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EFFECT OF SPEED, FEED & DEPTH OF CUT ON VIBRATION AND SURFACE ROUGHNESS DURING TURNING OPERATION

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ABSTRACT

The objective of this paper is to present the effect of turning parameters on vibration and work surface roughness of Inconel alloy steel, which was experimentally examined. In this study, tool vibration and surface roughness of Inconel material is calculated i.e tool vibration and surface roughness are the output of the study. And speed, feed and depth of cut are the input parameters. In this paper, experimental studies were performed on turning process and vibration is measured with the help of accelerometer along with a device called as Fast Fourier Transformer (FFT) analyzer, and also surface roughness is measured by surface roughness tester, along with Taylor Hobson Talysurf. In this experiment, it has been observed that turning parameters like speed, feed and depth of cut has significant effect on vibration of cutting tool and surface roughness of work piece. It also shows that the vibration and surface roughness of work piece is directly proportional to speed, feed and depth of cut during turning operation.

KEYWORDS: Turning Parameter, Inconel Material, Vibration, FFT & Surface Roughness

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Original Article

INTRODUCTION

Vibration is a frequent problem, which affects results of the machining and particularly, surface finish in turning operation. Tool life is also influenced by vibration. This implies several disadvantages, economical as well as environmental. In machining operation, the quality of surface finish is an important requirement for many turned work piece. Sever vibration occurs in the machining environment, due to a dynamic motion between the cutting tool and work piece. In all the cutting operation like turning, boring and milling, vibrations are induced due to the deformation of the work piece, machine structure and cutting tool. In a machining operation, forced vibration and self excited vibration are identified as machining operation. The surface finish of a product is typically measured in terms of a parameter, called as surface roughness. It is considered as an index of product quality]. Better surface finish can bring about improved strength properties such as resistance to corrosion, resistance to temperature and higher fatigue life of the machined surface. In addition to strength properties, surface finish can have an affect of the functional behaviour of machined components too, as in friction, light reflective properties, heat transmission, ability of distributing and holding a lubricant etc. Surface finish also affects production costs. For the aforesaid reasons, the minimization of the surface roughness is essential, which in turn can be achieved by optimizing number of the cutting parameters. During this experimental studies performed on turning process and vibration are measured with the help of accelerometer along with a device called as Fast Fourier Transformer (FFT) analyser, and also surface roughness is measured by surface roughness tester, along with Taylor Hobson Talysurf.

Objectives

- To study the effect of machining parameters like speed, feed & depth of cut on vibration of cutting tool and surface roughness of material
- To find out the optimum machining parameters, so as to minimize vibration and surface roughness.
- Condition monitoring of cutting tool using FFT analyzer.
- To study the effect of changes of materials on vibration of cutting tool and surface roughness of work piece.

EXPERIMENTATION

Materials and Equipements

The work piece used for the concluded experiment was Inconel material, which is austenitic nickel-chromium-based. It is a round bar of 40 Ø × 100 mm long. There are various series of Austenitic based material like 600, 718 and 825series. Inconel material is nickel-base super alloys, known as one of the most difficult to cut material because of the properties high hardness, high strength at high temperature, affinity to react with the tool materials and low thermal diffusivity. In this paper, attempt has been made to review recent work and key improvements in machinability and machining characteristics of Inconel 600, 718 and 825. The cutting tool used isTiN coated carbide insert with tool holder for using to removing the excessive material from the work piece.

A conventional lathe machine is used in this study, the lathe machine have plays main important role. All experimental study is done on this machine. The turning process on Inconel round bar with carbide insert tool is done with the help of lathe machine. The input parameter as spindle speed, feed & depth of cut is controlled on this machine.

Accelerometer is used for measuring the vibration of cutting tool during turning operation. Fast Fourier Transformer Analyzer is used for experimentation. In this study, the vibration of tool is to be measured. So, the cutting tool vibrations are measured by FFT analyzer. The FFT analysers consist of two components, namely Accelerometer and Analyzer. The accelerometer is attached to which, the vibrations are to be measured. The accelerometer can sense the vibration & this sensed vibrations are sent to the analyzer. The analyzer converts the sensed signal in to frequency, amplitude, RMS, displacement and so on. This frequency, amplitude, RMS is to displace on the computer. The FFT Analyzer is requiring the computer to show the vibration in different unit. Here, Mitutoyo Surftest SJ-210 is used for measuring surface roughness of machined component.

Experimentation

After deciding all the materials and equipments for experimentation, then we started the actual experiment, first the cutting material i.e. Inconel bar is fixed in lathe chuck, then inserted the cutting tool i.e TiN in tool post, in this tool post, the accelerometer is mounted, which is shown in fig. no 1, and this accelerometer is connected with the FFT analyser for analysing the vibration. And, this FFT analyser is connected with PC. After all setup, we started the simple turning operation, and this operation required parameters are speed, feed and depth of cut applied. After this process, FFT analyses the data recorded by accelerometer, and it is shown in PC. After completion of one experiment, the surface tester is mounted on tool post, and it is measured with the RMS value of this work piece.

Machining Vibration

In the experimental setup, the work piece material, Inconel round bars is held in headstock of the conventional lathe machine for machining purpose. The Accelerometer connected in tool post is there in that cutting tool, carbide insert tool is attached. Centre drilling was done and the job was held at the other end by the tail stock, and a skin pass was carried out. The setup was hence, complete and the runs could be carried out from here. Accelerometer is mounted on cutting tool and it is connected to FFT Analyser. The FFT Analyser consists of two components, namely accelerometer and analyser. This accelerometer is attached on the cutting tool on tool post, as shown in figure no.1. And, this accelerometer gets connected with analyser. Again, this analyser requires connection with computer so gets connected with PC.

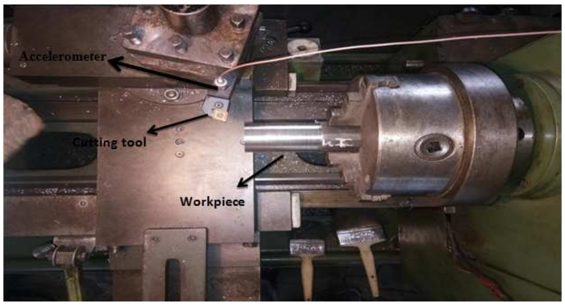

Figure 1: Cutting Tool with Accelerometer

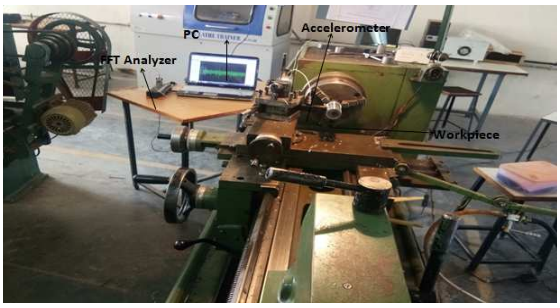

Figure 2: Actual Photo of Test Ring

Surface Finish

Surface roughness has been exactly measured with the help of a portable stylus-type profilometer, Talysurf (Taylor Hobson, Surtronic 3+, UK). Measurements were taken at different locations, and also the average was reported for every run.

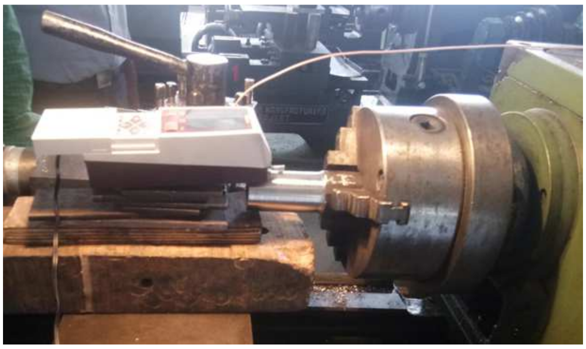

Figure 3: Setup of Talysurf for Measurement of Surface Roughness

PROCESS PARAMETER

Table 1: Factors and Levels for the Vibration and Surface roughness

Sr. No.	Parameter	Inconel 600			Inconel 718			Inconel 825		
1	Cutting Speed (m/min)	135	215	500	135	215	500	135	215	500
2	Feed (mm/rev)	0.22	0.40	0.71	0.22	0.40	0.71	0.22	0.40	0.71
3	Depth of cut (mm)	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5

In this experimentation, the above turning parameters and inconel materials are changing 3 times, by using this parameters, we can find that we measure 27 times vibration and surface roughness. During this investigation, the effect of turning parameter like speed, feed and depth of cut are the effect on tool vibration and surface roughness of work piece by turning Inconel bar. The design of experiment considered is 27, by using the variables like speed, feed and depth of cut, and it is shown in the following result table.

EXPERIMENTAL RESULT

Table 2: All Experimental Data

Sr. No.	Spindle Speed (rpm)	Feed (mm/revol.)	Depth of cut (mm)	Vibration (m/s^2)	Ra (μm)
For Inconel 600					
1	135	0.22	0.5	0.244	2.86
2	135	0.40	1.0	0.196	6.78
3	135	0.71	1.5	0.222	9.08
4	215	0.22	0.5	0.501	3.80
5	215	0.40	1.0	0.276	6.58
6	215	0.71	1.5	0.402	8.70
7	500	0.22	0.5	0.572	3.75
8	500	0.40	1.0	0.635	8.67
9	500	0.71	1.5	0.586	10.08
For Inconel 718					
1	135	0.22	0.5	3.68	1.56
2	135	0.40	1.0	4.07	1.10
3	135	0.71	1.5	4.45	6.50
4	215	0.22	0.5	3.65	0.70
5	215	0.40	1.0	4.15	1.84
6	215	0.71	1.5	4.36	6.84
7	500	0.22	0.5	4.59	1.93
8	500	0.40	1.0	4.21	1.66
9	500	0.71	1.5	4.95	5.84
For Inconel 825					
1	135	0.22	0.5	0.0124	4.21
2	135	0.40	1.0	0.0150	5.71
3	135	0.71	1.5	0.0270	10.94
4	215	0.22	0.5	0.0262	5.32
5	215	0.40	1.0	0.0311	3.59
6	215	0.71	1.5	0.0245	10.66
7	500	0.22	0.5	0.0612	3.62
8	500	0.40	1.0	0.0818	4.61
9	500	0.71	1.5	0.0661	6.62

From the above experimental result data, the value of tool vibration and also surface roughness of work piece results are plotted in a graph to give better understanding of results. From the experimental result, the turning parameters like speed, feed and depth of cut has significant effect on the cutting tool vibration and surface roughness of the work piece. And, the actual acceleration is measured by using a displacement sensor.

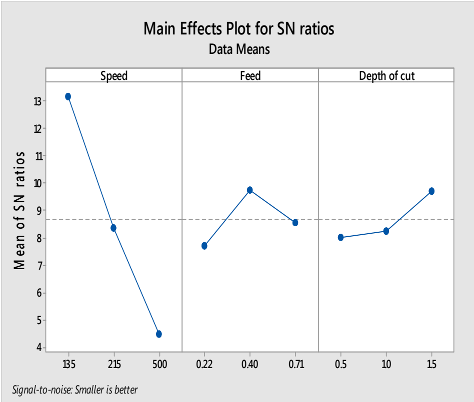

Figure 4: Main Effect Plot of SN Ratio for Inconel 600

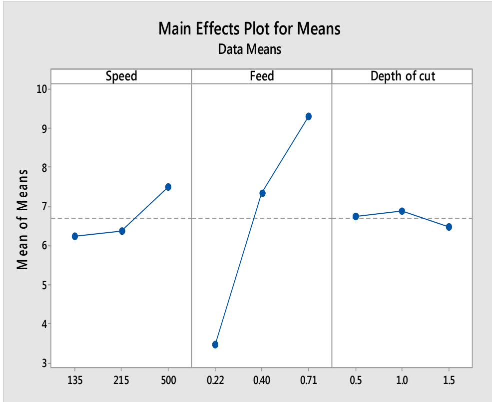

Figure 5: Main Effect Plot of Ra for Inconel 600

We can see that the P-value for the speed is 0.040 which is lesser than the significant value of 0.05. Hence, the model is significant.

S = 1.530 R-Sq = 96.4% R-Sq(adj) = 85.5%

We can see that the P-value for the feed is 0.022 which is lesser than the significance value of 0.05. Hence, the model is significant. The main effect plot for Ra shows that the surface roughness first decreases sharply with increase in depth of cut. After a point, gradually increase in cutting speed.

S = 1.162 R-Sq = 94.9% R-Sq(adj) = 91.6%

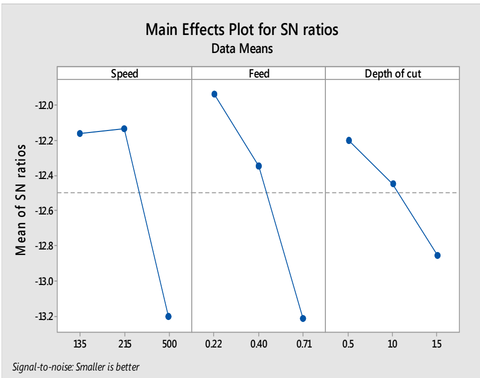

Figure 6: Main Effect Plot of SN Ratio for Inconel 718

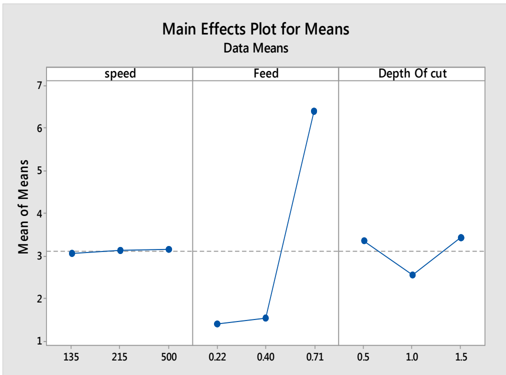

Figure 7: Main Effect Plot of Ra for Inconel 718

S = 0.4401 R-Sq = 93.4% R-Sq(adj) = 73.6%

The model is adequate as represented by the points falling on a straight line in the normal probability plot. It denotes that it is normally distributed. We can see that the P-value for the feed is 0.004, which is lesser than the significance value of 0.05. Hence, the model is significant.

S = 0.2945 R-Sq = 99.7% R-Sq(adj) = 98.6%

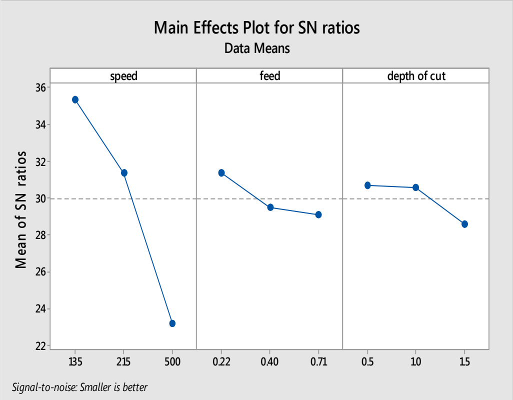

Figure 8: Main Effect plot of SN ratio for inconel 825

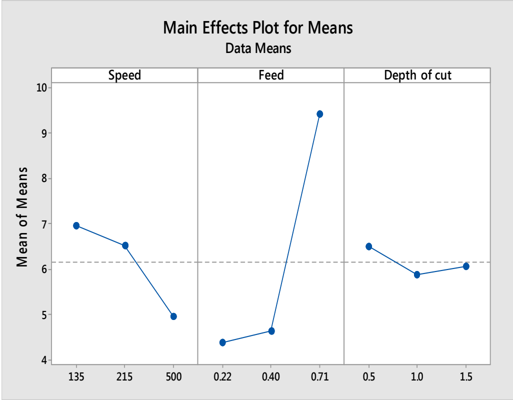

Figure 9: Main Effect plot of Ra for inconel

S = 2.574 R-Sq = 94.9% R-Sq(adj) = 79.6%

The model is adequate as represented by the points falling on a straight line in the normal probability plot. It denotes that it is normallydistributed. From the main effect plot it is understood that the surface roughness of work piece and vibration of cutting tool are mainly affected by speed and feed, whereas, the depth of cut has an insignificant effect on surface roughness and vibration. Vibration of tool and roughness of surface of the work piece increases with an increase in feed and decrease with an increase in cutting speed.

CONCLUSIONS

From the experimental result, the turning parameters like speed and depth of cut and feed have significant effect on the surface roughness of the work piece, and it is observed to be a relative degree of influence by induced vibration. It also shows that the induced vibration of cutting tool and surface roughness of work piece is proportional to speed, feed and depth of cut. Hence, the optimum machining parameters are speed and feed that help to reduce vibration of cutting tool and surface roughness of the work piece.

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