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Modelling of Plate-fin Heat Exchangers – Some Unique Aspects for Stainless Steel Construction

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ABSTRACT

Conventional brazed plate-fin heat exchangers made from aluminium have been in commercial use for many decades. They are high performance heat exchangers used in a wide range of applications from automotive through aerospace to process industry. However, their process industry applications are limited to cryogenic duties because of the use of aluminium as a material of construction. More recently a number of companies have developed plate-fin heat exchangers made from stainless steel. These heat exchanger are able to cope with high temperature, high pressure duties. Furthermore similar to aluminium plate-fin heat exchangers, they too offer the benefits of multi-stream capability.

Because of extensive work carried out by a number of research groups over many years, the thermalhydraulic characteristics of aluminium plate-fin heat exchanger are better known. Some of this information for aluminium plate-fin heat exchangers would be applicable to stainless steel plate-fin heat exchangers. For example, single phase thermal hydraulic characteristics would be expected to be identical because, under similar thermal-hydraulic conditions, these characteristics depend only on geometric factors such as the flow cross-section area, hydraulic diameter and surface roughness. Even if the metal thermal conductivities are very different between aluminium and stainless steel, they only affect the wall thermal resistance and fin efficiency.

In contrast to single phase heat transfer, the boiling heat transfer coefficient (more precisely the nucleate boiling component) depends on the wall superheat. Therefore stainless steel, with its thermal conductivity of less than 1/10th of aluminium, will have the following three effects.

1. The boiling heat transfer coefficient will decrease more rapidly along the fin height because of the decrease of wall superheat, resulting in a lower axial boiling coefficient.
2. The fin efficiency may be positively impacted due to this decreasing heat transfer coefficient along the fin height but there will be an overriding negative impact of lower thermal conductivity of stainless steel, with the net result of a lower fin efficiency.
3. The assumption of constant heat transfer coefficient along the fin height, used for deriving the standard fin efficiency expression, will not be necessarily valid.

This paper examines these three effects in detail. It also shows that under a wide range of operating conditions the local boiling heat transfer coefficient for stainless steel will be actually higher than that for aluminium. The reasons for behavior, which is contradictory to the first effect described above, are explained and finally comparison of overall performance of aluminium and stainless steel plate-fin heatexchanger is described.