Effect of Geometry and Arrangement of Pin Fin in Heat Exchanger: A Review

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***Abstract* -** Fin is heat-sinks that have extend surface from its base. It enhances the rate of heat transfer. Fin has two types, one is flat, pin. Effect of geometry which includes size, shapes, area, is considered. In arrangement of pin fin includes array pattern of pin fins in particular area or where it needs to setup on external surface. In this paper, We discussed about different types of geometry and arrangements like Drop fin, Elliptical fin. Fin winglet, pin fin with dimple, plane fin, wavy fin etc. Pin fin has a better capacity of heat transfer then the flat plate. Also when we are using different types of plate with dimples, distance between two consecutive pins and whole, rectangular pin or cylindrical pin, winglet type fins etc. This paper is concentrated only on heat exchanger heat transfer who discussed about how to increase the heat transfer rate with using different types of fins and in which is the best for high heat transfer in different applications. Also which type of arrangement is suitable for heat transfer? Different rates of geometry and arrangements of fins in particularly for pin fin are described in this paper.

Keywords: Enhanced heat transfer, Pin fins, Drop-shaped pin fins, Heat sink, Elliptical pin fins, Wavy rectangular winglet Dimple, Plate-fin heat exchanger, Wavy channel heat exchanger

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I. INTRODUCTION:

Fin is a heat sink that extended from its base. It is use for the heat transfer. Fin is enhances the rate of cooling the area or surface. It has types on the bases of,

A. Geometry
B. Arrangement
C. Heat sink fin type

On A. geometry based, they classified as, [1]

1. Wavy type
2. Triangular type
3. Staggered pin type
4. Continuous type
5. Interrupted Rectangular type (lanced & offset)
6. Inline pin type

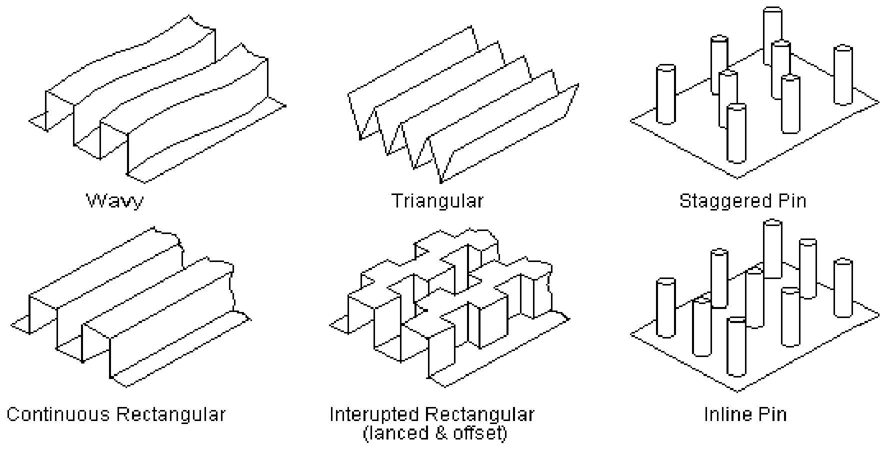

Fig 1: Types of Geometry of fins [2]

On B. Arrangement based, [3]

1. Plain arrangement
2. Perforated Arrangement
3. Serrated Arrangement
4. Herring bone arrangement

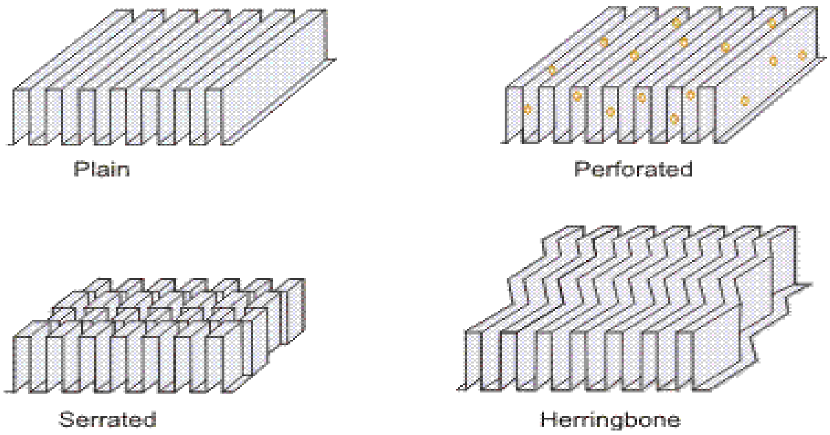

Fig 2: Types of arrangement of fin [4]

C. Heat sink fin type, [5]
1. Straight type
2. Pin type
3. Flared fin

Fig-3: Pin, straight, flared type [6]

As per above classification, we can judged that there are many geometries and arrangements which can gives different heat transfer rate.

II. LITERATURE REVIEW:

Straight and pin type both has big difference in their properties, shapes and other parameters as below,

Heat sink fin type	Width [cm]	Length [cm]	Height [cm]	Surface area [cm²]	Volume [cm³]	Temperature difference, $T_{case}-T_{air}$ [°C]
Straight	2.5	2.5	3.2	58	20	44
Pin	3.8	3.8	1.7	194	24	51

Table: 1 [7]

Two major arrangements of the pin fin, namely staggered and inline arrangements have been established in various industrial applications. Hence the comparison of pin fin cross-sections in the present work was done for both arrangements. [7]

Seeking for high compact heat exchanger, different measures have been suggested in the past to increase the heat transfer on heat exchanger side with the larger heat transfer resistance. Employing interrupted fins and incline lamellas (strip, louvered, and wavy fins) have been proven to be very effective in heat transfer enhancement. The mechanism responsible for enhanced heat transfer by such kind of fins lies in periodic interruption of thermal and fluid dynamic boundary layer and in the better mixing of fluid parts with different temperatures. Similar effects are achieved also with pin fins which are characterized with very high heat transfer coefficients but also with very high pressure drop. Hence the aim of the present work was the comprehensive and systematic investigation of the influence of pin cross-section on the pressure drop of pin fin arrays and on their overall performance. For present investigation the order of magnitude of pin dimensions was chosen according to pin fin heat-sinks used in electronic industry. [8]

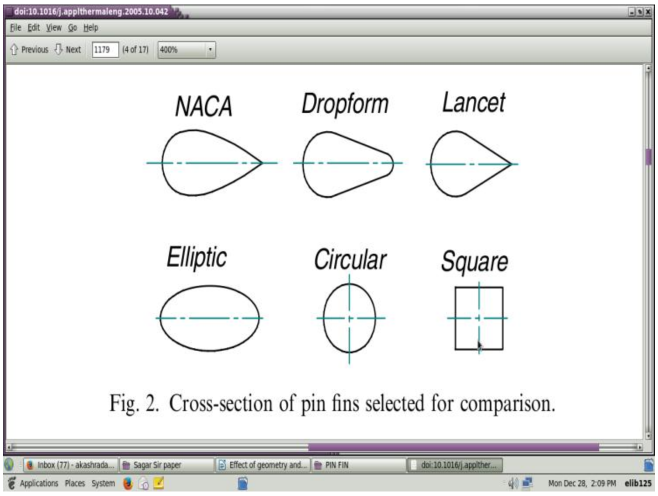

Fig-4:Cross-section of pin fins selected for comparison [8]

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Figure 5 shows the computational results of local Nusselt number distributions at the heated wall with different types of pin fin arrays when Re 1⁄4 6400. The local heat transfer was significantly enhanced in the regions near the pin fin circumferences for all the cases. In the rear wakes of pin fins, the local convective heat transfer capacities also remained at higher levels. These features may be attributed to the actions of the horseshoe and wake vortices. As noted circular pins have a wider separation region in the trailing edge of the pin. Consequently, circular pins seemed to have the strongest convective heat transfer intensity among the five cases in the current study. In addition, the windward blockage by a circular pin fin array was maximal for all cases; the flow was forced to follow a more twisted path around the pins, which
Decreased the pressure drop. [9]

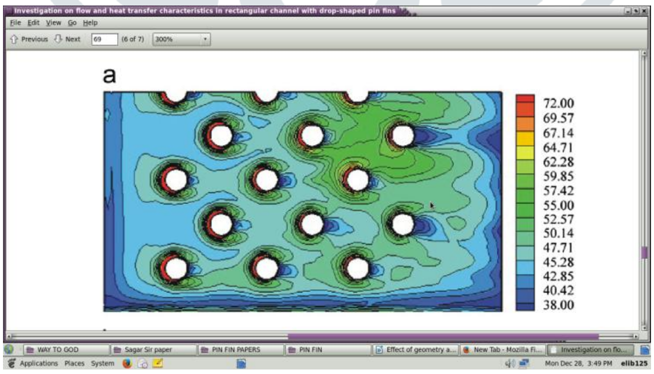

Fig: 5 Local Nu number distributions in Circular pin fins [9]

The heat transfer enhancement of drop-shaped pin fins is weaker than that of circular pin fins. Or the specific performance, the specific friction loss in drop-shaped pin fins was lower than that of elliptical and circular pin fins, which indicates that the drop-shaped pin is more advantageous than the others. Thus, drop-shaped pin fins are a promising alternative configuration to circular pin fins. [9]

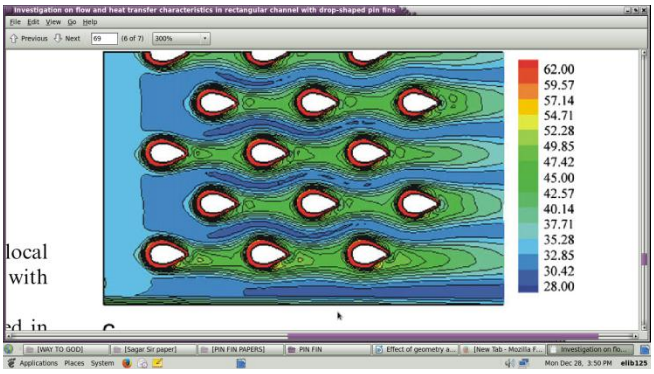

Fig: 6 Local Nu number distributions drop-A pin fins [9]

The effects of using the wavy rectangular winglet, conventional rectangular winglet configuration and without winglet as baseline configuration, on the heat transfer characteristics and flow structure are studied and analyzed in detail for the inline tube arrangements. The results showed that the wavy rectangular winglet can significantly improve the heat transfer performance of the fin-and-tube compact heat exchangers with a moderate pressure loss penalty. In addition, the numerical results have shown that the wavy winglet cases have significant effect on the heat transfer performance and also, this augmentation is more important for the case of the wavy-up rectangular winglet configuration. [10]

The dimples increase the near-wall turbulent mixing level by producing strong vortex flows, and therefore enhance the convective heat transfer in the channel. On the other hand,

The dimples enlarge the minimum cross section area transversely between the pin fins, and therefore the pressure loss in the flow can be reduced in the pin fin-dimple channels. [11]

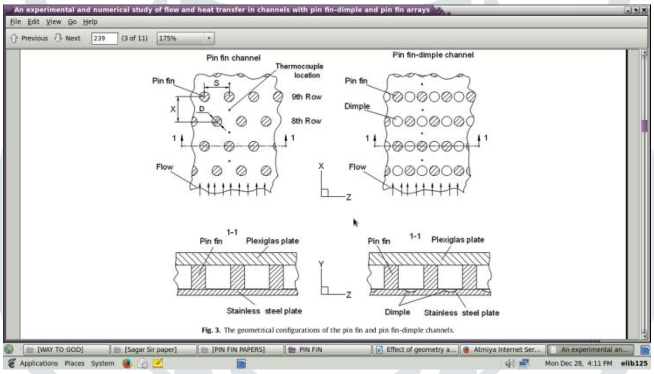

Fig: 7 the geometrical configurations of the pin fin and pin fin-dimple channels [11]

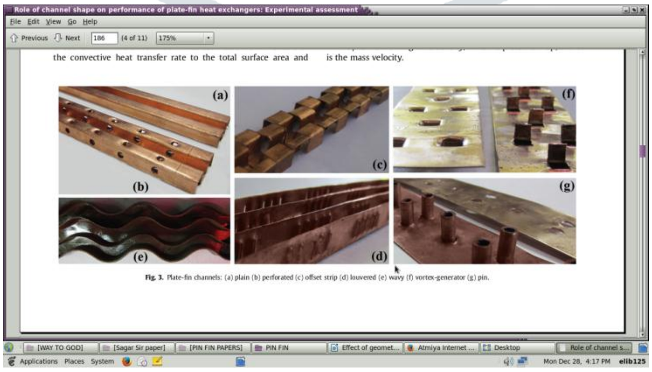

Fig: 8 Plate-fin channels: (a) plain (b) perforated (c) offset strip (d) louvered (e) wavy (f) vortex-generator (g) pin [11]

Colburn factor,

j = Nu / (Re (Pr) 1/3)

He highest values of the heat transfer coefficient and j factor are obtained by the vortex-generator, wavy, pin, offset strip, Perforated, louvered, and plain channels, respectively. Also, the greatest values of the pressure drop and f factor are acquired by the pin, vortex-generator, and wavy, offset strip, louvered, perforated, and plain channels, respectively. [11]

The influences of the seven geometrical parameters (wing height, wing width, channel length, longitudinal wings pitch, transverse wings pitch, wings attach angle, and wings attack angle) on the heat transfer and flow characteristics of copper water Nano fluids inside a plate-fin heat exchanger with vortex-generator channels was analyzed by a CFD approach. Three different values of the geometrical parameters were considered. The optimal geometry is obtained using a performance evaluation criterion, namely

The surface performance factor (i.e. Colburn factor to Fanning friction factor e j/f ratio). To validate the numerical results and detect the appropriate model for the prediction of nanofluids flow, experiments were carried out for the nanofluids in different nanoparticles weight fractions inside a reference model by using a precise fabricated experimental setup. The current study can provide some useful data to select the suitable working fluid and optimum geometrical parameters for use in a plate-fin heat exchanger with vortex-generator channels based on their specific applications. [12]

III. CONCLUSION:

After performing the review on bases of arrangement and Geometrical factors which are affecting on the heat transfer in heat exchangers.

1. Order of increasing the heat transfer rate in geometrical way is Wavy, triangular, staggered pin, continuous, interrupted rectangular (Lanced & Offset), and Inline Pin.
2. Increasing order of heat transfer rate in arrangements of pin fin is Plain, Perforated, Serrated, and Herringbone.
3. We can use inline pin fin in geometry and perforated or serrated arrangements for better heat transfer in heat exchanger.

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