Review Article

OPTIMIZATION FOR PLASTIC INJECTION MOLDING PROCESS PARAMETERS

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1. INTRODUCTION:

Injection molding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Faced with global competition in injection molding industry, using the trialand-error approach to determine the process parameters for injection molding is no longer good enough. Factors that affect the quality of a molded part can be classified into four categories: part design, mold design, machine performance and processing conditions. The part and mold design are assumed as established and fixed. During production, quality characteristics may deviate due to drifting or shifting of processing conditions caused by machine wear, environmental change or operator fatigue.

Determining optimal process parameter settings critically influences productivity, quality, and cost of production in the plastic injection molding (PIM) industry. Previously, production engineers used either trial-and-error method to determine optimal process parameter settings for PIM. However, this method is unsuitable in present PIM because of the increasing complexity of product design and the requirement of multi-response quality characteristics.

PROBLEM DEFINITION:

"The production of injection molded parts is a complex process where, without the right combination of material, part and mold design and processing parameters, a multitude of manufacturing defects can occur, thus incurring high costs. The injection molding process itself is a complex mix of time, temperature and pressure variables with a multitude of manufacturing defects that can occur without the right combination of processing parameters and design components. Determining optimal initial process parameter settings critically influences productivity, quality, and costs of production in the plastic injection molding (PIM) industry.

Till date, most production engineers have been using trial-and-error method to determine initial settings for a number of parameters, including melt temperature, injection pressure, injection velocity, injection time, packing pressure, packing time, cooling temperature, and cooling time which depend on the engineers' experience and intuition to determine initial process parameter settings. However, the trial-and-error process is costly and time consuming.

The problem for the proposed work is to discern the optimal values for the injection molding parameters such that any new component to be introduced for production could be taken up with ease through the trial and testing and later through the pilot production phase once we could establish the category that it belongs to - i.e. Material type and the Size. The reference chart so evolved during the dissertation work would prove handy while deliberating over the actual process/ production plan for any newly introduced component"

PRESENT THEORIES AND PRACTICES

Kamaruddin, Zahid A. Khan and S. H. Foong [1] has optimized the injection molding process parameters such as injection speed, injection pressure, holding pressure, melting temperature, holding time, cooling time using the Taguchi method. For improve the quality characteristic (shrinkage) of an injection molding product.

N.A.Shuaib, M.F. Ghazali, Z. Shay full, M.Z.M. Zain, and S.M. Nasir [2] has performed research to determine the factors that contribute to warpage for a thin shallow injection-molded part. The factors that been taking into considerations includes the mold temperature, melt temperature, filling time, packing pressure and packing time. The process is performed by simulation and experimental method by Taguchi and ANOVA technique are employed**.** Packing time has been identified to be the most significant factors on affecting the warpage on thin shallow part.

Tao c. Chang and Ernest Faison [3] has applied the Taguchi method to systematically identify the significance of seven injection parameters and their effects on the appearance (width) of weld lines. The contributions of each factor to the quality and the optimum condition were identified. The optimal condition for weld line appearance was experimentally verified.

K. R. Jamaludina, N. Muhamad, M. N. Ab. Rahman, S. Y. M. Amin, Murtadhahadi, M. H. Ismail [4] has optimized injection molding parameters for the highest green strength of the metal powder mixture using Taguchi orthogonal array. Parameters optimized are the injection pressure, injection temperature, powder loading, mold temperature, holding pressure and injection rate.

Zhao Longzhi1, Chen Binghui1, Li Jianyun, Zhang Shangbing [5] has analyzed multi-molding process parameters by the combination of orthogonal experiments and Mold flow simulation tests.

Wen-Chin Chen, Gong-Loung Fu, Pei-Hao Tai, Wei-Jaw Deng, Yang-Chih [6] has used Taguchi's parameter design methods with back-propagation neural networks, genetic algorithms, and engineering optimization concepts, to optimize the initial process settings of plastic injection molding equipment.

Velia Garc´ıa Loera, José M. Castro, Jesus Mireles Diaz, O´ scar L. Chaco´n Mondragon [7] has done study to set the process variables in a thermoplastic injection molding operation in considering multiple criteria in a simultaneous manner. The task has approached through the application of an optimization strategy based on data envelopment analysis (DEA).

Wen-ChinChen Tung-Tsan Lai, Gong-Loung Fu [8] has applied, Taguchi method, back-propagation neural networks (BPNN), and Genetic algorithms

(GA) to the problem of process parameter settings for Multiple-Input Single-Output (MISO) Plastic injection molding.

Yanwei1 Huyong [9] has combined the orthogonal experiment with CAD/CAE technique to optimize the injection molding process plan.

A. H. Ahmad, Z. Leman, M. A. Azmir1, K. F. Muhamad1, W.S.W. Harun1, A. Juliawati1, A.B.S. Alias [10] has analyzed the warpage defect on Acrylonitrile Butadiene Styrene (ABS). The approach was based on Taguchi's Method and Analysis of Variance (ANOVA) to optimize the processing parameters namely packing pressure, mould temperature, melt temperature and packing time for effective process.

The phenomenon of `Shrinkage' of the plasticized material while cooling leads to allied molding defects like warpage, sink marks along with the need to have a higher draft on the walls of the mold. Uneven shrinkage (due to uneven cooling / uneven sections) leads to warpage and sink marks. At present, the shrinkage is known for every variant of the plastic material with or without fillers. `Packing' is normally employed as a counter remedy for shrinkage. Though, there exists a solution, there is no defined method for arriving at the molding parameters that should be controlled for a certain variety of plastic and a certain configuration of a component. Development of injection molded component with focus over the molding parameters like melt temperature, injection pressure, injection velocity, injection time, packing pressure, packing time, cooling temperature, and cooling time to optimize the development cycle for the component.

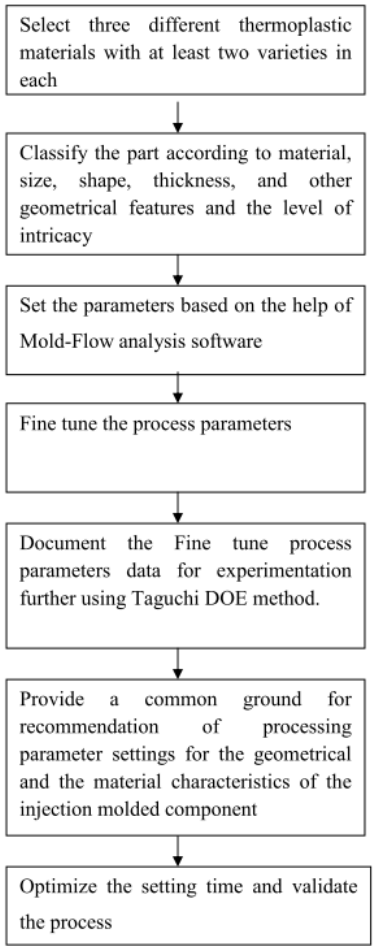
Current industrial practice: Customized approach based on experience for setting parameters.

SCOPE OF THE WORK:

- Study the injection molding process parameters for three different thermoplastic materials with at least two varieties in each.
- Develop a methodology to produce defects free parts by controlling the initial process parameters settings (like melt temperature, injection pressure, injection velocity, injection time, packing pressure, packing time, cooling temperature, cooling time, etc). Identify the critical parameters that need the longest time for iteration for study.
- The objective is to help to provide a common ground for recommendation of processing parameters settings according to geometrical and the material characteristics of the injection molded component.
- Optimize the setting time as a result.

SEQUENCE OF ACTIVITY/ FLOW CHART

- Select three different thermoplastic materials with at least two varieties in each of injection molded parts for study for the process parameters.
- While selecting, classify the parts according to material, size, shape, thickness, and other geometrical features and the level of intricacy
- Set the injection molded component parameters based on the help of Mold-Flow analysis software.
- Fine tune the process parameters for the injection molded component which can be considered for evaluation and observe the trend while setting each process.
- Document the Fine tune injection molded component process parameters data for experimentation further using Taguchi DOE method.
- Provide a common ground for recommendation of processing parameter settings according to geometrical and the material characteristics of the injection molded component.
- Optimize the setting time for injection molded component and validate the process.



EXPERIMENTATION:

The experimentation will be carried out over a suitable molding machine based on the tonnage requirement for the subject components. The mold should be functional and the study should be carried out for current parts under production. Materials to be included in the study would be thermo-plastic materials. Document the data for research and analysis further using DOE. Taguchi optimization method will used to evaluate best possible combination of the injection molding process parameters like melt temperature, injection pressure, injection velocity, injection time, packing pressure, packing time, cooling temperature, cooling time.

VALIDATION:

The process chart standardized with the values for the process variables will be validated for the upcoming automotive components that are awaiting pilot run of production. The process would be repeated for the variants to ensure consistency in the physical characteristics of the component produced. Validation will be carried out by bring out actual development of two components. Trials and testing would address the phase of validation as the mould would be tried out for checking the nature of the physical components as an outcome of the development process.

SOFTWARE:

Mold-Flow/ Moldex/ Pro-E Mold Advisor:

The use of this software would highlight the recommended values of the parameters for Injection Molding for the specified component design.

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