CFD Analysis & Optimisation Parametric Study on Heat Transfer Enhancement by various shapes of wings and Materials with Forced Convection

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ABSTRACT: *In recent years, vortex generators such as fins, notches, wings etc. have been successfully used for heat transfer enhancement of the modern thermal systems like dryers, electronic equipments etc. The aim of present study is to investigate Heat transfer coefficient in rectangular plates using various shapes such as spherical wings, tubular wings , bare plate using different material such as Copper, Brass and M.S plates and comparing the results using CFD Analysis and developing Mathematical modeling of the results. Therefore, a forced convection experimental setup is to be built to study the various parameters such as heat transfer coefficient, Reynolds number and Nusselt number.*

***Keywords* -** *heat transfer coefficient (h), the Nusselt number (Nu), and the Reynolds number (Re).*

I. INTRODUCTION

Various heat transfer enhancement techniques are used such as fins, ribs, dimpled surfaces, and protruding surfaces that generate vortices in a heat exchanger. Heat sinks and heat exchangers are used in many applications today and the most common material used is aluminum because of its high thermal conductivity (205 W/m.K), low maintenance and production cost, and less weight. Copper is also used at times because of its very high conductivity (400 W/m.K), but it is not commonly used because it is heavy and costly, Mild steel is approximately having (45 W/m.K). Higher thermal conductivity of brass makes it ideal for Heat Exchanger, (K of brass = 116 W/Mk).

II EXPERIMENTAL SETUP

Fig (1) shows the Test Section part of the Setup established and consists of following specifications:

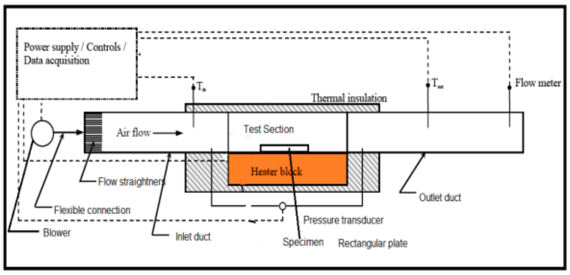

Figure 1: Test Section

2.1 Specifications
1. Blower – 1400 rpm
2. U-Tube Mano meter
3. P-type Thermocouples – 9 nos.
4. Dimmer stat 0-2 Amps, 230 V AC
5. Nichrome Heater plate: 1000 W
6. Duct – *Heat Pipe of diameter = 40 mm and *length = 1200 mm, Test section 300 mm.
7. Voltmeter=0-200 V
8. Ammeter=0-2 Amp
9. Temperature Indicator

III SPECIMENS

Fig (2), Fig (3) and fig (4) show the Rectangular Plates with spherical and Tubular wings consisting Copper, Brass and Mild Steel Material.

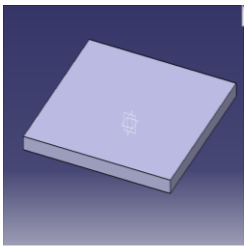

Figure 2: Bare plate

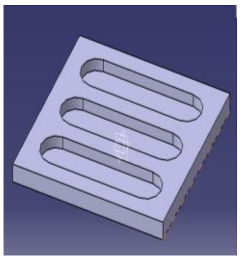

Figure 3: Tubular wing

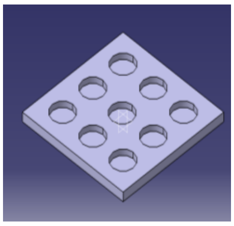

Figure 4: Spherical Wing

IV. METHODOLOGY

1. Fit the specimen inside the duct which consists of a seven thermocouples on a duct to measure the temperature at various points of ducts and specimen.

2. Switching ON the supply and Switching ON the blower units and allowing the flow of air.

3. Measure the flow of air through mano meter.

4. After attaining the steady stage note the temperature (T1 to T9) at an interval of 10 minutes and tabulate it.

5. Repeat same procedure for other specimens also.

6. Compare the result of three specimens analytically and conduct CFD Analysis of the same.

V. DESIGN OF EXPERIMENT

Table No.1 shows Design of the Experiment according to L9 Orthogonal Taguchi Method.

Sr No	***Input Parameters***	***Level 1***	***Level 2***	***Level 3***
1.	Voltmeter	50 V	75 V	100 V
2.	Mass flow rate (kg/sec)	6.32	6.58	6.99
3.	Material	Copper	Brass	M.S
4.	Design of Specimen	Bare	Spherical	Tubular

VI. EXPERIMENTAL RESULT TABLE

Exp. No.	**Volt meter (volts)**	**Mass Flow rate (kg/m^3)**	**Material**	**Design**	**h (w/m^2 K)**	**Re**	**Nu**
1	50	6.99	Cu	Bare	**0.036**	**221.5**	**1.49**
2	50	6.72	Brass	Spherical	**0.007**	**229.1**	**1.54**
3	50	6.95	M.S.	Tubular	**0.075**	**225.8**	**1.52**
4	75	6.55	Brass	Tubular	**0.018**	**210.3**	**1.44**
5	75	6.54	M.S.	Bare	**0.077**	**212.8**	**1.45**
6	75	6.32	Cu	Spherical	**0.013**	**215.6**	**1.46**
7	100	6.3	M.S.	Spherical	**0.029**	**231.2**	**1.55**
8	100	6.58	Cu	Tubular	**0.028**	**208.7**	**1.43**
9	100	6.54	Brass	Bare	**0.074**	**212.8**	**1.45**

VII. CFD MODELING

In this investigation a three-dimensional numerical simulation of the conjugate heat transfer was conducted using the CFD code FLUENT. The CFD modeling involves numerical solutions of the conservation equations for mass, momentum and energy following the Equations.

1. Continuity equation for an incompressible fluid

$$\frac{\partial p}{\partial t} + \nabla.(\rho\,\vartheta) = Sm \qquad (1)$$

2. Conservation Of momentum

$$\frac{\partial v}{\partial t} + \rho(\bar{\vartheta}\,\nabla.)\bar{\vartheta} = -\nabla p + \rho\bar{g} + \nabla.\tau ij + \bar{F} \qquad (2)$$

3. Conservation of Energy

$$\rho\frac{\partial}{\partial t}(\rho E) + \nabla\{\bar{\vartheta}(\rho E + p)\} = \nabla\left\{Keff\,\nabla T - \sum hi\,(\overline{\tau eff}.\bar{\vartheta})\right\} + Sh \qquad (3)$$

VIII. CFD RESULT TABLE

Sr No.	h (w/m²K)	Re	Nu
1	0.038	234.23	1.58
2	0.0098	238.18	1.62
3	0.083	222.36	1.59
4	0.017	203.52	1.36
5	0.075	221.27	1.4
6	0.014	225.96	1.4
7	0.028	241.49	1.7
8	0.032	198.46	1.51
9	0.057	201.16	1.53

IX. CONCLUSION

Comparing both Experimental and CFD Results we come to the conclusion that

% variation			
Sr No.	h (w/m²K)	Re	Nu
1	-5.6	-5.7	-6.0
2	-40.0	-4.0	-5.2
3	-10.7	1.5	-4.6
4	5.6	3.2	5.6
5	2.6	-4.0	3.4
6	-7.7	-4.8	4.1
7	3.4	-4.5	-9.7
8	-14.3	4.9	-5.6
9	23.0	5.4	-5.5

1. Experimental and CFD Results for Heat Transfer Coefficient and Reynolds number are same.

2. Nusselt number varies for both experimental and CFD Results with minor error.

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