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Thermal optimization of polymer injection mould : Application of Conformal Cooling design

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ABSTRACT

Conventionally, mould manufacturing relies on experience and intuitions after numerous times of "trial and error". Thus, it often results in performance and economic burdens. Nowadays, thanks to the rapid development of computers, moulds can be designed through theoretical and numerical methods, and their results can be predicted or directly simulated through "mould flow packaged software", thus improving the cost effectiveness and product quality. Though "packaged software" used by the industry can rapidly solve the problem of mould design, it cannot effectively help engineers simplify the complexity and fuzziness of the system. Besides, the packaged software for simulation is, in fact, only capable of solving 60%~70% of the problems encountered in design. The "trial and error" part is unavoidable, and the lack of experience among engineers in design still becomes an influential variable.

This paper presents new technological opportunities to design relevant cooling systems for polymer moulding process (in particular polymer injection moulding). Usually, the design of cooling systems is neglected during the product development lifecycle. Emergency of new *rapid prototyping* technologies, such as *layer manufacturing* (LMT) or *direct metal laser sintering* (DMLS), offer new capabilities to design efficient mould cooling systems. First experimental works show encouraging results: cycle time reduction is about 10-20% with respect to traditional machining method. These new technologies allow to design cooling channels taking the shape of the cavity. This new design method is well-known as *conformal cooling* [1][2].

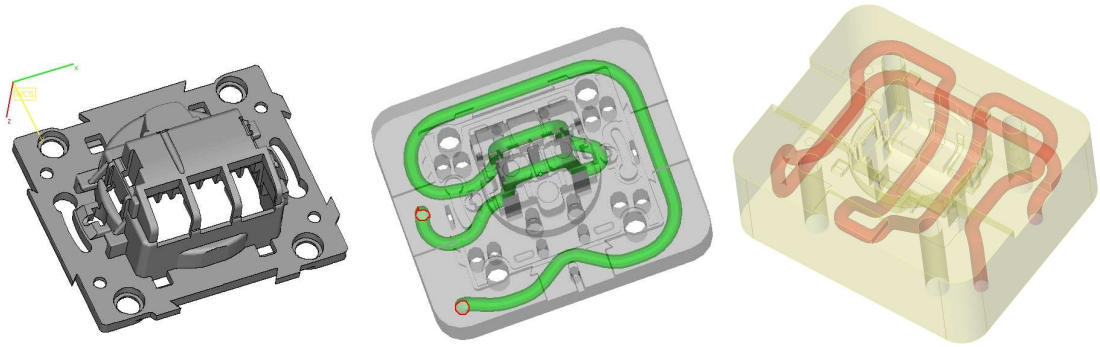

Figure 1 : Example of conformal cooling system– DMLS technology (courtesy of Legrand).

Now, the challenge we face with rapid prototyping technologies is to define the best practices to determine a relevant cooling system with respect to industrial constraints of product part development: performance, quality, cost reducing, time-to-market, and so on.

The presented methodology concerns the development of a new computer-aided tool based on two complementary numerical simulation approaches :

- *Direct numerical simulation of thermal properties governed by a well known experience and needs iterative process if optimal solution is wanted.*
- *Optimization method* based on *inverse problem*, constrained by quality product rules, in accordance to *conformal cooling surfaces calculation*.

First of all, the thermal inverse method provides optimal heat fluxes fitting with cooling objectives. The heat flux pattern is calculated on a large virtual domain initially defined around the cavity part.

In a second step, this inverse method is coupled with a topologic optimization method to reduce the computational domain to the required optimal conformal domain.

The last step consists in defining the best cooling system (cooling channels) based on the conformal surface characteristics. A new optimization problem is also required to perform the final cooling system design. This optimization problem is strongly constrained with industrial processing rules (geometry, cost, …).

This article described the first results obtained with respect to industrial use cases. The complementarities of direct and optimization approaches is shown. Best practices of conformal cooling methods are pointed out in order to fit with industrial objectives.

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