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Vibration Analysis using Accelerometer ADX345

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Abstract

This novel work is related to the vibrations in the drilling operations, where re-searcher focuses on an approach based on the Taguchi method with grey relational analysis for optimizing the process parameters. Taguchi Method is a statistical approach to optimize the process parameters and improve the quality of components that are manufactured. The objective of this study is to illustrate the procedure adopted in using Taguchi Method in the drilling operation. The parameters which affect the vibration is studies, i.e. Drill Diameter, Speed and Feed Rate, which is related to the performance characteristics.

I. INTRODUCTION

In many industries, drilling is a most important process; in drilling, it is observed that the vibrations occur due to machine parameters. External parameters produce the vibration can be controlled by the methods of vibration isolation and carrying out during the drilling operation. But, vibrations produced because of drilling itself, i.e. due to spindle speed and feed can-not be controlled completely and 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.

A. Sources of Vibration during Drilling Operation.

In Drilling Operation, two types of vibrations are observed:

a) External Vibrations

In a drilling operation, the spindle of the drill may vibrate because of the vibration developed by machine due to malfunctioning. These vibrations can be

Categorized as vibrations due to external parameters. Sources of external vibrations are as follows:

- Shaft Misalignment in the spindle, motor, nut-bolts and transmitting elements viz., pulley or gear drives
- Improper Foundation of machine
- Loosen fasteners such as nut-bolts, clamps etc.

b) Internal Vibrations

Internal Vibrations in the drilling operation are produced due to the drilling process itself!
Internal vibrations are unavoidable as they occur because of the internal characteristics of the system. Sources of Internal Vibrations are as follows:

- Spindle Speed
- Force exerted by the workpiece in the opposite direction to the drill motion
- Resistive torque by induced by workpiece during material cutting
- High feed rate
- High Overhung of drill

c) Types of Vibrations Produced During Drilling Operation

Vibrations in the drilling operation are produced in the two stages:

1. When the drill is rotating and approaching towards the workpiece.
2. When the drill is rotating and drilling a hole into the workpiece.

B. Contribution

We consider the vibration as measuring a parameter in the drilling operation. In this novel work, the internal vibrations are analyzed. For vibration analysis, S/R Ratio is considered for the optimum solution.

II. VIBRATIONS USING ACCELEROMETER

To calibrate the accelerometer to the gravitational reference, we need to determine the accelerometer output for each axis when it is precisely aligned with the axis of the gravitational pull. Acceleration can be measured in units of gravitational force or $g=9.8m/s^{2}$', where 1g represents the gravitational pull at the surface of the earth. Gravity is a relatively constant force and makes a convenient and reliable calibration reference.

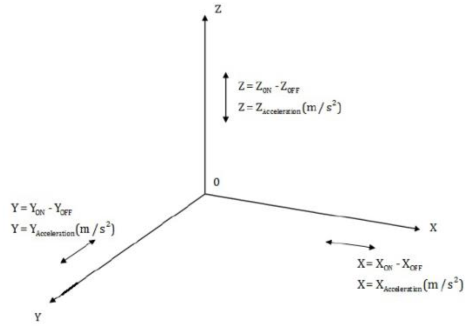

Figure 1: Axes of Acceleration Sensitivity

1. Appropriate arrangement of the Accelerometer (ADXL345) is necessary for an exact measurement.
2. After the part is configured for accurate measurement, a number of samples of X, Y and Z axes acceleration data should be retrieved from the sensor and averaged together.
3. The number of averaged values should be stored and labelled appropriately. The disabled data that is, X_{OFF}, Y_{OFF}, and Z_{OFF}.
4. By setting Bit D7 of the data format, the register system is enabling to collect the data. The output needs some time to settle after enabling. After allowing the output to settle, several samples of the X, Y and Z axes acceleration data should be taken again and averaged.
5. These averaged values should be stored and labelled appropriately as the value enabled, that is, X_{ON}, Y_{ON}, and Z_{ON}.

From figure 1 with the stored values for enabled and disabled, the test change is as follows:

$$X_{Acceleration} = X_{ON} - X_{OFF} \quad .... \quad (1)$$

$$Y_{Acceleration} = Y_{ON} - Y_{OFF} \quad .... \quad (2)$$

$$Z_{Acceleration} = Z_{ON} - Z_{OFF} \quad .... \quad (3)$$

The Resultant Acceleration calculated as

$$R_{Acceleration} = \sqrt{X^2{}_{\text{Acceleration}} + Y^2{}_{\text{Acceleration}} + Z^2{}_{\text{Acceleration}}} \quad ....(4)$$

Because the measured output for each axis is expressed in LSB's, X, Y, and Z are also expressed in LSBs. These values can be converted to g's of acceleration

A. Taguchi's Method

Taguchi method, a tool for parameter design. The performance characteristics have been determined for optimal machining parameters for minimization of vibrations. The predicted data got from mathematical models can be converted into a signal-to-noise (S/N) ratio. In Taguchi method, 'signal' represents the desired value (mean) for the output characteristics, and 'noise' represents the undesirable value (S.D.) for the output characteristics. It means that S/N ratio is the ratio of the mean to S.D. The feature that lower value represents better machining performance, such as surface roughness and flank wear is called \lower-the-better", LLB.

LSB Calculated as,

$$LSB = \frac{1}{N}\sum_{i=1}^{N} Y_i^2 \quad .... (5)$$

$$(S/N) \text{ Ratio} = - 10 \log_{10}(LSB)...(6)$$

Hence finally we defined the Signal to Noise Ratio (η) as,

$$\eta\left(\frac{S}{N}\right) = -10 \, log_{10}\left[\frac{1}{N}\sum_{i=1}^{N} Y_i^2\right] .. (7)$$

Where,
Y_i is the observed data of the experiment and
N is the number of experiments.

a) Steps Involved in the Taguchi Method

The use of Taguchi's parameter design involves the following steps.

- Identify the main function and its side effects.
- Identify the noise factors, testing condition and quality characteristics.
- Identify the objective function to be optimized.
- Identify the control factors and their levels.
- Select a suitable Orthogonal Array and construct the Matrix
- Conduct the Matrix experiment.
- Examine the data; predict the optimum control factor levels and its performance.
- Conduct the verification experiment

III. RESULTS

The vibration analysis depicted in the following figures has been done for 6mm, 8mm, 10mm and 12mm diameter at 525 RPM, 720 RPM and 1152RPM speed respectively.

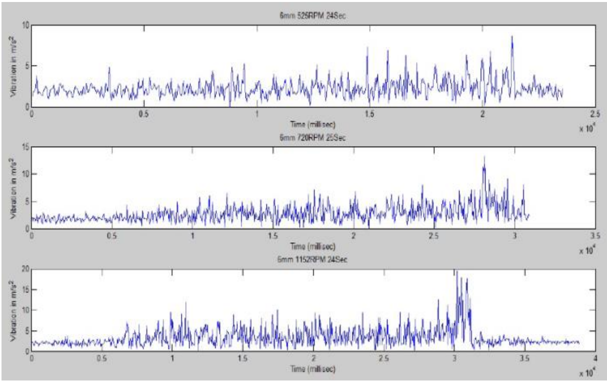

Figure 2: Matlab Simulation of Vibration analysis for 6 mm diameter at various speeds such as 525 RPM, 720 RPM and 1152 RPM.

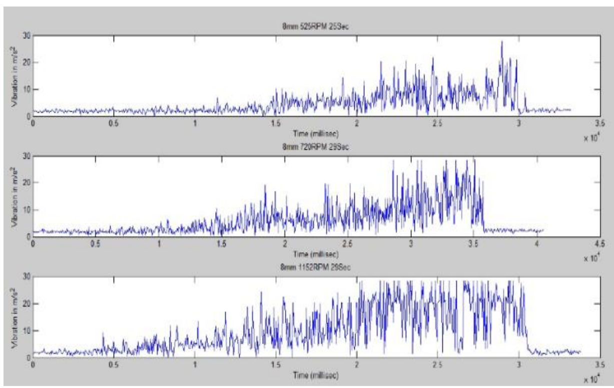

Figure 3: Vibration analysis for 8 mm diameter at various speeds such as 525 RPM, 720 RPM and 1152 RPM.

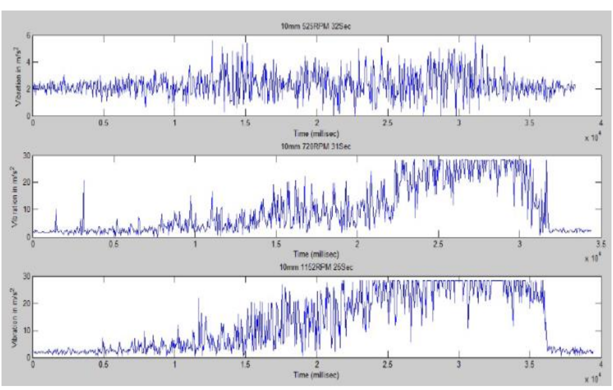

Figure 4: Vibration analysis for 10 mm diameter at various speeds such as 525 RPM, 720 RPM and 1152 RPM.

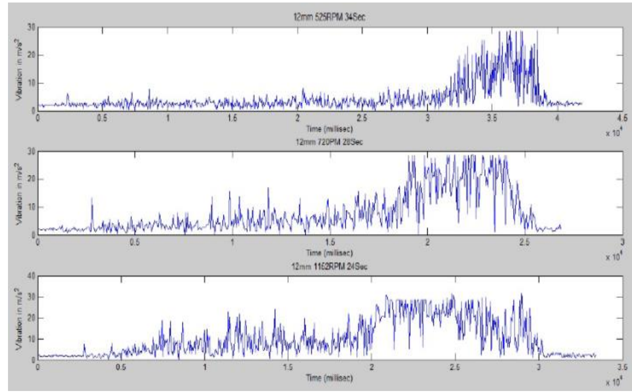

Figure 5: Vibration analysis for 12 mm diameter at various speeds such as 525 RPM, 720 RPM and 1152 RPM.

IV. SN RATIO CALCULATION USING TAGUCHI METHOD

Table 1: SNR Calculation for Drill diameter using Taguchi Method

Sr. No.	Diameter	S.N. Ratio
1	6mm	-10.56
2	8mm	-19.26
3	10mm	-21.93
4	12mm	-20.18

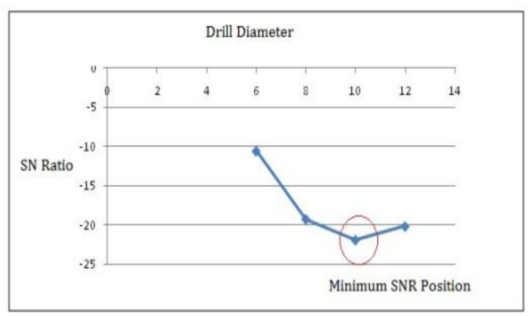

Figure 6: SNR Calculation for Drill diameter using Taguchi Method

Table 2: SNR Calculation for Speed using Taguchi Method

Sr. No.	Speed	S.N. Ratio
1	515	-14.10
2	720	-19.73
3	1152	-21.84

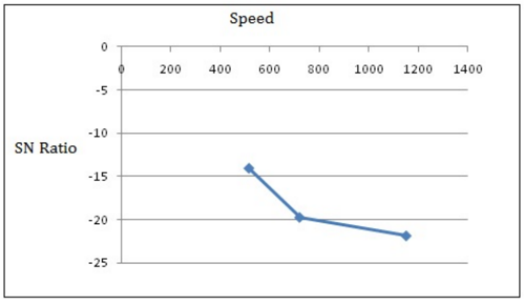

Figure 7: SNR Calculation for Speed using Taguchi Method

Table 3: SNR Calculation for Feed Rate us-ing Taguchi Method

Sr. No.	Feed Rate (mm/Rev)	S.N. Ratio
1	0.0093	-24.38
2	0.0096	-21.90
3	0.0108	-19.33
4	0.0134	-22.71
5	0.0143	-18.06
6	0.0148	-20.69
7	0.0166	-10.03
8	0.0168	-16.57
9	0.0178	-8.00
10	0.0228	-15.68
11	0.0238	-7.93

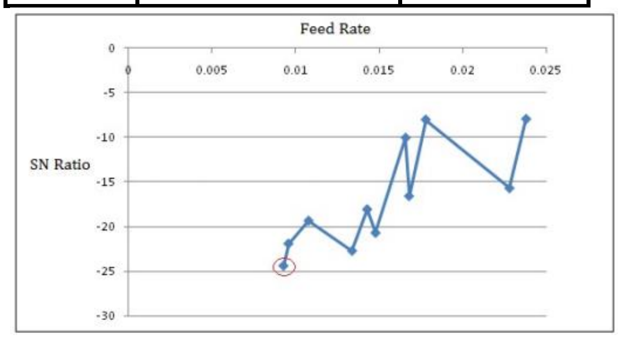

Figure 8: SNR Calculation for Feed Rate using the Taguchi Method

Table 4: SNR Calculation using Taguchi Method

Experiment No.	Drill Diameter	Speed	SNR
1	6	525	-7.9309
2	6	720	-10.7094
3	6	1152	-13.3028
4	8	525	-16.8309
5	8	720	-19.9057
6	8	1152	-23.1109
7	10	525	-8.2368
8	10	720	-23.0091
9	10	1152	-25.6886
10	12	525	-18.6359
11	12	720	-21.2113
12	12	1152	-23.6267

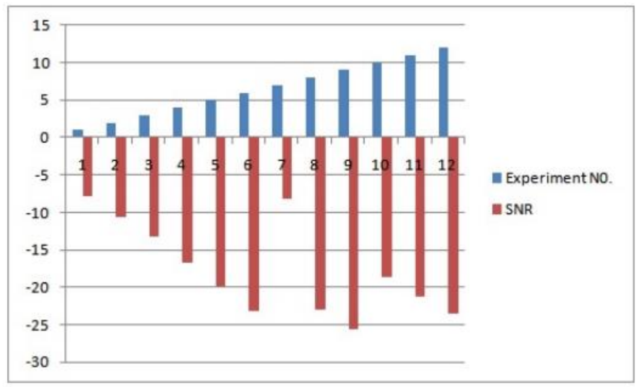

Figure 9: SNR analysis using Taguchi

V. CONCLUSION

As discussed, in the radial drilling operation, the interval vibration is observed**.** Scholar approach to finding the optimum solution to analyze the internal vibration. The basic concept originates from statistical analysis for a large amount of data. A grey relational grade obtained from the grey relational analysis was used to optimize the drilling parameters during the drilling of the mild steel specimen with vibrations. The experimental results show that the parameter Feed Rate and Diameter have the most significant effect on the vibrations.

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