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COMPARISON BETWEEN A CONVENTIONAL AND AN ANTIVIBRATING BORING BAR IN THE INTERNAL TURNING OF LONG OVERHANGS

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Abstract: The main objective of this work is to evaluate the use of an antivibrating in an internal turning tool in the machining of hardened steel, comparing it with a conventional solid bar, in order to verify if it is able to cut deep holes without damaging workpiece surface quality and tool life.

Keywords: *impact damper, hardened steel, surface quality, tool life*

1. Review of Literature

Internal turning of deep holes is a critical operation due to the fact that it demands the use of tools with long overhangs (distance between the tool tip and the tool fixation in the machine turret), what usually leads to tool vibration and, consequently, to high values of workpiece surface roughness [1].

Some passive dampers are:

- Damper Vibration Absorber (DVA) – consists of an additional mass-spring system connected to the bar, which needs to be set up in order to be tuned with the natural frequency of the structure [4]. According to the literature, this kind of damper works efficiently up to a tool bar L/D ratio of 15 [1].
- Tool bar with viscous elastic material – they are easy to apply in any kind of structure [3]. An example of this tool bar is the one called Silent Tool by the manufacturer. It consists of an interchangeable head and a body made of a heavy metal, supported by elements of rubber and oil [4].
- Friction Damper – it consists of several disks placed inside a cavity of the tool bar. Each disk rubs to other disk and also to the cavity wall in such way to dissipate vibration energy [5].
- Impact damper – the most usual of these dampers is the “particle impact damper”, which consists of hundreds of small particles (metallic, ceramic of little sizes) placed inside either the tool bar cavity or the workpiece wall using a reservoir stuck to it. These particles impact against the tool bar cavity while it vibrates and dissipate vibration energy [6]. A scheme of this kind of damper for internal turning tool bar is shown in *Figure 1* [7]. The behaviour of this

kind of damper is non-linear, what implies in some difficulties to control damping parameters like static stiffness (the bar loses some rigidity due to the cavity made in it), the restitution coefficient between the bar and the particles and the gap between the particles and the cavity wall [8]. On the other hand, it can provide high levels of damping along a large range of frequencies [9].

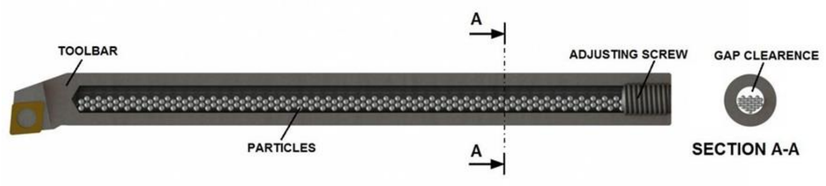

Figure 1
Scheme of a particle impact damping used in an internal turning tool [3]

2. Materials and Methods

All the internal turning experiments of this work were performed using a CNC lathe with 20 CV of power in the main motor and maximum spindle rotation of 4.500 rpm. Two types of internal turning tool holders (also called tool bars) were used in this work. The first was the one cited in the previous paragraph, which we call "solid bar". The second kind of bar was also the same kind of tool holder, but with its axial hole filled with spheres, which we called "impact damped (ID) bar". Three different diameters of spheres were used inside the ID bar – 5, 6.5 and 8 mm. Tool vibration was measured using a piezoelectric accelerometer stuck close to the tool tip placed in such a way to measure vibration in the radial direction related to the workpiece.

3. Results

The first part of the experiments had the purpose of evaluating the influence of the type of tool bar (solid and impact damped bar) in the maximum tool overhang possible. This evaluation was performed through the measurement of workpiece surface roughness and tool vibration in the internal turning of hardened steel.

Figure 2 shows the values of surface roughness for different tool overhangs and type of bars. The first thing to be pointed out in this figure is that for all type of bars, surface roughness remained almost constant as tool overhang increased up to an overhang value where a sudden increase of roughness occurred. The values of roughness above this point are too high to be used for turning of hardened steel (operation which intends to replace grinding). This sudden increase of roughness occurred with just few millimetres of increase (1 or 2 mm) in the tool overhang. This result indicates that the tool bar is very sensitive to small variations of rigidity when the tool overhang is in a value close to the limit. Therefore, this tool overhang value was considered the limit value for stable cutting and will be used to compare the performance of the different bars.

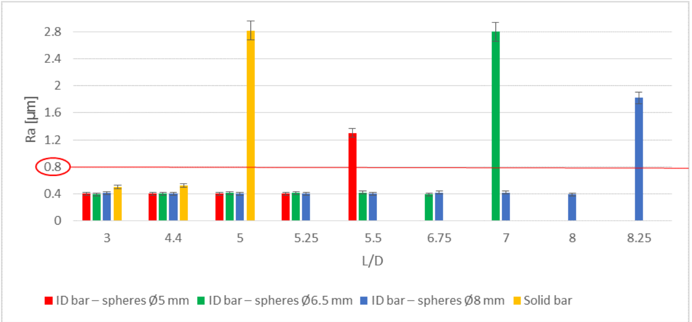

Figure 2

Roughness (Ra) obtained with all types of bars tested

To better understand the tool vibration effect on surface roughness, *Figure 3* was built. It shows the RMS of the tool acceleration signal (signal obtained by the accelerometer stuck on the tool) against the length to diameter (L/D) ratio for all types of bars used in the experiments. The main points to be highlighted based on the results shown in this figure are:

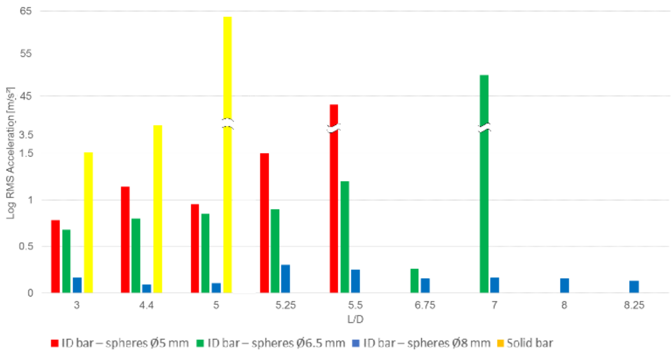

Figure 3

Tool vibration (RMS of the acceleration signals) for all types of bar tested

- Tool vibration remained almost constant with the increase of the tool overhang up to the point it suddenly increased in a certain value of tool overhang (called limit value for stable cutting). Small changes in the tool overhang close to the limit region generated this sudden variation, indicating that the tool bar is very sensitive to the rigidity change in this range of overhang;
- The use of internal turning tool bars with impact damper caused an increase of the limit value for stable cutting and, consequently, made possible the turning of deep holes;
- As the diameter of the spheres increased, the limit value for stable cutting also increased, indicating that the damping effect is higher when the mass of the spheres is higher and the gap between the spheres and the cavity wall is lower,

which cause, the increase of the impact momentum transfer. It is important to remember that the increase of the sphere diameter from 5 to 8 mm (respectively the smallest and the highest diameter used in this work) caused an increase of more than four times in the sphere mass.

4. Conclusion

Based on the results obtained in this work, it can be concluded for internal turning operations of hardened steels, in conditions similar to those used here, that:

– As tool overhang increases, the workpiece surface roughness and tool vibration keep almost constant up to the point where they increase suddenly (limit of stability). This point occurs, for impact damped tool bar with a tool overhang much longer than for solid bar;
– Tool vibration obtained with the impact damped bar is much smaller than the vibration obtained with solid bar even when the cut is stable. Even with this difference, surface roughness obtained with both kind of bars are similar, proving that, up to a certain level of tool vibration, it does not influence surface roughness;
– The use of the tool impact damper with spheres like the one tested in this work makes feasible the machining of longer holes than when a solid bar is used, without damaging surface roughness and tool life, due to its damping capacity;
– For the range of damper sphere diameter tested here, as this diameter increases, the performance of the tool damper improves and, consequently, even longer holes can be machined.

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References

[1] Suyama, D. I., Diniz, A. E., Pederiva, R. (2016). The use of carbide and particle-damped bars to increase tool overhang in the internal turning of hardened steel. *Intern. J. of Advan. Manuf. Tech.*, (86), pp. 2083–2092., https://doi.org/10.1007/ s00170-015-8328-z.

[2] Schneider, G.: Cutting tool applications chapter 10: boring operations and machines. *American Machinist. Modern Machine Shop*, http://www.opensource-machinetools.org/archive-manuals/Cutting-Tool-Applications.pdf; (accessed: 12. 02. 2020).

[3] Smith, G. T. (2008). Cutting *Tool Technology: Industrial handbook*. Southampton, Springer-Verlag.

[4] Dimarogonas, A. (1996). *Vibration for Engineers*. 2nd ed., New Jersey, Prentice Hall.

[5] Liu, X., Liu, Q., Wu, S., Liu, L., Gao, H. (2017). Research on the performance of damping boring bar with a variable stiffness dynamic vibration absorber. *Inter. J. of Adv. Manuf. Tech.*, (89), pp. 2893–2906.

[6] Bavastri C. A. (1997). *Redução de Vibrações de Banda Larga em Estruturas Complexas por Neutralizadores Viscoelásticos (Wide band vibration reduction in complex structures by viscouselastic neutralizers).* PhD thesis, UFSC, Florianópolis Santa Catarina, Brazil.

[7] Sandvik. Silent tool for turning: overcome vibrations in internal turning, http:// www.sandvik.coromant.com/en-us/products/silent_tools_turning (accessed: 15. 02. 2020).

[8] Hahn, R. S. (1951). Design of Lanchester damper for elimination of metal-cutting chatter, *Trans ASME*, 73, 3, pp. 331–335.

[9] Biju, C. V., Shunmugam, M. S. (2014). Investigation into effect of particle impact damping (PID) on surface topography in boring operation. *Int. J. of Adv. Manuf. Tech.*, (75), pp. 1219–1231.