# Optimization of Injection Moulding Process Parameters for Reducing Shrinkage by Using Genetic Algorithm Technique

Navin Kumar[1], Mayur Thombre[2]

[1]*PG Students,* [2]*Assistant Professor, Department of Mechanical Engineering, SSITM Bhilai, INDIA.*

## Abstract

*Injection molding is an important polymer processing operation in the plastic industry. In this process, polymer is injected into a mold cavity, and solidifies to the shape of the mold. Optimizing the parameters of the injection molding process is critical to enhance productivity. Productivity and quality are two important aspects have become great concerns in today's competitive global market. Every production/manufacturing unit mainly focuses on these areas in relation to the process as well as product developed. Injection moulding process, even now it is an experience process, wherein still the selected parameters are often far from the maximum, and at the same time selecting optimization parameters is costly and time consuming. In this work the sink mark or shrinkage during the process has been considered as productivity estimate with the aim to minimize it. This response requirements have been satisfied by selecting an optimal process environment (optimal parameter setting). The setting data and objective function is obtained by artificial neural network and regression analysis. Then objective function is optimized using Genetic Algorithm technique. The model is shown to be effective percentage shrinkage mark improved using optimized injection moulding process parameters as compared to previous literature.*

**Keywords:** *Injection Moulding Process, Shrinkage, Artificial Neural Network, Genetic Algorithm.*

## 1. INTRODUCTION

The industrial science of transforming plastics resins into useful things through the process of injection moulding has had a tremendous impact on industry and on most of our lives. The injection moulding process was first designed in the 1930s and was originally based on metal die-castings (Joseph and Malloy 1997). It is one of the most widely used processing methods for mass production of plastics parts. Over 32%, by weight, of all plastic parts are manufactured by this process (Turng 2001). It has many advantages to its credit. To name a few: it can handle complex shapes, deliver good reproducibility, able to produce near net-shape products, etc.

In the injection moulding process, hot melt of plastics is forced into a cold empty cavity of desired shape (mould). Then, the hot melt is allowed to solidify. Solidified part is ejected out of the mould upon opening. Although the process looks deceptively simple, prediction of the quality of the final part is a complex phenomenon due to the numerous processing variables. To ensure defect free products, it is imperative that the quantification of effects of the processing variables on the defects be made for understanding how to control such defects.

The injection moulding process uses large injection moulding machines as shown in the Figure 1.1 In which the plastics resin is transformed to shape everything from plastics toys to computer parts.

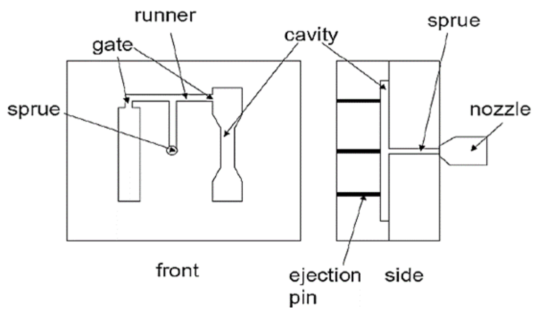


Fig 1.1 Line diagram of mould

## 2. PROBLEM IDENTIFICATION

Injection molding is the most commonly used technique in plastic molding. It has the advantage of good dimension control, good replication accuracy, short cycle time, and high productivity. However, molding at microscales presents great difficulties. In particular, molding microchannels with a high aspect ratio (depth: thickness) is not an easy task. In today's mold industry, in spite of the many simulation options available, initial stock block sizes are dimensioned based on a trial and error method. Only a small percentage of mold manufacturers employ simulation software to validate their mold designs, and typically this focuses on material flow and cooling challenges.

## 3. METHODOLOGY

Optimization of an efficient and optimized process parameters are very much required to replace the time consuming and expensive analyses for minimize the defects due to shrinkage. The Artificial Neural Network and Genetic Algorithm techniques can be coupled with optimisation the values of process parameters for minimization of the sink marks. Based on the literature survey Lal and Vasudewan [2] and its present status the following research methodology is formulated.

### *3.1 Selection of Plastic Material and Process Parameters*

Table 3.1 Properties of LDPE [2]

| Property | Unit | Typical Value |
|---|---|---|
| Density ($23^0$C) | g/cm3 | 0.918 |
| Melt flow index | g /10 min | 30 |
| Tensile strength at Yield | MPa | 10 |
| Elongation at Yield | % | 40 |
| Flexural Modulus | MPa | 140 |

Table 3.2 Process parameter and their level [2]

| Sr. No. | Factors | Code | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| 1 | Melting Temperature, (°C) | $T_m$ | 190 | 200 | 210 |
| 2 | Injection pressure, (MPa) | $p_i$ | 55 | 60 | 70 |
| 3 | Refilling pressure, (MPa) | $p_r$ | 75 | 80 | 85 |
| 4 | Cooling time, (s) | $t_c$ | 7 | 9 | 11 |

### *3.2Method*

From the optimization methods this work is particularly using ANN and GA optimization tool is used, the mathematical model or regression equation has been obtained from Minitab with desirability is 95.12% for the injection-molding optimization problem can be formulated as follows:

Minimize F(x)

**Subject to,**

$190 \leq T_m \leq 210$

$55 \leq p_i \leq 70$

$75 \leq p_r \leq 85$

$7 \leq t_c \leq 11$

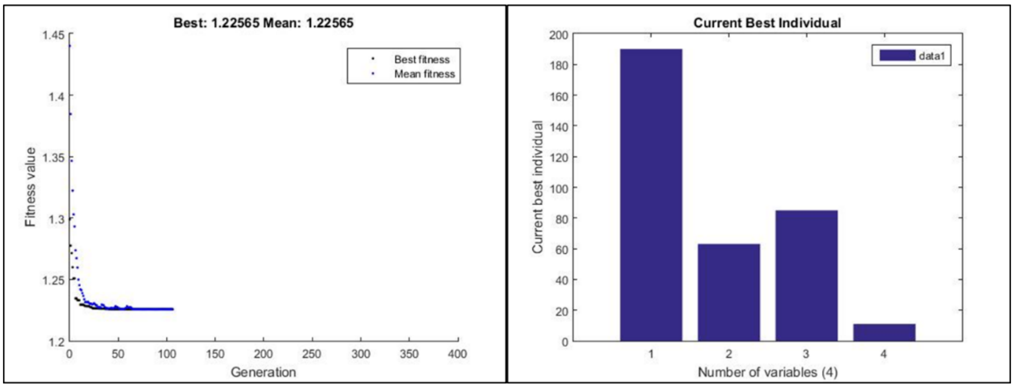


Fig 3.1 Graph for % shrinkage best and mean fitness value and best current individual

## 4. RESULTS AND DISCUSSIONS

The results of ANN coupled with GA used to predict and optimize the % shrinkage based on input process parameters in injection moulding process are shown and discussed below.

Table 4.1 Optimum value obtained in MATLAB GA tool (Present work)

| Melt Temp. | Injection Pressure | Refilling Pressure | Cooling Time | % Shrinkage |
|---|---|---|---|---|
| 190 | 63.097 | 85 | 11 | 1.225 |

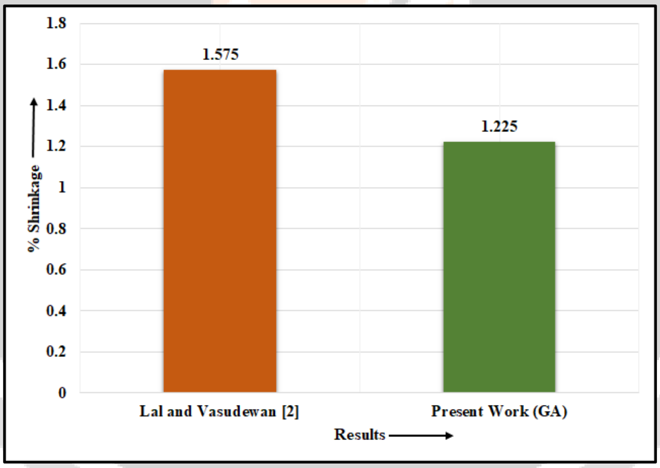


Fig 4.1 Graph plot for percentage shrinkage between existing [2] and present work

## 5. CONCLUSION AND FUTURE WORK

***Conclusion***

- The main purpose of the research work was obtained the process parameters that ensure the accurate melt temperature, injection pressure, refilling pressure and cooling time.
- This work results indicates that the present or proposed work approach can effectively help to engineers determine optimum process parameters setting and find the optimal response, which are competitive advantage of cost of product and quality.
- In this work, the process parameter was obtained i.e. melt temperature is 190 oC, injection pressure is 63.097 MPa, refilling pressure is 85 MPa and cooling time is 11second within constrains of machine tool and mold plastics.
- In this investigation, the good agreement with an artificial neural network coupled with Genetic algorithm for the prediction and optimization of machining parameter leading to minimize the percentage shrinkage.
- From this work, the difference in percentage shrinkage in injection moulding process in Lal and Vasudewan [2] and present work is 22.2% increased, which is good for production unit.

***Future Work***

- For the future work, the researcher should perform the experiments and other optimization tool using this methodology before producing new products and its mold.

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