Computational Fluid Dynamics Analysis of Porous Medium and its Effect of Temperature on air passing through radiator.

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ABSTRACT

Shapes of heat exchanger are generally rectangular & flow of the air through it is in circular periphery, producing low velocity zones and high temperature regions in corners. These stagnation zones may be avoided by using circular profile heat exchanger (radiator) or by using porous medium so that the temperature of inlet to radiators can be reduced [1]. So many researches are carried out on heat exchanger with square and rectangle profile but these approaches are not economic in nature instead of that use porous medium to reduce the temperature of inlet air to radiator are economic in nature.[2]

Keywords: Radiator, Porous medium, Ansys, CFD, Transient.

1. Introduction

Radiators are heat exchanger device used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in cars, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for automotive engine cooling.

1.1 Types of heat exchanger

- Plate and Frame Heat Exchangers
- Brazed Plate Heat Exchangers
- Welded Plate Heat Exchanger
- Plate-Fin Heat Exchangers
- Brazed Plate-Fin Heat Exchangers
- Diffusion-Bonded Plate-Fin Heat Exchangers
- Spiral Heat Exchangers

1.2 Log Mean Temperature Differences.

The **LMTD** is a logarithmic average of the temperature difference between the hot and cold streams at each end of the exchanger. The larger the **LMTD**, the more heat is transferred. The use of the **LMTD** arises, straightforwardly, from the analysis of a heat exchanger with constant flow rate and fluid thermal properties [2].

1.3 Energy Balance Equation.

The fluid which transfers energy to the other fluid is known as "Hot fluid". Due to loss of Energy, the temperature of the hot fluid goes down slowly [17]. The fluid which receives energy is known as "Cold fluid". The internal energy as well as the temperature of cold fluid increases.[18]. After neglecting the losses of energy from the heat exchanger to atmosphere.

Rate at which energy given by hot fluid = Rate at which energy is gained by cold fluid [3]

So $(mCp\Delta t)Hot = (mCp\Delta t)$ **Cold**

Where m is mass flow rate (kg/sec)

$\Delta t_{hot} = t_{(hot)\ inlet} - t_{(hot)\ outlet}$

$\Delta t_{cold} = t_{(cold)\ inlet} - t_{(cold)\ outlet}$

$t_{(hot)\ inlet}$ = Temperature of hot inlet fluid.

$t_{(hot)\ outlet}$ = Temperature of hot outlet fluid.

1.4 COMPUTATIONAL FLUID DYNAMICS.

Computational fluid dynamics or CFD is the analysis of problems which include fluid flow, heat transfer and associated phenomena such as chemical reactions with the aid of computer-based simulation processes .This technique is effective and covers a vast span of industrial and non-industrial application areas. Some examples are:

- aerodynamics of aircraft and vehicles: lift and drag
- hydrodynamics of ships
- power plant: combustion in internal combustion engines and gas turbines
- Turbo machinery: flows inside rotating passages, diffusers etc.
- Electrical and electronic engineering: cooling of equipment including microcircuits.

2. CALCUALTIONS.

2.1 MANNUAL CALCULATION OF L.M.T.D. WITHOUT USING POROUS MEDIUM BETWEEN RADIATOR AND FAN.

Procedure (LMTD):-

- **Calculate the rate of heat transfer from heat exchanger using hot or cold**

$$q = [mCp - T]$$

- **Calculate the overall heat transfer coefficient. Get the value of U as a function of A, using the formula,** $UA = \frac{1}{R}$
- **Calculate L.M.T.D.**

For parallel and counter flow-:

$$8\text{mean} = \frac{81-82}{\text{LN}\frac{81}{82}}$$

Calculate the area (or area related parameter) using

$$Q = UA8_{\mathbf{m}}$$

Table 1: DATA AVAIALBLE

SR.NO	OBSERVATIONS	AIR(COLD)	WATER(COLD)
1	**Inlet temperature**	**28**	**52**
2	**Outlet temperature**	**34.376**	**44**
3	**Flow mass rate (m)**	**525.35**	**100**
4	**Specific heat**	**1**	**4.187**
5	**Thermal conductivity**	**0.024**	**0.66**
6	**Density**	**1.1**	**1000**

The data specified in table no 1 is the operational parameters taken from the research paper. [3]

On considering above parameters and putting above Values in specified equations L.M.T.D is calculated as **13.79 degree centigrade.**

2.2 CALCULATION OF L.M.T.D. WITH USE OF POROUS MEDIUM BETWEEN RADIATOR AND FAN.

The porous medium which is soft building wood is considered here for further calculation and its all property is referred by the Ansys manual (4).The arrangement is shown by figure no 1.

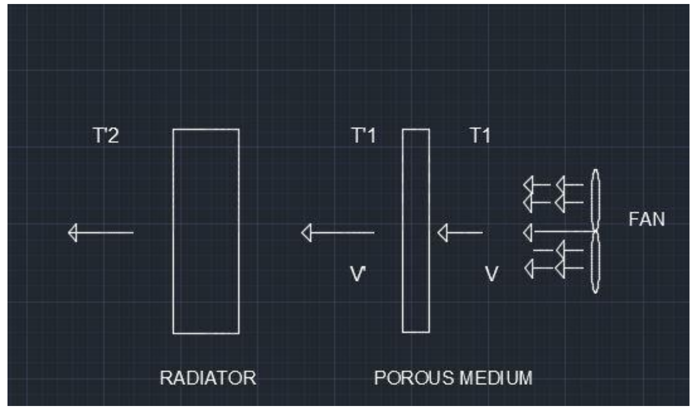

Figure 1

2.3 CFD analysis for velocity of air.

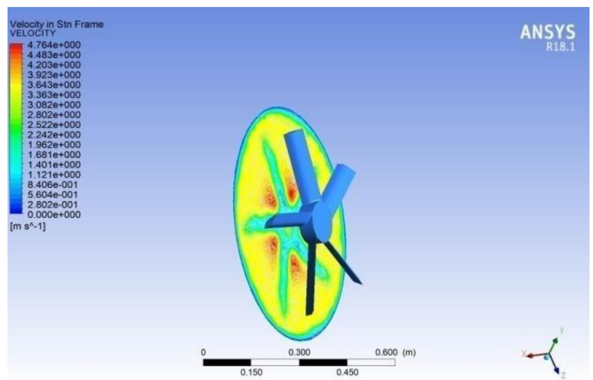

Figure 2

Figure no 2 shows the CFD analysis of fan and radiator when distance between fan and radiator in 0.1 meter (6)From above figure it can be seen that maximum velocity is 4.76 m/s. So for calculation average velocity is required it can be calculated by using function calculator of Ansys. On referring above the value average velocity is 2.54 m/s.

Figure no 3 shows the CFD analysis of fan and radiator when distance between fan, porous medium and radiator in 0.1 meter (31) From above figure it can be seen that maximum velocity is 4.74 m/s. So for calculation average velocity is required it can be calculated by using function calculator of Ansys. On referring below fig no 3 the value average velocity is 1.93 m/s.

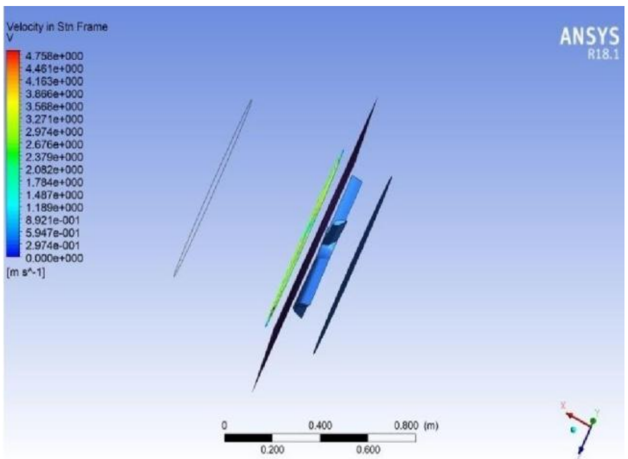

Figure 3

2.4 CFD analysis for temperature distribution at inlet and outlet end side of porous medium.

From the above analysis it is concluded that average velocity of air is 1.93 m/s here in figure temperature distribution analysis and calculation of average temperature is carried out through function calculator at inlet surface of porous medium as shown in fig no 4.The average velocity of air 1.93 m/s is taken as inlet for porous media. From fig it is seen that the average value of inlet temperature is approximately 304 Kelvin.

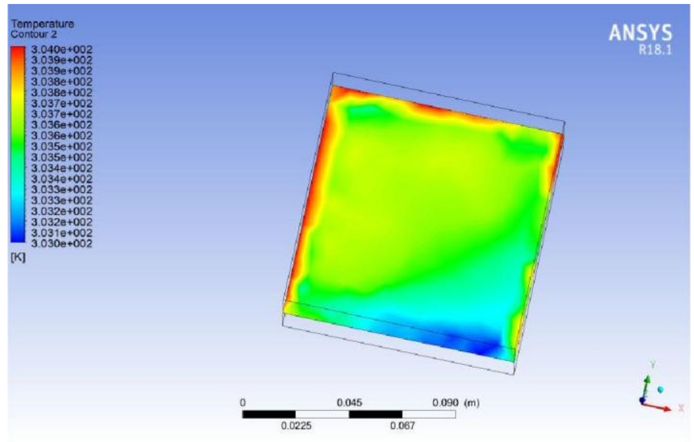

Figure 4

In figure no 5 cfd analysis at outlet of porous medium it is shown in below figure and also drops in temperature by 2 degree Kelvin is observed after passing through porous medium. The temperature at outlet is 304 degree Kelvin.

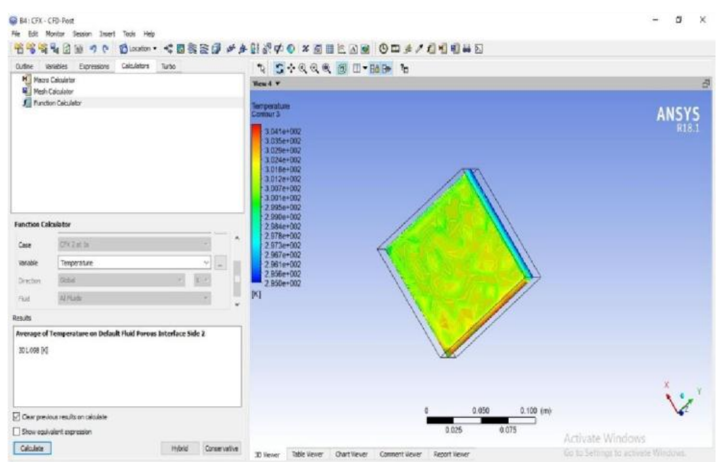

Figure 5