# Review on Plastic Moulding

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**Abstract**—*For making of plastic parts the injection moulding is mostly used. And is versatile for mass production of plastic parts. For determining the cycle time the cooling system is much important. A good cooling system design can reduce cycle time and achieve dimensional stability of the part. This paper describes a cooling channel system for injection moulding dies. Both simulation, optimization and experimental verification have been done with these new cooling channels system. An industrial part, a plastic bowel, with conventional cooling channels using the Moldflow simulation software for comparative parts. Experimental verification has been done for a test plastic part with mini injection moulding machine. Comparative results are based on temperature distribution on mould surface and cooling time or freezing time of the plastic part. The results provide a uniform temperature distribution with reduced freezing time and hence reduction in cycle time for the plastic part.*

***Keywords***—Conformal cooling channel, Cycle time Mouldflow, Square shape.

## 1.INTRODUCTION

Injection moulding is a widely used manufacturing process in the production of plastic parts [1]. The basic principle of injection moulding is that a solid polymer is molten and injected into a cavity inside a mould which is then cooled and the part is ejected from the machine. Therefore the main phases in an injection moulding process involve filling, cooling and ejection. The cost-effectiveness of the process is mainly dependent on the time spent on the moulding cycle in which the cooling phase is the most significant step. Time spent on cooling cycle determines the rate at which parts are produced. Since, in most modern industries, time and costs are strongly linked, the longer is the time to produce parts the more are the costs. A reduction in the time spent on cooling the part would drastically increase the production rate as well as reduce costs. So it is important to understand and optimize the heat transfer process within a typical moulding process. The rate of the heat exchange between the injected plastic and the mould is a decisive factor in the economical performance of an injection mould.

Heat has to be taken away from the plastic material until a stable state has been reached, which permits demolding. The time needed to accomplish this is called cooling time or freezing time of the part. Proper design of cooling system is necessary for optimum heat transfer process between the melted plastic material and the mould. Traditionally, this has been achieved by creating several straight holes inside the mould core and cavity and then forcing a cooling fluid (i.e. water) to circulate and conduct the excess heat away from the molten plastic. The methods used for producing these holes rely on the conventional machining process such as straight drilling, which is incapable of producing complicated contour-like channels or anything vaguely in 3D space.

## 2.INJECTION MOULDING PROCESS VARIABLES AND ARTIFICIAL INTELLIGENCE METHODS

According to Karbasi and Reiser, the injection molding process includes three nested process loops as shown in fig 1 . The first loop called machine control includes control of machine parameters, such as speed, pressure and temperature. The middle one (process control) includes such variables as in-mold temperature and pressure. The last loop, which is called set point control, takes care of part quality feedback.

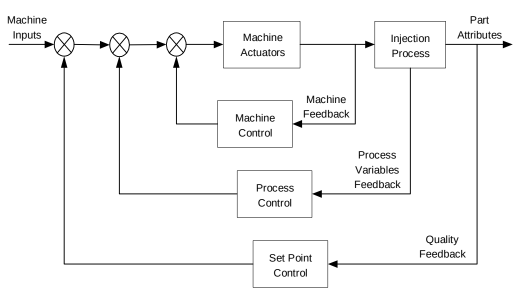


**Fig. 1** Injection molding control loops[1]

### 2.1. Artificial Intelligence Methods

According to Dang , there are two main groups of simulation-based optimization methods, which are direct discrete optimization and metamodel-based optimization methods. The methods and their short description , where GA stands for genetic algorithm, RSM for response surface methodology, RBF for radial basis function and ANN for artificial neural network. Of course, these are not all the simulation-based optimization methods used. Among others, in the metamodel-based methods group ANN is mentioned. This is one of the artificial intelligence methods that can be applied to build mathematical models of injection molding process with consideration of the most important parameters.

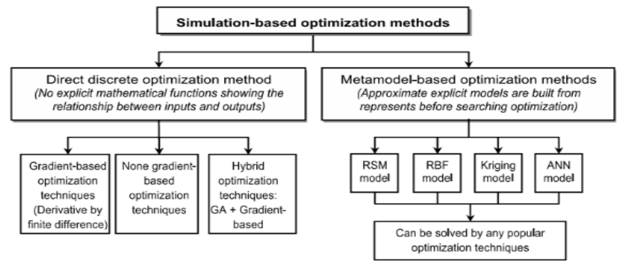


**Fig. 2**. Classification of optimization methods[1]

## 3. APPLICATION OF AI METHODS FOR THERMOPLASTICS INJECTION MOLDING

### 3.1. Heating And Cooling Systems

There are several techniques that can be applied to reduce time of the cooling stage of injection molding process and increase quality of a produced part. Conformal cooling/heating channels are one of them. They are "conforming" to the shape of the cavity in the mold making it possible to reduce part's temperature faster and more evenly. They allow coolant to access all part locations uniformly, making the process more efficient and consistent. However, they can also be used to increase temperature in the cavity, for example, during injection stage not to allow injected earlier plastics to cool down and solidify too early. This is important for increase of quality of injection molding of parts with very thick and very thin walls. Molds with such channels can be produced using direct metal sintering (additive manufacturing technique), as well as through vacuum diffusion bonding and liquid interface diffusion .

Kitayama et al. propose a framework for numerical and experimental examination of conformal cooling channels.

To asses cooling performance cycle time and warpage are considered. Melt temperature, injection time, packing pressure, packing time, cooling time, and cooling temperature are taken as the design variables. At first, a multi-objective optimization of the process parameters is performed, then the process parameters of the cooling channel are optimized. A sequential approximate optimization using a radial basis function network is used to identify a pareto-frontier. According to the model with optimized parameters, the conformal cooling channel is produced using additive manufacturing and the experiment is carried out to validate performance of the channel.

## 4. Conclusion

Quality issues are a common problem for injection molding process due to non-uniform temperature variation in the mold. During design of the molds for injection molding process, it is very difficult to achieve efficient cooling with uniform thermal distribution. It is attempted to be achieved through application of variotherm technology, as well as conformal cooling/heating channels. However, most of rapid heating and cooling systems are still difficult to apply in the mass production of plastic parts in injection molding industry due to extra complex heating setups, weak mechanical strength of the mold and lack of a standardized control option.

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