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OPTIMIZATION OF TURNING PARAMETER FOR AISI 4140 BY GREY RELATION ANALYSIS

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ABSTRACT

The present work concerned an experimental study of turning on chromium – molybdenum case hardening alloy steel of AISI 4140grade. The purpose of this thesis is to study the effect of speed, feed, and depth of cut on material removal rate, metal surface and tool wear in machining AISI 4140 alloy steel using tungsten carbide tipped cutting tool.The range of each parameter is set at four different levels. Mathematical models were deduced by software design Expert in order to express the influence degree of the main cutting variables such as cutting speed, feed rate and depth of cut on outputresponses. After taking the responses grey relation analysis apply on all experiment to optimize the input parameter for optimum response.

Keywords: Grey relation analysis, AISI 4140, Prameters.

1. INTRODUCTION

Metal cutting process forms the premise of the engineering industry and is concerned either directly or indirectly within the manufacture of nearly every product of our modern civilization. The cutting tool is one of the vital components in realizing the total potential out of any metal cutting operation.

Turning is an important machining process within which a single point cutting tool removes unwanted material from the surface of a rotating cylindrical work piece. Turning is employed to reduce the diameter of the work piece, typically to a nominative dimension, and to produce a smooth finish on the metal.

The selection of machining parameters for a turning operation is a vital task so as to accomplish high performance. By high performance, we tend to mean sensible machinability, better surface finish, lesser rate of tool wear, higher material removal rate, faster rate of production etc.

The surface finish of a product is sometimes measured in terms of a parameter called surface roughness. It's thought of as an index of product quality. Better surface finish can bring on improved strength properties like resistance to corrosion, resistance to temperature, and higher fatigue life of the machined surface.

Tool wear is an inherent development in every traditional cutting operation. Researchers try towards elimination or minimization of tool wear as tool wear affects product quality similarly as production costs. In order to enhance tool life, extensive studies on the tool wear characteristics need to be conducted. a number of the factors that have an effect on tool wear and surface roughness are machining parameters like cutting speed, feed, depth of cut etc., tool material and its properties tool geometry. Minimal changes within the above mentioned factors might bring on vital changes within the product quality and tool life.

Specifically, theory and information relating to the experiment and the turning process is presented. The scope of the review also extends to various optimization techniques that are used to obtain optimal solution mainly focusing on the Taguchi's Analysis. The turning operation is a basic metal machining operation that is used widely in industries dealing with metal cutting [1]. In a turning operation, a high-precision single point cutting tool is rigidly held in a tool post and is fed past a rotating work piece in a direction parallel to the axis of rotation of the work piece, at a constant rate, and unwanted material is removed in the form of chips giving rise to a cylindrical or more complex profile [2, 3]. This operation is carried out in a Lathe Machine either manually under an operator's supervision, or by a controlling computer program. There are two types of motion in a turning operation. One is the cutting motion which is the circular motion of the work and the other is the feed motion which is the linear motion given to the tool.

2. OBJECTIVE OF WORK

The aim of the present study is, thus, to develop a statistical model for using the main cutting parameters such as cutting speed, feed rate and depth of cut on Alloy Tool steel AISI 4140. Machining tests were carried out under different conditions with tipped Tungsten carbide cutting tool. To calculate constants and coefficients of these models, the software Minitab characterized by analysis of variance (ANOVA) and Taguchi's Analysis. This objective requires better management of the machining system. This literature includes information on hard materials, soft materials, and soft and abrasive materials used in turning, coating materials for cutting tools, wear observed during turning operations and surface finish of the machined work piece**.**

Tool wear is an inherent occurrence in any machining process. Wear affects tool life and product quality. Hence, improvements have to be made in order to increase tool life. Surface finish is also an important aspect of a machined product.

1. To study the influence/effect of machining parameters viz. speed, feed and depth of cut, on the tool wear of a cutting tool.
2. To study the influence/effect of machining parameters viz. speed, feed and depth of cut, on the surface roughness of machined material.
3. To determine optimum machining parameter settings for the chosen tool/work combination so as to minimize the tool wear and surface roughness using grey analysis Method.
4. To develop an empirical model for the Surface Roughness and the Tool Wear for the chosen tool/work combination within the specified domain of parameters.
5. The influence of cutting parameters (speed, feed, and depth of cut) on MRR, surface finish and Tool wear has been analyzed. Under the different cutting conditions.

MATERIAL

The present work deals with the turning of hard material such as AISI 4140 steel. It is an important engineering material employed in manufacturing of components in auto and aerospace industries. Since the present trend in the manufacturing industry is high speed dry machining, it was applied to evaluate the performance of coated tools in typical manufacturing processes.The workpiece material used for the experiments is Alloy steel 4140 of standard dimensions was used for machining with 40 mm diameter, 100 mm long (6 sample). The work piece used for the concluded experiment was AISI 4140 alloy steel. There are two series of alloy steels – 4140-series and 8620-series. AISI 4140 series steels find most wide use around the world .AISI 4140 is a chromium – molybdenum case – hardening steel that displays good strength, hardenability and toughness. Tool steels are high carbon steels (either carbon or alloy) possessing high hardness, strength and wear resistance. Tool steels are heat treatable. In order to increase hardness and wear resistance of tool steels, alloying elements forming hard and stable carbides (chromium, tungsten, vanadium, manganese, molybdenum) are added to the composition.The following table (Table 3) shows the levels of the cutting parameters chosen.

Table 3 Process Parameter of Turning Operation

Parameter	Level 1	Level 2	Level 3	Level 4
Cutting Speed (m/min)	120	160	200	240
Feed mm/rev	0.08	0.10	0.12	0.14
Depth of Cut (mm)	4	6	8	10

3. GREY RELATION ANALYSIS

The grey means the primitive data with poor, incomplete, and uncertain information in the grey systematic theory; the incomplete relation of information among these data is called the grey relation. First, the grey relation analysis was carried out to normalize the responses; surface roughness and chemical wear was normalized by given equation (1).

For lower-the-better criterion, the normalized data can be expressed as

$$X_i = \frac{max(y)_i - (y)_i}{\max(y)_i - \min(y)_i} \qquad \ldots..(1)$$

$where\ i = 1,2 \ldots..n$

The calculation of the grey relational coefficient and the weight of each quality characteristic is determined by equation (2):

$$G_i = \frac{L_{min} + \varepsilon L_{max}}{L_i(k) + \varepsilon L_{max}} \qquad \ldots\ldots..(2)$$

Where, Lminis the global minimum, Lmax is the global maximum and ε is distinguish coefficient which is taken in between 0 to 1 in this case 0.5 weight is taken.

Grey relation grade can be calculated by equation (3)

$$Grg_i = \frac{1}{n}\sum_{j=1}^{n} G_i(j) \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where n is the number of process responses. The lower value of the grey relational grade represents the reference sequence Grgi. As mentioned before, the reference sequence Grgi is the best process response in the experimental layout. The lower value of the grey relational grade means that the corresponding cutting parameter is closer to optimal.

4. RESULT

The responses result is obtain pass the machining and other measurement apparatus their reading and results are tabulated as per the experimental work are shown in the Table 5. The optimization technique are applied on responses and are tabulated in table 6.

Table 5 Results Obtained

S.No.	1) S (m/min)	2) f (mm/rev)	3) d (mm)	MRR (cm^3)	SR (µm)	FW.(mm)
1	120	0.08	4	3.34	4.63	0.543
2	120	0.10	6	3.65	4.25	0.585
3	120	0.12	8	3.01	4.34	0.552
4	120	0.14	10	5.44	3.65	0.755
5	160	0.08	6	4.11	6.59	0.464
6	160	0.10	4	5.89	6.65	0.500
7	160	0.12	10	5.87	6.88	0.674
8	160	0.14	8	5.92	6.93	0.400
9	200	0.08	8	6.87	5.16	0.435
10	200	0.10	10	3.34	6.30	0.590
11	200	0.12	4	3.41	6.40	0.522
12	200	0.14	6	4.01	6.63	0.702
13	240	0.08	10	4.32	6.93	0.621
14	240	0.10	8	4.42	7.02	0.384
15	240	0.12	6	4.98	6.67	0.560
16	240	0.14	4	5.74	5.49	0.585

Table 6 Observation table

S N.	Nij MRR	Nij SR	Nij FW	Gi MRR	Gi SR	Gi FW	GRG
1	0.085492	0.709199	0.552083	0.35348	0.63227	0.527473	0.504408
2	0.165803	0.821958	0.442708	0.374757	0.737418	0.472906	0.528361
3	0	0.795252	0.528646	0.333333	0.709474	0.514745	0.519184
4	0.629534	1	0	0.574405	1	0.333333	0.635913
5	0.284974	0.127596	0.757813	0.411514	0.364324	0.673684	0.483174
6	0.746114	0.109792	0.664063	0.66323	0.359658	0.598131	0.54034
7	0.740933	0.041543	0.210938	0.658703	0.342828	0.387879	0.463137
8	0.753886	0.026706	0.924479	0.670139	0.339376	0.868778	0.626098
9	**1**	**0.551929**	**0.833333**	**1**	**0.527387**	**0.75**	**0.759129**
10	0.085492	0.21365	0.429688	0.35348	0.388697	0.467153	0.40311
11	0.103627	0.183976	0.606771	0.358071	0.379932	0.559767	0.43259
12	0.259067	0.115727	0.138021	0.402923	0.3612	0.367113	0.377079
13	0.339378	0.026706	0.348958	0.430804	0.339376	0.434389	0.401523
14	0.365285	0	0.966146	0.440639	0.333333	0.936585	0.570186
15	0.510363	0.103858	0.507813	0.505236	0.35813	0.503937	0.455767
16	0.707254	0.454006	0.442708	0.630719	0.478014	0.472906	0.527213

ANOVA for GRG

The analysis of variance (ANOVA) (shown in Table 7) was used to study the significance and effect of the cutting parameters on the response variables i.e. MRR, SR and Tool wear.

ANOVA Analysis: GRG versus F (mm/rev), S (m/min), d (mm)

Linear Model Analysis: Means versus F (mm/rev), S (m/min), d (mm)

Table 7 Analysis of Variance for GRG

Source	DF	Seq SS	Adj SS	Adj MS	F	P
MRR	3	0.009485	0.009485	0.003162	0.29	0.828
SR	3	0.013803	0.013803	0.004601	0.43	0.740
FW	3	0.061463	0.061463	0.020488	1.91	0.229
Residual Error	6	0.064367	0.064367	0.010728		
Total	15	0.149118				

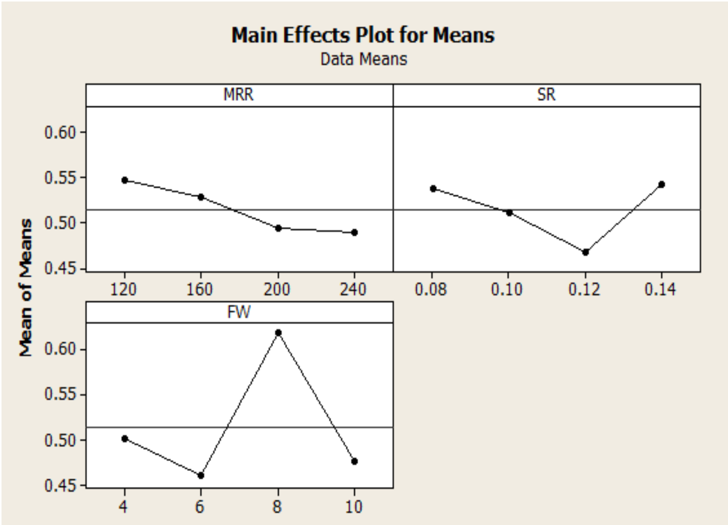

Fig 4 Mean Effect Plot for GRG

5. CONCLUSIONS

ANOVA analysis was carried out. Based on the experimental results presented and discussed, the following conclusions can be drawn on the effect of cutting speed, feed and depth of cut on the performance of Tungsten carbide tipped tools when turning AISI 4140 steel.The following conclusion can be drawn from the present investigation on mechanical properties of aluminum alloy Al 5052.

- ❖ The important factor affecting the MRR (Material Removal Rate) is cutting speed then depth of cut then feed rate. The optimum condition for best MRR is f=0.08rev/min, S=240 m/min and d=14 mm.
- ❖ For Surface roughness (SR) the most important factor are as follows: Cutting Speed, feed rate and depth of cut. The optimum condition for best SR is f=0.08rev/min, S=240 m/min and d=14 mm.
- ❖ Observation of Tool wear (TW) during experiment we find that the most affecting factors.

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