

# Improving Quality of PVC Pipes Using Taguchi Method

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**Abstract.** PT. XYZ is a company in the field of industrial manufacture of PVC pipe (Poly Vinyl Chloride). Pipe products produced often have a disability are not standards-compliant (5,5%) and exceeds the tolerance ( $\pm 1\%$ ), which has been set by the company. Competitive competition in product marketing lead companies needs to boost quality. The importance of quality is one of the reasons to research the quality of products produced by the company. This study using method seven tools and taguchi to analyze and improving the quality of pipe. Seven tools method used to identify factors that influence product defects. Taguchi method produces the optimum combination of factors that influence the level of significance is the coolant temperature 20 ° C at level 2, extruder temperature of 150 ° C at level 1, haul off the speed of 18 m / s at level 1 and a pressure of 0.06 MPa printing at level 1.

Keywords: **PVC, Quality, Seven Tools, Taguchi Methods**

## 1 Introduction

In the era of globalization, companies must be able to optimize their resources. Wherewith the enactment of the ASEAN Free Trade Area (AFTA) and the ASEAN-China Free Trade Area (ACFTA) in 2015, competition in the industrial world in both the manufacturing and service sectors is increasingly competitive. In this competition, companies must be able to compete to survive by demonstrating the superiority of each product produced. One way to show its superiority is to improve the quality of products manufactured under the wishes of consumers.

This condition also happened to PT. XYZ to continue to improve product quality by reducing the number of damaged products produced. PT. XYZ is a company engaged in manufacturing PVC pipe products (Poly Vinyl Chloride). In producing PVC pipes PT. XYZ still produces defective products, namely corrugated pipes, dented pipes, and charred pipes. The extrusion process strongly influences the quality of PVC pipes. Extrusion is the process of heating materials to become solid fluids carried out on an extruder machine. Where in the extrusion process, if the heating temperature is too high, it can cause the pipe to burn and the temperature too low, resulting in the pipe clumping. Coolant temperature and incompatibility Speed of extruder and haul off, where the speed of haul off is faster than the speed of the extruder resulting in corrugated pipes. Mismatch between printing pressure and haul off speed results in a dented pipe.

During the production process, the pipes often produced experience defects that are not under the standards and exceed the prescribed tolerance. Historical

data on the disability of PVC pipe production in September 2014 the average percentage of defective products reached 11.042%. The rate of disability is not under the standards set by the company, which is 6% with a tolerance of  $\pm 1\%$ . This resulted in the company having to recycle from defective products, to reduce product defects needed repair efforts. So in this study, researchers used seven tools as a tool to identify factors that cause product defects. The Taguchi method is used to determine the process so that it can control the condition of the process by observing the characteristics of the product and process parameters to obtain a combination of optimum factor levels from the process parameters.

## 2 Methodology

The research was conducted at pipe industry is located on Batangkuis Street Km 3.8 Pasar V, Telaga Sari Village. The object studied is PVC pipe products that do not meet company standards, namely corrugated pipes, dented pipes, and charred pipes. According to the relationship between one variable with another variable, the research variables are divided into:

1. Independent variable  
Independent variables are variables that affect the dependent variable, both positively and negatively (Sinulingga, 2011). The independent variables in this study are corrugated pipes, dented pipes, and charred pipes.
2. Intervening variables  
Intervening variables are a factor that theoretically influences observed phenomena (the relationship

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between the dependent variable and the independent variable becomes indirect) but cannot be seen, measured, or manipulated. Intervening variables are often also referred to as interrupting variables or intermediate variables that lie between the independent variables and the dependent variable (Sinulingga, 2011). The intervening variables in this study were identifying the causes of disability, the combination of optimum factor levels and proposed improvements to the highest probability of the cause of product disability.

3. Dependent variable

The dependent variable is whose value is influenced or determined by the value of other variables. The dependent variable in this study is the quality of PVC pipe products

### 3 Result and discussion

#### 3.1 Seven tools technique

Seven tools are the basic tools used to solve the problems faced by the production, especially on issues related to quality. Seven tools in this study were used to analyze the quality problems of pipes using checksheet, stratification, histogram, Pareto diagram, scatter diagram, control chart, cause and effect diagram. Based on these seven tools, the results of defects contained in pipes are corrugated pipes, dent pipes, and scorched pipes. Of the three defects, it is known that the frequency of defects that occur very often is the corrugated pipe with a total defect of 404, while the pipes are experiencing dents and scorched respectively at 214 and 58. Defects of these pipes can occur due to several factors, including human factors, machinery, methods, or materials. From human factors, defects can occur due to an inaccurate operator, factors such as the implementation of SOP that does not run in the company, machine-like factors such as temperature and engine speed are not suitable, and material factors such as material composition that is not blended evenly.

#### 3.2 Taguchi Method

1. Determination of variables not free

The non-dependent variable used in this study is the quality of pipe products. The characteristics used are smaller, the better, which means that the reduced number of defective products will make the quality better. The variables identified to affect the quality of PVC pipes based on the results of the causal diagram are as follows:

- Extrusion temperature which functions to fuse PVC pipe raw materials into solids.
- The rotating speed of the extruder machine serves to drain the material into the haul off towards the molding machine.
- The pressure of the printing machine serves to form a pipe when printing to be round.

- The speed of the haul-off machine functions to drain the liquid material from the extruder to the pipe molding machine and pull the pipe out of the molding machine.
  - The coolant temperature serves to cool the pipe after exiting the mold
2. Determination of number of levels and factor level values

The results of this level setting data can be seen in Table 1.

**Table 1.** Determination of Number of Levels and Factor Level Values.

Kode	Controllable Cause	Level 1	Level 2
A	Extruder temperature	150°C	180 °C
B	Stamping pressure	0,06 MPa	0,07 MPa
C	Speed haul off	18 m/s	22 m/s
D	Speed of extruder	27 m/s	30 m/s
E	Cooler temperature	17°C	20°C

3. Calculation of Degree of Freedom (DOF)

The degree of freedom is calculated to determine the minimum number of experiments that must be done.  $VOA = \text{number of experiments} - 1$ . The result of the degree of freedom can be seen in Table 2

**Table 2.** Calculation of Degree of Freedom.

Factor	Degree of Freedom (dof)	Result
A	2-1	1
B	2-1	1
C	2-1	1
D	2-1	1
E	2-1	1
BxD	(2-1) x (2-1)	1
<b>Total Derajat Kebebasan (dof)</b>		<b>6</b>

4. Selection of the Orthogonal Matrix

Based on the calculation of orthogonal matrix freedom degree, orthogonal matrix L8 (27) is chosen with the degree of freedom 7. Orthogonal matrix of experimental results of quality Matrix Experimental orthogonal results on PVC pipe quality can be seen in Table 3.

**Table 3.** Results of Experiments on Product Quality PVC pipe.

Sumbe r	Sq	V	M q	F-rasio	Sq'	p%
A	5,52 5	1	5,5 25	5,507	4,522	5,301
B	23,0 05	1	23, 00	22,930	22,002	25,792
C	8,12 0	1	8,1 20	8,094	7,117	8,343
E	38,8 08	1	38, 80	38,681	37,805	44,318

BxD	4,49 9	1	4,4 99	4,484	3,496	4,098
e	10,0 33	10	1,0 03		10,363	12,148
St	85,3 04	15			85,304	100
Sm	802, 268	1				
ST	892, 259	16				

5. Calculation of Factor Effects

The results of the calculation of the final SNR variance analysis can be seen in Table 4.

**Table 4.** Optimum SNR variance analysis.

Experiment	Orthogonal Matrix $L_8(2^7)$						Frequent of Reject (stem)		Average Reject (stem)	
	Factor						A	Replication 1		Replication 2
	A	B	C	D	E	BxD				
1	1	1	1	1	1	1	1	2	2	2
2	1	1	1	2	2	2	2	4	5	4,5
3	1	2	2	1	1	2	2	5	5	5
4	1	2	2	2	2	1	1	5	6	5,5
5	2	1	2	1	2	1	2	4	4	4
6	2	1	2	2	1	2	1	3	2	2,5
7	2	2	1	1	2	2	1	5	3	4
8	2	2	1	2	1	1	2	3	3	3

The interpretation of the results of calculating the number of PVC pipe defects can be seen in Table 5.

**Table 5.** Interpretation of the Results of the Amount of PVC Pipe Disability.

Response (Defective PVC pipe)		Prediction	Optimization
Taguchi experiments	Average	1,19	0,355
	Variability	4,28	1,247
Confirmation experiments	Average	1,1	0,408
	Variability	1,139	1,433

In Table, Taguchi's confidence intervals for process predictions are 1.19 with optimization of 0.355 and variability of 4.28 with optimization of 1.247. The confidence interval for the confirmation experiment is for the 1.1 average with 0.408 optimizations and 1.139 variabilities with 0.408 optimizations. Confirmation experimental results indicate that the optimal level setting is acceptable. It can be seen that the Taguchi experiment to the confirmation experiment has decreased in mean and variability.

**4 Conclusion**

The most influential factors were obtained from cause and effect diagrams and brainstorming which will be analyzed further with the Taguchi method, namely machine factors, including extruder speed, extruder temperature, haul off speed, printing pressure, and coolant temperature. The Taguchi experimental design obtains the combination of optimal level factors that have a significant effect as the basis for improving the quality of pipe products: extruder temperature 150 ° C at level 1, printing machine pressure 0.06 MPa at level 1, haul off speed 18 m / s level 1 and temperature cooling 20 ° C on level 2. So that in doing machine settings, the operator does not estimate the settings to fit.

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