Development of vibration control for chatter suppression in Application of boring bar

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Abstract - *Boring, also called as internal turning operation is the operation of enlarging the previously drilled hole. But, as the overhang increases this results deflection of boring bar which results in the vibration between a tool and a work piece. Vibration degrade the work piece surface quality as well as shorten the tool life. In this dissertation work passive damper (i.e .Nylon and PTFE) is used to suppress vibrations of boring bar and to improve the surface finish of the work piece as well as to increase useful life of the boring tool or boring bar. The experiments for boring operation are carried out on lathe by using boring tool with and without passive damper. The analysis is carried out using FFT analyzer. The machining parameters like spindle speed, feed and depth of cut are varied accordingly. The results i.e RMS value and surface roughness value Ra value are compared by using boring bar with and without damper. To determine natural frequencies and mode shape Modal analysis is also carried out.*

***Key Words*: Boring bar, passive damper, static stiffness, Vibration, Deflection, RMS Value, Modal analysis, FFT Analyzer, PTFE, Nylon, Surface Roughness**

1.INTRODUCTION

Boring operation uses cantilevered (i.e overhang) tooling which is less rigid than the tooling used for external turning. While machining deep hole it become necessary to use a tool with large length to diameter ratio. As this overhang increases this results deflection of boring bar which results in the vibration between a tool and a work piece. Vibration degrade the work piece surface quality as well as shorten the tool life. There are several ways that can be established by the different methods such as Active damping system, passive damping system or semi active damping system for the stability of that boring bar. By using this damping system the vibration from boring bar minimizes or reduces.

The objective of the vibration attenuation is to improve the dynamic stiffness of the machine tool structure, to increase the rate of material removal and thereby prolonging the life of the tool tip. Hence, it is important to limit vibrations of the machine tool structure as their presence results in poor surface finish, cutting edge damage, and irritating noise.

2. METHODOLOGY

2.1 Passive damper:-.

The boring bar is held in the tool post at one end and the remaining part is called as Overhang. Some length of the boring bar from carbide insert tip is known as cutting zone which cannot be damped. Thus, the remaining length in between the cutting zone length and that held in tool post needs to be damped. The cross-section of the passive vibration damper is thus of 20.2 mm inner diameter and 25.0 mm outer diameter. The length of passive vibration damper is divided into two parts of the overhang. i.e. 30% and 60% of the overhang. In this experiment, the overhang is divided into two parts viz. 120mm and 160mm of the boring bar. Hence, 30% and 60% of 120 mm means two dampers of 36mm and 72mm are developed. Also, 30% and 60% of 160mm means two dampers of 48mm and 96mm are developed. Thus, there are four possible lengths of a passive vibration damper for one material.In our experiment, we have selected two materials for the development of passive vibration damper. They are:

1. Nylon
2. PTFE (Teflon)

Nylon and Teflon are manmade synthetic polymers that are most widely used in the polymer industry. Nylon is a polyamide and Teflon is a fluoro polymer. Both of them possess a high molecular weight and they are thermoplastics. Teflon is chemically less reactive material with a high electric conductivity, and a very low coefficient of friction. Nylon is a silky material and it is an alternative for both metals and non-metals, including brass, bronze, wood, plastics, and rubber.

Various grades of steels are in all types of industries by considering their wide range of applications, carbon steel work pieces made from AISI 1062 were used during experimentation. The cutting trials were conducted on pre-machined commonly found sizes cylinders of outside diameter 113 mm, inside diameter 93 mm and length approximately of 59 mm. Twenty four such work-pieces were kept pre-machined and used during the various trials shows some of these samples and Table gives the chemical of AISI 1062steel.

Before machining.   After machining

Fig-1. Work pieces Before And After machining

Fig- 2. Drafting Image of AISI1062 Carbon Steel After Machining

Table- 1   Chemical Composition Of AISI 1062 Carbon Steel

C	Si	Mn	S	P
0.55 – 0.65	0.5	0.7≤1	0.05	0.04

2.2 Boring bar :-

The boring bar used in these experiments is Sandvik A20S-SCLCR 09 with through coolant .This boring bar when held in the tool post acts as a cantilever beam during the boring operation.

2.3 Experimental Procedure:-

In this Project work a passive damper is used to investigate the performance of boring tool under vibratory conditions. The experiments for boring operation are carried out using boring tool with and without passive damper. The frequency domain analysis is carried out using FFT analyzer. The machining parameters are varied by changing spindle speed, feed rate and depth of cut.

The boring operations were carried out on a lathe machine. The work piece was mounted in a chuck. The
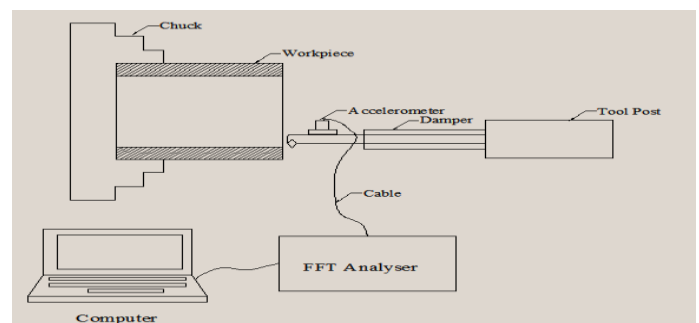

Fig- 3:- Experimental setup

machining parameters like feed ,speed, depth of cut etc. were selected based on the manufacturers recommendations and were changed according to the proposed conditions. Passive damper (i.e Nylon and PTFE) is introduced in between the tool insert and tool holder . The length of passive damper on boring bar and overhang length was changed. The Fast Fourier Transform (FFT) analyzer and accelerometer were used to obtain the readings. To measure the boring bar vibrations generated at the point of cutting, the accelerometers should be mounted in maximum possible close vicinity of the tool-work interface point. The deflections were measured in terms of acceleration by accelerometer. The results in the form of vibration acceleration (i.e.RMS value) and surface roughness (i.e.Ra value) are compared for conventional boring tool and boring tool fitted with passive damper and without damper

1. The Fast Fourier Transform(FFT) analyser is connected to the computer and accelerometer.
2. The passive vibration damper is inserted onto the boring bar according to the overhang.
3. This boring bar is then fitted in the tool post according to the overhang.
4. The accelerometer is the placed as near possible to the cutting zone so as to obtain the maximum accurate readings.
5. The workpiece is held in the chuck and made to rotate according to the speed (low and high) .
6. The carbide insert is then made to touch the inner surface of the workpiece. The initial jerk is neglected and readings for the remaining operation are recorded by the software with the help of accelerometer

2.4 Testing condition

Table- 2   Testing Parameters

Sr. No.	Parameter		Level	
			1	2
1	Spindle Speed - N (rpm)	A	140	200
2	Feed Rate - f (mm/rev)	B	0.04	0.08
3	Depth of Cut – t (mm)	C	0.5	1.5
4	Boring Bar Overhang – L (mm)	D	120	160
5	Damper Length - l (mm)	E	0.3 L	0.6 L

Table -3   Test Matrix

Run No.	Factors				
	A	B	C	D	E
1	1	1	1	1	1
2	2	2	1	1	1
3	1	1	1	2	2
4	2	2	1	2	2
5	1	2	2	2	1
6	2	1	2	2	1
7	1	2	2	1	2
8	2	1	2	1	2

2.5 Results

Table -4   RMS Value Of Acceleration

Run No.	Overall levels RMS value (m/sec^2)		
	Nylon Damper	PTFE Damper	Without damper
1	171	54.5	377.8
2	80.6	81.3	382.2
3	169.8	179.4	411.5
4	150.3	170.3	477.8
5	187.7	215.6	411.5
6	388.3	267.8	577
7	166	129.5	436.5
8	161.5	205.8	232.5

Table -5   Ra Value Of Surface Roughness

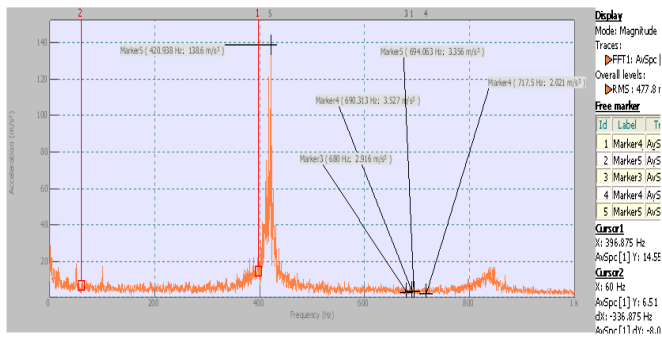| Run No.	Surface Roughness Ra (µm)		
	Nylon Damper	PTFE Damper	Without damper
1	3.78	3.17	5.83
2	3.12	3.34	6.23
3	3.68	3.82	6.78
4	3.16	3.92	6.94
5	3.77	3.98	6.62
6	4.27	4.05	7.16
7	3.46	3.27	6.81
8	4.13	4.59	5.97

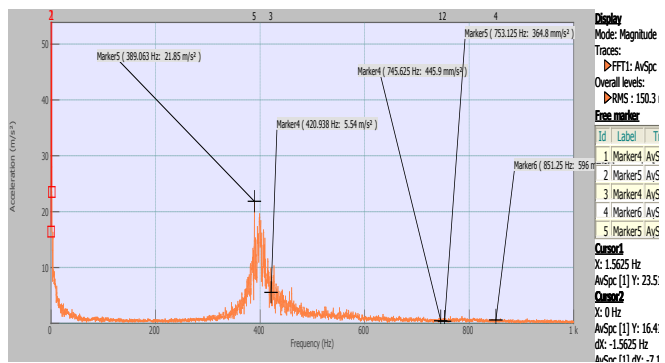**Chart -1**   Run No. 4 Without Damper

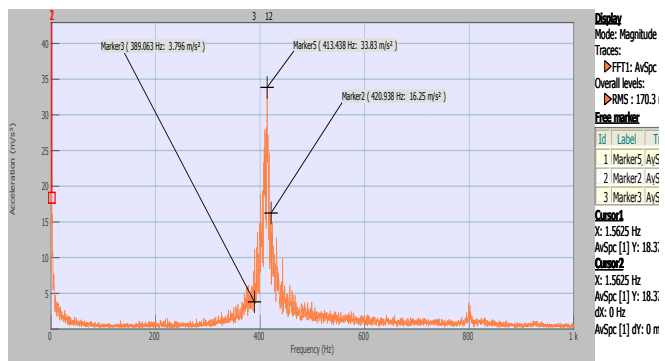**Chart -2**   Run No. 4 With Nylon damper

Chart -3   Run No. 4 With PTFE damper
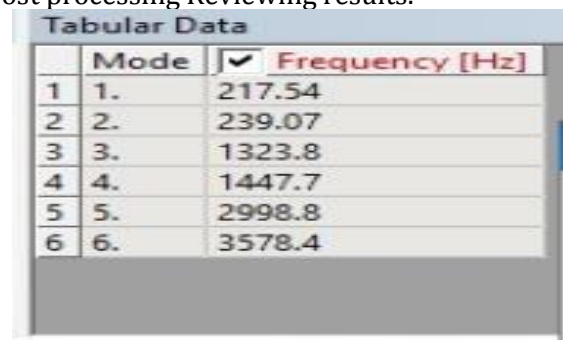
3.MODAL ANALYSIS

It is used to determine the natural frequencies and mode shapes of the structure. The natural frequencies and mode shapes are important in the design of a structure for dynamic loading conditions. A modal analysis is a technique used to determine the vibration characteristics of structures:

1) Natural frequencies– at what frequencies the structure would tend to naturally vibrate.

2)Mode shapes–In what shape the structure would tend to vibrate at each frequency.
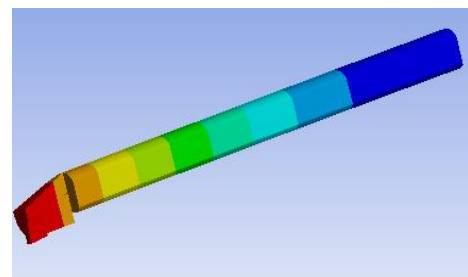
Modal analysis is performed on Ansys software

3.1 Steps in modal analysis:-

1. Creating 3D Geometry: 3D geometry is created by using CAD software.

2. Element selection: According to the size and shape of the geometry 3D element is selected.

3. Material properties: Given material properties are applied to the geometry.

4. Meshing: Meshing of the geometry as per required quality criteria.

5. Boundary conditions:-Boundary conditions are applied as per given in the design inputs.

6. solving equations
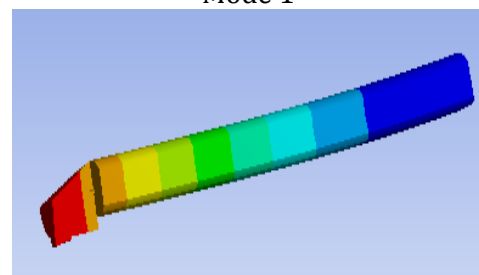
7. Post processing Reviewing results.

	Mode	✔ Frequency [Hz]
1	1.	217.54
2	2.	239.07
3	3.	1323.8
4	4.	1447.7
5	5.	2998.8
6	6.	3578.4

Tabular Data

Fig -4 : Natural Frequencies

Mode 1

Mode 2

Mode 3
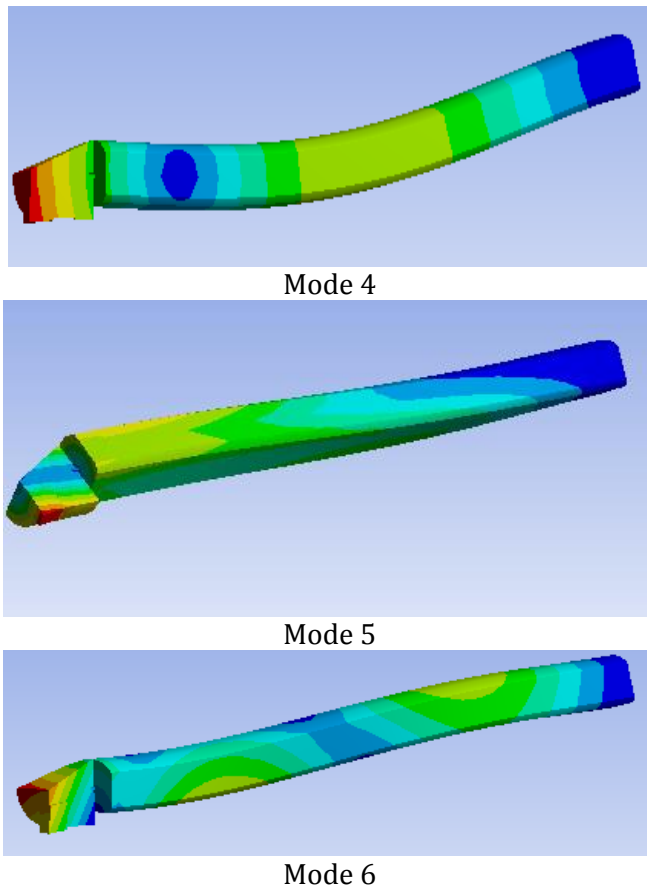
Mode 4

Mode 5

Mode 6
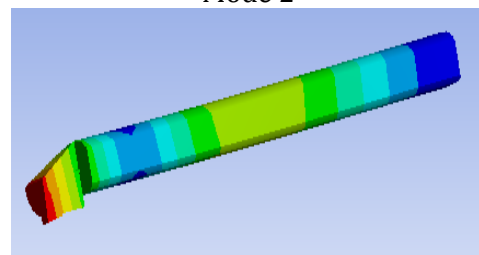
Fig -5 : Mode shapes

4. CONCLUSIONS

1) From the experimental analysis it is clear that by using passive damper vibration of boring bar is reduced which result in good surface finish.

2) From modal analysis it is clear that at a higher natural frequencies above 1500 Hz boring bar will undergo bending and twisting.

5.FUTURE SCOPE

FEA Analysis of passive damper can be carried out to see the stress distribution and also one can use different materials as passive damper to check the effectiveness of passive damping.

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