A REVIEW ON MICRO CHANNEL HEAT EXCHANGER ENGINE COOLING

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ABSTRACT:

Reducing the excessive heat from an engine is very crucial to avoid the damaging & overheating of the engine parts. Various methods used earlier include; using a radiator which has its own advantages and limitations. The micro heat exchangers has evolved as an efficient alternating method for heat removal from engine, The paper reviews research work carried out in the recent times to minimize heat from an engine at certain level, by using different methods.

KEYWORDS: Heat Exchanger, Automotive, Engine, Cooling etc.

INTRODUCTION

Micro heat exchangers are becoming an important area of interest in many new developing technology that require compact high heat energy removal solutions. Fields such as MEMS, microelectronics, biomedical, fuel processing, and aerospace are all pushing the limits of thermal management and are finding ways to make smaller devices with higher heat flux potential – requiring more efficient smaller heat exchangers to cool their hot working components. Micro channel heat exchanger technologies are emerging as a promising cooling solution offering high performance, compact size and lower pressure drops compared to conventional cooling technologies.

Tuckerman and Pease first proposed the concept of micro channel heat sinks in 1981. In the comparison with conventional heat exchanger micro channel has a higher heat transfer performance low to moderate pressure drops, smaller geometric size and lower coolant requirement and lower operational cost. Researchers have explained micro channel with different criteria. Some of those are reviewed here. First we discuss micro channel based on the hydraulic diameter of channel.

Micro channel based on the hydraulic diameter as:
Micro heat exchanger: 1 μm ≤ Dh ≤ 100 μm
Macro heat exchanger: 100 μm ≤ Dh ≤ 1 mm
Compact heat exchanger: 1 mm ≤ Dh ≤ 6 mm
Conventional heat exchanger: Dh ≥ 6 mm

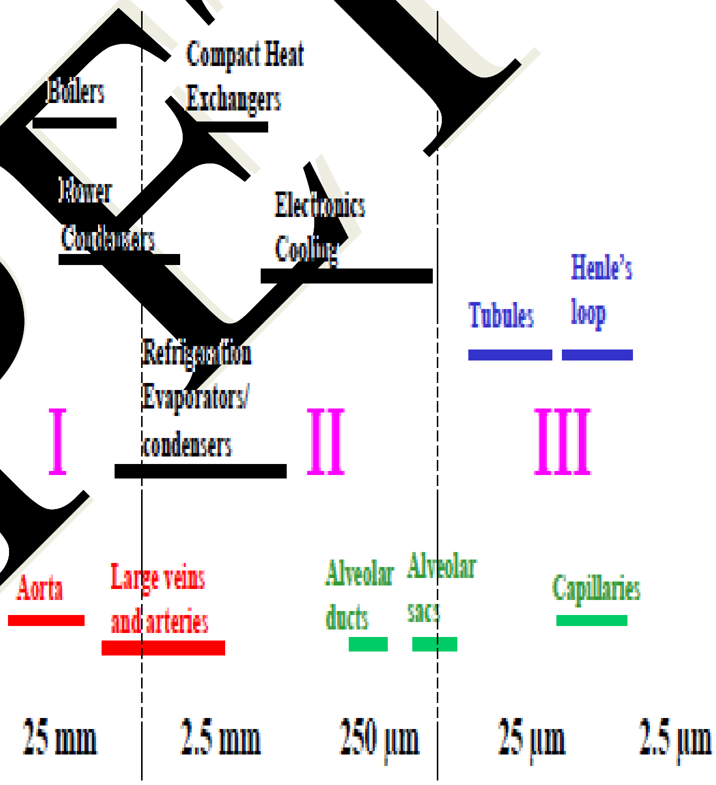

Figure 1: Ranges of channel diameters employed in various applications.

LITREATURE REVIEW:

D. B. Tuckerman et al first introduced the concept of microchannel heat sink in 1981. They proposed & demonstrated that use of microchannel is effective method for dissipation of heat for silicon integrated circuits. The microchannels fabricated in silicon chips which had channel dimensions of 50 μm wide & 300μm deep, were able to dissipate heat flux of up to 790 W/cm² while maintaining a maximum temperature difference between the substrate and inlet water of 71˚C.This research provide the base for number of innovative designs and research efforts in the area of microchannel cooling. The first demonstration consists of design and testing of a very compact water-cooled integral heat sink fabricated into silicon. He had investigated that the use of microchannel having high-aspect ratio, increases surface area & Reduces thermal resistance. [1]

Satish G Kandlikar et al focused on the development on thermal & fabrication aspect of microchannel, in electronics cooling application. They had reviewed that fabrication of microchannel from range of several millimeters to 0.1millimeter fabricated by standard machining technique & from 0.1 millimeter to 100micrometer; semi-conductor manufacturing technology can be used. Thus fabrication point of view there is virtually no limits on manufacturing the micro channel for thermal transfer application. [2]

Mark E. Steinke et al researched on the fabrication and testing of an offset strip fin enhanced microchannel heat exchanger for microprocessor cooling. The concept of using microchannel offset strip fins, the fluid enters a flow passage and travels in a short distance. Fluid encounters a flow obstruction in due to offset fins. The fluid must separate and move around the next fin, then it travels the length of the second fin and encounters another fin obstruction. As a result, the fluid never enters into a fully developed state and must split and move around the next fin. The results showed an improvement in the overall heat transfer and decrease in heat transfer resistances of the enhanced microchannel heat exchanger compared to plain microchannels. The unit thermal resistance of the plain microchannels is approximately 0.1 W/m²°C. The thermal resistance of the enhanced microchannel heat exchanger at the same flow and heat transfer conditions is 0.001 W/m²°C. There is a clear decrease in the thermal resistance and this would result in better thermal performance. [3]

Liu et al investigated the flow of Liquid in Micro channels. They concluded that the conventional theory is applicable for predicting the flow behavior [4].
Lee et al studied the plate fin micro channels by varying the aspect ratio. They proposed a generalized correlation for predicting Nusselt number. There was uncertainty over the applicability of conventional heat transfer theory for micro channel system [5].

Lee et al Investigated heat transfer rate & pressure drop analysis across the flow of fluid in oblique micro channel heat exchanger. They concluded that silicon based enhanced oblique microchannel have maximum heat transfer performance enhancement at 47% when Re = 680.They studied that for better heat transfer enhancement, smaller oblique angle is beneficial. Smaller angle results in resistance to flow and which generate larger secondary flow .Smaller fin pitch enables higher occurrence of thermal boundary layer re-development and secondary flow generation, thus further improve the heat transfer performance. [6]

Yan Fan et al researched by considering novel cylindrical oblique fin microchannel mounted on a cylindrical heat source like an enveloping jacket. Due to this periodic cylindrical oblique fin construction, a hydrodynamic boundary layer developed at the leading edge of the next downstream fin. Results in decrease the average thermal boundary layer thickness, increase the heat transfer performance and provides negligible pressure drop penalty because of flow mixing. In this paper cooling effectiveness has compared with conventional straight fin microchannel with Oblique fin microchannel through experimental and numerical approach using Reynolds number ranged from 50 to 500. The results shoeds that the averaged Nusselt number, (Nu_{avg}) increases up to [illegible]6% and the total thermal resistance decreases up to [illegible].1% for the cylindrical oblique-cut fin microchannel, also flow recirculation zone will form at larger Reynolds number. There is a great improvement in Heat transfer enhancement (E_{Nu}) and pressure drop penalty (E_f) in cylindrical oblique fin microchannel over conventional straight fin microchannel. [7]

Hee Sung Park et al (2014) reported the optimization method for maximum cooling efficiency of the micro channel heat exchanger by theoretical calculations and experiments. Also they found that developing flow model is appropriate to describing the heat transfer in a micro channel heat exchanger.

Satish G Kandlikar et al reviewed that fabrication of micro channel from range of several millimeters to 0.1millimeter fabricated by standard machining technique & from 0.1 millimeter to 100micrometer; semi-conductor manufacturing technology can be used.

S. Subramanian et al done comparison to investigate the performance enhancement of micro channel fins by modifying geometry of oblique fin micro channel. This study has shown that the increased heat transfer coefficient is achievable with lesser pressure drop penalty by using improved oblique fins micro channel.

Pei-Xue Jiang et al investigated for the same flow rate, the pressure drop in the MCHE with deep channels is much lower than in the MCHE with shallow channels, but the deference between their heat transfer rates is not large. The maximum volumetric heat transfer coincident in the MCHE with deep channels was 38.5 MW/(m3 K) for water flow rate of 0.34 kg/s and a pressure drop of 0.9 bar. 2. The transition from laminar to turbulent flow in the micro-channel heat-exchanger occurs much earlier, at Re _ 600, compared to usual fluid flow in large, smooth channels. 3. The MPHE has better heat transfer performance than the MCHE. The maximum water flow rate in the porous-media heat-exchanger was 0.067 kg/s, the corresponding maximum volumetric heat transfer coincident was 86.3 MW/(m3 K), and the pressure drop was 4.66 bar. 4. From the heat transfer point of view the MPHE is better than the MCHEs while the MCHE with shallow channels is better than the MCHE with deep channels. However, the MCHE with deep channels has the best overall thermal & hydraulic performance

B. X. Wang et al experimentally investigated the single-phase forced convective heat transfer characteristics of water/methanol flowing through microchannels with rectangular cross-section. The results provide significant data and considerable insight into the behavior of the forced-flow convection in microchannels. They show that liquid convection characteristics are quite different from those of the conventional cases and can be summarized as follows. For single-phase liquid forced convection through microchannels, a fully developed heat transfer regime is initiated at about Re = 100&1500. The transition to turbulent mode is influenced by liquid temperature, velocity and microchannel size. The well known Dittus & Boelter equation was modified with the only difference of empirical constant, i.e. equation (IO), to predict heat transfer; the rest &s are in quite s, good agreement with experiment data for fully ’ developed turbulent flow. Transition and laminar heat transfer in microchannels are highly strange and complicated. The range of transition zone, and heat transfer characteristics of both transition and laminar flow are highly affected by liquid temperature.

Zhaogang Qi et al, In this paper, the retrofitted microchannel evaporator and sub cooling PF condenser are proposed and experimentally compared with two currently used baseline heat exchangers. Based on components performance analysis, one baseline and one enhanced MAC systems were established and experimented in psychrometric calorimeter test bench. The microchannel evaporator consists of two rows microchannel tubes and louvered fins. It has advantages in compactness (volume reduced by 17.2% and weight reduced by 2.8%) comparing the baseline laminated evaporator. The biggest benefit of microchannel tube applied on evaporators is easy manufacturing to match variable performance requirements and to reduce the tooling investment. Although air side and refrigerant side pressure drop of the microchannel evaporator is slightly higher, its cooling capacity is higher than that of the baseline evaporator. The new SPF condenser is very similar with the normal PF condenser in structure but receiver-dryer is integrated in condenser core before the last two refrigerant passes. This design can reduce the volume and weight of SPF condenser core by 15.1% and 14.9% comparing the normal PF condenser, respectively. The components test data comparisons show that the SPF condenser can maintain much bigger sub-cooling temperature at condenser exit than that of the normal PF condenser although heat rejection is slightly lower. Bigger sub-cooling temperature means higher refrigerant enthalpy difference between evaporator inlet and outlet which will be benefit for cooling capacity improvement if the system mass flow is the same.

Tri Lam Ngo et al, Thermal-hydraulic characteristics of microchannel heat exchangers (MCHEs) with S-shaped and zigzag fins were investigated experimentally by varying Pr widely from 0.75 to 2.2 to confirm Pr dependence on heat transfer performance and pressure drop for carbon dioxide cycles. The Pr dependence was found for the empirical correlations of Nu and not for the pressure-drop factors of both MCHEs. The Nu correlations reproduce the experimental data of the overall heat transfer coefficients with the standard deviation of ±2.3% and ±3.0%, respectively, for the MCHEs with S-shaped and zigzag fins. The calculated pressure drop obtained from the pressure-drop factor correlations agree with the experimental data of pressure-drop Thermal-hydraulic characteristics of microchannel heat exchangers (MCHEs) with S-shaped and zigzag fins were investigated experimentally by varying Pr widely from 0.75 to 2.2 to confirm Pr dependence on heat transfer performance and pressure drop for carbon dioxide cycles. The Pr dependence was found for the empirical correlations of Nu and not for the pressure-drop factors of both MCHEs. The Nu correlations reproduce the experimental data of the overall heat transfer coefficients with the standard deviation of ±2.3% and ±3.0%, respectively, for the MCHEs with S-shaped and zigzag fins. The calculated pressure drop obtained from the pressure-drop factor correlations agree with the experimental data of pressure-drop

Hee Sung Park et al experimentally investigated friction factor and heat transfer in a range of microchannel arrays. The friction factor obtained by experiments showed excellent agreement with conventional hydraulic theory and also supported that the flow inside the microchannels was fully developed laminar in the range of our experiments (69 < Re < 800 and 106 lm < Dh < 307 lm). The heat transfer rates were also investigated by assuming fully-developed and developing temperature profiles. Our experimental results deviated from the Nusselt number calculated from conventional heat transfer theory. In order to predict the heat transfer rate accurately for practical applications, we proposed the correlation of Nu/(Re0.62Pr0.33) and Brinkman number which is confined to our experimental range.

CONCLUSION:

The survey made on various literatures available has pointed out that the micro channel heat exchangers are now being evolved such that they can be useful in Automobiles industry also. The basic quality of MCH to dissipate heat from a heat source within compact sizes has made researchers to think about its application in Automobiles. Especially in extracting heat of an engine. This again opens up a new area of future research.

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