TRANSIENT CONVECTIVE HEAT AND MASS TRANSFER IN SINGLE AND TWO PHASE FLOW: APPLICATION TO CRYOGENIC HEAT EXCHANGERS

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Practical and technological applications are now currently associated with transient conditions of thermal components. For example, the importance of such phenomena can be observed in car air-conditioning systems. Robust and relatively simple models are needed to perform automatic control of passenger comfort.

An other example is in astronautics, where rockets are always subject to important transient conditions, throughout the flight. A good management of unsteady thermal fluxes is necessary from the materials point of view, and also for a good energy efficiency of the whole system.

From another point of view, the mechanisms of transient behaviour of thermal components and systems have to be assessed and precized in order to have good fundaments of the associated physics phenomenons. The main interest is the physical significance of the current notion of transient heat transfer coefficient at the interface between a fluid and a material, or in a more complete case, the physical significance of a global unsteady heat transfer coefficient between to fluids separated by a wall, particularly for two-phase flow system.

The first point of this study concerns a synthesis of the literature, particularly over the twenty last years (it appears that this subject is more developed during this period). In the whole set of papers[1-5] introduced during this period, a critical summary is done with twenty five papers, that seem the more powerful. The main observation, extract from this basis, is that there are two main kinds of approach:

1- The global one, more powerful for heat exchanger inserted in complex systems and processes. The corresponding models are robust and calculations are easy. Some recent papers are devoted to plate heat exchangers, that are now commonly used with a proved efficiency.

2- The local approach, less developed, is more physical and accurate. It could be very useful, for integration in big computer codes or specific application codes where the transient case are mostly excluded or neglected. In that cases, results are more devoted to pertinent design of the system for a specific transient use.

On the basis of the preceding synthesis, some general models are proposed, that can be applied to describe globally the transient conditions of evaporator and condenser. These new models take the phase change mechanisms into account; and can be useful for the previous applications, where a global system approach is needed for optimization consideration. A sensitivity analysis and validation relative to results found in literature will be reported in the following paper (models are presently available by the authors).

Following the synthesis of local approach results, a more fundamental approach is developed (part of the present thesis of C. Jacquot, in development now), to see and precise the pertinence of the local transient heat transfer coefficient. Limitations of this notion will be entlightened; also some comparison will be perform with numerical simulations using CFD code as Fluent. The reconsideration of the heat transfer coefficient notion is done essentially for the following cases:

- variable physical properties.
- turbulence flow conditions.
- phase change.
- wall influence.

It seems today that these four cases are the more determinant in order to certify or not the definition of a genaral transient heat transfer coefficient.

CONCLUSION

In conclusion, from the practical side, new transient global models, relative to evaporator and condenser, are proposed in the present communication. From the fundamental side, a reconsideration of the notion of transient local heat transfer coefficient has been developed including comparison with numerical and published results. Applications of these two sides, have been focused on transient conditions of a rocket engine (regenerative cooling system, in extremes conditions) with cryogenics fluids, as well as air conditionning systems.

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