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Heat Transfer Analysis With Different Mass Flow Rate & Using Ethylene Glycol Coolant In Helical Tube Type Radiator.

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Abstract *— Automobile radiators are most important part of the heavy & medium vehicle. The flow behavior & temperature profile prediction in the radiator tubes are very useful information & is of great importance to the designer. CFD is very useful tool in accessing the preliminary design and performance of the radiator. In this paper, the model was done Pro-E software and imported in ANSYS-14.5. The analysis was done in CFX for helical tube configuration. The coolant considered as an Ethylene Glycol. The overall pressure & temperature distribution of the coolant was evaluated 20mm pitch helical tube used in radiator. From analysis, Mass flow rate very important role during heat transfer process. Analysis done with different mass flow rate & coolant used as ethylene glycol & we taken value of inlet temperature & outlet temperature, as well as inlet pressure & outlet pressure. From this value & graph derived that with decreasing mass flow rate; Temperature drop continuously increases & pressure drop continuously decreases. That means with decreasing mass flow rate we get more cooling effect & also friction decrease.*

Keywords- *Heat transfer analysis, helical tube, pitch, ethylene glycol coolant, pressure, heat transfer temperature, mass flow rate*

I. INTRODUCTION

Automobile manufacturers have challenge of developing compact and energy efficient cars which warrants a thorough optimization process in the design of all engine components. Radiators are one of the important parts of engine which are installed in automobiles to remove heat for better engine performance thus providing engine cooling and also heat removal during air-conditioning process. Today's engine require higher output with decreased space available for cooling air circulation which necessitates a better understanding of the complex cooling fluid flow characteristics and thermal performance of the radiator is necessary as the performance, safety and life of engine depends on effective engine cooling. About 30% of the thermal energy generated is dissipated to the coolant circulating in the engine-cooling jacket. The hot coolant coming out of engine jacket is to be cooled in a radiator and circulated again.

II. LITERATURE REVIEW

Hilde Van Der Vyer et al. (2003) conducted a CFD simulation of a 3-D tube-in-tube heat exchanger using Star-CD CFD software and made a validation test with the experimental work. The authors were fairly successful to simulate the heat transfer characteristics of the tube-in-tube heat exchanger. This has been used as the base for the procedures of CFD code validation of a heat exchanger.

Witry et. al.,(2003) carried out CFD analysis of fluid flow and heat transfer in patterned roll bonded aluminium radiator, in which FLUENT's segregated implicit 3-D steady solver with incompressible heat transfer is used as the tool. Here the shell side airflow pattern and tube side water flow pattern are studied to present the variation of overall heat transfer coefficients across the radiator ranging from 75 to 560 W/m^2-K.

Chen et al, (2001) made an experimental investigation of the heat transfer characteristics of a tube-and-fin radiator for vehicles using an experimental optimization design technique on a wind tunnel test rig of the radiator. The authors have developed the regression equations of heat dissipation rate, coolant pressure drop and air pressure drop. The influences of various parameters like the air velocity, inlet coolant temperature and volume flow rate of coolant on heat dissipation rate, coolant pressure drop and air pressure drop have been discussed in detail by means of the numerical analyses. The results provide a basis for the theoretical analysis of heat performances and structural refinement of the tube-and-fin radiator.

Sridhar Maddipatla, (2001) presented a method to design automobile radiator by coupling CFD with a shape optimization algorithm on a simplified 2D model. It includes automated mesh generation using Gambit, CFD analysis using Fluent and an in-house C-code implementing a numerical shape optimization algorithm. The flow simulations using FLUENT were performed using the classical simple algorithm with a k-ε turbulent model and second order upwind scheme. It involves calculating the overall pressure drop and mass flow rate distribution of the coolant and air in and around the single tube arrangement of an automotive radiator.

III ANALYSIS OF RADIATOR

Analysis is done in ANSYS-14.5 software with using CFX. The analysis is done on both helical tube radiator model and then performance comparison is done to understand importance of different mass flow rate with help of ANSYS software.

Input Data (Seth Daniel Oduro (2009))

Air inlet velocity	: 4.4 m/s
Air inlet temp	: ambient temp
Coolant inlet temp	: 98.75^{0}C
Outside temperature	: 25^{0}C
Coolant mass flow	: 2.3 kg/s, 2.0 kg/sec, 1.0 kg/sec & 0.5 kg/sec.
Flow region	: Laminar
Mass & Momentum	: Free slip wall

Overall heat transfer co efficient across the radiator ranges from 75 to 560 W/m^2-K

Radiator Specification for Helical Type Tubes:

Number of tubes	: 29
Helical type tube mean diameter	: 30mm
Pitch	: 15mm & 20mm
Inner diameter of tube	: 2 mm
Outer diameter of tube	: 4 mm

Assumptions

In order to solve the analytical model, the following assumptions are made:

Coolant flow rate is constant and there is no phase change in the coolant. Heat conduction through the walls of the coolant tube is negligible. Heat loss by coolant was only transferred to the cooling air, thus no other heat transfer mode such as radiation was considered. Coolant fluid flow is in a fully developed condition in each tube. All dimensions are uniform throughout the radiator and the heat transfer surface area is consistent and distributed uniformly. The thermal conductivity of the radiator material is considered to be constant. There are no heat sources and sinks within the radiator. There is no fluid stratification, losses and flow misdistribution. Momentum condition: Tube wall is stationary.

Case-I: Analysis of Radiator with different mass flow rate in Helical Tubes using Ethylene Glycol Coolant

Case I (a): Mass flow rate =2.3kg/sec in Helical Tube (Ethylene Glycol coolant)

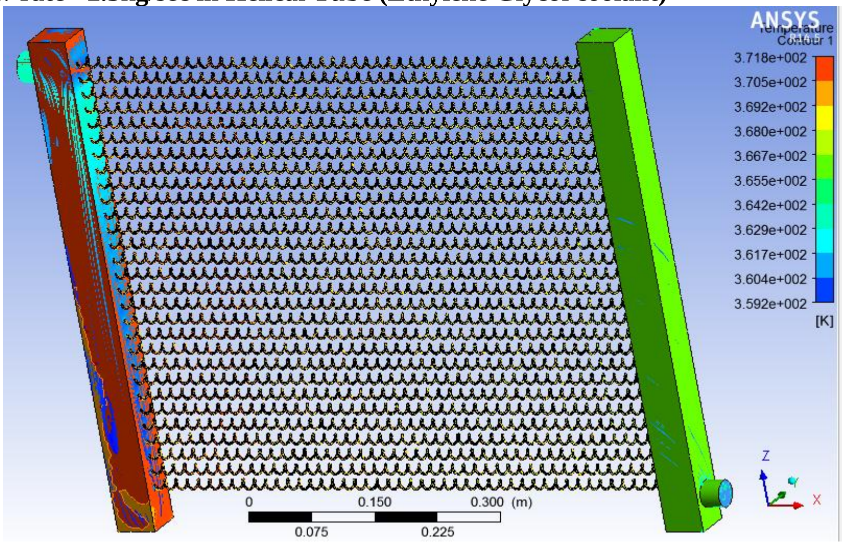

Figure 1: Temperature diagram of helical tubes used in Radiator. (M=2.3 kg/sec)

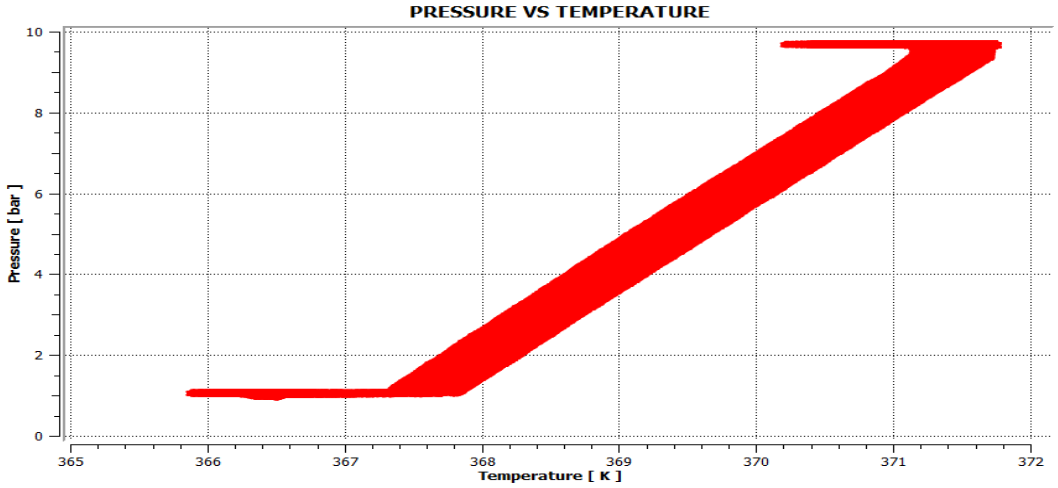

Figure 2: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=2.3 kg/sec)

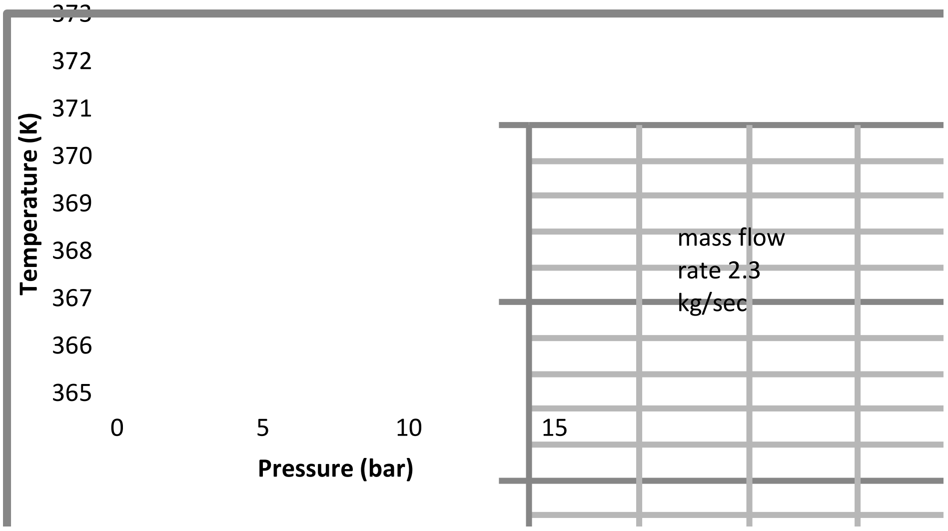

Figure 3: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=2.3 kg/sec)

Case I (b): Mass flow rate =2.0 kg/sec in Helical Tube (Ethylene Glycol coolant)

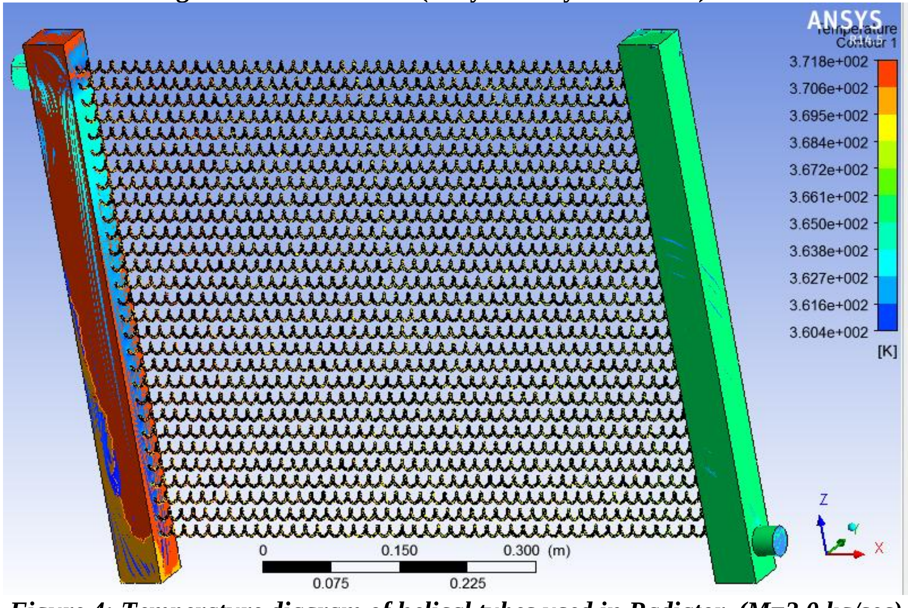

Figure 4: Temperature diagram of helical tubes used in Radiator. (M=2.0 kg/sec)

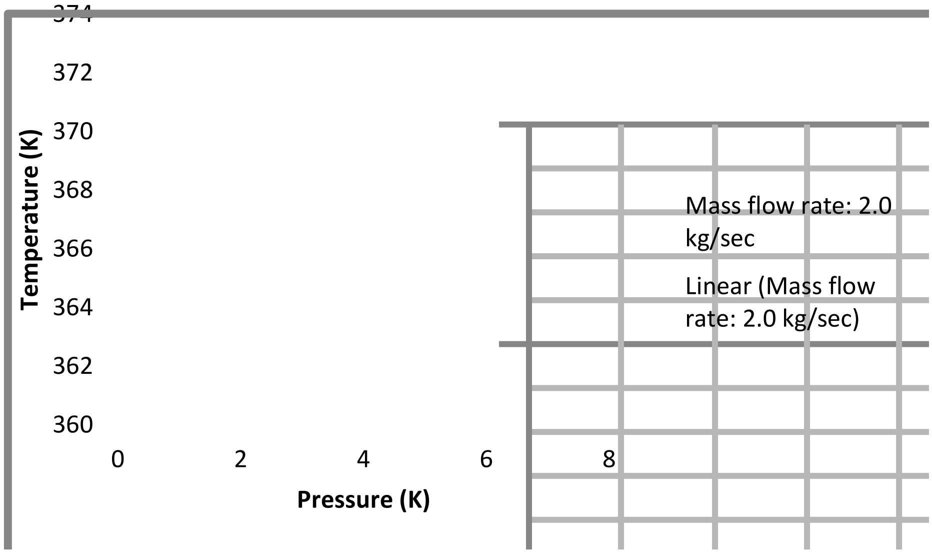

Figure 5: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=2.0 kg/sec)

Case I (c): Mass flow rate =1.5 kg/sec in Helical Tube (Ethylene Glycol coolant)

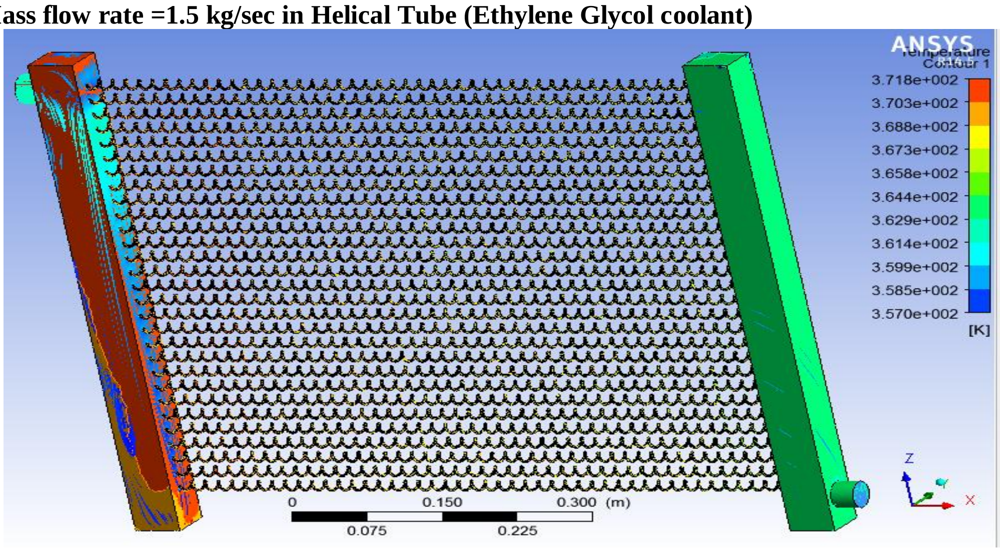

Figure 6: Temperature diagram of helical tubes used in Radiator. (M=1.5 kg/sec)

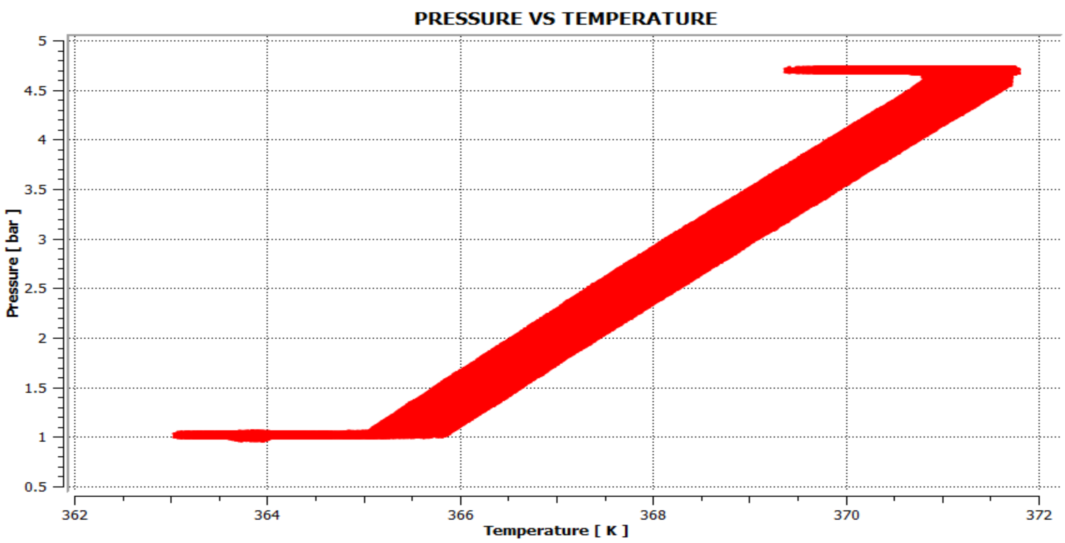

Figure 7: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=1.5 kg/sec)

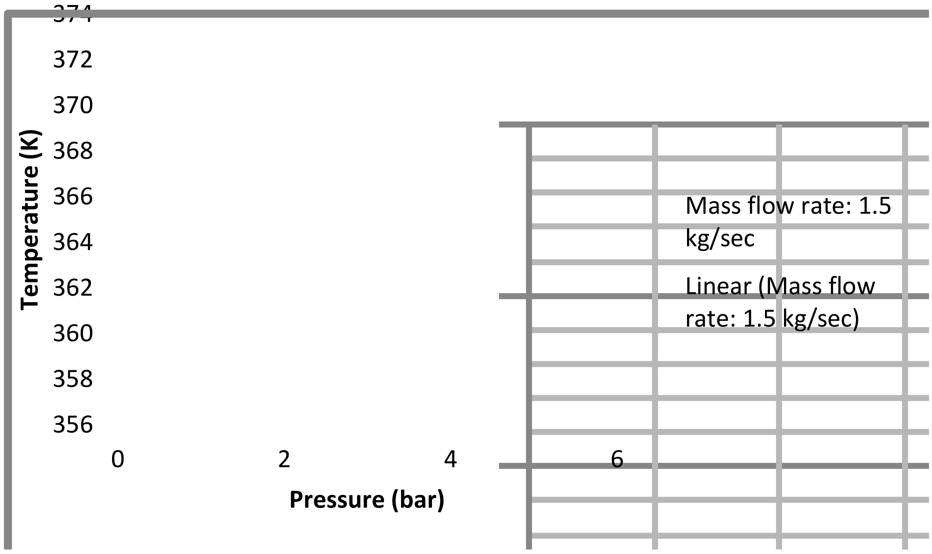

Figure 8: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=1.5 kg/sec)

Case I (d): Mass flow rate =1 kg/sec in Helical Tube (Ethylene Glycol coolant)

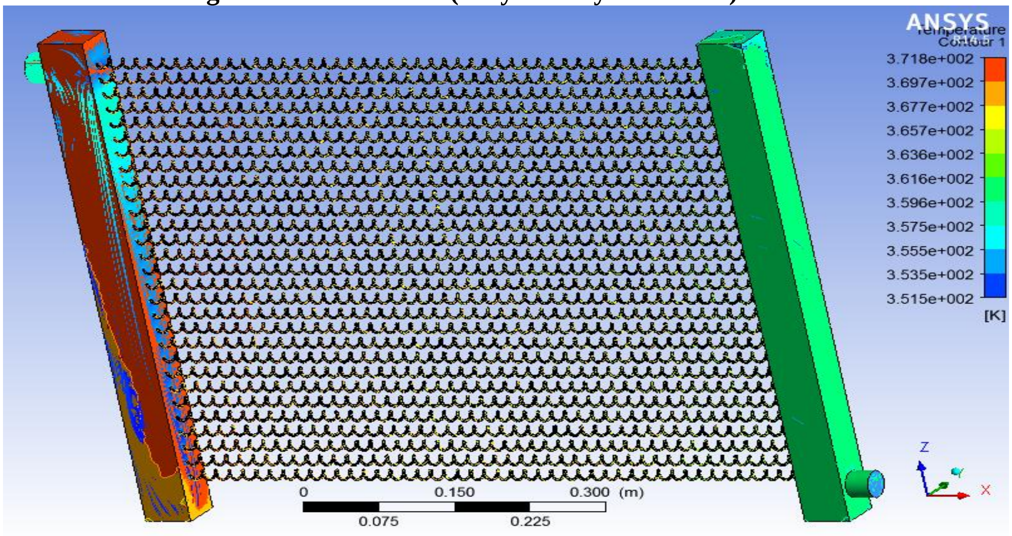

Figure 9: Temperature diagram of helical tubes used in Radiator. (M=1.0 kg/sec)

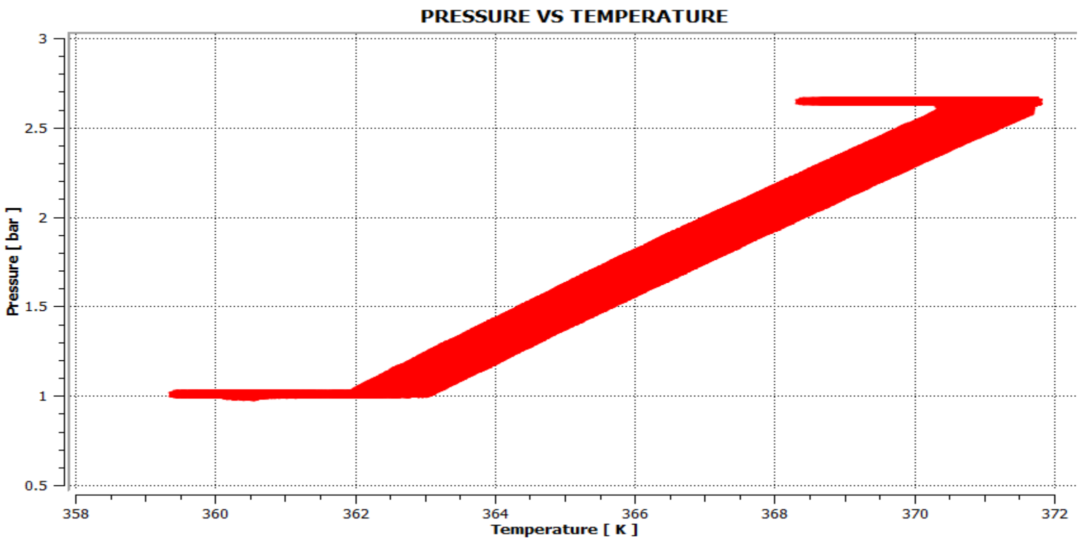

Figure 10: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=1.0 kg/sec)

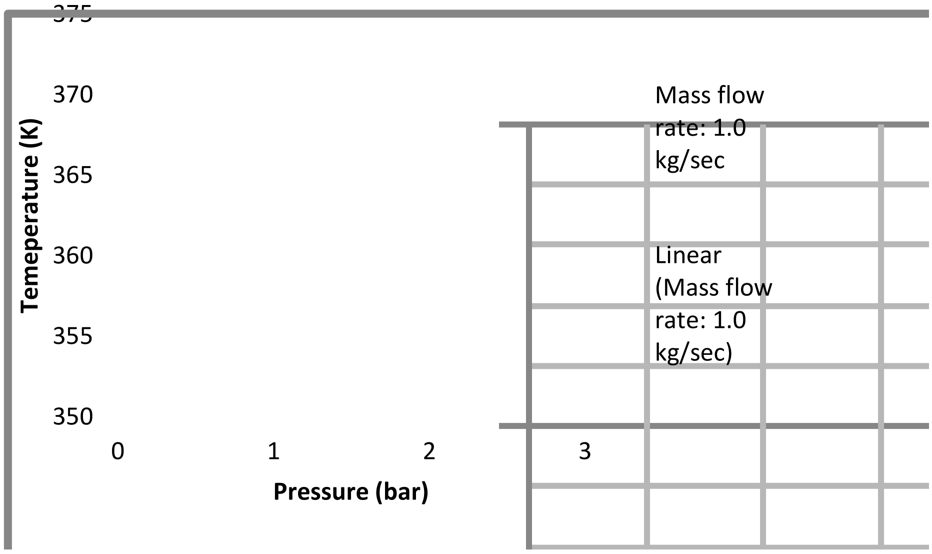

Figure 11: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=1.0 kg/sec)

Case I (e): Mass flow rate =0.5 kg/sec in Helical Tube (Ethylene Glycol coolant)

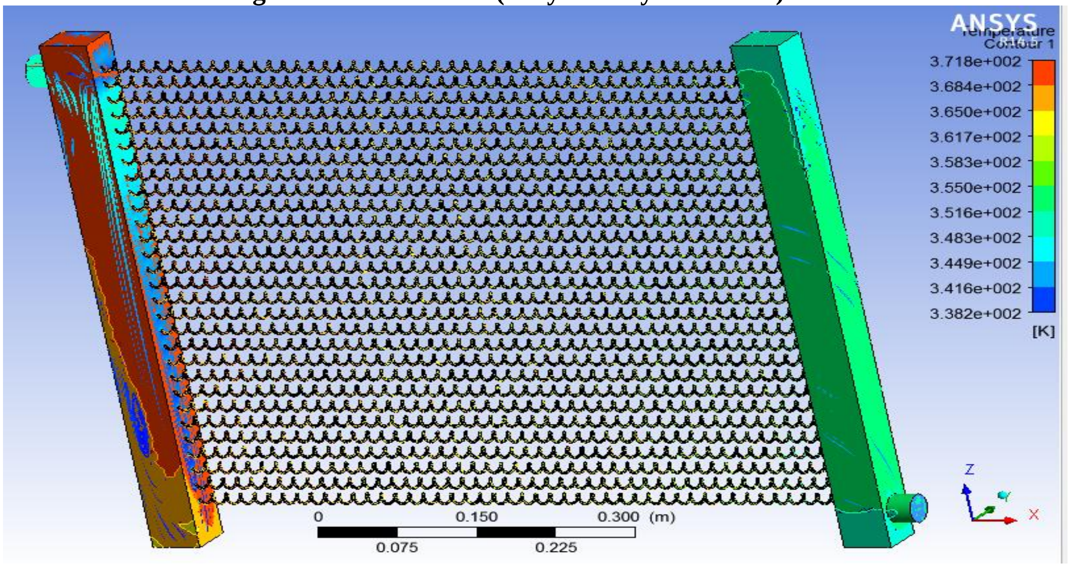

Figure 12: Temperature diagram of helical tubes used in Radiator. (M=0.5 kg/sec)

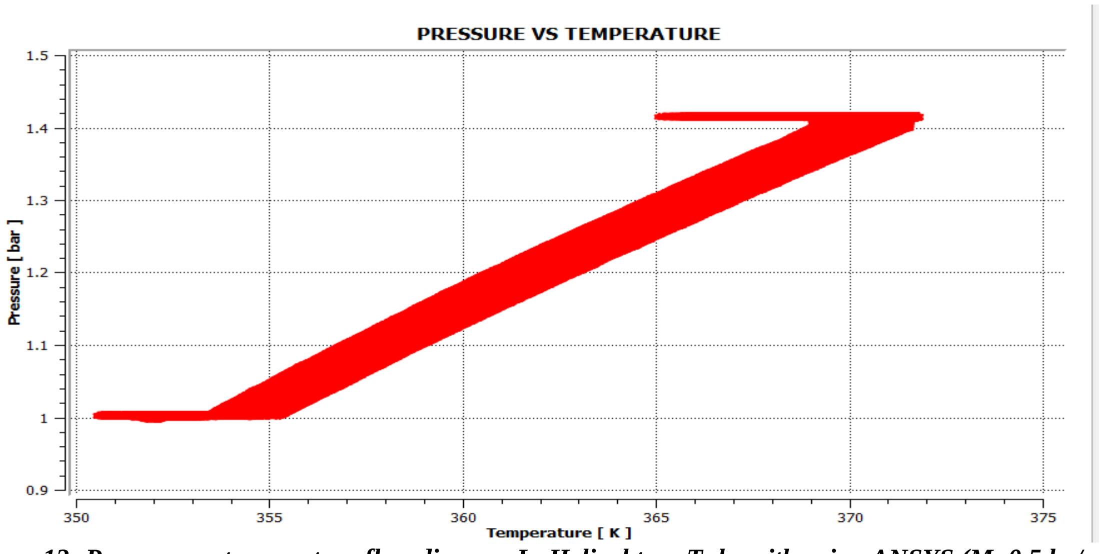

Figure 13: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=0.5 kg/sec)

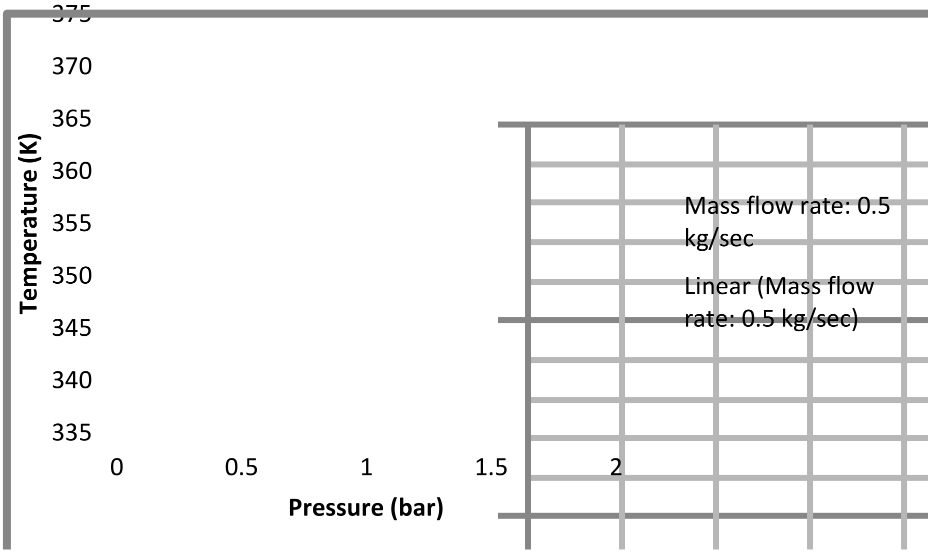

Figure 14: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=0.5 kg/sec)

Case I (f): Mass flow rate =0.3 kg/sec in Helical Tube (Ethylene Glycol coolant)

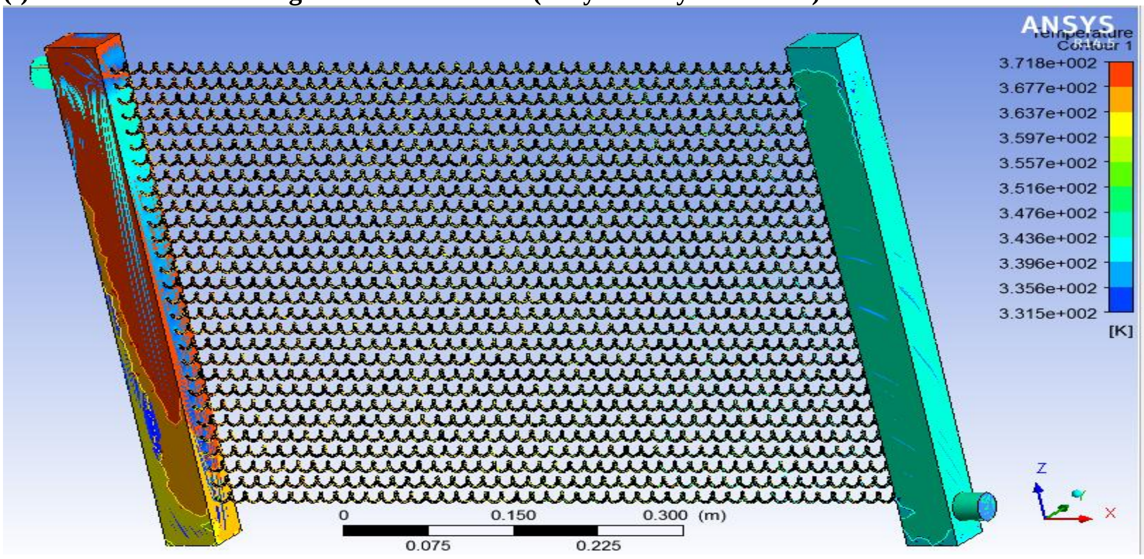

Figure 15: Temperature diagram of helical tubes used in Radiator. (M=0.3 kg/sec)

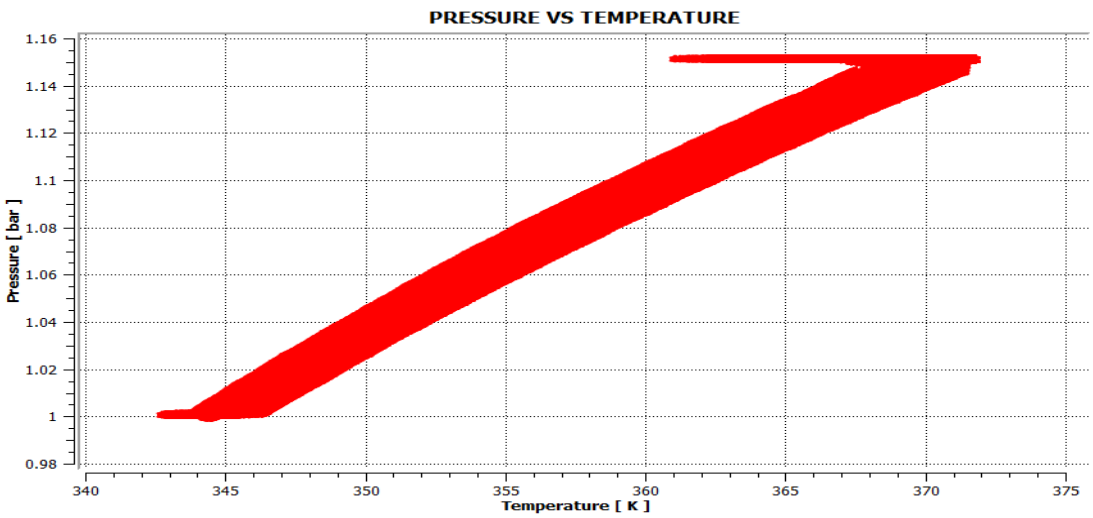

Figure 16: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=0.3 kg/sec)

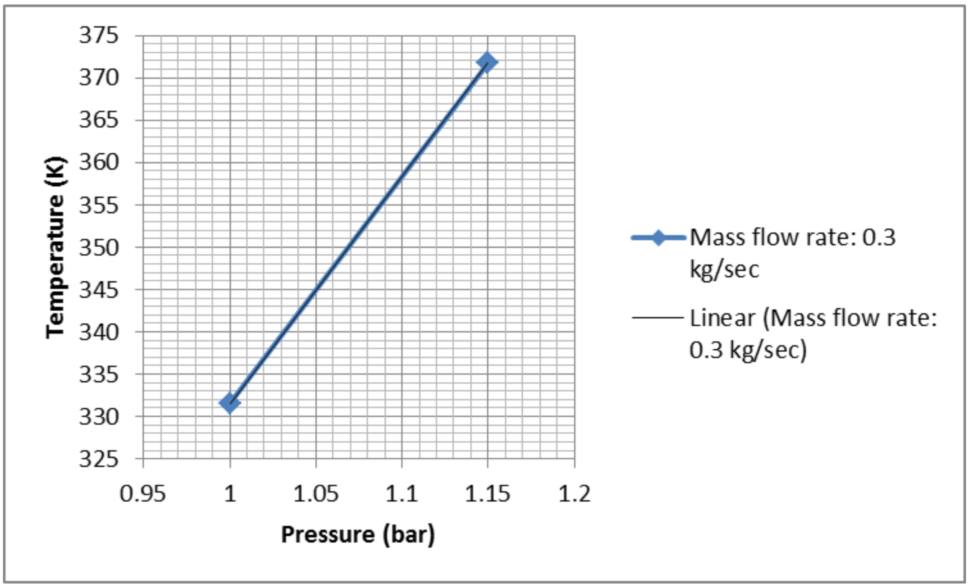

Figure 17: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=0.3 kg/sec)

Case I (a): Mass flow rate =0.1 kg/sec in Helical Tube (Ethylene Glycol coolant)

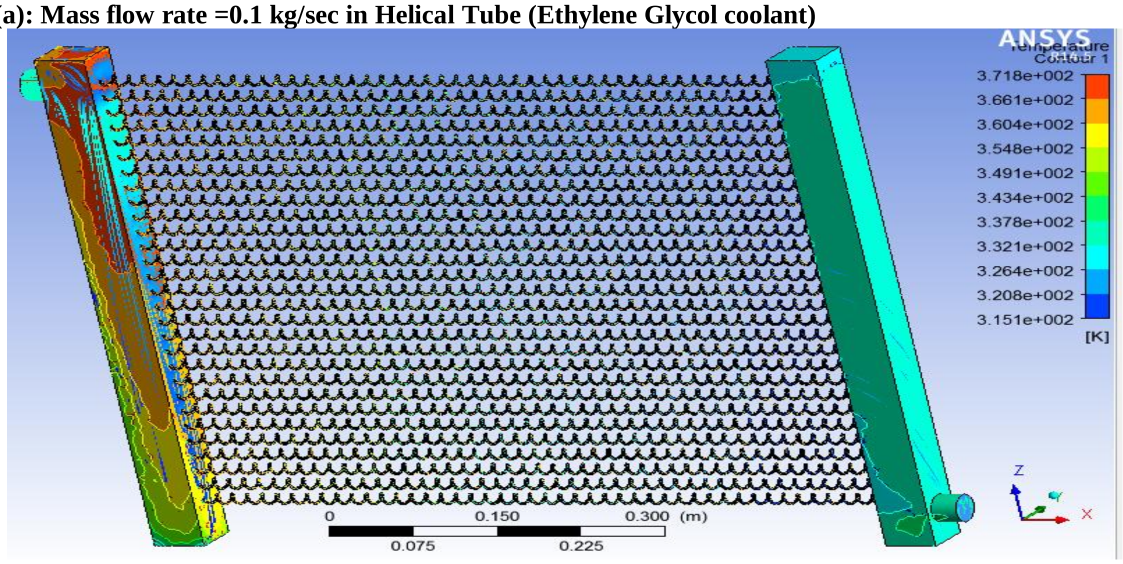

Figure 18: Temperature diagram of helical tubes used in Radiator. (M=0.1 kg/sec)

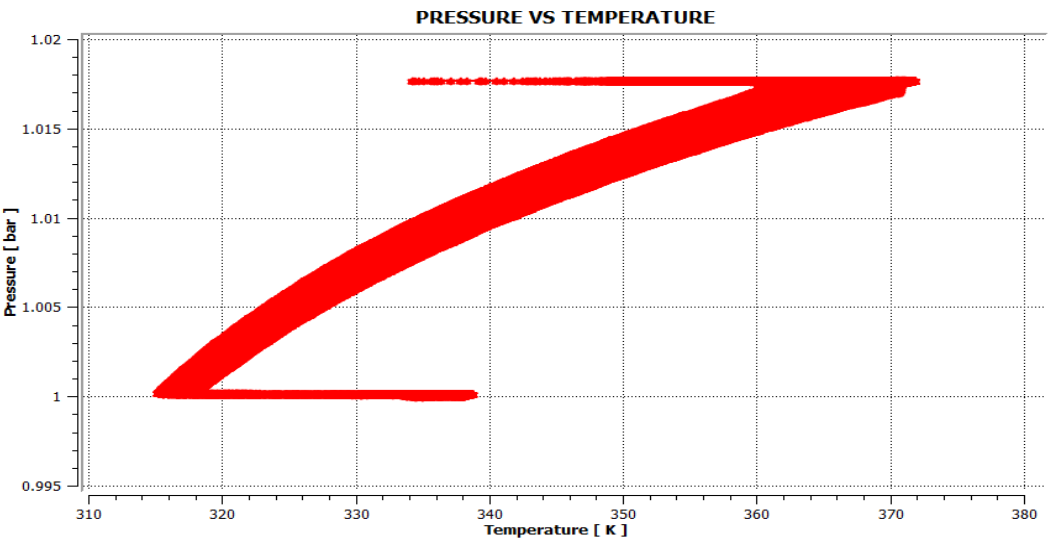

Figure 19: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (M=0.1 kg/sec)

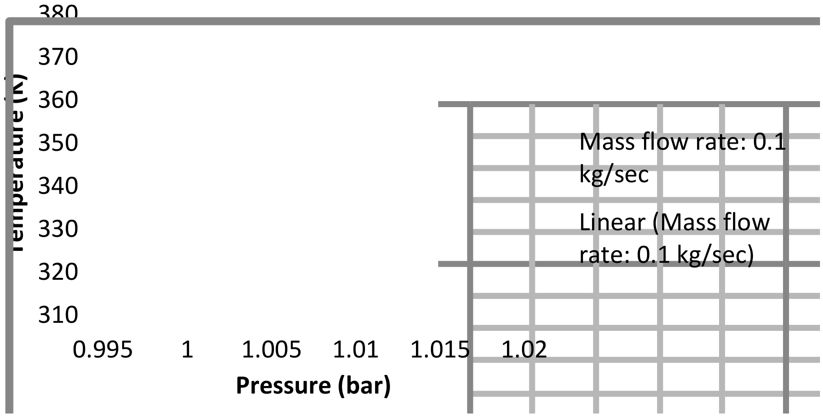

Figure 20: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (M=0.1 kg/sec)

Table 1: 20mm Pitch Helical Tube

Ethylene Glycol (kg/sec)	Inlet Temp (K)	Outlet Temp(K)	Δ T	Inlet Pressure (bar)	Outlet Pressure (bar)	Δ P
M=2.3	371.75	365.8	5.95	9.71	1	8.71
M=2.0	371.75	361	10.75	7.6	1	6.6
M= 1.5	371.75	357	14.75	4.7	1	3.7
M= 1.0	371.75	351.40	20.35	2.65	1	1.65
M=0.5	371.75	339	32.75	1.48	1	0.48
M=0.3	371.75	331.55	40.2	1.15	1	0.15
M=0.1	371.75	315.10	56.65	1.018	1	0.018

IV. CONCLUSION

Helical tube used in radiator's analysis done with used different mass flow rate & coolant used as ethylene glycol, get value in inlet temperature & outlet temperature, as well as inlet pressure & outlet pressure. For analysis we taken different mass flow rate like 2.3, 2.0, 1.5, 1.0, 0.5, 0.3, 0.1 kg/sec & we received result. We received result as a temperature difference between inlet temperature & outlet temperature of header of tube, which are 5.95, 10.75, 14.75, 20.35, 32.75, 40.2 & 56.65 with we get as a decreasing mass flow rate. Also we received Pressure difference like 8.71, 6.6, 3.7, 1.65, 0.48, 0.15 & 0.018 with respect to decreasing mass flow rate as shown in table 1 & figure 21. We take decreasing mass flow rate & getting Temperature drop continuously increases & pressure drop continuously decreases. That means with decreasing mass flow rate we get more cooling effect & also friction decrease. From analysis, Mass flow rate very important role during heat transfer process.

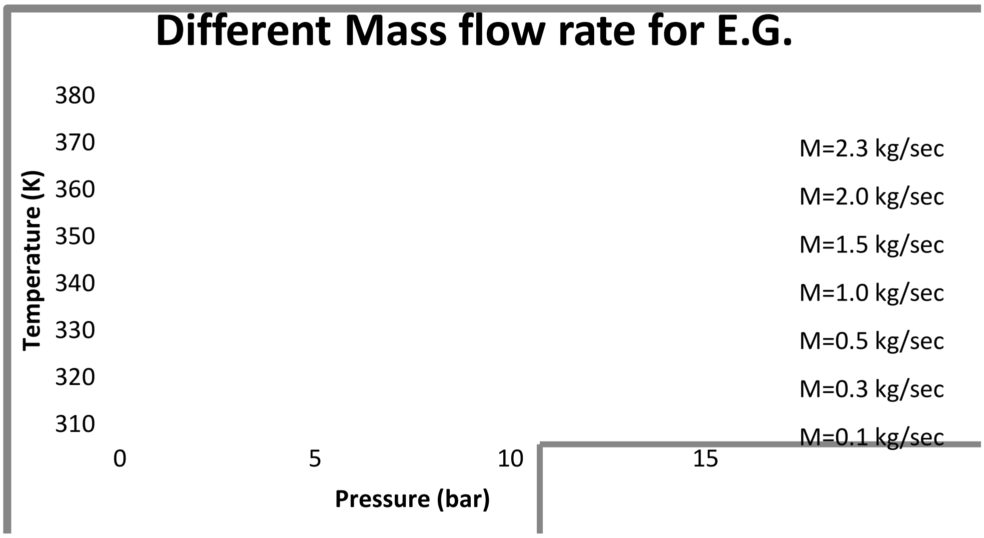

Figure 21: Different mass flow rate for Ethylene Glycol

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