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OPTIMIZATION OF VARIOUS DRILLING MACHINE PARAMETERS USING GREY RELATION METHOD AND ANOVA APPROACH

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ABSTRACT:

This paper is related to the vibrations in the drilling operations where as the processor parameters are optimized using grey relational analysis and Anova approach. The parameters which effect vibrations are Drill Diameter, Speed and Feed Rate which is related to the performance characteristics. A grey relational grade obtained from the grey relational analysis is used to optimize the process parameters. Optimal process parameters can then be determined by the Taguchi method using the grey relational grade as the performance index. Using these different characteristics, the parameters, including speed, drill diameter, and feed rate are optimized. The results show the parameter drill diameter and feed rate of drilling has most significant effect on the vibration.

KEYWORDS: Grey relational grade, Drilling, Feed Rate, Vibrations.

I. INTRODUCTION:

In many industries drilling is a most important process, while drilling it is observed that vibrations occur due to machining parameters. The vibrations produced by external parameters that can be controlled by the methods of vibration isolation and carrying out during the drilling operation. But if the vibrations are produced by drilling itself i.e. due to spindle speed and feed cannot be controlled completely.

So, such internal vibrations need to be avoided. As these vibrations depend upon the various machining parameters, calculation of vibrations can be done under different machining parameters.

So here we had conducted the study and the results can be summarized and the critical values of vibrations for various parameters are defined. And grey relational analysis is used for identifying the most affecting factor for the vibrations. [1]

II. DESING OF EXPREMENT:

A. INPUT PARAMETER:

1. Diameter
2. Feed rate
3. Speed

B. OUTPUT PARAMETER:

1. Vibrations

In this research we used the above mentioned input parameters to get the readings of the vibrations. After the reviewing of literature the input parameters diameter, speed and feed rate are consider and as an output the vibrations are measured. [2]

The Mild Steel material specimen has been used for the study and 6mm, 8mm, 10mm and 12mm drill diameter with same point angle is used for experimentation. Each fresh drill point was used to make the holes in order to nullify the effect of tool wear on cutting forces.

The objective of this research is to study the effect of different parameters such as speed, drill diameter and feed rate. So for this purpose we select different levels and combinations of diameter of drill, Speed and feed rate

For conducting the study, it has been decided to follow Taguchi method of experimental design. And examine and verify, grey relation analysis method. The most important output i.e. vibrations is analyzed in this research work. The effect of the variation in input process parameter is studied on this response parameter.

III. EXPERIMENTAL SETUP:

A. DRILLING MACHINE:

A radial drilling machine was used for the drilling operation of different speed and feed.

B. EXPERIMENTAL SETUP:

Figure 1 and 2 shows the schematic diagram of the present experimental setup. Details of the equipment, sensors and the cutting conditions for the drilling operation performed are given below. In all the drilling operations performed, no coolant was used. A resultant vibration in m/s2 values of vibration is recorded through an Accelerometer ADXL345. Signals from the Accelerometer ADXL345 were passed through Microcontroller – Arduino UNO and stored in the computer through a data acquisition system. Accelerometer ADXL345 was used to capture feed vibration signal that was attached on the top surface of the mild steel specimen.

Fig 1: Experimental Set-up

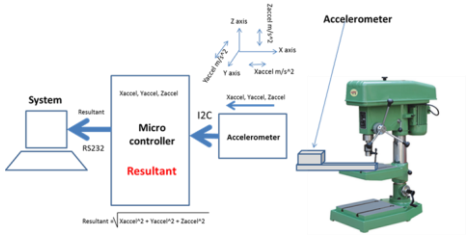


Fig 2: Experimental Set-up

Table 1: Study and Observation

Experiment no.	Drill Diameter	Speed (rpm)	Feed Rate (mm/rev)	Time s
1	6mm	525	0.0238	
2	6mm	720	0.0166	25
3	6mm	1152	0.0108	24
4	8mm	525	0.0238	25
5	8mm	720	0.01	29
6	8mm	115	0.0096	27
7	10mm	52	0.0178	32
8	10mm	720	0134	
9	10m	1152		28
10	12mm	525	0.01	34
11	12mm		0.0148	
12	12mm	115	0.0108	24

IV. METHODOLOGY:

A. GREY RELATIONAL ANALYSIS METHOD

In the grey relational analysis, the relationship between the desired and actual data is expressed by the grey relation coefficient calculated by normalizing the experimental results (vibrations m/s²). Then, the grey relational grade was computed by averaging the grey relational coefficient. The overall evaluation of the multiple process responses is based on the grey relational grade.

As a result, optimization of a single grey relational grade can be obtained from optimization of the complicated multiple process responses. In other words, the grey relational grade can be treated as the overall evaluation of experimental data for the multi response process. Optimization of a factor gives level with the highest grey relational grade. Data Pre-Processing is normally required, since the range and unit in one data sequence may differ from others.

In the study, a linear data preprocessing method for the vibration is the lower-the-better and is expressed as:

$$x_i(k) = \frac{maxy_i(k) - y_i(k)}{maxy_i(k) - miny_i(k)}$$

Where $x_i(k)$ is the value after the grey relational generation, min $y_i(k)$ is the smallest value of $y_i(k)$ forthe k^{th} response, and max $y_i(k)$ is the largest value of $y_i(k)$ for the k^{th} response.[4]

Table 2: Grey Relational Coefficient

Experiments	x_i(	Δoi	ς$_i$
1	0.740	595	0.854992
2	07921		0.922605
3	0.8414	0.158	998011
4	0.8391	0.1609	9422
5	0.8066	0.1934	0.943574
6	0.679	0.3202	0.787134
7	0.601	0.3989	0.713693
	0.646	0.3533	0.754481
9	0.554	0.4446	0.677013
10	0.8426	0.1574	1.0000
11	0.7371	0.2629	0.850883
12	0.6570	0.343	0.764347

An ideal sequence is $x_0(k)$ (k=1, 2, 3) for three responses. The definition of the grey relational grade in the grey relational analysis is to show the relational degree between the twelve sequences ($x_0(k)$and $x_i(k)$, i=1, 2, . . . , 27; k=1, 2, 3).

The Δ_{oi} was calculated for each of the following responses after considering $x_0(k) = 0$.

Where $\Delta_{0i}(k) = \|x_0(k) - x_i(k)\|$ is the difference of absolute value between $x_0(k)$ and $x_i(k)$;

The grey relational coefficient $\xi i(k)$ can be calculated as:

$$\xi_i(k) = \frac{\Delta_{min} + \varsigma\Delta_{max}}{\Delta_{0i}(k) + \varsigma\Delta_{max}}$$

ς =distinguishing coefficient (0_1); Δmin, smallest value of Δ_{0i}; and Δmax, largest value of Δ0i..

After averaging the grey relational coefficients, the grey relational grade Υi can be obtained as:

$$\Upsilon_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k)$$

Where *n* is the number of process responses. The higher value of the grey relational grade represents the stronger relational degree between the reference sequence $x_0(k)$ and the given sequence $xi(k)$. As mentioned before,

the reference sequence $x_0(k)$ is the best process response in the experimental layout. The higher value of the grey relational grade means that the corresponding cutting parameter is closer to optimal. In other words, optimization of the complicated multiple process responses is converted into optimization of a single grey relational grade.[5]

Table 3: Grey relational Grade

Experiments	γi	Order
1	0.854992	6
2	0.922605	5
3	0.998011	2
4	0.994220	3
5	0.943574	4
6	0.787134	8
7	0.713693	11
8	0.754481	10
9	0.677013	12
10	**1.0000**	1
11	0.850883	7
12	0.764347	9

According to the Taguchi method,[6] the statistic delta is the difference between the high and the effect in the grey relational grade factor, was used. A classification can be done to determine the most affective factor. So the multiple objective optimization problems are transformed into a single equivalent objective function optimization problem. The higher grey relational grade will be close to the optimal condition. Using the grey relational grade value, the mean of the relational grade for each level of different factors and the total mean of the grey relational grade is summarized in Table.

Table 4: Response table for GRG values for Diameter.

Level	Diameter	Grey Relational Grade
1	6mm	**0.9**
2	8mm	0.9083
3	mm	0.7
4		0.8
Delta		0.2102

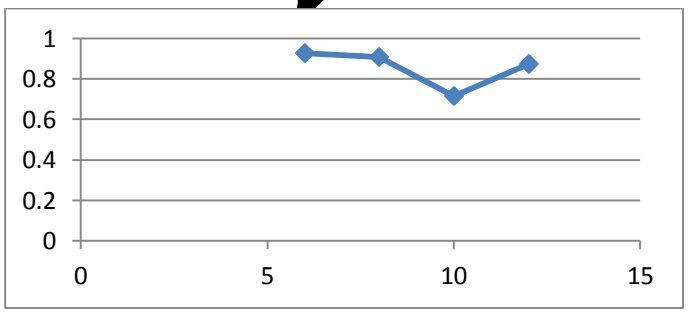


Table 5: Response table for GRG values for Speed.

Level	Speed	Grey Relational Grade
1	525rpm	**0.8907**
2	720rpm	0.8678
3	1125rpm	0.8066
Delta		0.0841

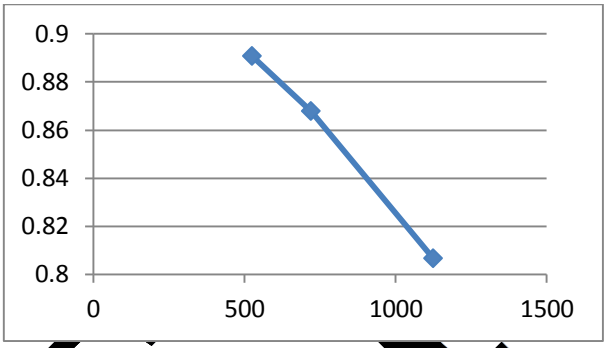
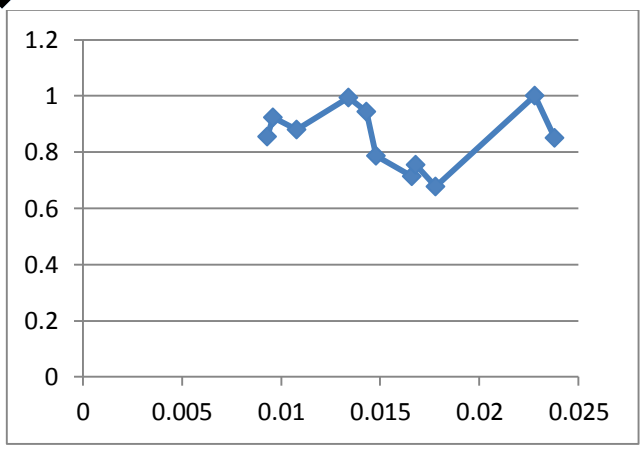


Table 6: Response table for GRG values for Feed Rate

Level	Feed Rate (mm/rev)	Grey Relational Grade
1	0.0093	0.8549
2	0.0096	0.9226
3	0.0108	0.8811
4	0.013	0.9942
5	0.013	0.9435
6	0.0148	0.7871
7	0.0166	0.7136
8	0.0168	0.7544
9	0.0178	0.6770
10	0.0228	**1.0000**
11	0.0238	0.8508
Delta		0.3230



According to the results presented in above *Tables* for vibrations, feed rate has the largest effect. Factor drill diameter is second and is followed by factor spindle speed.

From there the factors were ranked and it is found that the most significant factor was the FEEDRATE and the least significant factor was SPEED.

The optimal parameter setting was got from the combination of 520 RPM Speed, 6mm Diameter of Drill and

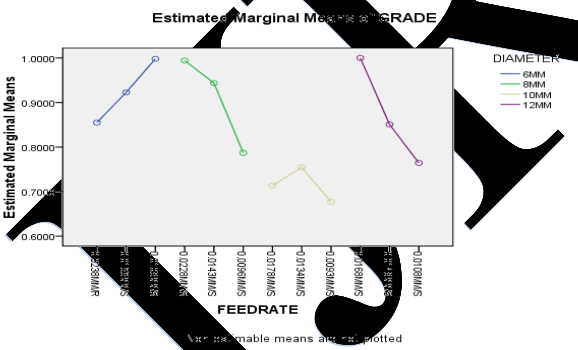
Feed Rate 0.0228mm/Revolution for the 12 experiment having highest performance this is observed in figures.[7]

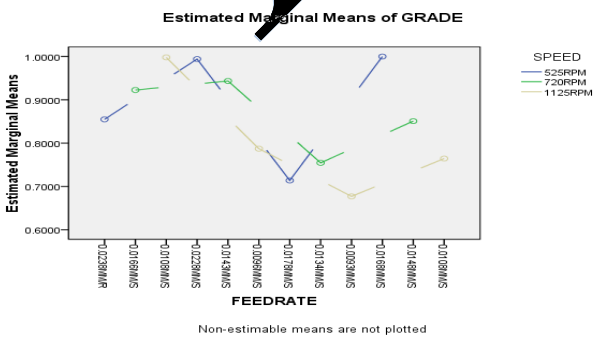
ANOVA

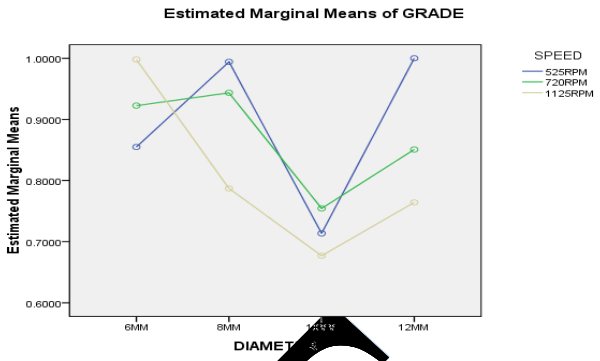
The purpose of the ANOVA is to investigate which factors significantly affect the performance characteristic. This is accomplished by separating the total variability of the grey relational grades, which is measured by the sum of the squared deviations from the total mean of the grey relational grade, into contributions by each drill parameter and the error. The percentage contribution by each factor to the total sum of the squared deviations SST can be used to evaluate the importance of the drilling parameter change on the performance characteristic.

In addition, the F test can also be used to determine which factor has a significant effect on the performance characteristic. Usually, the change of a determined factor has a significant effect on the performance characteristic when the F value is large. Results of the ANOVA Table indicate that diameter is the most significant factor for affecting the multiple performance characteristics. Based on the previous discussion, the feed rate affects mostly the vibrations, but through the F value and ANOVA proves that diame[illegible] have significantly affect the vibrations.[8]

SOURCE	SS	DF	MS	F	
DIAMETER	0.083	3	0.028	3.402	0.07
SPEED	0.015	2	0.008	0.512	0.616
FEEDRATE	0.148	11	0.013		-
ERROR	0.00	0			







CONCLUSION:

A grey relational [illegible]de obtained from the grey relational analy[illegible]s was use[illegible] optimize the drilling parameters during the drilling o[illegible] mild steel specimen with vi[illegible]ations. The experiment[illegible]sults show that para[illegible]eter Feed Rate and Diamet[illegible]as the most si[illegible]ficant effect [illegible] the vibrations.

Therefo[illegible]e integration of grey relational analy[illegible]nd the Taguchi Me[illegible]od can be applicable for the optimiza[illegible] of process para[illegible]eters and help to improve [illegible]ocess effi[illegible]y.

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