Selection of Optimal Factor Level From Process Parameters in Palm Oil Industry

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Absract. Kernel is side product from palm oil industry. Kernel is a world commodity therefore the quality must be standarized to international trade. The quality of kernel is influenced by dirt content and moisture. If the product doesn't fulfill the standard then the product is categorized reject. The result from the process are affected by ripple mill, drying temperature and cycling fan. Based on the kernel quality data this kind of industry is still exceed tolerance limit from moisture and dirt content, therefore need to be reduced. This paper describe the application of Taguchi Method for the selection of optimal factor level from the process to get a minimum dirt content and moisture. Orthogonal Array has been selected considering the various factor and levels, taguchi is applied to obtain the combination of factor and it's levels to get the minimum dirt content and moisture. The result form this paper is the factor that influence the defect are speed of ripple mill is 1300 rpm, drying temperature 65^0C and winowing cyclone fan level machine is level 3. By using factor and it's level, moisture content is reduced 0,316% and the dirt content is 0,386% from the existing production.

1. Introduction

Kernel is side product from palm oil industry. Nut is produced from screw press machine. In the beginning, kernel is mixed with other part such as shell, seed, and fiber. The separation of this product happened in the depricarper. Fibers and other dirts are separated from nut by blower. Nuts which has biggest spesific grafity will fall down to nut polishing drum. In this drum nut is cleaned free from the fibers and then is brought to dusttoner for cleaning small rocks and seed in order to have ripple mills in a good shape, and then nut into ripple mill machine to break the shell to get the kernel. The speed turn of ripple mill influenced its product, then kernel is brought to winowing system. The light particle will be absorb by winowing cyclon fan, therefore the kernel is separated. Power absorbed from winowing cyclon fan influenced the product. Kernel from winowing system is brought to kernel drying silo. Drying temperature of the silo influence moisture content of the product [1].

The fundamental principle of the Taguchi method is to improve the quality of a product by minimizing the effect of the causes of variation without eliminating them. Taguchi's method is an efficient and important optimization method based on orthogonal array concept which offers systematic and efficient process.

Many researchers using Taguchi Method for solving some experimental design problems. Slavica Miladinovic used Taguchi Method for the selection of optimal parameters of planetary arriving gear in order to reduce the safety coefficient for surface durability of a gear tooth. The research result with variance analysis (ANOVA) show that the greatest influence on the safety coefficient for surface durability of a gear is the gear module [2].

Madhoo G using Taguchi Method for Optimization of Process Parameters of Stir Casting Technique. Analysis of the result stated that properties the optimal heat treatment condition with respect to the Coefficient of friction (STB) of Al 6061-SiC-Gr composites is 7% of Gr under water quenching for a duration of 8.5 hrs.[3] Mavruz also using Taguchi Method for bursting strength optimization at knitwear industry [4]. Other researcher using taguchi method to solve the problem [5], [6], [7], but there are not many researchers using taguchi method in palm oil industry.

This paper describe the application of Taguchi Method for the selection of optimal factor level from the process to get a minimum moisture and dirt content. Orthogonal Array has been selected considering the various factor and levels, taguchi is applied to obtain the combination of factor and it's level which has significantly effect towards kernel product quality.

2. Methods

2.1. Taguchi methods

The study is in the form of experiment. Taguchi Method is a statistical method that allows independent estimation of the response with minimal number of experiments. Taguchi method is also used for increasing quality of product. Taguchi Method usually used for developing quality of industry products with proven success [8]. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. To determine the best design, it requires the use of a strategically designed experiments.

Taguchi introduced a unique concept known as Orthogonal Array [9] which tries to reduce the number of experimentation based on the trials by considering certain control parameters. Orthogonal array provides a minimum number of experimentation. In order to set up an experimental design following factor selected : ripple mill machine (A), drying temperatue (B) and winowing cyclone fan level (C).

Taguchi Method consist of several steps, such as :
1. Determine factors that became control
2. Determine level from each factors and choosing suitable orthogonal matrix for design experiment
3. Place the control factor into orthogonal matrix which is selected and conduct experiment
4. Confirmation conduct experiment and obtain confidence interval
5. Increasing quality based on optimal level factor combination

Taguchi Method used Signal to Noise ratio (S/N Ratio) for measure the variance from design experiment. S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). The method of calculating the S/N ratio defends at each run of the experiment. In Taguchi Method, there are 3 (three) characteristics values converted in Signal to Noise Ratio (S/N Ratio). These three values describe different characteristic of quality according to the purpose of the problem. S/N Ratio characteristic value are "Nominal is The best", "Larger is the better" and "Smaller is the better". For each level of process parameters, S/N Ratio is calculated based on S/N analysis smaller is better [10].

For "Nominal is The best"

$$\eta = S / N_T = 10 \, log \, \frac{y}{s_{\bar{y}}^2} \quad \text{………………...……(1)}$$

Larger is better;

$$\eta = S / N_L = -10 \, log \left(\frac{1}{n} \sum_{i=1}^{n} \frac{1}{y^2} \right) \text{…………(2)}$$

Smaller is better;

$$\eta = S / N_S = -10 \, log \left(\frac{1}{n} \sum_{i=1}^{n} y_i^2\right) \ldots\ldots\ldots\ldots(3)$$

At this research the quality characteristic is used smaller is the better, which is the smaller the defect products the better the result [11], [12].

3. Results and discussion

There are three factor has been selected considering the various factor and level. There are ripple mill machine (A), drying temperature (B), and winowing cyclon fan level (C). To select an appropriate orthogonal for this experiment, the total degree of freedom should calculated. There are 3 factors with 2 levels, which can be seen in table 1.

Table 1. Number of Control Factor and Their Levels

Symbol	Control Factors	Level 1	Level 2
A	Ripple mill machine (rpm)	1250	1300
B	Drying temperature (^{0}C)	60	65
C	Winowing Cyclon Fan	2	3

For this experiment L_8 (2^3) the orthogonal is choosen. Selection of proper orthogonal is done based on the total number of degree of freedom ,the degree of freedom calculated would be 3. The L_8 (2^3) Orthogonal Array which its rows which can be seen in table 2

Table 2. Orthogonal Array L_8 (2^3) Layout

Experiment	A	B	C	Dirt Content (%)	Moisture (%)
1	1	1	1	7,27	6,99
2	1	1	2	7,03	6,98
3	1	2	1	7,12	6,94
4	1	2	2	7,01	6,88
5	2	1	1	6,95	6,91
6	2	1	2	6,92	6,96
7	2	2	1	6,96	6,84
8	2	2	2	6,88	6,81

For identification the level effect from the factor of kernel quality, Therefore the average value for each levels to calculated using formula below :

$$Xn = \frac{y1+y2+....+yn}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

From the calculation of the level value and its factor, the average, the level value from the kernel product factor shown in table 3

Table 3. Average Response Moisture and Dirt Content Factor Effect

	Moisture Factor Effect			Dirt Content Factor Effect		
	A	B	C	A	B	C
Level 1	6,9475	6,9606	6,9206	7,11	7,04	7,07
Level 2	6,8806	6,8675	6,9075	6,93	6,99	6,96
Difference	0,0669	0,091	0,0131	0,18	0,05	0,12
Ranks	2	1	3	1	3	2

In this experiment (S/N) ratio is calculated by using smaller the better criteria as minimum value of dirt content and moisture. The equation for smaller the better characteristic as follows :

S/N= -10 log 1/n ($\sum y^2$) where

Y = the observed data

N = the number of obversations ....(5)

The analysis of experimental result based on (S/N) ratios provides the optimal factor levels. (S/N) ratio for moisture and dirt content can be seen at Table 4.

Table 4. Response for Signal to Noise Ratio for Moisture and Dirt Content

	(S/N)R Moisture			(S/N)R Dirt Content		
	A	B	C	A	B	C
Level 1	-16,8369	-16,8534	-16,8031	-17,0343	-16,9560	-16,9949
Level 2	-16,7528	-16,7363	-16,7866	-16,8132	-16,8527	-16,8527
Difference	0,0840	0,1171	0,0164	0,2211	0,0645	0,1422
Ranks	2	1	3	1	3	2

Table 3 and table 4 shows that ripple mill (A) is the factor which has the biggest effect in reducing response variance and the most influenced factor to kernel dirt content while drying temperature is most influence factor to kernel moisture content. The next step is analyzing measurement based on Signal to Noise Ratio (SNR). SNR analysis is used to choose the factors that have contribution at reducing variance of a response and for knowing the level factor which impact at the experiment result. The factors that have impact the quality characteristic variance, the data transformed to S/N ratio (Signal-to-Noise Ratio) with the "Smaller the Better" characteristic. [13] The variance analysis result and % contribution from each factors with the levels of confidence 90 %. shown at Table 5 and Table 6.

3.1. Analysis of Variance (ANOVA)
Anova is one of the most commomly used tools when it comes to statistical methods [14], [15]. The results of the (S/N) analysis were used for realization of ANOVA, allowing defining which factor and level influences the final results of experiments.Therefore, ANOVA analysis is used to find optimal factor levels. The variance analysis result and % contibution from each factor show at Table 5 and Table 6.

Table 5. Analysis of Variance SNR Dirt Content

Source	Dof	SS	MS	Fratio	Contribution (%)
A	1	0,0978	0,0978	18,4528	55,13%
B	1	0,0083	0,0083	1,5660	1,78%
C	1	0,0404	0,0404	7,6226	20,91%
Error	4	0,0213	0,0053		
Total	7	0,1678			

Table 6. Analysis of Variance SNR Moisture

Source	Dof	SS	MS	Fratio	Contribution (%)
A	1	0,0089	0,0089	89	32,71%
B	1	0,0773	0,0173	173	63,94%
C	1	0,0003	0,0003	3	0,74%
Error	4	0,0004	0,0001		
Total	7	0,0269			

Based on the performed ANOVA analysis, it can be calculated that the greatest influence on dirt content is ripple mill 55,13%, followed by level winowing cyclone fan 20,91 % and drying temperature at the end 1,78%. The moisture content can be concluded that the greatest influenced is drying temperature 63,94% and by ripple mill is 32,71%. Factor which has a less contribution for reducing the variance of response can be neglected.

3.2. Experiment confirmation

The last step in Taguchi is to create optimal level factor condition. From the result of level factor selection which are significantly affect to average moisture and dirt content and SNR obtain, the combination of optimal for dirt content are A at level 2, B at level 2 and C at level 2 (A_2, B_2, C_2)

Confidence interval for optimal prediction is :

a. Dirt Content

$$Cl = \pm \sqrt{F(0,05,1.7)x\ MSe\ x\ \frac{1}{neff}}\ \dots\dots\dots\dots\dots\dots\dots\dots\dots(6)$$

$$Cl = \pm \sqrt{5,59\ x\ 0,0053\ x\ \frac{1}{8}}$$

$Cl = \pm\ 0,0608$

The result is $6,8438 - 0,0608 \leq 6,8438 \leq 6,8438 + 0,0608$

While the confidence internal for experiment confirmation is :

$$Cl = \pm \sqrt{F(0,05,1.7)x\ (\frac{1}{neff} + \frac{1}{8})}\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(7)$$

$$Cl = \pm \sqrt{5,59\ x\ 0,0053\ x\ \frac{1}{8} + \frac{1}{5}}$$

$Cl = \pm\ 0,0424$

The result is $6,7660 - 0,0424 \leq 6,7660 \leq 6,7660 + 0,0424$

b. Moisture

$$Cl = \pm \sqrt{F(0,05,1.7)x\ MSe\ x\ \frac{1}{neff}}$$

$$Cl = \pm \sqrt{5,59\ x\ 0,0001x\ \frac{1}{8}}$$

$Cl = \pm\ 0,0083$

The result is $6,8275 - 0,0083 \leq 6,8275 \leq 6,8275 + 0,0083$

While the confidence internal for experiment confirmation is :

$$Cl = \pm \sqrt{F(0,05,1.7)x\ (\frac{1}{neff} + \frac{1}{8})}$$

$$Cl = \pm \sqrt{5,59\ x\ 0,0001\ x\ \frac{1}{8} + \frac{1}{5}}$$

$Cl = \pm\ 0,0134$

The result is $6,7340 - 0,0134 \leq 6,7340 \leq 6,7340 + 0,0134$

The result of experiment confirmation shows that the moisture and dirt content are lower than the tolerance limit of the factory and which is not optimal. Other researcher such as Slavica Miladinovic with the title Application of Taguchi Method for the Selection of Optimal Parameters of Planetary Driving Gear shows the result that safety coefficient for surface durability of driving gear is reduced

4. Conclusion

Factors that influence kernel quality are moisture and dirt content. Combination of optimal level factor which is effected moisture and dirt content are ripple mill at level 2 (1300 rpm), drying temperature at level 2 (65^0C) and winowing cyclon fane at level 2 (level 3).

Based on Taguchi and ANOVA analysis, conclude that the greatest influence on dirt content is ripple mill 55,13% and moisture content is drying temperature 63,94%. The optimal combination factor result

from Taguchi Method is proved succeed for reducing moisture and dirt content. This shows that the quality kernel is better.

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