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RESEARCH REGARDING THERMAL AND HYDRODYNAMIC PERFORMANCE LEVELS OF SURFACES WITH SINUOUS FINS FOR AUTOMOTIVE HEAT EXCHANGERS

NAGI, M[ihai]; CARABAS, I[oan] D[aniel]; ILIES, P[aul] & GHITA, E[ugen]

Abstract: *The work presented is based on experimental studies developed for five compact heat exchangers identically shaped, with the same frontal area, but different width. The influence of heat exchangers matrix width was identified, as well as the effect of sinuous fins pitch on thermal and hydrodynamic performance. Colborn criteria and friction coefficient values were studied for given Reynolds numbers.*
Key words: *heat exchanger width, thermal performance, friction coefficient, Reynolds*

1. INTRODUCTION

Compact aluminium heat exchangers were studied during the experimental research, with sinuous fins of different thickness, 0,14; 0,16; 0,3; 0,5 mm. The influence of "entry effect" on thermal and hydrodynamic performance for heat exchangers was identified.

2. THEORETICAL CONSIDERATION

If a small distance x (under 25% of the fin pitch) at fluid entry is considered, this portion can be considered a flat wall surface and fluid speed w_w to be parallel to thee wall. A laminar flow layer is observed (fig. 1), also called a hydraulic limit layer. This layer has a very low thickness δ_x at fluid entry and increases as the distance x is increased. This is known in literature as the "entry effect"(Arjanikov & Maltev, 1954).

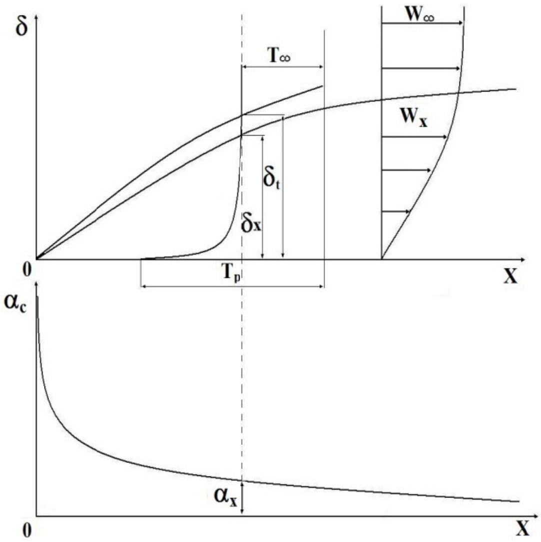

Fig. 1. Hydraulic limit layer at the entry on a plane surface

The thickness of the two layers can be considered to show a parabolic variation, but different for the two, δ_x - hydraulic limit layer thickness, δ_t - thermal limit layer thickness.

These two dimensions can be correlated with the following equation, as given by Plhausen (Ilies P et at., 2009):

$$\partial_t = \frac{\partial x}{\sqrt[3]{\Pr}} \tag{1}$$

Heat exchange between the fluid and the wall is most effective at the entry end of the wall, where the thickness of the limit layer is very small. A maximum value for the heat transfer coefficient ''α_x'' is noticed where the layer thickness is close to zero. This is called as the "entry effect", and can be induced on any surface, for a small given length (Bejan, 1973).

3. EXPERIMENTAL SETUP

A special installation was used for testing heat exchangers, a rig that can simulate working conditions as close to reality as possible. Multiple parameters were recorded at a very high level of precision. For studying thermal and hydrodynamic performance testing, aluminium water-air type heat exchangers were used, (Nagi et al., 1994) with plates and bars (fig.2.) (Leca, 1983).

Fig. 2. Sinuous fins Radiator 400x400xGxp heat exchanger

These heat exchangers had identical frontal areas, with rectangular section water canals also with identical dimensions. Air passage ways feature sinuous fins with a constant height of 8,8 mm, a pitch *p* of 3,5; 4; 5; 6,5 mm and matrix width *G* of 30; 45; 65; 95 and 115 mm (fig.3) (Nagi, 1996).

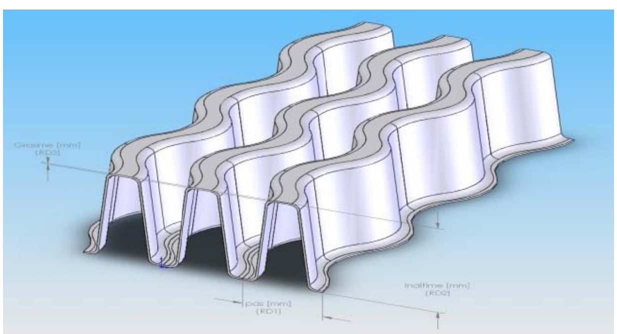

Fig. 3. Sinuous fin used for tested heat exchangers

4. PROCESSING EXPERIMENTAL DATA

Each device was tested in at least 30 functioning work regimes.

Data processing was done using the LabView 7.0 software, that monitors testing parameters with an error of <2%, can plot graphs of these parameters and controls the valve that regulates cold air flow. Recorded data was stored in Excel files.

5. RESULTS

Diagrams in figures 3, 4 and 5 were plotted based on the results obtained during experimental trials. Colborn j criteria for Reynolds (Re) number were plotted in figure 3 and 4 for heat exchangers with p =3.5 and 4 mm pitch, while figure 5 shows plotted results of the friction coefficient cf for a Reynolds number ranging from 600 to 3600, for sinuous fins compared to Kays and London type fins(Kays &London, 1984) **(**Nagi et al., 2006).

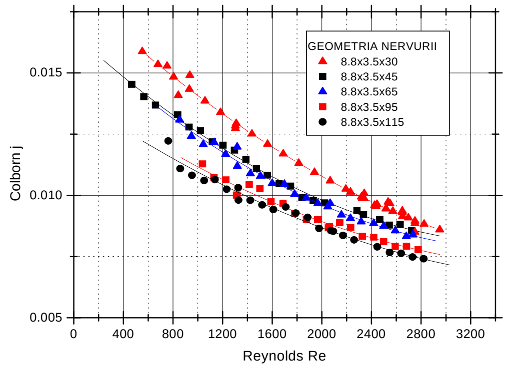

Fig.3. Colborn criteria variation for sinuous fins with 3,5 mm pitch

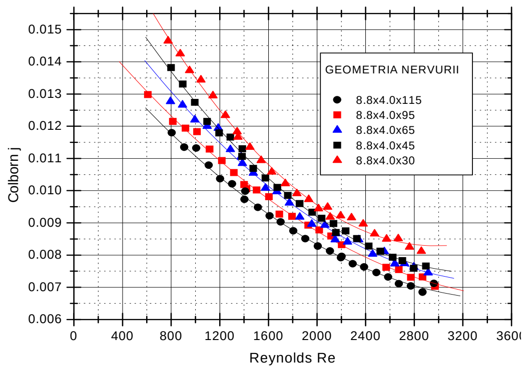

Fig.4. Colborn criteria variation for sinuous fins with 4,0 mm pitch

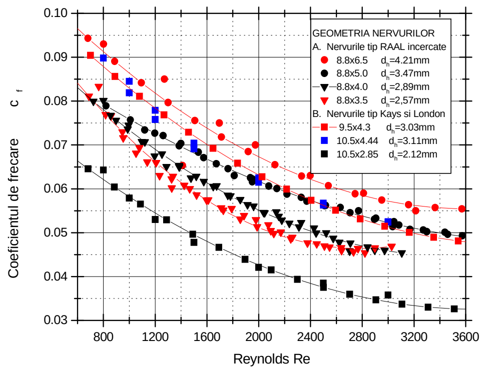

Fig.5. Friction coefficient variation for sinuous fins compared to Kays and London type fins

6. CONCLUSIONS

Heat exchange coefficient ''α_x'' shows a maximum value when the thickness of limit layer is close to zero.

By plotting the variation of the Colborn j criteria as a function of Re number, the obtained results were generalized. The obtained results can be analyzed from the point of view of their quality as well as quantity and the diagrams can be used with a high precision to design similar sinuous fins without any regard to the condition of the experimental trials. Colborn values are higher for short passage ways. The differences in Colborn values for the same family of heat exchangers and the same Re number are explained by the "entry effect". In this manner, the theory regarding this effect was proven by experimental trials.

Figure 5 shows that friction coefficient values for sinuous fins on the air side are dependent only on the hydraulic diameter of the passage ways. Hydrodynamic performance is better for sinuous fins (for the same hydraulic diameter) compared to those tried by Kays and London (the Kays and London fins are named sinuous but in fact they are discontinuous fins). This was to be expected, as thermal performance levels for sinuous fins are slightly lower regarding those tested by Kays and London (Nagi et al., 2008).

7. ACKNOWLEDGEMENTS

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