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DEVELOPMENT OF A FINITE ELEMENTS BASED ON SOFTWARE TOOL FOR THE GLOBAL THERMOMECHANICAL ANALYSIS OF PLATE-FIN HEAT EXCHANGERS

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ABSTRACT

The continuously need to optimize performances of heat exchangers (figure 1) constitutes one of the major objectives for Fives Cryo to develop their dedicated software tools. The constraints imposed by increasing design precision justify the need to develop adapted tools. Their aim is to bring better analysis of the thermal and mechanical behavior of the heat exchanger, on one hand according to a range of configurations (fins, bars and plates…), and on the other according to the imposed operating conditions (pressure up to 100 bar and temperature loads ranged between +100°C and -269°C).

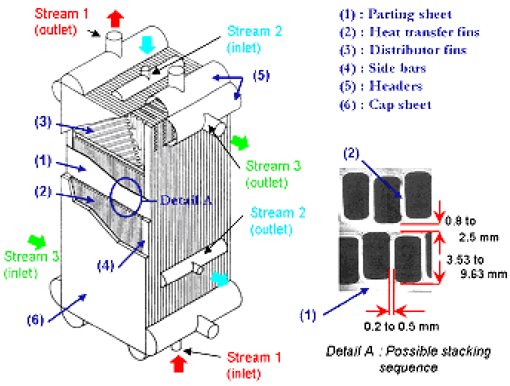

Figure 1: A typical multi-stream brazed aluminium plate-fin heat exchanger and its general description

In this paper we describe the work [1] of adapting and developing a software tool based on the linear thermomechanical FE modeling of the heat exchanger using homogenization techniques. Since a complete FEM model would lead to several millions of structural elements (solid), we propose a simplified 3D FEM model based on layer by layer homogenization techniques to obtain the equivalent (effective) stress-strain relations and thermal load vectors of the corrugated fins brazed with the parting sheets. So a methodology for modeling the heat exchanger constituted by stacking of sheets and different brazed fins with different orientations, pressure and temperature loading is adopted (figure 2). Since the stacking sequence is considered as aleatory, we seek to determine a characteristic range of the effective behaviour limited by a "rigid" and a "soft" medium behaviour which are respectively determined by a partially periodic mechanical approach (PPMH) and a partially periodic kinematical approach (PPKH). These techniques are based on classical Hill-Mandel [2] methods where periodicity and fins orientation in each layer is taken into consideration. Other classical techniques can be applied to the identical layer stacking (e.g. asymptotic method [3, 4]) where periodicity is considered in all directions. Then a practical implementation of these techniques is formulated in the aim of numerical resolution. Finally, homogenization techniques are applied to study the global loading due to the temperature and pressure internal loads.

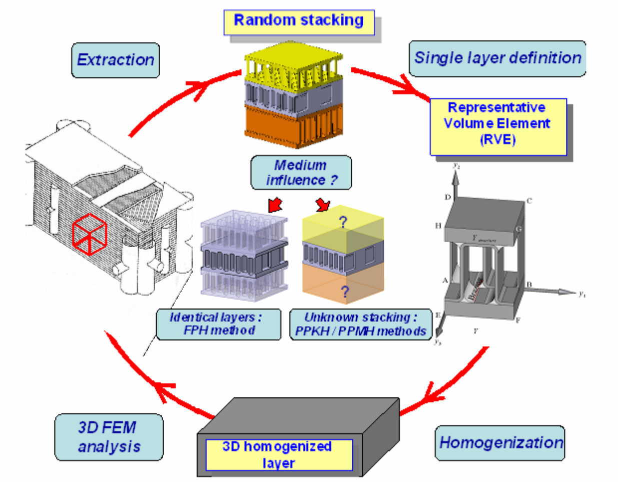

Figure 2: General homogenization approach for individual layer.

After the implementation of the adapted homogenization techniques, their numerical application and validation is discussed. A homogenization tool (HomPass) is thus developed in order to facilitate the numerical homogenization of the heat exchanger. That enables us to establish a library of elements having equivalent behaviors to each layer of brazed fins and sheets. This library can also include the elementary equivalent loadings in pressure and temperature. That contributes also to the development of the final software tool (SiTEME) dedicated to the global thermomechanical study of the heat exchanger. First results relating to the heat exchanger's core are then presented.

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