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# Fluid Flow within Radial Micro Channel Heat Sink: A Review

#### Naveen Bansal<sup>1\*</sup> and Satbir S. Sehgal<sup>2</sup>

<sup>1</sup>Mechanical Engineering Department, BHSBIET, Lehragaga, Sangrur - 148031, Punjab, India; naveenbansal1974@gmail.com <sup>2</sup>Mechanical Engineering Department, Chandigarh University, Mohali - 140413, Punjab, India; drsatbirsehgal@gmail.com

#### **Abstract**

**Objectives**: Micro channels are characterized as stream sections that have pressure driven measurements in the scope of 10 to 200 micrometers. **Methods/Statistical Analysis**: It is assumed that the present work would provide new direction to the researcher in the field of Micro Channel Heat Sink. **Findings**: Subsequent to looking into the progression in warmth exchange innovation from a verifiable point of view, the benefits of utilizing micro channels as a part of high warmth flux cooling applications is examined and research done on different parts of micro channel heat exchanger execution is assessed. **Application/Improvements**: The present condition of manufacture innovation is looked into, taxonomically sorted out and found to offer numerous new potential outcomes for building micro channels.

Keywords: Fluid, Heat Flux, Liquid Cooling, Micro Channel Heat Sinks, Radial Micro Channels

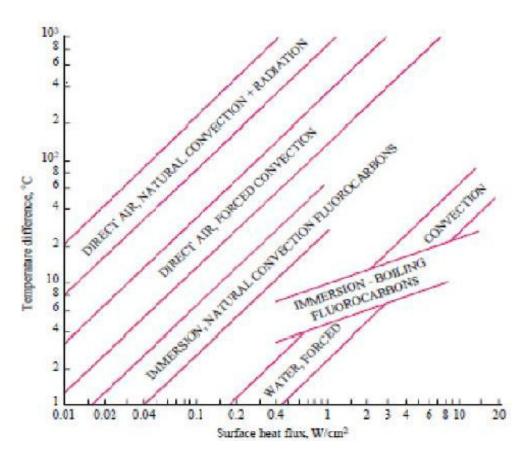
#### 1. Introduction

Throughout the most recent decade there has been a colossal enthusiasm for smaller scale and nano-innovation. As frameworks methodology infinitesimal scales, expanding deviations from the entrenched continuum laws are accounted for in<sup>1</sup>. The solaces of employment have pressurized the designers to fabricate the results of little size. Winning pattern of scaling down in electronic gadgets likewise requests better execution and unwavering quality. The electronic gathering incorporates a coordinated circuits mounted on the substrate, with popularity of miniatures the electronic circuit structural planning has likewise got to be perplexing. The expansion in intricacy of the circuits prompts impelling of numerous ICs on a little plate called motherboard, which make it a high well-spring of warmth era. There has been a slow increment

in warmth era by the segment and frameworks and they are requesting more productive electronic cooling. The heat administration of the high heat fluxes produced by chips is the hotly debated issue of sympathy toward the most recent one decade to enhance the execution of superior PCs, laser diodes and photograph optical gadgets. Traditional air-cooled heat sinks don't fill the need of heat evacuation as they have constrained heat exchange coefficient. Miniaturized scale channels go about as promising answer for this errand, as they give an extensive warmth exchange surface territory per unit liquid stream volume. Despite the extensive surface to volume proportion that prompts a high rate of heat exchange, yet consistent work is going ahead to improve the heat exchange rate making the small scale gadgets brilliant instruments for minimal warmth exchangers. The smaller scale channels are covered with various materials<sup>2</sup> to enhance the heat exchange

<sup>\*</sup>Author for correspondence

rate. Coatings of carbon Nano tube, composite material and different materials, most likely, has demonstrated change in heat exchange rate yet the heat fluxes produced by these miniatures are past their exchange rate. To counter this issue the smaller scale channels with fluid stream turned into the region of hobby. Small scale channels go about as an effective approach to disseminate heat from a surface yet the flow of the liquid is likewise a test<sup>3</sup>. Slacking of return of coolant to the cooling framework makes the coolant comes to at high temperature. As the liquid utilized as a part of small scale channels is for the cooling of the surface temperature of the miniatures to expand their execution, productivity and unwavering quality, this slacking represents an issue. Smaller scale channels can be characterized as channels whose measurements are under 1mm and more noteworthy than 1 µm. Beneath 1 μm the stream is portrayed as Nanoscopic. The warmth evacuation rate of the miniaturized scale channels relies on the different parameters, Channel geometry, header geometry, sort of liquid utilized have their own particular impacts on the heat evacuation rate. Small scale channels creation should be possible by the routines as typical as ordinary processing procedure to the many-sided Laser machining. For the mass machining the substance carving should likewise be possible on numerous materials, for example, glass, polymers, silicon and metals. Smaller scale channels with the course of de ionized water were initially proposed for gadgets cooling applications by in<sup>4</sup>, who utilized the immediate flow of water in miniaturized scale diverts manufactured in silicon chips. That was the insurgency ever. In spite of the fact that those smaller scales channel heat sinks were viable in heat evacuation rate however there was extensive weight drop amid the set up. From that point onwards different specialists enter-



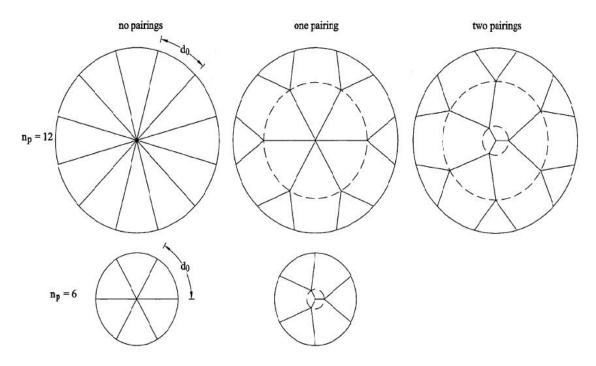
**Figure 1.** Heat fluxes at specified temperature differences with various heat transfer mechanisms and fluids.

tain themselves to enhance the warmth conveying limit of a smaller scale channel and to counter the regularly expanding heat era by the miniatures. So it is constantly attractive to have a uniform heat evacuation rate through the dividers of the small scale channel alongside the insignificant weight drop. The way to fulfilling this might lie in the vehicle systems of small scale channels. The diverse geometries of the small scale channels likewise assume the imperative part in the warmth evacuation. Different investigates have been done on the diverse geometries of parallel small scale channels. Normally the angle proportion of width to height were changed and contemplated, research take a shot at the states of the header i.e. trapezoidal, triangular, rectangular has additionally been finished. It is all around realized that the round or circular item has the most extreme surface territory so the warmth evacuation rate by the rectangular smaller scale channel won't not be adequate, that prompts the advancement of the round miniaturized scale channels having the blades radially set for the natural flow convective heat transfer<sup>5</sup>. Distinctive geometries of the spiral smaller scale channel were dissected numerically and a few geometries which

were concentrated tentatively were finished with constrained convection. Streamlining of the outspread blade size, perspective proportion<sup>6</sup>, diverse channel<sup>7</sup> and outlet blends and so forth were done numerically. Most recent the numerical investigation was done on the outspread miniaturized scale channel having the returned stream as shown in Figure 1. Consequently a dream is created to do the experimentation on spiral smaller scale channel heat sink with various configuration parameters.

# 2. Radial Micro Channel Heat Sink Process

Nature gives us some critical intimation with respect to the heat and mass exchange forms. Various attempts were done by various researchers to improve the heat carrying capacity of a micro channel system as to cope up with increase in heat generation. So it is always desirable to increase the temperature uniformity of the wall while decreasing the pressure drop. The key to accomplishing this may lie in the transport mechanisms of natural sys-



**Figure 2.** Cooling framework.

tems, such as the root system of plants or mammalian circulatory and respiratory systems. In these natural systems, high transport is achieved with low flow resistance through a series of consecutive branched channels. The concept behind this idea is to reduce channel wall temperature and pressure drop using multi scaled branching flow networks, is based on the efficient transport characteristics of biological systems8. The primary objective of the circulatory system is to provide blood to the capillaries where metabolic processes occur. Because it would be very inefficient for the heart to pump blood entirely through capillaries originating from the heart (source) and ending in the toes (terminal branch), it pumps blood first through larger-diameter arterial structures, which branch progressively to smaller and smaller diameters. An investigation of cellular metabolism and its associated power-law scaling relation to organism mass has resulted in two main theories of branching networks for optimization of transport processes: fractal like9 and non fractal. One of the conceivable superior warmth sink outlines fuses fluid stream, typically water, in micro channels arranged on or close to the silicon kick the bucket of the gadgets. Another superior cooling arrangement is the utilization of stream bubbling in micro channels. This system guarantees a significantly higher cooling potential, in light of the fact that the warmth exchange coefficient connected with stream bubbling10 is regularly a request of extent bigger than single-stage fluid warmth exchange coefficients. Besides, capacitive warming of the coolant is nearly non-existent because of the dormant warmth of the bubbling procedure. Notwithstanding every one of these points of interest, a few obstacles still exist to adequately utilize this cooling system for gadgets<sup>11</sup>. In that capacity ordinary connections don't hold in the micro channels. A second issue is that the framework level demonstrating of two-stage stream in micro channels has not got much consideration. In the past numerous Nitti gritty framework level models have been produced for atomic reactor cooling and refrigeration frameworks. Since the framework level plan and control emphatically impact the execution of the two-stage Micro Channel Heat Sink, it is foremost that a point by point, transient framework model is accessible for the architects of such a cooling framework as shown in Figure 2.

# 3. Use of Radial Micro Channels in Heat Sinks

Thermal management of devices under high heat fluxes, especially to cool of hardware or concentrated photovoltaics, is vital for the security and life of gadgets. Concentrated photovoltaic frameworks require straightforward, dependable and effective plans that give uniform, low temperatures, low weight punishments and the potential utilization of waste warm vitality. Attributable to their higher heat execution, mini channels are as a rule progressively utilized in procedure applications; the higher pumping power necessities are balanced with the general size and cost decreases. In the car and air industry, mini channels ended up being profitable in tending to the serious space imperatives. One of the conceivable elite warmth sink outlines consolidates fluid stream, normally water, in micro channels arranged on or close to the silicon kick the bucket of the gadgets. Another elite cooling arrangement is the utilization of stream bubbling in parallel micro channels. Minimized warmth exchangers utilize mini channels in these and numerous different applications. The microelectronics engineers, acquainted with the submicron scale in their IC outlines and the mechanical architects, acquainted with the mini channels in minimal heat exchangers, found the micro channel range as an alluring trade off in microelectronic cooling applications. In biomedical and optical applications, transitional Nano channels are regularly utilized. Radial micro channels provide the maximum surface are for the evacuation of the heat from the surface of the substrate. The various arrangements of the radial micro channels provide the different outcomes of the heat exchange rate. In the spiraling micro channel the flow rate of the fluid plays a vital role in the heat evacuation<sup>12</sup>. The forced convection of the fluid also enhances the heat removal rate as compared to the natural movement of the fluid done with the help of design parameters. The different shapes of the plenum also have the varying effect on the heat evacuation rate. The race is a long way from being done, with mechanical architects moving from the agreeable limitations heat sinks mounted on gadgets, segments and gatherings to the uncharted domains of micro channels, banding together with the micro electronics engineers for their on-chip

flight to meet the new micron and submicron measured heat and creation challenges. Understanding these frameworks will empower us to continue to the following level of Nanoi channels in organic applications.

## 4. Proof of Fabrication in Micro Channels

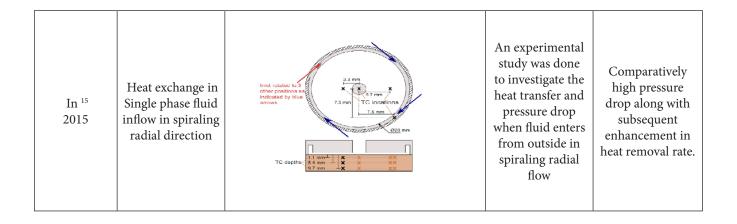
Heat exchange stream ways having a trademark measurement in the scope of 10-200 µm were characterized as micro channels. The heat sink is partitioned broadly into two parts: 1. Natural convection, 2. Forced convection, which can be sub portioned into - natural air convectionnatural liquid convection, - forced air convection, - forced liquid convection to ascertain the heat exchange coefficient. These further comprises of the single-stage locale, the subcooled bubbling district and the soaked two-stage area. Exhaustive work is going on the parallel flow micro channels related to the flow rate, its aspect ratio critical heat flux and many more parameters are coming under the scanner of various researchers. In the recent past the radial flow in the micro channels has become the area of interest of many researchers. Work has been initiated regarding the study of flow of fluid radially. Studies are in pipelines on the heat transfer rate and fluid flow analysis of the radial micro channels. Numerical analysis had already proceeded to analyze the pressure drop and heat exchange rate in the radial micro channels by varying the cross section of the micro channel<sup>13</sup>. The cooling of the circular disc were also carried out and analyzed with the fabrication of reverting radial micro channel. The fluid is made to pass from the set of radial channels and then reverted back from another set of radial channels placed over the same substrate, thus enhance the heat evacuation rate. Experimental and numerical analysis had already been conducted for the natural convection in radial Micro Channel Heat Sink. The development of micro channel-based heat exchangers has generally been paced by advances in micro fabrication innovation. It ought to be noticed that different subsets of these innovations can be helpfully connected to the manufacture of channels of both more noteworthy and lesser measurements, covering the extent from rotating micro channel14 to spiraling radial inflow Micro Channel Heat Sink<sup>15</sup>. The main real division distinguished in the taxonomic chain of importance is between scaled down customary and "present day" advances. Scaled down customary procedures are established in traditional machine shop and assembling hones however adjusted to accomplish micro scale highlights. The "present day" advances are harder to portray however are for the most part taking into account propels that happened in the last 50% of the 20th century, for example, lasers and micron-level photolithography. Another advancement in the heat evacuation study is of

Table 1. The comparative analyses of various advancements in the radial micro channels

Reference	AREA OF RESEARCH	VISUAL DEPICTION	RESEARCH WORK	REMARKS
In <sup>13</sup> 2008	Heat exchange in radial microchannel with varying cross sectional area	Pyrex water Silicon midp ate Silicon base Microcharnels Platinum neating element	A comparative study was done to analyze the variation in the heat evacuation rate between the radial channels with the variation in their cross sectional area axially to the parallel radial micro channel	Under the constraint conditions the converging radial micro channel comes out with superior results.

In <sup>5.</sup> 2009	Radial heat sink with natural convection	L type model	Numerical and experimental work on natural convection done with rectangular fins mounted radially. Cooler breeze is made to move from outer side and it rose up from center as it gets warmed up	Fin height, their numbers and their length are the deciding factor of heat removal. They are inversely proportional to evacuation rate
In <sup>7</sup>	Different arrangements of fins in radial heat sink under natural convection	(a) L type model  (b) LM model	Numerical heat transfer analysis and experimental validation of the analysis done and both came in good agreement .Flow of air was made to pass through arrangements L, LM, LMS of fins mounted radially	LM arrangement turns out to be the best performer that exhibited highest evacuation of heat from the source
In <sup>11</sup> 2011	Reverting microchannels with radial and dendritic design	A radial and dendritic design arrangement for reverting micro channel	A study was carried out with innovative design of reverting microchannels with two design: a) radial, b) dendritic. Variation in locality of Fluid collection was also studied likely at edge and at center.	The architecture of the radial reverting micro channel proves to be new hope of heat exchange rate as the results were overwhelming but these results came at the cost of pressure drop. Collection of fluid at center location has superiority over the edge collection

In <sup>14</sup> 2013	Review of Influence of centrifugal force on fluid flow in the rotating micro channel	f <sub>c</sub>	Analysis of flow pattern when the fluid pumped in such a way that centrifugal forces actuate the rotating microchannel with respect to the profile of the stationary radial microchannel	Significant deviation of flow parameters evolve at high rotational Reynolds number. Effect of Corriolis forces diminished at low rotational Reynolds number
In <sup>16</sup> 2014	Divergence and convergence in the flow area of the micro channel	Mass flow inlet  OF7  Pressure outlet	Deionized water was used as working fluid in the microchannel having the angle of 8° for divergence with diameter (hydraulic) of 156 microns for the study of heat evacuation rate	Higher heat transfer rate in the converging channel as compare to the diverging . the effort for pumping the fluid is also less in converging channel as compare to the parallel radial flow micro channel
In <sup>17</sup> 2015	Studied the effect of pulsating flow on heat transfer in the fractal microchannel		perform an simulation and experimental investigation is performed to study the heat transfer performance of fractal-like microchannel network, when the heat sink is subjected to pulsation flow for different frequencies.	Results show that the pulsation flow through fractal-like microchannel provides a lower maximum temperature and a better cooling capacity in this study.



the two phase Micro Channel Heat Sink, it was observed that no doubt enhancement in heat transfer took place but that too at the cost of pressure. Semiconductor and unified creation systems represent the majority of the "cutting edge" advances. In a few regards, scaled down customary systems is the most clear way to deal with making micro features. These smaller than expected procedures frequently utilize customary machine apparatuses particularly adjusted to work in the miniaturized scale administrate. The comparative analyses of various advancements in the radial micro channels are discussed in Table 1<sup>14-17</sup>.

### 5. Conclusion

A comprehensive comparative analysis of numerous electronics cooling radial micro channel technology has been offered. The conclusions drawn from this observe are though there is an enhancement in the heat transfer rate due to increase surface area of the micro channels but it happens at the expense of pressure. Largely numerical analysis has been done, experimentation is lagging behind and due to constraint condition in the analysis better results reflected which are less in agreement with the experimental data. Potential area of work is still beneath the layer. Optimization of the aspect ratio, number of channels, flow rate, location of the fluid collection and many more are the potential are in the radial micro channels, more intricate shapes in the radial micro channels and different flow arrangements with the latest machining techniques can improve the heat removal rate which the need of the hour as the heat dissipation by the miniatures is no longer job left with the forced convection air cooling system. Double phase cooling system in radial micro channel can spark a new era of cooling of miniatures, taking into consideration the drop in pressure. The nature of diverse exchange-off, but, is different from one cooling device to some other.

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