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REVIEW ON EXPLAINABILITY IN MICRO CHANNEL HEAT EXCHANGER (MCHX)

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ABSTRACT: The producers of air conditioners are searching for methods to boost efficiency and reduce costs as a result of the energy efficiency of air conditioning systems improving and costs rising. The cooling systems refrigeration business is interested in MCHX because of its numerous benefits, including a high heat spread efficiency, low liquid charge, modular construction, and light weight. MCHX is therefore progressively added to the air conditioning system. However, owing of the difficulties in resolving refrigeration mal-distribution and defrosting concerns, the MCHX has not yet been extensively adopted for mass-produced heat pump systems. The assembly technique used by MCHX has helped the company succeed and be beneficial. The methods of production for MCHX, fluid flow, and heat transfer properties in tiny tubes and MCHX have all been examined in this study. The mixture of copper (Cu) and aluminum (Al) in the Fin A tube Fahrenheit Exchanger (FTHX) along with MCHX, as well as an analysis of the rate at which heat is transferred (kW) and efficacy utilizing findings (Experimental and ANSYS), are also discussed in this article.

KEYWORDS: MCHX, Heat exchanger, Micro channel, HVAC, Fluid flow, Additive manufacturing and Fabrication.

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1. INTRODUCTION:

Energy Since energy usage is a necessary component of daily living, producing enough energy and using it wisely are vital for achieving sustainable economic development. Conservation of power and recycling procedures alongside the use of clean, new, and environmentally friendly energy sources have been included as a response of environmental concerns about trash disposal and thermal ones, air, and water pollution. A key element for numerous of the processes mentioned above are heat exchangers. A thermal exchanger is an electrically powered mechanism that transfers heat amongst any number of fluids being processed separate by a liquid passageway wall and operating at various temperatures.[1]. Heat is transferred over a limited temperature differential, and permanent friction flow produces entropy. There is an emphasis on both better heat transfers and flow performance since the elimination of entropy formation often results in the conservation liquid energy. Nearly every heat exchange mechanism conveys warmth via an imposed convection process. Mini heating elements with a range of tube forms, diameters, and configurations have been developed for applications where size is a constraint. Roughly 700 m2 m-3 of high heat transmission surface density is available from them. Standard tube of various sizes and shapes make up the airside of these air-to-liquid cross-flow warmth exchangers, which typically makes up around 80% of the system's total thermal conductivity.[2]. The creation of tiny flow routes, or "micro channels," is now conceivable because to developments in mini-machining and microminiaturization processes. Based on the optimized smaller channels buried inside the surface, a method, such as lowering energy losses caused by outside viscous flow through substrates, was implemented for the micro-channel technology. Microchannels that are and technology have drawn a lot of study interest as prime options for foreseeable heating exchange modules. FIGURE 1: MCHX explanation [3]

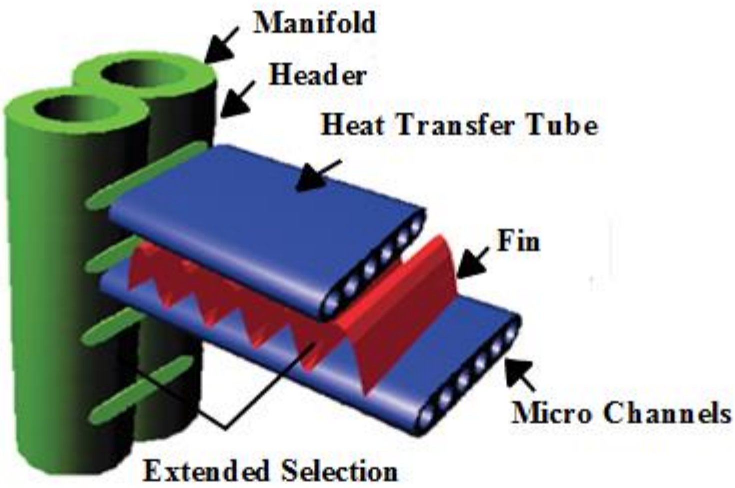

Figure 1: Parts of the MCHX

The term "micro channel" used in a heat exchanger has come to be recognized as a classification scheme for smaller-scale heat transmission related fluid circulation systems. The MCHX is most suited for usage in cooling machinery driven by conservation of energy and minimization of the ammonia charge, as well as in home and commercial air conditioning systems. It may be used successfully and efficiently in a variety of sectors, including the energy, automotive, off-road vehicle, the aerospace industry, HVAC, cryogenic, power, among electronics industries. Existing MCHXs have significant production costs while having inexpensive material prices. with order to conduct experiments with microchannel heat exchangers, many challenges must be addressed simultaneously.[4]

- ✓ Significant limitations may result from the research assembly's precise geometry and acceptability regulation across the microscale.
- ✓ Insufficient empirical findings, particularly for entryway region impacts.
- ✓ Some in-depth information cannot be measured experimentally [5].

In MCHX, the fluid flow is parallel and often evenly dispersed among several tiny tubes. That channel's rate of flow is decreased by this distribution. Utilizing MCHX, the second crucial aspect of electrical was created produced.[6] In certain instances, cold air was blasted while the channel's floor was heated electrically. In each scenario, the airflow is situated as near to the radiant heat source as is physically practicable. Direct scrutiny of MCHX with thermal functions utilized in research on electronic refrigeration may not always be relevant. Micro-channels as the primary components of MCHX are not often produced in large quantities or used commercially.[7].

MCHX has grown in popularity and potential in the fields of thermal engineering and research. Even though many academics have studied MCHX, only few have done in-depth study on the compound. Consequently, this research analyzed the design, fluid flow, and manufacturing processes for MCHX. [8].

2. LITERATURE REVIEW:

Due to MCHX's better efficiency warmth transfer velocity, more cost-effective design, as well as lightweight construction, it has been used more and more in the HVAC&R (Heating, The process of ventilation, along with Climate Control & Refrigeration) area. Additionally, it is critical that the development of refrigeration technologies, such as MCHXs, keep up with advancements with regard to manufacturing efficiency and heat management.[9] The production of MCHX might be done in a variety of ways. Therefore, Section 2.1 of this work describes the manufacturing processes for MCHX; Section 2.2 describes the digital manufacturing processes for MCHX; Section 2.3 describes the features of fluid circulation and transfer of heat in the tiny pores as well as MCHX; as well as Section 3 describes the findings and comments.[10].

2.1. MANUFACTURING METHODS OF MCHX:

The initial goal was to envision a form of heat exchange that could use more traditional automotive components and production methods. Manufacturing MCHXs is gaining significant attention in a number of emerging technological domains that need for compact extremely hot radiation removing systems. Micro-machining, diffusion closeness, mechanical removing them through and LIGA (Lithography) are some of the technologies used to make MCHX. The MCHX production procedures are described in Table 1, which lists along with their applications and drawbacks.[11]

Table 1: Manufacturing methods of MCHX with its uses and limitations:

AUTHOR NAME	MANUFACTURING METHODS USED	USES	LIMITATIONS
Venkata rajesh saranam, et al.[11]	Diffusion bonding	The diffusion bonding method showed good compactability, high ductility, improved long term strength, and good fatigue resistance.	The bonding pressure was much lower for diffusion bonding
Tisha Dixit, et al.[12]	LIGA	The fabrication of sheeting with tiny holes featuring length/diameter (L/D) ratios among 10 and twenty might be accomplished using the LIGA technique.	There would be a lower thermal conductivity in the LIGA method
Mayuri A. Raut, et al.[13]	Chemical etching	By using the chemical etching technology, MCHX could achieve high compactness and produce continuous and uniform channels.	There were some difficulties, like poor process control, poor particle control, high chemical disposal costs, etc.
Oliver Kraft, et al.[14]	Diffusion bonding	The method could predict the process parameters easily and help to evaluate the temperature	The method did not consider the microstructural change in the process
Tianrui Deng, et al.[15]	Chemical etching	This method helped the exchanger to produce uniform channels with low cost and high accuracy	Poor anisotropy, Poor particle control, and difficulty to use with the small features
Naser Haghbin, et al.[16]	Micro-machining	The method was used for mechanical and thermal works of MCHX with a high transfer coefficient	limited to just working with electrically conductive substances, whereas electrically inert alongside low-conductive compounds were very resistant to EDM micro-machining.

Ehsan Azarsa, et al. discussed the use of fluid jet micro-machining in the creation of large aspect ratio autonomous constructions. In order to optimize possibilities for heat transmission, the goal was to manufacture the most fins each length of material with the greatest aspect ratio possible in Al6061-T6. The findings demonstrated that because of the increased rate of weathering, greater rainfall volumes lowered the tendency for leveling.[12]. By employing these conventional production methods, certain dimensions were challenging to attain.

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Leland Weiss, et al. studied the functioning of copper copper MCHX utilizing LIGA in both physical and lattice Thermodynamics simulations. By using the high thermo conduction of MCHX, the efficacy of fuel transference was optimized. The findings suggested that the fluid used for working increased the device's ability to move energy by around 8%, having a thermal flux available in the amount of 8.7 KW/m2. The output fluorescence of a dry device was 7.6 KW/m2, but the input flux of a saturated instrument was 8.3 KW/m2. With the exception of the physical heat drain and cool source, the operating fluid served as a heat sink, bringing down the thermostat values to a typical of 9 oC[13].

Piyush Sabharwall, et al. outlined the diffusion binding manufacturing technique for MCHX for industrial operations. The capacity to integrate efficient heat exchange mechanisms on the nuclear heat transportation networks and an industrial procedure was necessary for the effective conveyance of energy and use in factories[14]. The findings contrasted results from experiments on ratios of the main component of the alloy (open circles) with those obtained from computationally diffusion modeling for Alloy 800H employing DICTRA (solid lines). The degree of agreement of the two distinct collections of statistics was quite good.

S.tsopanos, et al. described the process of the selective laser melt (SLM) used to make MCHX. SLM is a deviation from the conventional manufacturing processes since it is based on automated layers addition generation. The findings demonstrated that at the mean linear divergence level of 36°C plus a pressure drop of 3 bar in the hot water watch online, it was able to obtain a volumetric heat transmission factor of 3.14 MW/m3k and an overall heat transfer ratio of 2.22 KW/m2k[15].

2.2. ADDITIVE MANUFACTURING METHODS OF MCHX:
One kind of 3D printing is additive manufacturing. Using digital 3D design data, this method deposits material to manufacture components layer by layer. For instance, additive manufacturing creates an object from a finely ground powder rather than machining it from a solid block of material, step by layer. There are many methods of manufacturing, including stereolithography, was fuses deposition modeling (FDM), precise jet the process of s contact a process called ink-jet printing, and xurography. The comparison of MCHX additive manufacturing techniques is shown in Table 2.

Table 2: Comparison of additive manufacturing methods of MCHX:

AUTHOR NAME	FABRICATION TECHNIQUES	TYPICAL MICROFLUID RESOLUTION (μm)	ADVANTAGES	DISADVANTAGES
Suman Chakraborty, et al.[21]	Stereo-lithography	10–200 μm	With the capacity to fabricate internal micro-fluidic avenues, high resolution images might make more smoothly, bigger components.	High machinery investment expenses, pricey photocurable ingredients that are often unsuited for bioapplications, and convoluted printing guidelines

Akash S. Munshi, et al.[22]	FDM	400-1000 μm	Low-cost printing supplies, adaptable equipment, along with low-cost	Low printing quality frequently employs unsuitable materials for applications involving high temperatures
Jian-Zhong Fu, et al.[23]	Inkjet Printing	42-300 μm	It is possible to produce components using a wide range of materials at a low cost and fast speeds.	For enclosed channels, the electrical conductivity of the manufactured items was poor, and additional procedures or procedures are necessary for inner micro-channel construction.
Nicholas C. Speller, et al.[24]	Xurography	15-250 μm	Low-cost apparatus, quick production, and extensive fabrication	Producing the Complex's structure 3D tiny channels is really challenging.
Nan Zhang, et al.[25]	Selective Laser Sintering	100-600 μm	The produced components could be employed in high-temperature applications, could generate parts with better precision, and had superior structural strength.	expensive technological investment costs. Throughout the treatment, its exterior layer became rough, causing it to be more difficult to disinfect within the micro channels within it.
Pilnam Kim, et al.[26]	Soft Lithography	0.05-0.5 μm	The constructed technologies formed high-resolution micro channels and were safe.	Microchannel that are accessible for specific solvents may enlarge in response to some substances.

Daniel Filippini, et al. The fused the creation model was used to describe the extrusion-based additive manufacturing manufacturing MCHX equipment for commercial and biological purposes. Low prices, a fairly basic machine construction, and a large range of easily accessible components were the key contributors to its success. According to the high degree of roughness, the findings proved why the FDM approach was probably the most appropriate one for mixing. However, the problems caused by improper material circulation within the bore were not yet resolved.

Ali Yasser Thamer, et al. detailed the MCHX spirals xurographic heat sinks were described. A trio of xurographic spirals micro-channel heating elements with various tube lengths and widths, hydraulic diameters, aspect ratios, and spiral counts were developed, put to the test, and their results were evaluated. The results proved that heat transfer was not ideal. A lack of thermal conductivity had a negative impact on effectiveness, and additional fluxes in the spiral layout did not seem to improve it.

Wessel W. Wits, et al. discussed the use of MCHX for an energy conversion application using selective laser melted tech. Containing the aid of this technology, engineers were able to create an object with a significant amount of internal and exterior freeform elements inside a challenging 3D topology. According to the findings, completely sintered copper permeable produces an used in additive production had convection heat transmission indices with values over two times as great as those of readily available metal foam implants. However, because to a lack of information, it was unable to foresee both the system's general efficacy along with the consequences associated with structural factors.

Suresh V. Garimella, et al. outlined the analysis of MCHX Heat Barriers produced additively utilizing the direct metal laser sintering process (DMLS). A tiny amount of research has been done on the capabilities of different additive manufacturing techniques and materials to generate characteristics that are desired for micro-channel heating elements. The results demonstrated that while the rate of flow remained laminar, known linkages provided a good prediction of the hydraulic efficacy of the SMC cooling sink. The region of function that can be predicted using conventional associations across unidirectional flow is constrained by the high internal roughness, which causes an early transition to turbulence (Re 800) for both heat sinks.

2.3. FLUID FLOW AND HEAT TRANSFER CHARACTERISTICS IN MICRO-CHANNELS AND MCHX:

A micro-fluidics system's typical micro-channel size falls between 1 and 1000 m. In the tiny channels found in micro-fluidics systems, fluid may be moved in a number of different ways. Electro-osmotic flows and pressure-driven flows are two crucial mechanisms of fluid movement. Micro-channels are one of the key components of micro-machined fluid arrangements and play a significant role in the creation of compact circulation gadgets. In comparison to conventionally scaled avenues, radiative transfer of heat in miniature channels is much greater the is dependent on the Knudsen, Prandtl, Reynolds numbers, as well as aspect ratios. The schematic representation of electro-osmotic fluid movement inside a micro-channel is shown within Figure 2.

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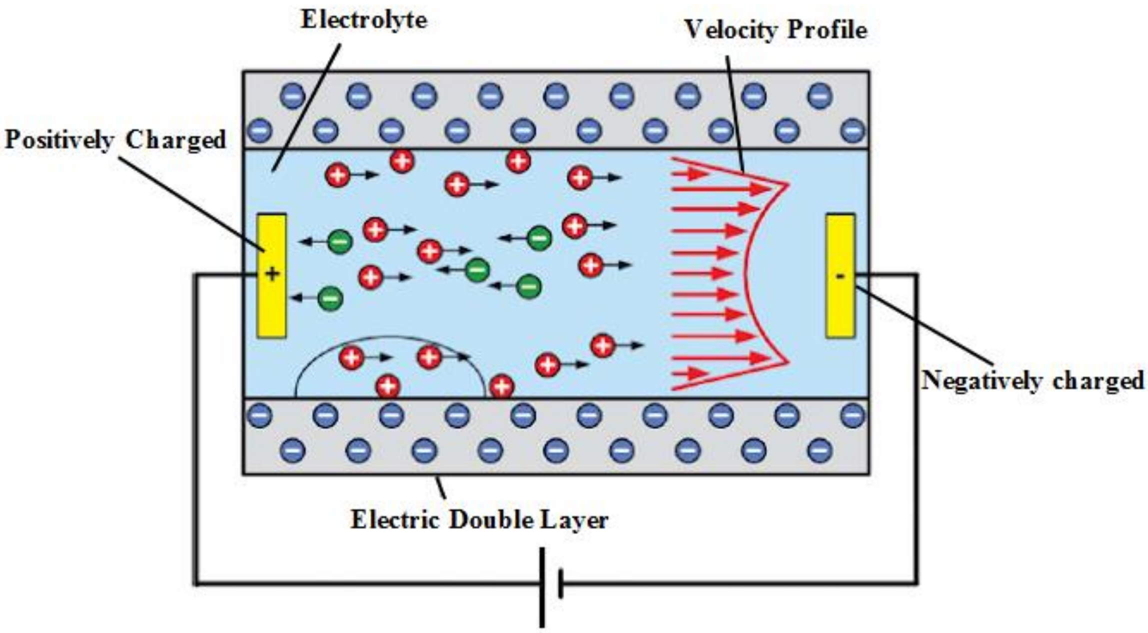

Figure 2: Schematic diagram of electro osmotic fluid flow in micro channel

Ralph Greif, et al. Through the use of a multi-nozzle architecture on the cool side, the increase in temperature transfer rate per single volume of MCHX was demonstrated. Water was employed as the working fluid, and a copper plate that measured 10 mm by 10 m by 0.9 mm was used as the fixed substrate. The findings demonstrated that the local ideal MN-MCHX obtained the greatest heat distribution rate per cubic meter of 14216.89 MW/m3. Contrary to the previous MCHX, the liquid's flow could not be categorized as cross, simultaneously or counter-flow.

Misba Jan, et al. detailed the heat transmission and fluid flow via micro-channels. through several industries, including biology, the aerospace sector, electronics, and microelectronic devices, fluid flow through miniature channels can be utilized for temperature control. The findings demonstrated that effective reporting of the impacts of surface roughness, axial conducting implications, and additional significant aspects, including geometry of surfaces and measurement precision, are essential in micro-scale fluid circulation and heat transfer measurements. But in-depth research was required, as well as precise micro-channel layout, production, and measurement.

2.3.1. FLOW FRICTION (F) AND POISEUILLE NUMBER (PO) FOR SINGLE PHASE FLOW IN MICRO CHANNELS:

The dropping of pressure (p) and heat transmission are influenced by the value of the friction factor (f), a measure of surface imperfections. For conventional pipes, the fully matured flow with laminar contact measurement is represented by the Poiseuille constant (Po), which is given in Calculation (1).,

$$Po = f\ Re = C \qquad (1)$$

Where C is a parameter that changes depending on the shape of the flow route. When utilizing the factor known as the Darcy friction on a circular pipe, the Po has a constant measurement of Po5fRe564 during the traditional laminar flow and is often regardless of the Reynolds

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quantity (Re). The f in miniature channels is typically thought to be greater than in ordinary tubes. The parameters employed in the miniature channels are described in Table 3 along with their corresponding formulations and applications.

Table 3: Parameters used in micro channels with their equations and uses:

AUTHOR NAME	PARAMETERS USED	PARAMETER FINAL EQUATION	USES
G. P. Peterson, et al.[35]	Friction factor (f)	$f = C / Re$	Employing how much friction is present option, the amount of H/W may be simply increased.
Takahiro Tsukahara, et al.[36]	Friction factor (C_f)	$C_f = 2\ \tau_w / u^2_m$	When the flow regime corresponding to helical turbulence, the friction factor maintained a high value that was similar to that of a fully turbulent regime
T. J. John, et al.[37]	Poiseuille number (Po)	Not available	Poiseuille number was applicable even for commercially available square micro-channels as small as 200 micrometre
Dilip Maiti, et al.[38]	Friction factor (f_m)	$Fm = (4\ \lambda / 3)/(L_s + b/6)$	Simulated values of f_m were used both in slip and no-slip conditions

QIAN LI, et al. investigated the experiments on the effect of heat forward and friction factor for one-phase water circulation in nickel with titanium micro-tubes. The findings demonstrated that, in compared to the thermal situation, the commencement of the transition area of the identical tube is delayed by constant heat flow circumstances because of greater Reynolds coefficients. Four metallic tubes or three platinum tubes successfully completed the heat transfer test. The findings for the chrome cylinders did not indicate that the transition zone was impacted by tube length.

Satish G. Kandlikar, et al. outlined the micro-channel one-phase liquid factors for friction. To find the differences, an extensive examination of earlier experimental data was carried out. The findings revealed that each side-wall's average roughness feature was 2.5 m, and the consequent e/Dh ratios was 0.01. The errors in the geometry measurement can frequently obscure a highly precise pressure drop evaluation. However, there could be no replacement for accurate numbers that were acquired by measuring the passageway curvature destructively.

S. Djellouli, et al. analyzed the scaling effects on micro-channel flow utilizing the variables of the friction factor. When attempting to assess a flow in two-dimensional in nature rectangular micro-channels utilizing water as the fluid of operation, the numerical approach was therefore used. The statistical results were uncovered to be in excellent accordance with the experimental results, indicating that these methodologies, when used in conjunction with precisely matched entry and boundary conditions, may be confidently used to forecast flow dynamics in micro-channels. However, sophisticated measuring methods were not feasible.

Z.H. Zheng, et al. described how the friction factor affected the flow dynamics and the transmission of heat of a rectangular micro-channel utilizing tiny fluid as the medium of operation. Their findings demonstrated that the coefficient of friction factor was somewhat unrelated to the factors ration and reliant on the overall percent of solid nanoparticle. The friction factor of the nano-fluid rose with the increase in aspect ratio under the exact same Reynolds value in the final findings. In the real forced flow procedure, the nanofluid concentration spread didn't seem uniform.

2.3.2. Critical reynolds number (Re_{cr}) for a single-phase flow in the micro channels:

It is generally known that Recr 2300 is the crucial Robbins numbers (Re cr) for conventional external ring pipe flowing. In interior flow of pipes, the shift from laminar to turbulent circulation typically starts at Re cr > 2300. In micro-channel, a delayed crossover is sometimes referred to as comparatively greater Re cr.

Gian Luca Morini, et al. The crucial Reynolds number was used to describe the smooth to turbulent motion changeover in micro-channels. It was discovered that the shift from the laminar to the tumultuous regime occurred at Reynolds numbers that were lower than anticipated. The findings indicated that it was conceivable for increasing relative roughness and a decreasing critical Reynolds coefficient to play a role in the transition from the laminar phase to the turbulent regime. Regarding Reynolds numbers below 1000, there was no compelling evidence from experiments to establish the presence of transitioning or turbulent flow patterns.

S. Blonski, et al. Using the crucial Reynolds number, volatility in the miniature channels was explained. When compared to macro scale, the flow properties of fluids in narrow channels often showed dramatic changes and were largely determined by surface effects. The findings indicated that flow instability could be caused by suitable alteration of the microchannel walls as early as critical Reynolds values of roughly 100. The deterioration of flow in a situation like this micro-channel did not always happen when one would typically anticipate.

Chao-Hong He, et al. studied the liquid flow properties inside the micro-tubes utilizing the crucial Reynold number. Controlling the functioning of microfluidic equipment required a basic comprehension and forecast of flow properties at the microscale. The findings indicated that the minimum Reynolds number had an uncertainty of around 2% when the investigation the analysis approach was taken into account. Determining the deviation criteria was challenging.

V. Kumaran, et al. [46] demonstrated how a soft wall-induced nonlinear instability caused a multifold drop in the change in key Reynolds amount and ultra-fast mixture in a micro-channel. The findings demonstrated that when the module of elasticity associated with the soft barrier was lowered, the Reynolds number needed fell. Because the surge tanks at the outflow were challenging, it is not possible to weigh the pressure findings from the waterway and the Y inlet directly with mathematical calculations.

2.3.3. HEAT TRANSFER CHARACTERISTICS–THE NUSSELT NUMBER (NU) FOR SINGLE-PHASE FLOW IN MICRO CHANNELS:

The the transmission of heat of a warmth-exchanging mechanism is often represented by a Nusselt number (Nu), a non-dimensional metric. The Nu is typically thought to be larger than micro-channels. In smooth micro-channel flow, the factor of Re varied from 0.3 to 1.96, and the numerator rises as the exponential of Re increases.

Ashaju, et al. explained the simulation of fluid flow and thermal transport in the gravity-dominated micro-channel using the nusselt number (Nu). The results showed that the gravity effect was more pronounced for Dh=199 μm as the Nusselt number for 60 was higher than the other two angles. Friction factor for micro-channel (Dh=199 μm) inclined at 60° exceeded the friction factors for other angles at a low range of Reynolds numbers $Re \leq 180$. But there was no direct relationship between the Nusselt number and the pressure drop.

Manoj Kumar Moharana, et al. described the ideal nusselt frequency for concurrently growing the inside flow in a square small channel under complementary circumstances. All those of the substrate's other portions that were outside were maintained at an adiabatic temperature. The findings made it abundantly evident that, for a particular flow rate and sf, the temperature-conductive ratio, abbreviated ksf, remained the primary determinant of the impacts of axis wall conducting on thermal transit behavior. As a result of axial back conduction caused by larger ksf, the median number for Nusselt is lower than it was in the situation when the thickness of the exterior wall remained insignificant.

G.P. Celata, et al. The nusselt factor (Nu) was used to describe the a single versus two-phase flow of of warmth using nanoscale pipes. It had been discovered that several little energetic parts were better than a few big ones in several purposes. The findings demonstrated that entry effects start to grow more significant at high Reynolds number values (Re >ReB) which prefer to raise the average price of the Nusselt coefficient. The coefficient of thermal conductivity in the convection boiling environment was dependent on the gases cleanliness and mass flow but was not indicative of temperature flux.

S. K. Saha, et al. The Nusselt coefficient was used to study single-phase heat transport on scaled nano-structured micro-channels. Six horizontal channels with a diagonal ratio of 1.729 make up the test portion. Each pair of channels is 350 m across and 605 m deep. The findings demonstrated that, with the insertion of nano-structured in micro-channels, the highest boost of around 21% in Nusselt number was obtained despite any discernible rise in pressure drop. It was discovered that the force that reduction within the nano-structured micro-channel remained marginally greater than that in a tiny channel made of plain aluminium.

Yitshak Zohar, et al. explained the Nusselt coefficient in forced conduction in small channels for single-phase flow of fluid. The integrated microsystem was created using traditional micromachining methods. The findings demonstrated that anticipated Nusselt number Nue clearly varied significantly from the median Nusselt value Nua, which indicated a very sluggish relationship with the number assigned by Reynolds. There was no laboratory or mathematical mistake to account for the significant difference among the projected actual median percent that Nusselt numbers.

2.3.4. FLUID FLOW AND HEAT TRANSFER CHARACTERISTICS IN MCHX:

The study on a one-phase gas-to-liquid fluid movement and the transfer of heat on MCHX for temperature and power generation is less developed than other investigations for semiconductors cooling. Compared comparison to the traditional gas-liquid heat exchanger, an unfinned microscopic bare tubing heat transfer device performed better. In order to create a model that forecasts the thermodynamic and fluidic properties to be employed in the design process, the efficiency and stress drop in miniature cross-flow heat transfer systems has been examined.

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Xiaowu Wang, et al. explained the flow and heat transfer characteristics of sinusoidal half-corrugated MCHX. outlined the sinusoidal half-corrugated MCHX's flow and heat transfer properties. Due to the structure of the heat transfer surface, hierarchical MCHX might increase the effectiveness of heat transfer but also result in a larger pressures drop. The results revealed three steps in the scorching curve of the plain-bottom micro-channels (MCH-00): Before the wall temp approaches the saturation temperature, bubbles may form because of the architecture in the concave micro-channels. The entering fluid could not be boiled at a temperature below freezing due to the insufficient effective heat flow.

Feng Yao, et al. examined the heat transmission and liquid flow in rough MCHX. A system for testing heat transfer and liquid flow performance was created, and many experimental tests were carried out. The findings showed that laminar flow and heat transmission in microchannels were significantly influenced by the surface roughness. The Poiseuille number of liquid laminar flow in micro-channels with roughness characteristics depends on both the Reynolds number of the liquid flow and the cross-sectional form of the rough micro-channels. However, it was challenging to depend exclusively on the average roughness index.

Kunpeng Chang, et al. With various groove shapes, MCHX's hydraulic flow and temperature transmission properties were discussed. There were five different versions of silicon-based MCHX created. The findings showed that positioning holes on channel edges may significantly boost overall performance. With the exception of rectangles, all groove forms might significantly increase overall performance. However, the rectangular grooved channel's overall performance can be worse than the smooth channel's.

H.A. Mohammed, et al. used nanofluids to characterize the heat transfer and fluid flow properties of MCHX. The heat transfer fluids utilized have a limit on their ability to transport heat. The findings demonstrated that MCHX and nanofluids seem to be the only currently viable answer for the cooling problem in the age of micro and nanotechnology in the majority of situations. However, despite their unique traits, the mechanics behind the heat transfer phenomenon were still not completely understood.

Mahmmod Yaghoubi, et al. described the performance of the counter-flow MCHX employing nanofluid as a coolant. Cu-water and Al_2O_3-water are two examples of tiny liquids that are used. According to the findings, adopting tiny liquids as a medium for cooling improved the heating capacity of CFMCHE without adding to the reduction in pressure because of both ultra-fine solid pieces and low volume percentage percentages. But the excess heat absorption was not caused by the nanoparticle.

Binghuan Huang, et al. examined the reentrant cavity MCHXs' flow along with heat transmission properties. The design and production of MCHXs that have or lack fan-shaped reentrant cavities. The findings demonstrated that, in comparison to a linear channel, reentrant cavities might lessen the volume loss in microchannels. Although the test segments were unheated, the outer diameter of the cavities might have a substantial impact on the ability of pressure-drop reductions. Ribs as well as fins couldn't be used, particularly on components that were affected by a surge in pressure drop or boosting electrically.

Jaeseon Lee, et al. detailed the reduced temperatures two phases MCHX's fluid flow as well as heat transmission properties. The complicated connected effects of hydrostatic diameter, micro-channel height, as well as sub-cooling affecting the cooling efficiency were explained and helped to understand using high-speed video cinematography. The findings demonstrated that reducing the coolant's temperature improved CHF, decreased size of bubbles and the formation effects, that prolonged the commencement of boiling. Despite burning out, heat fluxes greater than 700 W/cm2 could be controlled. It was challenging to capture the occurrence in longer chunks during the key heat flow.

3. RESULTS AND DISCUSSION:

This section explains the comparison of the cooling capacity of FTHX and MCHX, the composition of Copper (Cu), Aluminium (Al) in the FTHX and MCHX, and the comparison of the heat transfer rate (kW) and effectiveness using the results (Experimental and ANSYS). Cooling capacity is the measure of a cooling system's ability to remove heat. It is equivalent to the heat supplied to the evaporator/boiler part of the refrigeration cycle. Table 4 explains the types of heat exchangers vs types of heat transfer.

Table 4: Types of heat exchanger vs Types of heat transfer:

TYPES OF HEAT EXCHANGER	LATENT CAPACITY	SENSIBLE CAPACITY	TOTAL CAPACITY
FTHX	1750	4733	6480
MCHX	1854.67	4951.79	6773.86

There are three types of heat transfer such as latent capacity, sensible capacity, and Total capacity (Latent capacity + Sensible capacity). The two heat exchangers were considered such as FTHX [59] and MCHX [60]. Figure 3 explains the comparison of the cooling capacity of FTHX and MCHX.

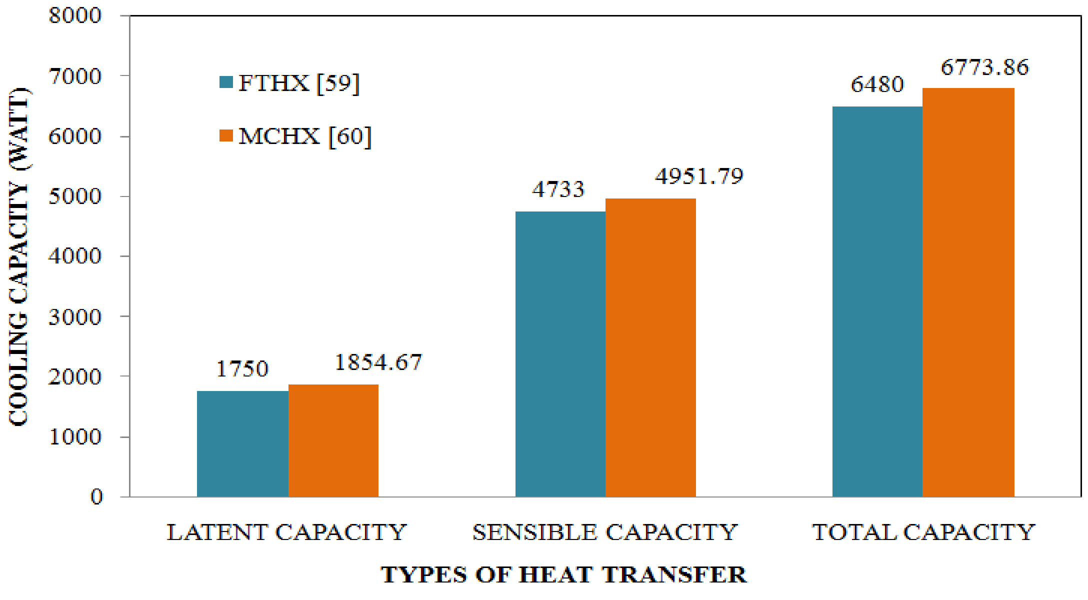

Figure 3: Comparison of the cooling capacity of FTHX and MCHX

MCHX cooling capacity is high (1854.67 watts, 4951.79 watts, and 6773.86 watts) in the latent capacity, sensible capacity, and total capacity. Both the latent capacity and sensible capacity increased considerably in MCHX.

There were some compositions of copper (Cu) and aluminium (Al) in the FTHX and MCHX [61]. Cu is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. Al has a great affinity towards oxygen and forms a protective layer of oxide on the surface when exposed to air. Figure 4 explains the composition of Cu and Al in the FTHX and MCHX.

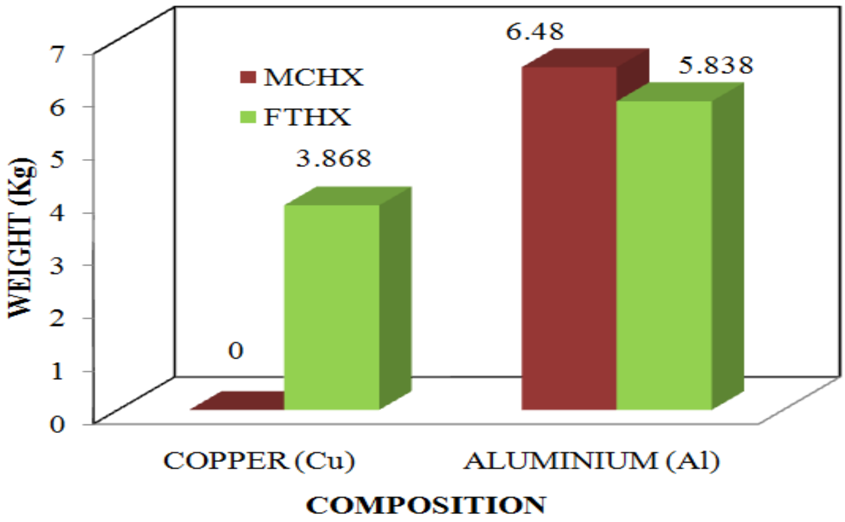

Figure 4: Composition of Cu and Al in the FTHX and MCHX

The composition of aluminium (Al) is more (6.48 Kg) in the MCHX when comparing with the FTHX (5.838 Kg). There is no composition of copper (Cu) present in the MCHX, but the composition of copper (Cu) is more in the FTHX.

The heat transfer rate of heat flow is the amount of heat that is transferred per unit of time in some material. The effectiveness (ϵ) of a heat exchanger is defined as the ratio of the actual heat transfer to the maximum possible heat transfer. Considering the two results (experimental [62] and ANSYS [63]), there is a comparison between the heat transfer rate and the effectiveness [64]. Figure 5 explains the comparison of the heat transfer rate (kW) and effectiveness using the results (Experimental and ANSYS).

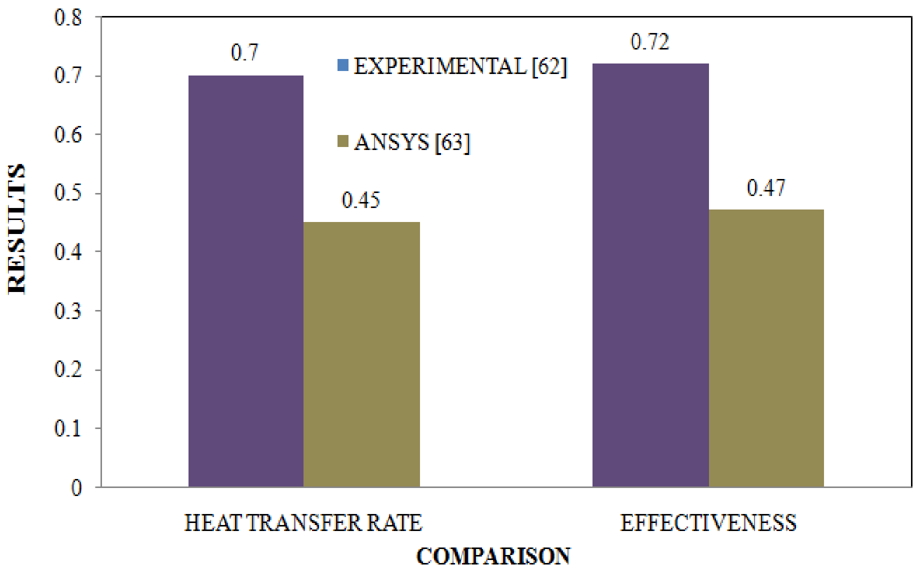

Figure 5: Comparison of the heat transfer rate (kW) and effectiveness using the results (Experimental and ANSYS)

Experimental results are high (0.7 and 0.72) in the heat transfer rate and the effectiveness. The ANSYS results showed less (0.45 and 0.47) in the heat transfer rate and effectiveness.

4. CONCLUSION:

The need for lightweight, miniature heat exchangers with better heat transfer is highlighted by rising energy needs and concerns about conserving the environment, energy, and materials. When compared to other traditional competitors, MCHX offers more advantageous characteristics. MCHXs for large-scale temperature and electricity use have received very less research and development compared to micro multichannel heat islands in the technology cooling business. Micro channels lack the kind of well-established flow rates, heat exchange relationships, and design processes seen in conventional energy transfer tubes. The manufacturing processes for MCHX as well as the properties of fluid the movement of heat in microchannels and MCHX were reviewed in this study. It previously compared to both heat transfer rate (kW) along with efficacy utilizing outcomes (Experimental and ANSYS) of the cooling capacities of FTHX and MCHX, the ratios of Copper (Cu) and Aluminium (Al) within the FTHX with MCHX, with the evaluation of the fluid transference velocity (kW) and effectiveness. If new methods of additive manufacturing are developed in future generations, they are expected to be safer than those that are now used.

REFERENCES:

[1] D. L. Achat, M. Fortin, G. Landmann, B. Ringeval, and L. Augusto, "Forest soil carbon is threatened by intensive biomass harvesting," Sci. Rep., vol. 5, Nov. 2015, doi: 10.1038/SREP15991.

[2] Taufiq and P. S. Dhakar, "A REVIEW STUDY THERMAL BEHAVIOUR OF PLATE HEAT EXCHANGER WITH," vol. 7, no. 9, pp. 600–604, 2020.

[3] R. B. Shaha and M. T. S. M. Pune, "Survey on Micro Channel Heat Exchanger for Air Conditioning Applications," vol. 05, pp. 204–207, 2020.

[4] D. C. Denkenberger, M. J. Brandemuehl, J. M. Pearce, and J. Zhai, "Expanded microchannel heat exchanger: Design, fabrication, and preliminary experimental test," Proc. Inst. Mech. Eng. Part A J. Power Energy, vol. 226, no. 4, pp. 532–544, 2012, doi: 10.1177/0957650912442781.

[5] K. Ambatipudi and M. Rahman, "Analysis of Conjugate Heat Transfer in Microchannel Heat Sinks," Numer. Heat Transf. Part A - Appl., vol. 37, pp. 711–731, Jun. 2000, doi: 10.1080/104077800274046.

[6] O. Siddiqui and S. Zubair, "Efficient energy utilization through proper design of microchannel heat exchanger manifolds: A comprehensive review," Renew. Sustain. Energy Rev., vol. 74, pp. 969–1002, Jul. 2017, doi: 10.1016/j.rser.2017.01.074.

[7] S. Lu and K. Vafai, "A comparative analysis of innovative microchannel heat sinks for electronic cooling," Int. Commun. Heat Mass Transf., vol. 76, May 2016, doi: 10.1016/j.icheatmasstransfer.2016.04.024.

[8] V. R. Saranam and B. K. Paul, "Feasibility of Using Diffusion Bonding for Producing Hybrid Printed Circuit Heat Exchangers for Nuclear Energy Applications," Procedia Manuf., vol. 26, pp. 560–569, 2018, doi: 10.1016/j.promfg.2018.07.066.

[9] Y. Han, Y. Liu, M. Li, and J. Huang, "A review of development of micro-channel heat exchanger applied in air-conditioning system," Energy Procedia, vol. 14, pp. 148–153, Dec. 2012, doi: 10.1016/j.egypro.2011.12.910.

[10] B. K. Paul, C. Song, K. Lee, B. M. Fronk, D. Sahoo, and M. Shipley, "Conceptual Design of a Manufacturing Process for an Automotive Microchannel Heat Exchanger," 17th Int. Refrig. Air Cond. Conf. Purdue, pp. 1–11, 2018, [Online]. Available: https://docs.lib.purdue.edu/iracc/2052/

DOI : https://doi.org/10.56452/7-12-41

[11] M. A. Raut et al., “Fabrication of Micro Channel Heat Sink by using Photo Chemical Machining,” Int. J. New Technol. Res., vol. 5, no. 4, pp. 72–75, 2019, doi: 10.31871/ijntr.5.4.30.
[12] researchgate, “a-Schematic-of-the-abrasive-slurry-jet-apparatus-b-orientation-of-orifice.” 2008.
[13] N. Yokoyama and M. Takaoka, “Energy-flux vector in anisotropic turbulence: Application to rotating turbulence,” *J. Fluid Mech.*, vol. 908, 2020, doi: 10.1017/jfm.2020.860.
[14] P. Sabharwall, D. Clark, M. Glazoff, M. Mckellar, and R. Mizia, “Diffusion-Welded Microchannel Heat Exchanger for Industrial Processes,” *J. Therm. Sci. Eng. Appl.*, vol. 5, Mar. 2013, doi: 10.1115/1.4007578.
[15] M. Nitsche and R. O. Gbadamosi, “Overall Heat Transfer Coefficient and Temperature Profile,” 2016, pp. 79–90. doi: 10.1016/B978-0-12-803764-5.00006-7.