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Performace evaluation of 250 ton capacity injection moulding machine for the production of exide battery casing and identification of related defects

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ABSTRACT

Injection Moulding (IM) is considered to be one of the most prominent processes for mass production of plastic products. One of the biggest challenges, facing injection molders today, is to determine the proper settings for the IM process variables. Selecting the proper settings for an IM process is crucial because the behavior of the polymeric material during shaping is highly influenced by the process variables. Consequently, the process variables govern the quality of the parts produced. The difficulty of optimizing an IM process is that the performance measures usually show conflicting behavior. Therefore, a compromise must be found between all of the performance measures of interest. This thesis demonstrates a method of achieving six sigma standards in small and medium plastic injection moulding enterprises. A modified six sigma cycle called DAURR (Diagnose, Analyze, Upgrade, Regulate and Review) based on Taguchi method, Regression analysis and Artificial Neural Network has been proposed in this work that can be used to find the best compromises between performance measures in IM, and potentially other polymer processes. Its feasibility was studied with the help of a case study. The method has been employed for the improvement in two quality characteristics (hardness and over shrinkage) of injection-molded nylon-6 kamani bush produced in a small enterprise. After the implementation of the proposed method, targets for improvement are clearly defined with the problems and causes being identified. The process parameters are then optimized for quality characteristics improvements so that the Six Sigma standard is reached. This research work provides methodology so that six sigma approaches can be applied and adjusted according to the requirements of small and medium enterprises (SMEs). This work also presents a novel, general and intelligent approach to multi response process optimization, with a purpose to obtain a single optimum setting of process parameters that meets specifications of all considered, possibly correlated, responses.

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I. INTRODUCTION

One of the plastic processing techniques is using injection moulding machine. The injection moulding process actually is the most practical and cost effective to produce plastic products. Plastic injection moulding defects such as warpage, sink marks, weld lines and shrinkage are the common defects occur in the plastics injected parts. The main cause of warpage is commonly known as the variation in shrinkage towards injection process of thin-shell plastic parts. Thick sections cool slower than thin sections. The thin section first solidifies, and the thick section is still not fully solidified. As the thick section cools, it shrinks and the material for the shrinkage comes only from the unsolidified areas, which are connected, to the already solidified thin section. In practice, the dimensions, potential for warpage and internal stress level for a plastics part will influenced by a variety of material, part geometry, tooling and processing related factors . Parts with thick wall are most difficult to cool and pack. Thicker sections take longer to cool and required additional packing .When parts have both thick and thin sections, gating into the thick section is preferred because it enables packing of the thick section, even if the thinner sections lead to shrinkage related internal stresses in the wall thickness regions. The shrinkage part easily transform into warpage if the parameter settings are not well control . The warpage and shrinkage is understood as the process of non-uniform (heterogeneous) change of the geometrical dimensions of products in time resulting in a change (distortion) of their original form. However, the researchers are using different parameter settings according to the part and raw material available thus it will contribute to the different results compare to each other. The scope of this study is focusing on the simulation of warpage defect on the raw materials including determination of the effective parameters that contribute to the defect, the selection of the orthogonal arrays (OAs) and determination of the optimum parameter. The selection of the orthogonal arrays (OAs) depends on the level and parameter involved thus the 3 levels and 4 parameters were chosen. The chosen parameters and level influenced the type of orthogonal arrays and the Taguchi L18 orthogonal arrays were used. Finally, the optimum parameters were determined by exploiting S/N ratio and ANOVA. If the part warps more than the tolerance allows, the warpage must be reduced. The complex interaction of part geometry, material, and processing parameters that lead to warpage. However, warpage can be broken down to three main causes as discussed in earlier section

- Orientation effects
- Area shrinkage effects
- Differential cooling effects

Once these three main causes of the warpage can be determined, the warpage can be reduced.

Objective

The main objective of writing review of warpage optimization of injection molded plastic part is to investigate the optimization techniques used for minimization of warpage by optimizing process parameters during injection molding. Highly complex design of plastic products now a days demands dimensional accuracy and good surface finish. As the injection molded part cools, uneven distribution of stresses is set up due to uneven cooling. These stresses warp the part and affect the dimensional accuracy of the part. So as to keep the warpage minimum, accurate prediction of optimum process parameters is very important. This review paper considers warpage as a main defect in the injection molded part. This paper presents an idea about research undertaken or completed on optimization of process parameters to minimize warpage, optimization techniques used, role of Finite Element Analysis (FEA) and most significant process parameters affecting the warpage.

II. LITERATURE REVIEW

Xiaoxin Wang et al. worked on reduction of sink mark and warpage of the molded part in rapid heat cycle molding process. To solve the problem of sink mark, they developed a new ‘‘bench form’’ structure for the screw stud on the product coupling with a lifter structure for the injection mold. To solve the problem of warpage, design of experiments via Taguchi methods were performed to systematically investigate the effect of processing parameters including melt temperature, injection time, packing pressure, packing time and also cooling time on the warpage. Injection molding simulations based on Moldflow were conducted to acquire the warpage of the plastic parts produced under different processing conditions.[1]

Ozcelik and Sonat have done warpage and structural analysis of thin shell plastic in the plastic injection molding. They used a thin cell phone cover. They observed the effects of the injection parameters on warpage for different thickness values using Taguchi method. They used Moldflow software to find warpage values. Then they determined the forces that cause the plastic part to fail at the points determined over the top surface of the cell phone cover using CATIA V5R12 (general structural analysis).[2]

Yi-Min Deng et al. used a hybrid of mode-pursuing sampling method and genetic algorithm for minimization of injection molding warpage. During optimization, Kriging surrogate modeling strategy is also exploited to substitute the computationally intensive Computer-Aided Engineering (CAE) simulation of injection molding process. By integrating the two algorithms, a new sampling guidance function is proposed, which can divert the search process towards the relatively unexplored region resulting in less likelihood of being trapped at the local minima. A case study of a food tray plastic part is presented, with the injection time, mold temperature, melt temperature and packing pressure selected as the design variables.

Behrooz Farshi et al. optimized injection molding process parameters using sequential simplex algorithm. They used warpage and shrinkage as defects in injection molding of plastic parts. Moldflow software package has been used to simulate the molding experiments numerically. Plastic part used is an automotive ventiduct grid. They used mold temperature, melt temperature, pressure switch-over, pack/holding pressure, packing time, and coolant inlet temperature as process design parameters.

Fei Yin et al. have done research on warpage prediction and optimization of plastic products during injection molding using back propagation neural network modeling. They developed a Back Propagation (BP) neural-network model for warpage prediction and optimization of injected plastic parts based on key process variables including mold temperature, melt temperature, packing pressure, packing time and cooling time during PIM. They used a approach of BP neural network trained by the input and output data obtained from the Finite Element (FE) simulations which are performed on Moldflow software platform. A kind of automobile glove compartment cap was utilized by them in this study. They proved that the prediction system has the ability to predict the warpage of the plastic within an error range of 2%.

Eghbal Hakimian et al. studied warpage and shrinkage properties of injection-molded micro gears polymer composites using numerical simulations assisted by the Taguchi method. Micro gears containing four cavities and consisting of three different types of thermoplastic filled with glass fibers were analyzed. The effects of the injection parameters on warpage and shrinkage at different fiberglass percentages and cooling temperatures were analyzed according to the Taguchi method.

III. METHODOLOGY

1) Inadequate Injection Pressure or Time
2) Inadequate Residence Time
3) Barrel Temperature too Low
4) Mold Temperature Too Low
5) Uneven Mold Temperatures
6) Nozzle Temperature too Low
7) Improper Flow Rate
8) Inconsistent Process Cycle
9) Inadequate Gate Size
10) Gate Location
11) Lack of Ejection Uniformity
12) Product Geometry

IV. EXPERIMENTAL AND VALIDATION

1) ALUMINIUM STRIP

PROPER WALL THICKNESS:

Choosing the proper wall thickness for your part can have drastic effects on the cost and production speed of manufacturing. While there are no wall thickness restrictions, the goal is usually to choose the thinnest wall possible. Thinner walls use less material which reduces cost and take less time to cool, reducing cycle time.

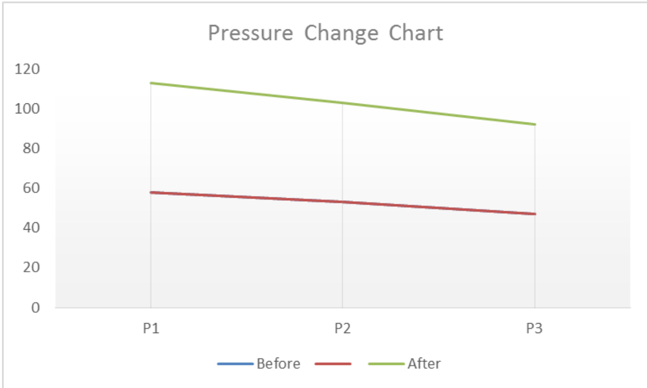
The minimum wall thickness that can be used depends on the size and geometry of the part, structural requirements, and flow behavior of the resin. The wall thicknesses of an injection molded part generally range from 2mm – 4mm (0.080" – 0.160"). Thin wall injection molding can produce walls as thin as 0.5mm (0.020").

Cycle Time (secs)) ±2%	Injection Time	Hold on Time	Cooling Time
95	12	10-5	48
Injection Pressure Gauge(kg/sqcm) ±2%	P1	P2	P3
	55	50	45
Injection Speed (cm/sec) ±2%	V1	V2	V3
	55	50	45

Table (a) Injection Pressure and Speed Chart After Change

Injection Pressure Gauge(kg/sqcm)	P1	P2	P3
Before	58	53	47
After			
	55	50	45

Table (b) Injection Pressure before and after



Graph (a) Pressure Change Graph

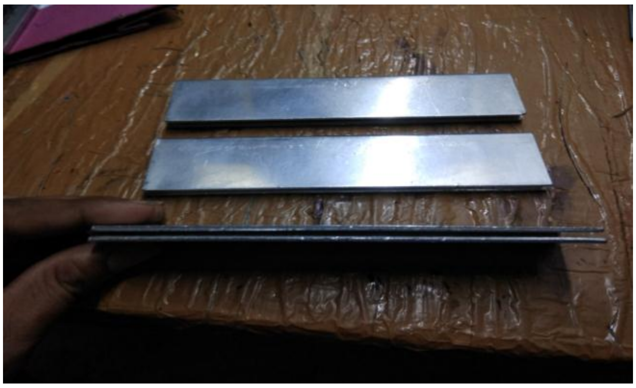


Fig. (a) Aluminum Strip

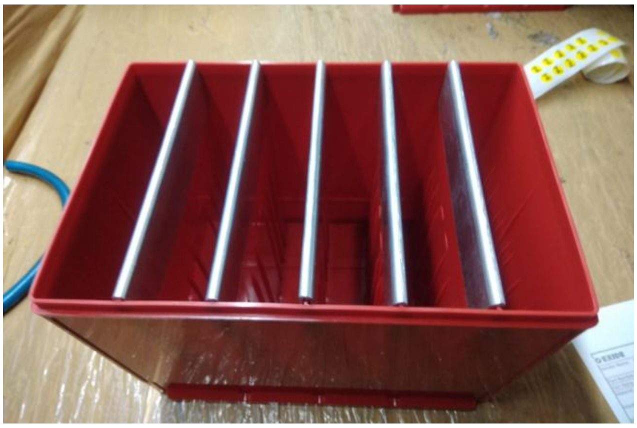


Fig. (b) Placement Of Aluminum Strip on Partition wall

2) Partition Bend Solutions

Gate Points

The problem arises when the gates are imbalanced in order to it balancing is necessary. It is as follows, To balance the gates of multi impression moulds to ensure that the impressions fill simultaneously this method is adopted when preferred balanced runner system cannot be used. The melt will take the easiest path hence once the runner system is filled, the impressions closest to the sprue will tend to fill first and those at greater distance will fill last. As a result some impressions may get over packed while others may be starved of material. To achieve balanced filling in impressions it is necessary to cause the greater restriction to flow of the melt to those impressions closer to the sprue and to progressively reduce the restriction as the distance from the sprue increases.

Container Name	Specification	Before	After
MF40 CONTAINER	2.9±0.1	2.75	2.92
	2.4±0.1	2.44	2.38
25-08-2018	2.4±0.1	2.4	2.4
	2.4±0.1	2.32	2.41
	2.4±0.1	1.92	2.4
	2.4±0.1	2.41	2.41
	2.9±0.1	3.25	2.91
MF40 CONTAINER	2.9±0.1	2.87	2.92
	2.4±0.1	2.41	2.41
26-08-2018	2.4±0.1	2.36	2.39
	2.4±0.1	2.27	2.4
	2.4±0.1	1.87	2.38
	2.4±0.1	2.4	2.4
	2.9±0.1	3.31	2.9
MF40 CONTAINER	2.9±0.1	2.75	2.92
	2.4±0.1	2.31	2.42
27-08-2018	2.4±0.1	2.16	2.4
	2.4±0.1	2.21	2.39
	2.4±0.1	1.89	2.4
	2.4±0.1	2.38	2.42
	2.9±0.1	3.39	2.91
MF40 CONTAINER	2.9±0.1	3.14	2.92
	2.4±0.1	2.37	2.39
28-08-2018	2.4±0.1	2.23	2.42
	2.4±0.1	2.26	2.39
	2.4±0.1	1.88	2.4
	2.4±0.1	2.28	2.39
	2.9±0.1	3.09	2.92
MF40 CONTAINER	2.9±0.1	3.14	2.92
	2.4±0.1	2.37	2.39
29-08-2018	2.4±0.1	2.22	2.4
	2.4±0.1	2.26	2.41
	2.4±0.1	1.89	2.4
	2.4±0.1	2.28	2.41
	2.9±0.1	3.04	2.93

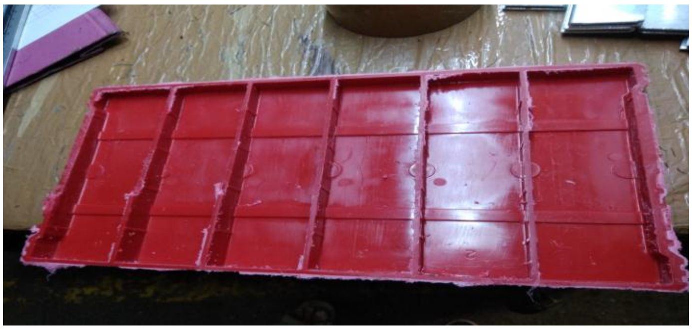
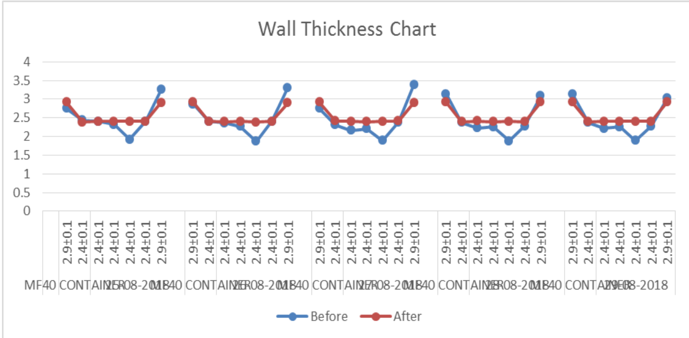


Fig. (c) Cut Section of MF-40 Container



Graph (b) Wall Thickness Chart

V. Conclusion

1) Aluminum Strip

As Aluminiun comes from the cateagory of metals which has a property of malleability as well as ductility.so it can be drawed in to thin strips .By imposing the component on the partion wall of battery casing it gives proper guide way .This strip is inserted when the battery casing is removed from the mould and it is kept till the battery casing gets cooled. Which lead to proper production in battery casing.

2) Silicon Spray

Silicon spray is serviceable from -40 to 200°C which permits the use on hot and cold .It enables the uniform temperature throughout the material as well as acts as a coolant for materials not having uniform temperature .It also leads to smooth run of production and maintains the surface colour finish.

Many of the times this spray is sprayed on the mould cavity as well as after each batch of production. It also enables the cooling effectively and it avoids sticking of moulding material .It has characteristics of preventing creaking, squeaking and corrosion. It prevents freezing and drying out. This product is water repel lent and has outstanding mechanical and thermal stability.

3) Gate Points

When the adequate moulding material is passed in cavity due to improper dimensions the material does not get equally distributed which leads to the problem in partition bend .To overcome this happening the gates point are drilled and welded to the company standard dimension and the gates point are maintained so that proper material flow takes place through the gates and the problem of partition bend , Inbow and Outbow is solved

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