Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 07, July - 2017

Quality Engineering for Quality Improvement of Cigarettes Paper

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***Abstract* - Quality control is a way of solving problems used to monitor, control, analyze, build and improve the quality of products and processes by using methods of quality methods. This company is a chemical company engaged in the production of cigarette paper. In the production process, there are several factors that affect the disability of cigarette paper both from machine, working method, material used and other factors. In this case, to analyze the causes of defects in cigarette paper products is done quality engineering using the Method of Surface Response Methodology, which is one of the methods in quality control techniques required to determine the optimal point of the factors that rotate the experimental unit. Analysis of 80-20 pareto diagrams shows the most dominant types of disability are cracks, wrinkles and curls. The analysis of fishbone diagrams shows the most effective factors for reducing one third type of disability pareto result is temperature madeleine roll, biocide mix and draw ratio. Quality technique using by response surface methodology to improve paper product quality. The optimum split factor for temperature was 128.445^{0}C, biocide mixture of 9,350 kilogram and ratio of yield 0.929.**

Keywords : Quality Engineering, Experimental Design, Response Surface Method

1. INTRODUCTION

The development of product competition in the global market today provides a separate demand for the company to make continuous improvement. Quality provides a very important role for business processes in improving the efficiency and effectiveness of competition in the global market (5). Quality control is a management function to control the number of defective products or that do not meet the specifications. Quality is one of the most important decision factors in the competition of product / service selection (4). Reduce the number of defective products into one of the paths that must be taken by companies to be able to compete in the global market.

Response Surface Methodology (RSM) is one of the experimental methods that are part of the Design Of Experiment (DOE) used to detect a particular function. RSM is derived from the discipline of science which aims to determine the relationship of variables to the response system that has been determined (6). One of the experimental approaches that is part of the DOE is the taguchi method. Taguchi is an experimental design approach that aims to optimize production processes and minimize costs. According to research conducted by Milkey even though RSM and taguchi have the ability to predict a system, the RSM method is more accurate than the taguchi method to model an observed response equation (3). Through the RSM approach the experimental design was developed to integrate all the variables into a regression equation that could provide the theoretical value of repairing a system. This Company is a chemical company engaged in the production of cigarette paper.

The production of this company is distributed to tobacco companies in Indonesia such as PT. Gudang Garam, PT. Dji Sam Soe and several other tobacco companies on the island of Sumatra and Java. In carrying out its production, product defects often occur in a very large number. The resulting defective product is reused as raw material in the next cigarette paper production. The raw material composition derived from the defective product is used in a small percentage when compared to the total number of defects so that the remaining defective product is made into inventory for use in the next production process. However, cigarette paper that is defective if stored for a long time in the warehouse will cause the defective product to become obsolete, while raw materials from defective products must be in good condition so as not to affect the composition of other raw materials.

Based on October 2016 historical data, the number of defective products produced reached 37,564 kg or 37,564 tons. Based on the explanation from the marketing management, the selling price of franco cigarette factory paper is Rp 20.000.000/ton, thus increasing production time and potential loss potential is 37,564 ton x Rp. 20,000,000/ton = Rp. 751.280.000, -. Therefore, a repair system is needed that aims to reduce the number of defective products, so as to reduce the losses experienced by the company.

2. EXPERIMENTAL

The problem raised to be analyzed in this research is the high defect of cigarette paper product causing big losses for company. Based on interviews with the company it is known that the defect of the product is caused by several factors, namely machine settings, material mix, operator negligence and working methods.

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Therefore, research is done to find the optimum point of the factor, so it can reduce the number of product defects. Oxidizing biocides used to work directly kill microorganisms while oxidizing non biocides plays a role to suppress the growth of microorganisms in secondary cooling systems (2). Based on the results of discussions with the mixed biocide company is needed to maintain the quality of cigarette paper. If the added biocide content is lacking, the mucus on the paper will persist and cause the paper to tear. The dependent variable is the variable that is affected or the result of the independent variable. In this case the dependent variable is the number of flawed cigarette paper. The independent variable is the research variable that influences and becomes the cause of change or the incidence of dependent variable. In this case, the independent variables are factors affecting cigarette paper defect, they are:

1. Temperature Modeleide Roll, is the amount of temperature used in the dryer to dry cigarette paper materials. Temperature suitability affects the moisture content and dryness of tobacco paper produced.
2. Biocide mix, is an additional material added to the paper machine during the production process. The function of biocide is to kill microorganisms in the paper material and remove the mucus contained in the material.
3. Draw ratio, refers to the ratio of the engine rotation rate found on the paper machine that gives the appeal to cigarette paper. The attractiveness of the attraction generated between machines will cause the paper to tear.

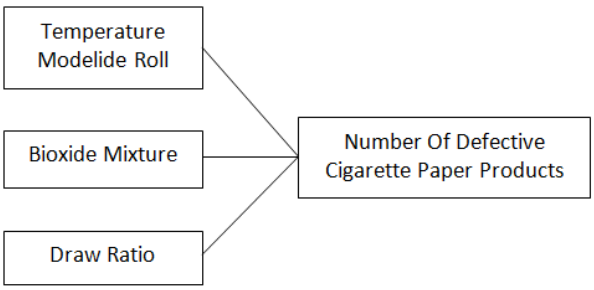

Figure 1 Conceptual Framework

2.1 Response surface methodology

Design Of Experiment (DOE) is a powerful tool to achieve product quality improvement and process efficiency. For manufacturing, DOE is more appropriate to conduct the appropriate experiments so as to save on trial costs. In the application of DOE, the most important process is to determine the value of the independent variable in accordance with the objectives of the experiment to be performed. DOE is one method that can be used to investigate the cause of the highly hidden variations of the problem. DOE also provides efficient and cost-effective experimental design techniques in the system modeling process.

There are several types of methods that are part of DOE, such as taguchi, ANOVA, Degree of freedom in DOE and response surface methodology. Response Surface Methodology or Method is a methodology consisting of a group of statistical techniques to build empirical models and exploit models. Reponse Surface Methodology is a model using experimental techniques, regression modeling, and optimization methods (7). The RSM approach was first introduced in the early 1950s applied to a chemical industry. Over the past 20 years, the use of RSM has expanded in the fields of chemical industry, electronics, machining, metal cutting to software.

To illustrate the use of RSM, suppose an engineer would like to find out how optimum the effect of temperature (X1), reaction time (X2) on the result of a process (Y).

$$Y = f(x1, x2) + e$$

The above e represents the error occurring at the time of observation of the y response (4). RSM is a combination of statistical and mathematical methods for the study of optimization of complex systems. RSM takes into account the interactions that occur between independent variables and determines optimum combinations to optimize more accurately. Through the application of Central Composite Design (CCD) based on RSM optimization response variable can be applied. So the value of the independent of the independent variable gives a significant influence on the response variable to be fixed.

Initial estimates of optimum conditions sometimes still deviated from the expected. Therefore, a systematic step is required to allow the experiment to move quickly toward the expected optimum point. When the expected optimum conditions have not been reached, the first-order model is considered as a preliminary estimate. Furthermore, steepest descent method is used to reach optimal point which more represent the actual condition (4).

The Steepest Descent method was first proposed by Box and Wilson in 1951 and has been further developed by Box and others. The Steepest Descent method is a function movement procedure at a given point that is x with a negative slope direction that will give the local maximum value of the minimized function. Each factor involved in the initial study, when the study ended, the polynomial interpretation of the surface response function was adjusted to the outcome and used to determine the direction of the next experiment. If this approach is used to maximize a function then it is called steepest ascent method whereas when used to minimize a function it is called steepest descent. Steepest ascent (descent) method is a technique to determine the optimum factor point for response variable (1).

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3. RESULTS AND DISCUSSIONS

Stratification of defective products is categorized into 5 types of product defects: cracked, wrinkle, curly paper, CHKSP and holes. To obtain the most dominant type of disability, a pareto analysis of 80-20 diagrams is used. From the results of pareto analysis is obtained that the percentage of disabilities that reach 80% is cracked, wrinkle and curly paper. By fixing these three defects, it is expected to reduce the number of defective products on the production floor.

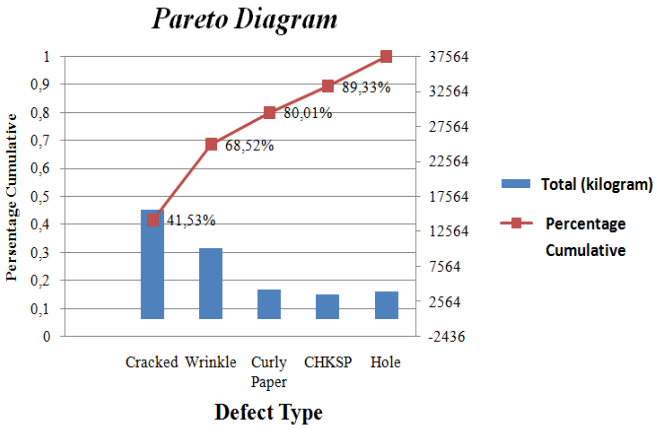

Figure 2 Pareto Diagram

Based on stratification and pareto diagram, the most dominant types of disability are cracked, wrinkle and curly paper. Furthermore, analysis of the causes of paper product defect problem using fishbone diagram is related to the three types of disability.

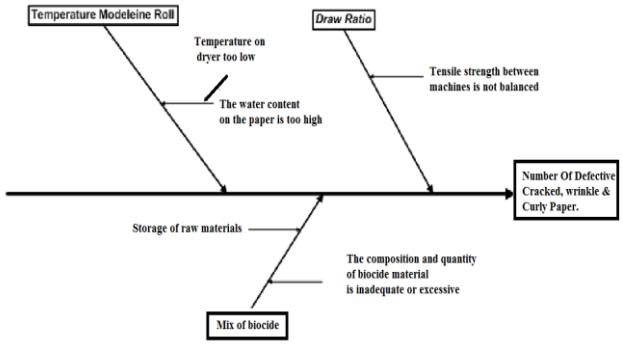

Figure 3 Cause And Effect Diagram

The results of fishbone making showed the most effective to be used as experimental factors with method of suface methodology method is madeleine temperature, biocide and draw ratio. After knowing the factors that affect the disability, then the next step is to determine the first order model. The first order model is made as an approach to find the optimal area to be used in the experiment. To build a first order model, firstly collected data with experimental design. Data collection using 9 treatments. From the collected results, the data is then processed by using the matrix approach. From the results of data processing, obtained first order model as follows:

$$Y = 798.9244 - 4.251x1 - 2.498x2 - 0.823x3$$

Steepest descent aims to find the optimum point that will be used in the next step, ie second-order determination. At this stage experimental experiments conducted by combining the three predetermined factors. The surface finish of machined surface is important in engineering Applications which have considerable effect on wear resistance, light reflection, heat transmission, coating and resisting fatigue of the material.

While machining, quality of the parts can be achieved only The result of the experiment with steepest descent was found that the minimum number of product defects was at 5th period, with temperature 1300C, biocide mixture 9,29 kg and draw ratio 0,93. This setting is set as the origin point for the next research is the determination of second-order model.

Based on the value of new factor determined through steepest descent, second-order determination using Centeral Composite Design (CCD) where in CCD was found star point (α). In this case α is 22/4 = ± 1.68. The second order trial was carried out with 15 experiments, 8 treatments of cubic point, 6 treated at star point (α) and 1 treatment at center point. After doing the calculation with matrix approach then obtained regression equation for second order as follows:

$$Y = 750,642 + 1,595X1 - 2,325X2 - 0,231X3 - 18,738X12 - 14,211X22 - 19,506X32 + 0,114X1X2 - 0,498X1X3 - 4,898X2X3$$

After the second-order model is declared in accordance with the experimental results, a contour plot is made to see the number of defective products when the value of the factor continues to be applied. From the graph shown by the countor plot it was found that the maximum defect for the temperature factor was 125.0 - 127.5 0C, for the biocide mixture was 9.24 - 9.28 kg and for the draw ratio was in the range of values 0.921 - 0.927. If the point factor is maintained then the number of defective products produced will remain large. For that we need a suggestion of improvement through the optimum point factor so that the quality of cigarette paper products increases as expected by the customer.

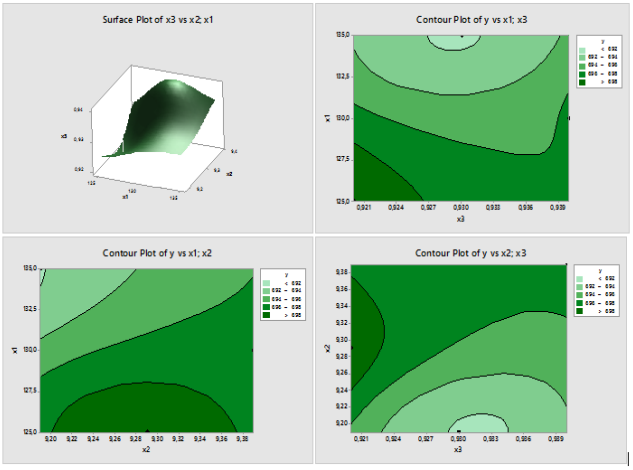

Figure 4 Contour Plot

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The determination of the factor optimum point is based on second order model analysis with the following results.

1. Temperature Madeleine Roll = 128,445 0C
This value indicates the optimum state for the temperature in reducing the number of defective cigarette paper products on the production floor. Optimal temperature will cause the dryer to function properly, so the paper will dry and not easily torn.

2. Biocide mixture = 9,350 Kg
This value indicates the optimum state for the biocide mixture in reducing the number of defective cigarette paper products on the production floor. The added biocide content will affect the amount of mucus present on the paper. If the added biocide is not enough, it will cause tobacco paper to easily tear, hollow or other defects.
3. Draw Ratio = 0.929
The draw ratio shows the comparison of the rate of engine speed on the production floor. If the draw ratio is not suitable then the paper will shrink, tear or other defects.

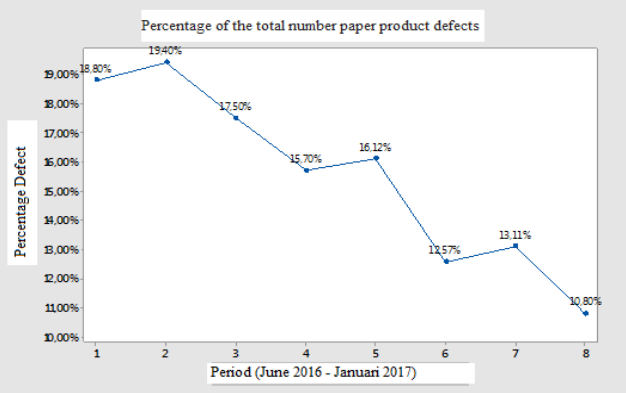

Figure 5 Comparison Before and After Performing Experimental Quality Engineering with Response Surfaces Methodology

Period 1-5 represents the production process conducted in June-October 2016 with an average percentage of the number of defective products of 17.50%. While the period 6-8 represents the production process in November 2016-January 2017 with the average percentage of defective products amounted to 12.16%. From the graph above can be seen the decrease of the number of defective products by 5.34% after applying the results of quality engineering in the form of an experiment using the method of response surface methodology.

4. CONCLUSIONS

Based on the application of response surface methodology and the analysis discussed in the previous chapter, the following conclusions can be drawn:
1. Based on the result of stratification type of product defect, it is found that the product defect type found in October 2016 is cracked, wrinkle, curly paper, CHKSP and holes.
2. Pareto analysis diagram 80-20 shows that the most dominant type of disability is cracked, wrinkle and curly paper. Furthermore, these three types of disability become the focus of analysis to reduce the type of disability cigarette paper products on the production floor.
3. Fishbone analysis diagram shows that the most effective factor to reduce the three types of disability pareto result is temperature madeleine roll, biocide and draw ratio mixture.
4. Engineering kualiatas in the form of experiments using response surface methodology showed that to improve the quality of cigarette paper products and reduce the number of defects used optimum factor point.

The optimum point of factor obtained for temperature is 128,4450C, biocide mixture is 9,350 kg and draw ratio 0,929.
5. The results of quality engineering using response surface methodology show that there is a decrease in the percentage of defects from the observation period (June - October 2016) by an average of 17.50% with the experimental period (November 2016-January 2017) with an average of 12.16%.

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