RESEARCH ARTICLE OPEN ACCESS

Improvement of Surface Finish by Vibration Control in Machine Tool Using Composite Material

Nisarg M. Trivedi*, Prof. J. R. Mevada**
*Student, M.Tech, (Department of mechanical engineering, ganpat university, kherva-384012),
**Associate prof., (Department of mechanical engineering, ganpat university, kherva-384012)

Abstract
In milling machine the main problem is vibration in machine tool which affects on quality of machined part. Hence these vibrations needed to suppressed during machining. Aim of study is to control different parameters like thickness of composite plates, cutting speed and depth of cut which affects on response like amplitude (acceleration) of vibration and surface roughness of machined part. In present work machine tool vibration on slotted table horizontal milling machine have been reduced using composites. In this work glass fiber epoxy plates and glass fiber polyester plates are used as composites. Initially holes are drilled on each composite plate. Mild steel plate is placed on the composite plates and setup is fixed to the table of horizontal milling machine using nuts and bolts. A milling operation is carried out. Amplitude (acceleration) of vibration is recorded on the screen of vibxpert signal analyzer and Surface roughness of machined mild steel plate is measured by tr110 surface roughness tester machine.
Keywords- horizontal milling machine, composite materials (glass fiber epoxy and glass fiber polyester plates), vibxpert signal analyzer, tr110 surface roughness tester machine.

I. Introduction

Milling is the most common form of machining, a material removal process, which can create variety of features on part by cutting away the material. In horizontal milling machine tool vibration occurs during machining process because of in homogeneous work piece material, disturbance in work piece or tool and variation of chip cross section. Effects of these vibration include reduction in tool life, improper surface finish and unwanted noise in machine tool. In order to suppressed these vibration, composite materials have been used. In present work glass fiber epoxy plates and glass fiber polyester plates used as composite material. Fiber glass also called glass reinforced plastic (GRP) or FRP is a fiber reinforced polymer made of plastic matrix reinforced by fine fibers of glass. Epoxy is thermosetting polymer formed from reaction of an epoxide with polyamine. Epoxies are known for their excellent adhesion and excellent mechanical property. Polyester is category of polymers which contain ester functional group of main chain. Depending on chemical structure polyester is can be thermoplastic. In this study composites have been utilized as bed to work piece because of its excellent damping characteristics and also it act as vibration absorber. Sung-kyum cho, Hyun-jun kim, Seung-hwan chang [1] shows application of polymer composites to the table top machine tool components for higher stiffness and reduced weight. To determine the specification of composite material vibration test were carried out.. Amir Rashid, cornel mihai nicolescu [2] work carried out for Active vibration control in palletized work holding system for milling. Palletized work holding system, due to their compact design, offer an opportunity to design active control system that are economical and easier to implement in the case of milling machine. Xinhua long , hao jiang, guang meng [3] presented active vibration control for peripheral milling processes. In this system work piece is driven by specially designed active stage to control relative vibration between the tool and work piece during milling process. Paper presented by C.Andesson, M.Andersson, J.E.stahl [4] shows experimental studies of cutting force variation in face milling. Paper presented by Yang shaohong, Wang anwen, Hu mingyong [5] shows damping properties of viscoelastic laminated plates with an unconstrained fiber reinforced layer. Using fiber reinforced viscoelastic layer has little affect on the nondimensional frequency, but can affectively improve the damping characteristics and reduce the resonance amplitude. Jean-Marie Berthelot, Mustapha assarar, Youssef sefrani, Abderrahim EI Mahi [6] work carried out for damping analysis of composite materials and structures. This paper is develop synthesis of damping analysis of laminated materials, laminated with interleaved viscoelastic and sandwich material. Paper presented by D.I.Kim, S.C.Jung, J.E.Lee, S.H.Chang [7] shows parametric study on design of composite foam resign concrete sandwich structure for precision machine tool structures. Ding Jiangmin [8] presented composite concrete bed for CNC machine tool. Paper shows two important functional requirement of CNC machine tool bed are high structural stiffness and high damping. Dr. Muhannad Z. khelifa, Hayder Moasa Al-shukri [9] presented fatigue study on E –glass fiber reinforced polyester composite under fully reversed loading and spectrum loading. Result of fatigue test show that the uniaxial composite has the highest strength and fatigue degradation is also highest. Paper presented by J.P.Talbot and J.Woodhouse [10] work carried out for the vibration damping of laminated plates. Paper presented by C.Y.Huang , J- J Junz wang [11] shows effect of cutting conditions on dynamic cutting factor and process damping in milling.

II. Experimental work

Purpose of experimental work was to reducing vibration during machining process. Glass fiber epoxy and glass fiber polyester plates used as composite material during experiment. Milling experiment were conducted on the mild steel work specimen mounted on two different type of composite materials during machining process. The experimental work was performed for work specimen of mild steel and composite plates is 150mm×150mm×6mm.

Figure1. mild steel plate placed on composite plate bolted to slotted table of milling machine

Glass fiber epoxy and glass fiber polyester plates below mild steel plate is tightly bolted on table of milling machine. Accelerometer is placed on mild steel during machining operation. The response signal amplitude (acceleration) is recorded and stored in vibxpert signal analyzer. Then thickness of composite plate is increased and observation are recorded. Experiment are conducted for 6mm, 12mm and 18 mm thickness of composite plates respectively. After machining of MS plate the surface roughness was measured by tr110 surface roughness tester machine. For the experiment, total three parameters are selected. These machining parameter and their levels are shown in table 1.

Table 1. machining parameter and their level

Level	Cutting speed (in rpm)	Thickness of composite plate (in mm)	Depth of cut (in mm)
1	50	6	0.1
2	85	12	0.2
3	150	18	0.3

III. Result and Discussion

Minitab generated design is used with three levels of each three factors. The number of experiment was 27 each set of composite material (glass fiber epoxy and glass fiber polyester). Parameters like thickness of composite plate, cutting speed and depth of cut affects on response parameter like amplitude (acceleration) and surface roughness shown in below table.

Table 2: Experimental result for glass fiber epoxy and glass fiber polyester composite plates

						Glass fiber epoxy		Glass fiber polyester	
Run order	Pt type	Blocks	Speed (in RPM)	Thickness (in mm)	Depth of cut (in mm)	Amplitude (Acceleration) in m/s^2	Surface roughness (Ra) in µm	Amplitude (Acceleration) in m/s^2	Surface roughness (Ra) in µm
1	1	1	50	18	0.3	0.259	1.58	0.269	2.19
2	1	1	50	12	0.1	0.240	1.86	0.319	2.16
3	1	1	150	18	0.3	0.298	2.01	0.662	2.41
4	1	1	50	12	0.3	0.236	2.43	0.170	2.64
5	1	1	150	18	0.1	0.834	1.34	0.499	2.04
6	1	1	50	6	0.2	0.231	2.53	0.427	2.68
7	1	1	50	6	0.3	0.231	2.28	0.335	2.34
8	1	1	85	12	0.3	0.214	2.72	0.319	2.38
9	1	1	150	18	0.2	0.621	1.62	0.670	2.28
10	1	1	150	6	0.3	1.567	2.67	1.194	2.72

11	1	1	85	6	0.1	0.440	2.32	0.376	1.87
12	1	1	150	6	0.1	0.977	2.21	0.498	2.09
13	1	1	85	6	0.2	0.469	2.69	0.695	2.06
14	1	1	50	18	0.2	0.262	2.18	0.301	2.35
15	1	1	150	12	0.3	1.039	2.00	0.781	2.53
16	1	1	50	12	0.2	0.246	2.07	0.173	2.58
17	1	1	85	18	0.1	0.162	1.48	0.482	1.96
18	1	1	50	6	0.1	0.443	2.18	0.227	2.12
19	1	1	85	18	0.2	0.356	1.76	0.352	2.28
20	1	1	85	12	0.2	0.147	2.28	0.515	2.44
21	1	1	150	12	0.1	0.392	2.43	0.274	2.48
22	1	1	50	18	0.1	0.335	1.32	0.214	1.93
23	1	1	150	12	0.2	0.482	2.40	0.437	2.36
24	1	1	150	6	0.2	1.142	2.40	0.862	2.54
25	1	1	85	12	0.1	0.141	2.13	0.752	2.27
26	1	1	85	18	0.3	0.760	2.03	0.511	2.53
27	1	1	85	6	0.3	0.564	2.88	0.883	2.68

3.1 Result and analysis for glass fiber epoxy

3.1.1 influence of amplitude

Result from 27 machining trial for glass fiber epoxy performed as per experimental shown in below.

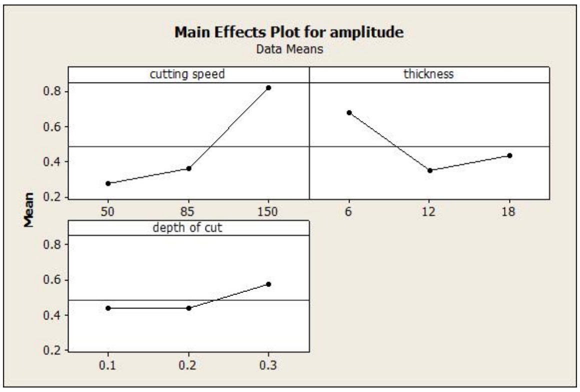

Figure 2. main effect plot for amplitude (acceleration)

Main effect plot for amplitude (acceleration). During machining process there are different parameter affected like cutting speed, depth of cut and thickness. This fig. 2 indicate that amplitude is increased with increasing cutting speed and depth of cut. In figure amplitude is decreased with increasing thickness of material so thickness is inversely proportional to amplitude.

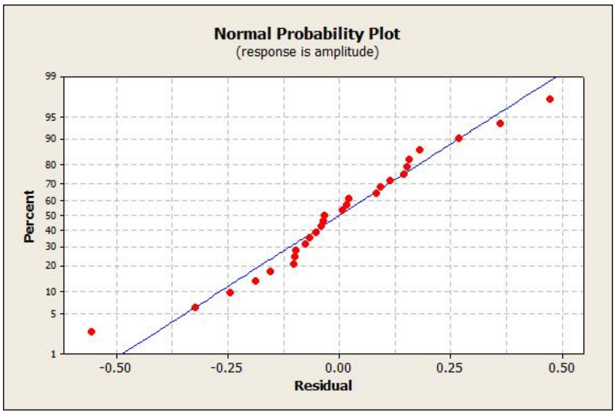

Figure 3: normplots of residual for amplitude (acceleration)

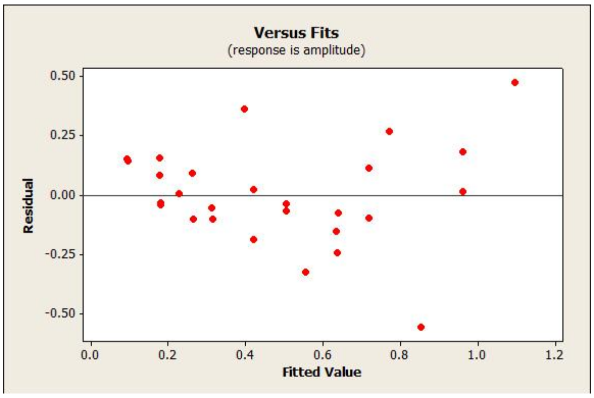

Figure 4: residual vs fits for amplitude

The normal probability plot of the residuals and the plot of the residual versus the predicted response for amplitude are shown above. The normal probability plot of the show that, the residual fall on near or straight line. This refers that errors are distributed normally. residuals versus the predicted response plot reveal that there is no obvious pattern and unusual structure. This implies that the model proposed is adequate. From table 3 it can be concluded that the P-value is less than 0.05 which means that the model is significant at 95% confident level. P value is define probability value.

Table 3: analysis of variance for amplitude

Source	DF	Seq ss	Adj ss	Adj MS	F	P
Cutting speed	2	1.52229	1.52229	0.76115	13.41	0.000
Thickness	2	0.51367	0.51367	0.25684	4.52	0.024
Depth of cut	2	0.10810	0.10810	0.05405	0.95	0.403
Error	20	1.13560	1.13560	0.05678		
Total	26	3.27966				

3.1.2 influence of surface roughness

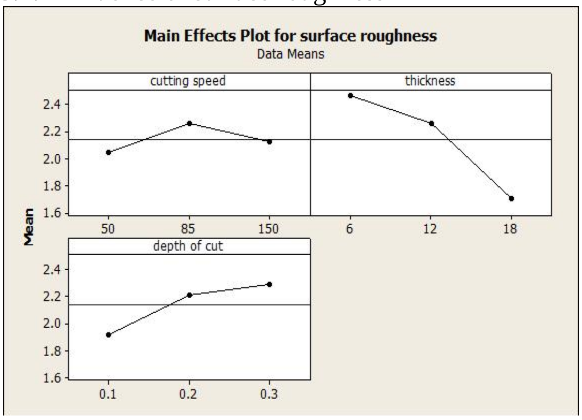

Figure 5: main effect plot for surface roughness

Main effect plot for surface roughness shown in fig.5. This fig. indicates that cutting speed is first increased than slightly decreased. It is inversely proportional to amplitude. Depth of cut increased and thickness is decreased.

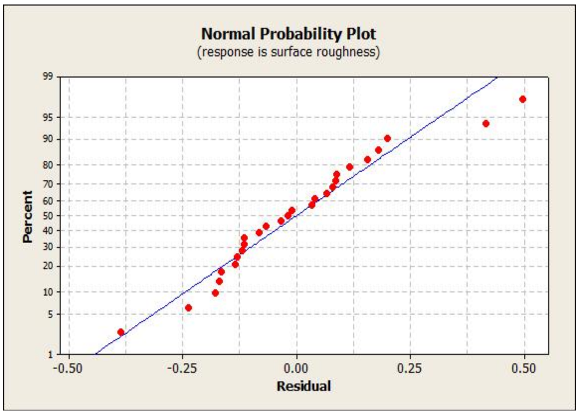

Figure 6: normplot of residual for surface roughness

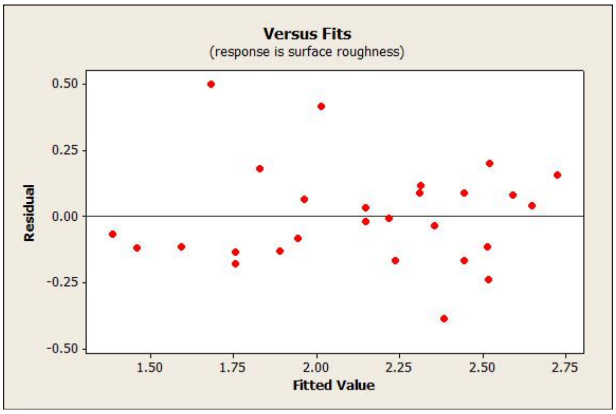

Figure 7: residual vs fits for surface roughness

The normal probability plot of the residuals and the plot of residuals versus the predicted response for surface roughness are shown. A check on probability plot of the show that, the residual fall or near straight line. This refers errors are distributed normally. residuals versus the predicted response plot reveal that there is no obvious pattern and unusual structure. This implies that the model proposed is adequate. The constant variance assumption can be checked with residual versus fits plot. A common pattern is that the residual increases as the fitted value increases. Table 4 shows P-value is less than 0.05 which means that the model is significant at 95% confident level.

Table 4.analysis of variance for surface roughness

source	DF	Seq ss	Adj ss	Adj MS	F	P
Cutting speed	2	0.19801	0.19801	0.09900	2.11	0.148
Thickness	2	2.78412	2.78412	1.39206	29.63	0.000
Depth of cut	2	0.68939	0.68939	0.34469	7.34	0.004
Error	20	0.93947	0.93947	0.04697		
total	26	4.61099				

3.2 Result and analysis for glass fiber polyester

3.2.1 influence of amplitude

Result from 27 machining trial for glass fiber polyester performed as per experimental shown in below.

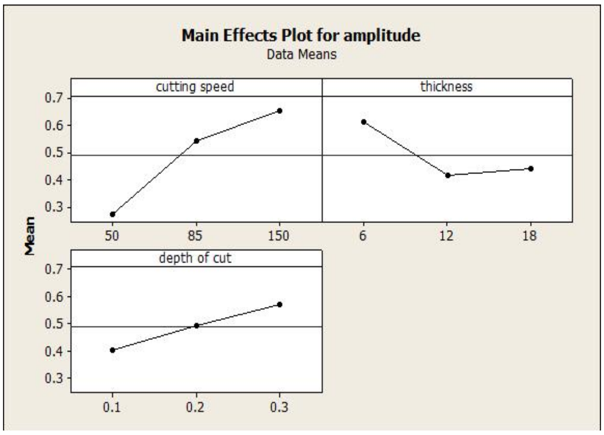

Figure 8.main effect plot for amplitude (acceleration)

During machining process there are different parameter effected like cutting speed, depth of cut and thickness. This fig. 8 indicates that amplitude is increased with increasing cutting speed and depth of cut. Then amplitude is decreased with increasing thickness.

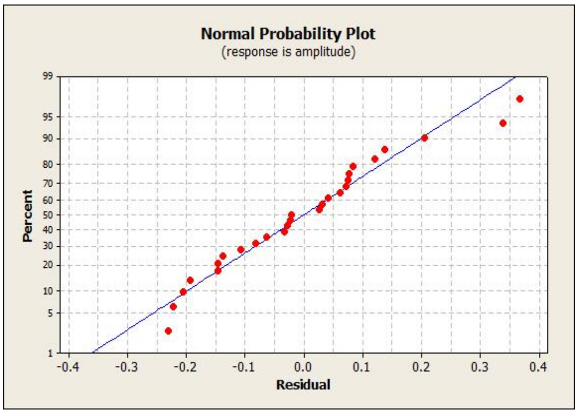

Figure 9. normplots of residual for amplitude (acceleration)

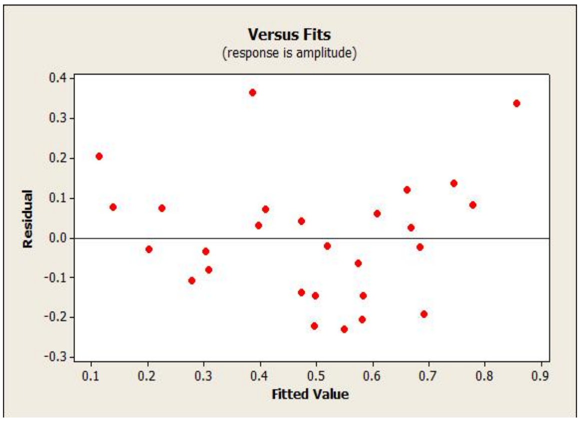

Figure 10: residual vs fits for amplitude

Normal probability plot of the residuals and the plot of the residual versus the predicted response for amplitude are shown above. The normal probability plot of the show that, the residual fall on near or straight line. This refers that errors are distributed normally. residuals versus the predicted response plot reveal that there is no obvious pattern and unusual structure. Following table 5 shows P-value is less than 0.05 which means that the model is significant at 95% confident level.

Table 5. analysis of variance for amplitude

Source	DF	Seq ss	Adj ss	Adj MS	F	P
Cutting speed	2	0.69755	0.69755	0.34878	11.17	0.001
Thickness	2	0.20362	0.20362	0.10181	3.26	0.059
Depth of cut	2	0.12236	0.12236	0.06118	1.96	0.167
Error	20	0.62425	0.62425	0.03121		
Total	26	1.64779				

3.2.2 influence of surface roughness

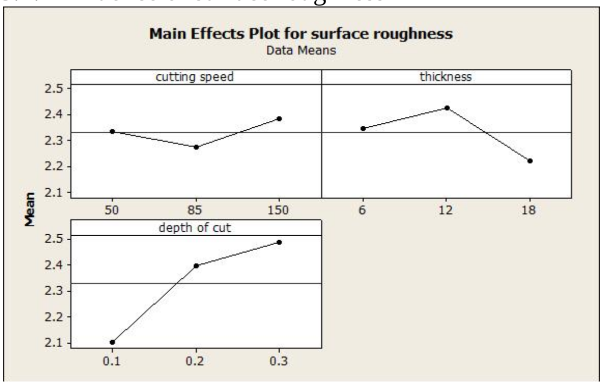

Figure 11: main effect plot for surface roughness

Main effect plot for surface roughness shown in fig.11. This is indicates that cutting speed is decreased than slightly increased. Depth of cut is increased and thickness is inversely proportional to cutting speed.

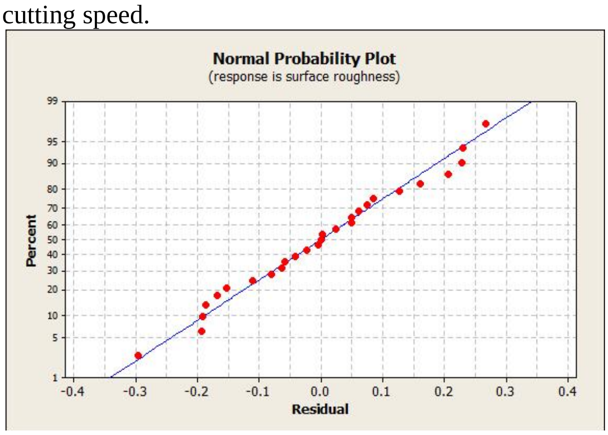

Figure 12: normplot of residual for surface roughness

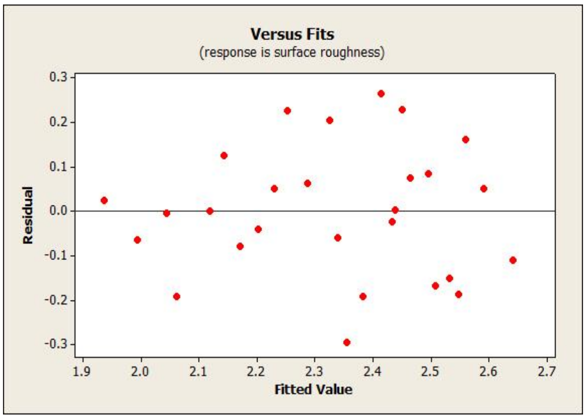

Figure 13. residual vs fits for surface roughness

Normal probability plot of the residuals and the plot of residuals versus the predicted response for surface roughness are shown. A check on probability plot of the show that, the residual fall or near straight line. This refers errors are distributed normally. residuals versus the predicted response plot reveal that there is no obvious pattern and unusual structure. This implies that the model proposed is adequate. Table 6 P-value is less than 0.05 which means that the model is significant at 95% confident level.

Table 6.analysis of variance for surface roughness

Source	DF	Seq ss	Adj ss	Adj MS	F	P
Cutting speed	2	0.05342	0.05342	0.02671	0.96	0.401
Thickness	2	0.19709	0.19709	0.09854	3.53	0.049
Depth of cut	2	0.74056	0.74056	0.37028	13.27	0.000
Error	20	0.55793	0.55793	0.02790		
Total	26	1.54900				

3.3 Discussion

- Amplitude (acceleration) is increased with increasing speed that indicates tool and work piece is rigidly supported to each other. If work piece is unsecured means not securely clamped on table then friction of milling may cause it to shift and alter the desired cuts.
- Amplitude (acceleration) is increased with increasing depth of cut that depends on tool life. As tool is used then teeth will wear down and become dull. A dull cutter is less capable of making precision cuts.
- Amplitude (acceleration) is decreased with increasing thickness. With increasing thickness of material vibration effect is reduced. If vibration is unbalanced then there are several factors affected like manual feed, improper bolted joint during experiment.
- Roughness is increased with speed then decreased. Decreasing of surface roughness define better surface finish. If tool wear produced during increasing of cutting speed then surface finish is improper.
- Roughness is increased with increasing depth of cut that depend on work piece quality. If work piece quality is poor that defines poor surface finishing.
- Roughness decreasing with increasing thickness which define better surface finish. If machine tool should not sufficiently strong then it increase the deflection during cutting which affect on surface finishing.

IV. Conclusion

This experimental work improve the surface quality of work piece by reducing vibration of horizontal milling machine tool using two different composite materials glass fiber epoxy and glass fiber polyester.

- In present work, two different types of composite materials glass fiber epoxy and glass fiber polyester used below the work piece. composite materials reduces the vibrations of the system during experimental observation. With increase in thickness of composites the vibrations are decreased.
- During experiment out of the two materials, amplitudes obtained are less for Glass fiber epoxy material. Therefore, it can be concluded that Glass fiber epoxy material can be used for machine tool structures to reduce the effects of vibrations.
- The decrease of vibration amplitude has been observed with increase of thickness between table and work piece for glass fiber epoxy but for glass fiber polyester vibration increases during experiment.
- Main effect plot and normal probability plot of amplitude and surface roughness shows that variation of response parameter with respect to controllable parameter which define glass fiber epoxy has better accuracy than glass fiber polyester.
- So it can be conclude that glass fiber epoxy is more useful than glass fiber polyester to reduce vibration effect.

References

[1] Sung-kyum cho, Hyun-jun kim, Seung-hwan chang, The application of polymer composites to the table top machine tool components for higher stiffness and reduced

weight, composite structure 93 (2011) 492-501.

[2] Amir Rashid, cornel Mihai Nicolescu, Active vibration control in palletized work holding system for milling , *International Journal of Machine Tools & Manufacture 46 (2006) 1626–1636.*

[3] Xinhua Long, Hao Jiang, Guang Meng, Active vibration control for peripheral milling processes, *Journal of Materials Processing Technology 213 (2013) 660–670.*

[4] C.Andesson, M.Andersson, J.E.stahl, experimental studies of cutting force variation in face milling, *International journal of machine tool and manufacture 51 (2011) 67-76.*

[5] Yang shaohong, Wang anwen, Hu mingyong, damping properties of viscoelastic laminated plates with an unconstrained fiber reinforced layer, 2011 Third *International Conference on Measuring Technology and Mechatronics Automation.*

[6] Jean-Marie Berthelot, Mustapha assarar, Youssef sefrani, Abderrahim EI Mahi, damping analysis of composite materials and structures, *composite structures 85 (2008) 189-204.*

[7] D.I.Kim, S.C.Jung, J.E.Lee, S.H.Chang, parametric study on design of composite foam resign concrete sandwich structure for precision machine tool structures, *Composite Structures 75 (2006) 408–414.*

[8] Ding Jiangmin, composite concrete bed for CNC machine tool, *2010 International Conference on Measuring Technology and Mechatronics Automation.*

[9] Dr. Muhannad Z. Khelifa, Hayder Moasa Al-Shukri, fatigue study on E –glass fiber reinforced polyester composite under fully reversed loading and spectrum loading, *Eng.& Technology, Vol. 26, No.10, 2008.*

[10] J.P.Talbot and J.Woodhouse, vibration damping of laminated plates, *Composites Part A 28A (1997) 1007-1012.*

[11] C.Y.Huang , J- J Junz wang, effect of cutting conditions on dynamic cutting factor and process damping in milling, *International journal of machine tool and manufacturing 51 (2011) 320-330.*