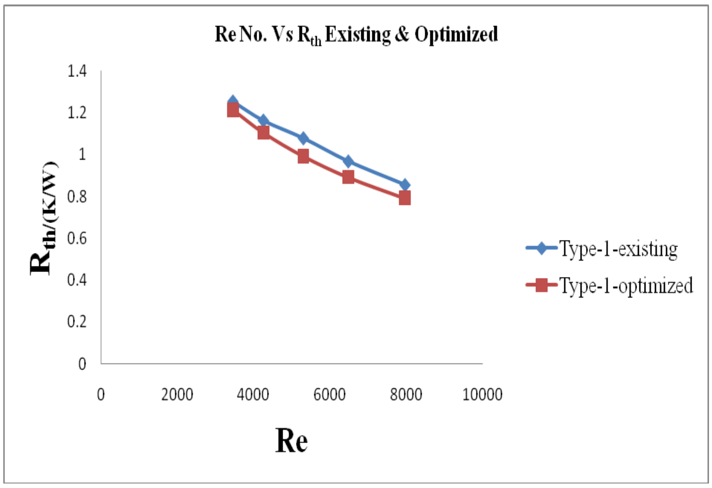


**Figure 12:** Existing & Optimized comparative results of thermal resistance for type -1 configuration of heat sink

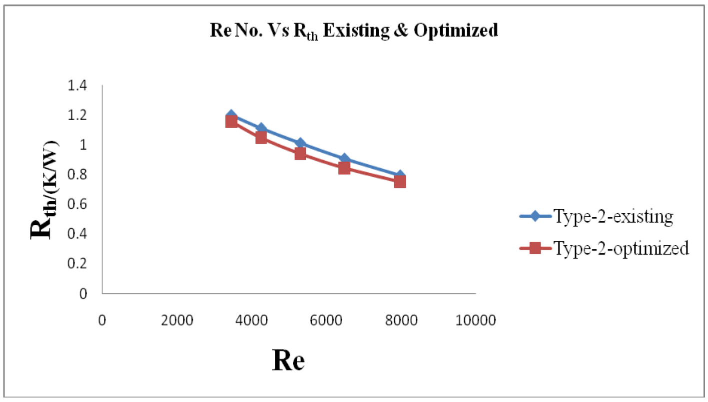


**Figure 13:** Existing & Optimized comparative results of thermal resistance for type -2 configuration of heat sink

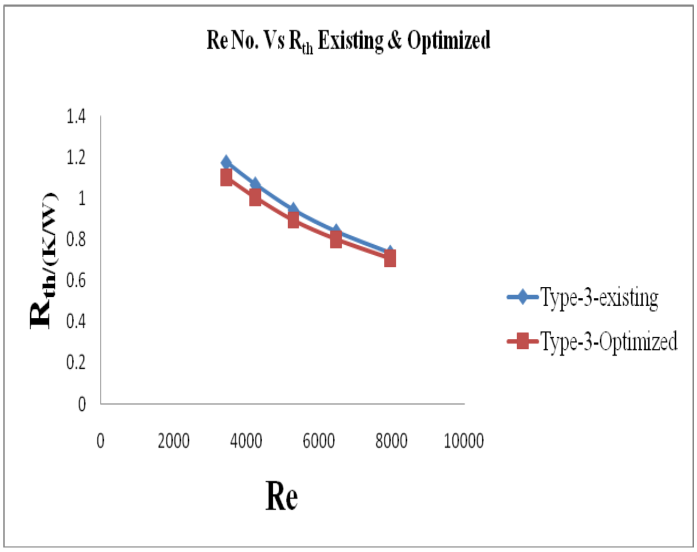


**Figure 14:** Existing & Optimized comparative results of thermal resistance for type -3 configuration of heat sink

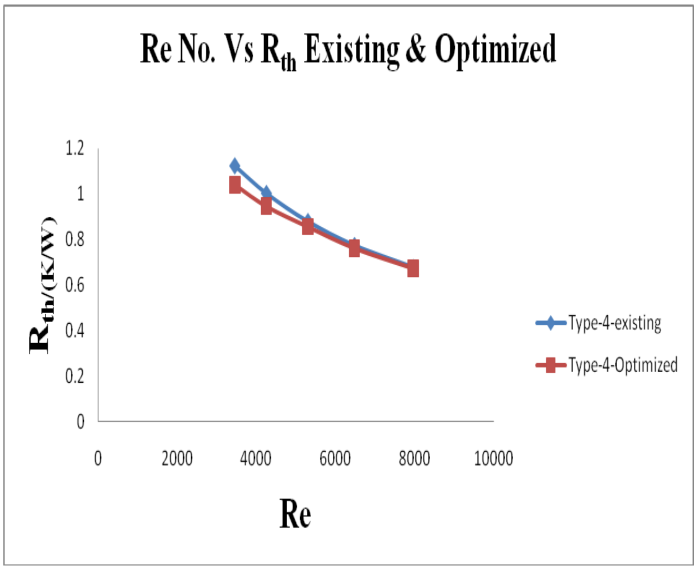


**Figure 15:** Existing & Optimized comparative results of thermal resistance for type -4 configuration of heat sink

## CONCLUSION

- The CFD (Computational fluid dynamic) model was developed on Uni-Graphics Nx-8.0 and analysis was done using the Ansys software fluent 15.0.
- Air velocity (Re number) is the fundamental parameter in the performance of rounded pin fin heat sink. The flow resistance will increase, and the thermal resistance and profit factor will decrease significantly, both are decreasing with increasing Re numbers.
- In the study, rounded pin fin, pin head radius is the key geometric parameter on the performance of heat sink. With an increases diameter head of pins, the flow resistance increases, and the thermal resistance and profit factor will notably decrease.

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