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"A REVIEW ON INVESTIGATION OF WORKING RANGES AND LEVELS OF PROCESS PARAMETERS OF INJECTION MOLDING PROCESS ON POLYPROPYLENE COMPONENTS BY USING OPTIMIZATION TECHNIQUES"

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ABSTRACT

This paper focuses on the overview of the importance of Injection molding machine, its parameters of the Injection molding, desirable properties of plastic material, mechanical behaviours of plastic materials, its influencing factors. The advantage of this process over metallurgical and nonmetallic manufacturing processes is that no additional finishing is required. It is also essential that this process can produce a complex geometric plastic product at itself. It is an automated process for the production of plastic products. Due to the growing demand for high-quality plastic products (in the context of high mechanical properties and dimensional geometry), the injection molding process should complete the changes according to the product requirements, which is possible when the operator can control parameters during the manufacturing process. To satisfy the content of quality plastic products, the configuration of the part to be prepared for manufacturing must be completed.

Key Words: *Desirability Function, Injection Moulding process, Tensile strength.*

I. INTRODUCTION

The injection molding process is the most versatile process for the manufacturing of complex plastic products and also more demanding because it can efficiently process the complex geometry of the products. However, injection molding operations can sometimes challenge the mold designer to design a mold that produces low-defect products because plastics are easily usable without such type of defects Warpage, shrinkage, weld lines, and air traps **(Saman et al. [2009])**. Also, Molding materials having different thermal properties that affect the mechanical properties of plastic parts during the injection molding process. Materials like steel, aluminium, etc. can be used for making the mold, but the aluminium mold has advantages in terms of weight, heat transfer and low production costs **(Ozcelik et al. [2010])**. The design of plastic molds is not only an essential process in the commonly used manufacturing process but also essential to control parameters to make defect-free products. The molding process of the hot injection material is allowed to freeze inside the mold. The solidified product of the net shape is thrown out of the mold when it is opened. Although this process is simple, due to many processing variables, predicting the quality of the final part is a complex phenomenon **(Mathivanan et al. [2010])**. As a result, the process of improvement and testing in the study parameters to optimize the injection molding process that can be implemented in the process. The need for a process of optimization is necessary for a broad sense. The manufacturing process of plastic parts presents discrepancies due to misinformation and lack of knowledge.

The main requirement is to check and to prevent the risks associated with the production of plastic products during the processing itself. The variation of the injection molding process should be such that the correct position of the response

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is within the range to be diagnosed then the empirically based predictive model approach is the most suitable solution for the injection molding process. For such type problems experimenter designed through different approaches like full factorial design, fractional factorial design, response surface method, Taguchi approach, etc. Out of which Taguchi approach design is performed due to its less no of experiments, which leads to reduce the time, the cost associated with it.

II. Literature Review

This review of literature of the plastic Injection molding process primarily related to the processing of plastic material inside the mold, optimization of injection molding process parameters, weight assignment methods for responses of the injection molding process. Apart from this focus of the survey is based on self-mixing and blending of material.

2.1 Process parameters optimization and simulation methods

The quality of the part depends on the processing area of the injection molding process and the processing conditions (discussed in section 2.1).

The processing condition of injection process depends on process parameters, such as temperature, time, pressure and environmental factors, which affect the response of the injection molding process, namely dimensional defects, mechanical properties and the cycle times for the production of the product. There has been a significant change over from the traditional injection molding process to the gas injection molding process, in terms of size, shape, and approach **(Guo et.al.[2014]).** Since the machine is properly inspected by inspection from time to time. However, a partial quality of the product remains necessary. Due to many hidden reasons, variation in physical properties (such as regrind resins are used), changes in ambient environment (e.g., humidity or temperature in the shop), and characteristics of the machine (especially using hydraulic power) occurs, the conditions of the procedure is re-read to reduce the quality of the part within the tolerance limit. Using specific control technologies to address the above problems and automated and adaptive quality control, various researchers have conducted an extensive research over the past two decades on appropriate process control systems. It is difficult to develop a possible control strategy without the full understanding of the relation and dependency between those variables **(Chen and Tung [2005]).**

The effect of the parameters on the response is also the specific task to find the optimal location of the solution. If the molten temperature is too high, then the need for injection pressure should be high. The content of degradable material has a high melting temperature. If the pressure of the injection can be very low, there may be a short shot and much flash inside the material **(Mok et. al.[1999]).** So to reduce defects the interaction between the melting temperature and the injection pressure is higher than the interaction between holding pressure and injection pressure **(Kamaruddin et. al.[2010]).**

The temperature of the melting temperature of the barrel, the temperature of the mold and the cooling temperature of the mold inside the material, pressure like injection, pressure of packing, time, time of cooling, packing time, injection time and environment such as injection, Example of parameters factors air current, humidity, temperature is considerable factor (**Parey, A. et al. [2007]).** The condition of the product depends on the process parameters. Based on the conditions of the injection molding process parameters, various researchers have been carried out using various adaptation techniques **(Pandey and Panda [2014]).** Various techniques are developed for such types of problems, which provide the best process areas for product development with the help of process parameters. Depending on its characteristics, advantages, disadvantages, and scope of the optimization approaches such as response surface model, bringing model, artificial neural network, genetic algorithm, and the previous researchers have addressed hybrid approach **(Singh, S. et al. [2013]**). Numerical optimization techniques can be classified according to the method of improving the design point after each iteration step; there are three types of optimization techniques: non-gradient-based, gradient-based and hybrid optimization techniques. It can be briefly described as follows:

The non-gradient-based optimization technique does not require an objective function, f (x); it can be isolated because the algorithms do not use derivatives off (x). Examples of non-gradient-based optimization techniques are adaptive simulated annealing, Hooke-Jeeves direct search, and genetic algorithm. These optimization techniques are meant to reach a globally optimal, but a large number of function evaluations are required. Example genetic algorithm is a well-known non-gradient based optimization technique, which is a stochastic search or optimization algorithm which imitates Darwin's biological theory of evolution **Saurabh Kumar Gupta et al. [2014]**.

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The gradient-based technique defines search directions by the gradient of the function at the current point. Example there are many kinds of gradient-based optimization techniques such as generalized reduced gradient, conjugate gradient, method of feasible directions, mix integer optimization, sequential linear programming, sequential quadratic programming, and Davidson–Fletcher–Powell. Gradient-based techniques, in general, allow for rapid convergence, but if the number of variables increases, it may be necessary to run them for long hours **(Srinivas and Vijayaraghavan et al. [2013]).**
Gradient-based techniques can also be a risk of local extremes for high nonlinear optimization problems. Hybrid optimization technique uses a combination of gradient-based and gradient-based technique to reduce the loss of single optimization technique problems. However, optimization methods based on simulation can divided into two categories of methods:
(1) Direct optimization methods
(2) Metamodel-based optimization methods
Direct optimization methods cannot define the relation between input and output variables. Such as Gradient-Based Optimization Techniques, Non-Gradient Based Optimization Techniques, and Hybridization-Based Optimization Techniques. Metamodel and hybrid model based optimization can detect optimal space by selecting a suitable model which establishes the connection between input and output variables **(Dang, X. P. [2014]**).

It is necessary to see the online and offline quality control of the injection molding process; the process can be controlled by the control of process parameters by the online artificial intelligence optimization methods and offline methods for cost minimization. Thus the objective is to improve the manufacturing process and quality of a product. For this, various researchers study of adaptation methods by considering the response as a dimensional defect, mechanical properties and cycle times of the process of construction by injection molding. In this section, the researcher's research has been classified, based on the methods and reaction behaviour of the study process.

2.1.1 Study based on Taguchi's Method

Ramesh et al. [2015] examined the sink marks, weld lines responses with the help of mold temperature, melt temperature, nozzle temperature and injection pressure as process parameters to study the headlight of the car as the product with the help of Taguchi's method. The study concludes that the clear light of the headlight can be control by nozzle temperature should be much less than the melt temperature to avoid the sink marks and vulnerability of the weld lines.

Mathivanan et al. [2010] present Sink marks depth as response study with the help of melt temperature, mold temperature, packing pressure, packing time, Rib to wall ratio, Rib to gate system and injection time with the help of Taguchi's experimental method. Sink marks depth can be minimized by minimizing Rib distance from the feed point.

Erzurumlu and Ozcelik [2006] studied the Warpage and sink marks responses with the help of rib cross-section, rib layout angle, melt temperature, mold temperature and packing pressure with the help of Taguchi's method. The study aim is to compare the Warpage and sink marks depth effect on different plastic materials PolyCarbonate/ Acrylonitrile butadiene styrene, Polyoxymethylene, Nylon-66. Based on the resulting warpage is found to be minimum in the PolyCarbonate/ Acrylonitrile butadiene styrene and sink index is found to be minimum Nylon-66.

Ozcelik et al. [2010] experimentally analyze tensile strength, Impact strength as the response of plastic material Acrylonitrile–Butadiene–Styrene by considering melt temperature, injection pressure, packing pressure and packing time as the process parameters. In their study of the experiment, they found that as packing pressure increases the tensile strength of material increased. In their study of the experiment, they found that as packing pressure improved the tensile strength of a material is increased.

Tsai et al. [2009] investigated light transmission, surface waviness and surface finish on the optical quality of lenses as the response by considering melt temperature, mold temperature, injection pressure, packing pressure as process parameters. In their studies, they found that injection pressure influenced responses. **Galantucci and Spina [2003]**

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analyze Warpage dimensional defect as a response of plastic products with the help of process parameters melt temperature, packing pressure and injection time by Taguchi's method. In their studies, they conclude that as the melt temperature rises, the warpage is less in plastic products.

Karasu et al. [2014] investigated Warpage as the response by considering melt temperature, mold temperature and packing time. Their study shows that Taguchi's method has advantages over other methods by considering the time and cost of the product manufacturing process.

Song et al. [2007] experimentally analyze warpage and filling condition as a response of process of a product with the help of Metering size, Part thickness, melt temperature, injection pressure, injection velocity process parameters by Taguchi's method. In their study, they concluded that for the molding of plastic parts with ultrafine walls, the thickness is the determining parameter.

Ghazali et al. [2011] investigated the warpage as response with the help of melt temperature, packing pressure, packing time, filling time by Taguchi's method on Nylon 66 plastic material production process manufacturing. In their study, they found that as melt temperature and packing time increases warpage get minimized in nylon 66 plastic products.

Liu and Chen [2004] experimentally analyze warpage response with the help of Short-shot size, water pressure, water temperature, and water injection delay time, melt temperature, mold temperature and holding time as process parameters with the help of Taguchi's method on Glass-fiber filled polypropylene composites. In their study, they note that as the melting temperature increases, warpage is minimized in polypropylene composite products. **Ahmad et al. [2009]** investigated warpage as the response by considering melt temperature, mold temperature, packing pressure, packing time on Acrylonitrile butadiene styrene plastic material product with the help of Taguchi's method. In their study, they find that melt temperature and mold temperature influential factor for control warpage of Acrylonitrile butadiene styrene plastic products.

2.1.2 Study based on Response surface method

Hazwan et al. [2017] examine the Warpage as the response by considering melt temperature, packing pressure, cooling time, coolant temperature as process parameters with the help of rotatable central composite design response surface method. In their analysis, they find that cooling temperature is the most effective factor, which affects the dimensional defect warpage.

Villarreal-Marroquín et al. [2011] investigate shrinkage and cycle time as response with the help of melt temperature, packing pressure with the help of Center composite design and Latin Hypercube design of response surface method. In their analysis, they find that melt temperature contribute significantly in cycle time and shrinkage.

2.1.3 Study based on different hybridization methods

Yin et al. [2011] inspect Warpage and clamp force as the combined response by considering melt temperature, mold temperature, packing pressure, packing time, cooling time as process parameters with the help of Backpropagation and Genetic algorithm method. In their research, they find that as packing pressure increases, the Warpage gets reduced and the clamping force needs more to keep the material in the mold.

Mehat et al. [2012] evaluate the shrinkage defect with the help of melt temperature, packing pressure, packing time, cooling time as process parameters with the help of Taguchi's method coupled with GRA. The melt temperature in their study is the most effective processing parameter.

Chen et al. [2008] surveyed on the product weight as response with the help of injection velocity, injection time, packing pressure as process parameters. In their studies, they find that packing pressure is a critical contributing factor

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to the increase in product weight.
Xu et al. [2015] examine the effect of Warpage as response with the help of melt temperature, mold temperature, injection velocity on the Polycarbonate plastic material by Artificial neural network and particle swarm optimization methods. In the study, they find that the melt temperature contributes a lot to the Warpage.

Gao and Wang [2009] explore study Warpage as response with the help of melt temperature, mold temperature, injection time, packing time, packing pressure by Kriging surrogate model combining the design of experiment methods. In the study, they find that the melt temperature is an effective factor for the warping of plastic products.

Chen et al. [2009] evaluate warpage as response with the help of melt temperature, injection pressure, packing pressure as process parameters by Taguchi's method coupled with desirability function. Melt temperature and filling/packing pressure found in both simulations and experiments, with the most critical factors being detected.

III. CONCLUSION

Since there are many studies have been done in the polypropylene plastic components materials, but a majority of researchers focused on the limited number of process parameters on the responses of an injection molding process, but none of them represented an optimization of input process parameters and factors with the advance hybridization techniques. The research on polypropylene plastic components manufacturing has never been attempted by the researchers with the help of advanced hybridization techniques like Taguchi with desirability function.

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