Vibration Reduction and Surface Finish Improvement in Boring Operation on Lathe by Viscoelastic Material Damper

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Abstract - *Boring operation is the most commonly used operation to enlarge the previously drilled hole. This operation is very critical process. Generally problems like surface roughness, noise, vibration and tool wear related problems occur. Of all the problems vibration is very critical problem. Different techniques are used to reduce the vibrations in boring bar. Mainly used techniques for vibration reduction are of active and passive type. This paper focuses on passive type of vibration reduction technique. Experimental investigation is achieved with the help of viscoelastic material dampers and with variation in boring process parameters like spindle speed, feed rate, depth of cut. With the help of FFT analyzer and surface roughness tester, results are compared for boring bar without and with viscoelastic damper fitted to boring bar. From the investigation it is observed that the overall vibration decreases and also improvement in surface finish is observed because of the dampers attached to boring bar.*

***Key Words*: Boring bar, Vibration, Passive Type Damping, Viscoelastic Damping Material, FFT Analyzer, Surface Roughness of Boring bar.**

1.INTRODUCTION

The lathe was very important to the Industrial Revolution. It is known as the mother of machine tools, as it was the first machine tool that leads to the invention of other machine tools. In machining, boring is the process of achieving holes of required diameter with greater accuracy that has been already drilled. In boring operation, single point cutting boring bar is used as a tool. The major concern in the boring operation is the vibrations produced by metal cutting. Due to vibrations, factors like product cost, productivity are also affected. The tolerance and surface finish required are also affected due to vibration. To minimize vibrations, techniques like active type damping, passive type damping and semi-active type damping can be used. This paper focuses on passive type damping for vibration reduction in boring operation.

2. VIBRATION REDUCTION TECHNIQUES

Some of the methods used in reducing the unwanted vibrations are as follows:

2.1 Active Type Damping

The aim of active type vibration reduction technique is to minimize the vibration of boring bar by automatic alteration of the system's structural feedback. The rule of active type reduction of vibration in machining is to study in real time the signal transmitted during machining, observe fluctuation and take care of it. In this method tool is fixed with piezoelectric actuators and force sensors with inter changeable tool head. Active type damping systems need wires for energy supply and data transfer that can interfere with the manufacturing process.

2.2 Semi Active Type Damping

Semi active control systems are a subtype of active type damping systems for which the energy needed is in smaller amounts than those of common active type damping. A battery power, for example, is sufficient to make them work. Semi-active type damping cannot remove or add energy to the system, but it can control in real time parameters of the structure such as spring stiffness or coefficient of viscous damping. The balance is guaranteed, in the impression that no fluctuation can develop, due to semi-active type devices utilizing the motion of the structure to develop the control forces.

2.3 Passive Type Damping

The rule of passive type damping is to convert the mechanical energy into some other form of energy, for example heat. Most common way to obtain passive type damping is by using viscoelastic materials which deplete the energy that is caused vibration. The use of viscoelastic materials for vibration reduction purposes is quite common; this method is being used in other fields, such as structural, spacecraft, aeronautics, automotive etc.

3. VISCOELASTIC MATERIALS

Viscoelasticity is the property of materials that show both viscous properties and elastic properties when they go through deformation. A viscoelastic material combines these two properties—it returns to its original shape after being deformed, but it is done slowly to prevent the next round of vibration. Passive damping using viscoelastic materials is used widely in both commercial and aerospace applications. Viscoelastic materials have long chain molecules which make them to convert mechanical energy into heat when they are deformed. Perhaps the most important advantage of Viscoelastic materials is that they have high energy dissipation capacity.

Table -1: Viscoelastic Materials

Sr. No.	Viscoelastic materials
1	Butadiene Rubber (BR)
2	Chloroprene
3	Ethylene-Propylene-Diene
4	Fluorocarbon Rubber
5	Natural Rubber
6	Polyurethane (PU)
7	Polyvinyl Chloride (PVC)
8	Silicon Rubber
9	Teflon
10	Thermoplastics

4. EXPERIMENTAL PROCEDURE

To study the effects of vibration on the boring bar, many tests were performed on number of work pieces. For experimentation, the boring bar used is of 16 mm diameter and 180 mm of length. Boring bar is of WIDAX made. And the work pieces used for tests are of EN8 material. Dimensions of work piece are 30mm length and 30mm internal diameter. Lathe machine with three jaw chuck is used in procedure. Tests were performed on work pieces with different values of machining parameters. The machining parameters included spindle speed in RPM, feed in mm/rev, and depth of cut in mm. Some tests were performed without damper and some with damper. Damper used were of Polyurethane (PU), Polyvinyl Chloride (PVC) and Teflon materials. For measurement of surface roughness, the surface roughness tester was used. Surface roughness is in terms of micrometers (μm).

Fig -1: Damper setup on boring tool

5. FIGURES, TABLES AND CHARTS

Fig -2: Setup

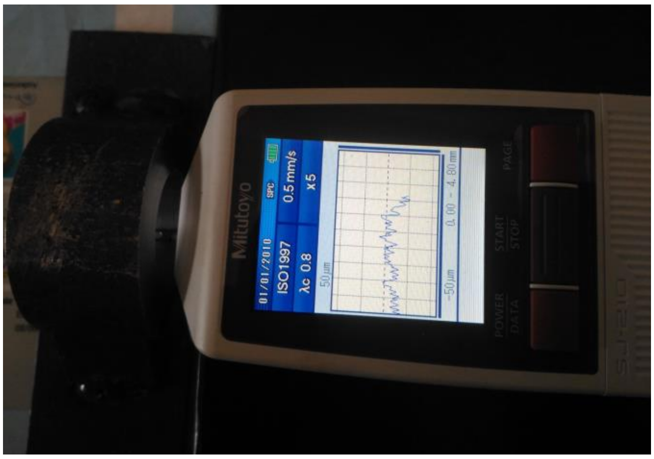

Fig -3: Surface Roughness Tester

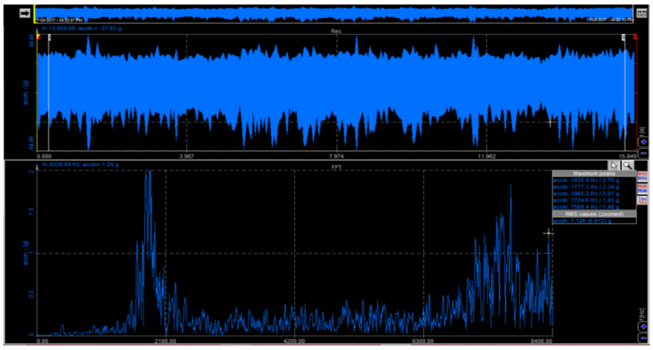

Fig -4: FFT Spectrum

Table -2: Specification of Surface Roughness Tester

Measuring Speed	0.25 mm/s
Sampling Length	0.08 mm
Display Languages	English, Czech, Dutch, French, etc
External I/O	USB I/F, digimatic output, printer output, etc
Calibration	Auto-Calibration
Power-Saving	Auto-sleep function
Power-supply	Two-way power supply: battery and AC adapter
Mass	Approx. 500g

Table -3: Conditions for experiment

Condition	Spindle Speed (rpm)	Feed (mm/rev)	Depth of cut (mm)
1	700	0.068	0.5
2	700	0.068	1
3	700	0.13	0.5
4	700	0.13	1
5	350	0.068	0.5
6	350	0.068	1
7	350	0.13	0.5
8	350	0.13	1

Table -4: Result Table for Surface Roughness

Case No.	No Damper (μm)	PU Damper (μm)	PVC damper (μm)	Teflon Damper (μm)	% Reduction with PU Damper	% Reduction with PVC Damper	% Reduction with Teflon Damper
1	1.413	1.105	1.36	0.938	21.80%	3.96%	33.62%
2	0.948	0.852	0.93	0.885	10.13%	2.22%	6.65%
3	2.522	1.81	2.46	2.313	28.23%	2.62%	8.29%
4	1.591	1.572	1.55	0.983	1.19%	2.83%	38.21%
5	4.583	2.358	3.17	3.688	48.55%	30.74%	19.53%
6	3.307	2.464	3.13	2.963	25.49%	5.23%	10.40%
7	3.843	3.17	3.25	3.264	17.51%	15.56%	15.07%
8	2.645	1.91	2.64	2.62	27.79%	0.26%	0.95%

Table -5: Result Table for Natural Frequency

Case No.	No Damper (Hz)	PU Damper (Hz)	PVC damper (Hz)	Teflon Damper (Hz)	% Reduction with PU Damper	% Reduction with PVC Damper	% Reduction with Teflon Damper
1	1835.9	1823.5	1660.2	1582	0.68%	9.57%	13.83%
2	1777.1	1699.2	1621.1	1611.3	4.38%	8.78%	9.33%
3	1787.1	1552.7	1621.1	1552.7	13.12%	9.29%	13.12%
4	1796.9	1562.5	1630.9	1552.7	13.04%	9.24%	13.59%
5	1835.9	1650.4	1669.9	1660.2	10.10%	9.04%	9.57%
6	1816.4	1660.2	1621.1	1650.4	8.60%	10.75%	9.14%
7	1787.1	1660.2	1669.9	1618.3	7.10%	6.56%	9.45%
8	1796.9	1750	1601.6	1543	2.61%	10.87%	14.13%

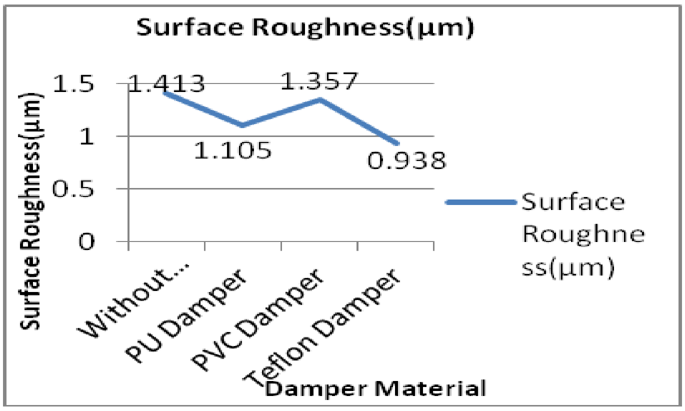

Chart -1: Surface Roughness vs Damer material

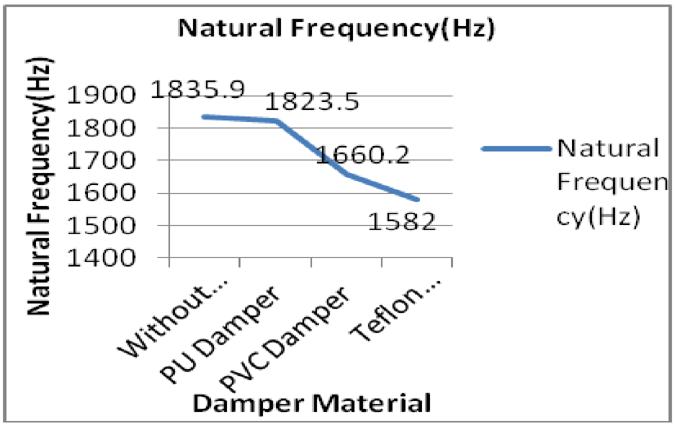

Chart -2: Natural Frequency vs Damper Material

6. CONCLUSION

To reduce the vibration of boring bar in boring operation, an innovational method is suggested. It is proved that passive type vibration damping method is quite impressive. The surface roughness value decreases up to 33% due to installation of Teflon damper on boring tool. The surface roughness value decrease up to 28% due to installation of PU damper on boring tool. There is not much decrease in surface roughness value due to installation of PVC damper on boring tool. The natural frequency value decrease up to 14% due to installation of Teflon damper on boring bar. The natural frequency value decrease up to 13% due to installation of Teflon damper on boring bar. There is not much decrease in natural frequency value due to installation of PVC damper on boring tool. Measured surface roughness values and natural frequency values are compared with PU, PVC and Teflon viscoelastic material dampers, Teflon gives better results. Hence it is concluded that Teflon material gives good results as a vibration damper.

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