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MATERIAL REPLACEMENT IN INJECTION MOLDING

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ABSTRACT

Material replacement in a product is a fatal thing for a company, because it will have a big impact on production operations, including the regulation of machine parameters, product quality, and production costs themselves. The difference in the specifications of the two materials will have a big impact on the parameter setting of the injection molding machine including the quality of the products it produces. Therefore, finished parts from new materials must be tested first to ensure that parts with new materials have no problems during the production process or customers later.

KEY WORDS: *Jig, Growing Industry, Price, Production. Quality,*

NOMENCLATURE

1.0 INTRODUCTION

Plastic molding is the process of forming an object or product from plastic material with a certain shape and size that is subjected to heat treatment and pressure by being injected into a mold or mold. Plastic products used in daily life are widely processed by injection molding machines. In the plastic molding process, attention is paid to several parameters, namely temperature, pressure and many other parameters used to produce the desired quality of plastic. With various types of existing materials, the setting of several parameters will also be different. Objective this study to get the right machine parameter setting for the injection molding machine after material replacement and to ensure that products with new materials can be used in the assembly process. To achieve the desired goals and avoid the spread of existing problems, in this study the following problem limitations will be given:

The basic material used for plastic manufacturing uses pure plastic pellets of PBT Torray 1184G-A15 and PBT Kingfa RG 151 and the parameters that are controlled are in the form of injection pressure, and injection speed.

1.1. Types of Plastic

Plastic is a polymer that has unique and unusual properties. A polymer is a material that consists of a unit of molecules called monomers. Broadly speaking, plastic is generally classified into 2 (two) types seen from its temperature, namely:
1. Thermoplastic material will soften when heated and after cooling it will be able to harden. Examples of thermoplastic materials are: Polystyrene, Polyethylene, Polypropylene, Nylon, Plastic, Flexi glass and Teflon.

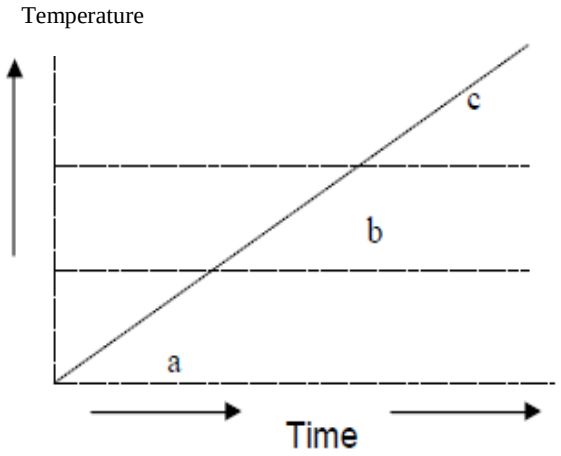

Figure 1. Plastic thermoplastic

Thermosetting material is plastic in liquid form and can be molded as desired and will harden if heated and still cannot be made into plastic again. Examples of thermosetting materials are: Bakelite, Silicon and Epoxy.

METALOGRAM
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December 15th 2024. Vol.01 No.01
December, 2024

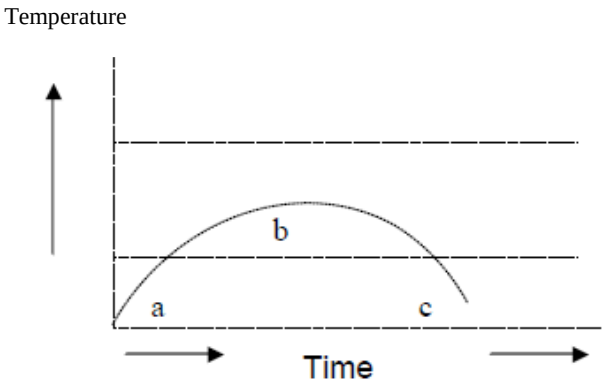

Figure 2. Plastic Thermosets

1.2 Plastic Injection Molding System

The injection molding process is the process of forming a workpiece from granular compound material that is placed into a hopper/passage and into an injection slander which is then pushed through the nozzle and sprue bushing into the cavity of the mold that has been closed. After a short time of cooling, the mold will be opened and the finished object will be ejected with an ejector.

1.2.1 Plastic Injection Process

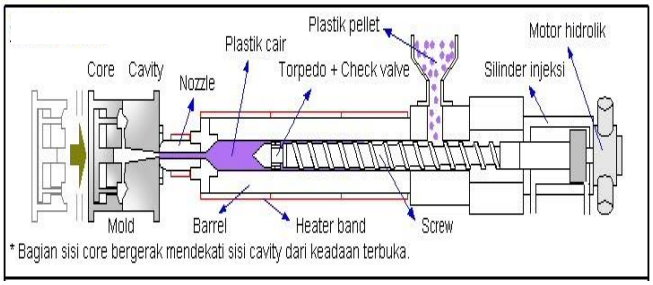

Figure 3. Mold close

In working cycle, the injection process begins with the process of closing the mold. The term mold in the world of plastic injection is a mold for the plastic injection process. The mold itself consists of 2 large parts, namely the "Core" side and the "Cavity" side. The cavity side is fastened to the "Stationery Platen" injection machine. While the core side is fastened to the "Moving Platen" of the engine, this part is what moves open and close.

1.2.2 Fill Injection

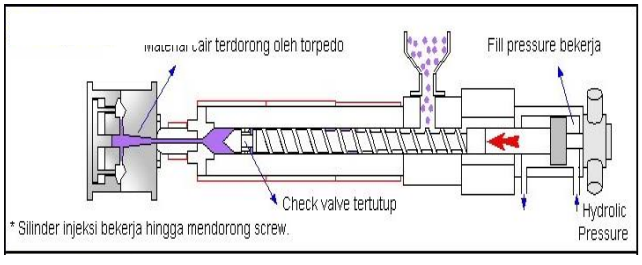

Figure 4. Fill Injection

After confirming that the mold is squeezed with high pressure, the injection unit consisting of Nozzle, Barrel, and Screw and so on, moves closer to the mold until the nozzle comes into contact with the mold, also with high pressure (Up to 100 kg/cm²). The image above shows that the nozzle has come into contact with the mold. The part of the mold that comes into direct contact with the nozzle is called the "Sprue Bush". Then the machine performs the filling injection process, which is injecting liquid plastic into the mold.

1.2.3 Holding Injection

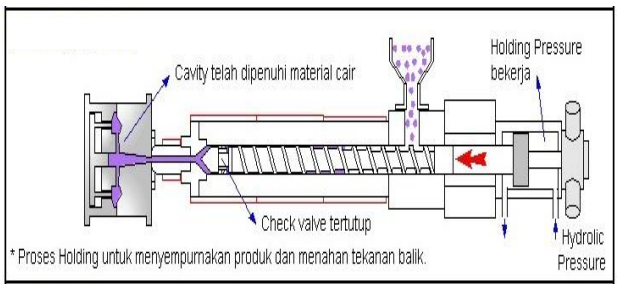

Figure 5. Holding Injection

The accuracy of the amount of pressure greatly determines the result of the product made, too big will be a problem, as well as if we make it too small. The need for the level of injection holding must be based on consideration of the needs of the product.

1.2.4 Charging & Colling

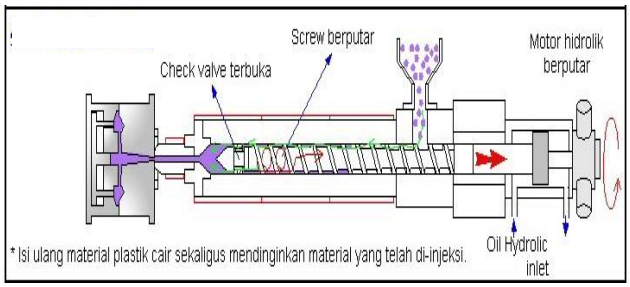

Figure 6. Charging & Colling

Recharge the liquid plastic to be ready to be injected in the next cycle, at the same time the calculation of the cooling time (Cooling) begins. The recommended parameter is that the cooling time must be longer than the charging time.

1.2.5 Mold Open

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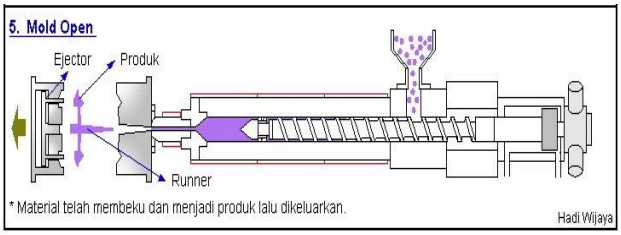

Figure 7. Mold Open

The ejector pushes the product from the core side to make it easy to take, of course the product must stick to the core side when the mold is open, and not to the cavity side, although it can be made that the product is attached to the cavity side, of course with the consideration of the product and the design of the mold designed in this way.

1.3 Types of Defects in Injection Molding

1. Short Mold

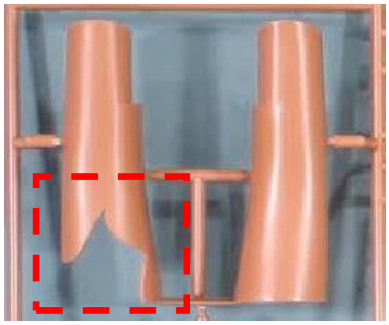

Figure 8. Shot mold

2.Flashing

Figure 9. Flashing

Causes of Flashing:
1. The injection pressure is too high.
2. The melting temperature is too high.
3. The holding time is too long.
4. The mold temperature is too high

3. Void

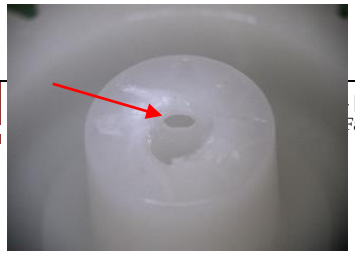

Figure 10. Void

Causes of void:
1. Lack of injection speed.
2. Lack of melting temperature.
3. Lack of injection pressure.
4. Less mold temperature.
5. Lack of injection time.

4. Flow Mark

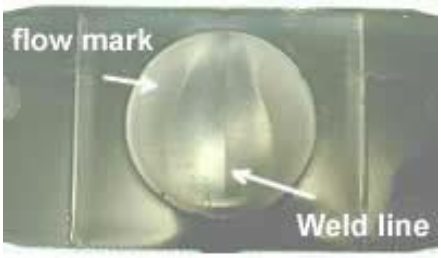

Figure 11. Flow Mark

Causes of flow mark:
1. The mold temperature is too low.
2. The injection pressure is not enough.
3. The speed of material flow is too slow.
4. The mold temperature is still lacking.
5. The temperature nozzle is not enough

2.0 METHOD

The main point of the research is how to get the right parameter settings to produce products that meet the specifications.

2.1 Materials & Machinery

2.1.1 Material

This study uses PBT (Polybutilene terephthalate) type material, with the following specifications:

Table 1. Material specification

Property	Material Type		Unit
	PBT Toray 1184 GA	PBT Kingfa RG151	
Tensile Strength	110	95	Mpa
Elongation at Break	3.3	3.4	%
Flexural Strength	170	150	Mpa
Flexural Modulus	5.5	5,6	Mpa

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-Mechanical Engineering and Energy-
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Impact Strength	5.5	7.0	J/m
Rockwell Hardness	85	120	-
Heat	205	205	℃
Mold Shrinkage	0.5	0.5	%
Water Absorption	0.07	0.07	%
Density	1.55	1.55	g/cm3
Glass Fibre Content	-	15	%

2.2 Machine

The machine used is a horizontal type molding injection machine with a capacity of 80 Tons.

Figure 12. Nissei Brand Injection Molding Machine

Machine Specifications:

1. Screw Stroke : 125 mm
2. Screw Speed : 0 ~ 250 rpm (High Torque)
3. Inject. Force : 18.6 Ton
4. Clamp Force : 80 Ton
5. Screw Diameter : 36 mm
6. Inject. Capacity : 127 cm3/shoot
7. Inject. Press : 1825 kg/cm2
8. Inject. Rate : 125 cm3

3.0 RESULT

3.1 Trial Data

From the experimental data carried out to get the right parameter settings to produce products that meet the standards, it can be seen from table 2 below.

Table 2 Experiment injection molding

No	Velocity	Pressure	Result/Material	
			PBT KINGFA RG 151	PBT TORRAY 1184G-A15
1	15	60	Short Mold /	Short Mold /
2	20	60	Short Mold /	Short Mold /
3	25	60	Short Mold /	Short Mold /
4	30	60	Short Mold /	Short Mold /
5	35	60	Short Mold /	Short Mold /
6	15	65	Short Mold /	Crack / Dimension
7	20	65	Short Mold /	OK
8	25	65	Short Mold /	OK / Dimension
9	30	65	Short Mold /	Crack / DO
10	35	65	Short Mold /	Crack / DO
11	15	70	Crack /	OK
12	20	70	Crack /	Crack / DO
13	25	70	OK	Crack / Flashes /
14	30	70	OK / Dimension	Crack / Flashes /
15	35	70	Crack / DO	Crack / Flashes /
16	15	75	Crack,	Crack / Flashes /
17	20	75	OK	Crack / Flashes /
18	25	75	Crack, DO	Crack / Flashes /
19	30	75	Crack / Flashes	Crack / Flashes /
20	35	75	Crack / Flashes	Crack / Flashes /

3.2 Product Data

The following is product data that has met the specifications using PBT KINGFA RG 151 material

Table 3. Product dimension

No	Spec	Measuring Equipment	Measuring Result n=3 Shots			Appearance
1	21 (+0.2/-0.05) Min: 20.95 mm Max: 21.90 mm	Microscope	21.76	21.086	21.072	OK
2	21 (+0.2/-0.05) Min: 20.95 mm Max: 21.90 mm	Microscope	21.188	21.191	21.195	OK
3	21 (+0.2/-0.05) Min: 20.95 mm Max: 21.90 mm	Microscope	21.110 21.137	21.106 21.139	21.112 21.141	OK
4	⌀ 35 (+0.2/-0.1) Min: 34.90 mm Max: 35.20 mm	Microscope	35.041	35.044	35.037	OK
5	19.6 ± 0.12 Min: 19.48 mm Max: 19.72 mm	Dial Gauge	19.607	10.602	19.606	OK
6	3-⌀2.2 ± 0.05 Min: 20.95 mm Max: 21.90 mm	Pin Gauge	2.19 2.19 2.19	2.19 2.19 2.19	2.19 2.19 2.19	OK

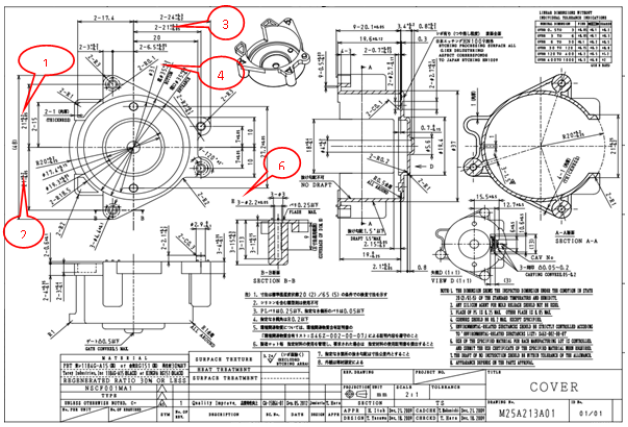

Figure 13. Drawing Product

4.0 DISCUSSION

From the experimental data above, there are differences in the condition of the parameters of the two materials. PBT Torray 1184G-A15 material gets the right condition at a velocity of 20% using 65% pressure, while PBT KINGFA RG 151 material gets the right condition at a velocity of 20% using 75% pressure and at a velocity of 25% using 70% pressure. This difference in velocity and pressure is caused by the fact that PBT KINGFA RG 151 material contains glass fiber

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content which makes this material harder than PBT TORRAY 1184G-A15 material (as attached in table 3.1. Material Specifications), so that when using PBT KINGFA RG 151 material, it requires greater velocity and pressure than using PBT TORRAY 1184G-A15 material. The temperature barrel condition on the engine also indicates that the PBT KINGFA RG 151 material is harder than the PBT TORRAY 1184G-A15 material.

Table 4. Temperature barrel setting

No	Temperature	PBT TORRAY 1184G -A15	PBT KINGFA RG 151
1	Nozzle Temp.	255 ℃	275 ℃
2	Front Temp.	250 ℃	260 ℃
3	Middle Temp.	240 ℃	240 ℃
4	Rear Temp.	230 ℃	235 ℃
5	Sv Temp.	55 ℃	60 ℃

4.1 Product Testing

The test carried out is a toughness test. Testing is carried out when the goods have been assembled (assembly) after installing screws (screws). The data we will take includes.

4.2 Test Methods

Setting Screw Driver Electric follow to specification 4.0 ~ 6.0 kgf.cm

Figure 14. Setting Screw Driver Electric

1. The product will be assembled by the Screw Driver Electric screwing process

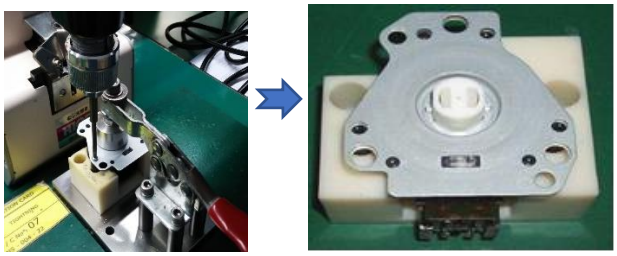

Figure 15. Proses Screwing

2. After assembling the product, it will be checked whether there are cracks (cracks) or not (appearance inspection).

Figure 16. Appearance Inspection

3. Return Torque Inspection (product strength)

Figure 17. Return Torque Inspection

4.3 Test Data

The following is data from the return torque inspection test with 3 methods, namely on the strength of the Screw Driver Electric 4.0 kgf.cm, 5.0 kgf.cm, 6.0 kgf.cm.

Table 5. Product Testing Data

No	Scale 4.0 kgf.cm				Scale 5.0 kgf.cm				Scale 6.0 kgf.cm			
	A	B	C	App	A	B	C	App	A	B	C	App
1	2,2	2,3	2,4	OK	2,5	2,6	2,5	OK	3,3	3,4	3,3	OK
2	2,3	2,2	2,3	OK	2,7	2,6	2,7	OK	2,9	3,0	3,1	OK
3	2,7	2,3	2,2	OK	2,6	2,7	2,6	OK	3,2	2,9	3,2	OK
4	2,4	2,4	2,2	OK	2,6	2,7	2,7	OK	2,9	3,3	3,3	OK
5	2,3	2,5	2,0	OK	2,7	2,5	2,7	OK	2,8	2,9	2,9	OK
6	2,0	2,0	2,3	OK	2,5	2,6	2,5	OK	3,1	3,2	3,1	OK
7	2,2	2,3	2,5	OK	2,8	2,6	2,7	OK	3,2	3,2	3,1	OK
8	2,4	2,3	2,3	OK	2,5	2,7	2,6	OK	3,2	3,2	3,2	OK
9	2,1	2,2	2,3	OK	2,7	2,7	2,8	OK	2,9	3,0	3,1	OK
10	2,3	2,4	2,0	OK	2,7	2,5	2,7	OK	3,0	3,1	3,0	OK

Specification: 1. Screw Tight Torque : 4.0 ~ 6.0 kgf.cm
2. Screw Return Torque : ≥ 1.4 kgf.cm

4.3.1 Trial and Testing Results

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Table 6. KINGFA RG 151 PBT Test Data

No	Scale 4.0 kgf.cm				Scale 5.0 kgf.cm				Scale 6.0 kgf.cm			
	A	B	C	App	A	B	C	App	A	B	C	App
1	2,2	2,3	2,4	OK	2,5	2,6	2,5	OK	3,3	3,4	3,3	OK
2	2,3	2,2	2,3	OK	2,7	2,6	2,7	OK	2,9	3,0	3,1	OK
3	2,7	2,3	2,2	OK	2,6	2,7	2,6	OK	3,2	2,9	3,2	OK
4	2,4	2,4	2,2	OK	2,6	2,7	2,7	OK	2,9	3,3	3,3	OK
5	2,3	2,5	2,0	OK	2,7	2,5	2,7	OK	2,8	2,9	2,9	OK
6	2,0	2,0	2,3	OK	2,5	2,6	2,5	OK	3,1	3,2	3,1	OK
7	2,2	2,3	2,5	OK	2,8	2,6	2,7	OK	3,2	3,2	3,1	OK
8	2,4	2,3	2,3	OK	2,5	2,7	2,6	OK	3,2	3,2	3,2	OK
9	2,1	2,2	2,3	OK	2,7	2,7	2,8	OK	2,9	3,0	3,1	OK
10	2,3	2,4	2,0	OK	2,7	2,5	2,7	OK	3,0	3,1	3,0	OK

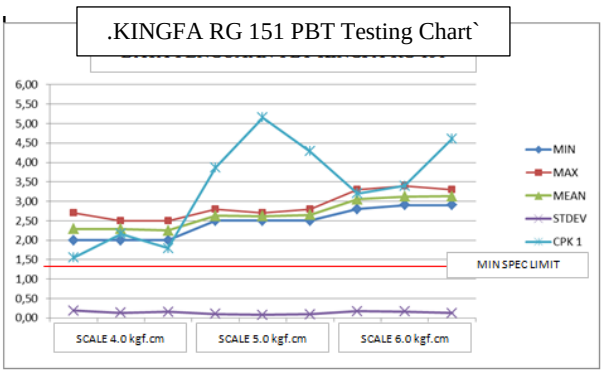

Figure 18. KINGFA RG 151 PBT Testing Chart`

Based on the data in the graph image above the result states OK and it can be seen from the Cpl value (Cpk 1) which is greater than 1.33, then the PBT KINGFA RG 151 material can be used sustainably. As a comparison material, I attach the following normal data using PBT TORRAY 1184G-A15 material:

Table 7. Normal Data PBT TORRAY 1184G-A15

No	DATA	SCALE 4,0 kgf.cm			SCALE 5,0 kgf.cm			SCALE 6,0 kgf.cm		
		A	B	C	A	B	C	A	B	C
1	MINIMUM	2,50	2,50	2,50	2,90	2,90	2,90	3,30	3,30	3,30
2	MAXIMUM	2,70	2,80	2,70	3,20	3,20	3,20	3,70	3,70	3,70
3	MEAN/RATA-RATA	2,63	2,66	2,64	3,03	3,04	3,05	3,51	3,50	3,48
4	*STANDARD* DEVIASI	0,08	0,08	0,08	0,09	0,11	0,10	0,12	0,12	0,12
5	CPK (Cpk 1)	4,98	4,98	4,90	5,73	5,09	5,66	5,87	5,61	5,64

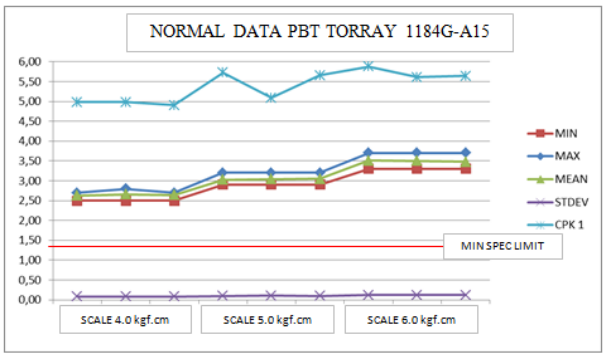

Figure 19. TORRAY 1184-A15 PBT Test Chart

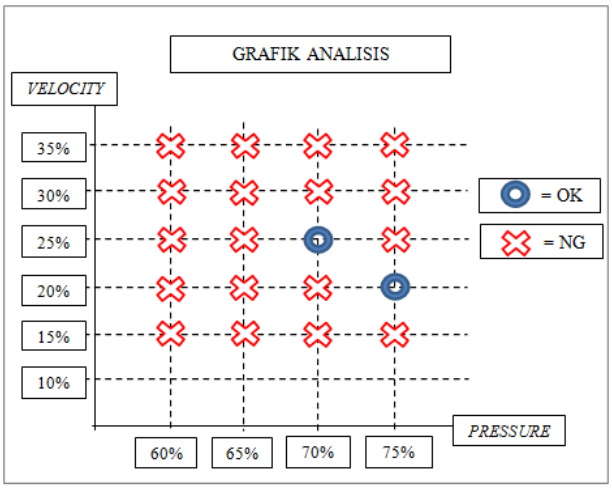

Figure 20. Parameter setting analysis chart

From the experimental data above, it is obtained that the right parameter settings for the PBT KINGFA RG 151 material are when using a velocity of 20%, the pressure used is 75%, and when the velocity is 25%, the pressure used is 70% to produce a product that meets the standards and specifications.

5.0 CONCLUSION

From the material analysis and the results of experiments and tests that have been carried out, it can be concluded that the smaller the velocity, the greater the pressure needed. This is because the KINGFA RG 151 material contains glass fiber content. From the test results and data, it can be seen that the results obtained from the PBT KINGFA RG 151 material are not much different from the data obtained from the PBT TORRAY 1184-A15 material, this is clearly seen from the results of the average and Cpl values, so that the material that PBT KINGFA RG 151 can be used sustainably.

5.1 Recommendation

In the next study, it may be possible to try other types of parameters or try by mixing recycled materials with virgin materials, with a mixing ratio of 10:90, 20:80, or 30:70. If the test results are

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declared OK, of course, this can further increase the company's competence.

REFERENCE

[1] Hanry Febryanto. 2013. Pengaruh Variasi Temperature dan Panduan Polyprorylene dengan Serbuk Arang Kayu Terhadap Kekuatan Impact pada Proses Injection Molding, Universitas Jember
[2] Imam Mujiarto. 2005. Sifat dan Karakteristik Material Bahan Plastik dan bahan Aditif, AMNI Semarang
[3] Buku Panduan. Manual Book Maintenance and Inspection Molding, Departement Part Production PT. Tanjung Harapan Sentranusa
[4] Buku Panduan. Molding Basic Course Schedule for Nidec Sankyo, Departement Part Production PT. Tanjung Harapan Sentranusa
[5] Hadi Wijaya. 2009, Hadi Wijaya's Blogger, Proses Injeksi Plastik, Trainner for New Engineering at PT. Epson

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