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EXPERIMENTAL INVESTIGATION TO STUDY THE INFLUENCE OF PROCESS PARAMETERS IN DRY MACHINING

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ABSTRACT

Dry machining is a machining process with out coolant, and it has become more popular as a finishing process. Thus, it is especially crucial to select the machining parameters to obtain the desired surface finish of machined component. In the present investigation, the influence of process parameters like speed, feed and depth of cut in dry-machining, are studied as surface roughness as the output response variable. The concept of Design of Experiments (DOE) was used for necessary experimentation. En31 bearing steel material was considered in the present study. The experimental results were analyzed statistically to study the influence of process parameters on surface roughness.

Keywords: dry machining, surface roughness.

INTRODUCTION

Machining hardened steels has become an important manufacturing process, particularly in the automotive and bearing industries. Abrasive processes such as grinding have typically been required to machine hardened steels, but advances in machine tools and cutting materials have allowed hard turning on modern lathes to become a realistic replacement for many grinding applications. There are many advantages of dry machining, such as increased flexibility, decreased cycle times, reductions in machine tool costs, and elimination of environmentally hazardous cutting fluids. Despite these advantages, implementation of hard turning remains relatively low, primarily due to concerns about the quality of hard turned surfaces and a lack of understanding about the surface behavior of polycrystalline cubic boron nitride (PCBN) cutting tools.

Because PCBN tools are expensive, excessive tool wear can eliminate the economic advantage of hard turning. To address this concern, this research investigated the effects of changing process conditions on behavior when turning hardened En31 steel (62 HRC) with PCBN cutting tools. Traditional techniques of characterizing tool condition (optical and scanning electron microscopy) provide important information about tool surface, but are generally restricted to qualitative analysis.

Dimensional accuracy and high quality surfaces are also required if hard turning is to replace any grinding process. A primary concern in hard turning is the generation of undesirable changes to the surface microstructure and the formation of tensile residual stresses. Additionally, surface roughness must be comparable to grinding if hard turned Surfaces are to be accepted. The results of this work indicate that proper selection of machining conditions yields acceptable dimensional accuracy and surface quality, and allows adequate tool life for most applications. This paper focuses on dry-machining of the bearing Steel En 31 which is widely used in engineering applications. The chemical composition of the En31 is shown in Table-1.

Table-1. Chemical composition of en31 material.

Material	C	Mn	Si	Cr	S	P
En31	0.9 - 1.20	0.30-0.75	0.10-0.35	1.0-1.60	0.05	0.05

In the recent past, the application of DOE has gained acceptance in the as an essential tool for improving the quality of goods and services. This recognition is partially due to the work of Taguchi, a Japanese quality expert, who promoted the use of DOE in designing robust products. Properly designed and executed experiments will generate more-precise data while using substantially fewer experimental runs than alternative approaches. They will lead to results that can be interpreted using relatively simple statistical techniques, in contrast to the information gathered in observational studies, which can be exceedingly difficult to interpret.

SELECTION OF PROCESS PARAMETERS

Performance of CBN cutting tools is highly dependent on the cutting conditions i.e. cutting speed, feed, feed-rate, and depth of cut [7]. Especially cutting speed and depth of cut significantly influence tool life [22]. Increased cutting speed and depth of cut result in increased temperatures at the cutting zone. Since CBN is a ceramic material, at elevated temperatures chemical wear becomes a leading wear mechanism and often accelerates weakening of cutting edge, resulting in premature tool failure (chipping), namely edge breakage of the cutting tool. In addition, Thiele *et al*. [24] noticed that when feed rate is increased, residual stresses change from compressive to tensile.

Based on the extensive literature review, process parameters considered for the present study are: speed, feed and depth of cut, Table-2 shows the details of the process variables and their levels considered.

Table-2. Process parameters.

Factors	Levels		
Speed, m/s	91	137	183
Feed, mm	0.076	0.114	0.152
Depth of cut, mm	0.1	0.15	0.2

Experimental investigation

Design of experiments concept was used for planning the necessary experimentation, L27 OA was used for experimental layout. The details of experimental layout are shown in Table-3.

Table-3. Experimental layout and output response.

#	**Speed,** (m/s)	**Feed** (mm)	**Depth of cut** (mm)	**Surface roughness** (Ra)
1	91	0.076	0.10	0.36
2	91	0.076	0.10	0.43
3	91	0.076	0.10	0.22
4	91	0.114	0.15	0.24
5	91	0.114	0.15	0.50
6	91	0.114	0.15	0.46
7	91	0.152	0.20	0.42
8	91	0.152	0.20	0.48
9	91	0.152	0.20	0.70
10	137	0.076	0.15	0.26
11	137	0.076	0.15	0.74
12	137	0.076	0.15	0.46
13	137	0.114	0.20	0.49
14	137	0.114	0.20	0.21
15	137	0.114	0.20	0.84
16	137	0.152	0.10	0.64
17	137	0.152	0.10	0.30
18	137	0.152	0.10	0.25
19	183	0.076	0.20	0.21
20	183	0.076	0.20	0.27
21	183	0.076	0.20	0.48
22	183	0.114	0.10	0.76
23	183	0.114	0.10	0.66
24	183	0.114	0.10	0.56
25	183	0.152	0.15	0.68
26	183	0.152	0.15	0.64
27	183	0.152	0.15	0.20

All the work pieces were machined and the roughness values for all the twenty-seven samples were measured, the corresponding surface roughness values are shown in the Table-3.

Analysis of Results

In any process there are two important factors which will control the process.

1) One is control factor, these are process variables like speed feed, temperature, flow etc, by varying these parameters one can study the influence of these parameters on response(Output, ex: surface roughness, dimensional accuracy, solidification time, stability etc.,)
2) The other factor which controls the process is known as noise which is difficult to identify and control individually, it is hidden factor and it is due to the influence of one or more process parameters
3) A measure of robustness that can be used to identify the control factor settings that minimize the effect of noise on the response. This can be obtained by calculating separate signal-to-noise (S/N) ratio for each combination of control factor levels in the design.

The results were analyzed statistically for signal to noise ratios and the response table for S/N ratio and data means were shown in Tables 4 and 5, respectively.

Table-4. Response table for signal to noise ratios.

Level	Speed	Feed	Depth of cut
1	7.947	9.08	7.763
2	7.634	6.84	7.246
3	7.06	7.177	7.632
Delta	0.887	2.696	0.517
Rank	2	1	3

Table-5. Response table for means.

Level	Speed	Feed	Depth of cut
1	0.4233	0.3811	0.4511
2	0.4656	0.5244	0.47
3	0.4956	0.4789	0.4633
Delta	0.0722	0.1433	0.0189
Rank	2	1	3

The data was further analyzed to study the interaction among process parameters and the main effects plot and interaction plots were generated and shown in Figures 1 and 2, respectively. Similarly contour plots are plotted surface roughness as output response and other

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process parameters are input process variables and shown in Figures 3 and 4, respectively.

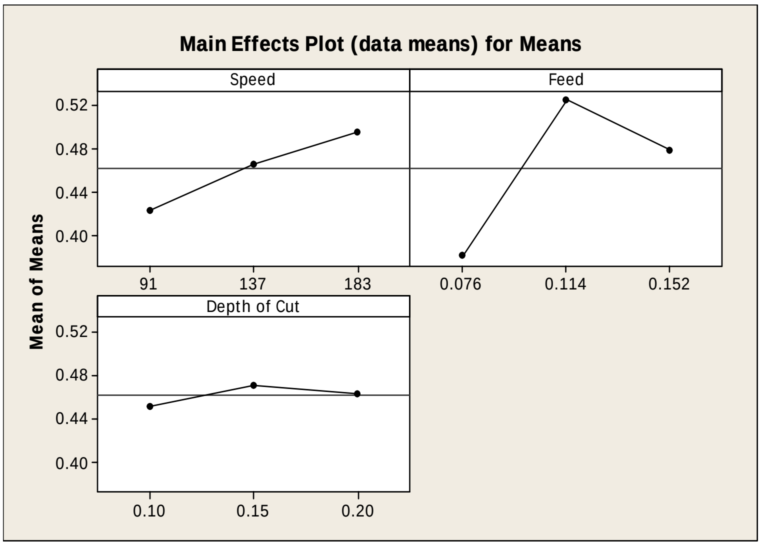

Figure-1. Main effects plot for surface roughness.

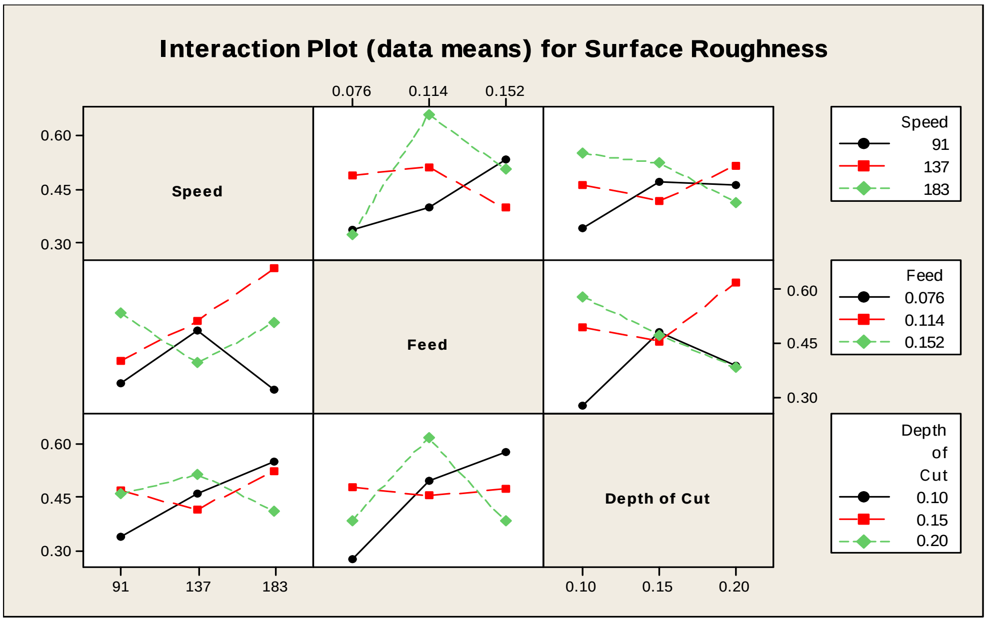

Figure-2. Interaction plot for surface roughness.

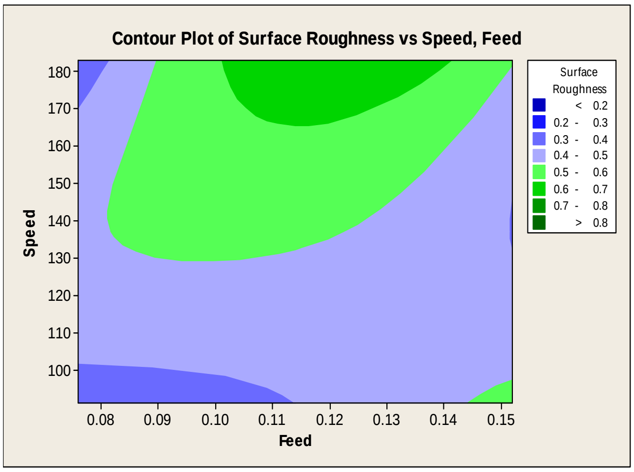

Figure-3. Contour plot for surface roughness vs. speed and feed.

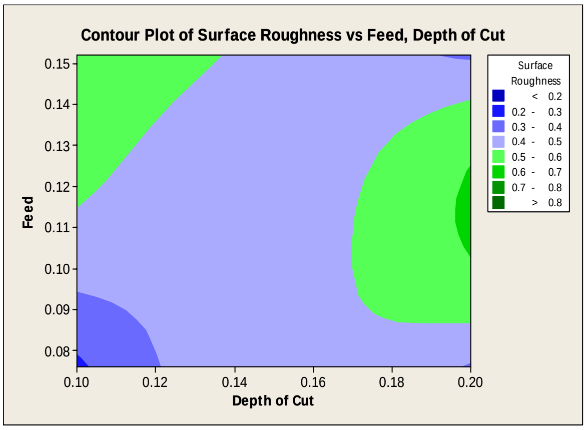

Figure-4. Contour plot for surface roughness vs. feed and depth of cut.

CONCLUSIONS

The following are the conclusions drawn from the present work: Concepts of dry machining and its importance in hard turning and the influence of environmental impact were studied. Surface roughness (Ra) values are increasing with increase in speed, depth of cut is not influencing much on roughness values, but the roughness values are varying nonlinearly with increase variation of feed. Strong interaction among all input process parameters was observed. Contour plots developed from analysis of results can be used for selecting the process parameters for desired surface roughness values.

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