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CFD Analysis & Experimental Study on Heat Transfer Enhancement by various shapes of wings and Material 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).

1. 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).

2. Experimental Setup

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

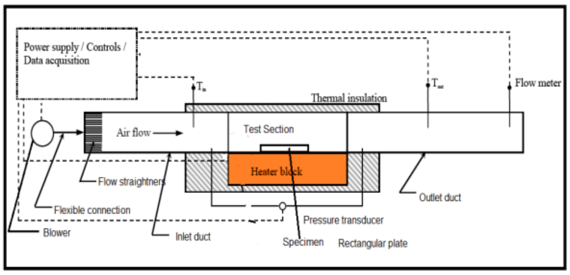


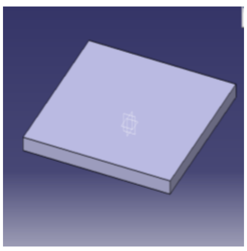
Figure 1: Test Section

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

2.2 Specimens

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



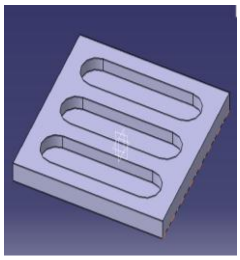


Figure 2: Bare plate

Figure 3: Tubular wing

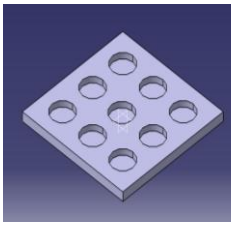


Figure 4: Spherical Wing

2.3 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 a nd conduct CFD Analysis of the same.

3. Design of Experiment

Table No.1: Design of the Experiment.

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

3.1 Observation and Result Table

The Observation table is designed according to L9 Orthogonal Array Method for Optimization. And the Results obtained are shown in Table No 2.

Table No. 2: Result Table

Exp. No.	***Voltmeter (volts)***	***Mass Flow rate (kg/m^3)***	***Material***	***Design***	***h***	***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

3.2 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.

3.3 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

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

4. Results and Discussion

From the Experimental Analysis it is observed that:
1. Heat Transfer coefficient of Bare Copper plate is found to be greater than other samples.
2. Reynolds number of Tubular M.S Plate while Nusselt number of Spherical M.S Plate is found higher.

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