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Experimental Analysis of Convective Heat Transfer from Plate Fin Array on a Exhaust Pipe of EGR System

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Abstract- **In this research, experimentally investigate convection heat transfer of Exhaust Gas Recirculation system with an array of square fins and fin spacing of 10, 20, and 30 mm and fin height 5mm,10 mm,15 mm. By changing the surface temperature by varying the input power of the heating element.To measure the temperature of various points on each EGR. We used six thermocouples and measured its temperature under the steady-state condition. In addition, average natural heat transfer coefficient increases to a certain value and then decreases when fin spacing increases. In Exhaust Gas Recirculation system Nitrous Oxides are formed at higher Temperature. This Nitrous Oxides are Very harmful For Environment. To Improve Heat transfer Characteristics of EGR pipe by placing Fins at different spacing and height such that it reduces temperature of Exhaust gases so that it helps in reducing Nox pollutants from Diesel Engines. For this Purpose we used fins with 10mm spacing & height 5 mm, 20 mm spacing & height 10mm and spacing 30 mm &height 15 mm and heat transfer like convection heat transfer coefficient and convection heat transfer rate are observed.**

Keyword- Natural convection, Convection heat transfer, Square fin, EGR

Nomenclature

Q Input Power (W)

V Potential Difference (Volt)

I Current (A)

S Fin Spacing (mm)

H Fin Height (mm)

Q_cConvection heat transfer rate (W)

Q_rRadiation heat transfer rate(W)

hConvection Heat transfer Coefficient

σStefan Boltzmann Constant,$5.67x10^{-8}$ $W.m^{-2}.k^{-4}$

Nu_{exp} Experimental Nusselt Number

Ɛ Emissivity

A_s Surface area(m^{2})

β volumetric thermal expansion coefficient(k^{-1})

T Temperature (k)

K thermal conductivity($W.m^{-2}.k^{-1}$)

I. INTRODUCTION

The diesel vehicles are more frequently used in modern transportation. Due to stricter regulations and concerns over global warming and human health problems. Unfortunately, exhaust gas produced by diesel vehicles, which include multi- toxic pollutants, such as nitrogen oxides (No_x), badly cause environment pollution and harm human health. Advanced combustion technologies have been developed to reduce PM and No_x during the combustion process in a cylinder. In order to restrain the formation of pollutants, exhaust gas temperature must be decreased significantly. Nusselt number and the effect of fin conductance on heat transfer performances. Plate-fin heat exchangers are widely used in process industries such as air separation and petrochemical industries to exchange heat energy among more than two fluids with different supply temperatures because of their higher efficiency, more compact structure and lower costs than two-stream heat exchanger networks. Exchangers in certain applications, especially in cryogenic plants .In the design of plate-fin heat exchanger, it is usually presumed that the inlet flow and temperature distribution across the exchanger are uniform and steady.Diesel engines are widely used in transportation. Now a days one of the restrictions of using diesel engine is the emission of nitrous oxides. Nitrous oxides are formed due to high combustion temperature, non-premixed combustion process and short duration of mixing in the combustion chamber.

II. LITERATUREREVIEW

In the recent literature, Yildiz and Yüncü [1] experimentally investigated natural convection heat transfer for annular fin arrays vertically on a horizontal cylinder by changing the fin diameter, fin spacing, and the base-to-ambient temperature difference. This study showed that all these three parameters determine convection heat transfer rate.

Kayansayan and Karabacak [2] experimentally investigated natural convection heat transfer from a horizontal isothermal tube with circular fins vertically attached to the tube. They carried out experiments over 16 test cases and changed the controlling parameters such as fin spacing (s) , temperature difference between the surfaces of the central tube and ambient temperature, ratio of outer diameter of the tube to the inner diameter (D_s d_s) , and ratio of the fin diameter to the tube diameter. In an early experimental study,

Elenbaas[3] investigated natural convection heat transfer from two parallel plates with a gap of *s*. He showed that dissipated heat to the ambient environment is a function of *s* the temperature of the plates. He also introduced a new parameter for the correlation of natural convection heat transfer from parallel plates with a gap of *s*.In another experimental study, Hahne and Zhu [4] used a thermo-visual method to obtain temperature distribution and mean heat transfer coefficient of a finned tube. They varied fin diameter for three test cases to find the effect of fin height on heat transfer. In another recent study, Chen et al. [5] found average natural convection heat transfer coefficient and fin efficiency of vertical square and annular fins on circular finned-tube heat exchangers.

H.-T. Chen and W.-L. Hsu, [6] "Estimation of heat transfer coefficient on the fin of annular-finned tube heat exchangers in natural convection for various fin spacing.

K. T. Park, H. J. Kim, and D.-K. Kim, [7]"Experimental study of natural convection from vertical cylinders with branchedfins.

LadommatosN,AbdelhalimS,ZhaoH,HuZ.[8]Thedilutio ,chemical, and thermal effects of exhaust gas recirculation on diesel engine emissions.

E. Pantow, J. Kern, M. Banzhaf, R. Lutz, A. Tillmann,[9] Impact of US02 and Euro4 emission legislation on power train cooling-challenges and solution for heavy duty trucks. Vehicle Thermal Management Systems Conference and Exposi- tion, Nashville, TN, USA, 2001.

Ladommatos N AbdelhalimS[10] are studied the thermal effects of exhaust gas recirculation on diesel engine emissions.

III.PROBLEM DEFINATION

I Diesel Engines Nitrous Oxides are formed at higher Temperature. These Nitrous Oxides are Very harmful For Environment. To Improve Heat transfer Characteristics of EGR pipe by placing Fins at different spacing and height such that it reduces temperature of Exhaust gases so that it helps in reducing No pollutants from Diesel Engines

IV.OBJECTIVE

- To investigate heat transfer performance in natural convection of plate fin. Study the effect of varying the height of plate pin fin on heat transfer coefficient. Study the effect of varying the spacing of plate pin fin on heat transfer coefficient. Experimental results are verified by using software.

V. METHODOLOGY

The experimental set-up used for present study is designed and will be fabricated with reference to the literature work. The set up will consist of the following parts

- Blower
- Heater
- Motor
- Panel Board
- Fin Arrays
- Thermocouples
- Temperature Indicator
- Orifice meter
- U-tube manometer

1. Experimental Procedure

When we start a blower it blows air which is passed through the heater where air gets heated.then this air is passed through the fin array.thermocouples are attached to the specimen which measures the temperature at various point.control panel is provided where we can change the input power.from heater air is passed through the orificemeter which is connected to the U-tube manometer.from manometer we can meausre air discharge.We used square fins o aluminium pipe with 10mm spacing & 5mm height,20mm spacing &10mm height and 30mm spacing &15 mm height.then we find the effect of fin spacing and fin height on convection heat transfer.

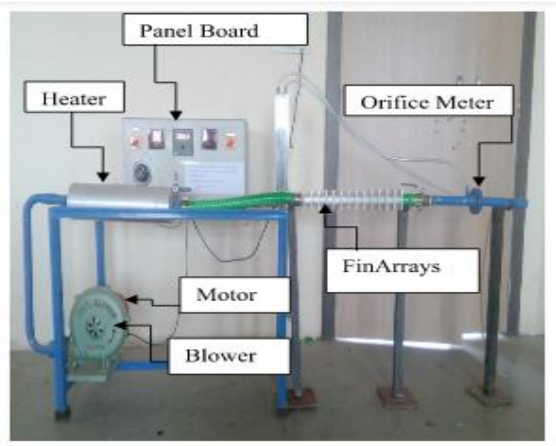

Figure 1 Expérimental Setup.

VI.CALCULATION

1. For S10 mm H5mm

Input Power can be calculated by

Q=V*I

=39*0.553

=21.567 W

Heat transfer by Radiation $Qr=\mathcal{E}*\sigma*A_{s*}(T_w^4-T_a^4)$

$=0.2*0.0000000567*0.154177(315.8^4-299^4)$

=3.41 Watt

Convection heat transfer rate can be calculated by

$Qc = Q-Q_r$

=21.567-3.41

=18.1516 watt

Convection heat transfer coefficient calculated by,

$h=Qc/A_{exposed}*Td$

=18.1516209/0.15417*16.8

$=7.0078\ W/m^2k$

Temperature difference, Td=Tw-Ta

=315.8-299 =16.8 k

$T_f = ((Ta+Tw)/2)$

=(299+315.8)/2=307.4 k

Experimental Nusselt number calculated by

$Nu_{exp}=((h*Lc)/k)$

= (7.007858118*0.0125)/0.0125

=3.268

VII. RESULTS AND DISCUSSION

Table 1 Result Table For S10 Mm H5 Mm

Q	Qc	h	Tf k	Nu_s	Nu_{exp}
21.57	18.15	7	307.4	2.71	3.27
38.53	32.96	8.15	312	3	3.76
60.13	51.64	8.9	318	3.23	4.03
81.32	69.68	9.29	324.1	3.37	4.14
101.75	87.4	9.94	329.3	3.45	4.37
120.71	103.75	10.27	332.25	3.54	4.48

Table 2 Result Table for S20 mm H10mm

Q	Qc	h	Tf k	Nu_s	Nu_{exp}
21.57	19	9.73	306.95	2.44	4.54
38.53	34.15	10.74	311.84	2.74	4.95
60.13	53.57	11.91	317.5	2.94	5.4
81.32	72.42	12.54	323.3	3.08	5.6
101.75	90.52	13.11	328.9	3.16	5.76
120.71	107.32	13.44	13.43	3.24	5.85

Table 3Result Table for S30 mm H15mm

Q	Qc	h	Tf k	Nus	Nuexp
21.57	19.11	10.29	307.8	3	4.79
38.53	34.34	11.47	313.53	3.33	5.26
60.13	53.72	12.49	319.7	3.58	5.63
81.32	72.66	13.25	325.85	3.72	5.88
101.75	90.85	13.84	331	3.83	6.05
120.71	107.45	14.14	336.15	3.9	6.09

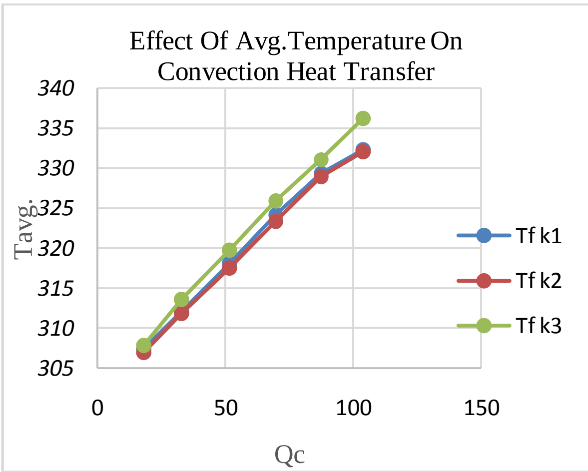

Fig.2 Effect of Avg.Temperature on Convection Heat Transfer.

We can easily make out from the graph that Avg. Temperature is increased then Convection heat transfer

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rate is increased. From above three Cases i.e. fins with 10 mm spacing and 5 mm height, fins with 20 mm spacing and 10 mm height and fins with 30 mm spacing and 15 mm height.we get better result for fins with fin 30 mm spacing and 15 mm height as compare to fins with 10 mm spacing and 5 mm height and fins with 20 mm spacing and 10 mm height.

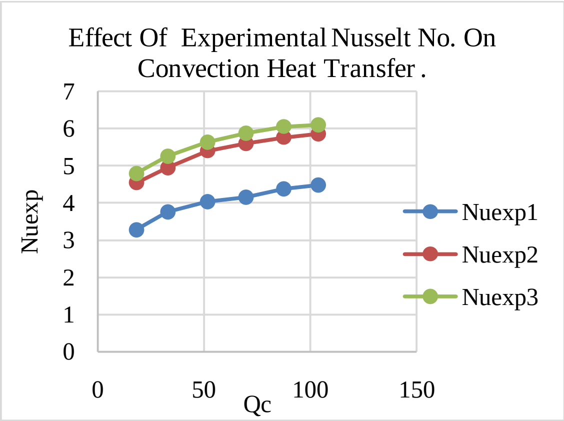

Fig.3 Effect of Experimental Nusselt No. on convection heat transfer

We can easily make out from the graph that Experimental Nusselt no. is increased then Convection heat transfer rate is increased. From above three Cases i.e. fins with 10 mm spacing and 5 mm height, fins with 20 mm spacing and 10 mm height and fins with 30 mm spacing and 15 mm height. We get better result for fins with fin 30 mm spacing and 15 mm height as compare to fins with 10 mm spacing and 5 mm height and fins with 20 mm spacing and 10 mm height.

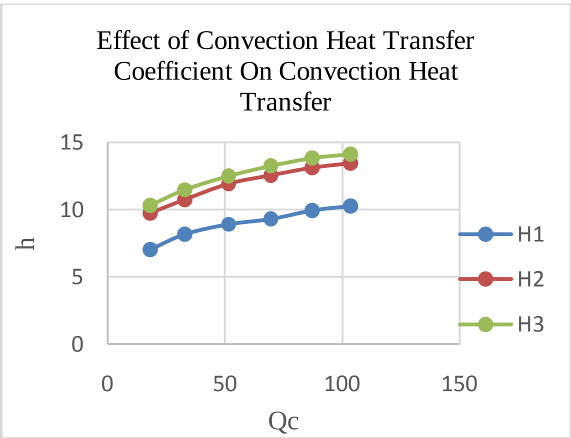

Fig.4. Effect of Convection heat transfer coefficient on convection heat transfer

We can easily make out from the graph that Convection heat transfer Coefficient is increased then Convection heat transfer rate is increased. From above three Cases i.e. fins with 10 mm spacing and 5 mm height, fins with 20 mm spacing and 10 mm height and fins with 30 mm spacing and 15 mm height. We get better result for fins with fin 30 mm spacing and 15 mm height as compare to fins with 10 mm spacing and 5 mm height and fins with 20 mm spacing and 10 mm height.

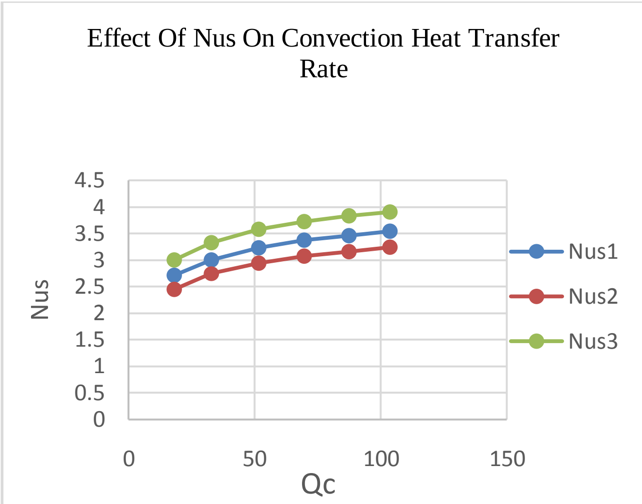

Fig.5. Effect of Nus on convection heat transfer

We can easily make out from the graph that when Nus increased then Convection heat transfer rate is increased. From above three Cases i.e. fins with 10 mm spacing and 5 mm height, fins with 20 mm spacing and 10 mm height and fins with 30 mm spacing and 15 mm height. we get better result for fins with fin 30 mm spacing and 15 mm height as compare to fins with 10 mm spacing and 5 mm height and fins with 20 mm spacing and 10 mm height.

1. Validation

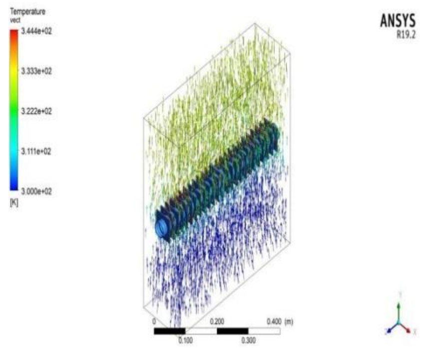

Fig.6 Temperature Distribution Contour

Fig.6 shows the Temperature Distribution Contour& as well as flow of air over plates for 10 mm spacing for square fin array of exhaust pipe of EGR. Air Temperature gets reduced from inlet to outlet. Then experimental and simulation results are compared.

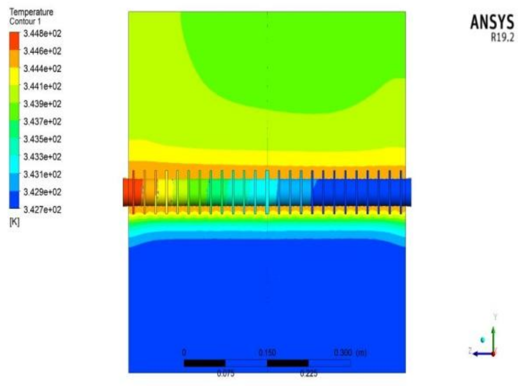

Fig.7 Temperature Distribution Contour

Fig.7 shows the Temperature Distribution Contour &as well as flow of air over plates for 20 mm spacing for square fin array of exhaust pipe of EGR. Air Temperature gets reduced from inlet to outlet. Then experimental and simulation results are compared.

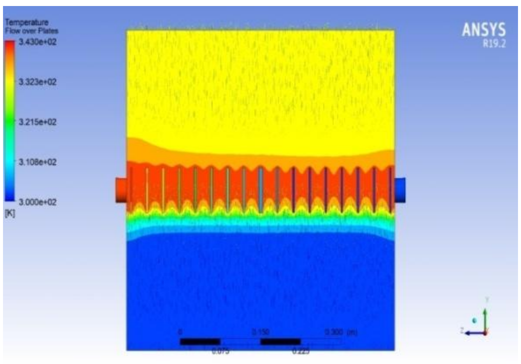

Fig.8 Temperature Distribution Contour

Fig.8 shows the Temperature Distribution Contour& as well as flow of air over plates for 30mm spacing for square fin array of exhaust pipe of EGR. Air Temperature gets reduced from inlet to outlet. Then experimental and simulation results are compared.

VIII. CONCLUSION

Effect of the various parameters like fin height and fin pitch etc. is studied in this work. Variation in the results due to the variation in like fin height and fin pitch is observed.

- Convection heat transfer rate is less for fins with fin spacing 10 mm and fin height5mm as compare to fins with spacing 20 mm & height 10 mm and fins with spacing 30 mm & fin height 15 mm.
- Convection heat transfer rate for fins with spacing 20 mm &height 10 mm.is more than fin with spacing 10 mm and fin height 5mm but less than fin with spacing 30mm and fin height 15mm.
- Convection heat transfer rate is higher in fin with spacing 30mm and fin height 15mm as compare to fins with spacing 10 mm & height 5 mm and fins with spacing 20 mm & fin height 10 mm.

Table 4 Comparison of Heat Transfer Coefficient for 10 mm fin spacing & 5 mm fin height

Heat Transfer Coefficient h (w/m^{2}k)			
Qin W	Cases	Experimental	ANSYS CFX 18.1
21.57	Plate fin with 10 mm fin spacing & 5 mm fin height.	7	7.3665
38.53		8.15	8.5595
60.13		8.9	9.3125
81.32		9.29	9.6456
101.5		9.94	10.3564
120.5		10.27	10.7654

Table 5 Comparison of Heat Transfer Coefficient for 20 mm fin spacing & 10 mm fin height

Heat Transfer Coefficient h (w/m^{2}k)			
Qin W	Cases	Experimental	ANSYS CFX 18.1
21.57	Plate fin with 20 mm fin spacing & 10 mm fin height.	9.73	9.9875
38.53		10.74	11.1241
60.13		11.91	12.4454
81.32		12.54	12.9325
101.5		13.11	13.5369
120.5		13.44	13.8773

Table 6 Comparison of Heat Transfer Coefficient for 30 mm fin spacing & 15 mm fin height

Heat Transfer Coefficient h (w/m^{2}k)			
Qin W	Cases	Experimental	ANSYS CFX 18.1
21.57	Plate fin with 30 mm fin spacing & 15 mm fin height.	10.29	10.6051
38.53		11.47	11.7332
60.13		12.49	12.8998
81.32		13.25	13.6195
101.5		13.84	14.1995
120.5		14.14	14.5129

Hence we conclude that increase in fin spacing and fin height convection heat transfer coefficient is increases which results in increase in heat transfer rate.for CFD analysis ANSYS FLUENT is use for simulation of EGR exhaust pipe and experimental and simulation results are compared which gives nearly same result.

IX.ACKNOWLEDGMENT

Authors are very thankful to the whole mechanical engineering department members.

REFERENCES

[1] Ş. Yildizand H. Yüncü, "An Experimental Investigation On Performance Of Annular Fins On A Horizontal Cylinder In Free Convection Heat Transfer," Heat And Mass Transfer, vol. 40, pp. 239-251.

[2] Kayansayan and Kara bacak investigated natural convection heat transfer from a horizontal isothermal tube with circular fins vertically attached to the tube.

[3] In an early experimental study Elenbaas[3] investigated natural convection heat transfer from two parallel plates with a gap of *s*. He showed that dissipated heat to the ambient environment is a function of *s* the temperature of the plates. He also introduced a new parameter for the correlation of natural convection heat transfer from parallel plates with a gap of *s*.

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[5] H.-T. Chen and J.-C. Chou, "Investigation of natural-convection heat transfer coefficient on a vertical square fin of finned-tube heat exchangers.

[6] H.-T. Chen and W.-L. Hsu, "Estimation of heat transfer coefficient on the fin of annular-finned tube heat exchangers in natural convection for various fin spacings,

[7] K.T. Park, H. J. Kim, and D.-K. Kim, "Experimental study of natural convection from vertical cylinders with branched fins," Experimental Thermal and Fluid Science,vol. 54, pp. 29-37, 2014.

[8] Ladommatos NAbde lhalimS, ZhaoH, HuZ. Thedilution, chemical, and thermal effects of exhaust gas recirculation on diesel engine emissions.

[9] E. Pantow, J. Kern, M. Banzhaf, R. Lutz, A. Tillmann, Impact of US02 and Euro4 emission legislation on power train cooling-challenges and solution for heavy duty trucks. Vehicle Thermal Management Systems Conference and Exposi- tion, Nashville, TN, USA, 2001.

[10] Ladommatos N AbdelhalimS[10] are studied the thermal effects of exhaust gas recirculation on diesel engine emission.

[11] Ibrahim H. Shah, Pawan Detwal, "Performance Study of EGR Cooler with Different Geometries & Comparison with Dimpled-Tube Type EGR Cooler using CFD," IJSRD, Vol.4, Issue 05, ISSN, 2321-0613, 2016