Postdoctoral fellow
CETHIL (12 months)

Experimental characterization of high temperature heat pipes submitted to thermal shocks for molding application

OUMOUSS project, funded by the AURA Region

Context:

The thermal control of injection molds for metallic or polymer materials is an important challenge, since the temperature uniformity of the molded piece determine the quality of the final product. Furthermore, a decrease of the mold heating-up stage and of the molding cycle duration are required, to reduce costs and scrapping. The actual cooling techniques are based, amongst others, on water circulation as close as possible to the molding surface (figure 1). The use of a high water mass flow rate enables a very efficient cooling, but causes corrosion and fouling problems.

The objective of the OUMOUSS project is to develop an alternative cooling system, leading to suppress the water circuit or to remove it at the mold periphery. This system is based on the insertion of metallic foams, coupled to heat pipes, into the mold structure. Owing to the resulting weight reduction, this honeycomb structure allows the reduction of the mold thermal inertia. It may also act as a thermal dissipater towards a cooling medium circulating inside the foam. A heat pipe is a tight enclosure containing a two-phase fluid, which evaporates at the contact of a heat source and condenses at the contact of the heat sink. The fluid is circulated under the action of capillary or gravity forces, in a passive way. Thus, heat pipes could act as high conductive materials, able to transfer the heat very efficiently between the heat source (molding surface) and the heat sink (cooling medium), to improve the fin effect of the foam, or to uniformize the temperature of the molding surface. For polymer molding applications, the use of air as the cooling medium instead of water may be considered, what would involve a technological breakthrough.

To fulfill the objective of the project, several scientific questions have to be addressed. Amongst them, a better understanding of the behavior of heat pipes submitted to thermal shocks is strongly required. In molding applications, heat fluxes up to 500 kW/m² are currently encountered and the reduction of the mold thermal inertia would strongly increase this value. Another major challenge is to select the appropriate working fluid, which depends on the heat pipe wall material and on the operating temperature. The third challenge is to design a judicious heat pipe type, enabling to transfer the heat from the mold surface to the metallic foam. Thermosyphons, capillary heat pipes and pulsating heat pipes were considered but further studies are required to select the best configuration.

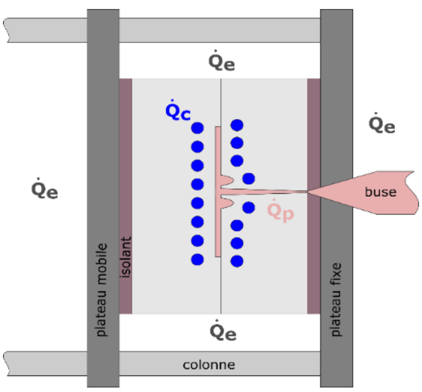

Figure 1: Schematic of a molding tool for polymers

Job description

The global objective of the postdoctoral work is to take in charge the various tasks of the project. Three specific test benches corresponding to the three scientific questions were already designed and manufactured in the first part of the project:

The first experimental mock-up consists in a piece of metallic foam equipped with embedded cylindrical heat pipes and submitted to representative operating conditions. The effect of various parameters - heat pipe dimensions, type of working fluid, of cooling medium, will be analyzed from the experimental results. The parameters required to simulate the thermal behavior of the complete mold equipped with the new cooling system will also be deduced from these results. The test bench can also be adapted to test mocks-up involving one or several pulsating heat pipes manufactured by 3D metallic printing.

The selection of the working fluid depends of the operating temperature of the application, on its thermal performance, and on the chemical compatibility with the materials of the heat pipe. An incompatibility would lead to non-condensable gases generation inside it, which would progressively hinder its correct operation. As the compatibility data are scarce in the literature, a second test bench has been developed, to study the chemical compatibility of various working fluids with the steel constituting the mold. Long-term tests will start under the supervision of the postdoctoral fellow.

The third test-bench consist of a IR laser enabling to provide fast transient thermal solicitations to a heat pipe. The thermal response of the latter is recorded by means of IR high speed camera. This innovative configuration will enable to provide useful information on the effect of thermal shocks on heat pipes, which is a topic that has been very scarcely studied in the literature.

The final design of the cooling system will result from the best trade-off between technological feasibility, thermal performance and mechanical strength, in close collaboration with the partners of the project (technical centers like IPC and CTIF, industrial companies like SANDEN) Due to the originality of the work, publications in scientific international journals and conferences are expected.

Profile

The candidates should have a PhD and have a strong experience on two-phase heat transfer phenomena. Good experimental skills are also preferred. Strong autonomy and adaptability are required to be able to deal and hierarchize the different tasks of the project.

Expected start date

Between March 2020 and September 2020

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