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CFX Analysis With Different Outlet Pressure & Using Methanol 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 Methanol. The overall pressure & temperature distribution of the coolant was evaluated 20mm pitch helical tube used in radiator. From analysis, maintain of outlet pressure of radiator is very important role during heat transfer process. Analysis done with different outlet pressure of the radiator & coolant used as Methanol & we taken value of constant inlet temperature & variable outlet pressure. From this value & graph derived that with taking different outlet pressure of radiator; maintained outlet pressure is very important role during heat transfer process. For analysis we taken mass flow rate 0.5 kg/sec & different outlet pressure of coolant like 0.25, 0.5, 0.75, 1.0, 1.5, 2.0 bar. We received result as a temperature difference between inlet temperature & outlet temperature of header of tube, which are 28.52, 31.25, 30.51, 33.25, 19.52 & 1.75, & Pressure difference like 0.43, 0.42, 0.42, 0.42, 4.0 and 124778 with respect to increasing outlet pressure of radiator. At outlet pressure 2 bar, we getting temperature difference only 1.75 & pressure difference 124778 which is not desirable. From analysis we have getting best result at Outlet pressure 1 bar with temperature drop 33.35 & pressure drop 0.42 bar.*

Keywords- *Heat transfer analysis, helical tube, pitch, methanol, 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	: 98.75^0C
Outside temperature	: 25^0C
Coolant outlet pressure	: 0.25 bar, 0.5 bar, 0.75 bar, 1.0 bar, 1.5 bar, 2.0 bar
Coolant mass flow	: 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	: 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 outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 0.25 bar (Methanol coolant)

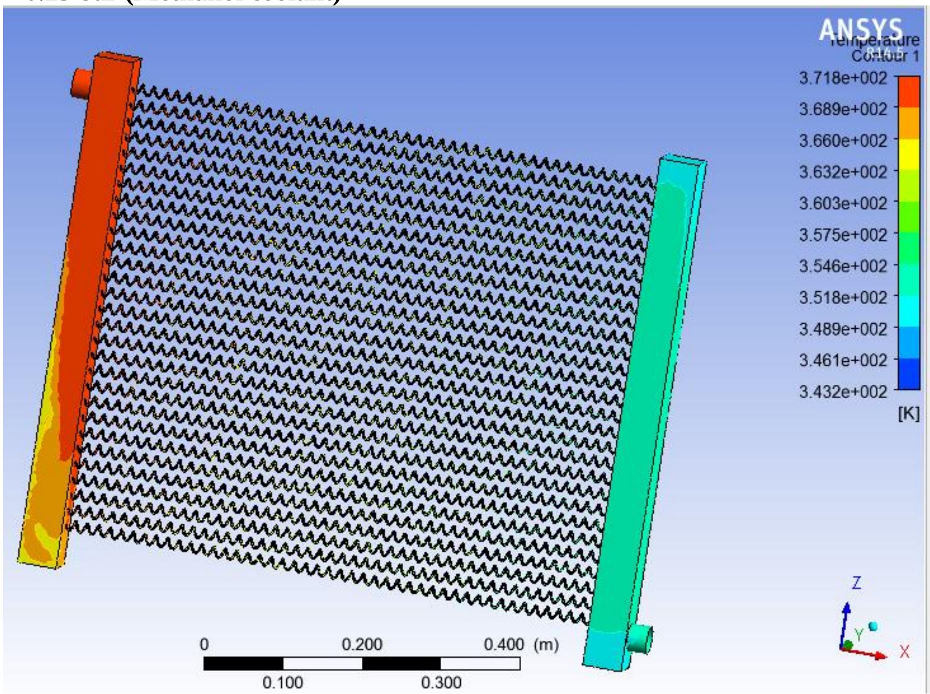

Figure 1: Temperature diagram of helical tubes used in Radiator. (Outlet Pressure = 0.25 bar)

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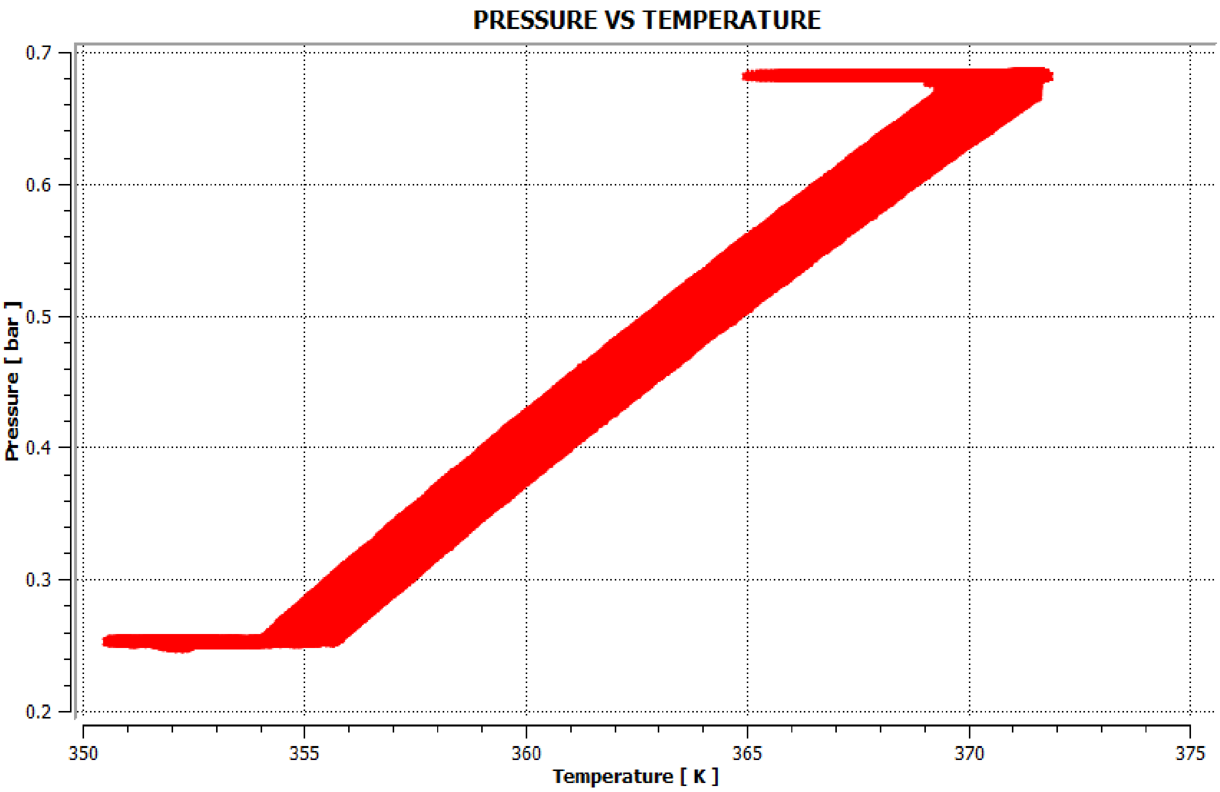

Figure 2: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure: 0.25 bar)

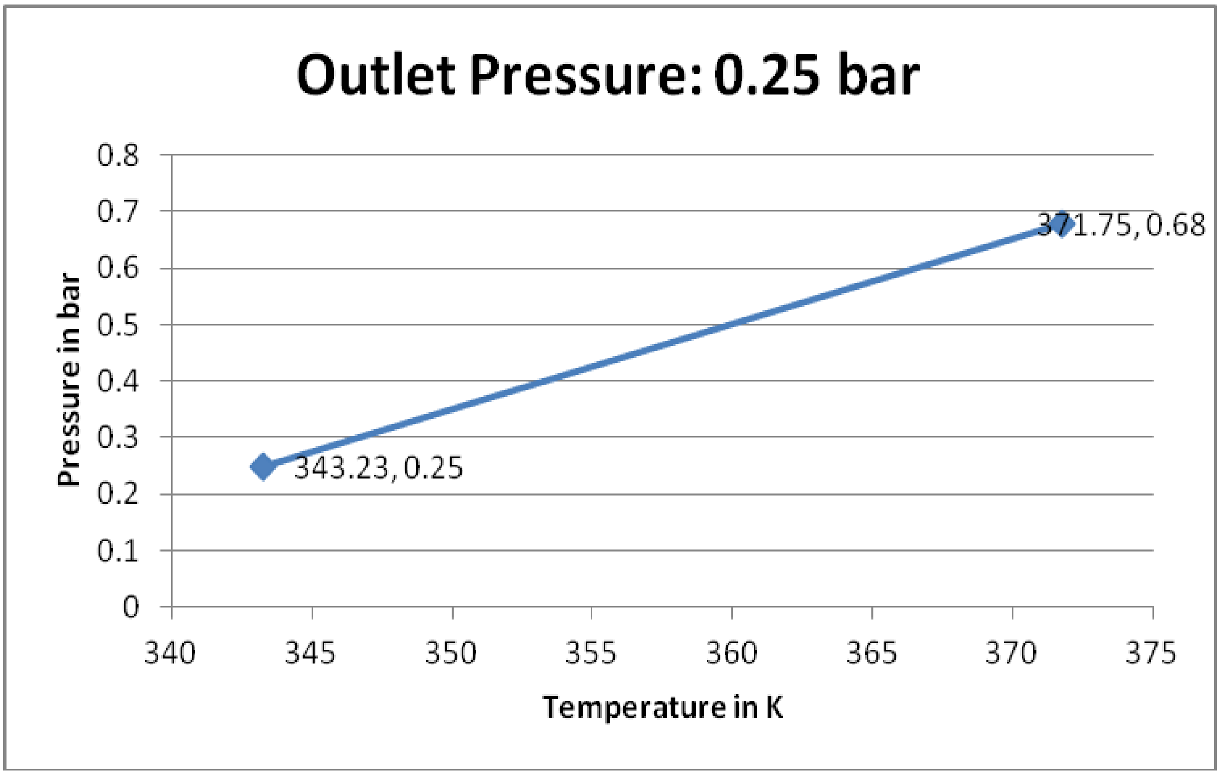

Figure 3: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure: 0.25 bar)

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Case-II: Analysis of Radiator with different outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 0.5 bar (Methanol coolant)

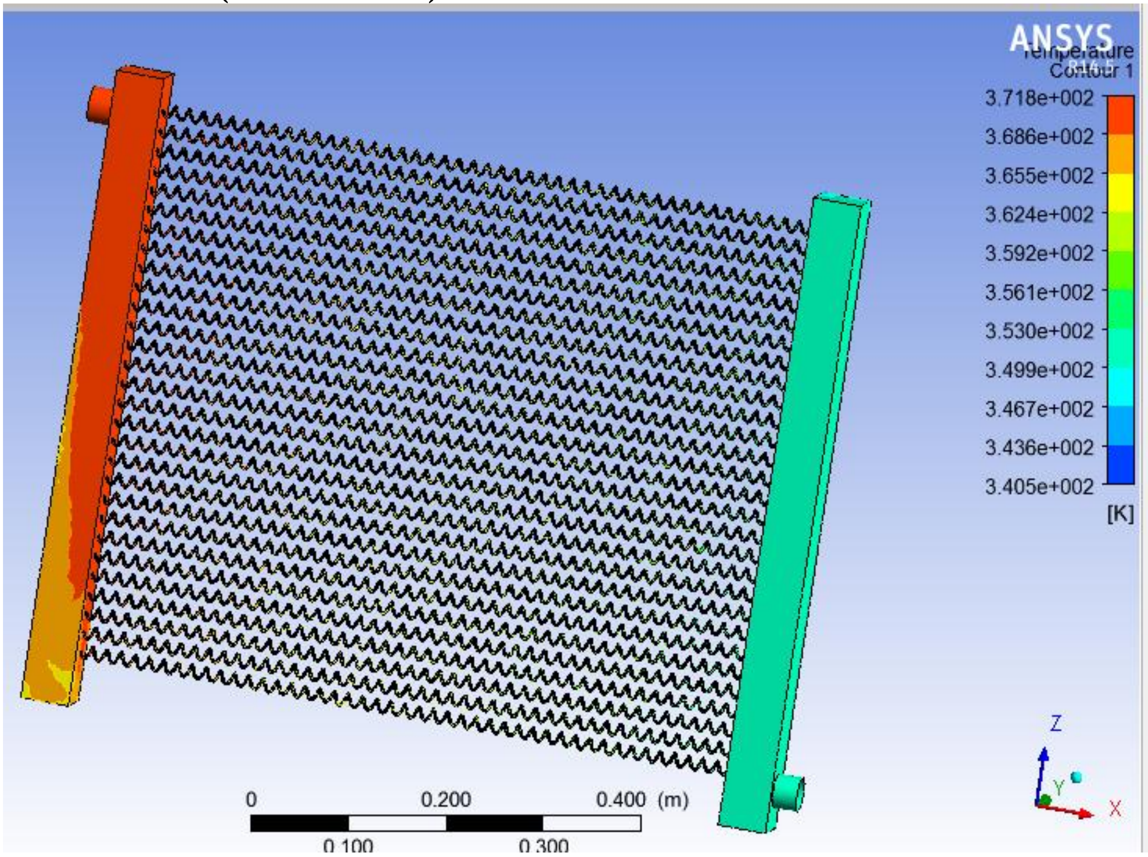

Figure 4: Temperature diagram of helical tubes used in Radiator. (Outlet Pressure = 0.5 bar)

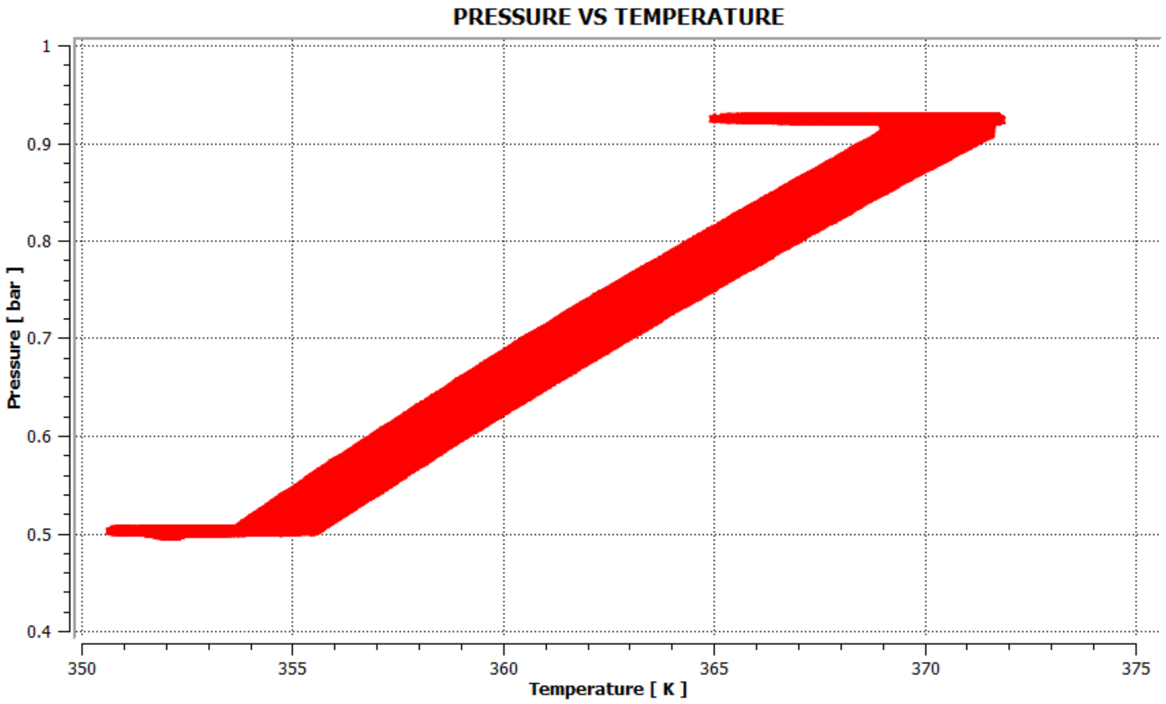

Figure 5: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure: 0.5 bar)

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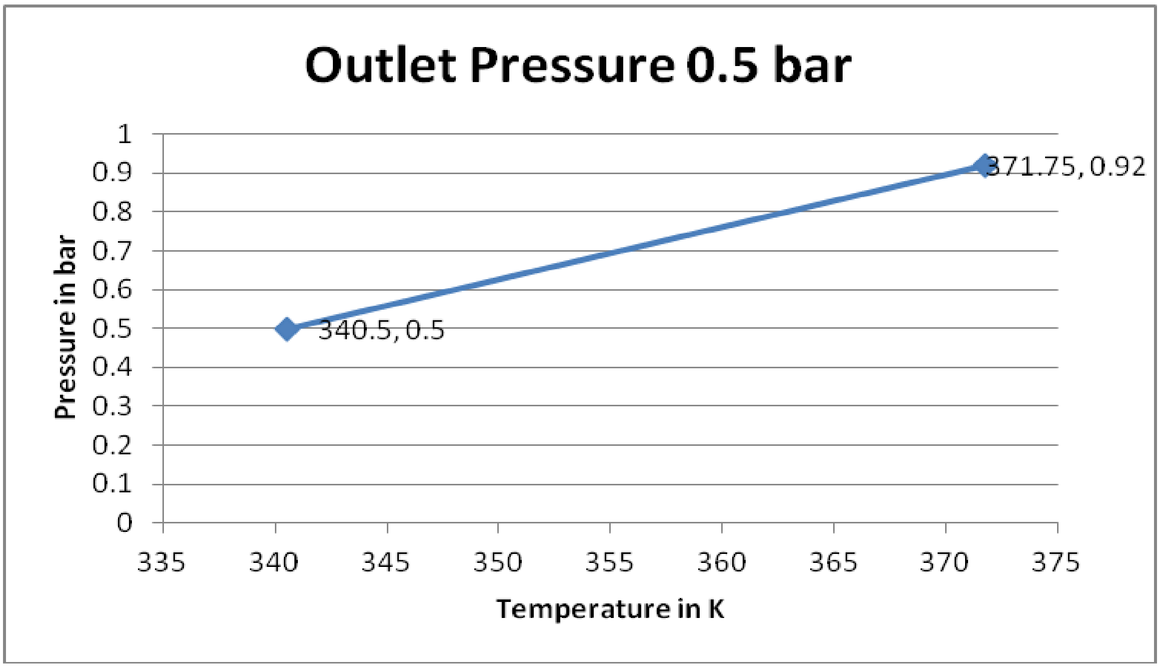

Figure 6: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure: 0.5 bar)

Case III: Analysis of Radiator with different outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 0.75 bar (Methanol coolant)

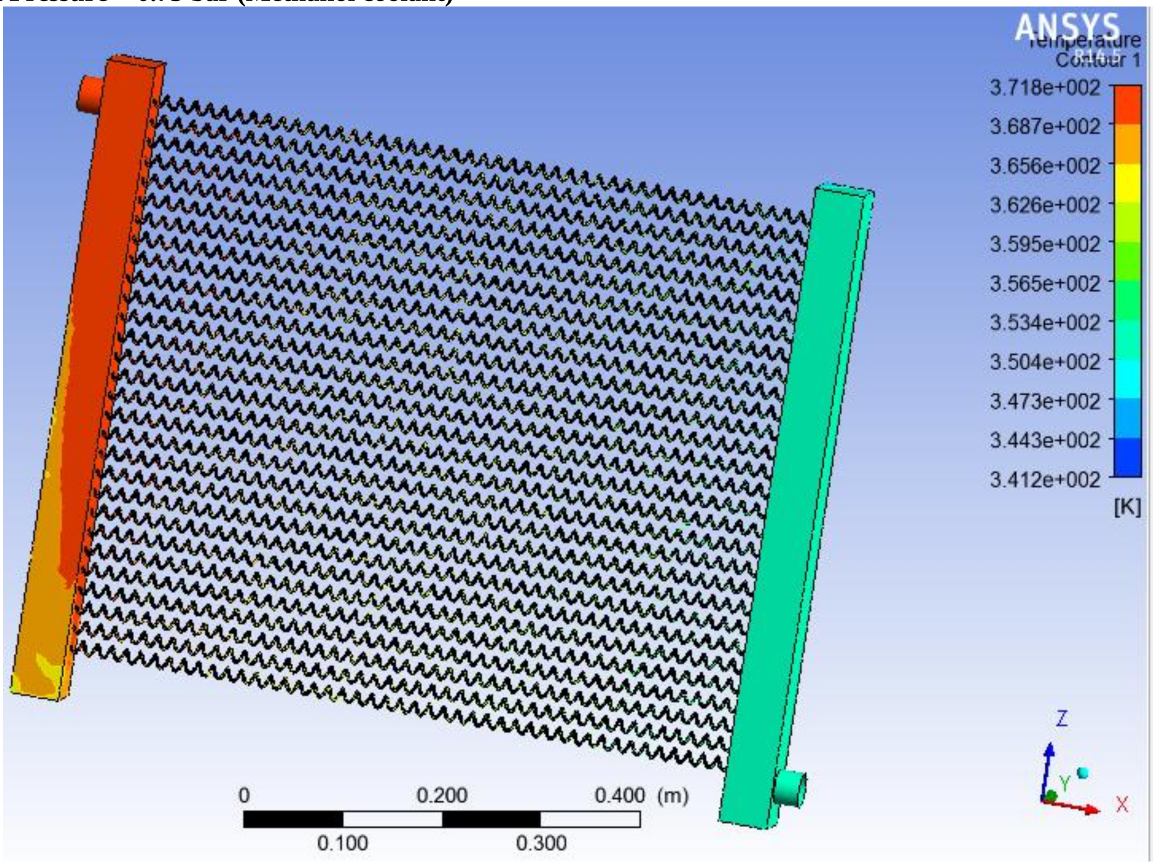

Figure 7: Temperature diagram of helical tubes used in Radiator. (Outlet Pressure = 0.75 bar)

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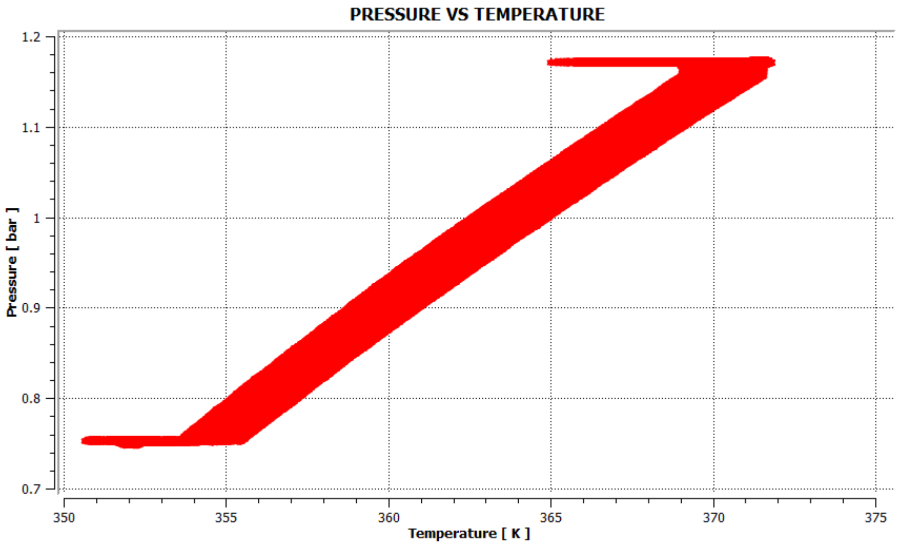

Figure 8: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure = 0.75 bar)

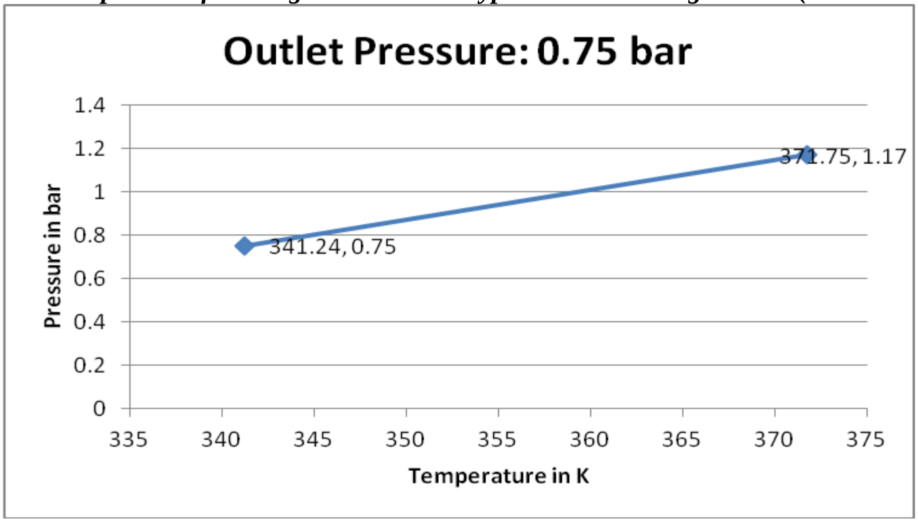

Figure 9: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure = 0.75 bar)

Case IV: Analysis of Radiator with different outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 1.0 bar (Methanol coolant)

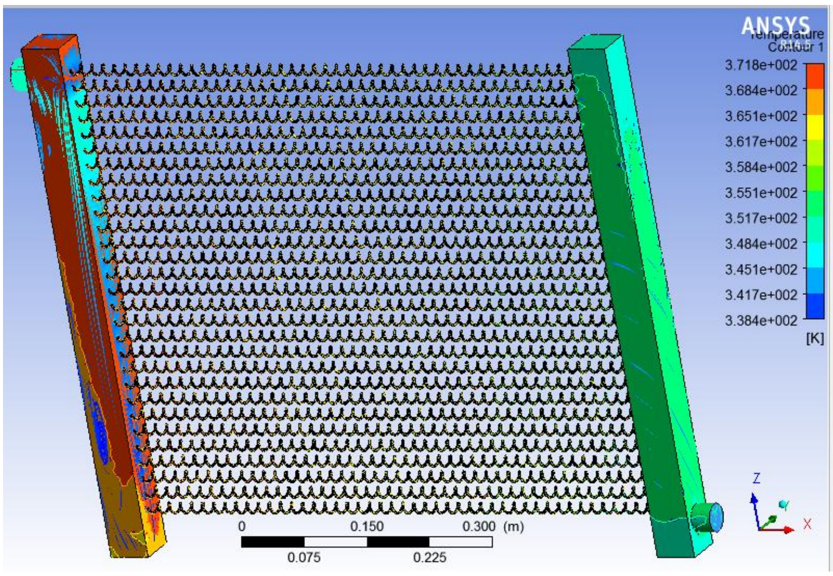

Figure 10: Temperature diagram of helical tubes used in Radiator. (M=2.0 kg/sec)

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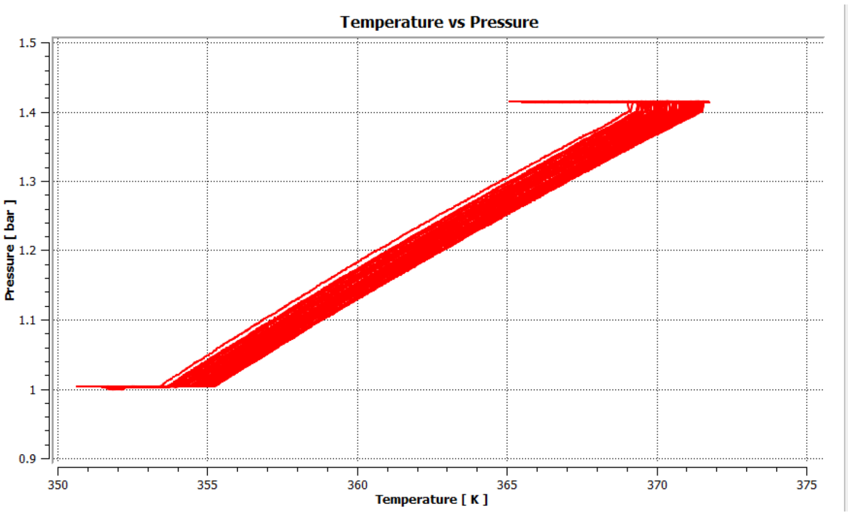

Figure 11: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure: 1 bar)

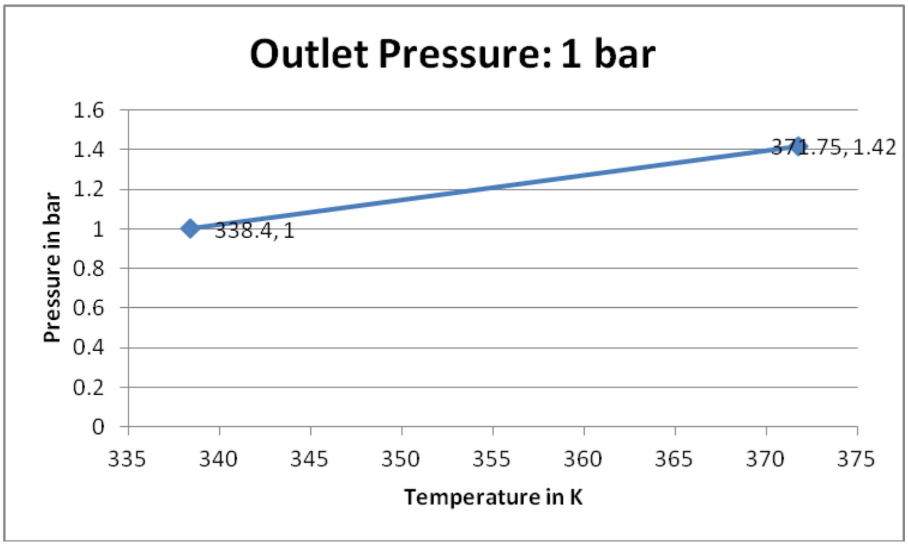

Figure 12: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure: 1 bar)

Case V: Analysis of Radiator with different outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 1.5 bar (Methanol coolant)

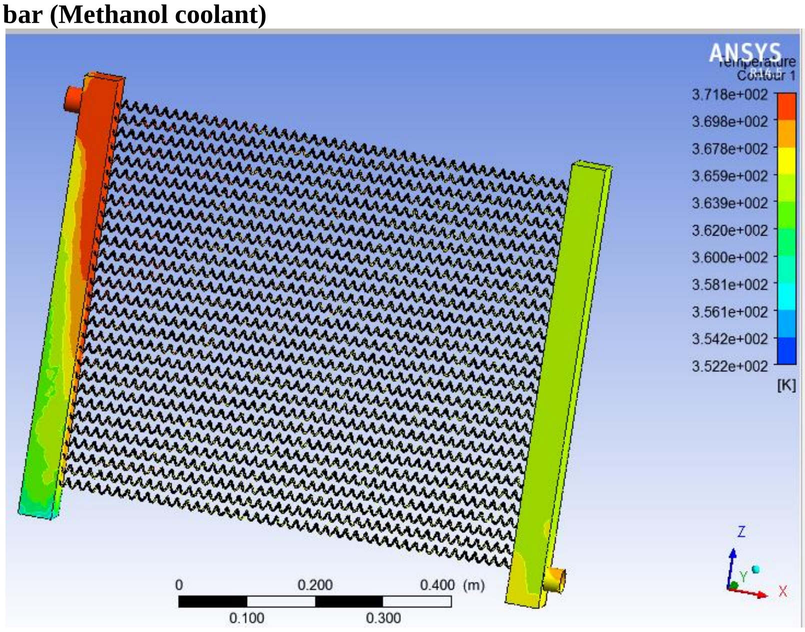

Figure 13: Temperature diagram of helical tubes used in Radiator. (Outlet Pressure = 1.5 bar)

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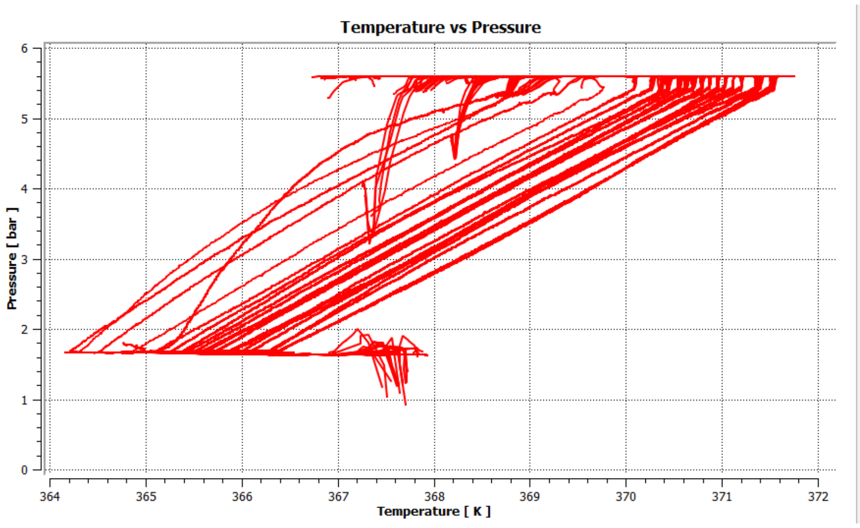

Figure 14: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure = 1.5 bar)

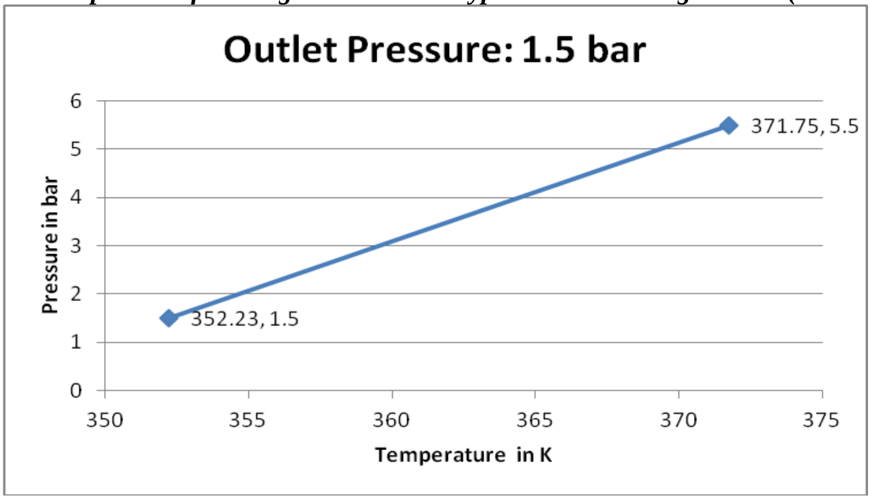

Figure 15: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure = 1.5 bar)

Case VI: Analysis of Radiator with different outlet pressure with Helical Tubes using Methanol Coolant with Outlet Pressure = 2.0 bar (Methanol coolant)

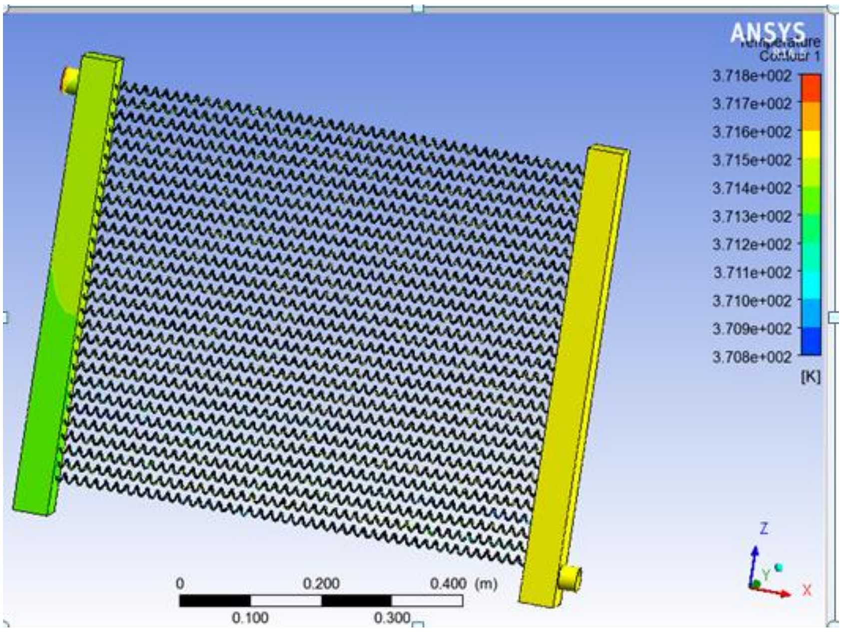

Figure 16: Temperature diagram of helical tubes used in Radiator. (M=1.0 kg/sec)

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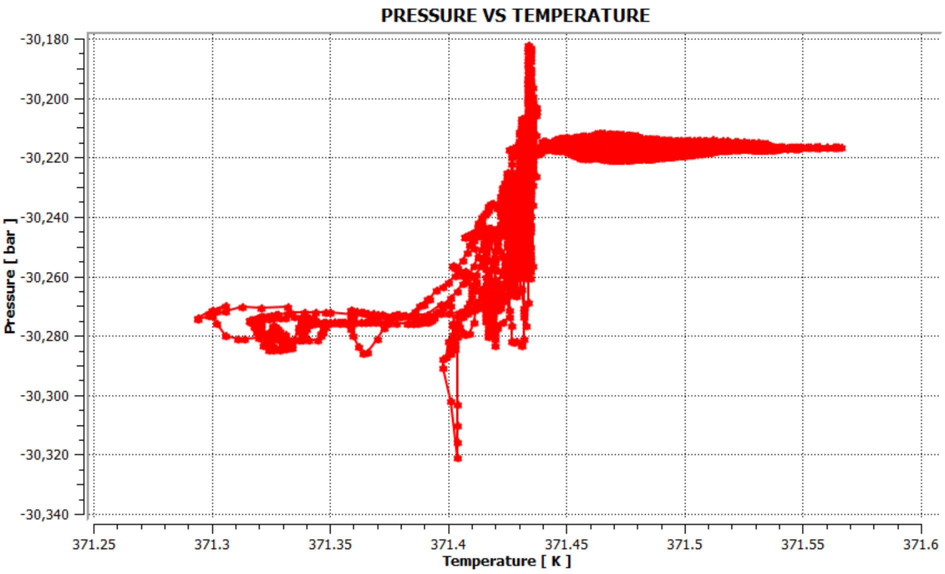

Figure 17: Pressure vs. temperature flow diagram In Helical type Tube with using ANSYS (Outlet Pressure = 2.0 bar)

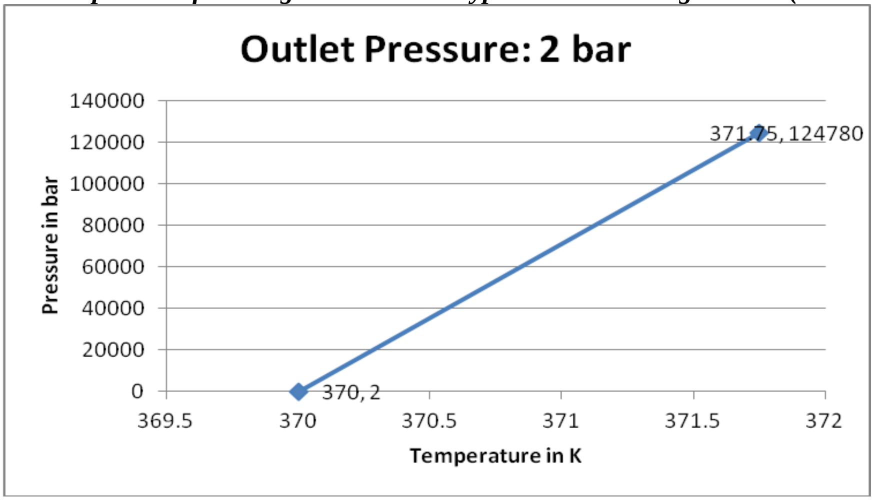

Figure 18: Inlet & Outlet Temperature VS Inlet & Outlet Pressure of Helical Tube (Outlet Pressure = 2.0 bar)

Table 1: 20mm Pitch Helical Tube

Methanol coolant (kg/sec)	Inlet Temp (K)	Outlet Temp(K)	Δ T	Inlet Pressure (bar)	Outlet Pressure (bar)	Δ P
M= 0.5	371.75	343.23	28.52	0.68	0.25	0.43
M= 0.5	371.75	340.50	31.25	0.92	0.5	0.42
M= 0.5	371.75	341.24	30.51	1.17	0.75	0.42
M= 0.5	371.75	338.4	33.35	1.42	1.0	0.42
M= 0.5	371.75	352.23	19.52	5.5	1.5	4.0
M= 0.5	371.75	370	1.75	124780	2.0	124778

IV. CONCLUSION

Helical tube used in radiator's analysis done with used 0.5 kg/sec as flow rate & coolant used as methanol with constant inlet temperature of coolant & maintained different outlet pressure, we get different value of outlet temperature of coolant & inlet pressure with considering different outlet pressure. For analysis we taken mass flow rate 0.5 kg/sec & different outlet pressure of coolant like 0.25, 0.5, 0.75, 1.0, 1.5, 2.0 bar. We received result as a temperature difference between inlet temperature & outlet temperature of header of tube, which are 28.52, 31.25, 30.51, 33.25, 19.52 & 1.75, and Pressure difference like 0.43, 0.42, 0.42, 0.42, 4.0 and 124778 with respect to increasing outlet pressure of radiator. At outlet pressure 2 bar, we getting temperature difference only 1.75 & pressure difference 124778 which is not desirable. From analysis we have getting best result at Outlet pressure 1 bar with temperature drop 33.35 & pressure drop 0.42 bar. From analysis, maintained outlet pressure is very important role during heat transfer process.

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