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# Optimization of Machining Parameters in Drilling of EN-31 Steel Alloy by Taguchi Based Grey Relational Analysis

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*ABSTRACT: The present paper focused on the optimization of machining parameters in drilling process of EN-31 steel alloy by Taguchi based Grey relational analysis. The single noise ratio and the analysis of variance (ANOVA)is employed for analysis the influences of machining parameters on surface roughness and metal removal rate. For conducting drilling experiments Taguchi $L_{27}$ orthogonal array was used. Quality with productivity is the demand of world manufacturing market. The demand and satisfaction of customer govern the world economy for witch fourth industrial revolution has taken place in the manufacturing world machining is a very important process. Therefore required productivity standards play an important role in machining operations. This one is a very effective aspect that machining condition such as cutting speed, feed and hole depth affect the performance of operation to a great extant. The parameters must be selected for high work efficiency to increase productivity, customer satisfaction and also for optimize economy for globalization.*

*The aim can be achieved by design of experiment. The work is conducted on the mechanical parameters which affect the efficiency of productivity in drilling on the surface roughness and metal removal rate of EN-31 material. Surface roughness was measured by using surface roughness tester and calculated by average method. Metal removal rate was calculated with the help of mathematical formula and mechanical parameters. Therefore, the optimized value of machining parameters for surface roughness and metal removal rate improve the demand and quality of product.*

*Key words- Drilling, Surface roughness, Metal removal rate, Taguchi grey relation, ANOVA, Noise ratio, EN-31 Steel alloy.*

## I. INTRODUCTION

Drilling process is so important that an estimate is approximately 75% of all metal cutting and machining operation is performed by drilling operations. Drilling involves the creating of holes that are right circular cylinders. However the process is counted as one of the most complex cutting characteristics of drilling that set it apart from other powered metal cutting operates such as in drilling cutting is combined with extrusion in the center of the drill, the chisel edge of the drill point pushes aside the material to make it at the center. Drilling is the most frequently used operation, in industry to produce holes very rapidly under efficient.

In general analysis it is found that in machining operation 30% is performed by drilling simultaneously for turning 20%, milling 16%, threading 15%, engraving 6% and others 13% that focused on the improvement of drilling process in the domestic industrial environment. Quality is a major aspect of production and also the important feature of manufacturing product. That can be described by various quality attributes. The attributes may be qualitative or quantitative. Quality is controlled during the production process and continuously being monitored till the product is not reached into the market. In any stage of manufacturing, poor quality is identified it means there is some mistake in process section, process condition and in the parametric combination for manufacturing process. In order to tackle such multi objective optimization problem, Grey relation analysis method is used. In quality aspect roughness is a good indicator of the performance of mechanical components but does not regular on the surface of the object. Quality and productivity are the two inter related aspects of any type of manufacturing model. Hence from the beginning of the researches to some of the most recent works on machining of EN-31 is carried out but still a lot of researches in the field of machining (drilling) on EN-31 is required. Simultaneously it is found that optimization of machining processes and parameters the most common are Surface Roughness (SR), Material Removal Rate (MRR) and Tool Life (TL) has been performed by using various techniques such as RSM, TAUCHI, FULL FACTORIAL, GENETIC ALGORITHM etc. But very limited work is reported using GREY RELATIONAL ANALYSIS. However, there are two aspects one is an output of single objective approach has a limited value to fix the optimal machining conditions, other one is complex nature of the machining processes, where several contradictory objectives must be simultaneously optimized for surface roughness measurement, mostly $R_a$ value has been taken in Multi-response optimization, system responses many variables due to which fixation of optimal machining condition becomes difficult. So in this area very less work has been reported. Cutting parameters such as cutting speed, feed rate are correlated with geometrical, dimensional features of the productivity with high quality features of the basic demand of today's market. A proper combination of cutting condition is extremely important because this determines surface quality of manufactured parts. For optimum selection of parameters of drilling process and for proving better solution, there is a need of a mathematical model.

Optimization of machining parameters in drilling of alloy steel EN-31 Steel will be quite useful and thus attempted in the present work.

The Taguchi grey relational analysis technology has been applied for optimization of machining parameters for minimum surface roughness and metal removal rate in drilling and the technology has been used due to facility of reduction in no of experiment, multi response can be done, single valued objective optimization output can be determined.

Steel alloys seem to be widely used in the manufacturing industries for making plastic molding dies, gears, different automobile parts etc. The EN-31bearing steel is applied for roller bearing components such as cylindrical, conical and needle rollers.

## II. EXPERIMENTAL DETAILS

Drilling operation was carried out on a VF30 CNC VS CNC in dry conditions. Technically specifications of the machine are summarized in Table 1.

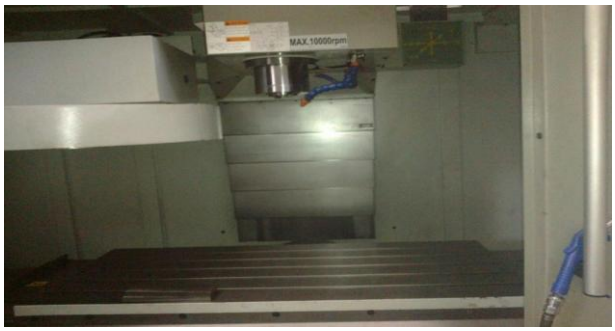


Fig 1 Experimental setup of drilling experiments

| | |
|---|---|
| **Model no.** | VF 30 CNC VS |
| **Longitudinal movement (X–axis)** | 800 mm |
| **Transverse movement (Y–axis)** | 350 mm |
| **Vertical movement (Z–axis)** | 380 mm |
| **Table size (L×W)** | 1060 × 315 mm |
| **Spindle speed(max.)** | 10000 R.P.M |
| **Spindle motor** | 3.7 KW |
| **Maximum load on table** | 300 kg |
| **Feed rate** | 1-5000 |
| **Power supply** | 415 V ,50 Hz,3 phase |

Table 1 Technical specification of VF 30 CNC Drilling Machine

Drilling operations were performed using commercial carbide twist drill of 10.08 mm diameter with point angle $118^0$ shown in the Figure 2

Fig 2 cutting tool

The machining experiments were performed on EN-31 steel alloy plate. Plate used in the experimentation was 170 mm in length with 80 mm width and 15 mm in thickness as shown in Figure 3 The chemical composition of EN-31 was obtained by spectro test and summarized in the Table 2.

Fig 3 work piece

Table 2 chemical composition of EN-31

| Chemical composition | percentage |
|---|---|
| C | 1.050 |
| Mn | 0.50 |
| Si | 0.270 |
| Cr | 1.050 |
| Mo | 0.020 |
| V | 0.010 |
| P | 0.057 |
| S | 0.072 |

Surface roughness of the work piece after drilling was measured by using surface roughness tester (Mitutoyo surface roughness test -4) in the figure 4

Fig 4 Mitutoyo Surface roughness test Model No SJ 304.design experiments are performed on the basis of level of cutting speed, feed rate and hole depth.

Table 3 Process control parameters and their levels according to TGRA

| Parameters | units | symbols | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|---|
| Speed | rpm | A | 800 | 1200 | 1600 |
| Feed | mm/rev. | B | 0.01 | 0.14 | 0.18 |
| Hole depth | mm | C | 05 | 10 | 15 |

## III. RESULT AND ANALYSIS OF EXPERIMENT

Traditional experimental design methods are very complicated and difficult to use. Additionally these methods also require a large number of experiments as the number of process parameters increases. Experiments are designed using Taguchi methods that effect of all the parameters could be studied with minimum possible number of experiments.
Using Taguchi method, appropriate Orthogonal Array has been chosen and experiments have been performed as per the set of experiments designed in the orthogonal array. Signal to Noise ratios are also calculated for analysing the effect of machining parameters more accurately.
There are Signal-to-Noise ratio of common interest for optimization of static problems used in present study as are:

$$\eta = -10 \log \frac{1}{n} \sum_{i=1}^{n} yi^2$$

Where, η-Signal to Noise (S/N) Ratio,

$y_i$ – i$^h$ observed value of the response,

n -Number of observations in a trial,

y-Average of observed values

Experimental results as per $L_{27}$ orthogonal array and the values are depicted in table 4.

Table 4 Experimental Result

| Expt. No. | Surface roughness (μm) | Metal removal rate(mm$^3$/sec) |
|---|---|---|
| 1 | 1.400 | 53.250 |
| 2 | 1.310 | 70.220 |
| 3 | 1.300 | 79.640 |

| | | |
|---|---|---|
| 4 | 1.299 | 74.220 |
| 5 | 1.290 | 99.120 |
| 6 | 1.280 | 111.12 |
| 7 | 1.100 | 95.500 |
| 8 | 1.020 | 127.36 |
| 9 | 1.019 | 143.22 |
| 10 | 1.015 | 79.500 |
| 11 | 1.000 | 106.11 |
| 12 | 0.998 | 119.47 |
| 13 | 0.995 | 111.44 |
| 14 | 0.991 | 148.59 |
| 15 | 0.990 | 167.26 |
| 16 | 0.950 | 143.10 |
| 17 | 0.930 | 191.04 |
| 18 | 0.860 | 71.680 |
| 19 | 0.800 | 106.00 |
| 20 | 0.730 | 141.51 |
| 21 | 0.710 | 159.30 |
| 22 | 0.740 | 148.36 |
| 23 | 0.742 | 198.12 |
| 24 | 0.840 | 222.99 |
| 25 | 0.845 | 190.76 |
| 26 | 0.841 | 254.68 |
| 27 | 0.840 | 286.71 |

Minimization of the surface roughness

The mean of the surface roughness value for each level of the drilling parameters was calculated using the average method and presented in Table 5. The order of importance of the controllable factors for minimization of surface roughness, in sequence is: speed, feed, Hole Depth (i.e. 0.970 >0.935>0.799).

Table 5 mean effect on surface roughness

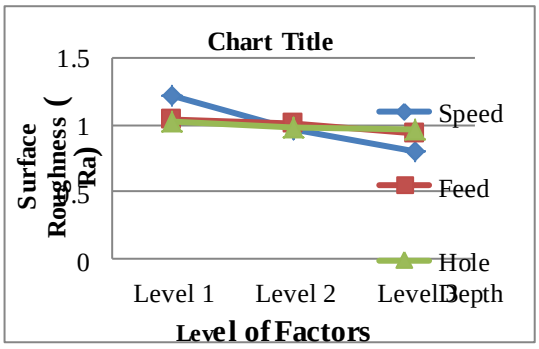
| Level | Speed (A) (rpm.) | Feed (B) (mm/rev.) | Hole Depth ( C ) (mm) |
|---|---|---|---|
| **1** | 94.85 | 101.6667 | 111.3483333 |
| **2** | 126.4667 | 142.3578 | 148.5283333 |
| **3** | **189.8256** | **167.1178** | **151.2655556** |
| Average | 137.0474 | 137.0474 | 137.04740 |
| Max. - Min. | 94.97556 | 65.45111 | 39.91722222 |
| Rank | **1** | **2** | **3** |

Table 6 mean effect on metal removal rate

| Level | Speed (A) (rpm.) | Feed (B) (mm/rev.) | Hole Depth ( C ) (mm) |
|---|---|---|---|
| **1** | 1.212222 | 1.039778 | 1.02388889 |
| **2** | 0.969778 | 1.006444 | 0.98644444 |
| **3** | **0.799222** | **0.935** | **0.97088889** |
| Average | 0.993741 | 0.993741 | 0.99374074 |
| Max. - Min. | 0.413 | 0.105 | 0.03014815 |
| Rank | **1** | **2** | **3** |

Graphical representation of mean effect on surface roughness

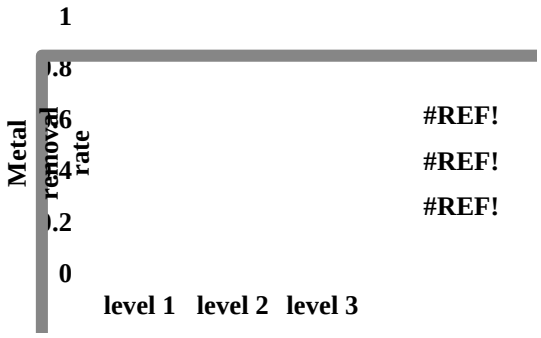



Maximization of material removal rate

The mean of the material removal rate (MRR) for each level of the drilling parameters was calculated using the average method and presented in Table 6. The order of importance of the control table factors for maximization of material removal rate, in sequence is: speed, feed, Hole Depth (i.e.,189.86> 167.20 >151).

Table 6 Mean effect on metal removal rate

Graphical representation of mean effect on metal removal rate




## IV. CONCLUSIONS

This paper has presented an application of Taguchi based Grey relational analysis for predicting and selecting the optimum parameter combination values of drilling parameters affecting the surface roughness and metal removal in drilling of EN-31 alloy steel.

1. The important conclusions drawn from the present work are summarized as follows: Cutting speed is the only significant machining parameter for surface roughness.
2. The increase in cutting speed produces better surface finish (i.e., surface roughness reduces).The surface roughness decreases from level one to level two and subsequently decreases to level three. For feed rate it is not much significant.
3. For rough machining conditions the most influencing parameters in decreasing order are feed rate, Hole Depth and cutting speed.
4. Out of three parameters considered feed rate is identified as the most significant an influential machining parameter followed by cutting speed. Whereas Hole Depth has the least influence on surface roughness and MRR for general machining conditions.
5. An increase in the value of predicted weighted GRG confirms the improvement in the performance of drilling process using optimal values of process parameters.
6. Taguchi grey relational analysis does not involve any complicated mathematical theory or computation and the us can be employed by the engineers without a strong statistical background.

Concluded Results for Material Removal Rate and Surface Roughness is presented in the table 7

**Table 7 Concluded Result**

| Parameters | Speed | Feed rate | Hole depth |
|---|---|---|---|

| | | | |
|---|---|---|---|
| MRR | 189.8256 | 167.1178 | 151.2655556 |
| Surface roughness | 0.799222 | 0.935000 | 0.970888890 |

REFERENCES

[1]. Abhang L.B. & Hameedullah M. (2010),"*Experimental investigation of minimum quantity lubricants in alloy steel turning"*, International Journal of Engineering Science and Technology, Vol. 2(7),pp.3045-3053.

[2]. Abhang L.B. & Hameedullah M. (2011)."Modeling and analysis for surface roughness in machining EN-31 steel using response surface methodology", International Journal of Applied Research in Mechanical Engineering, Vol.1, pp. 18-26

[3]. Abhang L.B. & Hameedullah M. (2010),"Experimental investigation of minimum quantity lubricants in alloy steel turning", International Journal of Engineering Science and Technology, Vol. 2(7),pp.3045-3053.

[4]. Gaitonde V.N., Karnik S.R. &Davim Paulo J. (2007)."*Taguchi multiple-performance characteristics optimization in drilling of medium density fibre board (MDF) to minimize delamination using utility concept"***,**Journal of Materials Processing Technology, Vol.196, pp. 73–78.

[5]. Haq NoorulA.,Marimuthu P. & Jeyapaul R. (2007)."*Multi response optimization of machining parameters of drilling Al/SiC metal matrix composite using grey relational analysis in the Taguchi method"*, Int J Adv Manuf Technol, Vol.37, pp. 250–255

[6]. Hochenga H. & Tsao C.C. (2005). "*The path towards delamination-free drilling of composite materials, Journal of Materials Processing Technology"*, Vol.167, pp. 251 Khanna O.P. &Lal M. (1999). A text book of production technology, Dhanpatrai publication

[7]. Kıvaka Turgay, Samtas Gurcan & CicekAdem (2012)."Taguchi method based optimization of drilling parameters in drilling of AISI 316 steel with PVD monolayer and multilayer coated HSS drills", Measurement, Vol.45, pp. 1547–1557.

[8]. Khashaba U.A., El-Sonbaty I.A., Selmy A.I.&Megahed A.A. (2010). "*Machinability analysis in drilling woven GFR/epoxy composites: Part II – Effect of drill wear"*, Composites: Part A,Vol.41, pp. 1130–1137

[9]. Khashaba U.A., El-Sonbaty I.A., Selmy A.I. &Megahed A.A. (2009)."*Machinability analysis in drilling woven GFR/epoxy composites: Part I – Effect of machining parameters"*, Composites: Part A, Vol.41, pp. 391–400

[10]. Liu Defu, Tang yongjun & Cong W.L. (2012)."*A review of mechanical drilling for composite laminates"*, Composite Structures, Vol. 94, pp. 1265–1279

[11]. Lauderbaugh Ken L. (2008)."*Analysis of the effects of process parameters on exit burrs in drilling using a combined simulation and experimental approach"*, Journal of Materials Processing Technology,Vol.209, pp. 1909–1919

[12]. Rajmohan T., Palanikumar K., Kthirvel M. (2011)."*Optimization of machining parameters in drilling hybrid aluminium metal matrix composites, Trans".* NonferrousMet. Soc. China, Vol.22, pp. 1286-1297

[13]. Rajmohan T. &Palanikumar K. (2012)."*Application of the Central Composite Design in Optimization of Machining Parameters in Drilling Hybrid Metal Matrix Composites"*, MEASUR

[14]. Tsao C. C. & Hocheng H. (2006)."*Evaluation of thrust force and surface roughness in drilling composite material using Taguchi analysis and neural network"*, Journal of Materials Processing Technology, Vol. 203,pp. 342–348.

[15]. Rivero A., Aramendi G., Herranz S. &Lacalle de Lopez L.N. (2006)."*An experimental investigation of the effect of coatings and cutting parameters on the dry drilling performance of aluminium alloys"***,**Int J Adv Manuf Technol, Vol.28, pp. 1–11.

*[16].* SadasivaRao T., Rajesh V. & VenuGopal A. (2012)."*Taguchi based grey relational analysis to optimize face milling process with multiple performance characteristics*",