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Survey on Micro Channel Heat Exchanger for Air Conditioning Applications

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Abstract The use of micro-channel heat exchangers are significantly increased in air conditioning applications due to its appreciative characteristics like higher mass and heat transfer rate, compact in design In the recent years, with increasing demand for lightweight and increasing the copper prices, copper substitution is also a widespread concern. Under the premise of meeting the heat exchange remand, micro-channel heat exchanger can reduce equipment weight, improve the device compact and improving heat transfer rate as compare to finned tube heat exchanger. The manufacturing costs can be reduced and the product competitiveness can be improved by using aluminums. In this review paper, characteristics of air conditioning system micro channel heat exchangers are analyzed. The micro-channel heat exchangers have higher surface contact area to volume ratio.In air conditioning system micro-channel heat exchanger can be applied as both the condenser and evaporator. As micro-channel heat exchangers are compact in size they are suitable for the automotive air conditioning system. Micro-channel heat exchanger the sensible and latent both cooling capacity increases and overall efficiency of air conditioning system increases.

Keywords —Air Conditioning, Micro-channel heat exchanger, Compact System, Heat transfer, Higher surface contact area.

I. INTRODUCTION

MICROCHANNEL HEAT EXCHANGERS

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions. If the ratio of surface contact area to volume is higher than it is called as compact heat exchanger. Micro channel heat exchanger are compact type of heat exchangers.

The concept of micro-channel heat exchanger was first proposed and used by Tuckerman and Pease[1]in 1981.Micro-channel heat exchanger is defined by Mehendale.S.S as if the hydraulic diameter of heat exchanger is less than 1mm.

It is a special kind of heat exchanger in the family of heat exchanger in the family of heat exchanger. In recent times there has been lot of interest regarding micro channel heat exchanger and there is lot of development.

To the rapid development of modern microelectronic mechanical requirements of heat transfer rate, micro-channel heat exchangers began to be used in cooling of high-density electronic devices in the 1980s, then appeared in the MEMS(microelectronic mechanics system) industry in the 1990s. With studies on

properties of micro-channel in depth and application in the promotion of electronic cooling, advantages of micro-channel heat exchanger which a traditional heat exchanger can not match gradually appear. And micro-channel heat exchanger began to enter the refrigeration and air conditioning industry. At the present scenario, the micro-channel heat exchanger has been applied in automotive air conditioning system. In householdair conditioning system, technology of micro-channel heat exchanger applied in single-cold air-conditioner condenser has gradually matured, however, this technology face big challenges, such as complex gasliquid two-phase uniform streaming[3]

Micro-channel heat exchangers use less refrigerant charge and thus compressor required to compress the refrigerant will be of smaller size. Thus power requirement for air-conditioner is reduced.

II. LITERATURE SURVEY

Heat exchanger with reliable and high performance has been the study focus of the refrigeration and air conditioning system. Conventional heat exchangers used in air-conditioners have limitations in their performance such as heat transfer coefficient is comparatively low, resulting in lower refrigeration effect and COP of the system.This drawback of the conventional heat exchangers justifies the need for use of micro-channel heat exchangers in Air-Conditioners.

By compared with the conventional heat exchanger, micro-channel heat exchanger is very different in flow characteristics and heat transfer characteristics due to structural and other differences. Some phenomena and new laws in the emergence in Micro-channel can be attributed to scale effects. Reduced

scale leads to enhance fluid compressibility effects[4]; the increased roughness leads to increase the drag coefficient[5,6]; as surface area to volume ratio increasing, the effects of the force associated with the area (surface forces, viscous forces, etc.) in micro-channel will be strengthened[7], and enhances the impact of axial heat conduction of micro-channel wall.[8-10]

In 2003 Qu et al[11]from Purdue Universityhe developed an annular flow model, for made a measurement of the saturated flow boiling heat transfer coefficient in water-cooled micro channel heat sinks, and captured the trend by the experimental data that heat transfer coefficient decreasing with increasing vapor quality in the low vapor quality region of micro-channels.

In 2004, Re'miRevellin et al[12] from Ljubljana University he made researches on two-phase flow characteristics of R-134a as refrigerant in 0.5mm channel, and summed up the relationship between mass flow and vapor quality in four different flow patterns. In the same year, G. Hetsroni[13] from Israel respectively compared some different laboratory condition, such

as compressible fluid and single-phase gas, smooth wall and rough wall, laminar and turbulent conditions to analyze the flow characteristics of liquid and gas flow in micro-channels under conditions of a small Knudsen and Mach numbers.

Microchannel Heat Exchanger- Present This paper is a synthesis of the design, operational and theoretical features of microchannel heat exchangers (MCHEX). The main contributions to the development of new design solutions and technologies in this field are presented. Differences by fluid flow and heat transfer between theoretical calculations and experimental results for MCHEX are shown. The advantages of a very high thermal load using MCHEX are pointed out. This justifies the interest in their use, generally, in compact thermodynamic systems and, particularly, in cooling Micro-Electro-Mechanical Systems (MEMS).

The heat transfer performance can be improved by using the micro-channel structure.The micro-channel geometry and size have impact on the performance of heat exchanger. Therefore, there will be great significance to explore the optimal structure of micro-channel during the micro-channel heat exchanger design.

In1991 and 1992, RW Knight[14,15] from there research he optimized the structure of micro-channel heat exchanger byreducing the maximum thermal resistance under conditions of given pressure drop.

Performance of Micro-Channel heat exchangers in Air Conditioners

From the survey micro-channel heat exchangers have been extensively used in automotive air-conditioning systems but never been used in residential air-conditioners. Hence researchers first studied the automobile air conditioners. Researchers have done thermal modeling of micro-channel and laminated types evaporator in automobile air conditioning system. The performance of micro-channel heat exchanger is compared with the laminated evaporator which was used in automotive industries. The numerical results of thermal modeling of laminated and mini-channel evaporators was validated with corresponding experimental data which was obtained from experiments performed on automobile air conditioning system in calorimeter test bench.

Figure 1 Micro-channel condenser

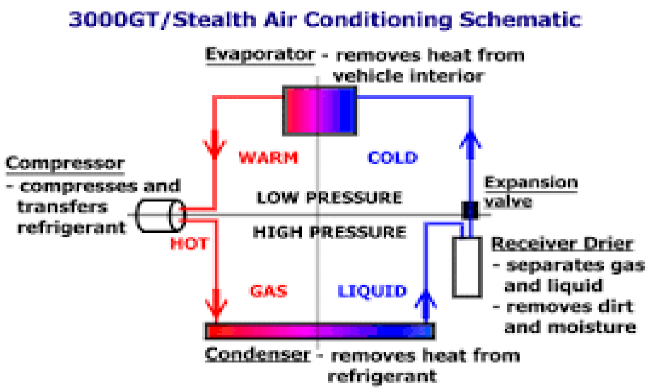

Figure 2 Air-conditioning system schematic

The performance of laminated and mini channel were also compared under various operating conditions. Researchers used ϵ- NTU method for evaluating and comparing the system under different conditions. After these experiments and results they concluded that the mini-channel evaporator had higher cooling capacity (7.2 %) and higher refrigerants pressure drop (45%) in comparison with the corresponding values in laminated evaporator assuming the same external geometry. The outlet air temperature and enthalpy of mini-channel evaporator was also lower (11%) and (8%) respectively, than that for laminated evaporator. This reduces the time period as well as power/fuel consumption for reaching the comfortable cabin temperature.

Researchers then carried out experiments on prototypes of residential air-conditioners compared the performance of residential air conditioning system having a fin and tube condenser & a micro-channel condenser experimentally. For determining the capacity and performance characteristics of the unit under standard climate condition methods of testing specified by ISHRAE standard IS1391 were followed. As per the test standards, air side and refrigerant side measurements are used to determine performance, particularly cooling capacity and energy efficiency ratio (EER). For this investigation, a commercially available capacity residential air conditioning system having fin and tube condenser served as the base system. Aftertesting the base unit the condenser was replaced by a micro-channel condenser with the same face area under identical test conditions. From test they concluded that sub-cooling of the liquid side is achieved for micro-channel heat exchanger and results in increase in refrigeration effect. Both the latent heat capacity and sensible heat capacity increased considerably in micro-channel heat exchanger. Cost of micro-channel heat exchanger is less as no copper is used. For same cooling capacity the refrigerant charge reduces up to 18%, thus reducing the refrigerant cost. So, the Overall performance of an Air-Conditioner can be enhanced by using micro channel heat exchanger.

Comparison of refrigerant charge used

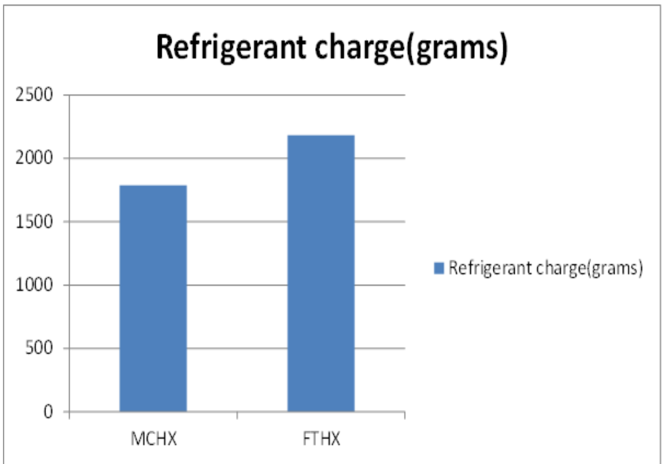

Figure 3 Refrigerant charge comparison

Table 1 Refrigerant charge comparison

Type of Heat Exchanger	Refrigerant charge
Micro-channel heat exchanger	1785gms
Finned tube type heat exchanger	2180gms

From the above results it is evident that due to reduction in size of heat exchanger the refrigerant charge has also reduced. There is 18% reduction in refrigerant charge in micro-channel heat exchanger as compared with conventional finned tube type heat exchanger.

Comparison of cooling capacities in both cases

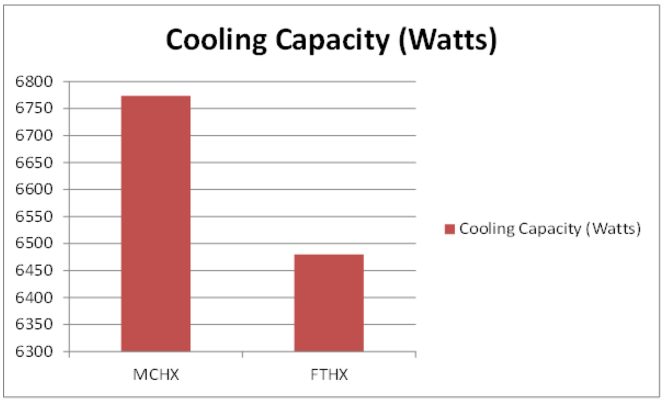

Figure4 Cooling capacity comparison [12]

Table 2 Cooling capacity comparison

Type of Heat Exchanger	Refrigerating effect/Cooling capacity
Micro-channel heat exchanger	6773.086 W
Finned tube type heat exchanger	6480 W

Thus from the above results, it is observed that as refrigerant charge in the system decreases, the refrigeration effect increases. Micro-channel heat exchanger has a higher cooling capacity as compared to the conventional finned tube type heat exchanger. There is 4.5% increase in the cooling capacity with the use of micro-channel heat exchanger in the air-conditioning system.

Comparison of COP of system in both cases

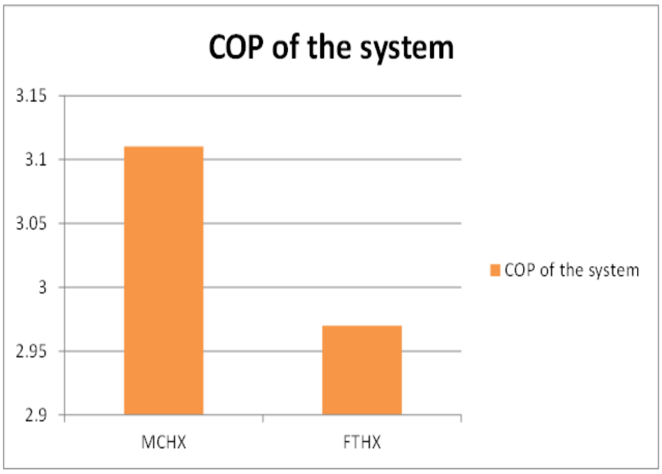

Figure 5 System COP Comparison[12]

Table 3 System COP comparison

Type of Heat Exchanger	COP of the system
Micro-channel heat exchanger	3.11
Finned tube type heat exchanger	2.97

From the above results it is indicated that the COP of the system increases if micro-channel heat exchangers are used in place of conventional finned tube type heat exchangers. There is a 4.7% rise in COP of the system in case of micro-channel heat exchangers.

Thus from this experiment it is proven that, micro-channel heat exchangers have higher performance as compared to finned tube type heat exchangers and hence can be viewed as a potential replacement for the conventional heat exchangers in HVAC industry due to rising energy efficiency standards.

III. CONCLUSION

In recent years, micro-channel heat exchanger has been more widely applied in the refrigeration and air conditioning industry due to its significant advantages over conventional fin & tube type heat exchangers. For the purpose of replacing all aluminum parallel flow heat exchangers as a heat exchanger for all kinds of air-conditioner, the improvement of anti-corrosion technology and degree of flexibility for product application should be done. In addition, refrigerant distribution characteristics should be improved. On the other hand, refrigerant flow mal-distribution is one of the main problem deteriorate heat transfer rate of air-conditioner. Hence, before designing the micro-channel, the pressure loss and heat transfer characteristics must be accurately predicted, while the theoretical basis which can accurately guide the design is not yet mature and there is no uniform industry standard in manufacturing. However, it is believed that with the study of micro-channel heat exchanger performances in-depth, optimization of heat transfer and existing problems in manufacturing and applications will be resolved & micro-channel heat exchanger will be more widely used in the HVAC industry.

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