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THE INFLUENCE OF PLASTIC EXTRUSION BLOW MOLDING PARAMETERS ON WASTE REDUCTION

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ABSTRACT

Growing demands of plastics deriving environmental and social concern on the plastics contained in municipal waste. Comprehending to this fact, this study emphasizes on minimization of plastic wastes during extrusion blow molding process by controlling the processing parameters including parison thickness, chiller temperature, melting temperature and extruder speed. L_8 Taguchi orthogonal array (OA), signal to noise (S/N) ratio and analysis of variance (ANOVA) were conducted to investigate the influence of numerous blow moulding processing parameters on the plastic wastes.

Keywords: extrusion blow moulding, taguchi method, waste reduction.

INTRODUCTION

Blow moulding makes it conceivable to make shaped items monetarily, in boundless amounts, with essentially no finishing required. Blow moulding is known as the third biggest plastic processing method worldwide for manufacturing a wide range of products in the plastics manufacturing industry. Extrusion blow moulding is one of the most popular blow moulding techniques that widely used in plastic industry and also known as industrial blow moulding. Extrusion blow moulding process is a framing process of a bladdery product by "blowing" a thermoplastic liquid tube called a parison fit as a fiddle of a mould hole. It is based on the capacity of thermoplastic materials to be mellowed by warmth and to be solidified when cooled. The purpose of extrusion blow moulding is to produce products with best quality characteristics such as good appearance and surface finish, mechanical and physical properties, dimensional stability and etc. However, extrusion blow moulding also produce lot of wastes which also refer as plastic scraps during the manufacturing process.

Many have studied the effect of parison thickness towards the quality of the final products by adopting numerical method [1-3]. Numerical techniques may help reducing machine setup time, tooling cost as well as optimizing process parameters. These techniques can be acceptable for the establishment or training of a numerical algorithm. But from industrial perspective, more rigorous technique is needed to capture the real phenomenon including minimizing the materials usage and environmental issues concerned. In fact, the resistance of plastics to degradation, the great variety of plastic products produced, the difficulty in separation of the different plastic material types due to similarities in physical characteristics, and the incompatibility between certain types particularly for composite plastic wastes limit the recycling as an alternative approach of plastic wastes disposal [4]. With the expanding expenses of landfill space, and with the accretion of enthusiasm for waste minimization, an assortment of strategies for reusing or reusing plastic waste as a solitary tar or in blend with different plastics are being developed [5]. Nonetheless,

Xiang *et al.* [6] expressed regarding recycling by reprocessing, natural issues in identified with discharges have been of worry to the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA). The emissions during reprocessing recycled plastic may became hazardous to the environment and health [7]. Therefore, it is necessary to reduce plastic wastes in industry before the environment conditions worsen.

Considering the expanding measure of waste created amid extrusion blow moulding procedure, thusly this study is focusing for investigating the impacts of processing parameters towards the plastic scraps generated amid manufacturing process. Taguchi method is adopted to assess the impact of processing parameters upon plastic scraps created.

MATERIAL AND EXPERIMENT PROCEDURES

In this study, Polypropylene (PP) was specified as material to be studied. The PP is supplied by Titan Petchem (M) Sdn Bhd. under the grade name of PM 655. Table-1 shows the general properties of the PP. The geometry of the bottle is show in Figure-1 and the bottle is produced by using SMC 1000DST extrusion blow moulding machine. The scraps produced during manufacturing process are collected as shown in Figure-2. The lip scrap is produced from blowing the parison tube into mould cavity to form the bottle and the bottom scraps is produced by clamping the mould before the parison tube is blown.

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Table-1. PP general general properties.

Properties	Value
Melt flow index (g/10min)	1.7
Melting temperature (°C)	230
Density ((kg/m^3)	900
Flexural modulus (MPa)	1717

Figure-1. Pharmaceutical bottle.

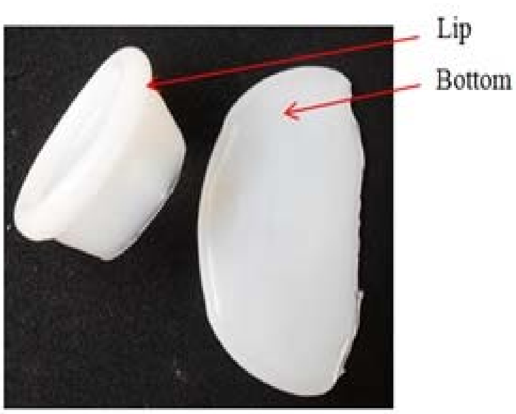

Figure-2. Scrap produce.

The experiment was conducted with four controllable two-level processing parameters: parison thickness, chiller temperature, melting temperature, and extrusion speed. Table-2 shows the selected processing parameters and levels. By using L_8 Taguchi OA as the experimental layout (Table-3), 8 trials of bottle sampled with ten reiterations were produced. Referring to Table-3, parison thickness (A) is assigned to column 1, chiller temperature (B) is assigned to column 2 and melting temperature (C) as well as extrusion speed (D) is designated to column 3 and 4 respectively. The scraps are used as specimen for weighing test indicates the production waste. The weight test is performed in a standard laboratory atmosphere of 23 °C using Shimadzu UX2200H electronic balancing.

Table-2. Processing parameters and levels studied.

Factor	Parameters	Unit	Level 1	Level 2
A	Parison Thickness	g	40	38
B	Chiller Temperature	°C	5	3
C	Melting Temperature	°C	160	165
D	Extrusion Speed	rpm	38/39	35/36

Table-3. The L_8 Taguchi orthogonal array.

Trial No.	Factors/ Column				Results	
	1	2	3	4	Weight	
	A	B	C	D	(g)	S/N ratio
1	40	5	160	38/39	6.9180	8.68
2	40	5	160	35/36	6.7510	10.61
3	40	3	165	38/39	11.1610	8.13
4	40	3	165	35/36	10.6510	9.55
5	38	5	165	38/39	10.7840	4.61
6	38	5	165	35/36	10.3740	6.89
7	38	3	160	38/39	7.0380	9.07
8	38	3	160	35/36	6.7800	4.96

ANALYSIS METHOD

In examining the outcomes, Taguchi method proposed the utilization of the S/N ratio to decide the nature of the attributes employed. As discussed by Ozcelik *et al*. [8], the signal to noise (S/N) ratio is a measure of achievement targeted at developing products and processes insensitive to noise factors. A high signal to noise (S/N) ratio suggests that the signal is much higher than the arbitrary impact of the commotion factors. The process or part operation persistent with the higher signal to noise (S/N) ratio at all times yields optimal quality attributes with least variance. In the Taguchi method, the quality attributes can be assigned into the smaller the better, the nominal the better and the bigger the better. In this study, the smaller value of the weight is expected. Therefore, the smaller the better signal to noise (S/N) ratio character is applied in the analysis, which can be calculated using Equation. (1):

$$\text{S/N ratio, } \eta = -10 \log \frac{1}{n} \sum y^2 \qquad (1)$$

where y_i is the value of the weight for the ith trials, n is the number of repetitions. The results of S/N ratios are listed in Table-3.

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RESULTS AND DISCUSSION

ANOVA is performed in order to statistically determine the influential parameters impacting the plastic wastage delivered and to know each processing parameters percentage contribution amid expulsion blow shaping during blow moulding extrusion. ANOVA results are shown in Table-4. In ANOVA, the *F*-proportion which otherwise called variance ratio, indicated as *F* in the Table-4, is utilized to distinguish the essentialness of the parameters by performing a test of importance against the blunder term at a fancied certainty level. A large *F* value will result in high percentage contribution, showing the relative significance of the parameters in impacting the plastic wastage. In this study, from the *F*-Table at 0.10 level of significance (90% confidence), the obtained result $F0.10$ (1,3) is 5.5383 for all parameters. Referring to Table-4, out of four parameters, melting temperature computed higher value of *F*-ratio compared to other parameters. Hence, statistically shows that melting temperature is a significant parameter affecting the plastic wastage. Furthermore, by looking at the percentage contribution of the four parameters, melting temperature also shows the highest percentage contribution. Hence, support the *F* ratio results.

In order to demonstrate the influence of processing parameters on plastic wastage, a graphical display of main effects of S/N ratio is plotted as shown in Figure-3. A greater S/N ratio shows that the parameters are much higher than the noise factor and most desirable. From the main effects plot it can be inferred that the melting temperature (factor C) is most critical parameter since incline inclination is huge and this outcome is like those got with ANOVA (Table-4). Figure-3 shows that the lower melting and chiller temperatures increase the plastic wastage. As the melting temperature decrease, the viscosity of the molten is increase. High viscosity of the molten material lowers its flow rate, resulting in thickening of the parison tube hence increase the weight of plastic wastage. Similarly, low chiller temperature increase cooling rate of the molten and decrease flow rate of the molten. On the other hand, the result depicts that higher parison thickness and extrusion speed will increase the plastic wastage. Thicker parison tube increases the weight of scraps produced. As the extrusion speed increases, more parison tube is extruded resulted in excessive material supplied during manufacturing process.

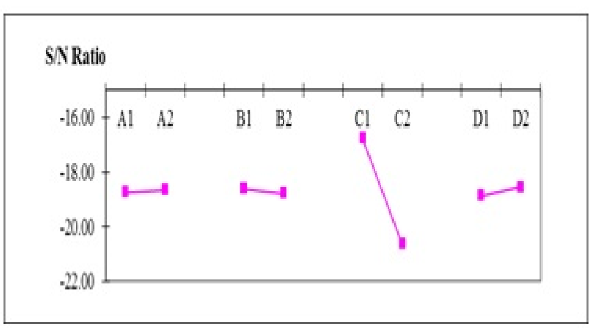

Figure-3. Main effect plot.

Table-4. ANOVA results for plastic wastage.

	Parameters/ Factors	DOF	S	V	F	P (%)
A	Parison Thickness	1	0.01	0.01	0.02	0.0
B	Chiller Temperature	1	0.07	0.07	0.09	0.2
C	Melting Temperature	1	29.9	29.9 9	39.8 9	92.2
D	Extrusion Speed	1	0.20	0.20	0.27	0.6
All others/error		3	2.26	0.75		
Total		7	32.5			100

CONCLUSIONS

In this study, the effect of extrusion blow moulding processing parameters including parison thickness, chiller temperature, melting temperature and extrusion speed on plastic wastage was clearly evaluated by the Taguchi method. From ANOVA outcome, melting temperature is identified as the most vital processing parameter influencing the plastic wastage.

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