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Analysis &Quality Improvement by using Quality Seven Tools Method & SEM PLS Analysis: A Case Study Market Defect Door Foam Shrinkage of Refrigerator Product

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Abstract:
Quality improvement activities are very important for companies in order to improve customer satisfaction. If any defective product is received by the consumer, it will reduce the value of customer satisfaction. One of the tools to analyze and improve quality problems is QC seven tools. QC seven tools method used to analyze and improve the market defect in the company PT XYZ. The problem was door foam shrinkage of refrigerator product at the period 2017-2018. Result of analysis obtained six root causes that is high rate of shrinkage urethane material, less amount of urethane material, low density urethane, output charging shape of urethane uneven, low jig temperature and making the inner door holes by manual. Others method used that are of statistical analysis are using SEM PLS software smart PLS. The results of the analysis gained two significant cause of low polyurethane/density (MP) and low jig temperature (TJ). Smart PLS Analysis results according to the QC seven tools, indicating that the statistical analysis can be applied to analyze the quality problems in the company PT XYZ so that becomes effective activities. The results of this activity can reduce the market defect from 0076% to 0.002% or decrease 97.47%.

Keywords:*Corporate Door Foam Shrinkage, Market Defect, QC Seven Tools, SEM-PLS.*

I. INTRODUCTION

The population in Indonesia every year continues to increase. The increase in population is accompanied by an increase in the number of families and also an increase in the value of GDP (Gross Domestic Product), which is a huge potential for a business industry manufacturing chain that manufactures and markets goods or products, especially products or household goods. In 2018, Indonesia's population increased by 1.003% from 264 million in 2017 to 265.05 million in 2018. In the same year there was an increase in GDP by 1.079% from 51.9 million in 2017 to 56 million in 2018. From the three items above, it can be seen that the enormous potential that is to be a consumer for the marketing of the manufacturing especially household appliances product.

According to (Hardi Purba & Aisyah, 2017) customers are very central parties in business transactions of products or services. The survival of an organization or company is very dependent on the customer. Once the importance of customers for a company so that in various ways the company seeks to how to meet customer or customer satisfaction through products or services by meet the desires of consumers by analyzing the factors that can be developed to increase the value or value of the product or service so that the potential for a positive market response.

Customer satisfaction is the level of consumer feelings after comparing the performance he feels compared to expectations. The level of customer satisfaction is determined by the size of the gap between consumer expectations with the reality of the product or service received by consumers. The

greater the gap between expectations and reality received by consumers, the greater the consumer's dissatisfaction with the product or service. Consumer dissatisfaction with a product or service because it is not in accordance with what is expected to have a negative impact on the success of the product or service. If this gap is not anticipated, it can cause a failure in marketing the product or service.

Study Literature

Quality

Quality is one indicator of fulfilling the wishes and needs of the customers in addition to price and on time delivery. The higher the level of quality provided by the company to consumers, the higher the level of customer satisfaction. According to (Tjiptono & Diana, 2001) state that quality is a dynamic condition associated with products, services, people, processes, and the environment that meets or exceeds expectations. According to (TUV Reinland, 2018) states that quality is the degree / level of characteristics inherent in products that meet the requirements.

According to (Yang et.al., 2019) prediction and factors that affect quality refrigerator panel deformation after foaming are studied and defined using three physical properties: temperature, density, and pressure to accurately predict rear panel deformation. Also can be used to predict the refrigerator panel deformation and some of its side effects. On the others a seat cushion having low density cannot achieve the resilience and hence seating comfort of a foam having higher density(Martin Glos, 2017).

QC Seven Tools

According to (Goetsch & Davis, 2014)QC seven tools are seven basic tools used to solve problems at production, especially on problems related to quality. The seven tools are flow chart, check sheet, control chart, cause and effect diagram, pareto diagram, histogram, and scatter diagram.

According to(Hardi Purba & Aisyah, 2017)The flow chart is a sequence of processes from beginning to end so that it can be mapped, analyzed which part of the process is not even precise is needed. The check sheet is a tool that facilities collection or relevan data, displaying it in a visual form easily understood. Check sheet make it easy to collect data for specific purpose and can be automatically converts them into useful information. Control chart is made to control statistical processes appropriately in accordance with the measurement data to determine the capability of the process. Cause and effect diagrams are tools that are not based on statistics to help identify and isolate problems. Pareto aims to show the priority order of a number of problems which are generally concentrated in one or two main problems, while other problems are less significant factors so that they can be ignored. A histogram is a graphical display of shapes to show the data distribution visually or how often a different value occurs in a data set. The benefits of using a Histogram are to provide information about variations in the process and assist management in making decisions in an effort to improve a sustainable process (continuous process improvement).Scatter diagram is a plot of data to examine the relationship between two variables from a set of measured data.

By using of QC seven tools can reduce defects by 90% in the chassis line and defects by 80% in the trim line in the automotive industry(Memon, 2019), reduce defect warp by 44% in the textile manufacturing (Suryoputro et.al, 2017), reduce rework in food industry by 80% (Ahmad & Hasan, 2016), reduce defect in the fan manufacture by 95% (Muhammad, 2015), reduce defect in the dry SLS product by over than 50% (Nurdin & Kusumah, 2018), reduce defect composition & temperature iron casting(Jadhaf et.al, 2013), increase capability process in drill manufacture (Patel, Shah, & Makwana, 2014), reduce defect in machine food industry (Sanny, 2015), and more effective analysis in manufacture process (Magar & Shinde, 2014).

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Also the implementation of Statistical Process Chart (SPC) can be control processes, identify problems from variations in processes in the food industry (Halim Lim et.al, 2015),control process at the Metal manufacture (Sousa et. al, 2017), automotive industry (Godina et al., 2018), mechanical component (Gejdos, 2015), bottle manufacturing (Mengesha, Singh, & Yimer, 2013)and developing country design (Madanhire & Mbohwa, 2016).

Partial Least Square – Structural Equation Modelling PLS is used for structural equation modeling in a research projects with limited data collected(Wong, 2013).Method for estimating (complex) path models with latent variables and their relationships (Sarstedt et.al, 2017).PLS handle all types of data, no metric to metric, with very minimal assumptions about the characteristics of the data (Sarstedt et.al, 2014). Also it handles both reflective and formative constructs and all recursive models are identified.

In the PLS structural equation model, have two sub models are the inner model and the outer model. The inner model which the relationships between the independent and dependent latent variables, and the outer model which the relationships between the latent variables and their observed indicators (Wong, 2013).

Methodology

This research uses two methods, namely using the QC seven tools method and SEM PLS statistical analytics to analyze the door foam shrinkage of refrigerator product problem. The QC Seven Tools method analyzes the problem by involving 4M factor: man, method, machine and material factors. The results of the analysis using the tool cause effect diagram shown in figure 2. After obtaining the main cause of the door foam shrinkage problem, an analysis of the determination of the dominant causes was carried out with the NGT (Nominal Group Technique) by the project team. So that the final root causes analysis the door foam shrinkage problem to be determined.

The second method used is the SEM PLS statistical method. This method processes data of three variables: raw material (RM) variable with indicators density polyurethane (MP), thickness panel sheet material (DSM) and polyurethane amount (IDP). Machine parameter (PAM) variable with indicators pressure hydraulic pump (PHP), machine pressure (PM), chiller temperature (TC), machine head temperature (THM), jig temperature (TJ), material tank temperature (TMT). Variable checking polyurethane (PP) with the indicator number of charging per second (JCD), cream time checking (PCT), gel time checking (PGT), tact free time checking (PTFT). Data processing variable data, carried out analysis using smart PLS software version 3.2.8.

The hypothesis determines that there are important factors that which will affect the door foam shrinkage. In that view, the research hypothesis is as follows:

1. H0: variabel will have a positive effect on defect of door foam shrinkage.
2. H1: variabel will haven't a positive effect to make defect of door foam shrinkage.

Data is collected from the CS sales company for 2 years start from January 2017 – December 2018 will be examined using QC seven tools method and Smart PLS version 3.2.8 to find out root causes and also to assess the research hypothesis.

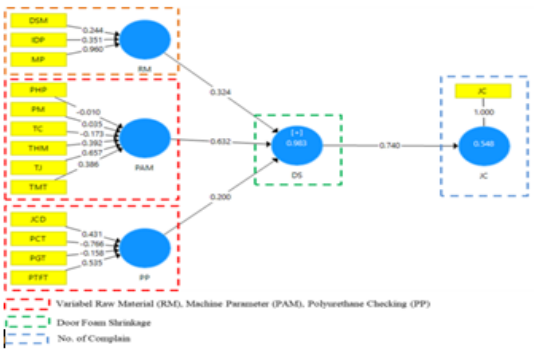

Figure 1 SEM PLS Research Model

Result

Evaluation of QC seven tools

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One of analysis with QC seven tools, that is make a cause effect diagram of 4 main factors of man, material, method and machine to determine the main cause of problem door foam shrinkage. Base on the team's discussion result, there were eleven main causes of the door foam shrinkage problem. The cause effect diagram can be shown.

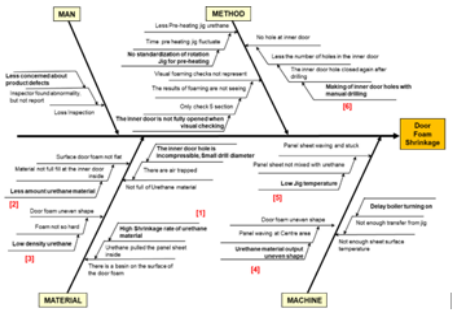

Figure 2 Cause Effect Diagram

Analysis result of door foam shrinkage problem with QC seven tools method, found eleven main causes. And continue using of NGT (Nominal Group Technique) technique and can be found six of dominant causes that is high rate of shrinkage urethane material, less amount of urethane material, low density urethane, output charging shape of urethane material uneven, low jig temperature and making the inner door holes with manual drilling that result in unstable holes.

Evaluation of SEM PLS method

For analysis using SEM PLS, must be considered of the construct model.In this research, the construct model is a formative model. So that the stages of evaluation follow the standard a formative model that was formative outer model & inner model confirmation (Sarstedt et al., 2017).

a. Evaluation measurement formative model (Outer Model)

There are three steps to analysis formative model (outer model), that is:

1. Convergent Validity,has been fulfilled base on the R-square value between 0.64-0.81.

Table 1 R-Square

Variable Manifest	R-Square	Explanation
Door Foam Shrinkage	0.981	> 0.64
No. of Complain	0.527	< 0.64

2. Collinearity Issue, has been fulfilled base on values of VIF <5

Table 2 Outer VIF

Variabel	VIF	Explanation
MP	1.759	< 5
DSM	1.260	< 5
IDP	2.314	< 5
TJ	2.266	< 5
THM	2.243	< 5
TMT	2.409	< 5
TC	1.576	< 5
PM	1.292	< 5
PHP	1.487	< 5
JCD	1.683	< 5
PCT	1.964	< 5
PGT	2.099	< 5
PTFT	1.643	< 5
JC	1.000	< 5

3. Significance and relevance of the formative indicators, has been fulfilled based on the value of P-value outer weight> 0.05

Table 3 P-Value Outer Weight

Indicator	Outer Weight	Explanation	Outer Loading
MP	0.634	> 0.5	0.893
TJ	0.520	> 0.5	0.836
DSM	0.100	< 0.5	0.242
JCD	0.083	< 0.5	0.290
IDP	0.056	< 0.5	0.179
PCT	-0.117	< 0.5	1.000
TC	-0.343	< 0.5	-0.580

b. Evaluation of structural measurement (Inner model)

1. Collinearity Assessment, has been fulfilled based on VIF inner model value <5.

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Table 4 VIF Inner Model

Variable	Door Foam Shrinkage	No. of Complain
Door Foam Shrinkage		1.000
Raw Material	1.612	
Machine Parameter	1.880	
Polyurethane Inspection	1.437	

2. Structural Model Path Coefficient, based on value of the T-statistic of the all variables is bigger than 1.960(value base on t Table significance 5%) and the value of P-value <α (0.05), so that the inner model is significant

Table 5 Coefficient and Effect Evaluation of Structural Model

Effect	Standard Dev.	T Statistic	P Value
Material Polyurethane -> Door Foam Shrinkage	0.125	7.135	0.000
Temperature Jig -> Door Foam Shrinkage	0.173	4.830	0.000

Figure 3 Result of Structural Model

3. Coefficient of Determination, the value obtained is 0.981, so it exceeds the R2value of 0.75.Data shows has large significance accuracy.

Table 6 Determination Coefficient

Variabel Manifest	R-Square
Door Foam Shrinkage	0.981
No. of Complain	0.527

Based on R2 values in table above, it can be seen that the value of R2 for the construct variable door foam shrinkage is 0.981, the value explains that the magnitude of the door foam shrinkage can be explained by its indicators of 98.1%. Then for the value of R2 obtained by the no. of complain construct of 0.527, the value explains that the magnitude of the effect of no. of complain can be explained by the indicators of 52.7%.

4. Effect Size, Based on f2value is over than 0.35 it can be seen that the raw material, machine parameter and polyurethane inspection has a large effect size of door foam shrinkage.

Table 7 Effect Size

Variable	Door Foam Shrinkage	No. of Complain
Door Foam Shrinkage		1.210
Raw Material	1.890	
Machine Parameter	12.678	
Polyurethane Inspection	1.658	

5. Predictive Relevance, value Q2 of door foam shrinkage is 0.981 and no. of complain is 0.527, it means value above 0.35 has a large predictive relevance. So that the predictive relevance for the door foam shrinkage and no. of complain is large.

Table 8 Predictive Relevant

Variable Manifest	Q^2
Door Foam Shrinkage	0.981
No. of Complain	0.527

The results of the analysis software smart PLS gained 2 dominant or significant cause of material indicator low polyurethane/density (MP) and low jig temperature(TJ).

Conclusions

The result of analysis door foam shrinkage problem of refrigerator product with QC seven tools method obtained 6 root causes that was high rate of

shrinkage urethane material, less amount of urethane material, low density urethane, output charging shape of urethane material uneven, low jig temperature and making the inner door holes with manual drilling that result in unstable holes.

The results of the SEM PLS analysis with smart PLS software version 3.2.8 gained 2 significant causes that was indicator low material polyurethane/density (MP) with significant value 0.634 and low jig temperature (TJ) with significant value 0.520.

Suggestion in this research is hange urethane material with less rate of shrinkage of urethane material from ± 2% to <1%, change density from> 30Kg / m3 to> 32Kg / m3this is according to (Morris & Fogg, 1979), increase amount of urethane, change shape of urethane output machine by straight shape, control of temperature jig by check sheet, and use punch die set for making inner door air vent hole.

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