OPTIMIZATION OF PLASTIC INJECTION MOLDING

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ABSTRACT:- Injection Molding is widely used to produce plastic products and components, which finds application in many industries as well as beneficial household products. Injection Molding process involves various parameters which contribute to the quality and productivity of plastic parts. Therefore computer aided engineering (CAE) software application is essential to enhance the quality of plastic parts in the injection molding industry. This paper deals with application of Moldflow Simulation Advisor Software to simulate the Injection Molding process. Simulation process parameters involved in this study were melt temperature, mold temperature, injection time of the materials and cooling time. In this study, polypropylene was injected in honey cup shape product under various processing parameters. Moldflow software simulated the injection process to study the effect of process parameters on warpage deflection of the honey cup. The orthogonal Arrays of Taguchi and signal to noise ratio utilized to find the optimal levels and to indicate the impacts of the process parameters on warpage. The most significant parameters found were the melt temperature and injection pressure for the material and the least was the cooling time. The research results indicate that the propose approach can effectively help engineers and lecturers determine the optimal process parameter settings and achieve competitive advantage of product quality and costs

KEYWORDS: Injection Molding, Moldflow, Taguchi, Warpage

1. INTRODUCTION

The thesis proposes a new addition / fertilization process for the rapid production of aluminum injection molds. This chapter introduces background and inspiration for this new fast tool manufacturing process and presents research objectives to eliminate the complete automated planning accomplishments of the process.

Background

In the last few decades there has been a revolution in design and manufacturing. With the advent of rapid prototyping, engineers have been able to test their form, fit and function to make straightforward parts from CD models. The advantage of fast prototyping systems is that they do not require any special tooling and process planning, so it does not require less or no human intervention. Whatever the complexity of the part, RP systems make part by piece-level.

Most rapid prototyping processes have been developed on the idea of the product being added; the main difference levels between these RP processes are built and materials used to make parts. For example, some processes, such as fused deposition modeling (FDM) and selective leveling (SLS), make parts by dissolving, contributing or softening of the material, whereas Stereo lithography (SLA) process makes photopolymers part of the therapy. In the case of lamination systems like Laminated Object Manufacturing (LOM), thin layers of material are cut into the desired Mold and connect together to make the parts together. These RP systems make parts using materials such as plastic, ceramics and a few limited metals. This limitation in content is usually used in RP technology to produce real functional parts [Gibson (2005)]. Although most rapid prototyping systems are suitable for testing, proper and functioning, they usually require longer processing times; That's just fair if only one or a few parts are needed. RP systems are not the best choice due to the cost and processing time for every part when it is required to build ten, or thousands of parts. The availability of fast prototyping systems in mass production areas is very limited, but some successes are starting to look.

2. Taguchi Method

Taguchi's philosophy is an efficient tool for the design of high quality manufacturing system. Dr. Genichi Taguchi, a Japanese quality management consultant, has developed a method based on orthogonal array experiments, which provides much-reduced variance for the experiment with optimum setting of process control parameters. Thus the integration of design of experiments (DOE) with parametric optimization of process to obtain desired results is achieved in the Taguchi method. [2]

Classical experimental design methods are time consuming. Many experiments must be performed when the number of control factors is high. Taguchi methods [7] use a special design of orthogonal arrays to study the entire factor space with only a small number of experiments. [3]

The Taguchi method attempts to optimize a process or product design and is based upon three stages, as follows:

1. Concept Design or System Design

2. Parameter Design

3. Tolerance Design

The concept design is considered to be the first phase of the design strategy. This phase gathers the technical knowledge and experiences to help the designer to select the most suitable one for the intended product. In parameter design, the best setting of the control factors is determined. This is perhaps the important step, as it does not affect the unit manufacturing cost of the product. The third step is performed only after completion of the parameter design step and is exercised when further improvements are required for the optimized design. This phase focuses on the trade-off between quality and cost. However, designers in this stage consider only tightening tolerances, upgrading material standards and components, if any, having a significant impact on quality through parameter design experiments. [8]

The Taguchi method uses the signal-to-noise (S/N) ratio instead of the average to convert the trial result data into a value for the characteristic in the optimum setting analysis. The S/N ratio reflects both the average and the variation of the quality characteristic. [3] The standard S/N ratios generally used are as follows: Nominal is best (NB), lower the better (LB) and higher the better (HB). The optimal setting is the parameter combination, which has the highest S/N ratio. Larger – the – better

For larger the better type characteristic S/N ratio is calculated as

S/N ratio (η)= $-10 \log10 (1/n\sum 1/yi^2)$

Where i=1 to n

Where n = number of replications.

This is applied for problems where maximization of the quality characteristic of interest is sought. This is referred to as the larger-the-better type problem.

Smaller – the – better

For smaller the better type characteristic S/N ratio is calculated as

S/N ratio (η) =$-10 \log10 (1/n\sum yi^2)$

Where i=1to n

This is termed a smaller-the-better type problem where minimization of the characteristic is intended.

Nominal – the – best

For nominal the best type characteristic S/N ratio is calculated as

S/N ratio (η)= $-10 \log10(\mu2/\sigma2)$

where μ = mean

σ = standard deviation

This is called a nominal-the-best type of problem where one tries to minimize the mean squared error around a specific target value. Adjusting the mean to the target by any method renders the problem to a constrained optimization problem. [8]

Another major tool used in Taguchi design is orthogonal array, which is used to study many design parameters by means of a single response. An orthogonal array may contain both an inner array (control array) and an outer array. The inner array represents control factors involving a number of variables under the control of the experimenter. Each experimental run of the inner array is replicated according to the outer array, which is another design array based upon a certain number of noise variables for which the experimenter either cannot control directly or chooses not to control. [8]

3. RESULTS AND DISCUSSION

Based on Taguchi's orthogonal design, the effects of several process parameters can be effectively determined by matrix experiments. In this study, the injection parameters taken are the dissolved temperature, the cooling time, the injection pressure and the temperature of the mold. This test will be conducted using the Taguchi L_9 (3^9) orthogonal arrays as shown in Table 4.1

Table: 3.1 L9orthogonal array

A Melt Temperature, °C	B Cooling Time,(s)	C Injection Pressure, MPa	D Mold Temperature, °C
1	1	1	1
1	2	2	2
1	3	3	3
2	1	2	3
2	2	3	1
2	3	1	2
3	1	3	2
3	2	1	3
3	3	2	1

The process parameters and layers are shown in Table 4.1 An experimental plan for the four dimensions with three levels was arranged using the Taguchi method (Table 4.1).

Table: 3.2 The process parameters and levels

Process parameters		**Level 1**	**Level 2**	**Level 3**
Melt temperature (⁰C)	A	180	210	240
Cooling Time, (s)	B	10	15	20
Injection Pressure (MPa)	C	90	80	70
Mold temperature (⁰C)	D	60	50	40

Minitab 15 software was used for numerical calculations. A test was organized using the L9 (34) orthogonal array (Table 3.1) of Taguchi.

Table 3.3 sets the constraints created by the Taguchi approach in Minitab. For example, the molding temperature is 180 °C, The cooling time is set in 10 seconds, the injection pressure is kept at 90 MPa and the mold temperature is 60 °c. Are set on.

Table: 3.3 L9 orthogonal array with parameters

A **Melt Temperature, (°C)**	**B** **Cooling Time, (s)**	**C** **Injection Pressure,(MPa)**	**D** **Mold Temperature,(°C)**
180	10	90	60
180	15	80	50
180	20	70	40

210	10	80	40
210	15	70	60
210	20	90	50
240	10	70	50
240	15	90	40
240	20	80	60

3.1 Material and Design

Polypropylene compound was used for this study. The properties of polystyrene compound are shown in table 4.4 Hood Cup detected in figs was painted in Autodesk inventor 2015 and Moldflow software will be exported for analysis. Optimized points to focus on Warpage

Table: 3.4 Typical properties of Polypropylene

Processing Temperature	87.8 - 274 ℃
Nozzle Temperature	204 - 235 ℃
Melt Temperature	160 - 320 ℃
Mold Temperature	4.00 - 91.0 ℃
Roll Temperature	40.0 - 50.0 ℃
Drying Temperature	60.0 - 100 ℃
Moisture Content	0.0500 - 1.00 %
Injection Pressure	2.76 - 103 MPa

Fig: 3.1 Honey cup product diagram (mm)

Warpage analysis

Warpage is a form of a disorder that can be made in plastic materials. This usually results from unequal strain that can be internal or external in physical material. Common causes of warfare include extreme body temperature on uneven physical pressure or plastic material. Wrap on the product, end cracking and more damage to the content. Extreme heat and coolness can easily cut off a piece of plastic.

For those results the war page reading can be seen in Table 4.5. The last column in Table 9.5 is to read S / N (signal for sound) ratio for the war page compiled in the Taguchi analysis method. The characteristics of S / N ratios can be divided into three categories: quality-best, small-to-good, and better when quality characteristics are consistent. The S / N ratio is applied in this analysis. Analysis is even better because this study is to maximize the war zones green zone within the best level of processing parameters.

Table:3.5

Trial no.	Control Factor				Warpage Green Zone (%)	S/N(dBi)
	Melt temperature A(°C)	Cooling time B(S)	Injection Pressure C (MPa)	Mold temperature D(°C)		
1	180	10	90	60	99.7	39.9739
2	180	15	80	50	99	39.9127
3	180	20	70	40	99	39.9127
4	210	10	80	40	91.99	39.2748
5	210	15	70	60	96	39.6454
6	210	20	90	50	97.7	39.7979

7	240	10	70	50	92.7	39.3416
8	240	15	90	40	94.4	39.4994
9	240	20	80	60	92.3	39.304

Depending on the data in Table 3.5, an S / N response figure can be made and shown in Fig.3.2 from the figure, the best set of compound dimensions to maximize the warpage green zone can be determined by seeing the high value level for each factor. Thus the result is 1, B2, C1 and D2; That is, to get and optimized parameter setting, the dissolved temperature is set to 180 o C, the cooling time is set to 15 seconds, the injection pressure is set to 90 MPa and the mold temperature is set to 50 o C.

Main Effects Plot for SN ratios

Data Means

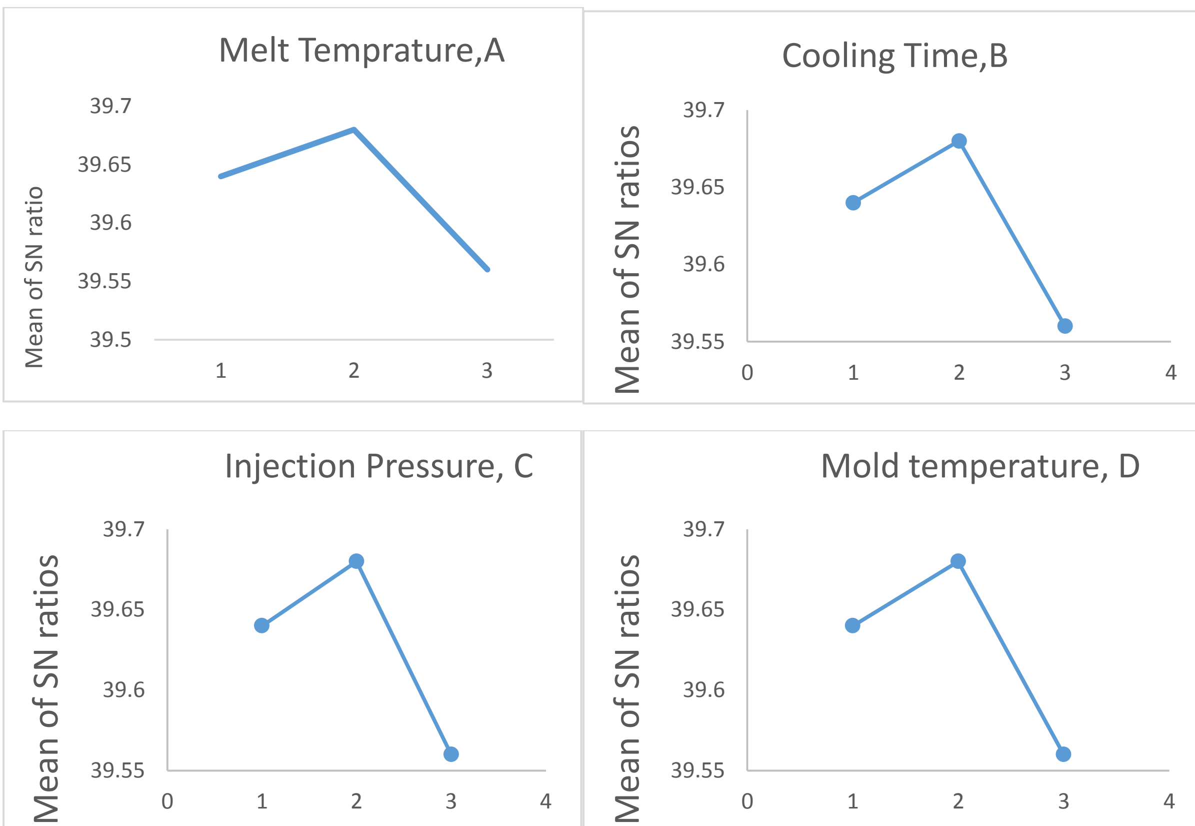

Fig: Main Effects Plot for SN ratios

As shown in Table 4.6, the response table for the S / N ratio shows that the factors affecting the most important method of warfare are dissolved at dissolved temperatures, then molds temperature, injection pressure and packing pressure. The ranks are identified by seeing the last row of this table

Table: 3.6 Warpage S/N ratio response

	A(°C)	B(S)	C(MPA)	D(°C)
1	39.93	39.53	39.76	39.64
2	39.57	39.69	39.5	39.68
3	39.38	39.67	39.63	39.56
Delta	0.55	0.165	0.26	0.12
Rank	1	3	2	4

4. CONCLUSION AND SUMMARY

This article shows a survey of research in the assurance of the procedure parameters for infusion shaping. Various research works dependent on different methodologies including numerical model, Taguchi strategy ,Counterfeit Neural Systems (ANN),Case Based Thinking (CBR), Limited Component Method(FEM),Non Direct Displaying, Reaction Surface Procedure, Straight Relapse Examination, Dark Normal Investigation An audit of writing on enhancement strategies has uncovered that there are, specifically, effective modern utilizations of plan of analysis based methodologies for ideal settings of procedure factors.

Taguchi strategies and reaction surface approach are powerful structure systems generally utilized in enterprises for making the item/process coldhearted toward any wild factors, for example, natural factors. Taguchi approach has potential for investment funds in trial time and cost on item or procedure advancement and quality improvement. There is general understanding that disconnected analyses during item or procedure configuration organize are of incredible worth.

Diminishing quality misfortune by structuring the items and procedures to be coldhearted toward variety in clamor factors is a novel idea to analysts and quality architects. ANN, and CBR are rising as the new approaches in the assurance of the procedure parameters for infusion shaping. A prepared neural system framework can rapidly give a lot of trim parameters as indicated by the aftereffects of the anticipated nature of shaped parts. Be that as it may, the time required in the preparation and retraining for a neural system could be long.

CBR frameworks can decide a lot of starting procedure parameters for infusion forming immediately dependent on the comparative case(s) without depending intensely on the master shaping faculty references.

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