INTERNATIONAL JOURNAL FOR INNOVATIVE RESEARCH IN MULTIDISCIPLINARY FIELD ISSN: 2455-0620 Volume - 7, Issue - 6, June – 2021
Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87 Impact Factor: 6.719
Received Date: 16/06/2021 Acceptance Date: 29/06/2021 Publication Date: 30/06/2021

CFD Analysis of Inclined Fin Array in Natural Convection

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Abstract: *Natural convection heat transfer analysis of rectangular inclined fin array was experimentally investigated. CFD analysis is conducted in order to establish effect of geometrical fin parameters for natural convection heat transfer from inclined rectangular fin arrays. Aluminum array with two different lengths viz. 100mm and 200mm were modeled. Convection heat transfer enhancement varies with fin height and fin length. Rectangular base was made incline from 0°to 90° keeping upward facing fins. The maximum heat input supplied is 100 W. It is observed that heat transfer rate does not change significantly for inclined fin arrays from vertical position to 10° inclination and from horizontal position to 80° inclination*

Keywords *– Natural convection, fin array, CFD.*

1. INTRODUCTION:

There is various ways to reject heat but simple way is use of fins or extended surfaces. It is observed that rectangular fins with different orientation viz. upward and downward better for electronics equipment. Solution for different inclined or facing heat sink is given in recent work. Effect of geometric parameters viz. fins height, fin length, aspect ratio and inclination over heat dissipation from heat sink is studied.

2. LITERATURE REVIEW:

B. Yazicioglu, H. Yuncu [1] concluded that the larger fin height results in higher convective heat transfer from fin array but for low base-to-ambient temperature difference it was insignificant. H. M. Mobedi, H. Yuncu [2] concluded that H/L ratio is governing parameter for fluid field and flow pattern. Burak Yazicioğlu and Hafit Yüncü [6] commented that the convection heat transfer rate from fins increases as fin spacing decreases, attains a maximum and then starts to decrease with the further decrease in the fin spacing..D.D.Palande et al[10] studied convective heat transfer of vertical plate and V fins.it is observed that V fin gives better enhancement than vertical fin. D.D. Palande, N.C. Ghuge et al[13] carry out heat transfer enhancement under assisting flow combined convection and found that for small velocity V fins gives better heat transfer rate than vertical fins.D.D.Palande,A. M. Mahalle[11] studied effect of angle of inclination and observed that the larger fin height results in higher heat transfer rate at constant fin spacing and fin length.Also it observed that small change in angle does not effect on heat transfer rate. Ilker Tari, Mehdi Mehrtash [3,4,5] they observed that for upward facing inclinations, the flow separation location plays an important role. Also, they found that the optimum fin spacing does not significantly change with inclinations suggesting the value as 11.75 mm. In this work, CFD analysis of inclined fin array and effect of angle of inclination under natural convection is carried out.

3. EXPERIMENTAL SEUP:

A schematic diagram of experimental set-up is shown in figure 1.The front surface of the frame is covered with acrylic sheet, which has arrangement to replace fin arrays. The experimental set-up consists of concrete base and supporting structure. The fin array is mounted on concrete block. Heater plate is placed between concrete block and fin array which is used for heating the aluminum fins. Five thermocouple is used to measure the base temperature of fin array. A volt meter and ammeter is used to measure the voltage and current, The entire assembly is mounted on single shaft which has bearing to rotate it for required angle of inclination protractor is used to measure inclination of the fin array

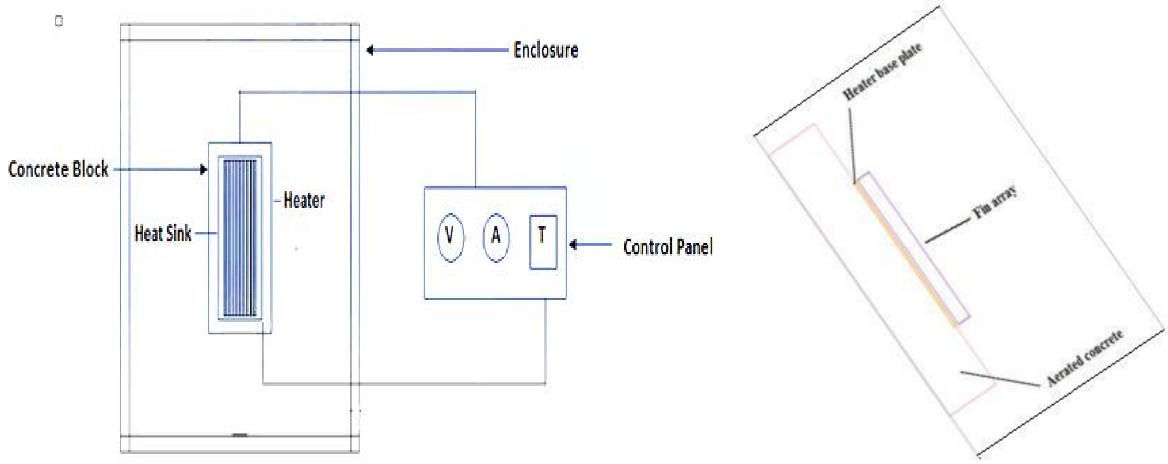

Figure. 1 Experimental set-up and Fin arrays[11]

Six different fin geometries made up of aluminium are modeled and mounted one by one over heater plate. Two fin length 200mm and 100mmwith fin width 180mm was modeled. The fin spacing was kept as 10mm and 7.5 mm for 200mm and 100mm length respectively. The fin height varies as 20, 40,60mm for 200mm length while 10mm, 20mm and 30mm for 100mm length as shown in fig. 1.The test section was kept in controlled room to establish free convection over fin arrays. The concrete block has good insulation capability and good thermal resistance.

4. CFD MODEL:

Two set of fin arrays with different fin height and optimized fin spacing, which has maximum heat transfer rate are analyzed by using FLUENT 14.0. A simplified model, as shown in figure 2, is created which consists of an aerated concrete block, a base plate for heat generation and fin array configuration

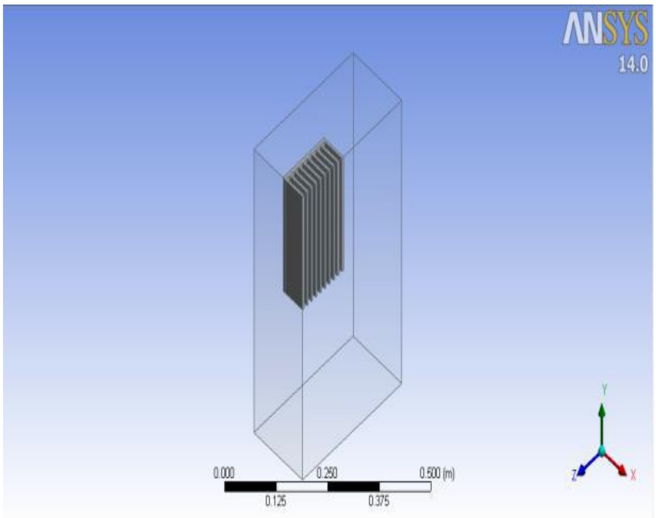

Figure 2 3-D model

In the model 250×200×100 mm concrete block is used as insulator over that fin model is mounted. The dimensions of heater plate are 200×180×5 mm for set-1 with heat sink length 200 mm and 100×180×5 mm for set-2 with heat sink length 100 mm. For both sets heater plate is buried 5 mm into the aerated concrete block to simulate the heat sink. The dimensions of the surrounding air are taken as 400×350×100 mm for set-1 with heat sink length 200 mm and 300×350×100 mm with heat sink length 100 mm. Bottom surface of model on which concrete block is mounted is taken as adiabatic wall and remaining enclosure wall is taken at ambient temperature Tabulated result of the analysis shows the comparison between total heat transfer rate obtained from FLUENT 14.0 and experimentally determined as shown in table 1

Table 1 Comparison of Total Heat Transfer Rate

Total Heat Transfer Rate (Qc)	
Experimental	**Ansys Fluent 14.0**
47.05	57.42
47.07	56.78
46.29	53.22
42.92	50.89
41.30	44.62
40.43	43.31
39.38	43.63

5. FLOW VISUALISATION:

5.1Variation in Flow type with angle of inclination

To show the variation of flow type with angle of inclination, the following fin configuration is taken. Fin height, H=60 mm Fin Length, L=200 mm Power input, Qin=60W. Effect of angle of inclination over streamline flow and thereby on natural convection heat transfer rate can be seen through Figure 3 and 4. Flow separation region, backflow region and chimney flow can be easily analysed by FLUENT

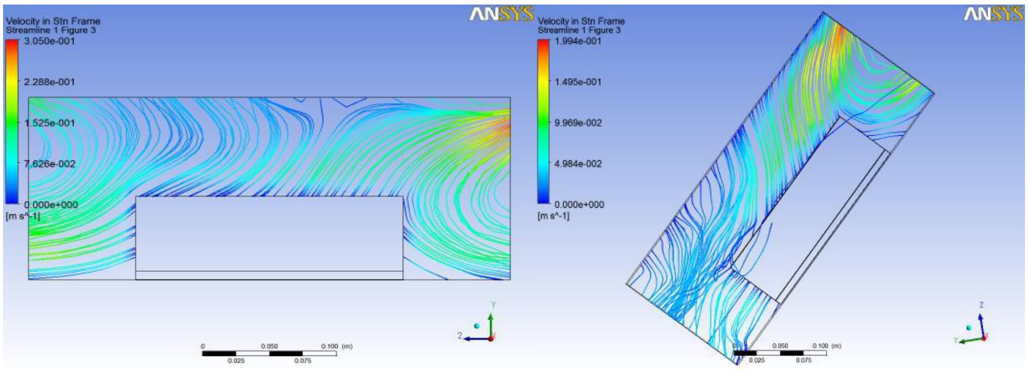

Figure 3 Streamlines for Horizontally (90°) oriented 45° inclined upward facing fins of Length L=200 mm and Height H=60 mm

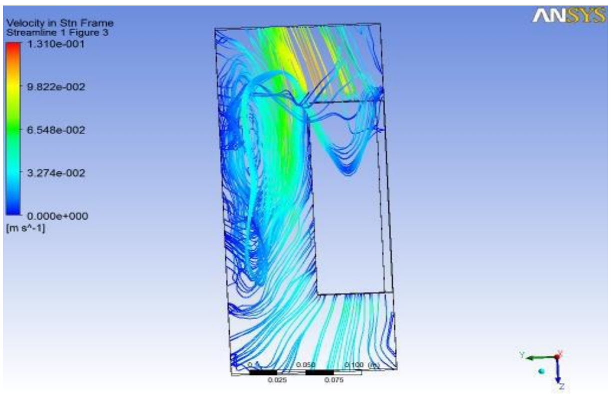

Figure 4 Streamlines for Vertically (0°) oriented upward facing fins of Length L=200 mm and Height H=60.

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5.2 Variation in Temperature with angle of inclination

To show the variation of temperature with angle of inclination, the following fin configuration is taken.Fin height, H=60 mm Fin Length, L=200 mm Power input,Qin=60W .Effect of angle of inclination over temperature distribution and thereby on natural convection heat transfer rate can be seen through Figure 5 and 6. Temperature distribution in domain and thus temperature contour is studied.

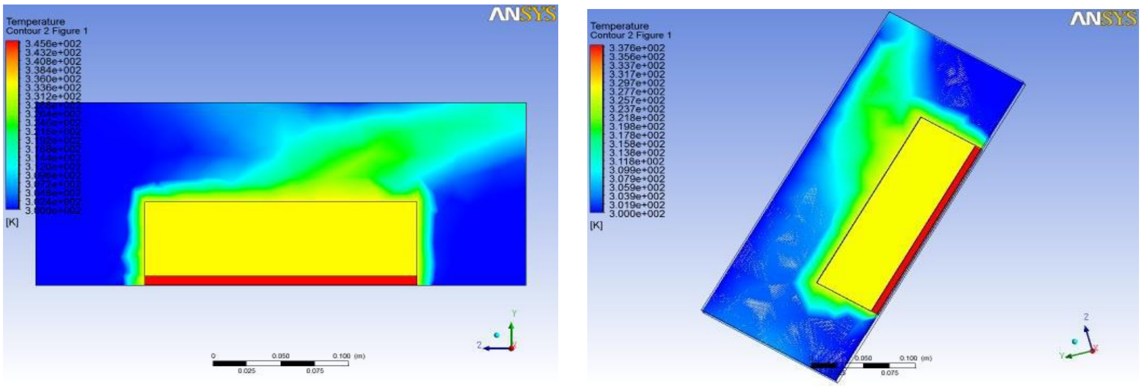

Figure 5 Temperature Contour for horizontally (90°) and45° inclined upward facing fins of Length L=200 mm and Height H=60 mm

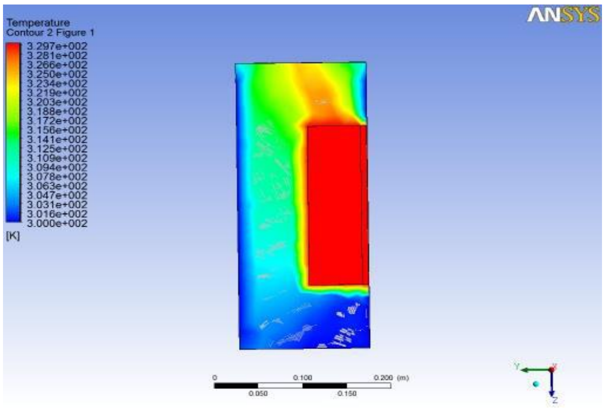

Figure 6 Temperature Contour for Vertically (0°) inclined upward facing fins of Length L=200 mm and Height H=60 mm

6. RESULT AND DISCUSSION:

Experimental study is followed by analysis of ANSYS FLUENT. Each component of the system (concrete block, heater base plate, fin array) is kept same for both the study. Also, certain identical assumptions are made for comparison. Comparison of total heat transfer rate value obtain in FLUENT software and by experimentation is shown through Figure 7 to 10. It is seen that experimentally calculated heat transfer rate and value obtained from FLUENT are in good agreement.

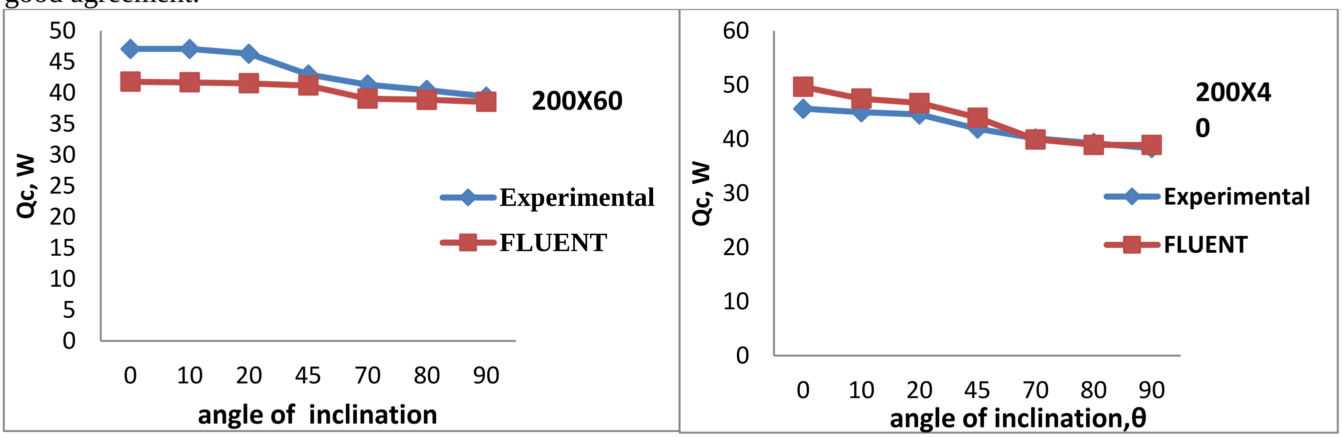

Figure 7 Comparison of Heat Transfer Rate value by experiment and FLUENT for Fin length L=200mm and Fin height H=60mm and H=40mm at 60W

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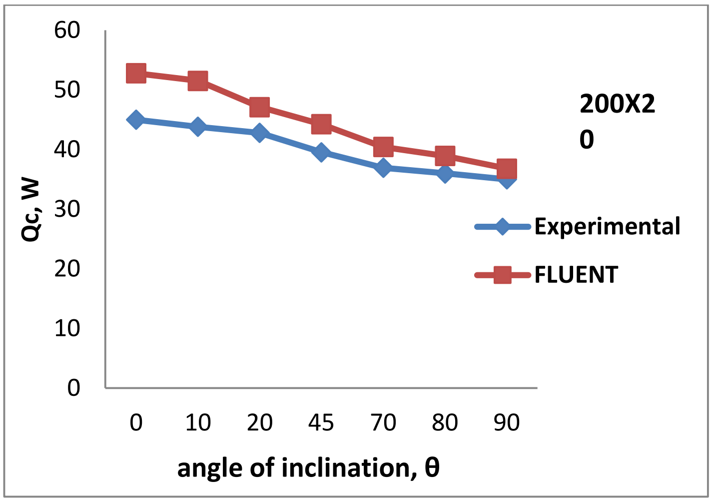
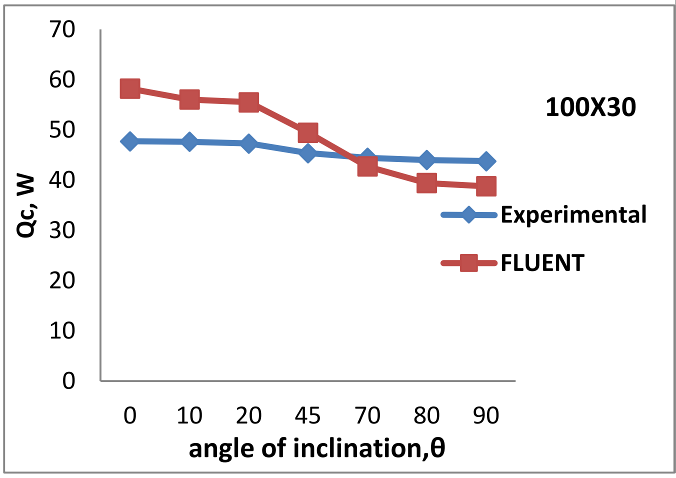


Figure 8. Comparison of Heat Transfer Rate value by experiment and FLUENT for Fin length L=200mm and Fin height H=20mm at 60W



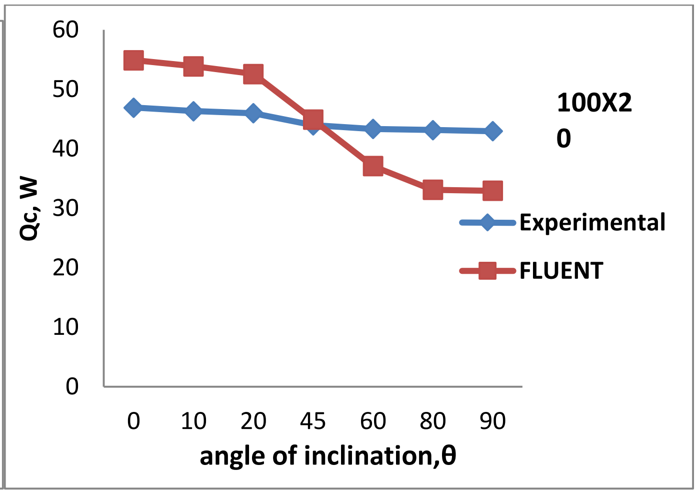


Figure 9. Comparison of Heat Transfer Rate value by experiment and FLUENT for Fin length L=100mm and Fin height H=30mm and H=20mm at 60W

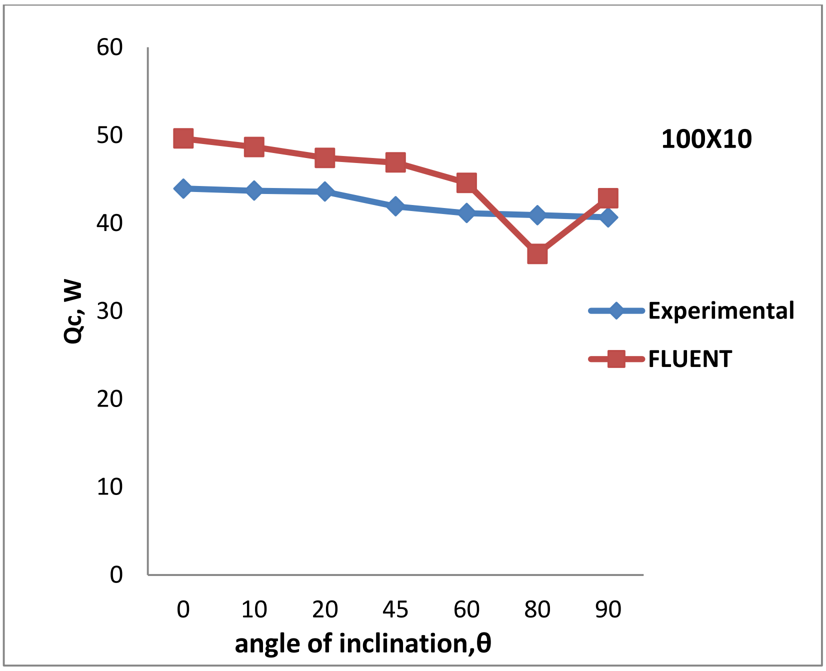


Figure 10. Comparison of Heat Transfer Rate value by experiment and FLUENT for Fin length L=100mm and Fin height H=10mm at 60W

As observed from Figure 7 to 10, the convection heat transfer rate from fin arrays depends on angle of inclination of fin array. Convective heat transfer decreases from vertical position (0°) to horizontal position (90°).

7. CONCLUSION:

Experimental and CFD analysis of 6 different fin configurations is done in ANSYS Fluid Flow FLUENT and Effect of angle of inclination is studied. It is observed that Larger fin height results in higher heat transfer rate at constant fin spacing and fin length. Also, decrement in heat transfer rate is more for large fin height, H=60 mm as fin array rotates from vertical (0°) to horizontal (90°) position. For inclination from vertical (0°) to 45°, heat transfer rate is maximum for fin length, L=200 mm and fin height, H=60 mm. Heat transfer rate does not change significantly for inclined fin arrays from vertical position to 10° inclination and from horizontal position to 80° inclination. CFD clarifies the air flow structure through each inclined fin arrays. Heat transfer rate decreases only due to separation of flow from fins and hence flow will observed as single chimney flow for horizontal position.

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