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PROCESS PARAMETER SETTING FOR RUBBER CUTTING MACHINE USING TAGUCHI TECHNIQUE

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ABSTRACT

Rubber is a natural substance that we get in the forests, we can obtain these exudations from tropical plants, rubber includes natural and synthetic rubber. Synthetic rubber are generally made by non-original product, say artificial petrochemical products. Rubbers find wide applications in automobiles, aerospace, electrical and many other manufacturing industries, for example tires, wipers, textile industry rollers, printing press, vibration isolators, etc. So rubbers find wide variety of applications in engineering field. Hence the parameters which affects the manufacturing of rubbers is to be studied. The parameters which affects manufacturing of rubber on lathe is analyzed in this project and its behavior is been studied. The parameters included cutting speed, feed and depth of cut on Ebonite rubber roller which is used in printing machine rollers. Parameters were varied and optimum parameters were found out using Design of Experiment (Taguchi technique), MINITAB 16 software and also the results were compared with the experimental results(Surface Roughness test using Taylor Hobson testing machine). These results were satisfactory, which saved the material wastage while manufacturing and ultimately the manufacturing cost was reduced. Labor time and lathe machine setting time was also reduced. Studying of these parameters are vital and most influencing in manufacturing of rubber products and there is wide further scope for studying of other parameters influencing machining of rubber.

INTRODUCTION

Machining has developed into essential to the modern and upcoming industry. It is used in the manufacturing and some are used indirectly of practically all goods and facilities being formed all over the world. The basis of every manufacturing such as darning machines, paper, drug, computers, cars, etc . Wherever materials are used in any man-made object, one can be sure that many of the jobs have reached their final stage through different machine tools and machining process. Even the parts made from plastics and rubber requires machining process.

1.1 Introduction to Rubber

Natural rubber since the latex squashy trees Hevea and Castilla was identified toward South American Indians in past eras. Latex was made to evaporate under sun and handled into usable objects (rubber spheres)."Caoutchouc", it was the earth's original name to identify the compressed juice of Hevea tree, French meaning original term for "weeping wood".

1.2 Composition of Natural rubber

The rubber which is made through latex which holds the mixture of hydrocarbon, rather lesser amounts of protein, starches, resin-like materials etc.

Proteins	2-2.7%
Resins	1.5-3.5%
Sugars	1-2%
Ash	0.4-0.7%
Sterol glucosides	0.07-0.47%
Water	55-65%

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Table 1 Composition of Rubber materials

Natural rubber is either exported are produced into "dry/rock-solid rubber" (in shim, thick rubber flat or brick forms).

1.3 Nitrile Rubber

The nitrile is elastomers existing polymers but "adiene-acrilonitrile". The basic manufacturing objects of such rubbers display an eminent gasoline. The nitrile rubber converse regards the vulcanized to excellent mechanical characteristics, small density set, some amount of abrasion resistance and little permeability to gases . Such manufacturing objects can resist temperatures up to -50 to +125ºC.

PROBLEM DEFINITION

Based on the literature review, the most affecting and influencing parameter in terms of surface roughness is the depth of cut and cutting speed. Going under a literature survey, there are many experimental analysis were made to give the best result for surface roughness, but traditional experimental design procedures is very complicated. The Design of Experiments under which Taguchi method is recommended which uses an Orthogonal array to study the parameters with only a lesser number of experiments. The most readily controlling factors in a wear behavior of surface roughness are found to be cutting speed, feed and depth of cut. Several inventions and studies have explored the effect of these factors on surface. Depth of cut and cutting speed were found to be more significant factor in influencing on surface roughness. It is also seen that as speed increased the surface quality was not achieved. The interaction of different factor combination also affects the surface roughness.

The Experimentation of Project study mainly deals with study of relative influencing parameters like cutting speed, feed and depth of cut on the rubber roller (Nitrile Rubber) which is been used for the purpose of printing. These samples would be prepared and tested as per ASTM standard. A Surface Roughness test would be conducted using surface roughness testing machine. The design of experiment approach using Taguchi's Orthogonal Array, with the help of MINITAB 16.0 software would be employed to acquire data. An orthogonal array,signal-to-noise ratio and Analysis of Variance would be employed to investigate the different response on the selected parameter. The confirmation test would be performed by selecting a set of parameters and compared with Taguchi's predicted optimum values. The study of surface roughness will be done with the help of Taylor Hobson Surface Testing machine.

Objectives

The objectives of the project

- To study the varying cutting speed parameters on the Rubber Roller affecting the Surface Roughness.
- To analyze the varying speed, feed and depth of cut by taking the different parameters and factors.
- To perform ANOVA and S/N ratio for the Surface Roughness response to find the optimum results.
- To find the optimum result using Taguchi's predicted values.

DESIGN OF EXPERIMENTS (DOE)

"Design of experiment is well controlled, systematized technique which is used to analyze, decide a relationship to the varies input parameters (X) disturbing a process and the output parameters of that process (Y)". This technique was first established in the 1920s and 1930s by Sir Ronald. A Fisher, the well-known mathematician and geneticist. Design of experiment involves designing fixed experiments of set, were all relevant parameters are changed methodically. Once the effects of these experiments are analyzed they help us to find optimal conditions, the parameters that are more influential on the results and those which are not effecting, as well as facts such as the existence of exchanges and interactions among the parameters.

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Taguchi's Methodology

Dr. Genichi Taguchi stresses the weight of quality designed into products and processes them rather than depending more on conventional tools. Taguchi's method changes from that of different primary experts in that he focuses more on engineering aspects of quality rather than on administration philosophy or statistics. Taguchi uses different experimental process to overcome the noise factor and give the better quality characteristics of the parameters taken for the robust design.

Orthogonal Arrays" (OA's)

A matrix testingcontains of set of trials, so thatvarying the sets of the several product and developing parameters under study forone experiment to alternative. After directing a matrix, the analyzed report taken from all experiments are taken to set the desired various effects of parameters can be studied. Conducting matrix experiments using special matrices, called as orthogonal arrays

The selection of OA mainly depends on

1. The desired number of effective factors and interactions of importance,
2. The desired number of levels for the factors of importance,
3. A desired experimental resolution.

Orthogonal Array Selection by Taguchi's Standard Table

Taguchi has tabulated 18 basic orthogonal arrays called as standard orthogonal arrays as shown in Table 4.1. An array term specifies the desired number of column and rows and also number of levels in each column.

Orthogonal Array*	Number of Rows	Maximum Number of Factors	Maximum Number of Columns at These Levels			
			2	3	4	5
L_4	4	3	3	—	—	—
L_8	8	7	7	—	—	—
L_9	9	4	—	4	—	—
L_{12}	12	11	11	—	—	—
L_{16}	16	15	15	—	—	—
L'_{16}	16	5	—	—	5	—
L_{18}	18	8	1	7	—	—
L_{25}	25	6	—	—	—	6
L_{27}	27	13	—	13	—	—
L_{32}	32	31	31	—	—	—
L'_{32}	32	10	1	—	9	—
L_{36}	36	23	11	12	—	—
L'_{36}	36	16	3	13	—	—
L_{50}	50	12	1	—	—	11
L_{54}	54	26	1	25	—	—
L_{64}	64	63	63	—	—	—
L'_{64}	64	21	—	—	21	—
L_{81}	81	40	—	40	—	—

* 2-level arrays: L_4, L_8, L_{12}, L_{16}, L_{32}, L_{64}.
3-level arrays: L_9, L_{27}, L_{81}.
Mixed 2- and 3-level arrays: L_{18}, L_{36}, L'_{36}, L_{54}.

Table 2: Standard Orthogonal Arrays

There are 3 parameter namely Speed (RPM), Feed (mm/sec) and Depth of Cut (mm),each parameter has 2 levels. The highest number of levels is 2, from the standard orthogonal arrays defined by Taguchi, the appropriate OA id L_8. The factors and levels related to project is been shown in below table 4.2.

Experiment	Speed (RPM)	Feed (mm/sec)	Depth of Cut (mm)
1	1	1	1
2	1	1	2
3	1	2	1
4	1	2	2
5	2	1	1
6	2	1	2
7	2	2	1
8	2	2	2

Table 3 Orthogonal array set of experiments

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Signal to Noise ratio

Here, the quality characteristic is continuous and non-negative—that is, it can take any value from 0 to ∞. Problems are categorized by the absence of ascaling factor or any other adjustment factor.

Ex- i. The surface defect count ii. pollution from a power plant

One might say that we can reduce the total pollutants emitted by reducing the power output of the plant. However, reducing pollution by reducing power consumption does not signify any quality improvement for the power plant. Hence, it is inappropriate to think of the power output as an adjustment factor.

Additional examples of smaller-the-better type problems are electromagnetic radiation from telecommunications equipment, leakage current in integrated circuits, and corrosion of metals and other materials.

TESTING OF SURFACE ROUGHNESS

FIG. 1 Preparing the test sample for testing the Surface Rouhgnes

The fig 1 shows the initial setup of the rubber roller. The required height is initially setup, than the probe is made to touch the surface of the rubber roller, the the shaft connected with the probe with diamond tip makes a linear moment, the round button is pressed and the machine work starts, the linear motion of the shaft takes automatically, than the surface value Ra in terms of micro meter(μm) shows in the machine a given screen, therefore we can measure our experimental rubber roller in this way.

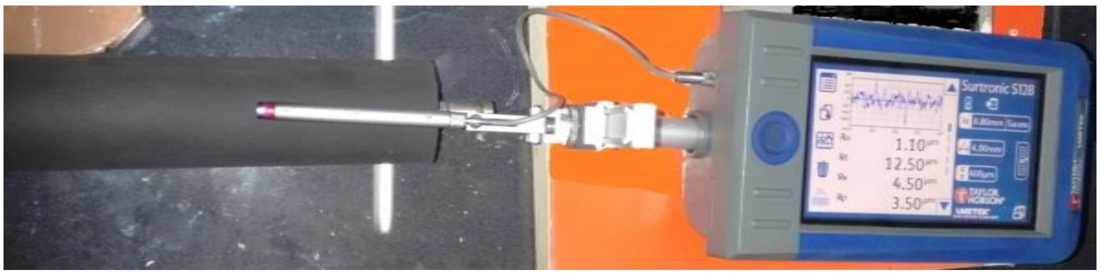

FIG. 2 Test result of the Surface Rouhgness

In the Fig 1 and Fig 2 , the Taylor Hobson surface testing machine is used to measure the surface roughness of the rubber roller, after maching on the lathe the testing on the surface testing machine is been done to know the roughness Ra(μm) value and validate the results obtained.

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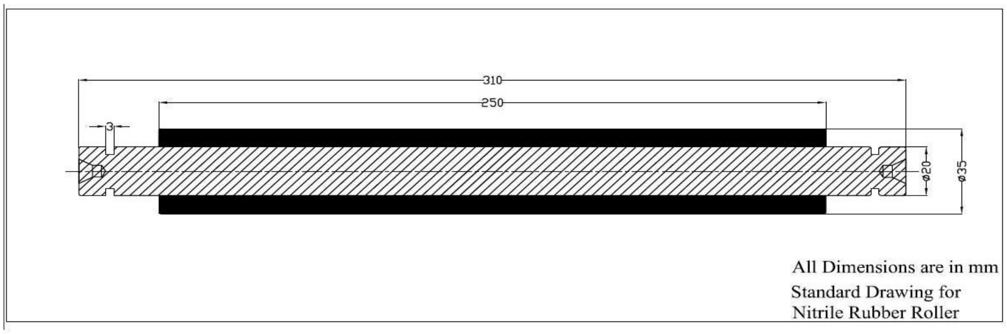

FIG. 3 Standard Drawing for Nitrile Rubber Roller

RESULT AND DISCUSSION

Taguchi L_8 Orthogonal Array Table With Measured Responses

SL No	Three Factors 2 Levels			Response for Surface Roughness µm
	Speed RPM	Feed mm/sec	Depth of cut mm	
1	230	0.50	0.5	1.34
2	230	0.50	1.0	1.53
3	230	0.75	0.5	1.70
4	230	0.75	1.0	1.10
5	330	0.50	0.5	1.12
6	330	0.50	1.0	1.10
7	330	0.75	0.5	1.70
8	330	0.75	1.0	1.07

Table 4-L8 Orthogonal Array Design Matrix

S/N Ratio Analysis

The influence of control parameters such as, Cutting Speed (RPM), Feed (mm/sec) and Depth of Cut (mm) on Rubber Roller had been investigated using S/N ratio analysis. The Surface Roughness characteristics selected is smaller the best type and similar type of response is used for signal to noise ratio given by

$\eta = -10\log 10\{1/n \sum y_i^2\}$ Smaller the better type for Surface Roughness (6.1)

Where, n=no. of replications

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L8Orthogonal Array Test	S/N Ratio for Surface Roughness (db)
1	-2.54210
2	-3.69383
3	-4.60898
4	-0.82785
5	-0.98436
6	-0.82785
7	-4.60898
8	-0.58768

Table 5 : S/N ratios for Surface Roughness of the Rubber Roller

Table 5 gives the results of ANOVA for Rubber Roller surface roughness. It is seen from ANOVA, that the Depth of Cut (mm) and Speed (RPM) have the major influence on surface roughness. The S/N ratio responses were used to analyze the formula (6.1) for all the eight tests in Table 6. Figures 4 shows the data means for main effects plot for S/N ratios intended for surface roughness graphically, whereas Figures 5 shows the interaction plot for S/N ratios for surface roughness.

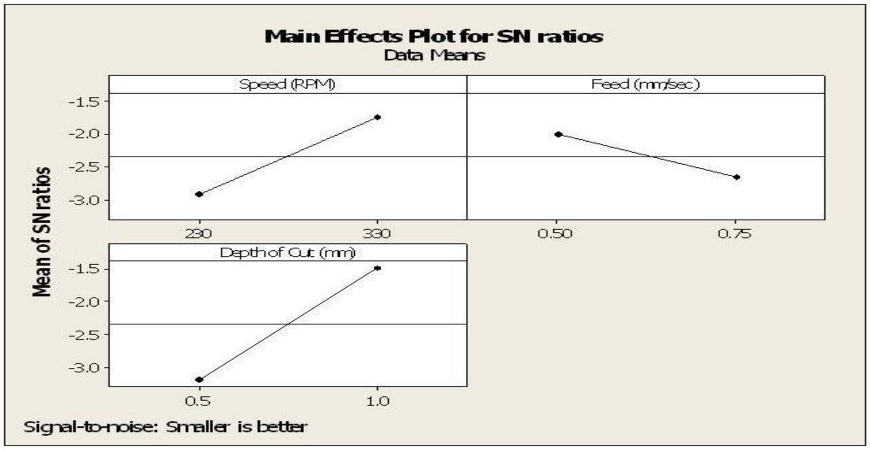

FIG. 4 Signal to Noise ratio for Smaller the better type

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The fig 4 shows the graphs obtained from the results as shown in the table 6.1 and 6.2. As the graph shows that if line is horizontal (x-axis) than there is no main effect, if it is crossing it, than there is a main effect. In the fig 6.1shows the Main effects plot forS/N ratios, cutting speed (RPM) and depth of cut (mm) has major effect on the surface roughness, were as effect of feed is decreasing as cutting speed and depth of cut increases.

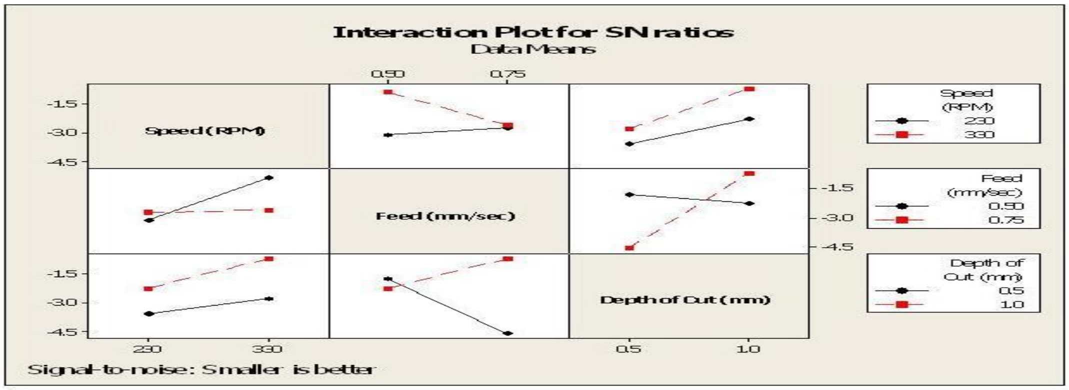

FIG. 5 Signal to Noise ratio interaction plots

The above fig 5 shows the Interaction plot for S/N ratios for data means, as in the fig 6.1 shows the main effect for the speed, feed and depth of cut effect over the surface roughness, here in the fig 6.2 the graph shows even there is an effect of depth of cut and feed. The percentage effect of depth of cut and feed is been shown in ANOVA table 6.3.

ANOVA Analysis

The analysis of variance (ANOVA) is used investigate the influence of wearing parameters like cutting speed(RPM), feed (mm/sec) and depth of cut (mm). The ANOVA establishes the relative significance of each factor in terms of their percentage contribution to the response. The ANOVA analysis was carried out for a 5% significance level (i.e., the level of confidence 95%) .

Source	DOF	Seq SS	Adj SS	Adj MS	F	P	Percentage Contribution
Speed	1	2.7190	2.7190	2.7190	19.07	0.143	12.55
Feed	1	0.8355	0.8355	0.8355	5.86	0.249	3.85
Depth of Cut	1	5.7922	5.7922	5.7922	40.62	0.099	26.75
Speed* Feed	1	2.1877	2.1877	2.1877	15.34	0.159	10.10
Speed* Depth of Cut	1	0.2997	0.2997	0.2997	2.10	0.384	1.38
Feed *Depth of Cut	1	9.6748	9.6748	9.6748	67.85	0.077	44.68
Error	1	0.1426	0.1426	0.1426			0.6586
Total	7	21.6516					100

Table 5: Analysis of variance results for S/N ratio for Surface Roughness

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Table 5 shows the results of ANOVA analysis for surface roughness. It is observed from the ANOVA analysis, that the Depth of Cut (mm) and Speed (RPM) have the major influence on rubber roller surface roughness material. The last column of the Table 6.3 shows the percentage impact of each factor for the total variation indicating, the degree of influence on the response value. It can be observed from the ANOVA Table 6.3, that the main effects, Depth of Cut (26.75 %) and Speed (12.55 %) have great influence on surface roughness and also the interaction of speed and depth of cut (44.68%) has more influence on the surface roughness.

Results Optimization

The response tables 6 indicates the average variation of S/N ratios, means for every level of surface roughness. The below table6.4 shows ranks based on MINITAB Delta statistics calculated by software, it compares the absolute amount for each varying parameters . The Delta statistic is the higher order minus the lower order average of S/N ratio and mean for each different factor. MINITAB 16 assigns proper rank created on Delta values; rank 1 indicates highest Delta value, rank 2 second highest, and so on.

Level	Speed (RPM)	Feed (mm/sec)	Depth of Cut (mm)
1	**-2.918**	-2.012	**-3.186**
2	-1.752	**-2.658**	-1.484
Delta	1.166	0.646	1.702
Rank	2	3	1

Table 6 Table of response to S/N ratio for Surface Roughness

Level	Speed (RPM)	Feed (mm/sec)	Depth of Cut (mm)
1	**1.418**	1.273	**1.465**
2	1.248	**1.393**	1.200
Delta	0.170	0.120	0.265
Rank	2	3	1

Table 7 Table of response Means for Surface Roughness

In this experimentation purpose was to minimize the surface roughness. In Taguchi experiments, always there would be maximize the S/N ratio. The S/N ratio marked with bold letters in the response tables 5 shows that the S/N ratios can be maximized at this level and surface roughness can be minimized at this level in mean response table 6.With the help of the Response Table of S/N ratio for Surface Roughness and Response Table of Means for Surface Roughness, the effect of depth of cut is affecting more and cutting speed is too have effect on surface roughness. Examining the main effects plots and interaction plots confirms the above results. The table 6.6 summarizes the predicted optimized Taguchi results.

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Factors	Levels for Surface Roughness
Speed (RPM)	2
Feed (mm/sec)	3
Depth of Cut (mm)	1

Table 8: Predicted Optimized Taguchi Results

S/N Ratio	-4.47547
Mean	1.6775

Table 9 Predicted Optimized Results

In the above Table 8, the Taguchi predicted optimized result value is been generated and taking these values a single test was conducted on another rubber roller and got a better response.

CONCLUSION

The following conclusions, can be made from the experimentation about the Rubber Roller wear behavior of Nitrile Rubber under the selected ranges of Cutting Speed (RPM), Feed (mm/sec) and Depth of Cut (mm)

- The Taguchi technique can be successfully used to study, the Roller surface wear behavior of Nitrile rubber.
- The ANOVA analysis shows that the Depth of Cut (26.432 %) and Speed (10.877 %) have major influence on Surface Roughness of roller.
- The interaction effect of parameters has a significance effect on surface roughness.
- As the chemical composition of the Nitrile rubber is made as per company standard, so the mixture of rubber composition has no much change in hardness of the rubber when measured by Shore durometer test equipment.
- With the help of Taguchi Predicted optimized results, the process was carried out and the company required standard surface roughness was achieved.
- The result obtained from theprocess parameter which gave a better response, the company saved rubber material which was wasted much while machining.
- The effects of different process parameters on the response were studied with the help of main effect and interaction plots to find the optimum values for process.
- The time for setting on the lathe machine and cost of machining was reduced to savings to the company.

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