

ANALYSIS OF THE EFFECT OF MACHINING PARAMETERS ON CORROSION CHARACTERISTICS IN TURNING PROCESS

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Abstract: Turning operation is one of the primary machining operations wherein enhanced machining performance is obtained by selection of suitable process parameters. High Strength Low Alloy (HSLA) medium carbon steels (EN24 steel) are considered to possess better mechanical properties than carbon steel. In this experimental study, the effects of machining parameters on functional attributes (surface roughness, corrosion rate, current density, wear rate and co-efficient of friction) of the machined samples are evaluated in turning of EN24 steel. The machining parameters selected are cutting speed, feed rate and depth of cut in order to enhance functional attributes of turned components. The result of the investigation revealed that the mentioned machining parameters are necessary and essential to evaluate the functional attributes of HSLA steel effectively.

IndexTerms – Turning, machining parameters, functional attributes, ANOVA.

I. INTRODUCTION

Turning is a primary and important machining process in engineering industries to obtain the desired shape and size. The achievement of high performance and selection of appropriate process parameters are significant tasks in turning operation. The proper selection of machining parameters leads to higher productivity and better output values in terms of low cutting force, minimum dimensional accuracy errors, better surface finish, long tool life and less power consumption [1, 2].

The quality of the machined component is assured by surface roughness measurement which is an important part of manufacturing. Surface roughness of the machined components influences the fatigue strength, wear resistance and corrosion resistance. Also, surface roughness measurement is an important performance characteristic in machinability study. Nowadays manufacturing industries give special attention to obtain good surface finish in machining operation [3, 4]. In engineering systems, iron and steels are mostly used due to multipurpose applications and least expensiveness. The main disadvantages of iron and steels are poor corrosion resistance in mild service situations. This corrosion resistance may reduce the load carrying capacity of the material. Corrosion measurement and its control in machining operation is one of the ways to improve their efficiency. There will be different solutions to solve this corrosion and extend life of the components. This achievement of optimum process parameters for any machining operation is one such consideration [5]. In order to achieve maximum efficiency of machined sample, it is highly essential to improve the functional attributes by selecting appropriate machining parameters. This study is used to enhance the efficiency of the system by improving functional attributes during service.

II. LITERATURE REVIEW

Horvath and Kiss [4] analyzed surface roughness parameters in turning of aluminum alloys. The result showed that cutting speed and feed rate had significant effect on surface roughness but the interactions of these factors also had much influence on surface roughness. Sharma et al. [6] investigated the effects of cutting fluid on surface roughness in turning of AISI D2 steel. The result indicated that surface finish increased due to the cutting fluid effect. De Oliveira Junior et al. [7] investigated corrosion analysis of machined component in turning of UNS32750 super stainless steel. In their work, the effects of coolant pressure, cutting speed and status (new and fresh) of cutting tools on corrosion resistance of the machined samples were investigated. The result revealed that coolant pressure, cutting speed and worn out tool were the most influenced parameters to ensure the maximum corrosion resistance of components. Hassiots and Petropoulos [8] investigated the relation between topographic parameters and corrosion resistance of turned components of St37 and Ck60 carbon steels. The results revealed that different corrosion behaviour were obtained based on machining conditions and types of steel used. The minimum surface roughness provided maximum corrosion resistance and also proper machining parameters control the corrosion resistance of the machined sample. Hassiots et al. [9] analyzed the effects of surface roughness parameters on corrosion resistance in turning of AISI304 stainless steel. The result mentioned that lower surface roughness parameters influenced corrosion behaviour of machined samples. Gravalos et al. [10] carried out pitting corrosion tests on turned super austenitic stainless steel surfaces, evaluating the influence of surface roughness and residual stress of these surfaces on pitting formation. They turned several work pieces using different values of feed, depth of cut and cutting speed and verified that no variable exerted a significant effect on residual stress, while feed exerted strong influence on surface roughness. After that, they subjected these turned surfaces with different values of roughness and residual stress to a pitting corrosion test and concluded that surface roughness is more important than residual stress in pitting formation. Low surface roughness contributed in reducing pitting, since the higher peaks of the surface roughness profile contributed in making the pitting formation easier. Moayed et al. [11] conducted a corrosion study on highly finished components. The result revealed that corrosion resistance increased when higher surface quality was considered. Gravier et al. [12] investigated corrosion behaviour of copper by considering residual stress, surface roughness and crystallographic texture in turning process. The result indicated that residual stress and surface roughness were the most influencing and crystallographic texture provided minimum influence on corrosion resistance of the machined samples. Devi et al. [13] investigated

corrosion study on EN24 and EN8 steel to enhance life of the steel. The result revealed that EN24 steel had better corrosion property than EN8 steel due to uniform distribution of carbide. Based on literature review, it has been found that few research works are carried out on functional attributes (corrosion rate, current density, wear rate and co-efficient of friction) of the machined sample. Hence an effort has been made to investigate the effect of process parameters on functional attributes of the machined components using statistical technique in the turning of EN24 steel.

III. METHODOLOGY

EN24 steel is used as work material, which possesses high mechanical strength than carbon steel. This steel is used for heavy duty drive shafts. Table 1 shows the chemical compositions of EN24 steel. The cutting tool material used is Chemical Vapor Deposition (CVD) multi layer coating (TiN/TiCN/AL₂O₃) of fine grained tungsten carbide 6% cobalt substrate with ISO geometry of CNMG 120408. In the coated element, TiN provides better heat resistance and lower coefficient of friction; TiCN provides wear resistance and thermal stability and Al₂O₃ provides crater wear resistance due to high-temperature conditions and hardness. Taguchi orthogonal array is used to study the effect of process parameters on performance characteristics with minimum number of experiments. In this work, L₁₈ orthogonal array is applied to conduct turning operations with different combinations of input parameters. Table 2 shows the levels of selected machining parameters and their values.

Table 1 Chemical compositions (wt %) of EN24 steel

Material	C	Si	Mn	Ni	Cr	Mo	S	P	Fe
EN 24 steel	0.40	0.22	0.55	1.6	1.2	0.3	0.02	0.02	Balance

Table 2 Machining parameters and their levels

Factors	Symbol	Levels		
		Level 1	Level 2	Level 3
Cutting speed (m/min)	v	95	155	215
Feed rate (mm/rev)	f	0.07	0.15	0.23
Depth of cut (mm)	d	0.5	1.0	1.5

The surface roughness of the machined components is determined by Mitutoyo surfstest SJ 301 roughness testing machine. The surface roughness is measured thrice for the machined sample and average value is considered for investigation. The corrosion rate and its current density are measured by potential dynamic polarization technique at room temperature and 0.5 mV/s scan rate, using electrochemical cell which contains three cells. These three-electrode cell consists of steel (working electrode), saturated calomel (reference electrode) and graphite (counter electrode), which are used to conduct polarization experiments. The machined samples are cleaned with the help of distilled water and acetone. Specimens are attached to a holder and kept exposed to the testing environment as to achieve maximum exposure of 1 cm² surface area, followed by dipping in 3.5% NaCl solution. This process is maintained an hour to measure the corrosion potential. Fig.1 shows the experimental set up for corrosion test to find the corrosion rate and current density of machined samples. The experimental results are presented in Table 3.



Fig.1 Corrosion test equipment

Table 3 Experimental results

Sl.no	Cutting speed (m/min)	Feed rate (mm/rev)	Depth of cut (mm)	Surface roughness (µm)	Corrosion current density (mA/cm ²)	Corrosion rate (mm/year)
1	95	0.07	0.5	1.121	0.00258	0.1229
2	95	0.15	1.0	1.620	0.0622	0.1742
3	95	0.23	1.5	2.073	0.0956	0.2795
4	155	0.07	0.5	1.043	0.00167	0.1024

5	155	0.15	1.0	1.452	0.0204	0.1821
6	155	0.23	1.5	1.965	0.0621	0.2364
7	215	0.07	1.0	0.986	0.00107	0.0711
8	215	0.15	1.5	1.347	0.0239	0.1473
9	215	0.23	0.5	1.850	0.0506	0.1961
10	95	0.07	1.5	1.027	0.00352	0.1158
11	95	0.15	0.5	1.278	0.0421	0.2142
12	95	0.23	1.0	2.121	0.0894	0.2953
13	155	0.07	1.0	1.004	0.00129	0.0932
14	155	0.15	1.5	1.674	0.0296	0.1648
15	155	0.23	0.5	1.941	0.0456	0.2201
16	215	0.07	1.5	0.994	0.00101	0.0842
17	215	0.15	0.5	1.437	0.0231	0.1376
18	215	0.23	1.0	1.864	0.0309	0.1861

IV. RESULTS AND DISCUSSIONS

In this investigation, objective parameters considered are surface roughness, corrosion rate, corrosion indensity, co-efficient of friction and wear rate of the machined samples. The experiments are carried out using L_{18} orthogonal array and results are displayed in Table 3. Fig. 2 shows the effects of machining parameters on surface roughness during turning of EN24 steel. The turning is performed at different combinations of machining conditions and the surface roughness value increases with increase of feed. This is mainly due to increased friction between work piece and cutting tool. Also, the application of cutting fluid is used to reduce the friction and improve the surface finish.

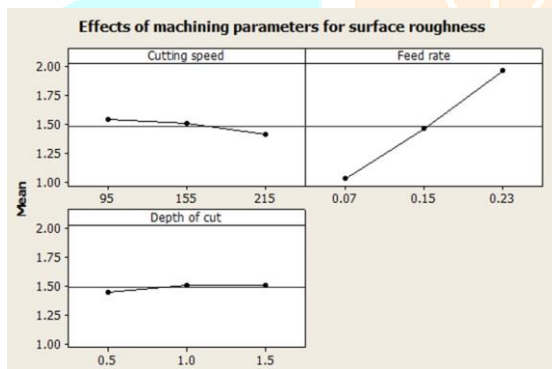


Fig.2 Effects of machining parameters on surface roughness

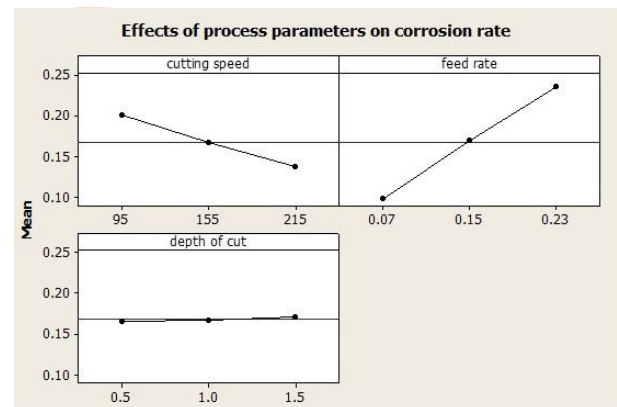


Fig.3 Effects of machining parameter corrosion rate

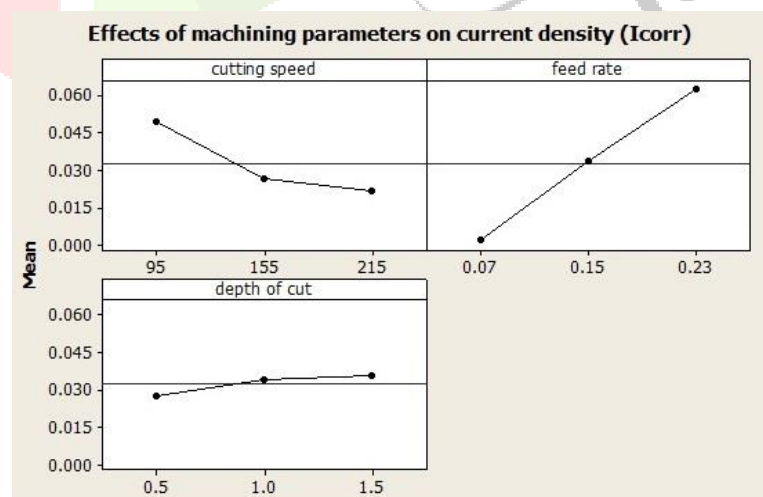


Fig.4 Effects of machining parameter on current density (I_{corr})

The cutting process may influence the corrosion rate and current density (I_{corr}) of a machined surface because it causes plastic deformation of the machined surface. Moreover, the cutting fluid lowers the temperature of the material in the cutting region; hence temperature of the machined surface influences corrosion resistance. This result indicates that lower temperatures in the cutting region are beneficial for surface corrosion resistance. Figure 3 and 4 show the main effect of the factors that influence the corrosion rate and current density (I_{corr}) of turned surfaces. These figures indicate that the use of higher level of cutting speed (215 m/min) and lower level of feed rate (0.07 mm/rev) generated

lower corrosion. When the cutting speed increased from 95 to 215 m/min, the corrosion rate also decreased. Increasing the cutting speed caused the cutting temperature to increase and is expected to weaken the material's corrosion rate. Surface finish is high at low feed condition, which is another parameter to be considered when analyzing the influence of the machining operation on the corrosion rate of the work piece. Therefore higher corrosion rate and minimum current density are obtained at higher level of cutting speed and coolant environment. The potention dynamic curves of machined samples at higher level of cutting speed and lower level of feed rate are compared with base material (Fig.5). From Fig 5, it can be noticed that current density (I_{corr}) values of machined samples are lower when compared to base material. This is due to moving of curves towards right, indicating minimum current density (I_{corr}) values. Thus higher corrosion rate is obtained at higher level of current density (I_{corr}) values.

V. CONCLUSIONS

This experimental study analyzed the effects of machining parameters for functional attributes in turning of EN24 steel using coated carbide tools. The following conclusions are derived from this analysis:

- The effects of machining parameters are analyzed for surface roughness, corrosion and wear resistance for the enhancement of functional life of the machined components.
- The surface roughness value is reduced with lower level of feed rate and coolant conditions.
- The maximum corrosion resistance and minimum current density values are obtained at higher level of cutting speed and lower level of feed rate.

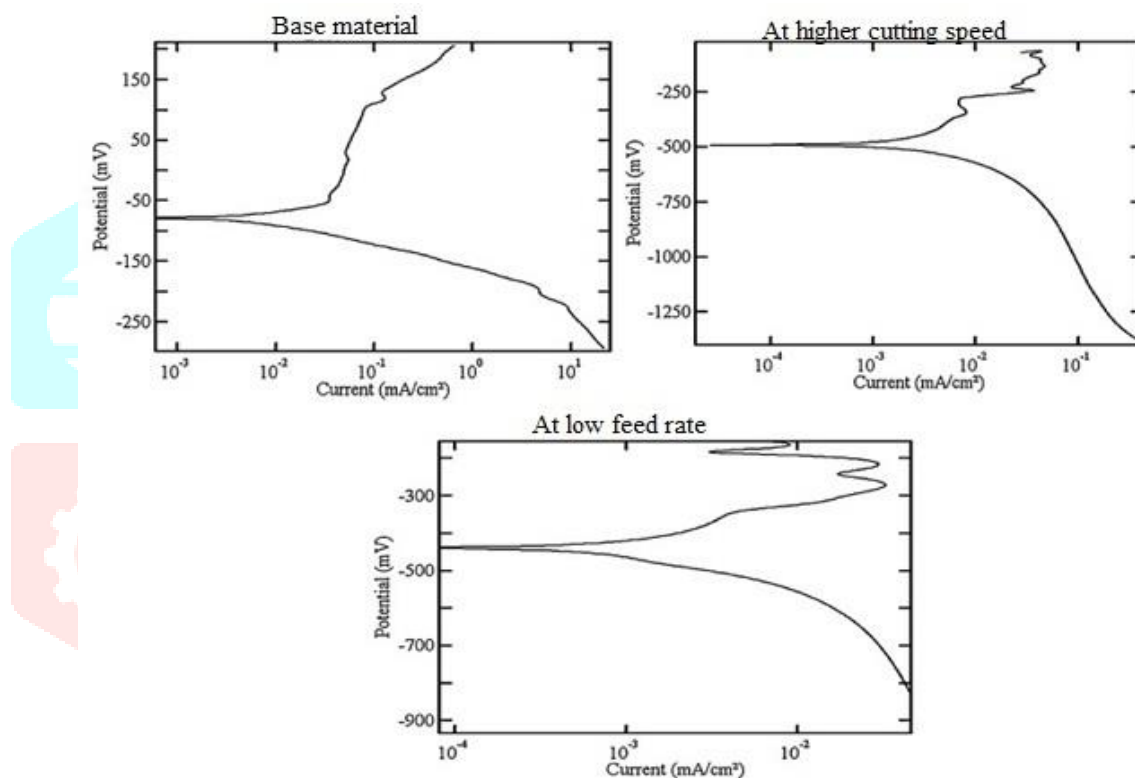


Fig.5 Potention dynamic curves of base material and machined samples

VI. REFERENCES

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