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The Research Analysis of Surface Finish and Wear on the Special Tribological Device

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Abstract

The main aim of scientific research of authors is to assess and compare the wear of hardened tool steel together with bearing steel which is surface inductively hardened to a depth of 1.5 to 2 mm. The experimental measurements for selected hardened steels will shows us that in terms of technological heredity of the wear surfaces in the tribosystems (adhesive wear) which is particularly more effective in supporting and surface finish (microgeometry) share when worn as well as influencing of surface after machining (hardening, respectively for turning of small and large tempered layer after grinding recess), i.e. hardness of the coating. This paper, together with published results is a basis that will enable optimizing the quality of hard turning process of these types of hard materials which are used for the special industry applications.

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Keywords: surface finish; tribological characteristics; radial wear; friction force

1. Introduction

Regularities of the cutting process create the required shape and size components constitute the essence of the machining process. Removing of material in the form of chips by technology of machining significantly affects the dimensional accuracy, geometrical shapes and surface quality. Surface quality is a complex concept characterized as the surface integrity. Then surface integrity [2] is a summary statement of the conditions of production of functional areas, various machining technologies used and their effect on the properties of machined surface. The efforts to complete concept of the quality of surface layers (surface integrity) is starting to take only in the recent decades.

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Nomenclature

a_p	depth of cut [mm]
D	outer diameter [mm]
ΔD	radial wear [µm]
f	feed rate [mm.rev^{-1}]
F_N	contact force [N]
F_T	friction force [N]
F_R	reaction force [N]
HSC	high speed cutting
HM	hard machining
l	distance [mm]
μ	friction coefficient [-]
t	time [min]
T	temperature [°C]
v_c	cutting speed [m.min^{-1}]

It is based on the technological processes and their effect on the depth and distortion of the surface layer. The parameters value of surface quality of machined parts is to be found in the production technology itself, particularly in machining. The geometry of machined parts is different apart from the ideal geometry entered by the technical documentation. The micro roughness is generated on the machined surface. The force have effects on cutting tool during the machining operation, then deforms the thin layer of the machined surface. As a result of this deformation and heating of the surface layer (the heat which is always accompanied by a machining process) is formed a tension in this layer and changes its physical and mechanical properties. The task of examining the surface integrity is to create new theories in addition of the current trends in technological practice, thus improving the functionality of the quality of component surfaces. About the analysis and research of tribological characteristics of the peer-reviewed literature sources dealt with the following authors. The authors Eriksson and Ollson [4] say that in many tribological sliding contacts, the transfer of material between the contacting surfaces is frequently a problem since it will strongly influence the contact conditions and thus the behaviour of the tribosystem.

For research and determination of the wear tribological characteristics of the grinding technology addressed his research by team of authors [5, 10]. In their study it can find an alternative approach which is presented for the study and characterization of contact phenomena in grinding. It consists of two complementary test benches: the On-Machine Test Bench and the High Speed Tribometer. They are designed to overcome the limitations of current grinding experimental studies.

According to the authors [7] the main performance characteristics of surface layers are as follows:

- the strength characteristics, including the fatigue strength;
- the tribological characteristics, such as the coefficient of friction, the wear rate, the seizure resistance, etc.;
- the anticorrosion characteristics, e.g., the corrosion wear rate;
- the appearance, i.e., colour, glitter, and aging resistance.

The machining processes that produce the texture of machined surfaces and provide the hardening of surface layers play a significant role in ensuring required performance characteristics of parts. In particular, it is known that 70 to 80% of the total change in the wear resistance is due to variations in the roughness parameters of friction surfaces.

The team of authors Rivas et al. [8] for his research dealt with the tribological aspects of the shafts and bearings. Their research were based on the identification of wear mechanisms present on the shaft and bearing tribological pair, as well as the analysis of mechanical and the tribological properties of the pair elements.

The authors R.J. Talib et al. [9] conducted experimental research about friction and wear characteristics of WC and TiCN-coated insert in turning carbon steel workpiece. The turning performance of the cutting tool inserts in dry machining was conducted at cutting speed of v_c = 60 m.min^{-1}, feed rate of f = 0.06 mm.rev^{-1} and depth of cut at a_p = 1.0 mm. The tests were conducted on 100 mm diameter and 140 mm long carbon steel rod (0.40 % C, 0.25% Si, 0.77 % Mn, 0.011% P, 0.24 % S and balance Fe) with hardness of 404 HV. The performance tests were carried out until the cutting tool inserts were unable to cut the work piece and the inserts were deemed not complying with international standard organization ISO 3685 requirement if the tool life is less than five minutes.

2. Analysis of wear and surface finish of machined surfaces

It is necessary to know the wear mechanisms that occur during the machining (HSC, HM) of metallic materials, in our case of the machining of hardened steel [3]. These wear mechanisms allows us to examine of the tribological analysis. This concept was introduced in 1966 by the Mr. Jost [1]. Tribology is therefore the notion that science and technology, independently of one another have begun exploring the friction surface to each other and develop their corresponding technological processes. Tribology therefore contains branch of friction, wear and lubrication. The structure of a tribological system [11] consists of four basic elements: the base body, acting against the body, surrounding medium and the surrounding environment. For these elements operates stressed summary consisting of the normal force F_n and cutting speed v_c and time t and last, but not least the temperature stresses. If we transpose these conditions the machining process, then the resulting system tool basic element - along with the outgoing chips acting against the body. It called substance and may affect the type of friction against the base body and the body, further cooling substances such as particles with a chemical reaction between the various system elements. Surrounding medium is generally air, being right on the tip of the cutting knife can be expected vacuum. Different is defined as usual the open and closed tribosystem. We can talk about an open system, when the basic body is permanently in contact with the new material acting against the body. Thus, they look almost all machining processes. In contrast, the principle of closed tribological system can be defined when the body repeatedly against the same-material comes into contact with the main body. Tribological interaction parameters resulting physical and chemical processes, which are reflected in four main mechanisms: adhesion, abrasion, surface quality and the tribochemical responses [2, 3]. The authors [1] carried out research on the tribological characteristics of thermally processed steels. In this paper, the research by the authors [4] deals about the field of heat-treated steels turned hard (HM technology) with cutting ceramics CC6050 dry cooling, as well as authors like to compare the measured and calculated values of hard turned and sanded samples. Arguably, the traditional grinding [6] now reached the limits of their best options.

3. Experimental details

Tribological test device (Fig. 1a) is used to measure the adhesive wear of machined surfaces of cylindrical test samples and test samples were therefore designed to specific dimensions because of wear measurements. The main part of the friction knot, which consists of two elements operating thrust perpendicular to the rotating sample from both sides (see Fig. 1b). These elements are the friction generated by the touch screen just under the surface of the specimen, i.e. grinding disc-shaped samples of cast iron casing and lapping using diamond paste. Pinch elements are hardened steel, tungsten carbide HW-K10. Each element applied to the specimen contact force, which can be set in the range of F_N = 0 to 650 N. The force is exerted by the pressure springs. Union member, in which the pinch elements, provides the same thrust of both elements. Test sample was deployed to the shaft and the screw facing up line cut forehead and then centered. Shaft speed of the test sample provides us the electric power P = 0.25 kW.

Belt drive allows you to change speed in three stages. Lubrication and cooling of the friction node provides a cooling system with pump and tank with a trickle of equipment. So we can vary the intensity of lubrication (cooling). The type of coolant it was used the emulsion DASCOL 2500 (ARAL) - E5%. The test of facility allows us how to monitor and evaluate the wear test specimen diameter, the frictional force F_t, the coefficient of friction μ and the temperature in the friction node T [°C] continuously in arbitrarily long time (up to 300 min = 5 hrs).

Wear surface of the samples was measured by inductive proximity sensor associated with the friction elements. Value is measured by inductive transducer converted into an electrical signal fed to a digital meter. It shows the measured value on display. The measurement of temperature was carried out with using of a thermoelectric temperature sensor and the value (height), which is shown on the display of the other device. Measurement of frictional forces F_t and the reaction force F_r is secured by means of resistance strain gauges placed on the arm firmly connected with the drag plate and at the same time was also controlled by a graduated U-dynamometer sentinel watches that measure the movement of the dynamometer arm.

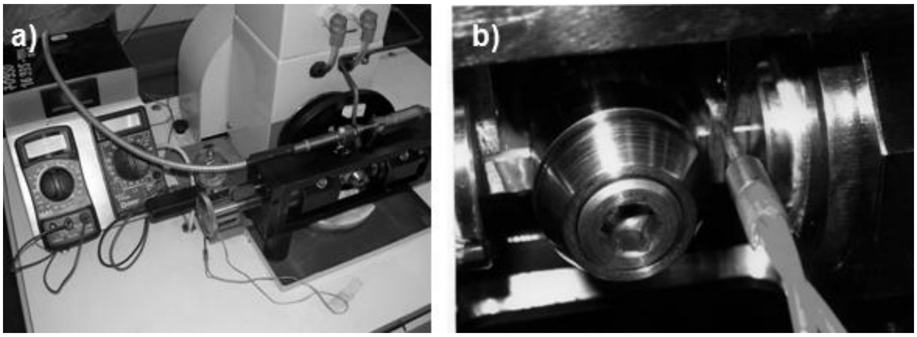

Fig. 1. (a) apparatus for determination of tribological characteristics; (b) practical sample measurement.

Measurement of the tribological characteristics of samples from high strength heat-treated steel turned dry, turned with coolant and grinded was carried out on the special tribological device (see in Fig. 2 a, b) designed and created by the author [1] from the Institute of machining in Trencin. The duration of each test was set at 300 minutes. Test equipment continuously evaluates of reaction force and temperature in friction knot. For the calculation of the coefficient of friction and reaction force are based on the structural design of friction tribological test of device node [1, 3]. To calculate the friction coefficient the equation:

$$\mu = \frac{F_R . l}{F_N . D} \tag{1}$$

where: F_R - reaction force [N]
l - distance sensor of reaction force from the axis of the sample (l = 0,147 m)
D - outer diameter of the measured sample [mm]

During the different tests at the selected contact force F_N and the sliding speed I recorded the value of drag force F_R [N] and the friction temperature T [ºC] and the final radial wear ΔD [mm]. From the measured reaction force F_R we can find frictional force F_T by the relation:

$$F_T = \mu . F_N \tag{2}$$

where: F_T - friction force [N]
F_N - contact force [N]

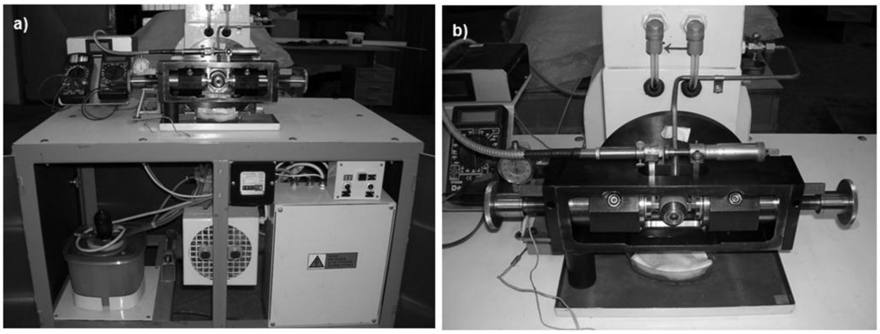

Fig. 2. (a) an overview for special tribological device with equipment; (b) an overview for the friction part of device.

4. Experimental procedure and results

The charts shown in the following pages are documented the measured and calculated values of the tribological samples from hard turned material of the type 102Cr6 and the type CT120 but also conventional turning (for comparison, since the authors [2, 3] studied not only heat treated steel) and round grinded samples.

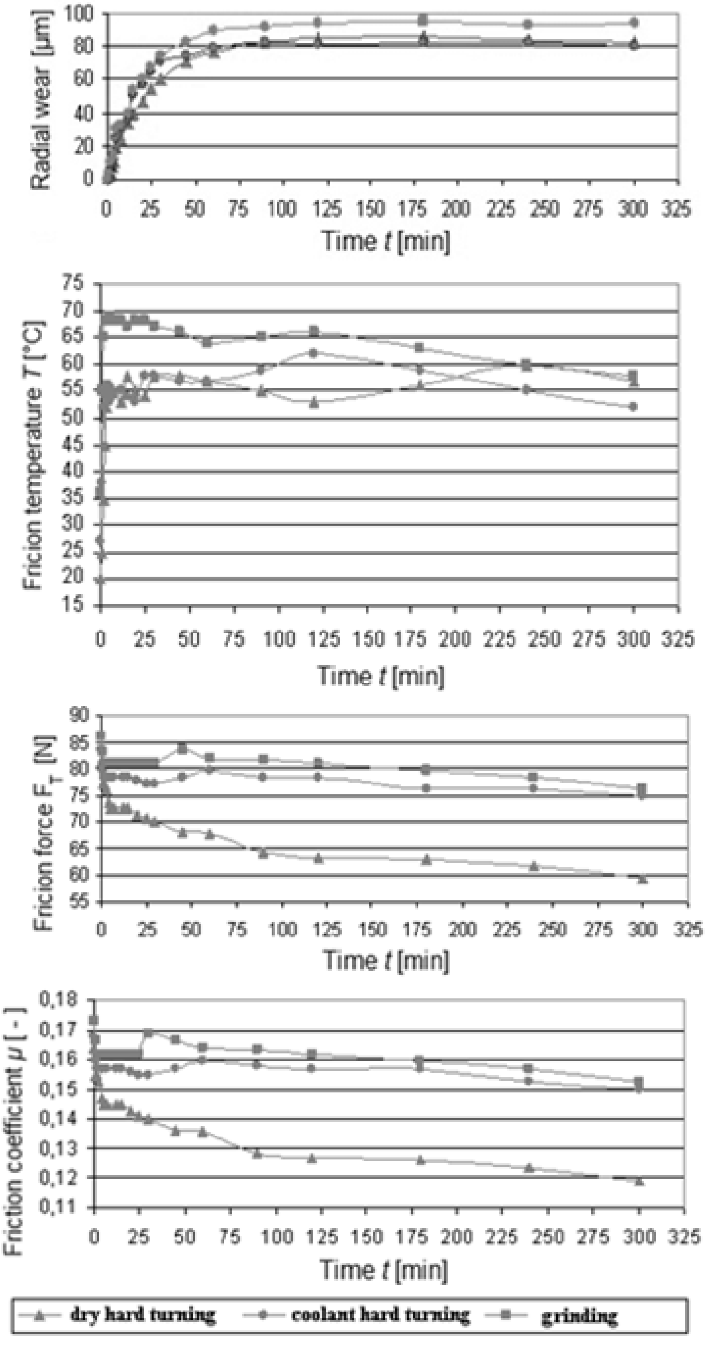

Fig. 3. graphical dependences of complex tribological characteristics when hard turning and grinding of bearing hardened steel 102Cr6.

Each measured and calculated value is an average, but is in fact it is the arithmetic mean of six values. Figure 3 and figure 4 show us the reached experimental measured and counted values from all realized measurements realized on the special tribological device (Fig. 2a). Test specimens for the graphs of Figure 3 were made of hardened steel bearing type 102Cr6. The samples (Fig. 4) used for the second cycle comparative experiments were made of hardened tool steel type CT120. The aim of this present study was to compare two different high strength steels in terms of surface finish, because it has not yet been realized and published sufficient information from the research and applied adhesive wear on high strength steel. Achieved and measured results of the tribological characteristics of high strength steels are shown in the graphs of individual variables studied and are shown in Fig. 3 and 4.

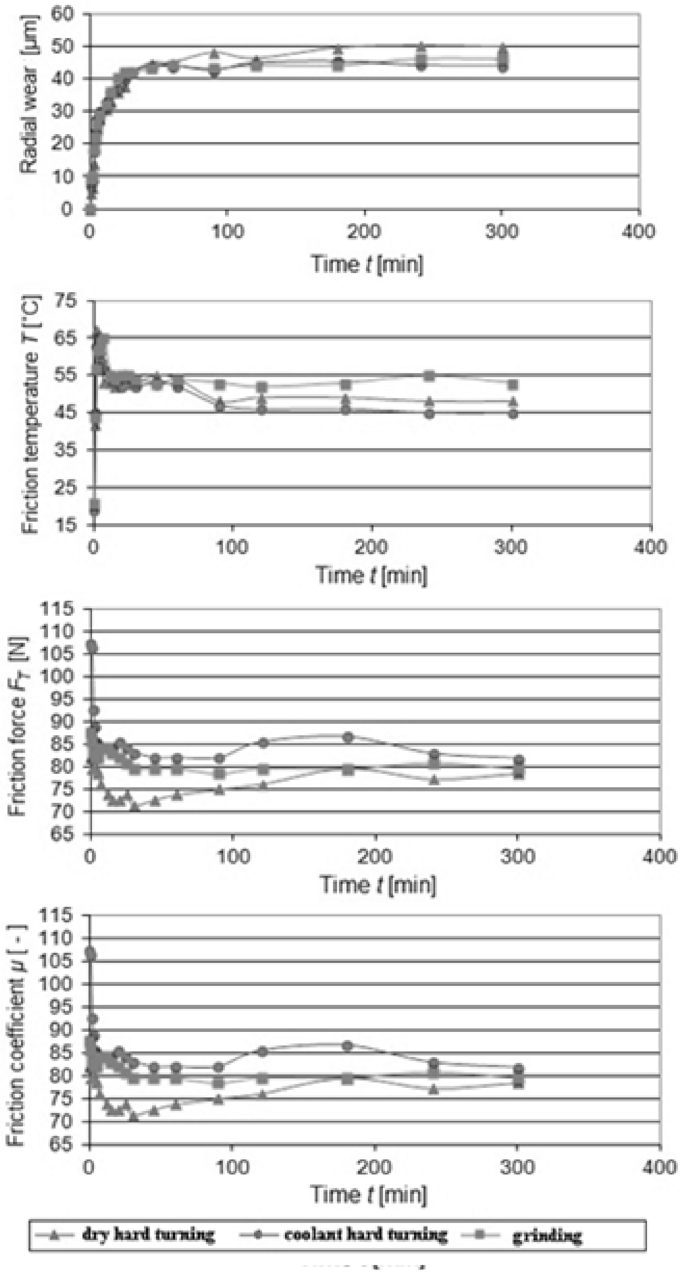

Fig. 4. graphical dependences of complex tribological characteristics when hard turning and grinding of tool hardened steel CT120.

Conclusion and discussion

Tribological tests were performed in the special tribological device with equipment and with coolant (Fig.1, b). Realized experiments confirmed us the fact about surface hardness of machined parts, then is more slowly wear out. The tribological characteristics of the individual measurements of compared hardened steels and a comparison chart of the tribological characteristics based on the following findings:

- the radial wear of all measured samples is always the largest recess after grinding, which may explain the slightly greater roughness of the sanded surfaces and thermal affection where there is a tempered martensite structure, unlike the hard turned surfaces;
- there is not a significant difference of ΔD in hard turning on samples and surface between samples turned dry or turned with coolant application;
- at the grinded surfaces is the largest and the friction force and coefficient of friction.

The experimental measurements for the authors selected hardened steel shows that in terms of technological heredity of surface wear in the tribosystems (adhesive wear) is particularly more effective in supporting and microgeometry share when worn as well as influencing surface after machining (hardening, respectively. slack for turning small and large tempered layer after grinding recess), i.e. hardness of the coating. While the literature sources and scientific papers from peer review journals are not present this type of data and examples of the functionality of the machined surfaces of realized experiments with these two types of hardened steels. Our accomplishments, although do not give complete information, but watching the other shows the direction in machining the same material, such as turning a polycrystalline cubic boron nitride and compared with the longitudinal grinding precise definition of cutting conditions. Previously documented changes by the other authors about of surface microgeometry, HV0.1 surface microhardness and structure indicate a possible change in performance of surfaces, which was confirmed by our tribological tests on these kinds of materials selected. The authors would like to in the future, extended his research to include other types of high-strength materials, which in this research did not address the authors of publications in impacted journals database. This would like the research to supplement and enrich it with additional knowledge. It opens the way for further research in this area to optimize the machining process in the production of their dominant functional areas.

Acknowledgements

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