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Review of Process Parameters of Injection Molding Process and Their Various Effects

S. S. Bajaj[1], J. J. Salunke[2]

[1,2]*Asst. Prof. Mechanical Engineering Department DIEMS, Maharashtra, India*

Abstract - Injection moulding is the most widely used polymeric fabrication process. It evolved from metal die casting, however, unlike molten metals, polymer melts have a high viscosity and cannot simply be poured into a mould. The selection of best suitable parameters for the process by trial and error method is very old technique. Design of Experiments method is used to select various process parameters and optimization is done with the help of ANOVA, Grey relational analysis, etc to obtain the effect of the process parameters on the injection moulded part. This paper is a review on various studies done to obtain best suitable process parameters for injection moulding and their effects on injection moulded parts.

Keywords: Injection moulding, Design of Experimentsl, ANOVA, Grey Relational Analysis.

I. INTRODUCTION

Injection moulding is the most widely used polymeric fabrication process. It evolved from metal die casting, however, unlike molten metals, polymer melts have a high viscosity and cannot simply be poured into a mould. Instead a large force must be used to inject the polymer into the hollow mould cavity. More melt must also be packed into the mould during solidification to avoid shrinkage in the mould. The injection moulding process is primarily a sequential operation that results in the transformation of plastic pellets into a moulded part. Identical parts are produced through a cyclic process involving the melting of a pellet or powder resin followed by the injection of the polymer melt into the hollow mould cavity under high pressure.

II. INJECTION MOULDING PROCESSING PARAMETERS

Mold temperature: - Mold temperature was defined as the temperature of mold surface in contact with melt.

Melt temperature: - Melt temperature was defined as the temperature at which the polymer changes from solid to liquid state, that is became fluid and can be injected in the mold.

Injection pressure: - Injection pressure was defined as the pressure on the face of the injection screw when melt material was injected into the mold.

Injection speed (or velocity): - The injection speed was defined as the speed which the polymer was injected into the cavity mold, determined by the screw movement on forward during melt injection.

Injection pressure: - Specimens molded with high values of temperatures and pressures exhibited low crystallinity and better feature replications.

Cooling time: - The cooling time was identified as critical factor that affects shrinkage.

III. EXPERIMENTAL COMPARISONS

(Alireza Akbarzadeh & Mohammad) studied the effect ofinjection molding parameters on shrinkage of polypropylene (PP) and polystyrene (PS). The author selected melting temperature, injection pressure, packing pressure and packing time as input parameters. The effects of these parameters on the shrinkage of above mentioned materials are studied using mathematical models. Regression models and Analysis of Variance (ANOVA) are used to study the relationship between input and output parameters. Based on ANOVA, for PP, packing pressure is most effective while injection pressure is least important and for PS, melting temperature is most influential variable while packing pressure and packing time are the next influential parameters. Warpage is one of the main defects in injection molding process and is caused due to anti-symmetric shrinkage.

(Anand K Dwiwedi, et.al) instead of the old concept of trial and error method to determine the process parameters for injection molding aimed to analyze the recent research to determine optimal process parameters of injection molding. The optimization of injection molding process parameters for polypropylene (PP) material has been done using Taguchi methodology. This methodology provides the optimum value of process parameters with the help of orthogonal array by conducting very few experiments. Processing temperature, Injection pressure, Cooling time and Injection speed are the selected process parameters. The process parameters are optimized by considering Tensile strength as responding factor. The response table for S/N ratio gave the best set of combination for process parameters and highest value for each factor is selected. For Tensile strength of PP, processing temperature is found most effecting factor followed by injection speed, injection pressure and cooling time.

(B.KC, et.al) applied the Taguchi method to optimize the injection moulding (IM) process parameters for sisal and glass fiber hybrid biocomposite. Injection pressure, melt temperature, mold temperature, holding pressure, cooling time and holding time are the six parameters selected that influence flow and cross-flow shrinkage. Two hybrid biocomposites were used with different content of sisal(SF) and glass fiber(GF); SF20GF10 and SF10GF20.L18 orthogonal array with a mixed-level design and signal-to-noise ratio (S/N) of smaller-the-better was used for experimental design. For both hybrid biocomposites, optimal injection molding settings for minimizing the shrinkage are injection pressure 90 bar, melting temperature 210 0C, mold temperature 40 0C, cooling time 40s, hold time 6s and optimal holding pressure for SF20GF10 was 70 bar and for SF10GF20 was 50 bar. Based on ANOVA analysis, injection pressure had significant influence on both flow shrinkage and x-flow shrinkage of SF20GF10. For SF10GF20, no factors show significant impact on flow shrinkage; however injection pressure and mold temperature had significant impact on x-flow shrinkage.

(D. Bhattacharya, et.al) aimed the feasibility of recyclability of polypropylene (PP) in injection molding based on grey relational analysis. Virgin to recycled material ratio (V: R), injection pressure (IP), injection temperature (IT) and injection speed (IS) were the parameters dictating the product's quality and they were all taken at three levels. The conclusion is obtained by results of various tests done on PP. The tests held are Tensile strength at the yield, Elongation at break, Density test and Vicat Softening Point test. The conclusion by test is the lower level of injection temperature, lower level injection pressure, higher level of injection speed must be chosen for virgin to recycled ratio of 95:05. Through investigation reveals that injection speed is the most dictating factor and other factors are injection pressure, virgin to recycled ratio and injection temperature.

Kingsun Lee and Jui-Chang Lin, studied finite element analysis (FEA) to explore the influences of the shrinkage of LED lampshades. The authors selected injection parameters and studied their effects on shrinkage size. The design of experiments was applied using Taguchi method. A set of experiments using Taguchi method was conducted to investigate the relationship between injection processing parameters and shrinkage. The smaller-the-better quality characteristics for minimum shrinkage should be used to obtain optimal injection molding performance. ANOVA verified that melt temperature is very significant processing parameter.

IV. EXPERIMENTAL TESTS

The effects of injection processing parameters are obtained with the help of various tests performed on injection moulded parts.

1. Melt Flow Rate Test (MFR).
2. Density Test.
3. Environmental Stress Cracking Resistance test (ESCR).
4. Vicat Softening Point test(VSP).

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