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Design and Optimization of Radiator for Liquid Cooling using Micro Channels

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Abstract: *The need to use micro channel in such radiator arise as need to increase the heat transfer rate from the radiator to better cool down the working fluid. The current radiator are not efficient in this process and thus hamper the performance of CPU, solution employed currently include increase the length of radiators and to accommodate multiple fans over it. The method we employed to tackle the issue was to introduce micro channels in the tube of the radiator. Use of micro channels increases the surface area of the passage through which the fluid passes, the increase in surface area leads to increased heat transfer rate which causes more heat loss through the system. Thus, increasing the efficiency of the radiator.*

Keywords: Micro channel, radiator, heat transfer rate, efficiency, surface area, temperature drop, pressure drop

I. INTRODUCTION

Heat Exchangers are devices designed to transfer heat between two or more fluids i.e., liquids,Vapours, or gases of different temperatures. Depending on the type of heat exchanger employed, the heat transferring process can be gas-to-gas, liquid-to-gas, or liquid-to liquid and occur through a solid separator, which prevents mixing of the fluids, or direct fluid contact. Regardless of the type and design, all heat exchangers operate under the same fundamental principles namely the Zeroth, First, and Second Laws of Thermodynamics which describe and dictate the transference or exchange" of heat from one fluid to another [3].

The flow configuration, also referred to as the flow arrangement, of a heat exchanger refers to the direction of movement of the fluids within the heat exchanger in relation to each other. There are four principal flow configurations employed by heat exchangers [4].

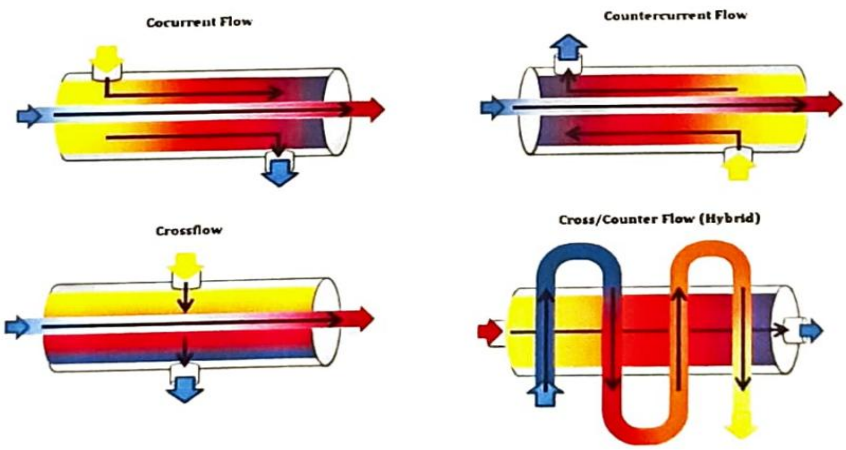

Figure 1: Heat Exchanger Flow Configurations

Micro Channel Heat Exchanger

Micro channel technology is being increasingly adopted by manufacturers in heating, air conditioning and refrigeration products, both for their enhanced energy efficiency, cost and reduced refrigerant charge. The goal with micro channel

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heat exchangers is to improve overall heat transfer, which could potentially reduce the temperature difference between the air and a refrigerant. Additionally, the heat exchangers minimise airside pressure drop, which results in more energy savings gained from the fan energy consumption.

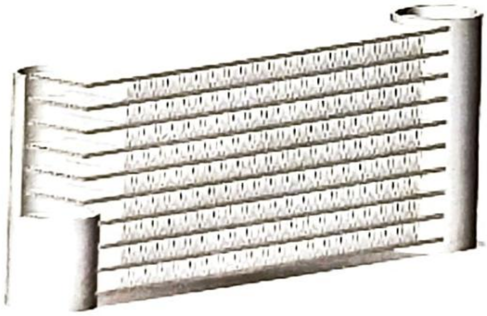

Figure 2: Micro Channel Heat Exchanger

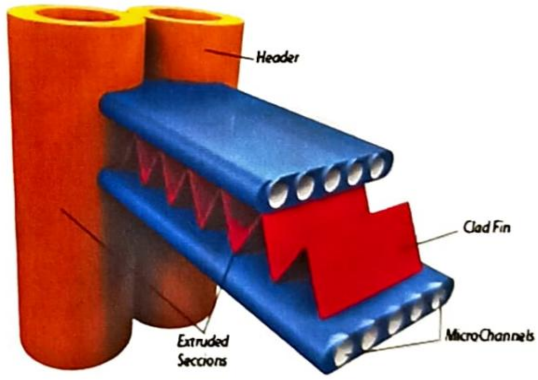

Figure 3: C/S View of Micro Channel H.X.

Radiators

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. Automobile radiators are constructed of a pair of metal or plastic header tanks, linked by a core with many narrow passageways, giving a high surface area relative to volume. This core is usually made of stacked layers of metal sheet, pressed to form channels and soldered or brazed together. For many years radiators were made from brass or copper cores soldered to brass headers.

CPUs

Alternately referred to as a processor, central processor, or microprocessor, the CPU (pronounced sea-pea-you) is the central processing unit of the computer. A computer's CPU handles all instructions it receives from hardware and software running on the computer. Computer processors are designed to run at high temperatures and it's completely normal for a CPU to heat up and to actually get very warm. In fact, temperatures of over 200 degrees Fahrenheit are frequently acceptable. If an efficient path for that heat doesn't exist, then the CPU will exceed its safe operating temperature.

Figure 4: CPU Radiator

PC Liquid Cooling Systems

The process starts with a baseplate that is connected to the IHS of the CPU with a layer of thermal paste. This allows for better heat transfer between the two surfaces. The metal surface of the baseplate is part of the water block, which is designed to be filled with coolant. The coolant absorbs heat from the baseplate as it moves through the water block. It then continues to move through the system and upward through one of two tubes to a radiator. The radiator exposes the liquid to air, which helps it cool, and fans attached to the radiator then move the heat away from the cooler. The coolant then re-enters the water block, and the cycle begins again.

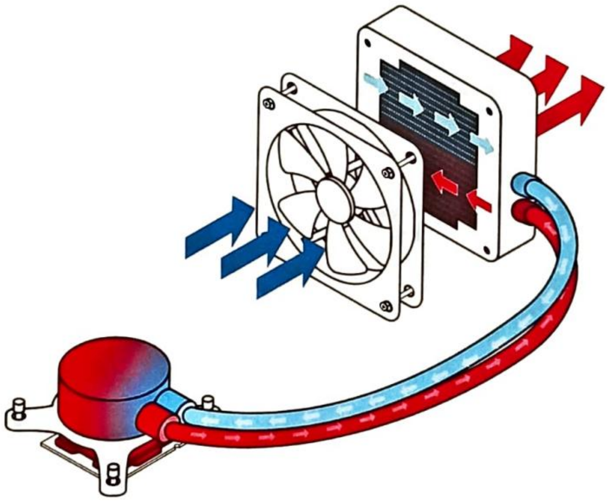

Figure 5: AIO Liquid Cooling System

Problem Statement

The existing pc (AIO) cooling system rely on radiator with wide tubes to cool down the working fluid in the closed loop. The radiators used are not very efficient and thus tor better performance bigger radiators are used. Cooling is required for CPU to give consistent performance. Using a Micro channels in radiator increases the surface area for heat transfer, thus providing better cooling effect at smaller size. Which will help in getting consistent performance from CPU.

Objective

- To increase the heat transfer rate to achieve higher temperature drop.
- To design micro channels of optimal diameter.

II. MATERIAL SELECTION

As there are many methods for selecting optimized materials, such as: Cost per unit property method, weighted property method, Digital logic method. The radiator has a unibody design, those it can be divided in critical segments such as - Tubes, Fins, Main body.

For these critical parts of radiator, we have used DIGITAL LOGIC METHOD. In which numerous material properties are specified and the relative importance of each property is not clear, determinations of the weighting factors, can be largely intuitive, which reduces the reliability of selection. The digital logic approach can be used as a systematic tool to determine. In this procedure evaluations are arranged such that only two properties are considered at a time. Every possible combination of properties or goals is compared and no shades of choice are required, only a yes or no decision for each evaluation.

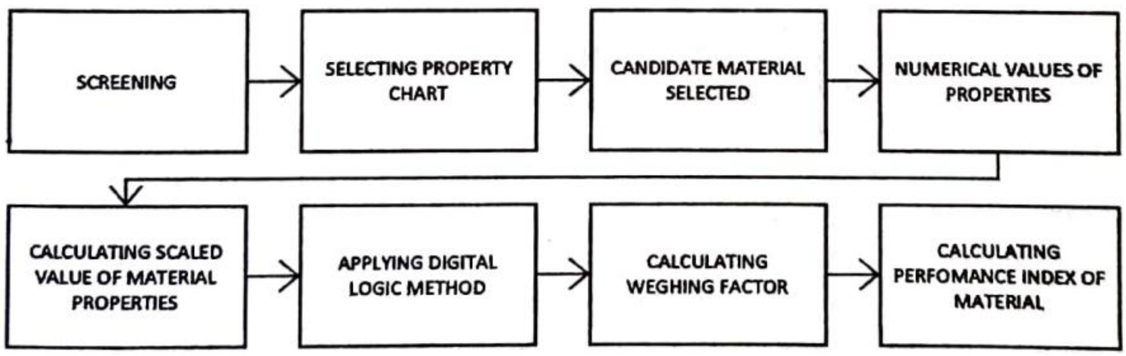

Figure 6: Digital Logic Method

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2.1 Selecting property chart.

The chart guides selection of materials for light, stiff, components. The moduli of engineering materials span a range of 107; the densities span a range of 3000. The contours show the longitudinal wave speed in m/s; natural vibration frequencies are proportional to this quantity. The guide lines show the loci of points for which E/p = C , (minimum weight design of stiff ties; minimum deflection in centrifugal loading, etc), El/2/p=C (minimum weight design of stiff beams, shafts and columns), El/3/p =C (minimum weight design of stiff plates)

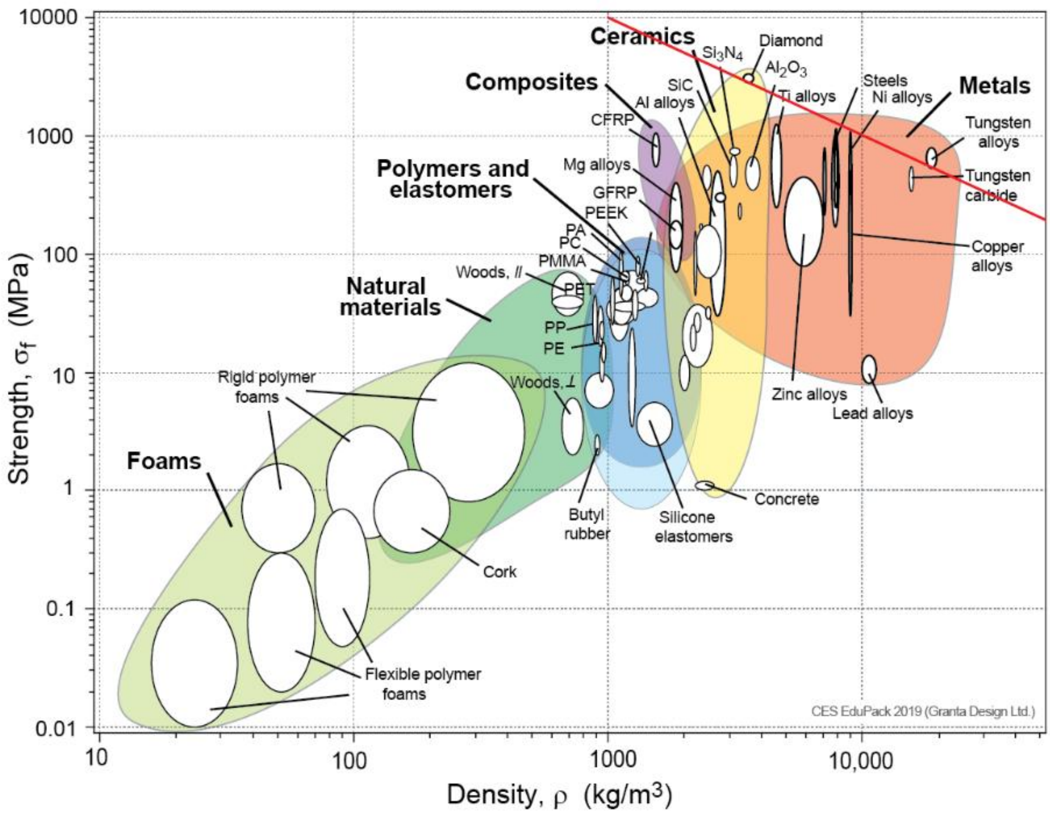

Figure 7: Performance Index Chart 1

2.2 Screening

- **Function**- To enable heat transfer
- **Objective** - Increase in heat transfer rate
- **Variable** - Wall thickness, tube diameter
- **Constraint** - Shape and dimensions

2.3 Candidate material selected

- Aluminium Alloy 3102
- Aluminium Alloy 3003
- Stainless Steel 304
- Monel 400

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2.4 Numerical values of properties

Table1: Numerical values of properties

Material Property	Tensile Strength (MPA)	Young's Modulus (GPA)	Thermal Conductivity (W/m-K)	Density (g/cm^3)
Al 3102	92	69	230	2.71
Al 3003	110	70	180	2.8
SS 304	580	200	16	7.8
Monel 400	540	160	23	8.8

2.4.1 Calculating scaled value of material properties

Scale property for friction co-efficient = (numerical value x 100 / max value in the list)

Table 2: The scaled value of material properties

Material Property	Tensile Strength (MPA)	Young's Modulus (GPA)	Thermal Conductivity (W/m-K)	Density (g/cm^3)
Al 3102	15.86	34.5	100	30.79
Al 3003	18.96	35	78.26	31.81
SS 304	100	100	6.95	88.63
Monel 400	93.1	80	10	100

2.4.2 Applying digital logic method

In comparing two properties or goals, the more important goal is given numerical one (1) and the less important is given zero (0). The total number of possible decisions N =n (n-1)/2, where n is the number of properties or goals under consideration.

Table 3: The digital logic method

Iteration Property	1	2	3	4	5	6	Total
Tensile Strength	1	0	0				1
Young's Modulus	0			0	0		0
Thermal Conductivity		1		1		1	3
Density			1		1	0	2

2.4.3 Calculating weighing factor

A relative emphasis coefficient or weighting factor, for each goal is obtained by dividing the number of positive decisions for each goal (m) into the total number of possible decisions (N).

Weighting Factor = Positive Decision /Total

Table 4: The weighing factor

Property	Positive Decision	Weighing Index
Tensile Strength	1	0.167
Young's Modulus	0	0
Thermal Conductivity	3	0.5
Density	2	0.33
Total	6	1

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2.4.4 Calculating performance index of material

Table 5: The performance index of material

Material	Performance Index
Al 3102	62.8
Al 3003	52.79
SS 304	49.423
Monel 400	53.54

III. ANALYSIS

3.1 Antec Radiator

Radiator used in the Antec ecosystem of liquid cooling peripherals. The dimensions of the design are based off of the radiator available in the market from Antec company.

Figure 8: Antec Radiator

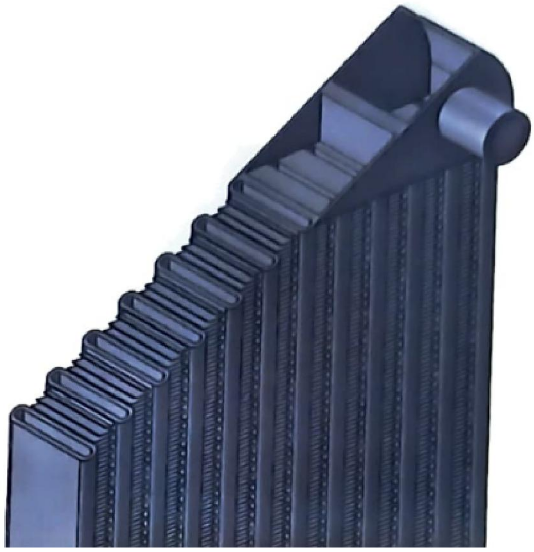

Figure 9:C/S view Antec Radiator

3.2 Micro Channel Radiator

Radiator designed with micro channels to increase heat transfer. The dimensions of the design were based on the radiators available in the Industry (antec). The constraint involved in the process were to mount the standard 120x120mm fans which are standard in the industry.

Figure 10: Micro channel Radiator

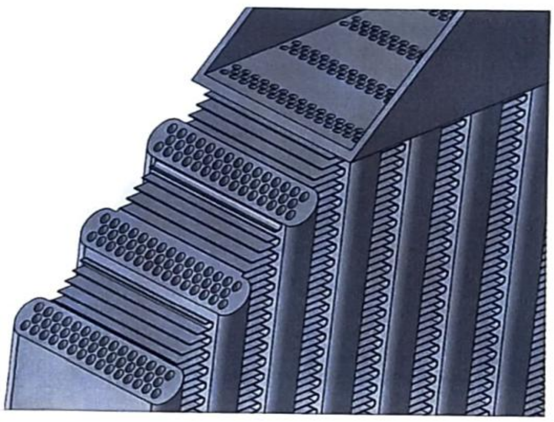

Figure 11:C/S view of Micro Channel Radiator

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3.3 Properties

Table 6: Properties

Properties	Antec Radiator	Micro Channel Radiator
Material	Aluminium	Aluminium
Micro Channel diameter /Wall Thickness	0.28 (Wall Thickness)	1 mm (Micro Channel diameter)
Dimensions	169 x 120 x 27mm	169 x 120 x 25.4mm
Speed	(900 - 1600rpm) ± 100	(900- 1600rpm) ± 100
Airflow	77 CFM	77CFM
Net Weight	0.68 KG	0.68 KG
Gross Weight	1.5 KG (max.)	1.5 KG (max.)
Water Pressure	1m ± 0.2m	1m ± 0.2m
Flow rate	1.5 L/min	1.5 L/min

3.4 Velocity

The flow trajectories represent the velocity flowing through the tubes/channel. When the fluid enters the tubes the pressure decreases and hence the velocity increases. This is in accordance with the Bernoulli's principle.

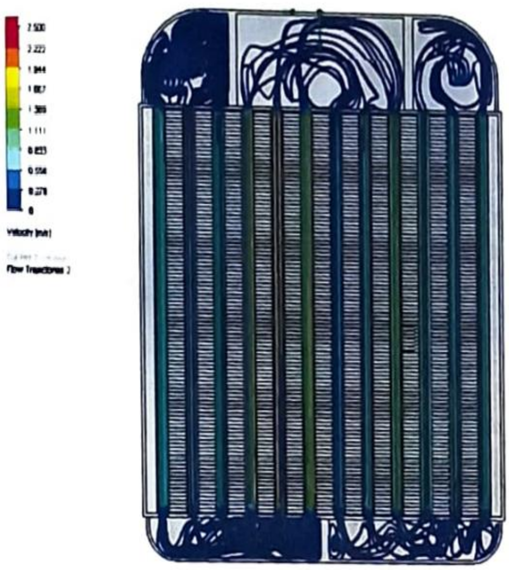

Figure 12: Velocity Cut-Plot

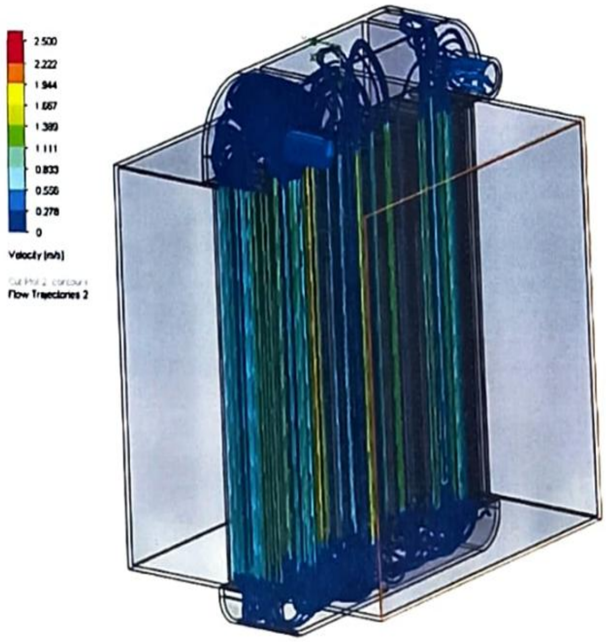

Figure 13: Velocity Flow Trajectory

3.5 Temperature

The flow trajectories represent the temperature of fluid flowing through the tubes/ channel. So as we can see the initial inlet temperature is 75 degree Celsius and as it passes through the tubes, the forced flow of the cold air around the tubes causes convection which leads to gradual fall in temperature throughout the tube. As, there is the temperature drop of 12-18 degree Celsius is obtained at the outlet.

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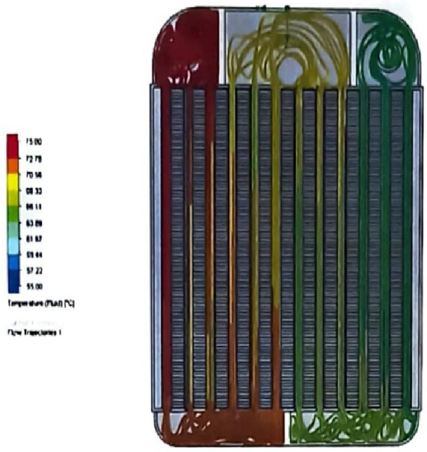

Figure 14:Temperature Cut-Plot

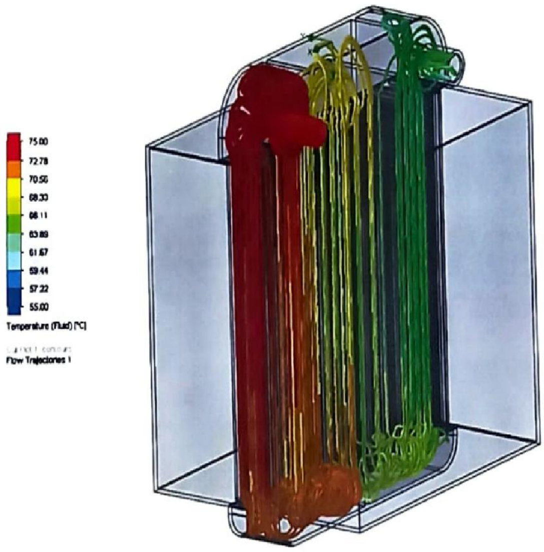

Figure 15:Temperature Flow Trajectory

3.6 Pressure

The flow trajectories represent the pressure throughout the tubes/channels. When the fluid enters the tube the velocity and hence the pressure decreases.

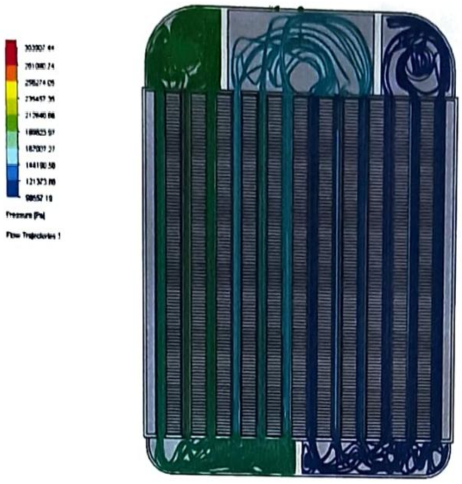

Figure 16:Pressure Cut-Plot

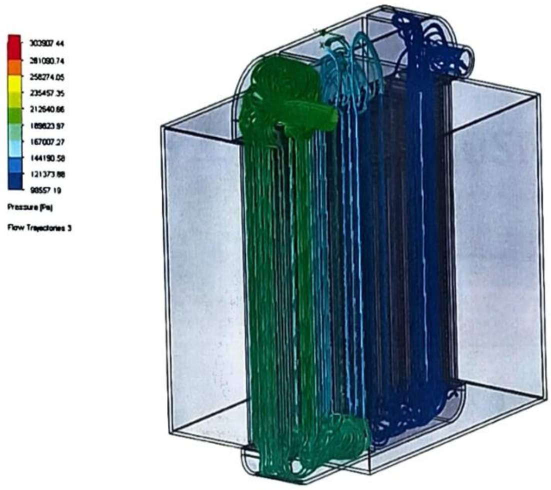

Figure 17:Pressure Flow Trajectory

IV. RESULTS

Different values of air flowing around the tubes were kept constant and the inlet velocity of the fluid entering the tubes constant and also determined the inlet temperature as 75 and 80 degree Celsius and then after running the simulation we get the outlet temperature as follows.

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Table7: Results

Radiator				Antec Radiator		Micro Channel Radiator	
Iteration	Air flow rate (m^3/s)	Flow rate (m^3/s)	Inlet Temperature (Celsius)	Outlet Temperature (Celsius)	Temperature drop	Outlet Temperature (Celsius)	Temperature drop
1	0.025	0.01	80	61.32	18.68	60.12	19.88
2	0.025	0.005	80	50.6	29.4	49.35	30.65
3	0.025	0.001	80	45	35	34.57	45.43
4	0.1	0.005	80	42.5	37.5	32.19	47.81
5	0.05	0.005	80	45.74	34.26	44.41	35.59
6	0.0363	0.00025	75			63.87	11.13
7	0.0363	0.00033	75			65.32	9.68

V. CONCLUSION

It was observed that introduction on micro channels in the radiator tubes, the rate of heat transfer increased. The cause of increase in heat transfer rate is the increase in surface area due to the introduction of multiple small/micro channels. But along with the increase in heat transfer rate which lead to greater drop of temperature at the outlet of Radiator. There was also observed a significant amount of pressure drop along the micro channels. Thus, there is an increase the efficiency of the radiator, the increase in temperature drop was in the range of 1-5°C, this concluded that the use of using micro channels lead to increased heat transfer rate.

REFERENCES

[1] Sanjay B. Ghorpade, Bhupendra D. Jadhav, Pranjali T. Maskar, Manoj M. Dongare, Vaibhav S. Pawar,Lubricant oil & Diesel analysis based diagnostic framework for machine components & V-Ti ceramics as additives for lubricants and plasticizers, Materials Today: Proceedings,2022, ISSN 2214-7853,https://doi.org/10.1016/j.matpr.2022.12.033.

[2] Binghuan Huang, HaiwangLi,Shuangzhi Xia and TiantongXu (2020). Experimental investigation of the flow and heat transfer performance in micro-channel heat exchangers with cavities, International Journal of Heat and Mass Transfer, 159, (2020), 120075.

[3] ShimaSoleimani Matthew Campbel and Steven Eckels. Performance analysis of different transverse and axial micro-fins in a turbulent-flow channel, International Journal of Thermal Sciences, 149, (2020), 106185.

[4] MladenBoanjakovic , Simon Muhic and Ante Cikic (2019).Experimental testing of the heat exchanger with star-shaped fins, International Journal of Heat and Mass Transfer 149, (2019), 119190.

[5] Xiang Zhang, Ratrnesh Tiwari., Amir H. Shooshtari and Michael M. Ohadi. An additively manufactured metallic manifold-microchannel heat exchanger for high temperature applications, Applied Thermal Engineering 143, (2018), 899-908.

[6] Mr. Manoj M. Dongare, Prof.Richa S. Agrawal, Mr. Vijay B. Dhadke "MODEL ANALYASIS OF SEED DRILL GROUND OPENER (TYNE)" International Journal for Science and Advance Research in Technology, 2(4). Volume 2, Issue 4, April 2016.https://ijsart.com/Home/PastIssueList?v=2&i=4#

[7] Manoj Kr. Gupta and R.R. Sahoo (2016). Performance of Micro-channel Heat Exchanger in Automotive Radiator, Journal of Aeronautical and Automotive Engineering (JAAE), P ISSN: 2393-8579; e-ISSN: 2393-8587.

[8] Yanhui Han, Yan Liu, Ming Li and Jin Huang (2011). A review of development of micro channel heat exchanger applied in air-conditioning system, Science Direct Elsevier Energy Procedia 14 (2012) 148 153.

[9] ASHBY, M. F., & CEBON, D. (1993). Materials selection in mechanical design. Le Journal de Physique IV, 03(C7), C7-1-C7-9.