A Survey Approach of Optimization of Injection Moulding Process Parameter

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ABSTRACT

This review paper found the better optimization techniques which the effects degree of different moulding process parameters for shrinkage. The mold design can fasten the mold developing schedule, thus shorten the cycle of product development, and improve the quality of products and the competitive ability of enterprise. Injection molding is one of the most important and common plastic formation methods. Combination of modeling tools and optimization algorithms can be used in order to determine optimum process conditions for the injection molding of a special part. Using the trail and error approach parameters for injection moulding no longer good enough. So, this work research has been finding optimizations of processing parameters for robust parameter design. In this study has been taken Artificial neural network method for solving the problem which are give useful result.

Keywords: Injection moulding, optimization, Process parameter, ANN tool, Shrinkage.

I. INTRODUCTION

Plastics has become the fundamental drivers of innovations and new product development. Uses of plastics are intertwined in every part of our contemporary life style and have become indispensable; products made out of plastics range from sophisticated medical implants to disposable household implements. Intelligent and innovative use of plastics have opened up new avenues in the polymer-electronics sector; from organic light emitting diodes to electro-optical and bioelectrical complements, from low-cost plastics chips to flexible solar cells. Some of the plastics can conduct even electricity and emit light, leading to development of creative applications. Great popularity in use of plastics can be observed in automobiles and in a wide variety of industrial applications.

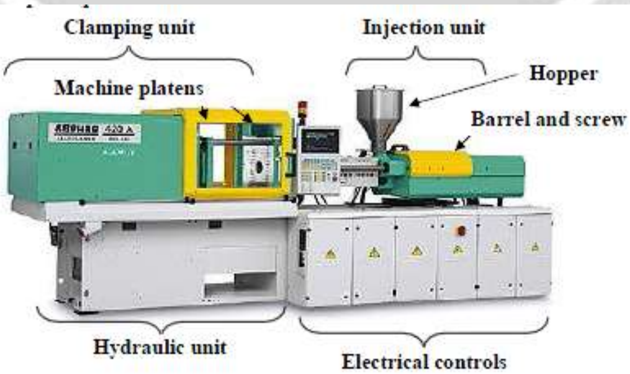

Fig 1. Injection Molding Process [2]

Injection Molding (IM) is considered the most prominent process for mass production of plastic parts. More than one third of all plastic products are made by injection molding, and over half of the world's polymer processing equipment's are used for the injection molding process [Osswald et al. 2002]. Injection molding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Its complexity and the enormous amount of process parameter manipulation during real time production create a very intense effort to maintain the process under control. Complexity and parameter manipulation may cause serious quality problems and high manufacturing costs [Cabrera et al. 2002].

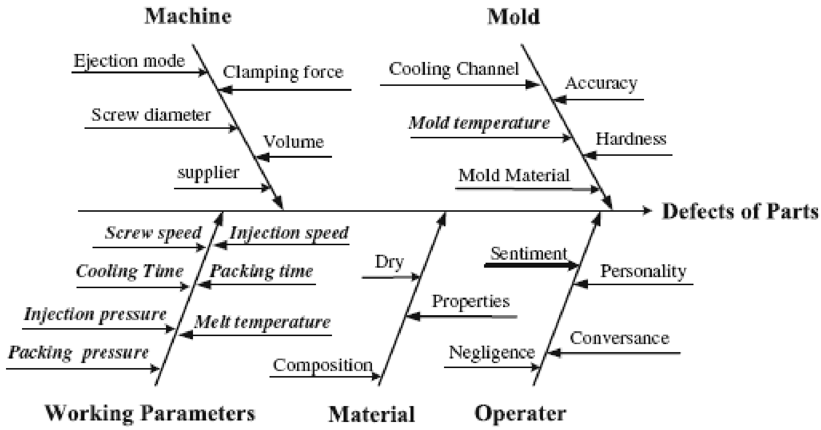

Fig 2. Cause-and-effect diagram shown in fishbone schematics [3]

II. LITERATURE SURVEY

The various literature survey detailed in below:

Chang and Tsaur (1995). Based on the rheological properties of polymers, an integrated theory and computer program was developed in this study for simulation of such behavior. Hybrid finite-element and finite-difference methods were employed for simulating the injection moulding filling, packing, and cooling processes. A control volume method was applied towards both finding the melt front position and also calculating the temperature and pressure profile at any instant during the filling process. A modified Tait equation provides a description of the pressure-volume-temperature relationship of crystalline polymers. The Malkin's kinetics model was employed to describe the behavior of polymer crystallization. The flow induced and thermal induced-residual stresses employed as the initial conditions in the solid mechanics analysis were obtained with the linear thermoviscoelastic model. The displacements, including the thickness direction of part, which could not be calculated by the traditional bending moment method, were solved by using the numerical solid mechanics analysis with the three-dimensional finite element methods. The theoretical results were also correlated using commercial FE flow simulation software. Though the integrated program was able to simulate shrinkage and warpage on moulded products, the sink simulation was not modelled conclusively.

Substantial numbers of research studies, using physical experiments, were made to understand the injection moulding process for various objectives. Some of which are meant to validate the FE flow simulations. Practical experimental studies on injection moulding process are prohibitively costly and time consuming. Complexity and cost increases, if one needs modification on moulds on a continuous basis to conduct any useful study. Hence, practical studies had rather limited scopes. However, few investigators conducted practical experimental studies for the study of sink marks.

Dan and Bistany (2000) investigated the possibility of reducing sinks with beryllium copper as mould material using laboratory level experiments. It was found that material with higher thermal conductivity aids in the reduction of sink.

Ernst et al (2003), An approach for design of mould elements like core and cavity inserts of the injection moulds was attempted by iteratively coupling structural analysis with FE flow simulations. The developed approach was reported to have resulted in quicker realization of the parts. Using suitable rheological data even new materials can be simulated in FE flow simulation packages.

Turng et al (2002), In spite of the virtual advantages of FE flow simulation, if one needs to understand a system from the standpoint of "input-output" relationships one may have to resort to computationally intensive trial and error iterations. To bridge the gap, few researchers attempted integration of FE simulation tool with some optimization routines. Few other researchers coupled DOE, Taguchi, Artificial Neural Network (ANN), fuzzy control, etc. with FE flow simulations.

Dubey et al (2005), a unique cooling control system was developed and implemented to control the plastic part average cavity temperature inside the mold cavity on plastic injection molding machine by utilizing coolant flow as the manipulated variable. An algorithm was developed to automatically conduct open loop experiments, perform system identification, controller tuning and perform control simulations. The tuning parameters were then downloaded to another controller for real time control of part cavity temperature. The PI controller demonstrated good performance for both control simulations and when implemented practically on machine. This approach can be readily applied on industrial machines and it creates the foundation for implementing more advanced control schemes such as model based predictive control and quadratic regulator types.

Erzurumlu and Ozcelik (2006), he objective of this paper consists of minimization of the warpage and sink index in terms of process parameters of the plastic parts have different rib cross-section types, and rib layout angle using Taguchi optimization method. Considering the process parameters such as mold temperature, melt temperature, packing pressure, in addition to rib cross-section types, and rib layout angle, a series of mold analyses are performed to exploite the warpage and sink index data. The polymeric materials were selected PC/ABS, POM, and PA66. Taguchi optimization method was used by exploiting mold analyses based on three level factorial design. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio, the analysis of variance (ANOVA) are utilized to find the optimal levels and the effect of process parameters on warpage and sink index. Confirmation analysis test with the optimal levels of process parameters are carried out in order to demonstrate the goodness of Taguchi method. From this, it can be concluded that Taguchi method is very suitable to solve the quality problem occurring the injection-molded thermoplastic parts.

Fang et al (2005), The response surface methodology (RSM), which typically uses quadratic polynomials, is predominantly used for metamodeling in crashworthiness optimization because of the high computational cost of vehicle crash simulations. Research shows, however, that RSM may not be suitable for modeling highly nonlinear responses that can often be found in impact related problems, especially when using limited quantity of response samples. The radial basis functions (RBF) have been shown to be promising for highly nonlinear problems, but no application to crashworthiness problems has been found in the literature. In this study, metamodels by RSM and RBF are used for multiobjective optimization of a vehicle body in frontal collision, with validations by finite element simulations using the full-scale vehicle model. The results show that RSM is able to produce good approximation models for energy absorption, and the model appropriateness can be well predicted by ANOVA. However, in the case of peak acceleration, RBF is found to generate better models than RSM based on the same number of response samples, with the multiquadric function identified to be the most stable RBF. Although RBF models are computationally more expensive, the optimization results of RBF models are found to be more accurate.

Pujari and Naik (2015), in the present study, the simulation for optimization of plastics injection molding processing parameters Based on The Minimization of Sink Marks have been performed by Taguchi method & Moldflow software. The following conclusions were obtained.
(1) The simulation considering the sequence of effects degree of different molding process parameters for surface sink marks ranked in the holding pressure; melt temperature, cooling time and injection pressure. The holding pressure is the most important effect.
(2) The optimized parameter combinations of different factors are considered as melt temp 235°c; injection pressure 80 bar; holding pressure 55 bar & cooling time 50 sec, and its sink marks index is 2.674, which is the best data compared with other parameter combinations.

Meiabadi et al (2013), he purpose of this research was to obtain the process parameters that ensure the accurate part weight, less process cycle time, and injection pressure. The research results indicate that the proposed approach can effectively help engineers determine optimal process parameters setting and achieve competitive advantages of product quality and costs. The efficiency of the method depends on the selection of appropriate process parameters, process parameter ranges and accuracy of Moldflow simulations and neural network predictions. In this study, the process parameters were determined within constraints of machine tools and mold steel. Thus, some parameters could not be considered as the parameters for optimizing the injection process. Because of the fixed mold constraint, the gate location and coolant point could not change their locations. For future study, the researcher should perform the experiments using this methodology before producing new products and its mold.

Bharti and Khan (2010), his article presents a review of research in the determination of the process parameters for injection molding. A number of research works based on various approaches including mathematical model, Taguchi technique, Artificial Neural Networks (ANN), Fuzzy logic, Case Based Reasoning (CBR), Genetic Algorithms (GA), Finite Element Method(FEM), Non-Linear Modeling, Response Surface Methodology, Linear Regression Analysis, Grey Rational Analysis and Principle Component Analysis using cavity pressure signals have been described. A review of literature on optimization techniques has revealed that there are, in particular, successful industrial applications of design of experiment-based approaches for optimal settings of process variables. Taguchi methods and response surface methodology are robust design techniques widely used in industries for making the product/process insensitive to any uncontrollable factors such as environmental variables. Taguchi approach has potential for savings in experimental time and cost on product or process development and quality improvement. There is general agreement that off-line experiments during product or process design stage are of great value. Reducing quality loss by designing the products and processes to be insensitive to variation in noise variables is a novel concept to statisticians and quality engineers.

ANN, GA, and CBR are emerging as the new approaches in the determination of the process parameters for injection molding. A trained neural network system can quickly provide a set of molding parameters according to the results of the predicted quality of molded parts. However, the time required in the training and retraining for a neural network could be very long. By using GA approach, the system can locally optimize the molding parameters even without the knowledge about the process. In practical use, the convergence rate to an optimal set of process parameters could be very slow in some occasion. CBR systems can determine a set of initial process parameters for injection molding quickly based on the similar case(s) without relying heavily on the expert molding personnel.

III. CONCLUSION

The study was focused on the application of the ANN optimization techniques to find the optimum levels and response of injection moulding plastic components. Injection molding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. By using this method, it can optimize the process parameters and achieving the minimum shrinkage, which improve the quality and overall in production. Artificial neural networks (ANNs) are defined as mathematical models which represent the biological process of a human brain. There are three main components in the ANNs; neurons or processing elements (PE), interconnections, and learning rules.

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