OPTIMIZATION OF TURNING PROCESS PARAMETERS, ON EN 9 CARBON STEEL USING GREY RELATIONAL ANALYSIS

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ABSTRACT
Present paper entails the optimization of the machining process parameters for the turning of EN 9 carbon steel (it is a carbon steel, also known as 070m55, available in diameters, flats, squares and plates – it can be used for gears, sprockets and cams) on the lathe machine using a combination of the Taguchi and the Grey Relational Analysis to yield a minimum cutting forces and expected minimum surface roughness. Process parameters chosen are as the rotational speed, a feed, the depth of cut and a selected cutting fluid. The experiments which are conducted as per the Taguchi experimental designs and the L_9 orthogonal array were carried out in the experiment. The Analysis of variance (ANOVA) has also been used to evaluate the most impact of processing parameters which were resulted in the experiment. The reversion equations were also been established between a process parameters & the responses. The results that indicate the depth of cut is an important factor on that affecting a cutting force & the surface roughness assessed by the feed, a speed and the cutting fluid.

KEYWORDS: Grey relational analysis, Taguchi method, EN 9 Carbon steel, turning operation.

INTRODUCTION
Process plays a key role in different type of machining operations as it produces various shapes like straight, curved, conical cylindrical and etc. the process parameters influence the quality of mechanical machining processes, here the chosen process parameters such as feed, speed, cutting speed, cutting fluid and etc. Inorder to obtain high cutting performance, it is intended to optimize machining process parameters thus, cutting forces influences the deformation of the work piece, dimensional accuracy and chip formation. In an operation surface roughness influences the resistance and the fatigue strength. Therefore it is required to evaluate a selected material cutting forces and surface roughness
The chemical composition of EN 9 carbon steel is as followed in Table 1:

Table 1:

Chemical Elements	%age of Comp
Carbon	0.5-0.6
silicon	0.05-0.35
Manganese	0.5-08
Sulphur	0.06
Phosphorous	0.06
Chromium	-
Molybdenum	-
Nickel	-

LITERATURE REVIEW

Subhakanta Nayak, B.C.Routara et al., Optimized the Multiple Performance Characteristics In Electro Discharge Machining Using Grey Relational Analysis

Franko puh, zoran jurkovic, mladen perinic, miran brezocnik, stipo buljan et al., optimized the machining parameters for turning operation with possible characteristics using grey relational analysis

D. U. Braga et al., investigated a minimum quantity of lubricant (MQL) and a diamond coated tool in the drilling of aluminum-silicon alloys

N. Gopikrishna et al., studied the impact of cutting fluid on surface roughness during machining of EN 24 and EN 8 by using CNC Milling Machine and Determined Surface Roughness

K. G. Nikam1 et al., made an experiment of Optimization of Surface Roughness of EN8 Steel by Changing Cutting Parameters and Insert Geometry in Turning Process

Deng et al., proposed a grey theory includes relational analysis, modeling Prediction, and decision making of a system

Pankaj Sharma, Kamaljeet Bhambri et al., investigated the Parameters of CNC Turning by Taguchi based Grey Relational Analysis

EXPERIMENTATION

EXPERIMENTAL PROCEDURE

1. TAGUCHI METHOD

It is a statistical tool used for optimizing the parameters and for essential analysis works. This technique applies orthogonal arrays from DOE, is used to study a many number of variables with a small number of experiments. The experimental results transforms into a signal to noise (S/N) ratio. Method applies ratio as a measure of characteristics with expected quality, deviating from or nearing to desired values. Methodical procedure classified quality characteristics into three categories which are smaller the better, Normal the better, and higher the better.

The Basic Formulae used for signal to noise ratio given as follows:

Lower the better: S/N ratio (□) =

$$-10 \log_{10} \frac{1}{n} \sum_{i-1}^{n} y_i^{\,2}$$

Where n = no: of replications; y_i = observed value

Normal the better, S/N ratio (□) =

$$-10 \log_{10} \frac{\mu^2}{\sigma^2}$$

Where σ = variance and μ = mean

Larger the better: applies where bigger values are required, S/N ratio (□) =

$$\frac{1}{n} \sum_{i-1}^{n} \frac{1}{y_i^{\,2}}$$

2. SELECTION OF PROCESS PARAMETERS

As per the Taguchi's - Design of Experiments, for L_9 Taguchi orthogonal array which is suitable for three levels and four parameters such as, Depth of cut, fees speed and cutting fluid were selected as process parameters (Given in the Table 2) in this experiment.

Table: 2

Process parameters	Type - I	Type - II	Type - III
Speed (rpm)	450	720	910
Feed (mm/rev)	0.020	0.078	0.26
Depth of cut (mm)	0.4	0.98	1.2
Cutting oil	Pongomia	Neem seed oil	Cutting fluid

EXPERIMENTAL DETAILS

Type I, II, and III samples quality was measured in terms of surface roughness of a sample surface using Talysurf profilometer. According to L_9 orthogonal array the carried out experiments on a Lathe machine and were tabulated in a table 3 which is as follows:

Table 3:

Exp No:	control factors and their suitable levels			
	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

RESULTS AND DISCUSSIONS

- Optimization of process parameters:
- Information, Data to be normalized
- To be calculated corresponding grey relational coefficients
- To calculate grey relational grade
- To perform analysis
- To select cutting parameters optimal levels

In the Turning Operation, smaller the cutting force and lower the surface roughness indicates high performance and the steps given above are to optimize the turning operation parameters using grey relational analysis.

Table 4

Specimen no:	Cutting Force	Surface Roughness
1	**28.00**	**2.66**
2	**82.05**	**4.98**
3	**164.90**	**9.68**
4	**78.82**	**2.89**
5	**125.02**	**7.48**
6	**88.64**	**5.86**
7	**96.23**	**8.69**
8	**71.01**	**3.18**
9	**130.0**	**7.12**

Here in this study, the surface roughness and cutting force of a sample in different process parameters are listed in the Table 4 below which were the response value achieved from L9 orthogonal array, as shown in the Table 5 – gray relational generation of each performance characteristics,

Table 5 – gray relational generation of each performance characteristics

Specimen no:	Cutting Force	Surface Roughness
1	0.0000	0.0001
2	0.8	0.7
3	0.01	0.012
4	0.728	1.0023
5	0.526	0.486
6	0.6	0.71
7	0.551	0.842
8	0.316`	0.27
9	0.85	0.78

Table 6 – evaluation of surface roughness for each of the responses

Specimen no:	Cutting Force	Surface Roughness
1	1.12	1.00
2	0.8	0.76
3	0.12	0.14
4	0.8	0.98
5	0.423	0.38
6	0.6	0.712
7	0.6	0.246
8	0.8	0.912
9	0.342	0.426

Table 7 – grey relational coefficient of each performance characteristics

Specimen no:	Cutting Force	Surface Roughness
1	0.38	0.353
2	0.494	0.482
3	1.012	1.18
4	0.512	0.4
5	0.684	0.682
6	0.567	0.486
7	0.54	0.742
8	0.462	0.387
9	0.74	0.582

Based on the process parameters, the surface roughness of the specimens were determined and resulted in the table 6, using grey relational coefficient of each performance characteristics, surface roughness for specimens resulted in the table 7 and the relevant grades for specimens were resulted in the table 8

Table 8 – Grey relation grade

Specimen no:	Grey Relation grade
1	0.346
2	0.48
3	1.000
4	0.398
5	0.687
6	0.498
7	0.684
8	0.398
9	0.674

Calculated the total mean grey relation grade and resulted in the table 9, which is shown below

Table 9 – Response table for Grey relation grade

factors	Grey relation grade			
	Level 1	Level 2	Level 3	Max-Min
Speed (rpm)	450	720	910	**0.124**
Feed (mm/rev)	0.020	0.078	0.26	**0.252**
Depth of cut (mm)	0.4	0.98	1.2	**0.350**
Cutting oil	0.536	0.528	0.598	**0.092**
Total mean Grey relation grade = 0.554				

CONCLUSION

The process parameters of turning operation were optimized to better yield surface roughness at smaller cutting forces that were achieved and description of such results were highlighted in the study .

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