

**TESTING OF HEAT TRANSFER ENHANCEMENT IN RECTANGULAR
MICRO CHANNEL**Rohit Pingale¹, Prof.Siddaraj Allurkar², Prof.Girish Gudi³¹ PG Student, DPES, Wagholi² Mechanical Engineering, DPES, Wagholi³ Mechanical Engineering, DPES, Wagholi

Abstract —In our work numerical analysis is has carried out for rectangular micro channels with sets of rectangular configurations, in order to find optimum configuration of micro channel. Analysis of rectangular micro channel has carried out with constant base area of 30mm length and 20 mm width.. As compare to other configurations the heat transfer coefficient is more and dominant so 260 μ m diameter micro channel. Also as the heat input increase the configuration with higher hydraulic diameter show less pressure drop as compare to hydraulic diameter of 260 μ m.

Keywords- Micro channel, Heat transfer, Pressure drop, Heat transfer coefficient, Pressure Drop

I. INTRODUCTION

Over the course of the past couple of decades, many conflicting accounts of results on the validity of classical macro scale equations for Micro channels fluid flow and heat transfer have been given. Among this research are the investigations of the validity of the macro scale equations for friction factor, transition Reynolds number, and Nusselt number on the microscope. The High heat transfer rate is the need of many systems in today's world in order to improve their performance by maintaining their operating temperature below acceptable levels as in case of high performance computer chips is below 100 °C, microelectronic equipment. This can be achieved by both direct geometry advantage of "higher heat transfer area" and "higher heat transfer coefficient". For various heat and mass transfer applications a micro channel device has received increasing attention for applications such as microelectronics, Micro channels reactors, micro-rockets, and microbiological systems.

To cope with demand for more efficient cooling technology for next generation of high power electronics devices, various kinds of micro heat exchangers and two phase micro channel heat sink are required. Energy conversion, recovery and generation often require high effectiveness heat exchangers. Functions can include recuperation, waste heat recovery, boiling a working fluid, condensation, evaporation in cooling systems and high flux heat removal. In many applications, emphasis is placed on small, light-weight and high-performance devices, especially if the overall systems using heat exchangers are meant for portability, must be air-lifted or for retro fitting existing systems where space constraints are dictated. The micro channels are attracted on important research interest due to rapid growth of applications in microelectronics. Among the research that has been conducted within the academic and industrial communities are investigations of the validity of the macro scale equations of friction factor and Nusselt number on the micro scale. Over the course of the past couple of decades, many conflicting accounts of results on the validity of classical macro scale equations for Micro channels fluid flow and heat transfer have been given.

1.1. Historical Review

The first concept for using micro channels as a heat exchanger device for VLSI circuits was conceived by Tuckerman and Pease (1981). It was found that the micro channels are very effective in heat dissipation. The reason for very high heat removal was associated with the fact that micro channels have very small hydraulic diameters ranging to up to a few hundred microns. This was in conjunction with the significant area enhancement due to the finned surface.

Because of smaller free flow areas, the power needed to pump fluid through smaller passages also increased a lot. Thus increased pressure drop was a concern. Very high pressures required to maintain the flow through these channels assured that micro channels predominantly operated in the laminar regime. Although micro channels promised to be very effective, initially Micro channels research did not receive an impetus. Intel developed the 80286 microprocessor which had significantly reduced the power consumption of the microelectronic device which implied less waste heat. Recently, computer has reached processor speed exceeding 3.6 Gigahertz. Further increase in speed is being limited by the ability to dissipate the heat generated by these chips. Insufficient rejection of heat will result in computer failure.

The microelectronics, telecommunications, power electronics and to some extent the electrical power industries are constantly striving towards miniaturization of devices that inevitably results in greater power densities. Therefore there is a challenge of heat removal from these high flux devices.

II. PROBLEM DEFINITION, OBJECTIVE, AND METHODOLOGY

2.1 Problem statement

Developing technology requires compact and high heat energy removal solution .Such compact and high energy removal solutions can be obtained by using micro channels .For developing such cooling devices Analysis and study of micro channel is necessary because flow of working substance through micro channel is quite different conditions to that of conventional channels And we have to analyze validation of correlation available for macroscopic level with microscopic level

2.2 Objective

The objectives of project are as listed below:

1. Design and manufacturing of rectangular micro channel.
2. Development of experimental setup of rectangular micro channel.
3. Performance analysis of rectangular micro channel.

2.3 methodology

Methodology for project is listed as per below:

1. Theoretical study of flow of refrigerant through rectangular micro channel by using available correlations.
2. Development of rectangular micro channel test setup by considering literature review
3. Perform experiment on test setup and encrypt result.
4. Performance analysis of rectangular micro channel.
5. Make conclusion based on result.

III. EXPERIMENTAL SET UP

3.1 Design Of Test Set Up:

Tuckerman And Pease First Suggested The Use Of Micro Channels S For High Heat Flux Removal; This Heat Sink Is Simply A Substrate With Numerous Small Channels And Fins Arranged In Parallel, Such That Heat Is Efficiently Carried From The Substrate Into The Coolant.

The Study Was Conducted For Water Flowing Under Laminar Conditions Through Micro Channels Machined In Silicon. By Referring Basic Refrigeration Cycle We Have Designed Block Diagram Of Basic Refrigeration Cycle

Which Consist Of Following Components Compressor, Condenser, Expansion Valve & Micro Channels Manifold Is Used Instead Of Evaporator Because Its Size Is Compact. Also Heat Transfer Coefficient Of Micro Channels Has Great Efficiency As Compared To Other Evaporator. Therefore Micro Channels S Is Used To Increase The Efficiency Of Heat Transfer.

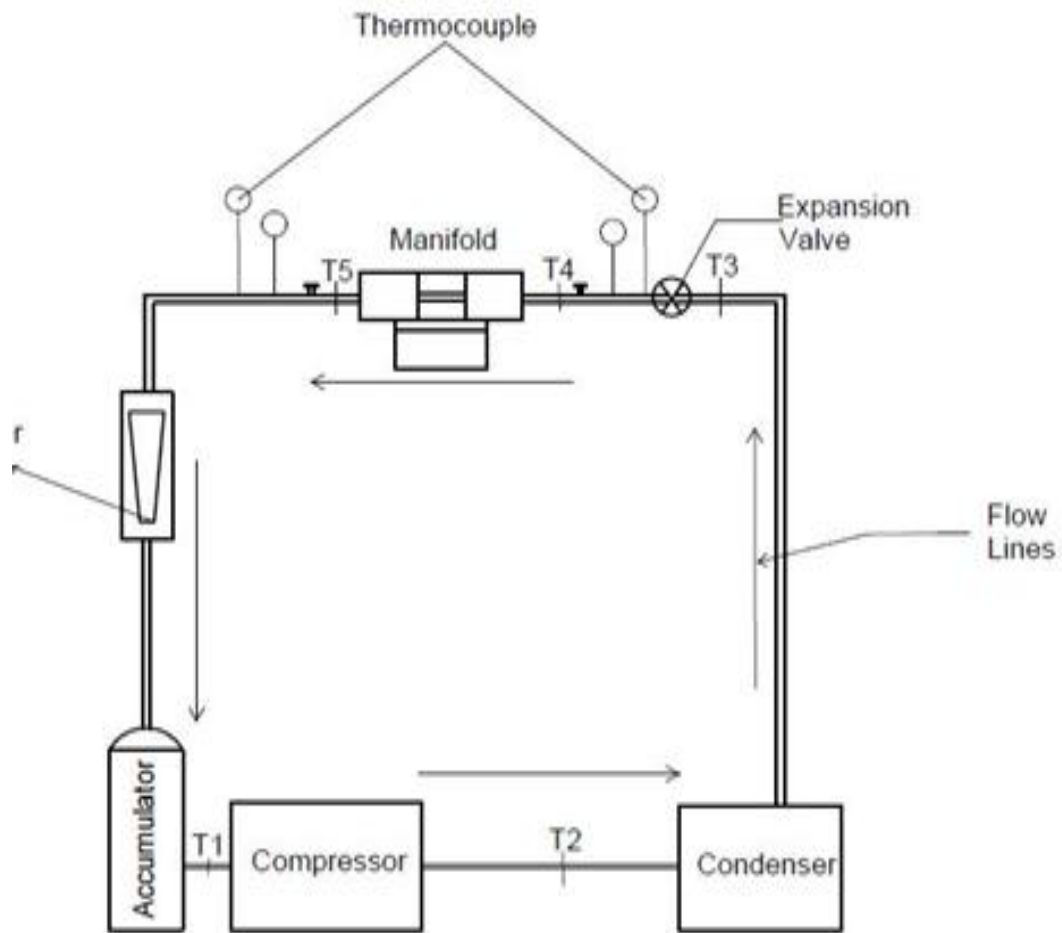


Figure 3.1 Flow Loop Of Experimental Test Set Up

3.2 Notations Used:

1. T1- Inlet Temperature of Compressor In $^{\circ}\text{C}$.
2. T2= Inlet Temperature of Condenser In $^{\circ}\text{C}$.
3. T3= Inlet Temperature of Expansion Valve In $^{\circ}\text{C}$.
4. T4= Inlet Temperature of Manifold In $^{\circ}\text{C}$.
5. T5=Temperature at Bottom Of Copper Plate.
6. T6=Temperature at Top Of Copper Plate.
7. C=Compressor Reading.
8. W=Wattmeter Reading.
9. D=Dimmer Stat Reading.
10. S=Subzero Reading.
11. R=Rota Meter Reading.
12. P=Pressure Gauges Reading.

3.3 Details Of Experimental Setup:

The Below Diagram Represents The Details Of Experimental Setup Which Includes The Components Of The Setup-Compressor, Condenser, Accumulator, Micro Channels Manifold, Expansion Valve, Temperature Indicator, Rotameter, Energy Metre, Wattmeter, Pressure Gauges, Dimerstat Etc.

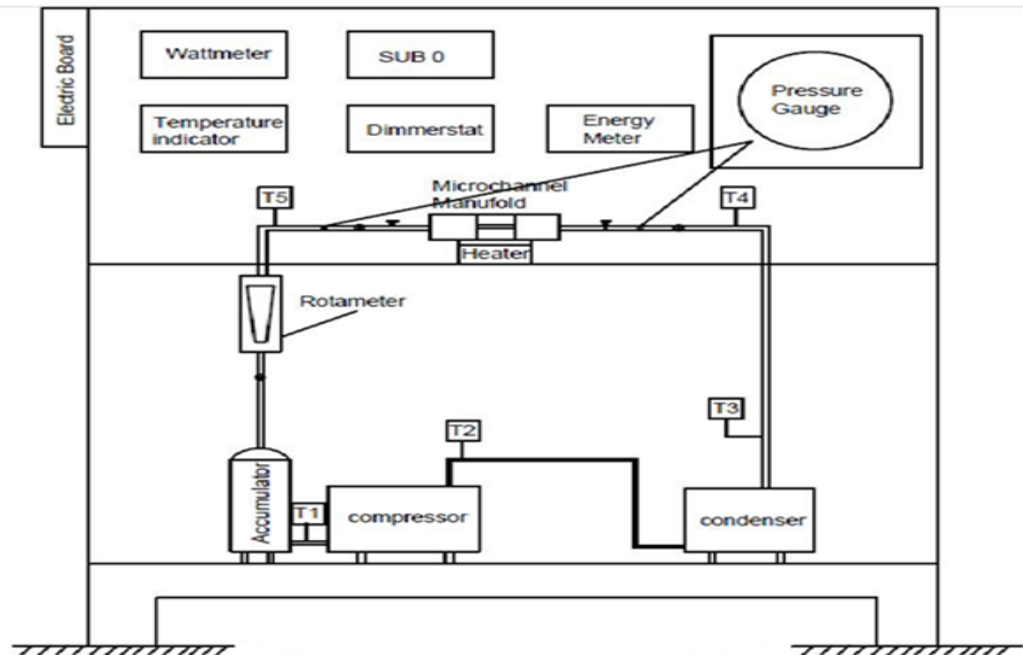


Figure 3.2- Test Loop Sysetm Of Micro Channels

3.4 Experimental Set Up Details

- 1] Set Up Consist Of Compressor From Which Cooling Refrigerant Is Circulated.
- 2] Compressor Is Used For Compressing The Refrigerant Up To Sufficient High Pressure And Temperature Compression Is Done On Vapor.
- 3] After There Is Condenser Where It Is Cooled At Constant Pressure By Rejecting Heat To Condenser.
- 4] The Liquid From Condenser Goes To Expansion Valve Where Temp. And Pressure Reduces And Converts Into Vapour.
- 5] Finally Low Pressure, Low Temp. Passes To Manifold Where It Absorbs Latent Heat At Constant Pressure And Convert Into Vapour State.
- 6] Again Supplied To Compressor. Thus Cycle Is Completed.
- 7] Accumulator Act Storing Energy.
- 8] Heater Is Used For Heating Purpose In Manifold.
- 9] Rota Meter Is There For Flow Measurement.
- 10] Piping For Circulation Of Cooling Refrigerant.
- 11] Manifold Having Inlet And Outlet And Have Copper Micro Channels In It.

3.5 Experimental Procedure:

1. Refrigerant From Compressor Is Compressed Into Circuit By Compressor 'C' Whose Capacity Is 1 Hp. The Flow Is Measured And Metered By Rot Meter.

2. Metered Flow Is Entered Into Compressor Of Whose Temperature Is Measured By Thermocouple (T1). Purpose Of Compressor Is To Ensure Laminar Flow Of Water Through Micro Channels.
3. Atmospheric Temperature Is Measured By Thermometer (T1). Heat Is Supplied To Copper Plate By Heater Whose Temperature Is Measured By Thermocouple (T5).
4. Temperature At The Surface Of Copper Plate Is Measured By Thermocouple (T6). Heat Of Copper Plate Is Carried By Refrigerant While Passing Through Micro Channels.
5. Compressor And Its Temperature Is Measured By (T3) Thermocouple. After There Is Condenser Where It Is Cooled At Constant Pressure By Rejecting Heat To Condenser The Liquid From Condenser Goes To Expansion Valve Where Temperature And Pressure Reduces And Convert Into Vapors.
6. Finally Low Pressure, Low Temperature Passes To Manifold Where It Absorbs Latent Heat At Constant Pressure And Convert Into Vapors State.
7. Again It Is Supplied To Compressor. Thus Cycle Is Completed, Same Procedure Is Repeated By Changing Copper Plate Micro Channels Manifolds For Different Dimensions. Accumulator Is Used To Storage Of Energy And Supply Of Energy When Required.

IV. EXPERIMENTAL RESULTS

Experiments were carried out for hydraulic diameter of 230 μm with heat input of 25 Watt to 150 Watt with a variation of flow rate of 0.0016 kg/sec, 0.033 kg/sec, 0.066 kg/sec, and 0.1 kg/sec. The tests have been carried out as per experimental procedure explained above. The experimental results of the rectangular Micro channels are given as follows,

Q-Watt	T- $^{\circ}\text{C}$	Re number	Nu number	h-Watt/ $\text{m}^2 \text{ K}$
25	2.50	38.94	7.5	10225.80
50	4.81	38.88	7.49	10225.85
75	8.56	38.81	7.48	10225.91
100	10.67	38.78	7.47	10225.97
125	12.79	38.72	7.46	10223.03
150	14.05	38.66	7.44	10223.12

Table 4.1 Experimental results of Micro channels with length of 30mm for hd-230 μm

4.1. Experimental results:

Experiments has carried out on a single Micro channels for giving heat input in steady state condition with the help of micro heater. The temperature difference reading is noted and results are presented for the rise in refrigerant temperature as follows.

4.2 Experimental results Heat input Vs temperature difference:

Experimental conclusions for rectangular Micro channels of l-30mm

- 1] Now for experimental result we taken reading for temperature only, so results of temperature difference verses heat input are represented.
- 2] The graphs for experimental results for temperature difference across the micro channels is 10 to 20% less as compared to theoretical results for different heat input, flow rate for 30mm length
- 3] As heat input increases the configuration with higher hydraulic diameter show decrease in temperature difference of refrigerant.
- 4] Temperature rise of refrigerant R-22 ranges from 0.89 to 28.95 using various configurations for different heat input.

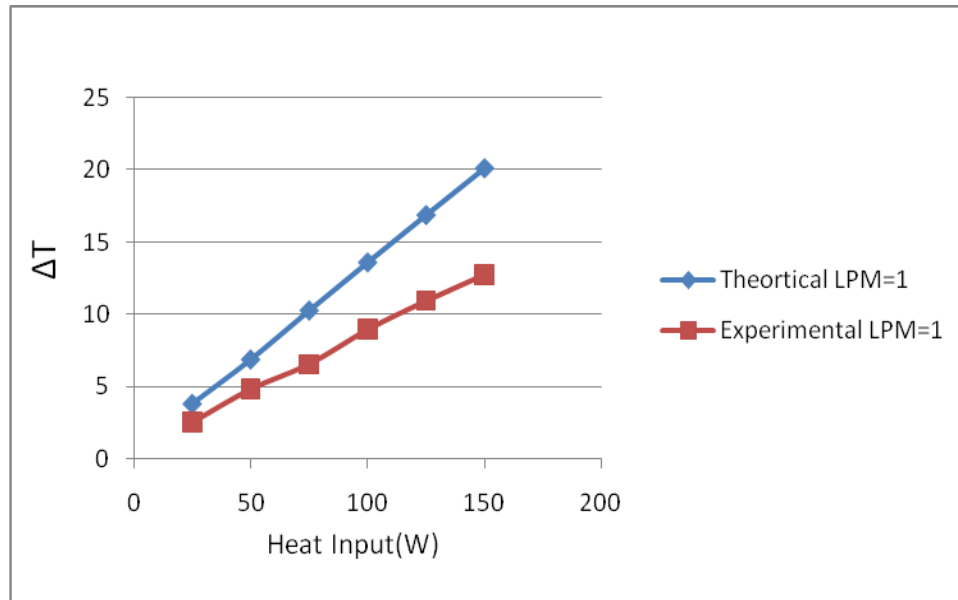


Fig.4.2 Heat input Vs temperature difference for flow rate of 0.016kg/sec

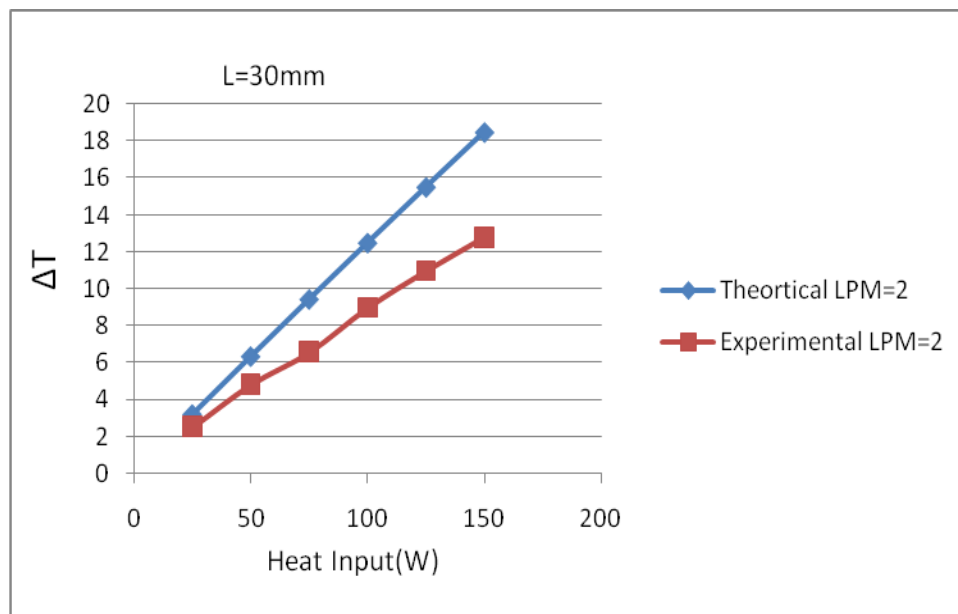


Fig.4.3 Heat input Vs temperature difference for flow rate of 0.033kg/sec

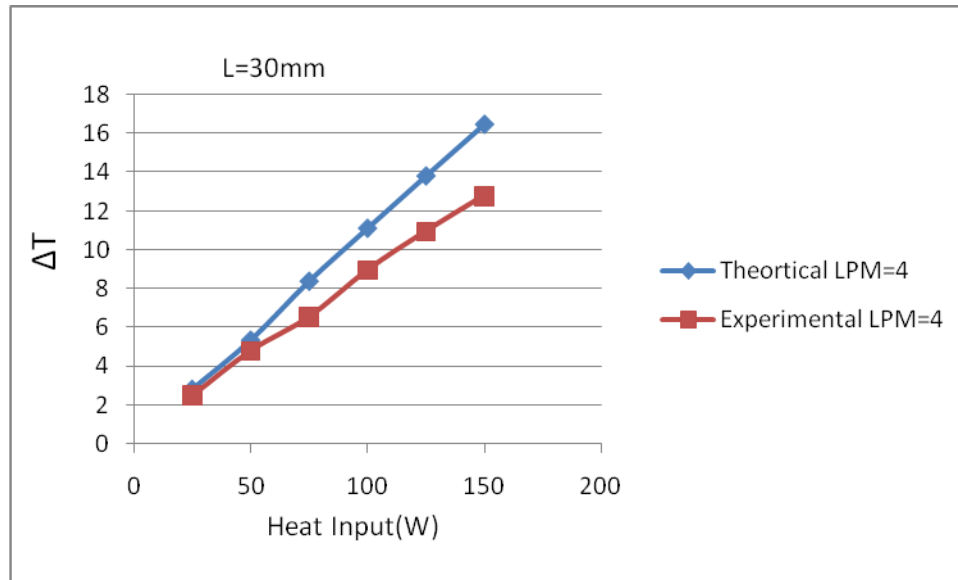


Fig.4.4 Heat input Vs temperature difference for flow rate of 0.066kg/sec

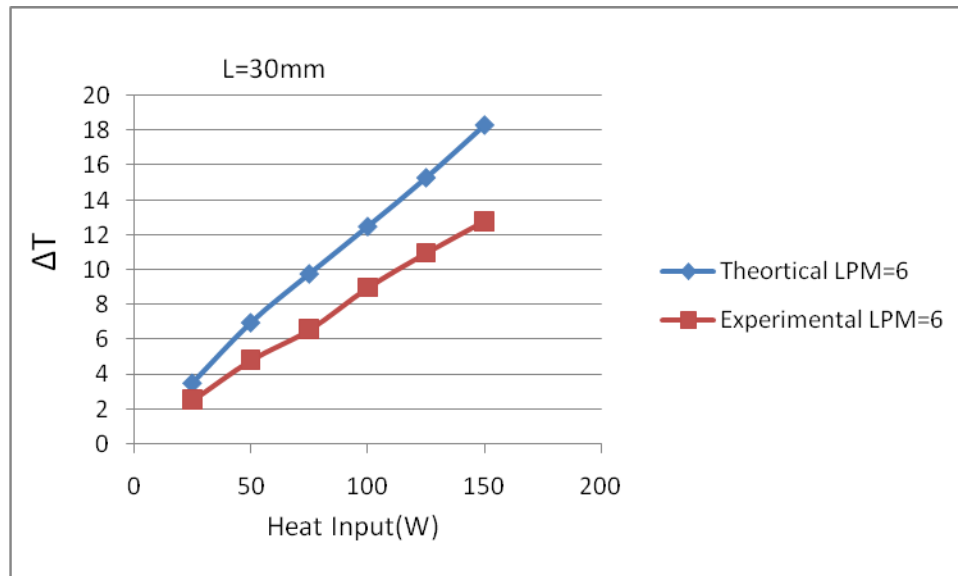


Fig.4.5 Heat input Vs temperature difference for flow rate of 0.1 kg/sec

V. CONCLUSIONS AND FUTURE SCOPE

5.1 CONCLUSION

- 1] The heat transfer coefficient for hydraulic diameter of 260 μm is having value of $12000\text{W/m}^2\text{k}$. As compare to other configurations the heat transfer coefficient is more so 260 μm diameter Micro channels diameter is more optimistic as compare to other configuration of Micro channels theatrically.
- 2] As heat input increase the configuration with higher hydraulic diameter show less pressure drop as compare to hydraulic diameter of 260 μm . The range of pressure drop for Micro channels is observed of 0.026 Kpa. For hydraulic diameter of 370 μm the pressure drop is minimum of 0.01 Kpa.
- 3] Experimental results and theoretical results comparison with validation is to be study in next phase of project.

5.2 FUTURE SCOPE

- 1] We have manufactured and tested rectangular micro channels of various configurations, in order to find optimum configuration. There are various other configurations of micro channels like triangular, trapezoidal, Rectangular, circular, etc. Exhaustive research and experiments should be conducted in order to find out more suitable profiles of micro channels for various applications.
- 2] For accuracy of experimental results, the accuracy of profile should be maintained precisely. Therefore, more accurate and precise manufacturing processes should be found out. But, for mass production of Micro channels s, the process should be economical. Therefore, the process should be accurate as well as economical.
- 3] Instead of copper, more economical and effective materials should be found out. Materials like silicon are semiconductors which give better results Should Be Tried. Also, they are easy to machine and are cheaper, therefore, more economical than copper. Exhaustive research should be conducted to find out many other materials. With use of refrigerant it can give more accurate result and best method should be finding to increase progress in this area.

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