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# Fin pitch to effect efficiency of evaporator and HVAC

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***ABSTRACT:*** *Efficiency of a heat exchanger, such as a multi-flow heat exchanger (evaporator), is critical to any air-conditioning system. A large amount of experimental work has already been performed for the enhancement of air-side heat transfer. However, there is a further need to investigate flow profiles and the related heat transfer characteristics for complex geometries of a heat exchanger. In this direction, tests at two levels are conducted to verify the effect(s) and measure the variation(s) for further conclusion: a component level test (evaporator level) for cooling capacity and pressure drop; and a system level test on a plastic case of HVAC unit that includes evaporator, heater, blower motor, fan and the dampers. The findings indicate that an economic heat transfer enhancement can be achieved by fluctuating the fin density.*

***Keywords:*** *Fin pitch, evaporator, HVAC,*

## I. INTRODUCTION

All air conditioning systems contain at least two Heat Exchangers, usually called Condenser and the Evaporator. In either case, Condenser or Evaporator, the refrigerant flows into the heat exchanger and transfer heat, either gaining or releasing as a cooling medium. The Heat Exchangers are critical parts in a complete A/C System, and use lightweight aluminum materials to improve on heat transfer.

Studies have been done on different type of evaporator used in commercial and as well as industrial refrigeration applications. These are air-cooling evaporators which transfer heat from refrigerant-to-air using tubes to carry refrigerant with fins profiles onto the tube exterior [1]. Individual tubes of the heat exchanger are arranged in multiple rows of parallel circuits to achieve increased thermal performance [2]. Refrigerant evaporates inside the tubes as it absorbs heat from air flowing over the outside surface across finned tubes.

Traditional heat exchanger devices such as plate type, plate fin type and tubular type operate on the principle of temperature difference between two mediums and can realize efficient sensible heat transfer from one fluid to another [3, 4]. With the development of design of heat exchanger and making some changes without heavily affecting the cost, the heat transfer enhancement can be achieved. One such type of Multi flow heat exchanger (evaporator) is our target. A large number of experimental works has already been performed for this enhancement of air-side heat transfer; however, the flow profiles and the related heat transfer characteristics in the complex geometries are still needed to be verified. There are several geometric and the flow variables that affect the heat transfer coefficient and friction factor for a fin-tube type multi flow evaporator [5, 6]. Without consideration of the tube layout and fin shape, the geometry specific variables can be: fin height, fin spacing, fin thickness, tube diameter, tube pitch and the number of rows. In addition, the flow variables can be: air velocity, density, viscosity, thermal conductivity and the specific heat. Our target is to check the behavior in terms of cooling capacity, pressure drop, air flow and power consumption by changing the fin spacing of evaporator in auto air conditioning system. Fin spacing are also referred to as “fin pitch”. The density of fins, when applied to an evaporator, may have a dramatic effect on evaporator and the resulting capacity loss; this is largely due to blockage of airflow. Although, increased fin density (decreased fin spacing) may be desirable because it increases the surface area available for heat transfer, the reduced spacing between fins will result in a decrease of the open area available for air flux to flow. Earlier studies [7] have shown that the heat transfer coefficient near the fin base, having closer fin spacing, is smaller than achieved with the greater fin spacing; it is because usually, the smaller gap fin spacing creates thicker boundary layers. In addition, the stagnation zone formation at the root of the fin and thetube surface is swept by a non-turbulent flow; and therefore, it is excluded from taking part in active heat transfer. Thus, the allowable extent of reducing the fin spacing will depend on the velocity and turbulence of the flow within the inter fin spaces.

## II. EXPERIMENTAL METHODS

In this paper, evaporator (heat exchanger) is being targeted to determine and compare the cooling capacity, pressure drop, air flow and the power consumption with two different fin pitches in auto air conditioning system. Following testes are conducted to verify the effect and measure the variation for further conclusion:

- Component Level Test (Evaporator Level) for evaluating Cooling Capacity and Pressure Drop
- System Level Test (a plastic case of HVAC unit that includes evaporator, heater, blower motor, fan and the dampers) for recording Air Flow and Power Consumption

One such multi flow type, RS (Revolutionary Slim) evaporator (Fig. 1.) is picked keeping all design parameters, including the frontal area, unchanged.

Fig. 1. Revolutionary Slim evaporator: length x breath x core-thickness as (191 x 172.5 x 38) mm

The model is run for two different fin pitches 2.6 mm and 3 mm; the data is collected and analyzed to indicate any change in heat transfer. It is also noted that the air-side cross-sectional area decreases with distance from the air flow inlet, accelerating the air as it flows across the tubes; thereby, improving the air-side local heat transfer coefficient.

## III. RESULTS

The results are compiled for cooling capacity and pressure drop obtained though component level test, and for airflow and power consumption through system level test as follows.

### 3.1 Component (evaporator) level test results for cooling capacity and pressure drop

The test is conducted with different air flow values to measure cooling capacity. The range of air flow values considered are at 275, 325, 375 and 425 CMH.

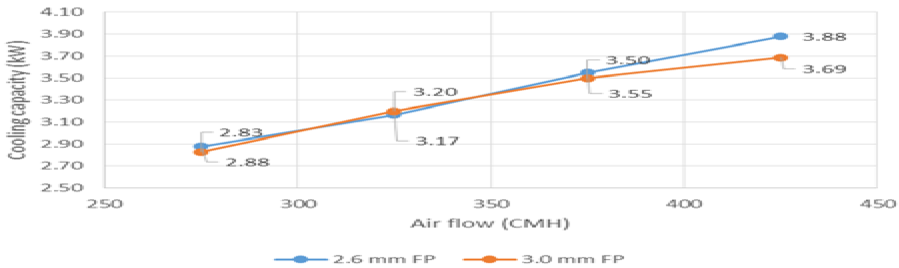



Fig. 2. Air flow verses cooling capacity

The test is conducted to measure pressure drop for the same range of air flow values as while evaluating for cooling capacity.

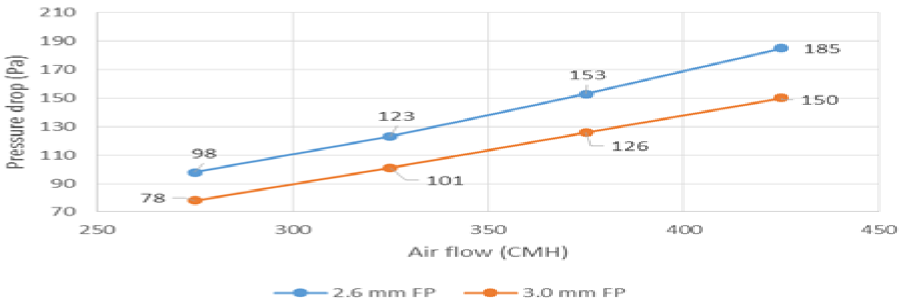



Fig. 3. Air flow verses pressure drop

With increase in air flow, the cooling capacity and pressure drop are also increasing, and the pattern is non-parallel for the two fin pitches. The variation in cooling capacity started with almost coinciding values at air flow of 275 CMH, however, differences started to emerge for higher values of air flow. The values for pressure drop for 2.6 mm FP have consistently shown higher values compared to the fin pitch of 3 mm.

### 3.2 System level test results for airflow and power consumption

A system level consists of plastic case of HVAC unit that includes evaporator, heater, blower motor, fan and the dampers. The test is conducted at different voltage values of 8.0, 10.0, 12.0 and 13.5 V. The conditions for HVAC air inlet temperature is maintained at 27ºC, RH of 50%, and condenser air inlet temperature at 35ºC.

Variation of air flow and effect on power consumption with varying voltage are respectively plotted in Fig. 4. and Fig. 5.

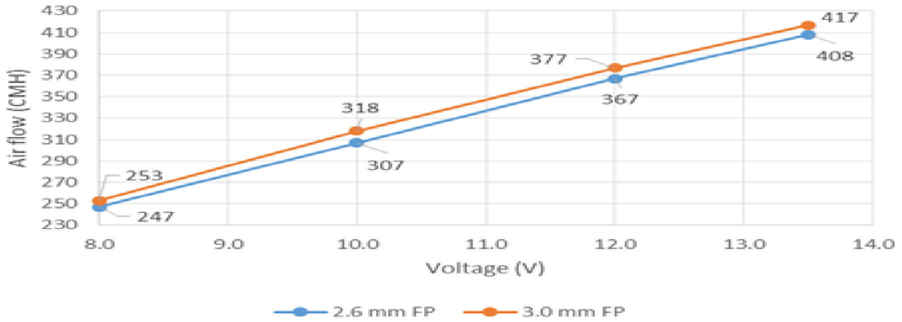



Fig. 4. Voltage verses air flow

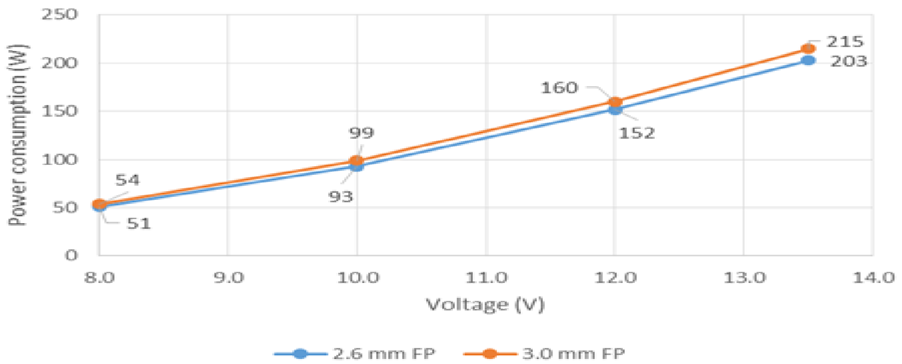
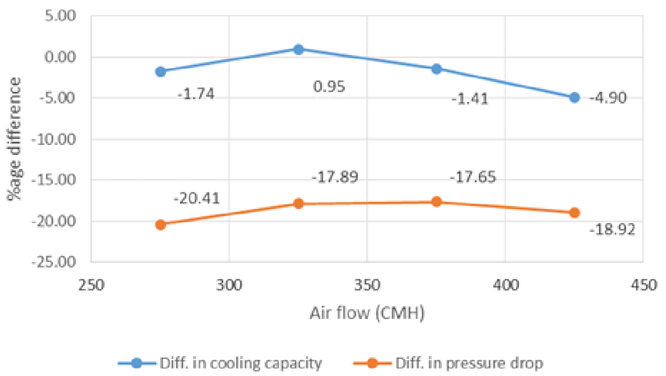
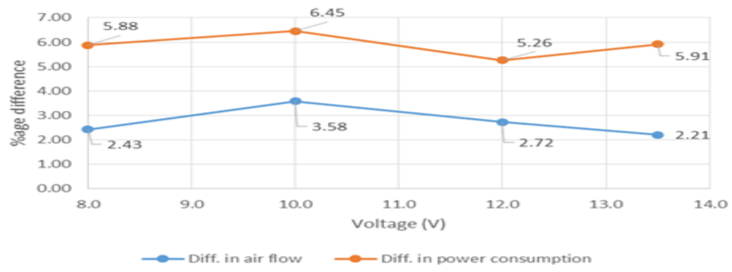



Fig. 5. Voltage verses power consumption

In Fig. 5., it is noteworthy that the power consumption is increasing with the in increase in voltage; and it is at a relatively higher rate for 3 mm FP. The plots are not parallel and so the differences are plotted in Fig. 6. to establish percentage variations with the changing parameters. The percentage differences are measured relative to 3 mm fin pitch.




(a)




(b)

Fig. 6. Percentage difference for factors, (a) Air flow, (b) Voltage

In Fig. 6a. for cooling capacity, the percentage difference decreases at different values of air flow than 325 CMH. Similar pattern is seen with pressure drop in Fig. 6a. It is now clear from Fig. 6b that the percentage variation of air flow is non-consistent for the fin pitches tested. Therefore, the following conclusions are drawn.

## IV. CONCLUSION

In this paper, evaporator (heat exchanger) is being targeted to determine and compare the cooling capacity, pressure drop, air flow and the power consumption with two different Fin Pitches in auto air conditioning system. Following test has been conducted to verify the effect and measure the variation for further conclusion

- Component Level Test (Evaporator Level) for Cooling Capacity and Pressure Drop
- System Level Test (a plastic case of HVAC unit that includes evaporator, heater, blower motor, fan and the dampers) for Air Flow and Power Consumption A complete understanding of the fin spacing effect and its relation to heat transfer and pressure drop behavior of evaporator is needed. Therefore, the effect of the fin spacing was investigated with two different Fin pitch 2.6 mm and 3 mm keeping all design parameters same. It resulted that the air-side cross sectional area decreases with the distance from the air flow inlet, accelerating the air as it flows across the tubes and, therefore, improving the airside local heat transfer coefficient.

Experiments are performed on Revolutionary Slim evaporator in auto air conditioning system. While keeping other geometric parameters fixed, observations are made for fin pitches (fin spacing) of 2.6 mm and 3 mm; a total of 32 variations are made. Air-flow varied from 275 CMH to 425 CMH with an interval of 50 CMH, to find its effects on cooling capacity and pressure drop. The percentage difference in cooling capacities are noted to vary from 0.95% to -4.90%. While a maximum percentage drop in pressure is noted, at an air flow of 275 CMH, to be -20.41% for increase in fin pitch by 0.4 mm from 2.6 mm. Effects on air flow and power consumption are observed for a range of variation in voltage at 8.0 V, 10.0 V, 12.0 V and 13.5 V. For this range, with the increase in fin pitch, a maximum increase in air flow is by 11 CMH from 307 CMH at 10.0 V; and the power consumption is increased by 6.45%, which is maximum

## V. ACKNOWLEDGEMENTS

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