Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

APPLICATION OF TAGUCHI METHOD IN OPTIMIZATION OF PROCESS PARAMETERS FOR PADDY HUSKER IN PEELING MACHINE PRODUCTION PROCESS

Suwattanarwong Phanphet[a], Surapong Bangphan[b]
[a]Department of Industrial Technology , Faculty of Science and Technology Chiang Mai Rajabhat University 202 Chang phuak Road, T.Chang phuak, A.Muang Chiang Mai, THAILAND 50300
email: suwatwong_pha@cmru.ac.th, suwattwong@gmail.com
[b]Department of Industrial Technology Education, Faculty of Engineering, Rajamangala University of Technology Lanna, Chiang Mai, THAILAND, 50300,
email: pong_pang49@yahoo.com, surapongb@edu.rmutl.ac.th

Abstract

This paper reports on an optimization of peeling machine production Process by the effects of process parameters for paddy husker applying Taguchi method to improve the quality of manufactured goods, and engineering development of designs for studying variation. Thai jasmine rice (Khao Dok Mali Rice 105) is used as the selection for carrying out the experimentation to optimize the Paddy Husker. There are three process parameters i.e. Round per minute, Rubber of clearance, and Paddy of moisture respectively. Operating range is found by experimenting with round per minute and taking the lower levels of other parameters. Taguchi orthogonal array is designed with three levels of peeling machine production parameters with the help of software Minitab release19.00 In the first run twenty seven experiments are performed and paddy husker is calculated. When experiments are repeated in second run paddy husker is calculated. Taguchi method stresses the importance of studying there sponse variation using the signal–to–noise(S/N)ratio, resulting in minimization of quality characteristic variation due to controllable parameter. The paddy husker was considered as the quality characteristic with the concept of the larger -the-better. The S/N ratio for the larger-the-better. Where n is the number of measurements in this case, n=27 and y (response = broken of percentage) is the measured value.

Keywords: Application, full factorial design, optimization, analysis of variance, turning machine.

INTRODUCTION

The introduction of robust design proposed by (Taguchi, G.,1991) or so-called Taguchi method, in quality engineering resulted in significant improvement of quality characteristic (QCH) in product/process design. Taguchi method focuses on determining the effects of the control factors on the robustness of the product's function. Instead of assuming that the variance of the response remains constant, it capitalizes on the change in variance and looks for opportunities to reduce the variance by

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

changing the levels of the control factors. In Taguchi method (Phadke, M. S.,1989) fractional factorial experimental designs, or so-called orthogonal arrays (OAs), are utilized to optimize the amount of information obtained from a limited number of experiments, where columns represent factors to be studied and rows represent individual experiments. In the analysis of OA data, signal-to-noise (S/N) ratio is employed as a quality measure to decide the optimal levels of control factors. Then, in statistical analysis of S/N ratio, analysis of variance (ANOVA) is performed to determine significant factor effects. In ANOVA, pooling-up , technique, or the sum of squares for the bottom half of the factors corresponding to about half of the degrees of freedom, is used to obtain an approximate estimate of error variance. In order to test factor's significance, F value of four is adopted to decide significant factor effects (Belavendram, N.,1995). Taguchi method has been widely used for quality improvement in tremendous business applications (Li, M. H., Al-Refaie, A. and Yang, C. Y.,2008),(Li, M. H. and Al-Refaie, A., 2009). Taguchi's contribution to quality engineering has been extensively elaborated and analyzed by several researchers (Maghsoodloo, S., Ozdemir, G., Jordan, V. and Huang, C. H., 2004),(Pignatiello, J. J., 1988). Nevertheless, there is much discussion in literature about the invalidity and deficiency of his statistical techniques (Nair, V. N.,1992). Among them (Leon, R. V., Shoemaker, A. C. and Tsui, K. L.,1993) introduced the concept of performance measure independent of adjustment as a replacement for S/N ratio (Box, G. and S. Bisgaard., 1988). used sampling experiments with random numbers to illustrate the biasproduced by pooling (Tsui, K. L.,1996). mentioned that Taguchi's analysis approach of modelling the S/N ratio leads to non-optimal factor settings due to unnecessary biased effect estimates. (Ross, P.J.,1996). pointed out that pooling-up technique may tend to maximize the number of factors judged incorrectly as significant (Abbas Al-Refaie. and Ming-Hsien Li.,2010) suggested the use of data compression measures combined with S/N ratio to assess noise factor effects. Products have quality characteristics (QCHs) that describe their performance relative to customer requirements or expectations (Abbas Al-Refaie. and Ming-Hsien Li., 2010). Typically, the quality characteristic (QCH) can be divided into three main types including: the-smaller-the-better (STB), the-nominal the- best (NTB), and the-larger-the-better (LTB) types. When investigating the effect of process factors on a QCH of main interest, there is a risk that the experimenter will infer the wrong decision from the test data (Abbas Al-Refaie. and Ming-Hsien Li., 2010). When a truly insignificant factor is tested and found to be significant, alpha error occurs (Taguchi, G. ,1991). The decision will be then to use these factors for further experimentation and perhaps product or process design thinking that some factor will cause an improvement, when, in truth, this factor will not help (Abbas Al-Refaie. and Ming-Hsien Li.,2010). This will merely confuse and lead the engineer and the scientist astray (Abbas Al-Refaie. and Ming-Hsien Li., 2010),(Li, M. H. and Al-Refaie, A., 2009) investigated the alpha error of Taguchi method with L16 (215) for the LTB type QCH using simulation (Wu, D. H. & Chang, M. Sh., 2004). applied the Taguchi method to optimize the process parameters for the die casting of thin-walled magnesium alloy parts in computer, communications and consumer electronics (3C) Industries. The Taguchi method was successfully applied to determine the optimal combinations of drilling parameters and to minimize machining costs and time in drilling of AISI 316 stainless steel. In this study, paddy husker were peeled by machined on rice peeling machine production process. The

ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

settings of rice peeling machine production process parameters were determined by using Taguchi's experimental design method. Orthogonal arrays of Taguchi, the signal-to- noise (S/N) ratio, the analysis of variance (ANOVA), and regression analyses are employed to find the optimal levels and to analyze the effect of the rice peeling machine production process parameters on round per minute, rubber of clearance and paddy of moisture values. Confirmation test with the optimal levels of production process parameters was carried out in order to illustrate the effectiveness of Taguchi's optimization method.

EXPERIMENTAL PROCEDURE

Taguchi Experiment: Design and Analysis

Essentially, traditional experimental design procedures are too complicated and not easy to use. A large number of experimental works have to be carried out when the number of process parameters increases. To solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with only a small number of experiments (Yang WH, Tarng YS., 1998).There is a broad consensus in academia and industry that reducing variation is an important area in quality improvement (Shoemaker, A. C., K. L. Tsui.,1991),(Thornton, A. C., S. Donnely.,1999),(Gremyr, I., M. Arvidsson, et al.,2003),(Taguchi G., Chowdhury, S., and Wu, Y.,2005). The enemy of mass production is variability. Success in reducing it will invariably simplify processes, reduce scrap, and lower costs" (Box, G. and S. Bisgaard., 1988). Definition of quality loss as "the amount of functional variation of products plus all possible negative effects, such as environmental damages and operational costs" supports this view (Taguchi, G.,1993),(Taguchi G.,1990),(Taguchi, G.,1985),(Taguchi, G.,1986) received international attention for his ideas on variation reduction, starting with the translation of his work published in (Taguchi and Wu,1979). The main objective in the Taguchi method is to design robust systems that are reliable under uncontrollable conditions (Taguchi, G.,1978),(Byrne D. M. , S. Taguch.,1987),(Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000) have been widely utilized in engineering analysis and consist of a plan of experiments with the objective of acquiring data in a controlled way, in order to obtain information about the behavior of a given process. The greatest advantage of this method is the saving of effort in conducting experiments; saving experimental time, reducing the cost, and discovering significant factors quickly. Taguchi's robust design method is a powerful tool for the design of a high-quality system. In addition to the S/N ratio, a statistical analysis of variance (ANOVA) can be employed to indicate the impact of process parameters on paddy husker values. The steps applied for Taguchi optimization in this study are as follows.

1. Select noise and control factors
2. Select Taguchi orthogonal array
3. Conduct Experiments
4. Round per minute, rubber of clearance, and paddy of moisture

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

5. Analyze results; (Signal-to-noise ratio)
6. Predict optimum performance

Confirmation experiment

Taguchi's Parameter Design Approach

In parameter design, there are two types of factors that affect a product's functional characteristic: control factors and noise factors. Control factors are those factors which can easily be controlled such as material choice, cycle time, or mold temperature in an injection molding process. Noise factors are factors that are difficult or impossible or too expensive to control. There are three types of noise factors: outer noise, inner noise, and between product noise. Examples of each type of noise factor and controllable factors in product and process design are listed shown in Table 1. Noise factors are primarily response for causing a product's performance to deviate from its target value. Hence, parameter design seeks to identify settings of the control factors which make the product insensitive to variations in the noise factors, i.e., make the product more robust, without actually eliminating the causes of variation (Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000). Design of experiments techniques, specifically Orthogonal Arrays (OAs), are employed in Taguchi's approach to systematically vary and test the different levels of each of the control factors. Commonly used OAs include then L27 several of which are listed shown in Table 1. The columns in the OA indicate the factor and its corresponding levels, and each row in the OA constitutes an experimental run which is performed at the given factor settings. The paddy husker values corresponding to each experiment were shown in Table 2. It is up to the experimental designer to establish the appropriate factor levels for each control factor; typically either 3 levels are chosen for each factor. To implement robust design, Taguchi advocates the use of an "inner array" and "outer array" approach. The "inner array" consists of the OA that contains the control factor settings; the "outer array" consists of the OA that contains the noise factors and their settings which are under investigation. The combination of the "inner array" and "outer array" constitutes what is called the "product array" or "complete parameter design layout." Examples of each of these arrays are given in the case study in the next section. The product array is used to systematically test various combinations of the control factor settings over all combinations of noise factors after which the mean response and standard deviation may be approximated for each run using the following equations (Phadke, M. S., 1989),(Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000).

Mean response:

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i \tag{1}$$

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Standard deviation:

$$S = \sqrt{\sum_{i=1}^{n} \frac{(Y_i - \bar{Y})^2}{n-1}} \quad (2)$$

The preferred parameter settings are then determined through analysis of the "signal-to-noise" (S/N) ratio where factor levels that maximize the appropriate S/N ratio are optimal. There are three standard types of SN ratios depending on the desired performance response (Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000).

Smaller the better (for making the system response as small as possible):

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

Nominal the best (for reducing variability around a target):

$$S/N_T = 10 \log\left(\frac{\bar{y}^2}{S^2}\right) \quad (4)$$

Larger the better (for making the system response as large as possible):

$$S/N_L = -10 \log\left(\frac{1}{n}\sum_{i=1}^{n} \frac{1}{y_i^2}\right) \quad (5)$$

These S/N ratios are derived from the quadratic loss function and are expressed in a decibel scale. Once all of the SN ratios have been computed for each run of an experiment, Taguchi advocates a graphical approach to analyze the data. In the graphical approach, the S/N ratios and average responses are plotted for each factor against each of its levels. The graphs are then examined to "pick the winner," i.e., pick the factor level which as in (1) best maximize S/N and as in (2) bring the mean on target (or maximize or minimize the mean, as the case may be). Using this information, the control factors can also be grouped as follows (Phadke, M. S.(1989),(Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000).

1. Factors that affect both the variation and the average performance of the product.
2. Factors that affect the variation only.
3. Factors that affect the average only.
4. Factors that do not affect either the variance or the average.

Factors in the first and second groups can be utilized to reduce the variations in the system, making it more robust. Factors in the third group are then used to adjust the average to the target value. Lastly, factors in the fourth group are set to the most economical level. Finally, confirmation tests should be run at the "optimal" product settings to verify that the predicted performance is actually realized. A demonstration of Taguchi's approach to parameter design serves as our case study in the next section (Phadke, M. S.(1989).

Taguchi methods which combine the experiment design theory and the quality loss function concept have been used in developing robust designs of products and processes and in solving some taxing problems of manufacturing (Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.,2000).

Taguchi suggests that the response values at each inner array design point be summarized by a performance criterion called a signal to noise ratio. S/N ratio is expressed in decibels (dB). Conceptually, the S/N ratio (η) is the ratio of signal to noise in terms of power. Another way to look at it is that it represents the ratio of sensitivity to variability (Taguchi G., Chowdhury, S., and Wu, Y., 2005),(Raymond H. M., Andre I. K., and Geoffrey, V.(1992). The higher the SNR, the better quality of product is. The idea is to maximize the SNR and thereby minimizing the effect of random noise factors has significant impact on the process performance [28],[29]. Therefore, the method of calculating the S/N ratio depends on whether the quality characteristic is smaller-the-better, larger-the-better, or nominal - the- best (Taguchi G., Chowdhury, S., and Wu, Y., 2005),(Palanikumar, K.,2006),(Ross, P.J.,1996),(Roy, R.K., 2001). In this research twenty seven experiments were conducted at different parameters. For this Taguchi L27 (33) orthogonal array was used, which has nine rows corresponding to the number of tests, with three columns at three levels. L27 ($3^{3)}$ OA has eight DOF, in which 3 were assigned to three factors was assigned to the error. For the purpose of observing the degree of influence of the process parameters in paddy husker, three factors, each at three levels, are taken into account, as shown in Table 1. The paddy husker values corresponding to each experiment were shown in Table 2. According (P.G.Kochure, K.N.Nandurkar., 2012). Finding the best working parameters of induction hardening of EN8 D steel. A L27 orthogonal array, signal to noise ratio, analysis of variance (ANOVA) are applied to study performance characteristics of peeled by machined on rice peeling machine production process with consideration of paddy husker, case rubber of clearance. Multiple regression equations are formulated for estimating the predicted values of paddy husker and case rubber of clearance. The results have been verified by confirmation experiments

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Table 1 Peeling machine production process parameters.

Parameters	Code	Levels		
		1	2	3
Round per minute (Min./Rev.)	R	1,440	1,460	1,480
Rubber of clearance (mm.)	RC	1.20	1.40	1.60
Paddy of moisture (percentage.)	PM	12	14	16

Table 2 Taguchi L27 (3^3) OA for paddy husker (units for factors coded units).

No.	R	RC	PM	Response (%)
1	1	1	1	-
2	1	1	1	-
3	1	1	1	-
4	1	2	2	-
5	1	2	2	-
6	1	2	2	-
7	1	3	3	-
8	1	3	3	-
9	1	3	3	-
10	2	1	2	-
11	2	1	2	-
12	2	1	2	-
13	2	2	3	-
14	2	2	3	-
15	2	2	3	-
16	2	3	1	-

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Table 2 (Cont.) Taguchi L27 (3^3) OA for paddy husker (units for factors coded units).

No.	R	RC	PM	Response (%)
17	2	3	1	-
18	2	3	1	-
19	3	1	3	-
20	3	1	3	-
21	3	1	3	-
22	3	2	1	-
23	3	2	1	-
24	3	2	1	-
25	3	3	2	-
26	3	3	2	-
27	3	3	2	-

Case Study: Parameter Design of a Paddy Husker

The case uses Taguchi's parameter design approach to integrate product and process design decisions for paddy husker used in a peeling machine production process.

The Taguchi method was accomplished with three parameters: between rubber of clearance, round per minute and paddy of moisture. It was performed according (values of these parameters are listed shown in Table 1 and 2), and brown rice peeling machine in Figure 1.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

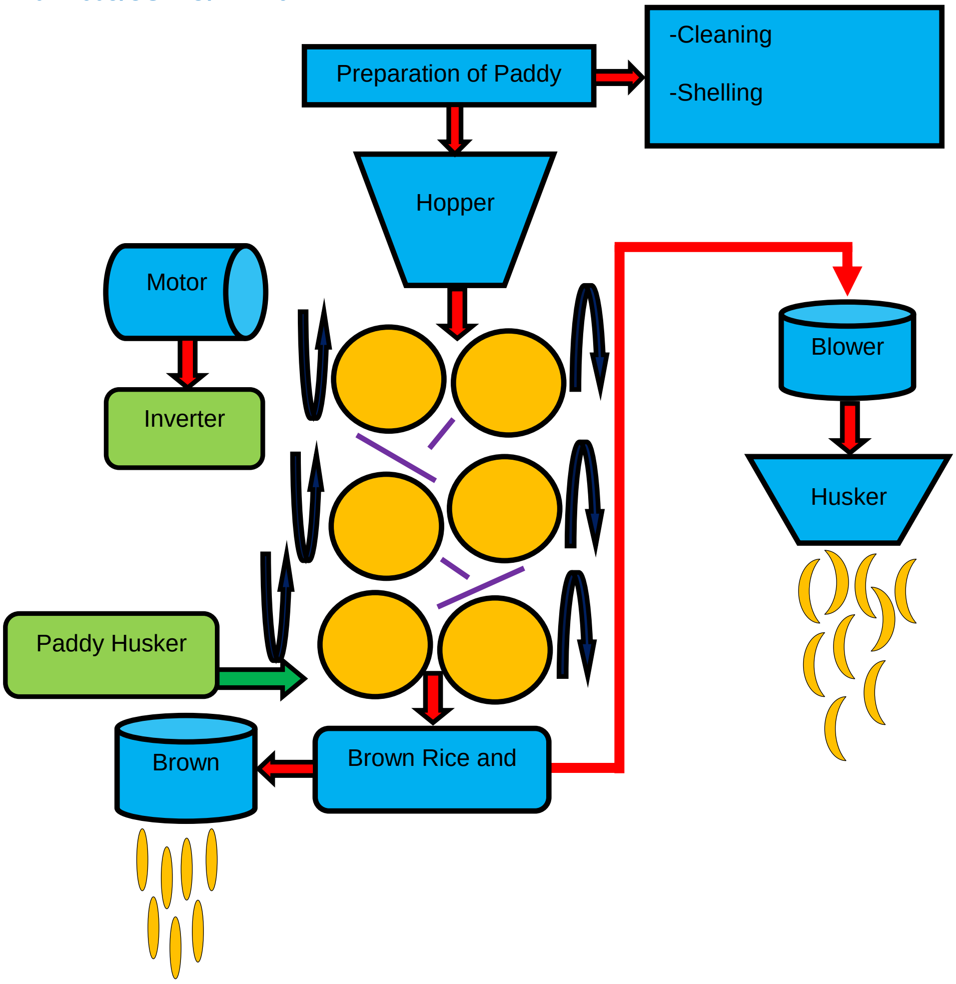

Figure 1 Diagram of paddy husker production process

RESULTS AND DISCUSSION

Regression analysis

The applied R, RC and PM were considered in the development of mathematical models for the paddy husker. The correlation between factors (applied R, RC and PM) and paddy husker on the peeling machine production process were obtained by multiple linear regressions. The standard commercial statistical software package Minitab Release 19.00 was used to derive the models of the form:

A. DOE and full factorial design. The DOE simulation was accomplished with two parameters: spindle of speed (SS), flow rate (FR) and depth of cut (DC) respectively. It was performed according (see Table 3 and 4), and production process by turning machine in Figure 2. A model fitting was accomplished for the first 81-full factorial design in Table 3. The independent (SS, FR with DC) and the dependent variables were fitted to the second-order model equation and examined in terms of the goodness of fit. The analysis of variance (ANOVA) was used to evaluate the adequacy of the fitted model. The R-square value (determination coefficient) provided a measure of how much of the variability in the observed response values could be explained by the experiment factors and their interactions. DOE order defines the sequence that variables should be introduced in response surface analysis. See Table 3 shows the results according to simulated analysis performed in MINITAB Release 19.00 used for simultaneous optimization of the multiple responses. The desired goals for each variable and response were chosen. All the independent variables were kept within range while the responses were either maximized. The significant terms in different models were found by analysis of variance (ANOVA) for each response. Significance was judged by determining the probability level that the F-statistic calculated from the data is less than 5%. The model adequacies were checked by R2, adjusted-R2 (adj-R2). The coefficient of determination, R2, is defined as the ratio of the explained variation to the total variation according to its magnitude. It is also the proportion of the variation in the response variable attributed to the model and was suggested that for a good fitting model, R2 should not be more than 100 %. A good model should have a large R2, adj-R2. Response surface plots were generated with MINITAB Release 19.00 according Taguchi, G.,1978).

Regression equation equations were obtained from design of experiments. Using all values (tests 1 to 81) to the system analysis, the following polynomial equations were generated according (Taguchi, G.,1978).

The estimated regression coefficients for percentage of MRR using data in uncoded units:

The total set of experiments that are performed is obtained by combining the L27 array of control factors (the outer array) with the L27 array of noise factors (the inner array). The total number of experiments is the product of the number of runs of each array, i.e., 9 x 3 or 27 experiments. For each experiment, the pull-off force is measured using the specified settings for each control factor level and noise factor level. The average pull-off force for each combination of the control factors R, RC and PM respectively. Since the objective in the experiment is to maximize the pull-off force, the signal-to-noise ratio for “Larger is Better” is also computed for each set of runs. These results are summarized in Table 3 Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to controllable parameter. The paddy husker was considered as the quality characteristic with the concept of "the larger-the-better", Where n is the number of measurements in a trial/row, in this case, n=27 and y (response= broken of percentage) is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration Equation (5) with the help of software Minitab Release 19.00. The paddy husker values measured from the experiments and their corresponding S/N ratio values are listed shown in Table 3.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Table 3 Taguchi, L27 (3^3) OA for paddy husker(units for factors: uncoded units).

No.	R	RC	PM	Response (%)
1	1,440	1.2	10	25.5
2	1,440	1.2	10	25.3
3	1,440	1.2	10	25.4
4	1,440	1.4	12	19.8
5	1,440	1.4	12	19.7
6	1,440	1.4	12	19.8
7	1,440	1.6	14	21.4
8	1,440	1.6	14	21.3
9	1,440	1.6	14	21.2
10	1,460	1.2	12	26.8
11	1,460	1.2	12	26.9
12	1,460	1.2	12	26.6
13	1,460	1.4	14	29.9
14	1,460	1.4	14	29.8
15	1,460	1.4	14	29.7
16	1,460	1.6	10	31.2
17	1,460	1.6	10	31.3
18	1,460	1.6	10	31.4
19	1,480	1.2	14	32.5
20	1,480	1.2	14	32.4
21	1,480	1.2	14	32.6
22	1,480	1.4	10	33.4
23	1,480	1.4	10	33.5
24	1,480	1.4	10	33.6
25	1,480	1.6	12	24.5
26	1,480	1.6	12	24.6
27	1,480	1.6	12	24.6

Analysis and discussion

Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the process parameters on paddy husker in peeling machine is the level with the greatest value in shown Figure 2 and 3 respectively.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

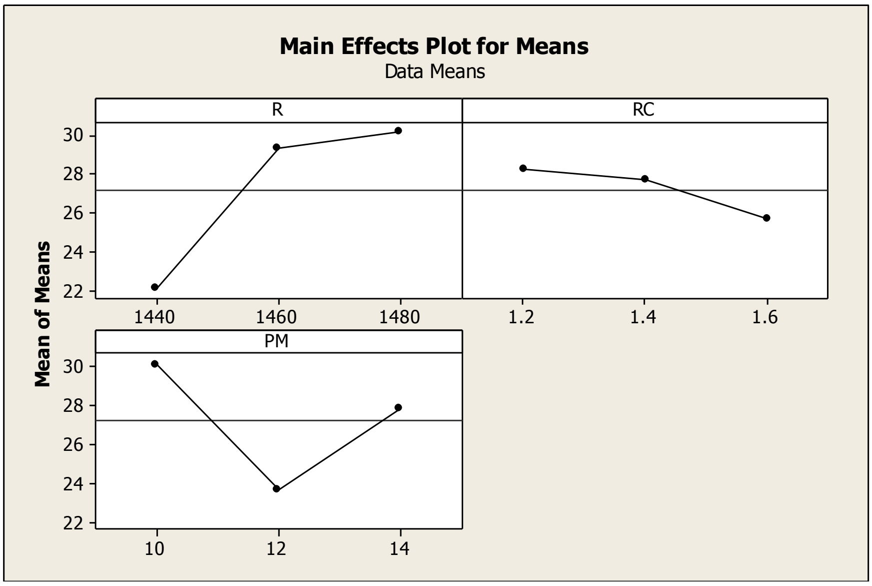

Figure 2 Effect of process parameters on paddy husker in peeling machine for means

The analysis of S/N ratio of paddy husker found that the first factor that causes paddy husker to be small is round per minute, having rubber of clearance and paddy of moisture as secondary factors, respectively. After that, the analysis is made to determine suitable factor of each main factor from S/N ratio as shown in Figure 3.

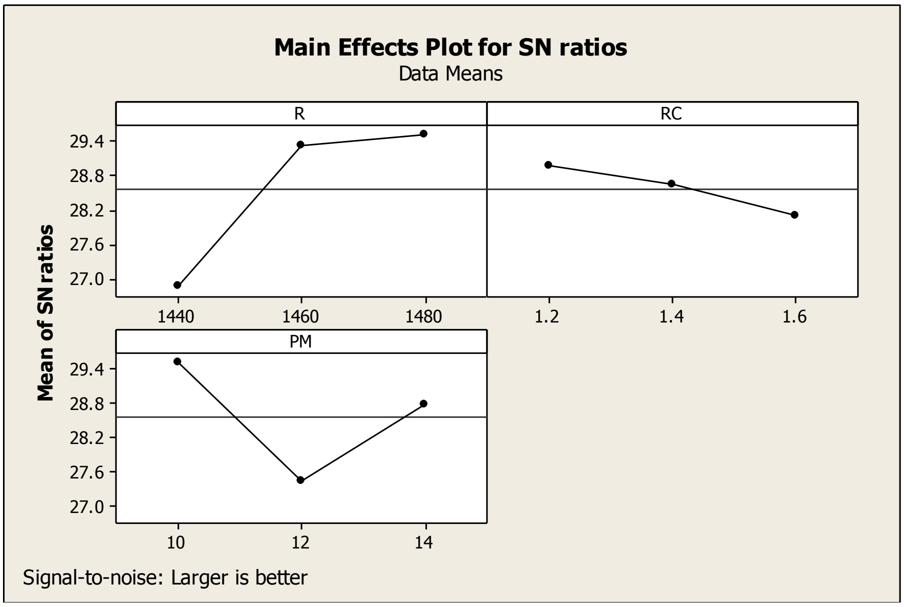

Figure 3 Effect of process parameters on paddy husker in peeling machine for S/N ratios

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Round per Minute:- The effect of parameters round per minute on the paddy husker values is shown above Figure 3 for S/N ratio. Its effect is increasing with increase in round per minute up to 1,480 min/rev. beyond that it is decreasing. So the optimum round per minute is level 1 i.e. 1,440 min/rev.
Rubber of Clearance:- The effect of parameters rubber of clearance on the paddy husker values is shown above Figure 3 S/N ratio. Its effect is increasing with increase in rubber of clearance So the optimum rubber of clearance is level 2 i.e. 1.2 mm. Paddy of Moisture. The effect of parameters paddy of moisture on the paddy husker values is shown above Figure 3 for S/N ratio. Its effect is increasing with increase in paddy of moisture. So the optimum paddy of moisture is level 2 i.e. 12 percentage. The Linear Model Analysis: Means versus R, RC, PM is shown in Table 4 and Table 5 respectively.

Table 4 Estimated model coefficients for means.

Term	Coef	SE Coef	T	P
Constant	27.2111	0.3658	74.383	0.000
R 1,440	-5.0556	0.5174	-9.772	0.010
R 1,460	2.0778	0.5174	4.016	0.057
RC 1.2	1.0111	0.5174	1.954	0.190
RC 1.4	0.4778	0.5174	0.924	0.453
PM 10	2.8556	0.5174	5.520	0.031
PM 12	-3.5111	0.5174	-6.787	0.021
S = 1.097	R-Sq = 98.7%	R-Sq(adj) = 95.0%		

Table 5 Analysis of variance for means.

Source	DF	Adj SS	Adj MS	F	P
R	2	116.229	58.114	48.25	0.020
RC	2	10.402	5.201	4.32	0.188
PM	2	62.736	31.368	26.04	0.037
Residual Error	2	2.409	1.204		
Total	8	191.776			

The Linear Model Analysis: S/N ratios versus R, RC, PM are shown in Table 6 and Table 7.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Table 6 Estimated model coefficients for S/N ratios.

Term	Coef	SE Coef	T	P
Constant	28.5638	0.06645	429.848	0.000
R 1,440	-1.7030	0.09398	-18.121	0.003
R 1,460	0.7517	0.09398	7.999	0.015
RC 1.2	0.3981	0.09398	4.236	0.051
RC 1.4	0.0707	0.09398	0.753	0.530
PM 10	0.9389	0.09398	9.991	0.010
PM 12	-1.1381	0.09398	-12.111	0.007
S = 0.1994 R-Sq = 99.6% R-Sq(adj) = 98.5%				

Table 7 Analysis of variance for S/N ratios.

Source	DF	Adj SS	Adj MS	F	P
R	2	13.1104	6.55520	164.95	0.006 (significant)
RC	2	1.1497	0.57487	14.47	0.065
PM	2	6.6497	3.32485	83.66	0.012 (significant)
Residual Error	2	0.0795	0.03974		
Total	8	20.9893			

Statistically, F-test provides a decision at some confidence level as to whether these estimates are significantly different (Unitek Miyachi Group.,1996),(S.C. Juang and Y.S. Tarng.,2000),(T. R. Lin.,2002),(N. Tosun, C. Cogun, and G. Tosun.,2004). Larger F-value indicates that the variation of the process parameter makes a big change on the performance. Table 4 shows estimated model coefficients value for Means of p values on constant term lower than 0.05 shows that the established model is meaningful. Since the value of R2 (adjust) is 95 %, expressiveness of the model is high. Table 5 analysis of variance for means, This indicated that peel machine type (RC) the non significant effect on paddy husker values. Table 6 estimated model coefficients for SN ratios shows estimated model coefficients value for Means of p values on constant term lower than 0.05 shows that the established model is meaningful. Since the value of R2 (adjust) is 98.5 %, expressiveness of the model is high. Table 7 shows the results of ANOVA for paddy husker for a level of significance of 5% (0.05). From ANOVA Table 7, it is found that, R (Round per Minute) and PM (Paddy of Moisture) is the significant parameter on process parameters for paddy husker in peeling machine production process. The rubber of clearance is found to be insignificant from ANOVA for paddy husker study. F-test is carried out to judge the significant parameter affecting the paddy husker. The larger F-value affects more on the performance characteristics is shown in Table 7. The sum of squares, mean square, F value, residual and also percentage contribution of each factor were shown in above ANOVA Table 5 and 7. The degrees of

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

freedom (df) for each factor is calculated as:degrees of freedom (df) of total is 8 In Taguchi method, the term signal represents the desirable value, and noise represents the undesirable value. Process parameters with the highest S/N ratio always give the best quality with minimum variance (Nalbant M. et al.,2007). The S/N ratio for each parameter level is calculated by finding the average of S/N ratios at the corresponding level. Table 8 shows the response table for S/N ratio of paddy husker for larger is better obtained for different parameter levels. The S/N ratio for each parameter level is calculated by finding the average of S/N ratios at the corresponding level. The response for S/N ratios (Larger is better) and Means is shown in Table 8 and 9.

Table 8 Response for signal to noise ratios (larger is better).

Level	R	RC	PM
1	26.86	28.96	29.50
2	29.32	28.63	27.43
3	29.52	28.10	28.76
Delta	2.65	0.87	2.08
Rank	1	3	2

Table 9 Response for means.

Level	R	RC	PM
1	22.16	28.22	30.07
2	29.29	27.69	23.70
3	30.19	25.72	27.87
Delta	8.03	2.50	6.37
Rank	1	3	

Conclusion

This paper has presented an application of the parameter design of the Taguchi method in the optimization in the peeling machine production process parameters by paddy husker. A three-factor three level Taguchi experimental design was used to study the relationships between the peeling machine and the three controllable input peeling machine production process parameters such as, round per minute, rubber of clearance, and paddy of moisture respectively. The following conclusions can be drawn based on the experimental results of this research work:

1.Taguchi method orthogonal array design method is suitable to analyze this problem as described in this paper.

2.It is found that the parameter design of Taguchi method provides a simple, systematic and efficient methodology for the optimization of the peeling machine production process parameters by paddy husker.

ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

3.For main effects round per minute and paddy of moisture; have significant effect on the peel machine production. This is consistent with the conclusions from the study of other investigators.
4.The round per minute and paddy of moisture has the most significant effect on the peel machine production.
5.Taguchi Analysis: RESPONSE versus R, RC, PM Predicted values , Factor levels for predictions of round per minute is 1,440 min/rev., rubber of clearance (RC) is 1.2 millimetres and paddy of moisture(PM) is 12 percentage on peeling machine production process.
6.The experimental results confirmed the validity of the used Taguchi method for Enhancing the peeling machine production process performance and optimizing the peeling machine production process parameters by paddy husker
The results of this study have clearly indicated full factorial design is an effective method for optimization of material removal rate. Response surface methodology was successfully applied to optimize spindle of speed, flow rate and depth of cut on turning machine that was not a carbide tool. When productions into the formulation, the optimized levels of R-Squire (adjust) was 99.99 % and standard deviation was 0.0035189 yielded lowest material removal rate. The predicted value produced 0.0473 grams of MRR is in close agreement with turning machine activity produce from experiment, which is 0.034 grams of MRR and the confidence interval between 0.0432-0.0514 grams. This study clearly showed that full factorial design was one of the suitable methods to optimize the best operating conditions to maximize the lath removing. Graphical response surface and contour plot were used to locate the optimum point. The statistical fitted models and the contour plot of responses, can be used to predict values of responses at any point inside the experimental space and can be successfully used to optimize the production process by turning machine. Applying the principles of design of experiments using full factorials can build confidence in the practice and can be further expanded.

Acknowledgment
Financial supp9ort integrated Economic and Social Enhancement Project for Sub-District (1 Tambon 1 University) Chiang Mai Rajabhat University area of responsibility Muang Ngai Sub-District, Chiang Dao District, Chiang Mai province name of project/activity in operation Revitalizes the community economy in a new way with science. Technology and innovation in the case of Muang Ngai Sub-District, Chiang Dao District, Chiang Mai Province and support integrated Economic and Social Enhancement Project for Sub-District (1 Tambon 1 University) Rajamangala University of Technology Lanna area of responsibility Nong Phueng Sub-District, Saraphi District, Chiang Mai province name of project/activity in operation revitalizes the community economy in a new way with science. Technology and innovation in the case of Nong Phueng Sub-district, Saraphi District, Chiang Mai Province are gratefully acknowledged.

ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Reference

Taguchi, G. (1991). Taguchi Methods Research and Development. American Suppliers Institute Press, Dearborn, Vol.1,MI.

Phadke, M. S.(1989). Quality Engineering Using Robust Design. Prentice-Hall, Englewood Cliffs, NJ.

Belavendram, N.(1995). Quality by Design-Taguchi Techniques for Industrial Experimentation. *Prentice Hall International*.

Li, M. H., Al-Refaie, A. and Yang, C. Y.(2008). DMAIC Approach to Improve the Capability of SMT Solder Printing Process. IEEE Transactions on Electronics PackagingManufacturing, Vol. 24, pp 351-360.

Li, M. H. and Al-Refaie, A. (2009).The Alpha Error of Taguchi Method with L16 Array for the LTB Response Variable Using Simulation. *Journal of Statistical Computation and Simulation*, Vol.79, No. 5, pp. 645-656.

Maghsoodloo, S., Ozdemir, G., Jordan, V. and Huang, C. H. (2004).Strengths and limitations of Taguchi's Contributions to Quality Manufacturing and Process Engineering. *Journal of Manufacturing Systems*, Vol. 23, No.2, pp. 73-126.

Pignatiello, J. J. (1988). An Overview of the Strategy and Tactics of Taguchi. IIE Transactions: Industrial Engineering Research and Development, Vol. 20, No. 3, pp. 247-254.

Nair, V. N.(1992). Taguchi's Parameter Design: a Panel Discussion. Technometrics, Vol.34, pp.127-161.

Leon, R. V., Shoemaker, A. C. and Tsui, K. L.(1993). Discussion of a Systematic Approach to Planning for a Designed Industrial Experiment. Technometrics, Vol. 35, pp. 21- 24.

Box, G. and S. Bisgaard.(1988). Statistical Tools for Improving Designs. Mechanical Engineering, Vol.110, No.1, pp. 32-40.

Tsui, K. L.(1996). A critical look at Taguchi's modelling approach for robust design . *Journal of Applied Statistics*, Vol. 23, No.1, pp. 81-95.

Ross, P.J.(1996). Taguchi Techniques for Quality Engineering. *Mcgraw-Hill International Editions*, ISBN 0-07-114663-6.pp.329.

Abbas Al-Refaie. and Ming-Hsien Li.(2010). Alpha Error of Taguchi Method with Different OAs for NTB Type QCH by Simulation. Quality Technology & Quantitative Management , Vol. 7, No. 4,pp. 337-351.

Wu, D. H. & Chang, M. Sh.(2004). Use of Taguchi Method to Develop a Robust Design for the Magnesium Alloy Dies Casting Process. *Materials Science and Engineering*, Vol. 379, pp. 366–37.

Yang WH, Tarng YS.(1998). Design optimization of Cutting Parameters for Turning Operations Based on the Taguchi method. *Journal of Material Processing Technology*, Vol.84, pp. 122–129.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Shoemaker, A. C., K. L. Tsui.(1991). Economical Experimentation Methods for Robust Design. *Technometrics*, Vol 33 No. 4, pp. 415-427.

Thornton, A. C., S. Donnely.(1999). More Than Just Robust Design: Why Product Development Organizations Still Contend With Variation and Its Impact on Quality. Annual Taguchi Symposium, ASME.

Gremyr, I., M. Arvidsson, et al.(2003). Robust Design Methodology: Status in the Swedish Manufacturing Industry. *Quality and Reliability Engineering International*, Vol. 19, No. 4, pp. 285-293.

Taguchi G., Chowdhury, S., and Wu, Y.(2005). Taguchi's Quality Engineering Handbook. *John Wiley&Sons*, Inc. ISBN 0-471-41334-8. p.1662.

Taguchi, G.(1993). Taguchi on Robust Technology Development - Bringing Quality Engineering Upstream. ASME Press, New York.

Taguchi G.(1990). Introduction to Quality Engineering. Asian Productivity Organization, Tokyo.

Taguchi, G.(1985). Quality Engineering in Japan. Bulletin of the Japan Society of Precision Engineering, Vol. 19, No. 4, pp. 237-242.

Taguchi, G.(1986). Introduction to Quality Engineering -Designing Quality into Products and Processes. Asian Productivity Organization, Tokyo.

Taguchi, G.(1978). Off-line and On-line Quality Control Systems. Proceeding of International Conference on Quality, Tokyo, Japan.

Byrne D. M. , S. Taguch.(1987). The Taguchi Approach to Parameter Design. *Quality Progress*, Vol. 20, No. 12, pp. 19-26.

Wysk, R. A., Niebel, B. W., Cohen, P. H., and Simpson, T. W.(2000). Manufacturing Processes. Integrated Product and Process Design, McGraw Hill, New York.

Raymond H. M., Andre I. K., and Geoffrey, V.(1992). Response Surface Alternatives to the Taguchi Robust Parameter Design Approach. *The American Statistician*, Vol.46,No.2, pp: 131-139.

Zeydan, M.(2008). Modelling the Woven Fabric Strength Using Artificial Neural Network and Taguchi Methodologies. International Journal of Clothing Science and Technology, Vol.20,No.2, pp. 104-118.

Palanikumar, K.(2006). Cutting Parameters Optimization for Surface Roughness in Machining of GFRP Composites Using Taguchi's Method. *Journal of Reinforced Plastics and Composites*, Vol. 25, No.16, pp. 1739-1751.

Ross, P.J.(1996). Taguchi Techniques for Quality Engineering. Mcgraw-Hill International Editions, ISBN 0-07-114663-6.pp.329.

Roy, R.K.(2001). Design of Experiments Using the Taguchi Approach. A Wiley-Inter science Publication, ISBN 0-471-36101-1.p.538.

P.G.Kochure, K.N.Nandurkar. (2012). Taguchi Method and ANOVA: An Approach for Selection of Process Parameters of Induction Hardening of EN8 D steel. *International*

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online): 0493-2137
E-Publication: Online Open Access
Vol:54 Issue:08:2021
DOI 10.17605/OSF.IO/RZ7K9

Journal of Advance Research in Science, *Engineering and Technology*, Vol.01, Issue 02, pp. 22 -27.

Unitek Miyachi Group.(1996). Welding Material Control. Technical Application Brief, Vol. 2, pp. 1–5.

S.C. Juang and Y.S. Tarng.(2000). Process Parameter Selection for Optimizing the Weld Pool Geometry in the Tungsten Inert Gas Welding of Stainless Steel. *Journal of Materials Processing Technology*, Vol.122, pp. 33–37.

T. R. Lin.(2002). Optimization Technique for Face Milling Stainless Steel With Multiple Performance Characteristics. *International Journal of Advanced Manufacturing Technology*, Vol. 19, pp. 330–335.

N. Tosun, C. Cogun, and G. Tosun.(2004) .A Study on Kerf and Material Removal Rate in Wire Electrical Discharge Machining Based on Taguchi Meth. Journal of Materials Processing Technology, Vol.152, pp. 316–322.

Nalbant M. et al.(2007). Application of Taguchi Method In the Optimization of Cutting Parameters for Surface Roughness in Turning. Materials and Design, Vol. 28, pp. 1379-1385.