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Vibration mitigation using passive damper in machining

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ABSTRACT: *This paper introduces a vibration mitigation for boring bar with enhanced damping capability. The principle followed in this paper was to enhance the damping capability, minimizing the loss in static stiffness through implementation of passive damper. The newly designed tool has been compared to a conventional tool. The evaluation criteria were the dynamic characteristics, frequency and damping ratio, of the machining system, as well as the surface roughness of the machined work pieces.*

Keywords: *boring bar, passive damper, static stiffness, surface roughness, vibration mitigation*

I. INTRODUCTION

Vibrations are undesirable for structures, due to the need for structural stability, position control, durability (particularly durability against fatigue), performance, and noise reduction. Vibrations are of concern to large structures such as aircraft, as well as small structures such as electronics.

Vibration reduction can be attained by increasing the damping capacity and/or increasing the stiffness (which is expressed by the storage modulus). The loss modulus is the product of these two quantities and thus can be considered a figure of merit for the vibration reduction ability.

Damping of a structure can be attained by passive or active methods. Passive methods make use of the inherent ability of certain materials (whether structural or non-structural materials) to absorb the vibration energy (for example, through mechanical deformation), thereby providing passive energy dissipation. Active methods make use of sensors and actuators to attain vibration sensing and activation to suppress the vibration in real time.

The attenuation of machine tool vibration is a field of research that has been the concern of many engineers over the past few decades. The driving force behind the ongoing research can be related to the fact that the level of vibration at the tool tip, limits the tool life as well as tolerances and the surface finish obtained by the machining process. Traditionally, the rate of material removal is reduced to obtain the required tolerances and surface finish The reduction in rate of material removal reduces the efficiency of the machine, since the component manufacturing time is increased and lower production is obtained from the machine over a period of time 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

Acoustic noise emission during the machining process results from the relative motion between the tool tip and work piece. High levels of acoustic noise can cause discomfort in the working environment. The problem is related to the dynamic stiffness of the machine tool structure. By improving the dynamic stiffness of the structure, the level of noise emission from the machining process can be reduced.

II. EFFECTS OF VIBRATION ON MACHINING

Tool or work-piece vibration in machining processes is the main limiting factor for metal removal rate and machining efficiency. In boring process due to the slenderness of boring bar, its flexibility is much more than the work-piece.

Accordingly, the tool is more susceptible to vibrations. On the other hand, boring is a process that is used in finishing of precise components.

Tool vibrations result in poor surface finish, reduced tool life, dimensional errors and may also introduce chatter, which is highly unfavorable. Therefore, the machining parameters should be set in a way to avoid any kind of unstable vibration during the machining process.

Tool vibrations- The machine, cutting tool and work-piece form a structural system with complex dynamic characteristics .Under certain conditions this system may undergo excessive vibrations

Types of vibrations- In machine tool structures can be generally categorized into three main groups: Free or transient vibrations: Free vibrations in machine tools occur almost in every machining operation. The vibrations due to the initial engagement of the tool and work-piece or the vibrations caused by the rapid reciprocal motion of the machine tool table are some sorts of transient vibrations. The machine tool vibrates in its natural modes until the vibration is damped.

Forced vibration: Forced vibrations occur when a periodic force is applied to the machine tool structure. The engagement of multi- insert tools in the cut and the run-out of the tooltip are the two main sources of forced vibrations. Also, there exist other sources like the vibrations transmitted to the machine tool by its foundation from the nearby machinery .The system vibrates in the actuating frequency and if this frequency coincides one of the system's natural frequencies the resonance occurs.

Self-excited vibration: The most important type of vibration n machining processes is self-excited vibration. When the tool initially engages the cut, it undergoes transient vibrations .If machining parameters like depth of cut, federate and cutting speed are not set properly, transient vibration may lead to self excited or chatter operations.

III. TOOLS AND TECHNIQUES FOR VIBRATION MITIGATION

3.1 Active vibration control

There is different method for the introduction of secondary vibration in boring bars. Here the actuator is mounted in a milled space in a longitudinal direction below the centerline of the boring bar. When the actuator applies a load on the boring bar in its longitudinal direction due to the expansion of the actuator, the boring bar

Will bend and stretch. By introducing secondary anti-vibrations via the actuator applied bending moment on the boring bar, the original vibrations from the cutting process can be reduced

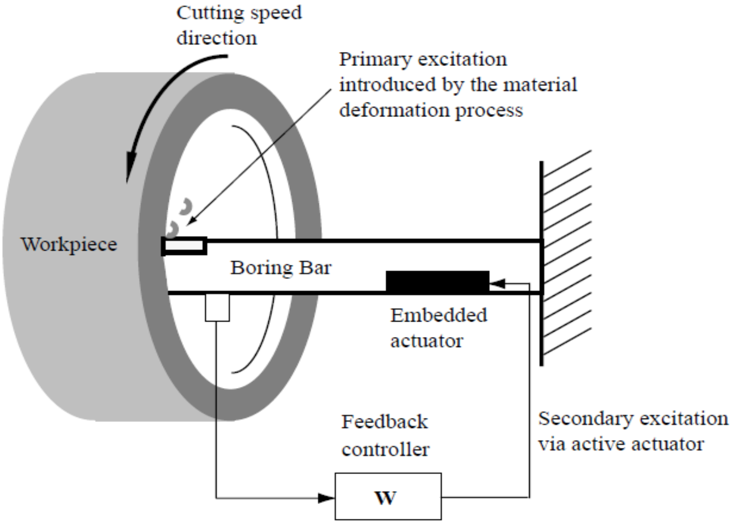

Fig 3.1Active Boring bar control system

3.2 Passive vibration control

Particle damping is a passive damping concept to use metal or ceramic particles or powders of small size that are placed inside cavities within or attached to the vibrating structures shown in fig . Metal particles of high density such as lead or tungsten steel are the most common materials for better damping performance. In contrast to viscoelastic materials which dissipate the stored elastic energy particle damping treatment focuses on energy dissipation in a combination of collision, friction and shear damping. It involves the potential of energy absorption and dissipation through Momentum exchange between moving particles and vibrating walls, friction, impact restitution, and shear deformations. It is an attractive alternative in passive damping due to its conceptual simplicity, potential effectiveness over broad frequency range, temperature and degradation

Insensitivity and very low cost

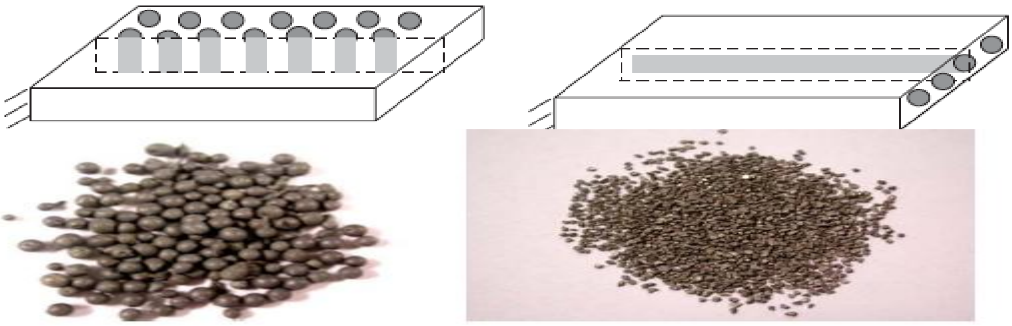

Fig 3.2 Particle Damping

IV. EXPERIMENTAL PROCEDURE

Number of experiments was conducted to analyze the effect of vibration on surface finish. Boring bar of 20 mm × 20 mm cross-section and 200 mm long of WIDAX make is used. The work piece material used for study is EN9. The boring operations were carried out on CNC turning centre

The work piece was mounted using a pneumatic chuck in CNC turning centre. The machining parameters like feed (feed rate s-0.9mm/min), depth of cut (t=0.6 mm), clamping pressure (10 bar), etc. were selected based on the manufacturers recommendations and were kept constant for all the samples used. Only the cutting speed, passive damper position on boring bar and overhang length was changed. The recommended parameters are shown in table 4.1. Boring was carried out for 110 mm internal diameter


Fig 4.1 boring bar


Fig 4.2 installation of boring bar


Fig 4. Sample work piece

Table 4.1

Boring Tool	BT1	BT2	
Overhang length L (mm)	30	60	90
Position of passive damper	Vertical	Horizontal	
Cutting speed (rpm)	70	140	210


Fig 4.4 CNC Turning Centre

RESULT

Speed-210 rpm, Depth of cut-0.6 mm, Feed-0.09 mm/min

Sr. No	Overhang length of Boring bar (mm)	Surface finish (µm) without passive damper	Surface finish (µm) With passive damper	
			Vertical	Horizontal
1	30	2.63	2.41	2.63
2	60	2.59	2.51	1.46
3	90	2.80	3.19	3.25

V. CONCLUSION

An innovative method is proposed to reduce tool chatter and enhance surface finish in boring operation. The results prove the passive damping technique has vast potential in the reduction of tool chatter. Passive dampers are also relatively cheaper than other damped boring bars. It is therefore concluded that passive damping has a good effect in improving surface finish in boring operation

Significant improvement is observed between the results of surface finish obtained using boring bar without passive damper and boring bar with passive damper.

REFERENCES

Journal Papers:

[1] Lorenzo Daghini, Andreas Archenti, and Cornel Mihai Nicolescu "Design, Implementation and Analysis of Composite Material Dampers for Turning Operations" World Academy of Science, Engineering and Technology vol 53(2009).

[2] B. Moetakef-Imani, N.Z.Yussefian "Dynamic simulation of boring process" International Journal of Machine Tools & Manufacture vol 49 (2009) pp 1096–1103

[3] L. Andr´en and L. H°akansson Active "Vibration Control of Boring Bar" Vibrations Department of Signal Processing School of Engineering Blekinge Institute of Technology August, 2004

[4] Zhiwei Xua, Michael Yu Wangb, Tianning Chen "Particle damping for passive vibration suppression: numerical modeling and experimental investigation" Journal of Sound and Vibration vol 279 (2005) pp 1097–1120

[5] Lonnie Houck, Tony L. Schmitz, K. Scott Smith “A tuned holder for increased boring bar dynamic stiffness” Journal of Manufacturing Processes Vol.13 (2011) pp 24–29

[6] Dai Gil Lee, Hui Yun Hwang, Jin Kook Kim “Design and manufacture of a carbon fiber epoxy rotating boring bar” Composite Structures Vol 60 (2003) pp 115–124

[7] Norikazu Suzukia, Kohei Nishimurab, Ryo Watanabea, Takashi Katoa and Eiji Shamotoa “Development of novel anisotropic boring tool for chatter suppression” vol 1 (2012) pp 56 – 595th CIRP Conference on High Performance Cutting 2012

[8] M. H. Migue, L.Rubio, J.A.Loya, J.Fernandez-Saez “Improvement of chatter stability in boring operations with passive vibration absorbers” International Journal of Mechanical Sciences vol 52 (2010) pp 1376–1384.