ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome V (Year 2012). FASCICULE 1 [January–March]. ISSN 2067-3809

[1.] Jozef MAJERÍK, [2.] Nina DANIŠOVÁ

SURFACE FINISH ANALYSIS OF WEAR ON TRIBOLOGICAL FACILITY

[1.] DEPARTMENT OF ENGINEERING TECHNOLOGY AND MATERIALS, FACULTY OF SPECIAL TECHNOLOGY, ALEXANDER DUBCEK UNIVERSITY IN TRENCIN, SLOVAKIA
[2.] INSTITUTE OF PRODUCTION SYSTEMS AND APPLIED MECHANICS, FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA, SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA, SLOVAKIA

ABSTRACT: *Laws of the cutting process create the required shape and size components constitute the essence of the machining process. Removing material in the form of chips by cutting affects the accuracy of dimensions, geometric shapes and surface quality. Surface quality is a complex concept characterized the surface integrity. Surface integrity is a summary statement of the conditions of production of functional areas, technologies used and their effect on the properties of machined surface. Efforts to complete concept of quality of surface layer (surface integrity) is starting to take only in recent decades. 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 machine parts is to be found in the production technology itself, particularly in machining. The geometry of machined parts is different from the ideal geometry entered drawings. On the machined surface generated micro roughness. The force effects of cutting tool during operation, then the thin layer of the machined surface deforms. As a result of deformation and heating of the surface layer heat (heat- that is always accompanied by a machining process) are formed in this layer of tension and change and its physical and mechanical properties. The task of examining the surface integrity is to create new theories in light of current trends in technological practice, thus improving the functionality of the qualitative component surfaces.*
KEYWORDS: *Hard turning technology, grinding, surface integrity, surface functionality, tribological characteristics, radial wear, friction coefficient, friction force*

INTRODUCTION

It is necessary to know the wear mechanisms that occur during the machining of metallic materials, in our case the machining of hardened steel. These wear mechanisms allows us to examine the tribological analysis. This concept was introduced in 1966 by Mr. Jost [5]. 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 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", cutting speed "v_c", time and 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" 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 "open" and "closed" tribo-system. 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 tribo-chemical responses [5]. 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 with cutting ceramics CC6050 dry cooling, as well as authors like to compare the measured and calculated values of hard turned and sanded samples.

MEASUREMENT OF FUNCTIONAL SURFACES OF COMPLEX VARIABLES STUDIED STEELS

Tribological test device used to measure the adhesive wear of machined surfaces of cylindrical test samples, 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. 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.

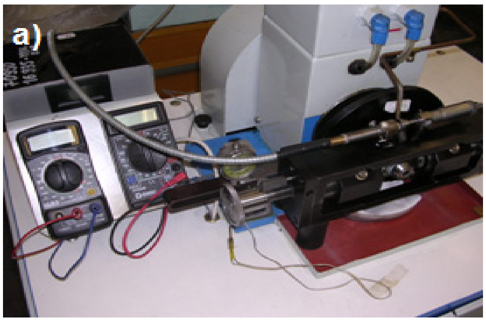

Fig.1a: Apparatus for determining the operation [authors]

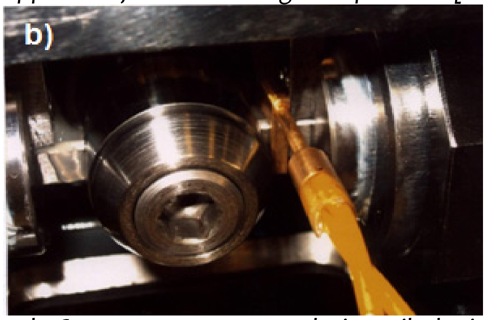

Fig.1b: Course measurements during tribological characteristics [authors]

Test sample was deployed to the shaft and the screw facing upline 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 3 stages. Lubrication and cooling of the friction node provides a cooling system with pump and tank with a trickle of equipment, so I can vary the intensity of lubrication (cooling). How a coolant I used emulsion DASCOL 2500 (ARAL) - E5%.

The test facility allows you to monitor and evaluate the wear test specimen diameter, frictional force (F_t), coefficient of friction (μ) and temperature in the friction node (°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.

Temperature measurement was carried out using a thermoelectric temperature sensor and the value (height) 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.

Measurement of tribological characteristics of samples from heat-treated steel construction turned dry, turned with coolant and round grinding was carried out in conditions on tribological devices designed for the Department of machining and assembly in Trencin. The duration of each test was set at 300 min. Test equipment continuously evaluates reaction force and temperature in friction knot. For the calculation of the coefficient of friction and drag force are based on the structural design of friction tribological test device node. [4]

To calculate the friction coefficient the equation:

$$\mu = \frac{F_R . l}{F_N . D} \qquad (1)$$

where: F_R - drag force [N]; l - distance sensor drag force from the axis of the sample (l = 0,147 m);

D - outer diameter of the 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 [°C] and the final radial wear D_d [mm]. From the measured drag force we find F_R F_T frictional force by the relation:

$$F_T = \mu . F_N \qquad (2)$$

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

RESULTS OF TRIBOLOGICAL TESTS

The charts shown in the following pages are documented measured and calculated values tribological samples from cultivated material 102Cr6 hard but also conventional turning (for comparison, since the authors [2, 3] studied only uncooked, steel) and round grinding. Each measured and calculated value but is in fact the arithmetic mean of 3 values.

Table 1: steel 102Cr6 dry hard turned, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ[-]
0	0	20	81,75	0,1638
1	2	25	77,28	0,1546
2	4	35	77,28	0,1546
3	8	45	76,13	0,1523
4	11	52	73,71	0,1474
5	20	56	72,56	0,1451
7	25	55	72,56	0,1451
12	34	53	72,56	0,1451
15	39	58	72,56	0,1451
20	47	55	71,35	0,1427
25	55	54	70,77	0,1415
30	60	58	70,14	0,1403
45	71	58	68,3	0,1366
60	77	57	67,78	0,1356
90	82	55	64,21	0,1284
120	85	53	63,42	0,1268
180	86	56	63	0,126
240	84	60	61,85	0,1237
300	83	57	59,43	0,1189

Table 2: steel 102Cr6 hard turned with coolant, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ[-]
0	0	27	83,67	0,1678
1	3	38	79,69	0,1594
2	6	52	78,49	0,1569
3	10	54	78,49	0,1569
4	12	56	78,49	0,1569
5	24	53	78,49	0,1569
7	29	54	78,49	0,1569
12	36	55	78,49	0,1569
15	51	54	78,49	0,1569
20	57	53	77,91	0,1558
25	65	58	77,3	0,1546
30	71	58	77,3	0,1546
45	75	57	78,4	0,1565
60	79	57	79,69	0,1594
90	83	59	78,51	0,158
120	81	62	78,51	0,158
180	82	59	76,13	0,1523
240	82	55	76,13	0,1523
300	80	52	74,92	0,1498

Table 3: steel 102Cr6 round grinded, F_N = 500N

t [min]	ΔD [μm]	T [°C]	F_T [N]	μ [-]
0	0	36	86,12	0,1729
1	4	55	83,27	0,1665
2	10	65	80,85	0,1617
3	12	68	80,85	0,1617
4	15	68	80,85	0,1617
5	30	69	80,85	0,1617
7	32	68	80,85	0,1617
12	40	68	80,85	0,1617
15	54	67	80,85	0,1617
20	60	68	80,85	0,1617
25	67	68	80,85	0,1617
30	74	67	80,85	0,1617
45	82	66	83,42	0,1668
60	90	64	82,06	0,1641
90	92	65	81,74	0,1635
120	94	66	80,85	0,1617
180	95	63	79,69	0,1594
240	93	60	78,49	0,1569
300	94	58	76,13	0,1523

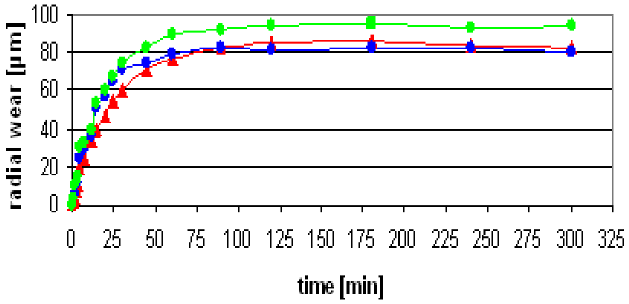

Figure 2a. Complex tribological characteristics of samples of material 102Cr6. The radial wear vs. time

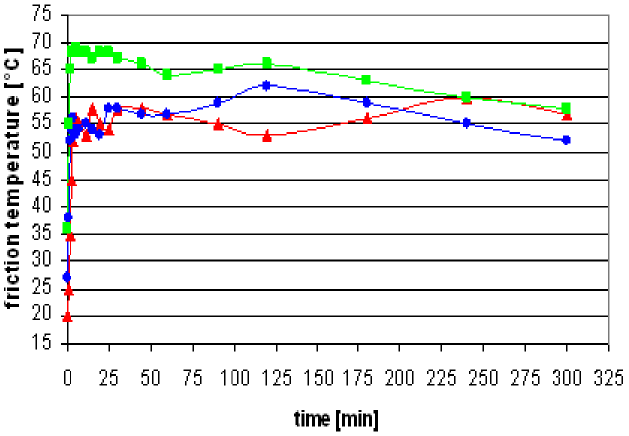

Figure 2b. Complex tribological characteristics of samples of material 102Cr6. The friction temperature vs. time

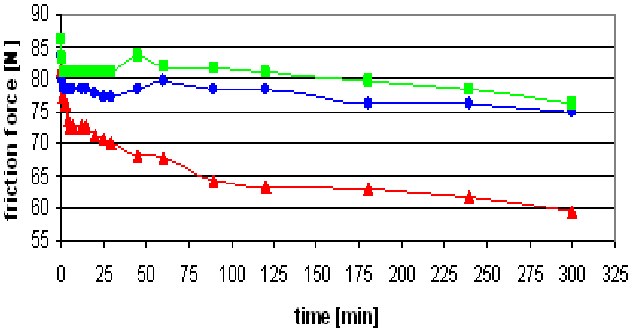

Figure 2c. Complex tribological characteristics of samples of material 102Cr6. The friction force vs. time

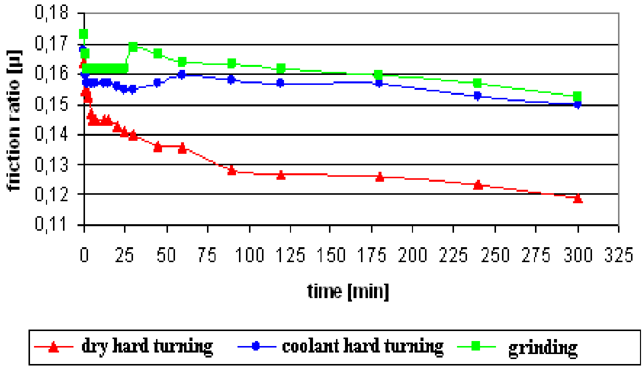

Figure 2d. Complex tribological characteristics of samples of material 102Cr6. The friction ratio vs. time

CONCLUSIONS

Tribological tests were performed on tribological equipment with cooling (see Fig.1, b). Performed experiments confirmed the fact about machined parts surface hardness, then is more slowly wear out. The tribological characteristics of the individual measurements of hardened steel and a comparison chart of the tribological characteristics based on the following findings:

- *ΔD radial wear of samples measured 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.*
- *turning on hard surfaces is not a significant difference in ΔD 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 selected hardened steel shows that in terms of technological progeny of wear surfaces in tribosystems (adhesive wear) is particularly 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 are not present data and examples of the functionality of the machined surfaces of hardened steel. 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 of microgeometry, microhardness and structure indicate a possible change in performance of surfaces, which was confirmed by tribological tests on all kinds of materials selected.

ACKNOWLEDGMENT

Presented article was also supported by Slovak Scientific Grant Agency of the Ministry of Education and Sciences (VEGA grant project no. 1/9428/02).

REFERENCES

[1.] BÁTORA, B., VASILKO, K.: Obrobené povrchy. Technologická dedičnosť, funkč- nosť. Monografia. TnU FŠT Trenčín. GC-Tech. 2000, 183 strán.

[2.] MAJERÍK, J.: Náhrada brúsenia kalených ocelí tvrdým sústružením. In: Strojárstvo/ Strojírenství – Mechanical Engineering Journal, ISSN 1335-2938. - Roč. 12, č. 5(2008), s. 170-171,180.

[3.] MAJERÍK, J., PAVLÍK, P.: Overenie možnosti náhrady brúsenia tvrdým sústružením s PKNB z pohľadu integrity povrchu, In: Funkčné povrchy 2006 [zborník]: Zborník prednášok z medzinárodnej vedeckej konferencie. - ISSN 1336-9199. - Trenčín. - 277 s. - ISBN 80-8075-137-4. - s. 121-128.

[4.] MAJERÍK, J.: Overenie možnosti náhrady brúsenia kalených ocelí tvrdým sústružením z pohľadu integrity povrchu, KOM FŠT TnUAD Trenčín – Slovakia, Dissertation work, p. 136, 2004.

[5.] WEINERT, K.: Spanende Fertigung. 1. ausgabe VULKAN-VERLAG, Essen, 1994 s.28÷30.

ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

ISSN: 2067-3809 [CD-Rom, online]