Experimental environment for convection heat transfer teaching in finned systems

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Introduction

Defined as the energy that is changed between systems with different temperature values, the heat could be transfer though three specific ways: conduction, radiation and convection. While the first one happens though the environment, in other words, due to the molecular agitation, the radiation occurs with transfer of energy that was generated by electromagnetic waves. The convection, on the other hand, is the heat change between a surface and a movement fluid, and it can be made in free or forced ways [1].

In the free manner, the air, who is considerate a movement fluid, gets in touch with a hot surface. The air is heated and, consequently, it starts to rise because of the density reduction. The forced convection is characterized by process of help the air movement on the heated surface, by means of a fan [2].

With the objective of study and compare the convections in free and forced ways over heat transfer pinned extended surface, under different voltages. This project utilized the HT-19 Armfield equipment.

Through this accessory, also experimental data from heat transfer flat plate were been collected to graphics formulations that relate the temperature variation with time.

Methodology

Developed by the Armfield Education Division, that designs and manufactures equipment for engineering education and research used by universities, colleges, schools and research centers around the globe, the HT-19 equipment (Figure 1) was made to demonstrate the phenomena of natural (free) and forced convection [3].

With height of 0.95m, this accessory consists of a bench mounted vertical air duct, with a transparent front allows visualization of the whole experience process. The air duct has an aperture positioned at the rear wall, into which three different types of heat-transfer surfaces can be inserted. This work used the flat plate heat exchanger and the cylindrical pin heat exchanger, according to Figure 2 [3].

Each one of these heat exchanger has thermocouple connections to be linked to auxiliary equipment HT10XC, who is responsible for the electric energy provision [3].

This accessory also shows the temperature data of each thermocouple,

Fig 1 – HT-19 equipment

electric current and experimental air velocity in real time.

On the HT-19 base, there is a centrifugal fan, which generates the air flux inside the duct. The velocity variation happens with the rotation of fan bottom localized in the lower duct part [3].

Using the Armfield software that follows HT-19, it was gotten the registers of all variables measured to analyze and performance comparisons.

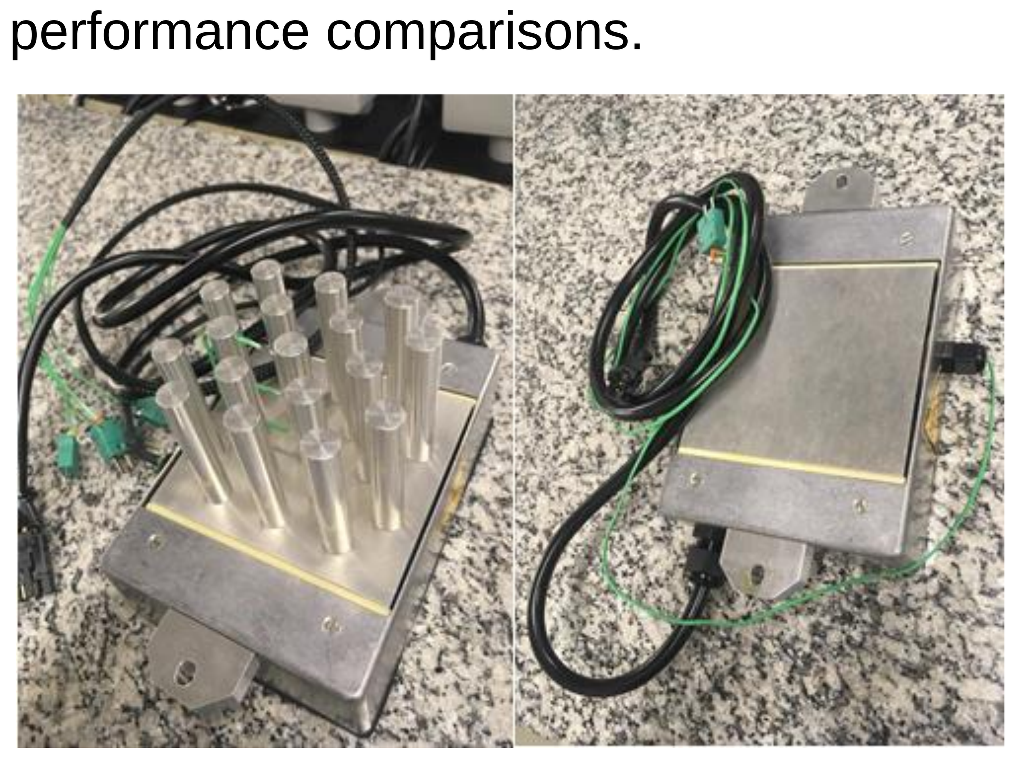

Fig 2 – Cylindrical pin and flat plate heat exchangers

Results

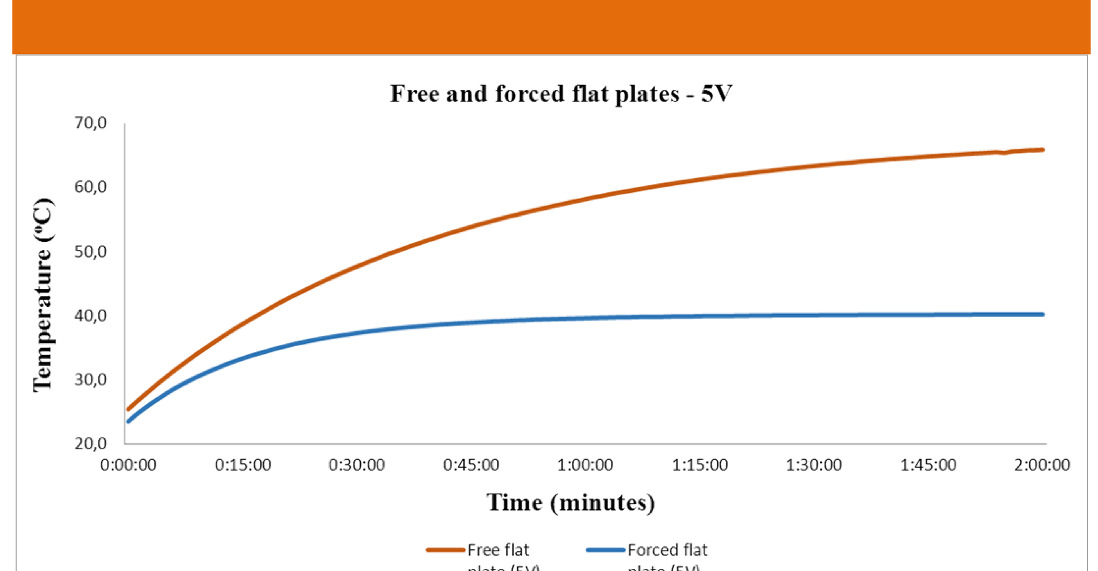

Fig 3 – Forced and free convection effects on flat plate heat exchanger

The Figure 3 shows that the permanent regime, in both cases, was achieved approximately in two hours of experience. It is observed that in forced convection, the plate temperature is lower then in free convection, due to the higher value of thermal transfer coefficient *h* (W/(m^2K)) and, consequently, the higher heat flux.

Table 1 – Reynolds and Grashof Numbers obtained from convection heat transfer tests using the flat plate heat exchanger

Dimensionaless		Regime
Reynolds	31499,71	laminar
Grashof	370513,781	laminar

The Reynolds' number, which determines the type of flow regime on forced convection surfaces, resulted in a laminar regime, presented a value less then 5 x 10^5.

The function of Reynolds' number in forced convections is similar to the one proposed by Grashof in natural convections. Considering the regime as turbulent with values above 10^9, the experiment could be characterized as a laminar regime.

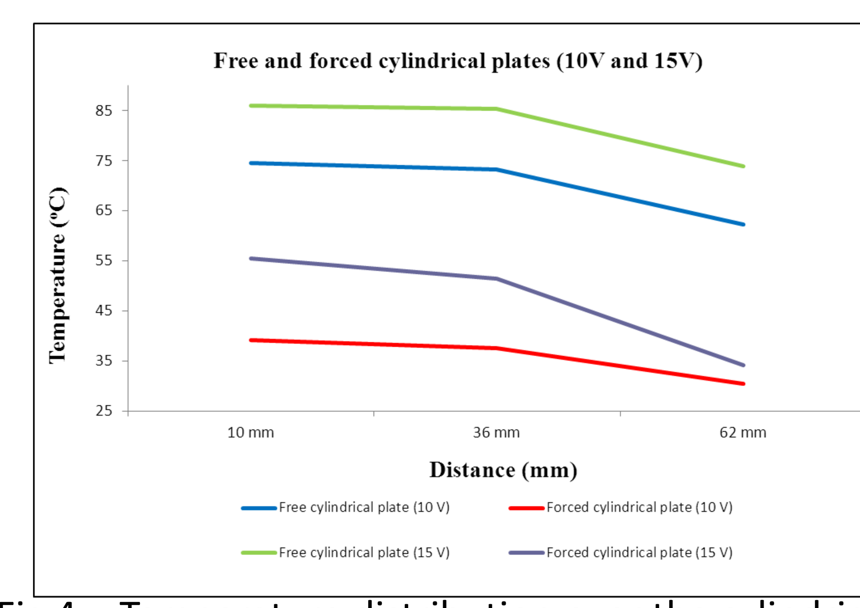

Fig 4 - Temperature distribution over the cylindrical fin surface

According to Figure 4, it could be possible to observe that the power increase, such in free convection as in forced one, caused the temperature increase.

It was confirmed, in both convections of 10 and 15 Volts, that the temperature decreased gradually while the distance between cylindrical fin point and plate base increased. When it was compared both convections, the forced one resulted in lower temperatures, which coincides with the results that were achieved by experiments using flat plate of 5 Volts.

Conclusions

The experimentation is a complement to the theory that assists the training of future engineers, which allow a critical view on the results obtained. This study was able to support performance data of heat transfer by free and forced convection, and an application of finned surfaces.

Acknowledgments

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