International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 4, July 2014, PP 234-241
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Investigation of Surface Roughness of SS 304 Using Damper in CNC Turning

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Abstract: *In machining operation, the quality of surface finish is an important requirement for many turned work-pieces. Thus, the choice of optimized cutting parameters is very important for controlling the required surface quality. The focus of present experimental study is to optimize the cutting parameters using two performance measures, machine tool vibration and work-piece surface roughness. Optimal cutting parameters for each performance measure were obtained employing Taguchi techniques. The Taguchi L 9 run, signal to noise ratio and analysis of variance were employed to study the performance characteristics in turning operation. The experimental results showed that the machine tool vibration can be sensed and used effectively as an indicator to control the cutting performance and improves the optimization process. It is possible to increase machine utilization and decrease production cost in an automated manufacturing environment.*

Keywords: *Surface roughness, tool vibrations, Taguchi parameter design, turning*

1. Introduction

Increasing the productivity and the quality of the machined parts are the main challenges of metal-based industry; there has been increased interest in monitoring all aspects of the machining process. Surface finish is an important parameter in manufacturing engineering. It is a characteristic that could influence the performance of mechanical parts and the production costs. The ratio between costs and quality of products in each production stage has to be monitored and immediate corrective actions have to be taken in case of deviation from desired trend.

Surface roughness measurement presentsan important task in many engineering applications. Many life attributes can be also determined by how well the surface finish is maintained. So many researchers were try to optimize the surface roughness.**Palanikumar(2006)** found that surface roughness plays animportant role in many areas and is factor of great importance in evaluation of machining accuracy **Thamizhmani (2006)** studied to analyze the optimum cutting parameters to minimize the roughness in turning SCM 440 alloy steel by Taguchi method. The result of the experiment suggests that the insert radius and feed rate are the main controllable parameters which affect surface roughness more in turning AISI 1030 carbon steel. Instead of engineering judgment surface roughness can be improved by this approach .**Puertas (2003)** state vibration can be measured in terms of peak acceleration, r.m.s value of velocity, peak to peak displacement.

Ghani (2002) presented a study of tool life, surface finish and vibration, while turning nodular cast iron using ceramic tool. They found that surface finish was to be almost constant with the progression of the flank wear under different cutting conditions **Bonifacio(1994)** presented a study on correlating tool wear, tool life, surface roughness and tool vibration in finish turning with coated carbide tools. They concluded that the feed didn't influence the vibrational signal and had a little effect on surface roughness. The surface roughness value decreases slightly after a short cutting time due to chamfering of the edge radius.**Thomas(1996)** studied the effect of tool vibration on surface roughness during lathe dry turning process on mild carbon steel samples at different levels of speed, feed, depth of cut, tool nose radius, tool length and work piece length.

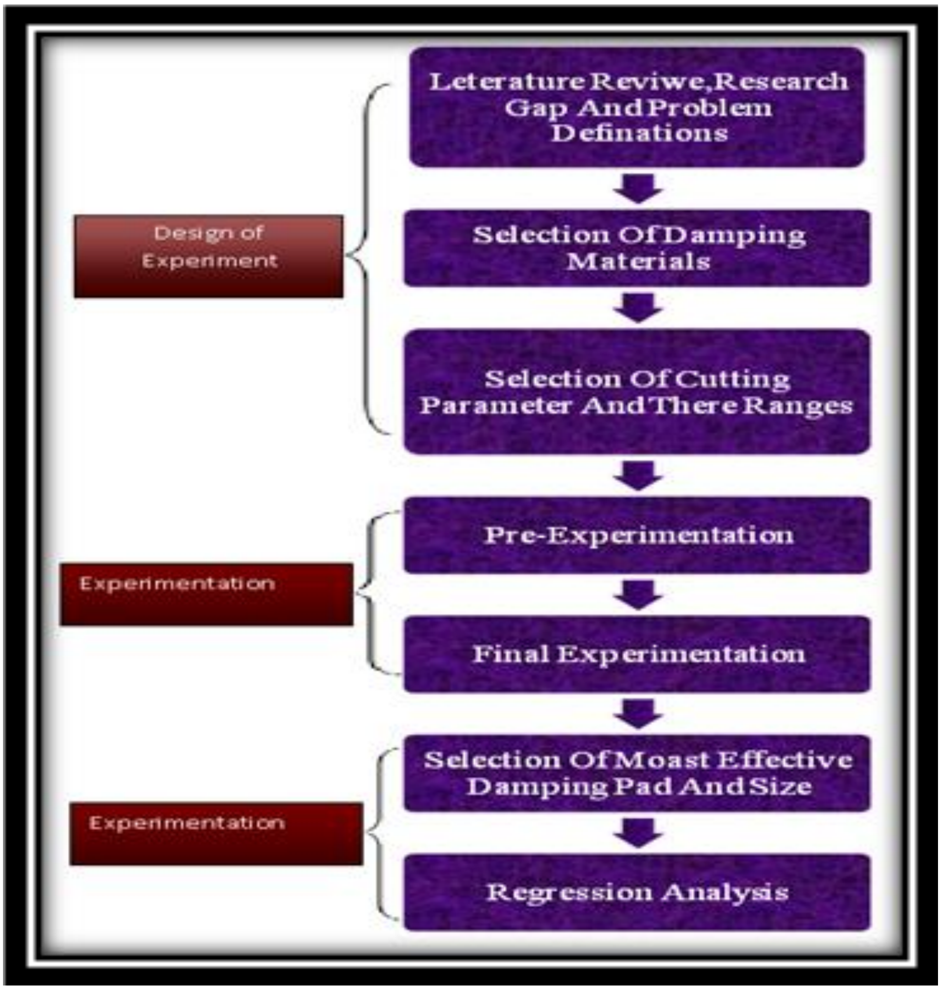
Safeen(2007) studied the effect of cutting tool vibration on surface roughness of work piece in dry turning operation .The surface roughness of the work piece is proportional to cutting tool acceleration. This effect interact with other independent variable such feed rate, depth of cut, speed. Surface roughness of work piece increases parallel to the tool vibration with increasing tool over hang.

Dogra(2011) presented a research on effect of tool geometry variation on tool wear ,surface roughness and surface integrity of the machined surface. They concluded during finish hard turning increase in the rake angle or the chamfer angle as well as the hone cutting edge radius allowed an increase in the compressive residual stress in the subsurface. Further the increased radius of a cutting tool will produce larger compressive residual stress beneath the machined surface**.** Increasing the nose radius has a direct effect on cutting forces which leads to a significant increase in the ploughing effect in the cutting zone. **Gaitonde et al**. used the technique artificial neural network (ANN) method and using this surface roughness model is being developed to investigate the cutting conditions during turning of steel, 9SMnPb28k (DIN)..They concluded from their experiment that the surface roughness is highly sensitive to feed and speed while depth of cut has less effect on it. They also concluded that ANN can detect any value of non linearity that exists between the process response and the input parameters and exhibits good generalization.

All researchers have focused on effect cause parameter on vibration and effect of vibration on various parameters like surface roughness for ductile material like aluminum, MS, copper etc. Also they provide suitable solution for that. But they very little focused on effect of vibrations on surface roughness of hard material like SS304, titanium etc even though they having some good property .In this present work attempt is made to investigate the effect of cutting parameters on tool vibration and surface roughness.

2. METHODOLOGY

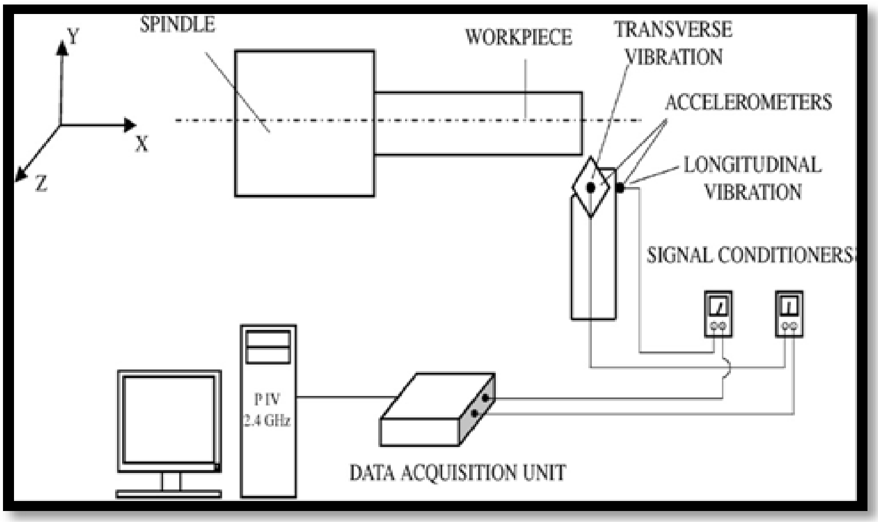
The general methodology for this project work can be explained with the help of flowchart shown in Fig



3. EXPERIMENTATION

Design of Experiment (DOE) approach is selected for investigation effect of varying controllable parameter on acceleration, since Taguchi design of 9 runs is efficient to study the effect of two or more factors these three levels of factor are referred as low intermediate & high level. In this experiment amplitude of vibration, average tool temperature and surface roughness are measured with and without damping pad.Tool without damper and with damper is shown in Fig

Diagram shows tool without and with damper



Layout diagram for experiment

In experimentation tool is supported with and without damper and corresponding reading are taken for same operating conditions .Work piece used for present work is SS304 because of their good properties. Insert selected for turning operation is TNMG 160408-61 with nose radius of 0.6 mm . whole experiment is carried out on CNC machine and machine tool vibration is measured by using FFT analyzer. Also surface roughness is measured by using surface roughness tester .

3.1. Pre-Experimentation

Purpose behind pre-experimentation is to set the levels of the cause parameters which are to be used during experiment. By carry out pre-experiment it is easy to determine the level of 3 cause parameters. The cause parameters used for experimentation are namely Cutting Speed (CS), Depth of Cut (DOC) and Feed Rate (FR).During experimentation it is assume that other parameters like insert nose radius, nose angle and other tool geometry remains constant. During pre-experiment Neoprene rubber is use as damper. Levels of parameters are decided by keeping two parameters constant and varying single parameter. from pre-experimentation following levels are decided.

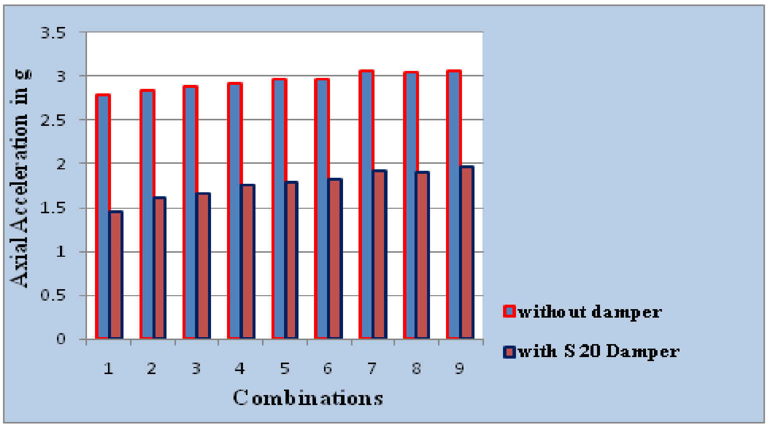
Parameters	Level 1(minimum)	Level 2(mean)	Level 3(maximum)
Cutting speed (CS) C1	420	520	620
Depth of cut (DC) C2	0.4	0.5	0.6
Feed rate(FR) C3	0.15	0.2	0.25

3.2. Final Experiment

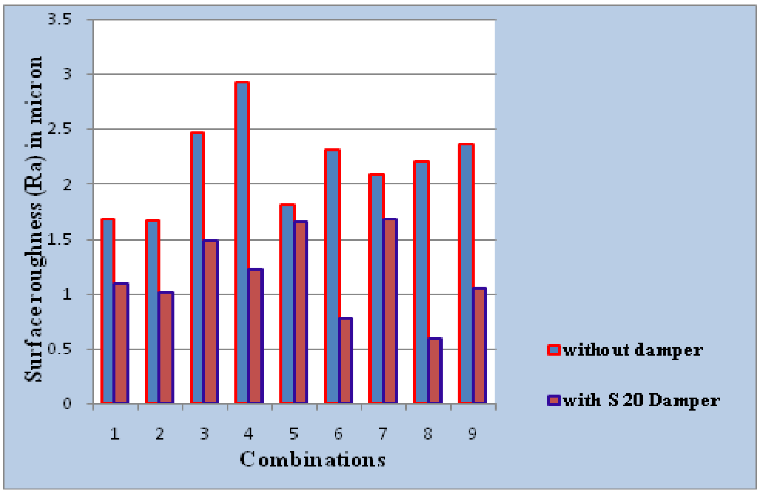
For final experimentation S-20 damper is used

CS rpm	DC mm	FR mm/rev	Amplitude of Acceleration of cutting tool in g				Surface Roughness Ra	
			Axial Direction (RMS)		Tangential Direction (RMS)			
			Without Damper	With Damper	Without Damper	With Damper	Without Damper	With Damper
420	0.4	0.15	2.79	1.459	0.217	0.202	1.684	1.086
420	0.5	0.2	2.834	1.615	0.228	0.204	1.67	1.014
420	0.6	0.25	2.884	1.666	0.273	0.234	2.461	1.475
520	0.4	0.2	2.926	1.753	0.248	0.227	2.926	1.223
520	0.5	0.25	2.96	1.796	0.36	0.29	1.805	1.654
520	0.6	0.15	2.964	1.823	0.277	0.242	2.301	0.776
620	0.4	0.25	3.062	1.912	0.256	0.21	2.08	1.682
620	0.5	0.15	3.046	1.896	0.269	0.23	2.204	0.587
620	0.6	0.2	3.057	1.963	0.259	0.223	2.36	1.044

4. Results and Discussion



Axial-acceleration with and without damper



Surface roughness of work –piece without and with S-20 damper it is observed that by using S 20 damper axial acceleration and surface roughness are reduce by great extend.

4.1. Regression Analysis

By using this data we can compare the vibration parameter with damp condition and without damp condition. Also ANOVA and Regression analysis can validate above result.

4.2. The Regression for Axial Acceleration

Axial Acceleration (C4) = 0.467 + 0.00172 C1 + 0.547 C2 + 0.653 C3

Where C1 is cutting speed, C2 is Depth of cut And C3 is feed rate.

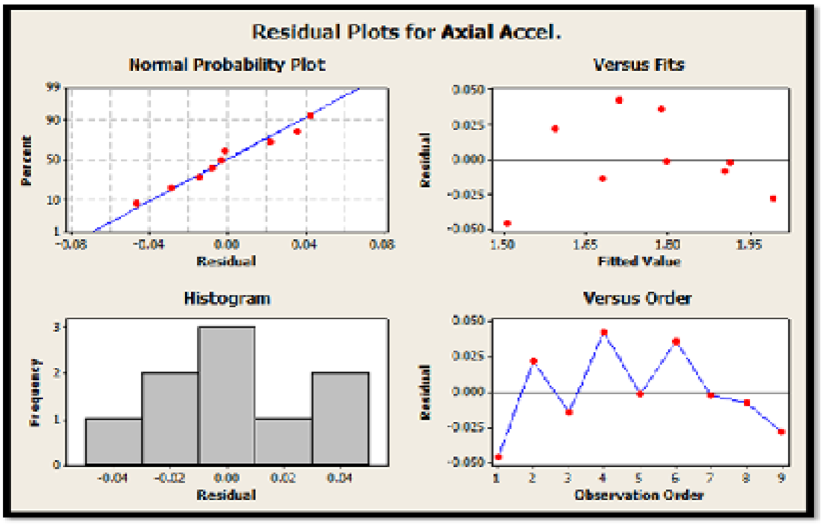
Predictor	Coefficient	SE Coefficient	T	P	VIF
Constant	0.4672	0.1256	3.72	0.014	
C1	0.0017183	0.0001515	11.34	0.000	1.000
C2	0.5467	0.1515	3.61	0.015	1.000
C3	0.6533	0.3030	2.16	0.084	1.000

S = 0.0371108   R-Sq = 96.7%   R-Sq (adj) = 94.7%

4.3. Analysis of Variance for Axial Acceleration

Source	DF	SS	MS	F	P
Regression	3	0.201493	0.67164	48.77	0.000
Residual Error	5	0.006886	0.001377		
Total	8	0.208380			

Source	DF	Seq SS
C1	1	0.177160
C2	1	0.017931
C3	1	0.006403



Residual Plot for Axial Acceleration

Above table shows regression for axial accelerations which indicate 96.7% of variation in the rating observations. The adjusted R is 94.7%, which is a decrease of 2.0% R^2value indicate that the degree of closeness of variable with best fit line and parameters are closely co related with each other. From ANOVA table it is clear that feed rate is most significant parameter for axial accelerations. Above graph shows the residual plot for axial accelerations for given regression.

4.4. Regression Analysis for Surface Roughness

The regression equation is

Surface Roughness = 0.404 - 0.000437 C1 - 1.16 C2 + 7.87 C3

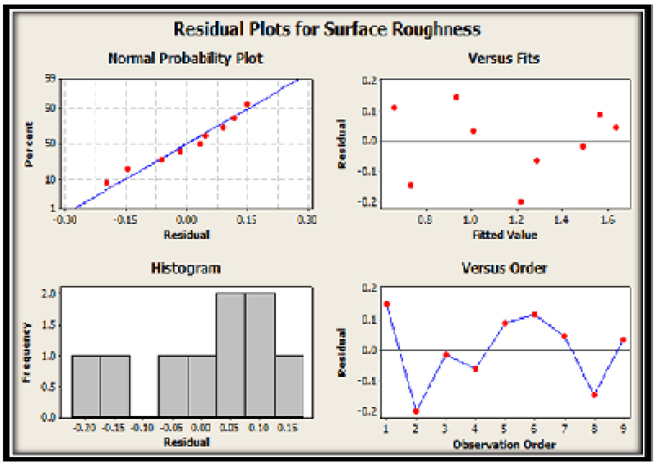
Predictor	Coefficient	SE Coefficient	T	P
Constant	0.4036	0.5078	0.79	0.463
C1	-0.0004367	0.0006126	-0.71	0.508
C2	-1.1600	0.6126	-1.89	0.117
C3	7.873	1.225	6.43	0.001

S = 0.150064   R-Sq = 90.1%   R-Sq (adj) = 84.1%

4.5. Analysis of Variance for Surface Roughness

Source	DF	SS	MS	F	P
Regression	3	1.02202	0.34067	15.13	0.006
Residual Error	5	0.11260	0.02252		
Total	8	1.13461			

Source	DF	Seq.SS
C1	1	0.01144
C2	1	0.08074
C3	1	0.92984



Residual plot for surface roughness

Above table is showing regression for surface roughness which indicates 90.1% of variation in the rating observations. The adjusted R is 84.1%, which is a decrease of 6.0 %. R2 value indicates that the degree of closeness of variable with best fit line and parameters are closely co related with each other. From ANOVA Table it is clear that feed rate is most significant parameter for surface roughness. Above graphs shows the residual plot of regression for surface roughness

5. CONCLUSION

The effect of cutting parameters such as cutting speed, depth of cut and feed rate on machining variables is evaluated. The testing result showed that the developed method was successful. Based on the current study, the following conclusions can be drawn:

- ✓ S-20 damper absorbed 37.5% of tangential acceleration
- ✓ As S-20 damper having good damping capacity to which it shows less vibration and good surface finish.

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