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Design and Evaluation of Perforated Fins with Different Array of Fins Structure by an Active Mode of the Cooling System

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Abstract

This research is based on Fin made of Aluminium AL-1060 in different geometries. The heat transfer analysis has been analysed and calculate average Nusselt number with decreasing order of inter-fin spacing ratio and increase in projected area. The design of Aluminium AL-1060 fins is enhanced the efficiencies with decrease in Reynolds number. Fins are made out of Aluminium AL-1060 in different geometries and heat transfer analysis is done. In order to calculate average Nusselt number consideration is given to the decrease in inter-fin spacing ratio and increase in projected area. Reynolds number, fin spaces (pitch) and fin height are influenced the heat transfer of Aluminium AL-1060. Experimental investigation shows optimal results at 42,000 Reynolds number, 100 mm fin height and 3.417 Sy/D pitch for minimal friction factor.

Keywords: *Aluminium AL-1060, Heat Transfer, Perforated fins, Reynolds number*

1.0 Introduction

In the field of engineering more than 50000 materials available for the study. During the research work it is very difficult to choose a material form vast availability of things for a required purpose. Disaster courses because of mistake. In the war of 1914, due to low toughness of welding the merchant ship is broken in the mid of sea this is not happen due to enemy but due to improper research or work. Lot of properties are required to studies by researcher during the selection and choosing of material. It may be found that many of the properties are unfamiliar these are considered as a first course of material. Amol B. Dhumne *et al.*[1] studied circular cross section perforated pin fin on a rectangular heat sink is studied with a parameter of pressure drop and heat transfer analysis. found that perforated fin has better performance than solid fins circular cross section fins. The efficiency of a system is depend upon the clearance ration and inter fin spacing ration. Lower the Reynolds number with a lower C/H ratio and spacing ratio. Bayram Sahinet[2] perforated square fins are used for analysis the performance of heat exchanger. The parameter used for analysis was Clearance Ration is 0.33, Reynolds number is in the range of 13500 to 42000. Length to width ratio is 1.208, 1.524, 1.944 and 3.147 result found that perforated

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square fin with fin aspect ratio 1.944 gives better heat transfer enhancement efficiency. The efficiency ratio is in the range of 1.1 to 1.9. Saad A. El-Sayed[3] the author studied the geometry of fins, flow of fluid, and pressure drop characteristics in the array of rectangular fin array. The geometric parameter are varies in the term of thickness, spacing between the fins, and number fin for the testing purpose. The flow rate is constant and the shroud clearance is no clearance in starting case after words it increases. Found that the Nusselt number fin increases with decrease in fin height and increasing the fin thickness, and inter fin space. Nusselt number decreases with increase in clearance between the tip to shroud at a aspect ratio is 1.25. R. Karthikeyanet *et al.*[4]**.** The rectangular duralumin flat surface heat sink with a cylindrical and square shape cross section fin is used. The pattern of array used is in-line and a staggered manner. The parameter used for analysis is clearance ratio, spacing between the fin, and Reynolds number are in varied form. The experimental results found that lower the spacing distance, clearance ration and higher the Reynolds number increases the higher heat transfer performance with staggered arrangement. Jeng[5] studied the heat transfer performance and pressure drop in a square fin array on rectangular heat sink with transient heat transfer system. It is found that Square fin array is better in result that circular pin fin array. During the performance the pitch value is plays a key role. Abdullah *et al.*[6] the researcher finds the optimal way of finding the fins material, size, and number of fins. He observed that triangular dimension perforation fin, fin thickness, solid counterpart, enhance the heat transfer rate and decreases the use of material. In a staggered arrangement lower fin distance ratio, lower Reynolds number, and lower clearance ratio enhance the heat transfer rate. Vanfossen[7] described staggered arrangement in a pin fins. Aspect ratio of fin is 4 is more heat transfer that aspect ratio of fin is 2. Eight row array fin is greater heat transfer than four row array. Over heat transfer is 35% more than end wall. Sunil[8] a circular profile fin with a rectangular heat sink has been investigated by computational fluid dynamics. Found that friction factor decreases with increase in Reynolds number. Giovanni[9] a rectangular channel equipped with array of diamond shape element is studied on a parameter of heat transfer and pressure drop. The aspect ratio of diamond was 4. The heat transfer is measured by liquid crystal thermography. Found that diamond shape heat transfer rate with constant mass flow rate is increased by 27% at aspect ratio is 4.4. Haq[10] found that ratio of spacing to diameter ratio in a transverse direction and in transverse direction is 1.63 for polytetra fluoranthene pin fin. Nitin Pawar *et al.*[11,12] this paper deals with the plus shape fins to enhance the heat transfer rate in LED bulb with aluminium as a heat sink of capacity 50 W. It found that 50 W capacity bulb surface temperatures is 38°C and concluded that more heat transfer rate than conventional fins. Mukhopadhyay[13] used Taguchi method to study the analysis process of a cold storage. Change in entropy during the expansion process in a refrigeration process and any cold storage system. Author proposed a mathematical model for a change in Entrophy using a L9 and L18 orthogonal array. Banerjee *et al.*[14] carried out heat transfer characteristic of an annular finned tube in different climatic condition. FLUENT tool is used for simulation and find the values of various parameter like heat transfer coefficient, heat flux, pressure drop. Computations were performed for perforations at 30° interval starting at ±60°, ±90°, ±120°, ±150°, and ±180° from the stagnation point. the fin q and h performance ratios increased by 5.96% and 7.07%, respectively. Found that pressure drop up to 11.87% and increase in heat flux and heat transfer coefficient is 1.70% and 2.23% respectively at 120^0 location provided in simulation tool. They studied passive heat transfer method in a solar air heater for heating purpose. Found that better performance in terms of cost that active system in solar heater. Kukulka[15]. In this paper transient mode of heat transfer on a flat surface. Rigidized Metals Corporation shows surfaces enhance heat transfer, minimize cost and save energy. Maroof *et al.*[16] studied compound cylindrical perforated pin fins on rectangular heat sink on the parameter of heat transfer analysis. The geometry of fin is 50% of 100 mm square and 50% of cylindrical. Re = 13500-42000, Clearance ratio is 0 to 0.33.

2.0 Experimental Setup

The below mentioned Figure 1 show that the block diagram of an Experimental set up with equipment like heater, blower fin plate and control panel etc.

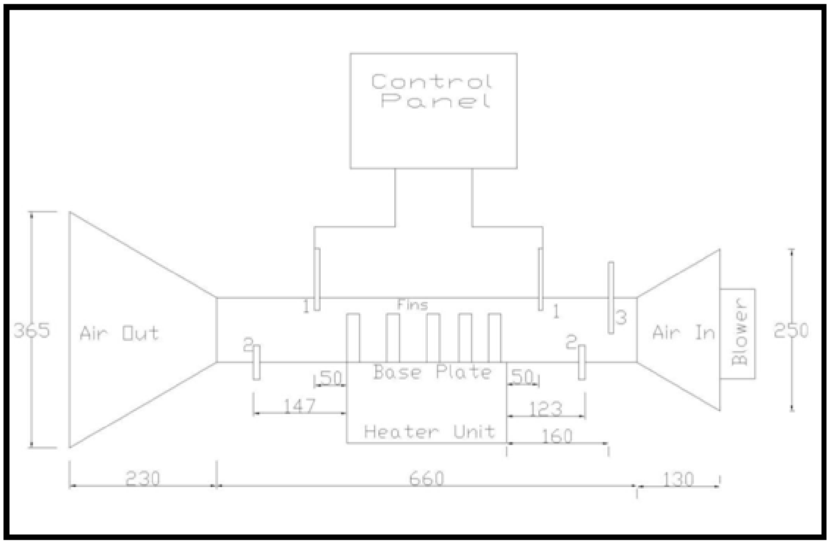


Figure 1. Block diagram of Experimental set up.

The specification of an equipment of a various part are mentioned are as follow

2.1 In Situ Duct

The range of is. The Figure 2, shows the duct image is used during a test set up.

Tunnel Specification:
width = 250 mm
the total length = 100 mm
Internal c/s of the channel = 1000 mm²
Power = 0.5 H. P
Speed = 13000 rpm
Reynold number = 12000 to 45000

Figure 2. Main Duct used in Experimental set up.

2.1.1 Heat Source

The area of cross section is 62500 mm². A electric heater is used with a 200 W capacity. Figure 3 shoes the image of a heater. The heater is 220 v with 10 amp current.

The details of a Heat source are defined in a Table 1 with a equipment used in experimental set up.

Figure 3. M. S plate electric hater of 200 W.

Table 1. Specifications of Heater Unit

Type	Flat
Capacity	2000watt
Heater plate	250x250mm
Plate Material	M.S.
Bed Insulation	Asbestos Blanket
Surrounding Insulation	Ceramic Wool

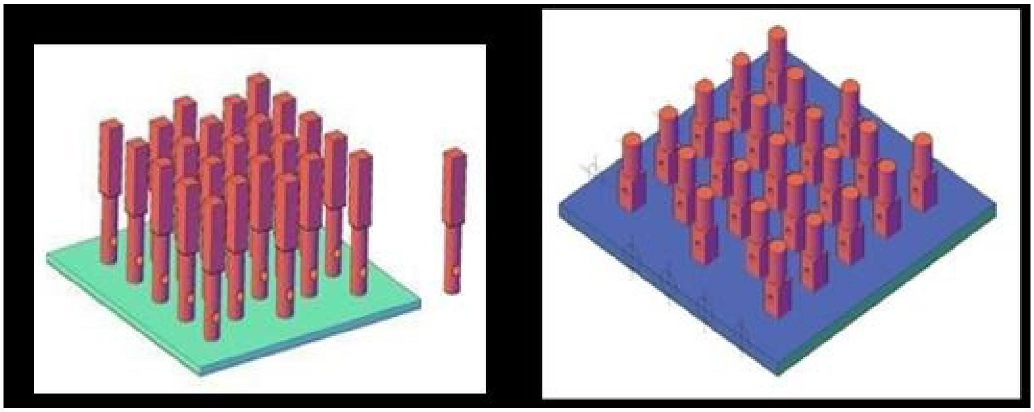


Figure 4. Staggered Fin on horizontal plate of CAD model.

Figure 5. Photographic view of actual fin base array.

2.1.2 Heat sink

The dimension of a plate is (250×250×6) mm. The material used is aluminium for study of all heat sink. The fins dimensions i.e., cross section area is (15×15×50) mm. cylindrical diameter shape is 15 mm. Figure 4 shows the image the fin array pattern used in an experiment.

The Below mentioned Table 1 and Table 2 gives the dimensional details of fins with number of quantity used in Experimental set up.

The below mentioned Table 3 gives the information of spacing between the two fins are also presented in the term of Sy/D ratio with a quantity of a fins used.

Table 2. Details of geometrical parameter of Fins

Sr. No.	Particular	Size	Quantity
1	Base Plate (Without Fins)	(250x 250) mm	01
2	Base Plate (With Fins)	(250x 250) mm	06
3	Perforated Fins	100 mm(Height)	108
4	Base Cylindrical Fins	100mm(Height)	54
5	Base Square Fins	100mm(Height)	54

Table 3. Stream wise distance ratio and number of fins on base plate

Sr No.	Sy/D	Number of fins
1	1.208	25
2	1.944	18
3	3.417	11

2.1.3 RTD Sensor

The sensor used in the Experimental set up is RTD sensor. The photographic view of a sensor is shown in Figure 5.

The sensor used in the Experimental set up is RTD sensor. The specification of a sensor given in Table 4.

Table 4. Specifications of the RTD Sensor

Type	PT 100
Range	0-450°c
Wire length	1 meters
Wire length	2 meters
Total	No.

3.0 Experimental Analysis

The various testing has been carried out at different condition and parameters at constant Sy/D = 1.208, Fins Geometry: Square Fins, Fin height = 100 mm, No. of fins = 25. The result of mentioned dimension fins given in Table 5.

The various testing has been carried out at different condition and parameters at constant Sy/D = 1.208, Fins Geometry: Cylindrical Fins, Fin height = 50mm No. of fins = 25. The result of mentioned dimension fins given in Table 6 and typical photographic view of RTD Sensor has been represented in Figure 6.

Figure 6. Photographic view of RTD Sensor.

Table 5. Testing result of fins at Sy/D result 1.208 of Square Fins

Sr. No.	Velocity(m/s)	(T_s)	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	29	53	1.012764	1.01277
2	3	100	30	50	1.01343	1.01271
3	4	100	30	52	1.012764	1.03102
4	5	100	30	50	1.01343	1.01257

Table 6. testing result of fins at Sy/D result 1.208 of Cylindrical fins

Sr. No.	Velocity(m/s)	Ts	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	28	55	1.0131	1.0182
2	3	100	29	52	1.0131	1.0182
3	4	100	29	54	1.0164	1.012033
4	5	100	29	52	1.0164	1.01322

Table 7. Testing result of fins at Sy/D result 1.944 of Square Fins

Sr. No.	Velocity(m/s)	(T_s)	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	29	53	1.012764	1.0130338
2	3	100	30	52	1.01296	1.01257
3	4	100	30	51	1.01296	1.01292
4	5	100	29	50	1.01296	1.013243

Table 8. Testing result of fins at Sy/D result 1.208 of Cylindrical fins

Sr. No.	Velocity(m/s)	(T_s)	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	30	49	1.0112	1.01188
2	3	100	30	52	1.0112	1.01653
3	4	100	28	50	1.0146	1.01653
4	5	100	29	49	1.0146	1.01351

Table 9. Testing result of fins at Sy/D result 3.417 of Square Fins

Sr. No.	Velocity(m/s)	(T_s)	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	30	44	1.0146	1.01188
2	3	100	30	42	1.0112	1.01188
3	4	100	29	41	1.0131	1.01032
4	5	100	31	40	1.0098	1.01032

Table 10. Testing result of fins at Sy/D result 3.417 of Cylindrical fins

Sr. No.	Velocityy (m/s)	(T_s)	(T_{in})	(T_{out})	Inlet Pressure (P_{in} N/m^2)	Outlet Pressure (P_{out} N/m^2)
1	2	100	29	43	1.0146	1.01188
2	3	100	29	42	1.0112	1.01188
3	4	100	29	42	1.0131	1.01032
4	5	100	29	43	1.0098	1.01032

The various testing has been carried out at different condition and parameters at constant Sy/D = 1.944, Fins Geometry: Square Fins, Fin height = 100mm, No. of fins = 18. The result of mentioned dimension fins given in Table 7.

The various testing has been carried out at different condition and parameters at constant Sy/D = 1.944, Fins Geometry: Cylindrical Fins, Fin height = 50mm No. of fins = 18. The result of mentioned dimension fins given in Table 8.

The various testing has been carried out at different condition and parameters at constant Sy/D = 3.417, Fins Geometry: Square Fins, Fin height = 100mm, No. of fins =11. The result of mentioned dimension fins given in Table 9.

The various testing has been carried out at different condition and parameters at constant Sy/D = 3.417, Fins Geometry: Cylindrical Fins, Fin height = 50mm No. of fins = 11. The result of mentioned dimension fins given in Table 10.

The mentioned equation No 1 is used to calculate the Nusselt Number of a working Fluid.

$$Nu(p2) = 45.99Re\text{^}0.396 \times (1 + C/H)\text{^} - 0.608 \times (Sy/D) - 0.522 \times Pr\text{^}0.33 \quad (1)$$

Table 11. Calculation reading of an experimental set up with Square fins and circular fins at Sy/D = 1.208

	Nu/Nus2	Nu/Nus3	Nu/Nus4	Nu/Nus5	Re2	Re3	Re4	Re5	F2	F3	F4	F5	n2	n3	n4	n5
Base Square	24.30	21.32	18.96906	17.93052	16836.43	25632.26	34176.35	42091.09	1.047651	1.011478	0.987442	0.970395	1.592217	1.36979	1.235737	1.146937
Base Cylindrical	24.3001	21.3002	19.16644	17.98	16836.43	25632.26	34176.35	42091.09	1.047651	1.011478	0.987442	0.970395	1.592217	1.36979	1.235737	1.146937

Table 12. Calculation reading of an experimental set up with square shaped fin and circular fin at Sy/D = 1.944

	Nu/Nus2	Nu/Nus3	Nu/Nus4	Nu/Nus5	Re=2	Re=3	Re=4	Re=5	F2	F3	F4	F5	n2	n3	n4	n5
Base Square	20.6339	18.1231	16.61112	15.88231	16836.43	25254.65	33203.29	42091.09	1.02802	0.993758	0.971282	0.952213	1.622545	1.40338	1.27364	1.168784
Base Cylindrical	18.38398	16.14694	14.88236	13.98725	17337.03	26005.55	34674.06	42091.09	1.005387	0.971878	0.948783	0.933532	1.637665	1.416395	1.277781	1.192115

Table 13. Calculation reading of an experimental set up with square shaped fin and circular fin at Sy/D = 3.417

	Nu/Nus2	Nu/Nus3	Nu/Nus4	Nu/Nus5	Re=2	Re=3	Re=4	Re=5	F2	F3	F4	F5	n2	n3	n4	n5
Base Square	13.69545	12.02893	11.02356	10.42003	17337.03	26005.55	34176.35	42091.09	0.960272	0.928267	0.907305	0.891641	1.714411	1.482772	1.344603	1.247981
Base Cylindrical	13.84006	12.15595	11.13827	10.42003	17337.03	26005.55	34176.35	42091.09	0.960272	0.928267	0.907305	0.891641	1.637665	1.416395	1.277781	1.192115

The below mentioned equation No 2 is used to calculate the Renault Number of a working Fluid.

$$Re = \mathrm{Dh} * \mathrm{U}/\mathrm{v} \tag{2}$$

The mentioned equation No 3 is used to calculate the Efficiency of a Experimental set up.

$$\eta = \frac{ha}{hs} = 51.09Re^{-0.358} \times \left(1+\frac{c}{h}\right)^{0.1028} \times \left(\frac{Sy}{D}\right)\hat{}0.0812 \tag{3}$$

By using above mathematical equation 1, 2 and 3, the following calculation has been done by using an reading from testing result of Table 5. It shows the Nusselt number, reynold number, friction force and efficiency of a square shaped fin and circular fin in Table 11.

The below calculation has been done by using an observation Table 6. The Table 12 shows the Nusselt number, reynold number, friction force and efficiency of a square shaped fin and circular fin at Sy/D = 1.944.

The calculation has been done by using an observation Table 7. The Table 13 shows the Nusselt number, reynold number, friction force and efficiency of a square shaped fin and circular fin at Sy/D = 3.417.

3.1 Taguchi Method

The Taguchi method approach to optimization of process parameters like quality, productivity and performance in the aspect of the process. It is an offline quality control method to improve the quality of a product. The analysis of variance (ANOVA) is employed to investigate the thermal performance of an experimental set up.

Table 14. Estimated Model Coefficients for SN ratios

Term	Coef	SE Coef	T	P
Constant	-64.216	0.00777	-8264.74	0.000
Sy/D=1.208	-1.9227	0.009828	-195.628	0.000
Sy/D= 1.944	-0.819	0.009828	-83.327	0.000
Re= 16000	1.2601	0.009828	128.208	0.000
Re= 25000	-0.1516	0.009828	-15.426	0.004
Pr =0.69	-0.0124	0.007371	-1.685	0.234
(1+C/H) =1.00	0.0124	0.007371	1.685	0.234

Table 15. Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Sy/D	2	35.6517	35.6517	17.8259	41010.03	0.000
Re	2	8.5181	8.5181	4.259	9798.32	0.000
Pr	1	0.0012	0.0012	0.0012	2.84	0.234
(1+C/H)	1	0.0012	0.0012	0.0012	2.84	0.234
Residual Error	2	0.0009	0.0009	0.0004	-	-
Total	8	44.1731	-	-	-	-

Table 16. S/N ratio evaluation for most influencing parameters

Level	Sy/D	Re	Pr	(1+C/H)
1	-66.13	-62.95	-64.22	-64.2
2	-65.03	-64.36	-64.2	-64.22
3	-61.47	-65.32		
Delta	4.66	2.37	0.02	0.02
Rank	1	2	4	3

Table 17. Table for Means response

Level	Sy/D	Re	Pr	(1+C/H)
1	2039	1439	1717	1669
2	1795	1694	1654	1687
3	1191	1892		
Delta	848	453	63	18
Rank	1	2	3	4

Taguchi Design:
Taguchi Orthogonal Array
L9 (3^4), Factors: 4, Runs:9, Columns of L9 (3^4) Array, 1 2 3 4
Taguchi Analysis: Nu versus Sy/D, Re, Pr, (1+C/H)

The following Table 14 gives a reading of a model coefficients model for SN ratio the analysis of Taguchi method.

The following Table 15 gives a reading of a variance coefficients model for SN ratio the analysis of Taguchi method.

The following Table 16 gives a reading of a variance coefficients model for SN ratio the analysis of Taguchi method.

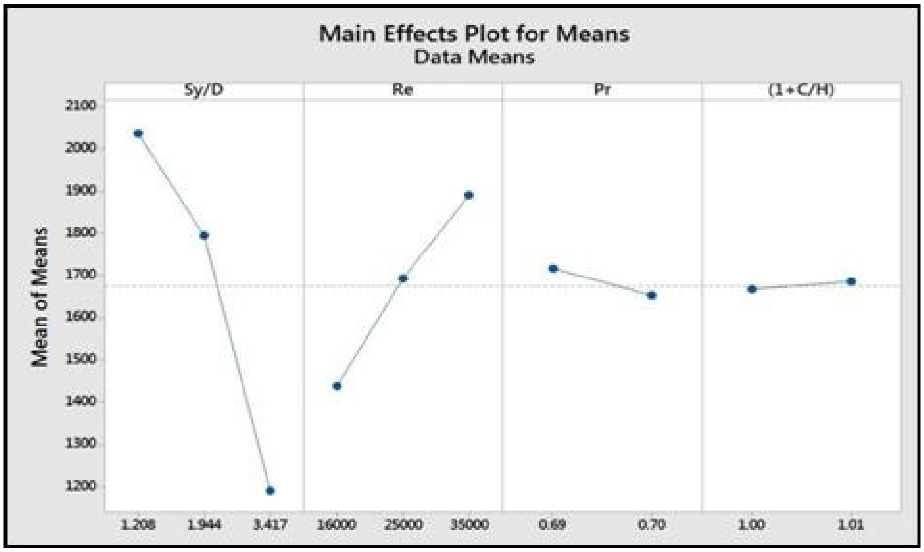
The following Table 17 gives a reading of a mean values for a SN ratio the analysis of Taguchi method.

The following Graph 1, gives a graph of a mean values for a means ratio by the analysis of Taguchi method.

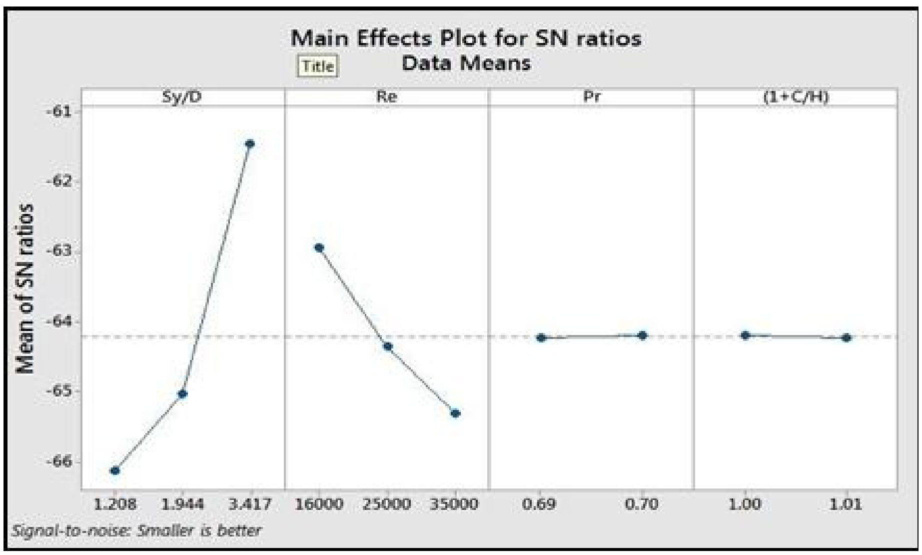
The following Graph 2, gives a graph of a mean values for a SN ratios by the analysis of Taguchi method.

Table 18. Values of Variance in regression analysis

Parameter	DF	Adj SS	Adj MS	F	P
Regression	4	1454148	363537	109.23	0.000
Sy/D	1	1139706	1139706	342.44	0.000
Regression	1	305772	305772	91.87	0.001
Pr	1	8018	8018	2.41	0.196
(1+C/H)	1	652	652	0.2	0.681
Error	4	13313	3328		
Total	8	1467461			



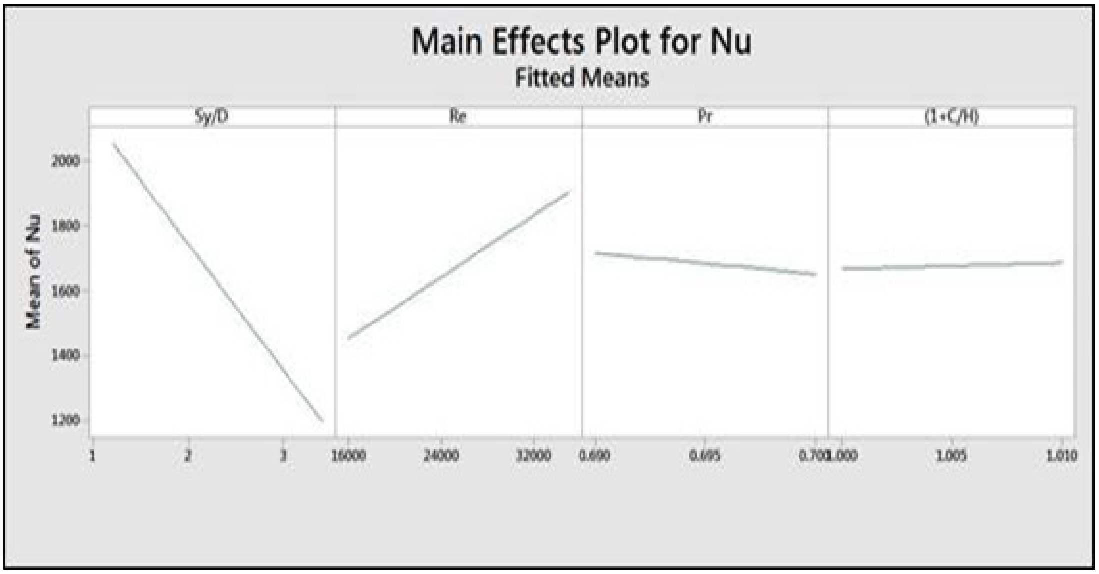
Graph 1. Main Effects Plot for Means.



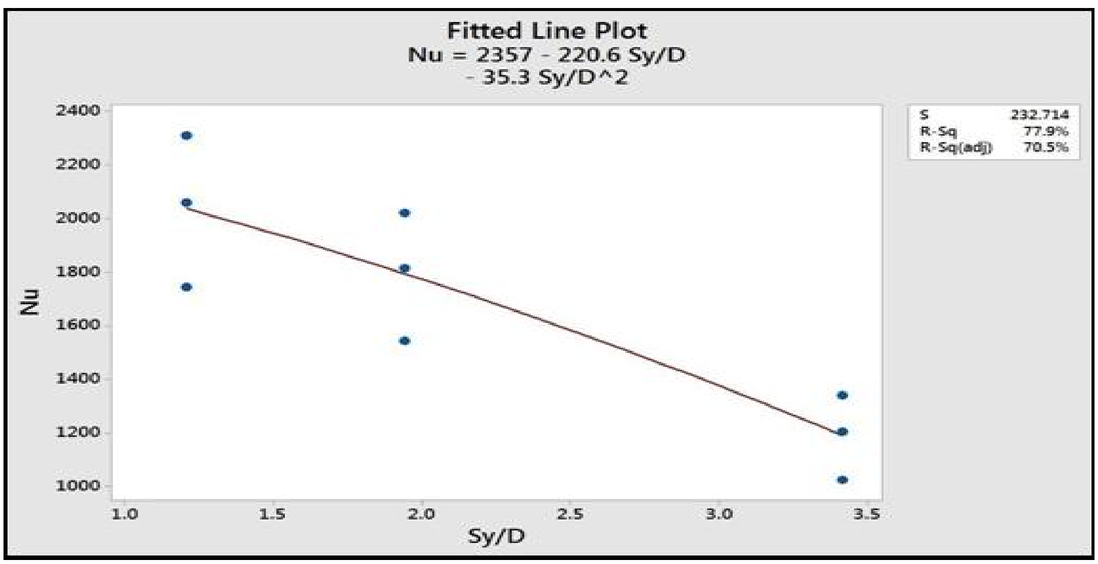
Graph 2. Parametric representation of signal to noise ratio.

Table 19. Regression Analysis

Term	Coef	SE Coef	T	P	VIF
Constant	4522	4984	0.91	0.416	
Sy/D	-387.5	20.9	-18.51	0	1
Re	0.02375	0.00248	9.59	0.001	1
Pr	-6332	4079	-1.55	0.196	1
(1+C/H)	1805	4079	0.44	0.681	1



Graph 3. Main Effects Plot for Nu.



Graph 4. Fitted Line: Nu versus Sy/D.

The Following Table 18 gives the information of a regression analysis in the parameter of Nusselt number, Sy/d ratio, prandtl number, and (1+CH) value.

The Following Table 19 gives the information of a regression analysis in the parameter of S-57.6908, R-sq - 99.09%, R-sq(adj) - 98.19%, R-sq(pred) -93.56%. The equation used in regression analysis is used is mentioned below as equation Number 4.

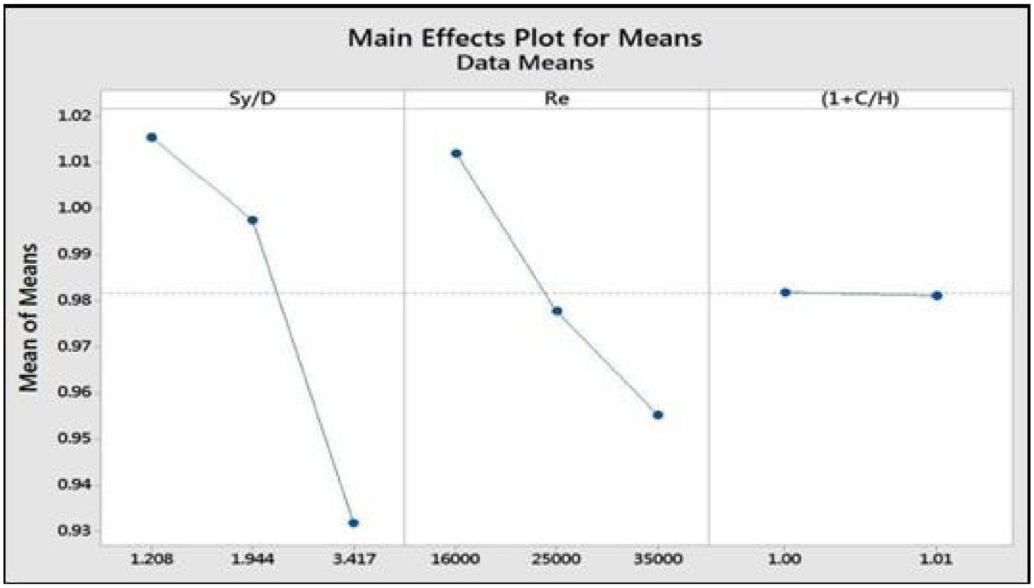
$$Nu = 4522 - 387.5\ Sy/D + 0.02375\ Re - 6332\ Pr + 1805\ (1+C/H) \quad (4)$$

The following Graph 3 gives a graph of a mean values of nusselt number and parameter Sy/D, Reynold number, Prandtle number, (1+C/H) by the analysis of Taguchi method

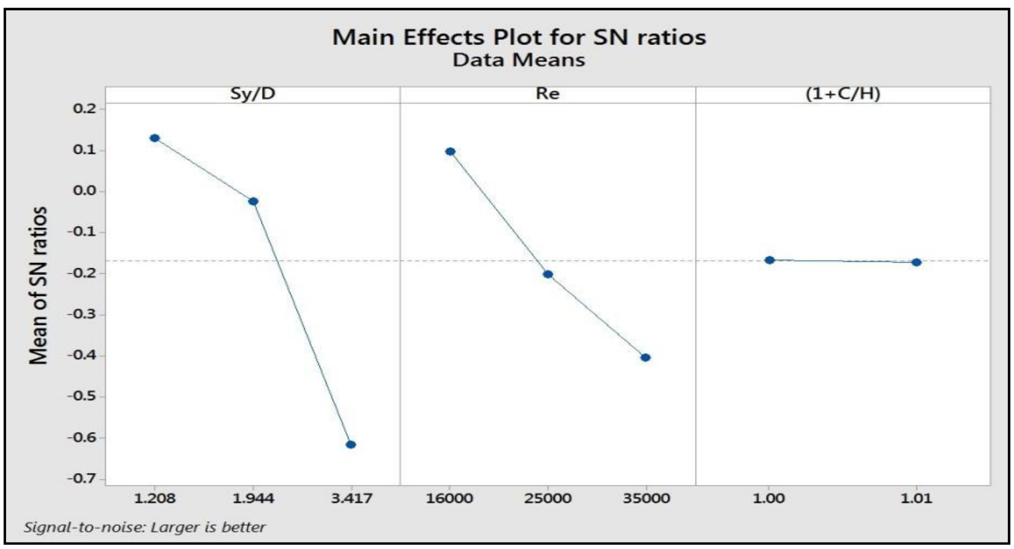
The following Graph 3, plotted the value between Nusselt number and Sy/D ratio. The relation is defined between the two variable mentioned in the equation No. 05 and equation number 06, the mathematical relation is used for plotting the below Graph 4.

The regression equation is

$$Nu = 2357 - 220.6\ Sy/D - 35.3\ Sy/D^2 \quad (5)$$



Graph 5. Main Effects Plot for Means.



Graph 6. Parametric representation of signal to noise ratio.

Table 20. ANOVA for Friction Factor (F)

Source	DF	Adj SS	Adj MS	F	P
Regression	3	0.016205	0.005402	86.45	0.000
Sy/D	1	0.011431	0.011431	182.95	0.000
Re	1	0.004773	0.004773	76.38	0.000
(1+C/H)	1	0.000001	0.000001	0.02	0.903
Error	5	0.000312	0.000062		
Total	8	0.016518			

Table 21. Coefficients for Friction Factor (F)

Term	Coef	SE Coef	T	P	VIF
Constant	1.214	0.561	2.16	0.083	
Sy/D	-0.03881	0.00287	-13.53	0	1
Re	-0.000003	0	-8.74	0	1
(1+C/H)	-0.071	0.559	-0.13	0.903	1

Table 22. Response Table for Means Effectiveness

Level	Sy/D	Re	(1+C/H)
1	0.399	1.643	1.449
2	1.433	1.419	1.447
3	0.514	1.284	
Delta	0.115	0.359	0.002
Rank	2	1	3

S = 232.714 R-Sq = 77.9% R-Sq(adj) = 70.5% (6)

The following graph 5, plotted the value between Means of means versus Sy/D ratio, Reynolds number, and (1+C/H). That the variation in (1+C/H) and Means of Mean values is constant.

The following graph 6, plotted the value between Means of SN ratio versus Sy/D ratio, Reynolds number, and (1+C/H). That the variation in (1+C/H) and Means of Mean values is constant.

Regression analysis is done using the parameter friction force using Tougachi Method. The table is created between parameter like friction force, Sy/D ratio, Reynolds Number, (1+C/H) which is shown in Table 20, 21, 22.

The Table 20 shows a value of Variance for Friction Factor in various parameter noted a pressure value is identified only on (1+C/H) parameter.

The Table 21, shows a value of coefficients of friction factor in various parameter noted a pressure value is identified on (1+C/H) and constant parameter. The model specification is S - 0.0079046, R-sq - 98.11%, R-sq(adj) -96.97%, R-sq(pred) - 93.90%.

The Table 22 shows a value of mean effectiveness by using equation number (7) with a parameter Sy/D, Reynold number, (1+C/H).

F = 1.214 - 0.03881 Sy/D - 0.000003 Re - 0.071 (1+C/H) (7)

4.0 Results and Discussion

4.1 Heat Transfer

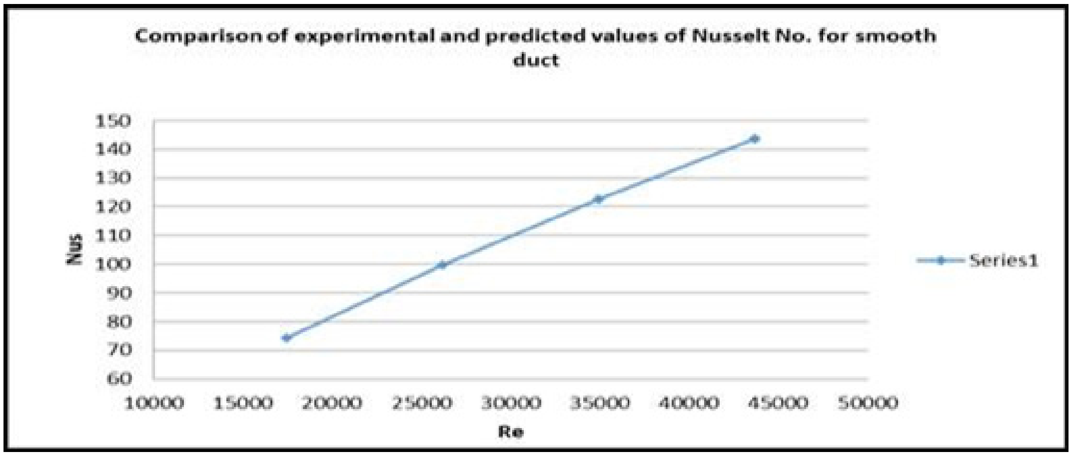
Graph 7, shows the Nu/Nus based on the sink area, Reynolds number is used as function for the three different pin fin Spacing i.e., Sy/D = 1.208, 1.944, 3.417. It is seen from this Graph that Nu/Nus increases with decreasing Fin Spacing. As the surface area increases with increasing Number of the fins, Nusselt number also increases.

4.1.1 Experimental Work

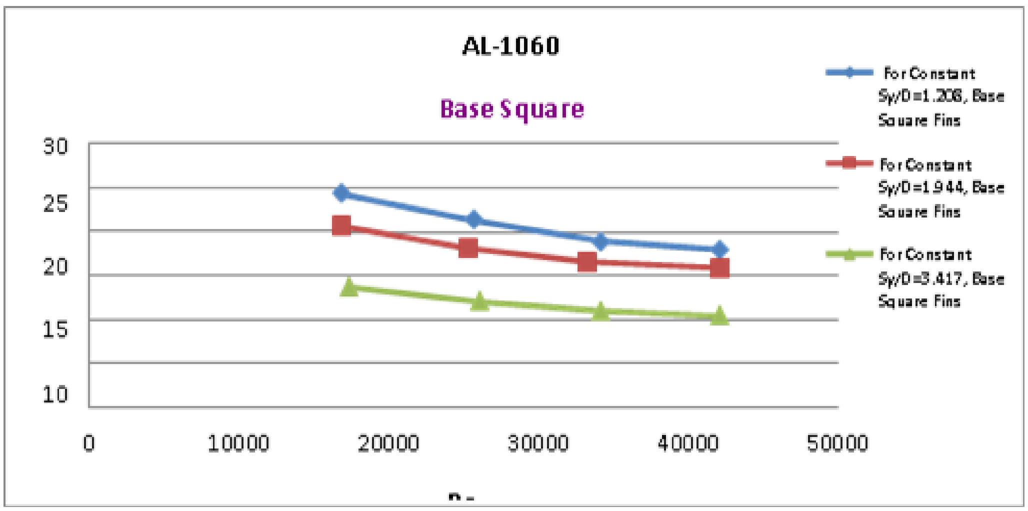
The graph 8, define the comparison of fins at various Sy/D ratio found that Fins with Sy/D ratio = 1.208 is better performance than other to ration.

The graph 9, define the comparison of cylindrical fins at various Sy/D ratio found that Fins with Sy/D ratio = 1.208 is better performance than other to ration, the material used for aluminium is AL-1060.

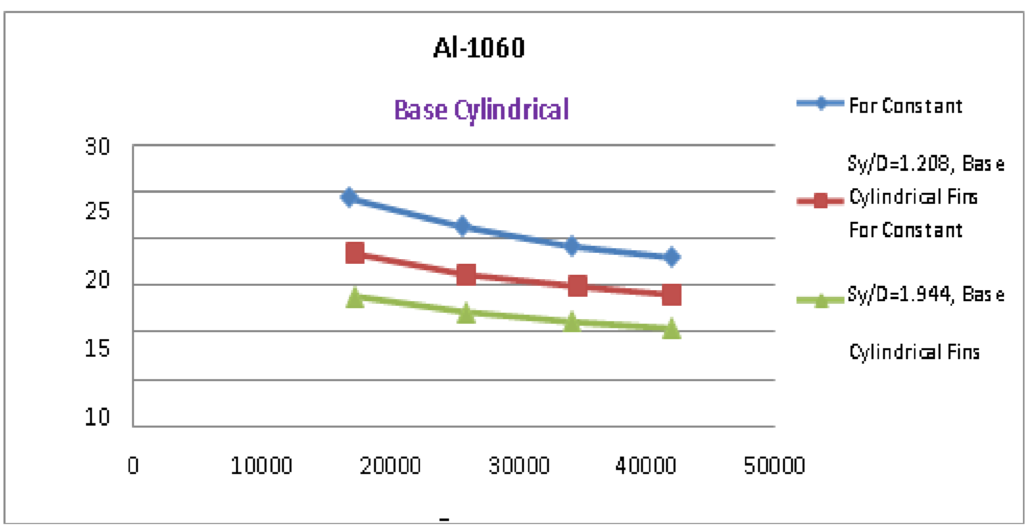
The Nusselt number is function of sink area and pattern of flow will reflect the effect of the variation. Heighted fins also enhance the turbulence of the flow in



Graph 7. Nusselt number analysis for a smooth duct.



Graph 8. Variation of Nu/Nus based on Projected area with Reynolds No. at Sy/D = 1.208 for Base Square.



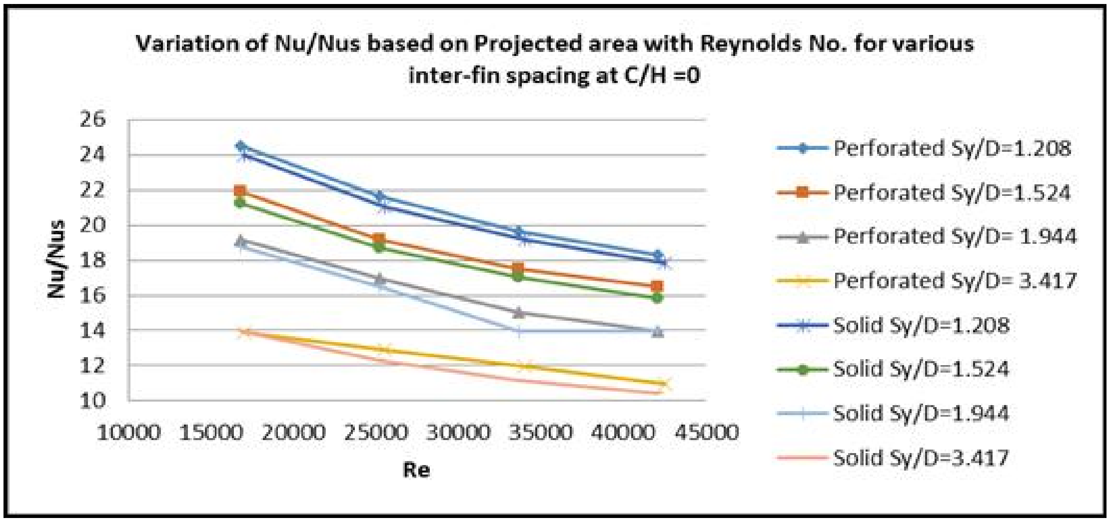
Graph 9. Parametric variation of base cylinder.

the channel, increase in the heat transfer. It shown from Graph 8 and 9 that due to the multiple jet-spray flows. It is found that perforated fin has greater heat transfer than solid fins.

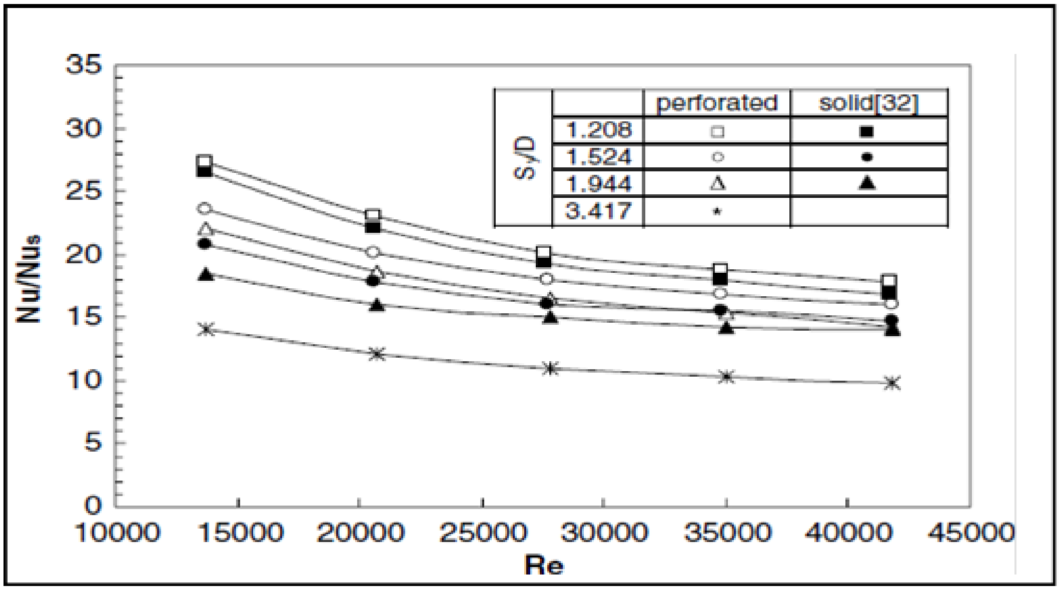
4.1.2 Reference Work

Graph 10 and 11 shows the relation of the Nu/Nus is depending upon of the duct Re and Sy/D. Sy/D ratio and fin numbers is inversely proportional to each other. Number of fins increases with increase in the total heat transfer area which increases Nu/Nus. Due to increase in surface area as well as jet impingement to next fin hence conclude that Perforated fins more efficient than solid fins.

Friction Factor in Projected work with Reynolds number for different inter-fin space ratios (Sy/D) at C/H = 0 are given in Graph no 10 and 11 respectively. It can be seen from Graph 12, 13 and 14 that the friction factor increases with decreasing Sy/D Ratio. Because the Number of pin fins increases with decreasing Sy/D Ratio, the by-pass area over the fin tips decreases. Thus, resistance against to the flow increases.

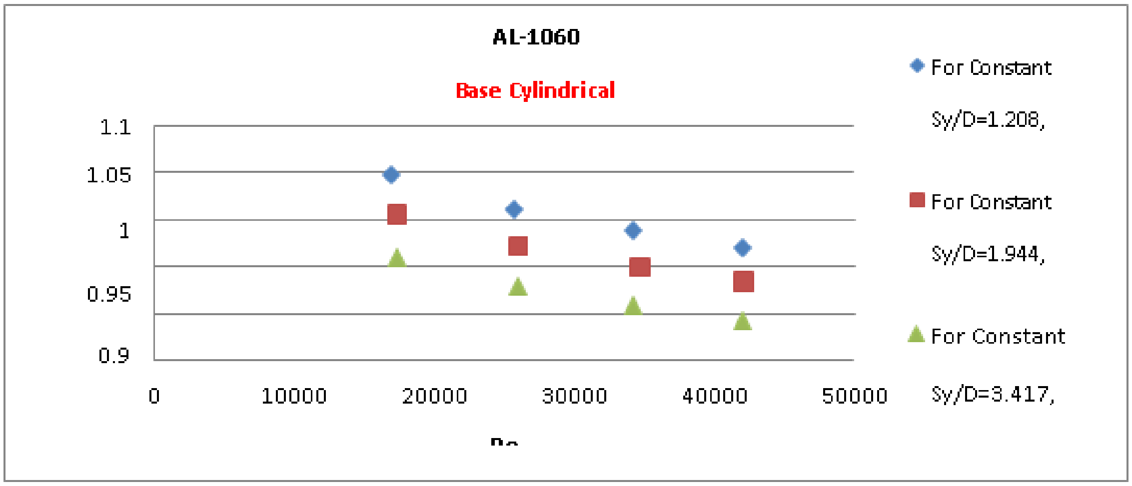


Graph 10. Variation Re Vs. Nu/Nus for Cylindrical fin.

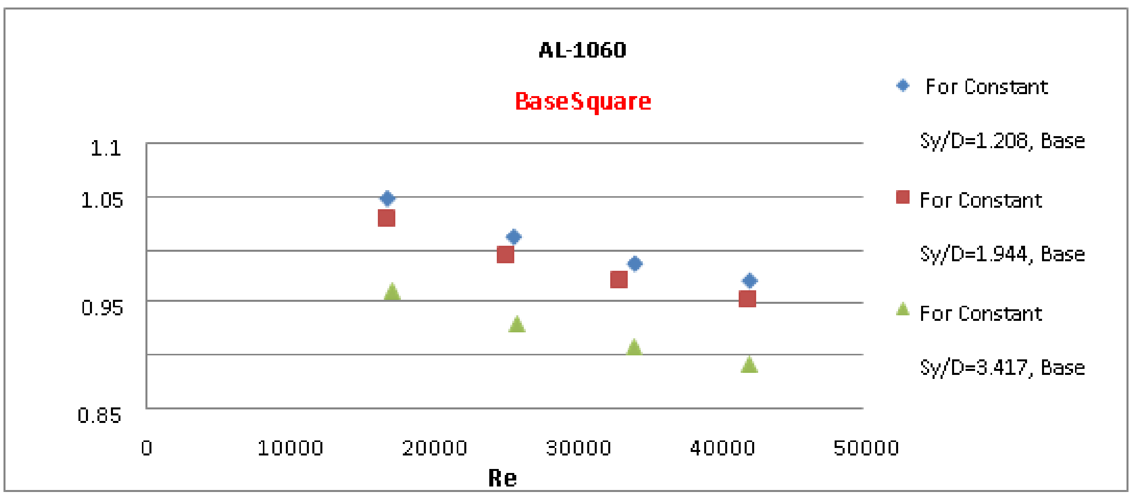


Graph 11. Variation Re Vs. Nu/Nus of Square Fins.

4.1.3 Projected Work



Graph 12. Variation Re Vs. friction factor for Cylindrical Fin.



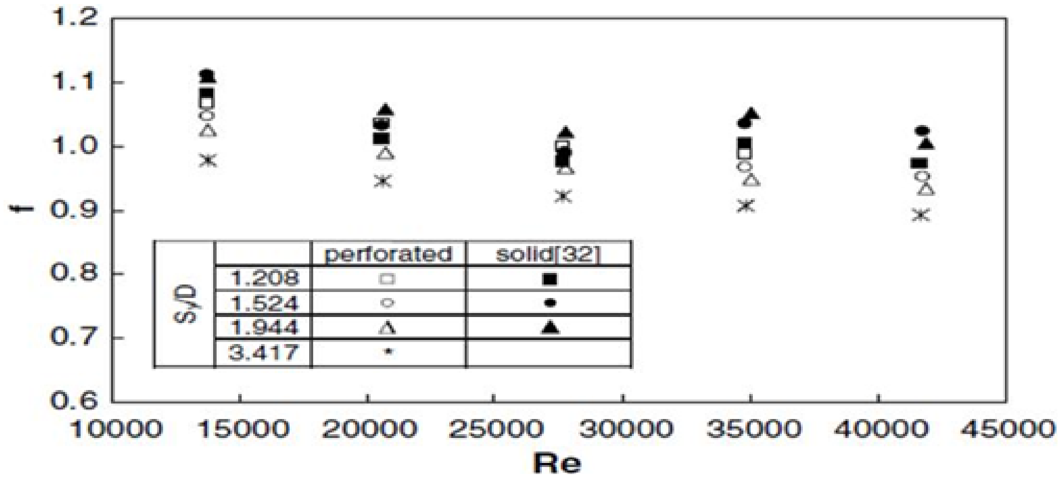
Graph 13. Variation Re Vs. friction factor of Square Fins.

4.1.4 Reference work

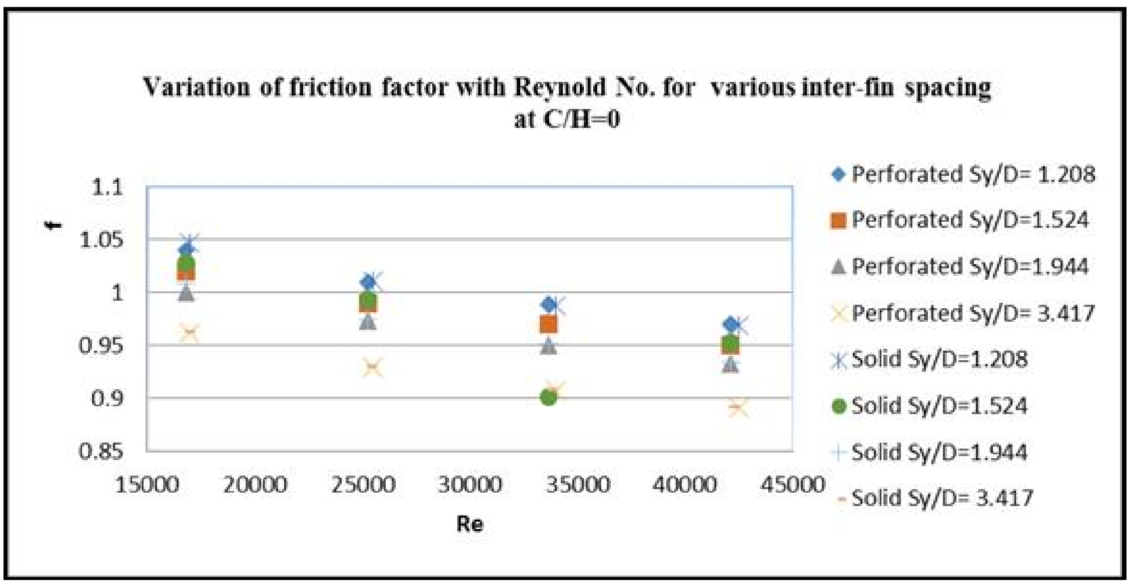
F are not related to the Re. Fin heat exchanger effected more stream wise distance than a span wise distance. Perforated fins reduces the resistance of flow. Hence state that due to less in flow resistance friction factor is less in perforated fin than solid fins.

The graph 15, shows that the perforation of fins is inversely proportional to friction factor with Reynolds number. Found that Perforated fin Sy/D ratio 3.417 has the better result than other perforated and solid fins.

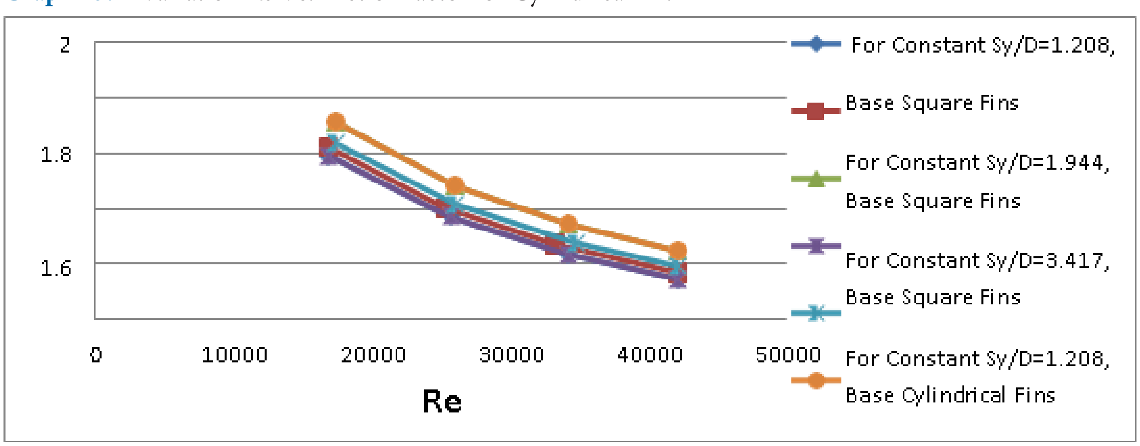
The enhancement in the efficiency is shows in the graph 16. With consideration of inter-fin distance ratio. The value of g is always greater than 1 for net energy gain. Reynolds number increase the efficiency of system decreases at same inter-fin spacing ratio. Same as with Sy/D ratio also. Lower the inter fin distance and spacing ration enhance the heat transfer performance.



Graph 14. Variation Re Vs. friction factor of Square Fins.



Graph 15. Variation Re Vs. friction factor for Cylindrical fin.



Graph 16. Variation Re Vs. enhancement efficiency (g) for various inter-fin spacing ratios.

5.0 Conclusions

Friction factor and the various design parameters effect on the heat transfer for the heat equipment with cylindrical cross-sectional perforated pin fins were surmised by Taguchi method and experimental method. The effects of the flow and heat transfer performance are observed. The following observations are:

- Fin is made out of Aluminium AL-1060 in different geometries and heat transfer analysis is done. In order to calculate average Nusselt number consideration is given to the decrease in inter-fin spacing ratio and increase in projected area.
- Due to decreased inter-fin spacing ratio, friction factor increased as per design.
- The design of Aluminium AL-1060 fins is such that Enhancement efficiencies increase with decrease in Re. Re led to an enhancement in the heat transfer rate. .
- Aluminium AL-1060 with different inter-fin spacing, different shapes and heights has been designed such that a significant increase in heat transfer rate.
- Using Aluminium AL-1060 we designed fins, one with base square while other with cylindrical base. In both the types of fins the same optimum results were obtained at 42,000 Reynolds number, 100 mm fin height and 3.417 Sy/D pitch.
- The most effective parameter on the friction factor was found to be number of fins mounted on base plate. When all the goals were taken into account togather the trade-off among goals was considered and the optimum results were obtained at 42,000 Reynolds number, 100 mm fin height and 3.417 Sy/D pitch.

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