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INFLUENCES OF SHIM MATERIALS ON THE SURFACE QUALITY DURING THE HARD TURNING

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ABSTRACT

In this investigation, an attempt is made to show the influence of shim materials on the surface quality during hard turning of bearing steel. Using shims made of natural and composite materials to enhance the damping properties of the ceramic inserts holding systems, surface roughness is being evaluated.

KEYWORDS: Surface Roughness, Machining, Shim Materials

INTRODUCTION

Hard turning, which is the dominant machining operation performed on hardened materials, is defined as the process of single-point cutting of part pieces that have hardness values over 45 HRC but which are typically in the 58-68 HRC range.

The world-leading manufacturer of cutting tools, Sandvik Coromant, defines hard materials as those with hardness of above 42 HRC and up to 65 HRC [1]. Hard machining is found to be very efficient in many branches of industry, including the automotive, aerospace, bearing, hydraulic and die/moulds sectors.

The finishing operations on machine parts in a highly tempered or hardened state with hardness value in excess of 60 HRC are grinding processes, but recently hard cutting operations using tools with geometrically defined cutting edges have become increasingly capable of replacing them and guaranteeing comparable surface finish.

However, grinding and turning are machining operations so opposite in nature that their full substitution is not always easy or possible. Some inherent differences between these machining processes are as follows [2]:

- Hard turning is a much faster operation because it can be done in one setup and pass under dry conditions.
- Lathes offer more production flexibility.
- Rough and finish operations can be performed with one clamping using a CNC lathe
- Multiple turning operations are easier to automate through tool changes on turning centre or turning cell.
- Since hard turning is done dry, there are no costs for coolant, its maintenance or disposal.

In particular, the hard cutting process performed with ceramic or CBN tools can often cut manufacturing costs, decrease production time (lead time), improve overall product quality, offer greater flexibility and allow dry machining by eliminating coolants (Figure 1).

There are many opportunities for substituting grinding by turning operations when finish-machining of hardened ferrous materials. In general, hard turning reduces both equipment cost and personal expenses because it can be performed in one pass using one setup.

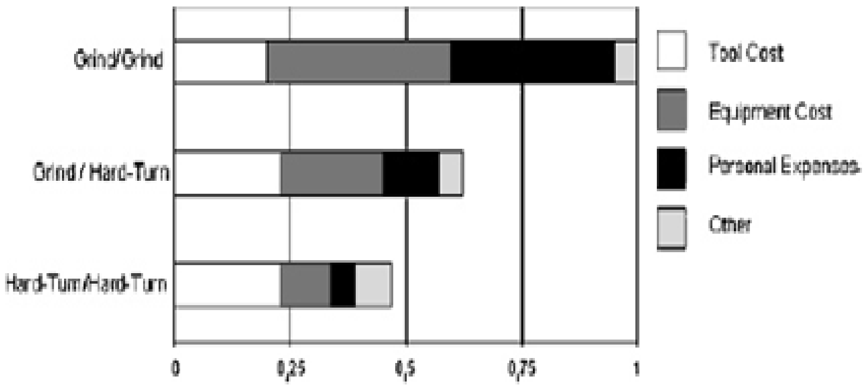

Figure 1: Cost Comparison of Turning versus Grinding [3]

Hard turning is implemented with high cutting speeds that cause high frequency vibrations, which requires a higher standard of the inserts fixing systems. High frequency vibrations affect the quality of machining surface within the fixing system of cutting insets (Figure 2) consisting of shim, insert, clamping, and the differential screw.

In the machining processes chatter is a common problem affecting the result of the machining process and become a common limitation to productivity. Chatter vibrations can imprint a poor surface finish on the workpiece and can damage the cutting tool and the machine. Also, severe acoustic noise in the working environment frequently occurs as a result of dynamic motion between the cutting tool and the workpiece. For these reasons, chatter avoidance is a topic of enormous interest [3-10]. Recent investigations have pointed out the use of natural and composite materials as shim material that can enhance the damping capability [11].

Figure 2: Fixing System for Screw Clamping Tool

Experiment

An important component is the shim on which the insert rests in the tip seat. The shim protects the insert holder against chip wear under the insert. The shim also ensures that deformation does not occur in the tip seat and provides protection when there is insert breakage. It also provides protection against indentations caused by double-sided insert geometry. It is technically better to use shims made from materials which have high damping properties like natural stones (granite, greenstone, quartzite, sandstone), composite material such as sintegran (synthetic granite) or mixed from them. The aim of this study is analyzing the possibilities for enhancing the quality of machined surface produced by hard turning by implementing damping characteristics for shim materials.

In order to investigate, a set of experiments is done to measure the acoustic effect of vibrations and the surface roughness of the machined work piece using various shims materials as shown in Table 1. The hard turning is performed on the lathe 16K20VF1 using rough cutting consisting of tool body, shim, insert screw and ceramic insert (VOK60); the work piece material is bearing steels with diameter 135 mm and hardness 55 HRC. In order to measure the quantitative characteristics within the cutting zone, the following instrument has been used: vibration sensor DH-4-M1 and data equitation card. During the experiment, the measurement period is 6 seconds and the frequency is 20 KHZ, the cutting feed S=0.06 mm/rev. depth of cut t = 0.15 mm and the cutting inserts and shim are replaced after each stage.

Table1: Various Shim Materials

No	Material Types	Chemical Composition
1	Standard (VK15 alloy)	Carbide, tungsten 85% , Cobalt 15%
2	Sintegran	Grains of a granite - 67% Small grains of gabbro-diabase - 10% volume, a polymeric bonding material 23% volume.
3	Natural granite	Natural stones
4	The chlorite	Natural stones
5	Sandstones	Natural stones

EXPERIMENTAL RESULTS

The result of acoustic vibration measurement significantly depends on the shim type. Figure 3 shows the acoustic spectrums of various types of shim. According to these specters, we can observe differentiations of frequencies. Table 2 shows the results of measurement interpretation for various ranges of frequencies. Root mean square values are taken to evaluate the general amplitude of the measured stage. The experiment shows that the sandstones shim has the lowest value of the acoustic signal for all frequencies.

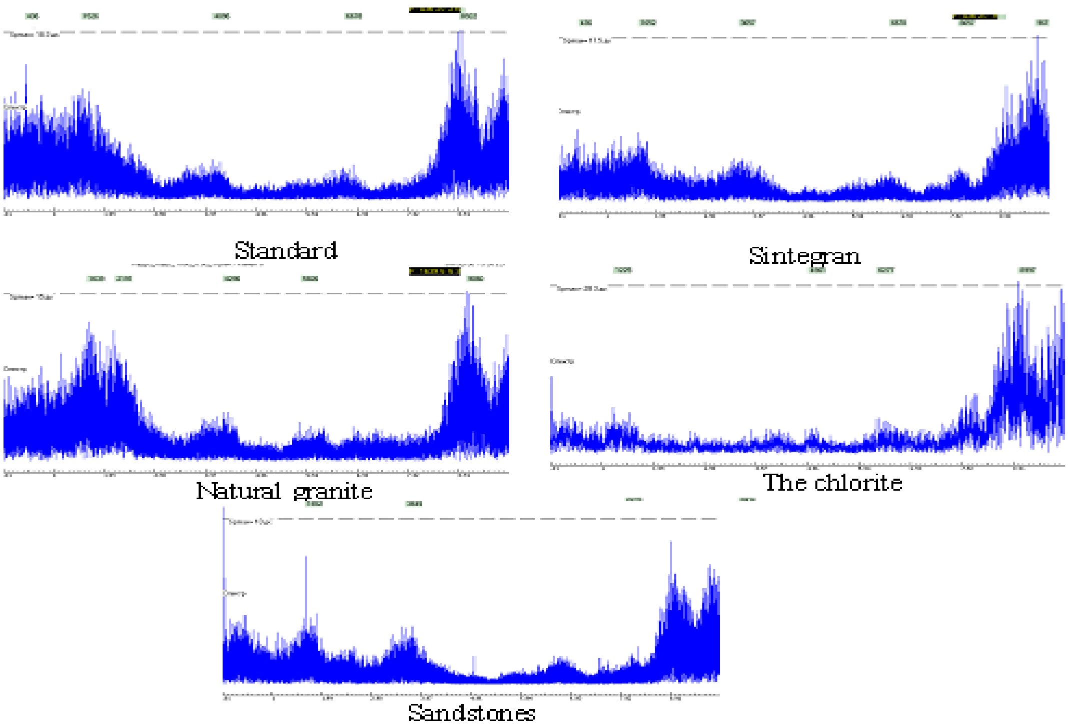

Figure 3: The Acoustic Spectrums of Various Types of Shims

Table 2: Measurement Interpretation for Various Ranges of Frequencies

Shim Materials	Range of Frequencies						
	All Range of Frequencies, HZ.	More than 1000 HZ	0 - 1000 HZ.	350 - 700 HZ.	700 – 1400 HZ.	1400 – 2800 HZ.	2800 – 5600 HZ.
	RMS	RMS	RMS	RMS	RMS	RMS	RMS
Standard (VK15 alloy)	288	243	137	87	114	132	58
Sintegran	206	188	69	43	59	72	62
Natural granite	250	216	247	55	80	142	60
The chlorite	232	216	40	23	23	33	37
Sandstones	151	139	54	34	33	52	48

Table 3: Surface Roughness

Materials Types	Ra
Standard (VK15 alloy)	0,32
Sintegran	0,18
Natural granite	0,38
The chlorites	0,24
Sandstones	0,48

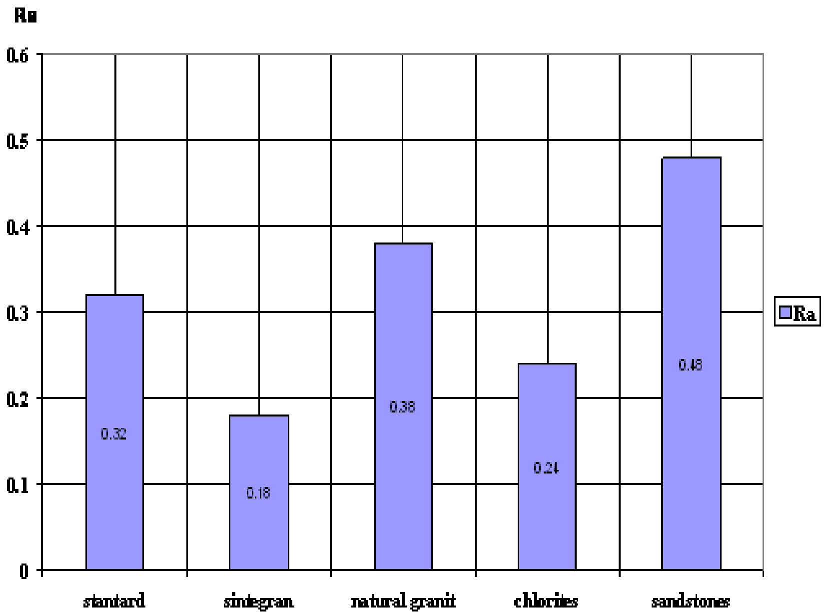

Figure 4

CONCLUSIONS

The minimum surface roughness given in Table 3 and Figure 4 is obtained when using shims of sintegran, the same conclusions could be inferred using to RMS values of acoustic measurements for various ranges of frequency.

The experimental results show that the chlorites and sandstones have the minimal acoustic activity, the sandstones shim has the minimal vibration within high frequencies: within the low frequencies the chlorites shims has shown advanced priority against the other shims, the experiment also shows that shims consisting of minerals and composite materials have advanced machining conditions and high vibration absorption, and effectively fixing the cutting inserts results in increase in the quality of machined surface.

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