OPTIMIZATION OF CRITICAL PROCESSING PARAMETERS FOR PLASTIC INJECTION MOLDING FOR ENHANCED PRODUCTIVITY AND REDUCED TIME FOR DEVELOPMENT

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ABSTRACT

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. Up to now, most production engineers have used 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 method for finding the optimized solution would involve use of Flow analysis software like Mold-Flow. The use of this software would highlight the recommended values of the parameters for Injection Molding for the specified component design. Defect prevention coupled with minimum cycle time results in optimization of the process.

Mold-flow software offers simulation of the melt during passage through the Mold. The design features like the gate, vent holes, draft, etc too can be improved through the interface. A real time analysis of the flow helps to identify the problem areas and depicts the results while the parameters are manipulated for effecting better results.

- Set the parameters based on historical data and experience.
- Fine tune the process parameters for the component which can be considered for evaluation and observe the trend while setting each process.
- Document the data for research and analysis further using DOE (Taguchi Method/Minitab).
- Derive a standard based on the material and the configuration.
- Optimize the setting time and validate the process Injection Molding Machine Sectional view.
• Document the data for research and analysis further using DOE (Taguchi Method/Minitab).
• Derive a standard based on the material and the configuration.

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 trial and-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.

OBJECTIVES OF THE WORK

• Identify optimized levels for each factor for the processing
• Provide for a reference chart for thermoplastic material – Poly Propylene (PP) for setting the levels for each Factor
• Reduce the development time for the current process while reducing the number of defects

PROPOSED 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.
• Optimize the setting time as a result.

2. LITERATURE REVIEW

1. Author name is Tuncay Erzurumlu, Babur Ozcelik, paper name is “Minimization of warpage and sink index in injection-molded thermoplastic parts using Taguchi optimization method.” The objective of this paper consist 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. A number of mold analyses consisting of 243 trails based on a full factorial, three level, design were conducted to collect the warpage and sink index data obtained from mold analyses.
2. Author Name L.M. Galantucci, R. Spina paper name is Evaluation of filling conditions of injection moulding by integrating numerical simulations and experimental tests. Through data integration between FEA and the Design of experiment approach, the parts with complex geometries was studied to optimize injection process parameters improve the product quality. Using the FE
system, a deeper investigation of stress and strain distributions can be performed to predict defect presence in the final product.

3. **Author name** Keun Park a,*, Jong-Ho Ahn b  
**paper name** is “Design of experiment considering two-way interactions and its application to injection molding processes with numerical analysis” The optimal design for injection molding processes is sought by using the design of experiment (DOE) and numerical analysis. The proposed approach has been applied to the injection molding process of a deflection yoke, a precision electrical part with high geometric complexity.

4. **Author name** Kevin Alam, Musa R. Kamal  
**paper name** is “A robust optimization of injection molding runner balancing” A general methodology to robust process optimization that incorporated several innovative strategies was developed and applied to the injection molding runner balancing problem. The key parameter was the diameter ratio between the secondary runners furthest from the injection point. Optimizations that varied the runner lengths in addition to their diameters significantly reduced the volume needed to balance a robust runner system, when compared to the results of optimizations.

5. **V.N. Gaitonde a,*, S.R. Karnik b, J. Paulo Davim c**  
**paper name** is “Taguchi multiple-performance characteristics optimization in drilling of medium density fiberboard (MDF) to minimize delimitation using utility concept” This paper presents the methodology of Taguchi optimization method for simultaneous minimization of delimitation factor at entry and exit of the holes in drilling of SUPERPANMDF panel. In this study, the effects of feed rate and cutting speed on multiple-performance characteristics were investigated statistically.

**CFD-based predictive control of melt temperature in plastic injection molding.** The methodology is based on using CFD to generate, via open-loop testing, a temperature and input dependent system model for multi-variable control of a three-heater barrel on an injection molding machine. This paper demonstrates the use of transient CFD simulations to develop a dynamic process model required in model predictive control based on expected process set-point changes in melt temperature.

4. **SCOPE OF THE WORK**

- Study the injection molding process parameters for thermoplastic material Poly Propylene
- Develop a methodology to produce defects free parts by controlling the initial process parameters settings (namely - melt temperature, injection pressure, packing pressure).
- Identify the critical parameters that need the longest time for iteration for study.
- Provide a common ground for recommendation of processing parameters settings according to geometrical and the material characteristics of the injection molded component.

**METHODOLOGY**

- Select a popular variety of Poly Propylene (PP) for injection molded parts for studying the process parameters.
- Classify the parts according to size and shape
- Conduct trial while setting the process parameters with levels determined through historic data
- Using Taguchi method for DOE, document and analyze the data for experimentation
- Optimize the levels for each factor
- Apply the optimized levels to a new component for validation
EXPERIMENTATION

L&T Demag Plastic Injection Molding machine with a capacity of 40Ton to be used for the experimentation. Upon completion of mold development, the mold to be installed over the machine for trials. Suitable setting values (levels) to be selected for the parameters of processing based on the DOE result. Optimization to be carried out till the defects are minimized. Visual inspection of the components can be done during the settings.

VALIDATION

Comparison over the optimized levels achieved through DOE (Taguchi Methods) with the samples achieved during the physical experiments shall be done using visual aids (Magnifier/Microscope). A good match over the results by each methodology would suggest the thesis work as validated. Typically, an error or difference of about 15~20% for such studies can be accommodated.

REFERENCES

3. Processing Parameter Optimization For Injection Moulding Products In Agricultural Equipment Based On Orthogonal Experiment And Analysis Yanwei1 Huyong IEEE 2011 PP 560-564.
5. Optimization of Plastics Injection Molding Processing Parameters Based on the Minimization of Sink Marks Zhao Longzhi1, Chen Binghui1, Li Jianyun, Zhang Shangbing IEEE 2010 PP 1-3