IMPROVEMENT OF rHDPE PLASTIC QUALITY USING SIX SIGMA AND TAGUCHI METHODS

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Abstract This study aims to determine the optimum process parameters in producing plastic bag in the application of Blown Film Extrusion Process. It is very critical to enhance product quality by optimizing the parameter, since preventing defected product not only can minimize cost but also can attract more customer. Recycled High Density PolyEthylene (rHDPE) was studied in this experiment which widely used in both industry appliance and household. In accordance with the purpose of this research mentioned above, Six Sigma and Taguchi were adopted to define which factors and levels affected the quality of product, namely extruder temperature, extruder rotation, winder rotation, and take up rotation. The orthogonal array of Taguchi’s L9 (3⁴) was used to carry out the experimental plan. The effect of parameter was evaluated through weight measurement of specimen. The result of the study reveals that the quality of products were optimized under the process combination of extruder temperature 170°C, 3,468 RPM screw rotation, rotation takes up 1,242 RPM, and winder rotation 1,620 RPM.

Keywords: Blown Film Extrusion, Plastic, Quality, Six Sigma, Taguchi

1. Introduction

Plastics, which are usually synthesized using non-renewable fossil resources, are materials that are very often used in modern life. At present, there are mounting environmental problems regarding polymeric waste, especially Polyethylene (PE) and Polypropylene (PP) which are the two most common plastic materials encountered. In 2017, domestic plastic consumption reached 4.4 million tons [1]. These plastic materials cannot be biodegradable, the decomposition process takes a long time, maybe up to hundreds of years [2].

The concept of sustainable development comes from the efficient use of natural resources and the expansion of new technologies that can be achieved by reducing raw material consumption and pollution emissions and increasing waste recycling rates. Therefore, recycling plastic can be a solution. However, recycled plastic tends to have a lower level of performance than pure plastic, so the application of recycled plastic is limited. By optimizing production process parameters, recycled plastic products with desired material properties will be achieved.

PT. Asia Recycle Mandiri is a plastic recycling company that uses Recycled High-Density Polyethylene (rHDPE) material, which means that the HDPE material in this production process is 100% recycled material. The Extrusion Blown Film process is used in the production process in this company. In this process the polymer is melted and extruded through an annular mold and air is released from the mold to blow a balloon-like tube and cooled by an air ring at a certain distance forming a film. The results of the blow will go through the rolling process so that the plastic will be flat and collected in the form of a roll. This process is followed by cutting, sealing, printing, quality checking and packing processes [3]. PT. ARM still has internal problems, where the company's operations are still unstable. The discovery of defects that exceed the standard allows this company to experience a decrease in customer loyalty that has an impact on the company’s revenue.

Table 1 is the data on the product number and product defects of PT. ARM 2017. The standard percentage of defects is 4-5% for HD defects and 18% for Finishing defects. It can be seen in Table 1 that the percentage of plastic bag defects in this company is still very high, therefore quality control to minimize defects is very necessary.
Table 1. Data on Total Production and Defect in 2017

| Month | HD Production (Kg) | HD Defect (Kg) | HD % | Finishing Production (Kg) | Finishing Defect (Kg) | Finishing % |
|-------|-------------------|---------------|------|---------------------------|-----------------------|-------------|
| 1     | 35.968            | 1.162         | 3.13 | 229.823                   | 41.769                | 18.2        |
| 2     | 35.843            | 1.237         | 3.4  | 209.864                   | 36.654                | 17.5        |
| 3     | 38.969            | 1.377         | 3.5  | 236.081                   | 40.162                | 17.1        |
| 4     | 27.482            | 1.478         | 5.3  | 202.670                   | 35.075                | 17.3        |
| 5     | 27.456            | 1.660         | 5.8  | 212.278                   | 39.72                 | 18.5        |
| 6     | 24.102            | 1.080         | 4.5  | 97.300                    | 18.994                | 19.2        |
| 7     | 21.553            | 2.032         | 9.4  | 115.920                   | 23.978                | 20.7        |
| 8     | 21.565            | 4.600         | 21.3 | 171.154                   | 38.593                | 22.5        |
| 9     | 31.493            | 1.495         | 4.75 | 149.532                   | 27.628                | 18.5        |
| 10    | 31.259            | 1.792         | 5.8  | 123.327                   | 23.811                | 19.3        |
| 11    | 30.069            | 2.024         | 6.8  | 167.524                   | 32.236                | 19.2        |
| 12    | 26.372            | 1.884         | 7.14 | 196.547                   | 40.569                | 20.6        |

One method that can be used to carry out the Taguchi control quality method which is included in the offline quality control. Off line quality control activities will drive to minimize product deviations from predetermined quality characteristics so that it comes to consumers the product will be truly feasible to use because it matches the specifications [4]. The Taguchi method is a system in engineering quality that considers saving experimental costs by applying engineering concepts and statistics [5]. In applying the Taguchi method, influential factors to defects are needed. The identification of these factors can be done using Six Sigma tools. DMAIC Six Sigma Process changes from the company's view of quality, from the final quality inspection to inspection in the process. Required companies to implement preventive measures against defects better. From the Six Sigma analysis, the factors that prioritize the quality of the production process of the plastic bags are obtained hence the quality control can be carried out according to the Taguchi experiment. Taguchi is a Robust Design so that the experiments are not sensitive to the variations caused by other factors.

From this study, the level of the most optimal factors will be obtained on each factor, hence production parameter that can be determined which can help reduce deviations in the products are produced.

2. Method

This research uses descriptive and experimental research methods, namely by describing a phenomenon, events, events that occur now and conducting experiments directly with the object of research. The object of this research is rHDPE plastic bag. This research was conducted at PT. Asia Recycle Mandiri, Karanganyar Regency from August to December 2018.

2.1 Stages of Research

In conducting this research it is divided into several stages, namely:

2.1.1 Preliminary stage

The following is a preliminary study:

1. Field Study

Field studies are carried out by directly examining the company's production to find out the process of producing plastic bags and defective products that occur in the production of plastic bags

2. Literature Review

Literature studies are carried out in the hope that theories and methods related to the problem and research objectives are obtained.

3. Identification and formulation problems

The identification phase serves to understand the problems that occur in the company.

4. Determination of research objectives

The research objective was carried out based on the formulation of the problem described earlier.
5. Formulation of the hypothesis  
The formulation of hypotheses is done hence research can be done.

2.1.2 Data Collection Phase  
The following types and data sources used in this study:

1. Primary Data  
In this study the primary data obtained from observations of the factors that affect the level of damage to plastic bag products of PT. ARM in 2018.

2. Secondary Data  
Recorded data in the company, the library materials and the company literature is secondary data that will be used in this study. Secondary data collected were company profile data, total production of rHDPE plastic bags in 2017, and defective product data in the production process of rHDPE plastic bags at PT. ARM.

2.1.3 Data Processing Phase  
Processing and analysis of data were obtained from observations in the company done by using Six Sigma and Taguchi methods. Data processing is related to product quality (product defects) by using the Six Sigma method by performing DMAI method. From the results of the analysis, identification was done to which production parameters affect the defect. The next step is improvement using the Taguchi method, where the first thing that needs to be determined is the determination of quality characteristics. Then determine the level for each factor and orthogonal array and the number of experiments to be carried out. Then Taguchi experiments, data processing, calculation of confidence intervals, optimal level settings, and confirmation experiments as a form of experimental validation.

2.1.4 Analysis and Conclusion Phase  
The analysis was conducted to determine the suitability between the results of the study and the research objectives described in the previous chapter.

The research conclusions are taken from the results of data processing and analysis that has been done. This is based on the research objectives set in the previous chapter.

The flow of research conducted in this research is illustrated in Figure 1.

3. Results and discussion  
3.1 Six Sigma  
The data obtained from the company is processed based on the DMAI cycle (Define, Measure, Analyze, Improve) on the Six Sigma method so that priority issues can be obtained, then improvement recommendations will be given as an effort to reduce defects in rHDPE plastic bag products at PT. ARM.
3.1.1 Define Stage
In the Define stage, a definition and description of the quality problems faced by PT. Asia Recycle Mandiri along with determining the goals to be achieved. At this stage the researcher mapped the object of research using a flowchart to determine the production process of rHDPE plastic bag.

After knowing the production process, then the definition of Critical To Quality is carried out and the collection of rejected data. Table 2.

3.1.2 Measure Phase
At this stage, prioritizing the improvement of process capability calculations and calculation of DPMO values and sigma levels are carried out. Figure 3 is a Pareto diagram showing the frequency of the types of defects that occur in the production process of rHDPE plastic bags at PT. ARM. Figure 3 reflects the most frequent sequence of defective product, Check Meter. The number of defects has the largest percentage, where the estimated type of defect, Check Meter for the total number of defects, amounting to 48.92%. In accordance with the Pareto Diagram principle, it was found that the priority of defect made as an object of improvement is Check Meter. The process of cutting and sealing cannot be carried out further in this study because it requires certain machine setting in the process. In the [6], one of the significant parameters in the plastic production process is the packing / sealing pressure.

In reality at PT. ARM, the sealing machine used is still semi-manual, while using a lever operated by the operator. The parameters on the machine are only temperature sealing. In carrying out the production process, plastic bags at PT. ARM can be distinguished based on the thickness of the plastic per meter, or what is often called a Check Meter. Certain thickness is produced according to customer demand. The greater the check meter, the greater the thickness of the plastic. A good quality check meter needs to have the same value or ± 0.2 gr with a predetermined standard. The value of a check meter that is not suitable will harm both the company and the customer. If the check meter exceeds the specifications, then the loss is in the company because it means that the material is issued more so the plastic is thicker than the specifications that have been made. Conversely, if the check meter is less than the specifications, then the customer will feel lost because the thickness of the plastic is not up to the standard they expected. In this study, the Check Meter to be studied was 9gr / m.

Based on Figure 4, it is a proportional control map or \(^{-p}\)-chart for the blowing and rolling process. According to the results of the calculation for the controller map, the calculation of the UCL value is 0.0805 and LCL is 0.0635. There are a lot of observations that go beyond the limit at UCL in the blowing and rolling process hence the production is unstable because of variations in special causes that occur in this process and will be searched using the 5 why Analysis in the next stage. The following are the results of the calculation of the process capability values for the production process of rHDPEplastic bags shown in Table 3.

Because 1,00 ≤ Cp ≤ 1,99, which is Cp = 1,198, the process capability is not enough to improve the zero failure target.
**Figure 2.** Flowchart of Production Process of rHDPE Plastic Bags at PT. ARM

**Figure 3.** Pareto diagram of defects in rHDPE plastic bags PT. ARM
Table 2. Critical-to-Quality (CTQ) Recap in rHDPE Plastic Bag Production

| No | Process                  | Defect          | Note                                                                 |
|----|--------------------------|-----------------|----------------------------------------------------------------------|
| 1  | Washing                  | -               | -                                                                    |
| 2  | Grinding                 | Big Flakes (BF) | The size of the splinter or plastic count is still too large to process |
| 3  | Melt Pelletizing         | Hard Pellet (HP) | The resins are too hard / there are grains that have not melted completely |
| 4  | Blowing and rolling      | Fish Eye (FE)   | Surface defects are characterized by circular cavities with thinner layers than other parts |
|    |                          | Setelan (ST)    | Thick surface defects. Almost the same as FE, but has a shape from end to end of the plastic |
|    |                          | Cek Meter (CM)  | Plastic scales per meter do not match the specified specifications. |
|    |                          | Shrinkage (SK)  | Wrinkling plastic surface                                            |
| 5  | Cutting and sealing      | Sealing (S)     | Sealing Defect                                                       |
|    |                          | Handle Misalignment (HM) | Cutting the bag handle is not symmetrical                           |
| 6  | Packaging                | -               | -                                                                    |

Table 3. Calculation of Process Capability Value (Cp) for Plastic Bags

| Process                        | Total Defect | DPMO | Sigma Level | Cp  |
|--------------------------------|--------------|------|-------------|-----|
| Blowing and rolling            | 16.160       | 18.038 | 3,596       | 1,198 |

3.1.3 Analysis Phase

5 Why Analysis. Discussions with the production manager and several heads of production departments were carried out to obtain sources of causes of defects which can be seen in Table 4.

3.1.4 Improve Phase (Taguchi)

In this study, improvements were made using the Taguchi method. This method is used to optimize the level settings to minimize defects that occur.
Table 4. Analysis of 5 Why Defect Check Meters for rHDPE Plastic Bags at PT. Asia Recycle Mandiri

| Defect Description                                                                 | Why 1                                                                 | Why 2                                                                 | Why 3                                                                 | Why 4                                                                 | Why 5                                                                 |
|-----------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|
| There is a problem with the plastic film drawing system                           | Density between layers of roll is not uniform                        | Pressure between nip rollers is not appropriate                      | Nip roller is too tight on one side                                  | Dirty bearing                                                       | Roller cleaning is not scheduled properly                          |
| Plastic film stretches too far                                                    | Engine pressure is too high                                          | Film take-up speed and winder speed are not suitable                 | Screws + die speed is not stable                                     | Air rings are not set correctly                                     | The absence of machine settings that are used as company standards  |
| Cooling of the bubble film is not evenly distributed                              | Die too cold                                                        | Heating the engine too fast                                         | Die too cold                                                        | Air rings are not set correctly                                     | The absence of machine settings that are used as company standards  |
| Die / extruder has a problem                                                       | The melting flow is not evenly distributed on the die / extruder     | Uneven pressure distribution                                        | Screw + die speed is too high                                       | The absence of machine settings that are used as company standards  | The absence of machine settings that are used as company standards  |
| Dirty die lane                                                                    | There is residual material burning and mixed with new resin         | There is residual material burning and mixed with new resin         | There is no filter / die cleaning schedule                          | There is no filter / die cleaning schedule                          | The absence of machine settings that are used as company standards  |
| Material / resin / pellet has problems                                             | There are variations in material viscosity                          | The pellet hasn't melted perfectly                                  | Heating temperature is not suitable                                 | The resin / pellet on the die that was off was not cleaned again    | The resin / pellet on the die that was off was not cleaned again    |
|                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                 |                                                                                                                                                                                                 | 82                                                                 |
1. Determination of Quality Characteristics
   The determination of the quality characteristics of the expected plastic bag production process is Nominal The Best which is 9 gr/m of Check Meter Value, hence it can improve the quality of plastic bags and reduce defective output.

2. Determination of Influential Factors and Levels

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**Table 5. Taguchi Factors and Levels**

| Influential Factors                        | Factor 's Level |
|-------------------------------------------|-----------------|
|                                          | 1               | 2               | 3               |
| Extruder Temperature (screw+die) (°C)     | 160             | 170             | 180             |
| Screw Rotation (RPM)                     | 3.288           | 3.468           | 3.648           |
| Take up Rotation (RPM)                   | 1.242           | 1.302           | 1.362           |
| Winder Rotation (RPM)                    | 1.560           | 1.620           | 1.680           |

**Table 6. Average Check Meter Calculation Results**

| Experiment | Control Factor | Result | Average |
|------------|----------------|--------|---------|
|            | A   | B   | C   | D   | I   | II  | III  |       |
| 1          | 1   | 1   | 1   | 1   | 8,1 | 8,3 | 8,2  | 8,20  |
| 2          | 1   | 2   | 2   | 2   | 8,6 | 8,5 | 8,4  | 8,50  |
| 3          | 1   | 3   | 3   | 3   | 7,7 | 7,8 | 7,9  | 7,80  |
| 4          | 2   | 1   | 2   | 3   | 8,1 | 8,1 | 7,9  | 8,03  |
| 5          | 2   | 2   | 3   | 1   | 8   | 7,9 | 7,8  | 7,90  |
| 6          | 2   | 3   | 1   | 2   | 9,6 | 9,5 | 9,9  | 9,67  |
| 7          | 3   | 1   | 3   | 2   | 8,6 | 8,8 | 8,7  | 8,70  |
| 8          | 3   | 2   | 1   | 3   | 9,1 | 9   | 9,2  | 9,10  |
| 9          | 3   | 3   | 2   | 1   | 10,8| 10,6| 10,8 | 10,73 |
Table 5 is a causal factor identified by the quality characteristics of the plastic bag production process. Orthogonal arrays carried out in this study are \( L_9 = 3^4 \).

a. Extruder Temperature
The extruder box is the part where the plastic pellets are melted. Providing the appropriate temperature can produce perfect plastic liquid, not clumping and not too hot which causes the quality of the bag yield to decrease. The rHDPE material used as a production process input has resistance to temperatures up to 185 °C (Callister, 2006). In this research, the temperature of the extruder machine was observed with a factor level of 160 °C, 170 °C and 180 °C. The maximum temperature of 185 °C was not used in this study because based on discussions with the production party the use of temperature 185 °C is rarely used, it is feared that too hot temperatures will cause the material to burn and the quality of the plastic to decrease. Moreover, the material used is recycled which has been done before.

b. Screw rotation
In addition to temperature, there is a speed factor for the extruder screw in the extruder box. Polymer flow depends on the viscosity. Viscosity will vary based on the shear rate and melting temperature. Therefore, the screw rotation on the extruder machine controls the polymer shear rate. If the screw rotation is too low, this will cause the hardening of the material inside the extruder and produce pronging. Pronging is a polymeric material that hardens and can disrupt the smooth process of blowing the bag. Conversely, if the extruder rotation is too high, it is feared that it can cause a larger plastic thickness than the specifications. This is due to the flow of polymers that have moved forward while the previous polymer is still running. Screw rotation factor levels in this study were 3,288, 3,468, and 3,648 RPM, respectively.

c. Take up rotation
Take up speed in the blowing and the rolling machine is related to the theory of Blow Up Ratio in the Blown Film Extrusion process. Blow up ratio (BUR) is a mathematical calculation in determining the diameter of a plastic film. BUR also affects the orientation of polymer molecules [7]. The film is pulled to reach the main diameter of the bubble. At the same time, the film is taken up towards the engine. By pulling the film in two directions, the molecules become oriented in both directions, forming the desired bubble size. Incorrect calculation of BUR will result in defects due to incongruous pulls. However, because the blowing and rolling machines in the company are semi-manual machines, there is no BUR setting. The settings related to BUR are only for take-up rounds. The level of taking up a rotation factor in this study is 1,242, 1,302, and 1,362 RPM. At PT. ARM, the engine for this parameter is seen in the form of speed, therefore it uses RPM units.

d. Round Winder
The roll winder function is similar to take up, which is to roll plastic, but the position of the winder is at the bottom of the blowing and rolling machine. Take up rolls up the blowing plastic from the top of the machine, while the winder rolls up the plastic that has been made from the bottom so it doesn't loosen. This parameter has an RPM unit with the values of the factors of 1.560, 1.620 and 1.680.

3. Implementation of the Taguchi Experiment
At the stage of the Taguchi experiment, the influential factors in the production process of 4 9gr / m rHDPE plastic bags will be assigned to the orthogonal array table. Table 6 is the result of the Taguchi experiment. The examination of plastic bags is carried out following the company's quality control section, after the roll process is complete, weighing the plastic bag is done. Observation of the number of plastic bags is carried out every 15-30 minutes. The data on the results of the Taguchi experiment is the weight of a plastic bag (check meter).
The choice of the best value based on the quality criteria used is Nominal. The best. In this study, the target value is 9gr / m. From the calculation of the response table above (Table 8), obtained one of the levels of the factor issued 9gr / cm, namely Factor A Level 2 (Extruder Temperature 170 °C), Factor B Level 2 (Screw Rotation 3,468 RPM), Factor C Level 1 (Winder Rotation 1,242 RPM), and Factor D Level 2 (Take Up Rotation 1,620 RPM).

4. Calculation of Analysis of Variance (ANOVA)

The Taguchi method uses ANOVA attribute data to look for factors that influence the response value. The following table 7 is the result of the ANOVA table.

| Source | SS   | DF | MS   | Fratio | SS' | Ratio % |
|--------|------|----|------|--------|-----|---------|
| A      | 8.69 | 2  | 4.35 | 300.95 | 8.67| 38.58   |
| B      | 6.09 | 2  | 3.05 | 210.95 | 6.07| 27.00   |
| C      | 4.97 | 2  | 2.48 | 171.87 | 4.94| 21.98   |
| D      | 2.45 | 2  | 1.22 | 84.79  | 2.42| 10.78   |
| Error  | 0.26 | 18 | 0.01 | 1      | 0.38| 1.67    |
| SSTotal| 22.46| 26 | 11.12|        |     |         |

Table 8. Response Table

| Factor | A     | B     | C     | D     |
|--------|-------|-------|-------|-------|
| 1      | 8.17  | 8.31  | 8.99  | 8.94  |
| 2      | 8.53  | 8.50  | 9.09  | 8.96  |
| 3      | 9.51  | 9.40  | 8.13  | 8.31  |
| Diff   | 1.34  | 1.09  | 0.96  | 0.64  |
| Rank   | 1     | 2     | 3     | 4     |

It can be concluded that factors A, B, C, and D have an influence on the value of check meters. Factor A (temperature extruder) has the largest contribution among other factors, which is 38.58%. This is in accordance with [8] statement, which conducted an experiment Taguchi HDPE material against shrinkage defects, it was found that the melting temperature was the most effective parameter in reducing shrinkage defects. Extrusion temperature is one of the factors that play a major role in determining the properties associated with the final film plastic produced. The melting temperature of 170 °C is the temperature that is suitable for HDPE. Temperatures that are too low can allow the plastic to not completely melt, while too high a temperature significantly increases the number of molecules activated and speeds up the movement of molecules, and thus increases the reaction. Higher temperatures involve more energy and can cause degradation [9]. So it is very possible that the contribution of the temperature factor of the extruder is the biggest among other factors.

The next 27% influential factor is factor B (screw rotation). During extrusion, pellets, powders or resins are flowed forward through a barrel, so that the screw rotation/speed contributes to heating and plasticization. Extruder screw mixes powder or resin and gives homogeneous melting results to the mold [10]. In table 6 it can be seen that the temperature is too high along with screw rotation resulting in a high thickness of plastic. This is in line with [11] which states that an increase in lamellar thickness (layer) can be induced by
annealing (heating) and high screw speeds while the rolling speed is low.

The third influential factor is factor C (take-up rotation) with a contribution of 21.98%. Take Up Ratio (TUR) is defined as the speed of the film at the nip roll at the speed of the polymer melting at the exit of the mold. According to [12], high Take Up values are associated with a greater reduction in film thickness. Stable operations are also limited to higher take-up. For a high take-up ratio, the possibility of other instabilities arises called draw resonance instability.

Finally, the winder rotation is 10.78%. This factor, though not significant, still has an influence on the quality of plastic bags. The quality of winding results depends on take-up, the more films are drawn, the more strains there is, so that it is increasingly difficult for rolling winders [13].

| Table 9. SNR Response Table |
|-----------------------------|
| Factor | A | B | C | D |
| 1    | -40.00 | -39.73 | -38.69 | -40.29 |
| 2    | -37.81 | -40.33 | -40.03 | -38.67 |
| 3    | -40.87 | -38.61 | -39.96 | -39.72 |
| Diff | 3.07 | 1.73 | 1.34 | 1.63 |

| Table 10. End Result of SNR ANOVA |
|-------------------------------|
| Resource | SS | DF | MS | Fratio | SS' | Ratio % |
| A        | 14.96 | 2 | 7.48 | 33.01 | 14.51 | 53.67 |
| B        | 4.60 | 2 | 2.30 | 159.34 | 4.15 | 15.35 |
| C        | 3.39 | 2 | 1.69 | 117.22 | 2.93 | 10.85 |
| Pooled   | 4.08 | 2 | 0.23 | 16 | 5.44 | 20.12 |
| SST      | 27.03 | 8 |
| Mean     | 14.084,12 | 1 |
| SSTotal  | 14.111,16 | 9 |

5. Calculation of SNR Value

6. Determination of Optimum Setting Level

Table 9 above is different from the previous Table 10 shows the comparison of the effect of average response table, where the variance each parameter performed on the observed CTQ response table is used to see the effect of product based on the average factor and variance. variance, while the average response table is utilized so that the level of factors that have the highest / optimal contribution and affect the average value is known.

From Table 10, pooling is only one factor, namely Calculation of Average and SNR Value are shown factor D, because that factor has the lowest Sum of in Figure 5 and 6. Squares (SS) value of the other three factors. While factors A, B, and C are influential and high. Confirmation Experiment contributing factors compared to factor D. Figure 6 shows that the confirmatory experimental Calculation of contribution percentage shows the results for SNR values can be accepted with percentage of error contributions of 20.12%, which consideration of the confidence interval. It can also means that significant influential factors are not be interpreted that the results of the Taguchi lost from the experiments.

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setting can be used as a reference in an effort to improve the check meter value of rHDPE plastic bag. In addition, using the optimal factor level, ten c. experimental plastic bags have a standard check meter values company which is 9gr / m ± 0.2 cm. So it can be concluded that by using optimal factor and level factors, plastic bags can be produced with a check meter value determined by the company.

4. Conclusion
From the results of research and data processing with the Six Sigma and the approach of the Taguchi method can be drawn as follows:
a. rHDPE plastic bag which has the highest d. number of defects in the blowing and rolling process. Critical To Quality (CTQ) in the process is fish eye, settings, check meter, and shrinkage.
b. Defect Per Million Opportunity (DPMO) value for current conditions in the blowing and rolling process is 18,038, sigma 3,596 level and process capability 1,198. Because of 1.00 Cp ≤ 1.99, which is Cp = 1,198, then the process capability is not up to enough so that the process needs to be increased in order to get to the zero failure target.
The causative factors for defects in rHDPE plastic bags were sought using 5 why analysis. Based on the results of discussions with the production parties at PT. ARM, the problem that was given a recommendation for improvement for check meter defects is that roller cleaning is not scheduled properly, there is no machine setting that is used as a company standard, the air ring is not set properly, the resin/pellet on the die that was off is not cleaned again.

Recommendations for improvements given based on the results of the Response Table and ANOVA in the Taguchi experiment. Optimal level settings are obtained from controlled factors, factors that have a high level of significance and a large contribution to the reduction in this experiment are melting temperatures of 170 °C, with a contribution of 34.76%, 3,468 RPM screw rotation with a contribution of 27%, rotation takes up 1,242 RPM with a contribution of 21.98%, and the last D factor of winder rotation 1,620 RPM which is 10.78%.

Table 10. Effect of factors on the average and variance calculation of Taguchi

| Factor | Rank | Effect | Level |
|--------|------|--------|-------|
|        | Mean | Variance |        |
| A      | 1    | 1      | Significant and Great Contribution | A2     |
| B      | 2    | 2      | Significant and Great Contribution | B2     |
| C      | 3    | 3      | Significant and Great Contribution | C1     |
| D      | 4    | 4      | Significant and Small Contribution | D2     |
Comparison of Confidence Intervals
Average Value of Check Meter

Figure 5. Average Trust Interval Hose

Comparison of Confidence Intervals
SNR Value of Check Meter

Figure 6. SNR Trust Interval Hose

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