COMPARISON OF PROPERTIES OF STEEL 100Cr6 AND C56E2 IN THE PROCESS OF MACHINING

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Abstract

A use of selected steels in the industrial practice is very important and frequent and this is the reason why it is necessary to know their qualities not only from the standpoint of material, but also regarding its machinability with the aim to gain a product of a fine quality in optimal economic conditions. Machinability was compared in cases of steel 100Cr6 and steel C56E2 directly in the production process by means of experimental verification of deterioration of cutting materials, measurements of dynamics of a cutting process, evaluation of macrostructure and quality of surface layers.

Keywords: Steels, properties, machinability, verification

1. INTRODUCTION

Currently, in order to save costs is pressure put in every area of mechanical engineering to reduce costs and increase productivity. In the process of machining the reduction includes a reduction of major and minor times and cost of cutting tools. The way to reduce the cost of cutting tools, however, does not mean buying cheaper and less quality cutting tools, but it is mostly about optimization of its perfect use. Not only tools but mainly the material has a great influence on the cutting process [1, 2]. Nowadays, there occurs a tendency of "lean" manufacturing, which aims to minimize the work in process, there origins a primary question of stable processes. Each machine in the line must be so set up that the next machine does not wait for material, which increases a demand on reliability of the process. Optimization of machining processes is essential to meet these requirements. The instability process of one machine affects performance and quality of the whole line, resulting in higher losses [1, 3].

The paper is designed to analyze differences in machined materials 100Cr6 and C56E2, watch the differences in the process of machining. Its aim is to verify the effects of alloying addition to machining process. The main parameter in this comparison is a test of durability of cutting plate while monitoring cutting blade wear and roughness of machined surfaces. Other parameters are cutting forces monitored by cutting force sensor, a comparison of microstructure of both materials, monitoring of roughness produced parts and a comparison of resulting chips observed in both machined materials [4, 5].

2. WHEEL BEARINGS

Roller bearings can be considered as an integrated construction element which allows a mutual movement of parts of machinery and equipment while capturing the external forces. The most common assembly consists mostly of two rings, rolling elements and the cage. The roller bearing is characterized by a relative rotational movement between rings that is realized through the rolling elements that dumps between the raceways and simultaneously transmit acting forces [6, 7].

Requirements for wheel bearing, (**Figure 1**)**:** low friction, support of external forces, transferring torque from the drive shaft, durability, precise wheel guidance with high stiffness, ensuring placement ABS encoder.

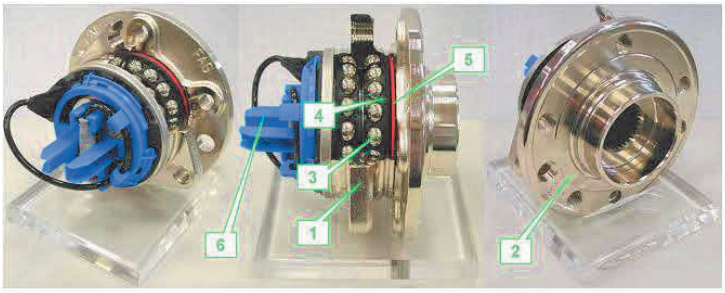


Figure 1 The 3rd generation wheel bearing with the ABS encoder, 1- AU-outer ring, 2 - FL - flange on which is attached the wheel, 3 - ball, 4 - cage, 5 - the seal, 6 - ABS encoder power [8]

Other requirements: an easy assembly and disassembly, a maintenance-free operation, corrosion resistance, low noise, low vibration, strength, heat resistance, light weight, environmental friendliness [8].

For comparison of machinability of materials 100Cr6 and C56E2, we used the following methods and measurements: cutting plates wear course (VB, KT), measurement of cutting forces measurement of roughness during production and comparison of microstructure.

3. EXPERIMENTAL VERIFICATION

The parameters of the machine on which the test was performed: *Numerically controlled lathe EMAG VSC 130 TWIN*

Type of cutting plates used in the test

Type of cutting plate: TNMG 16 04 12-MF 4215, **Figure 2**,

Type of substrate: gradient (WC + Co)

Technology of the coating: CVD

Type of coating: MT - Ti(C,N) + Al_2O_3 + TiN

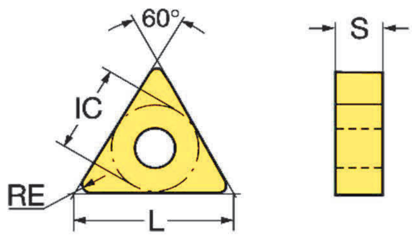


Figure 2 Dimension triangular cutting plates

Cutting parameters: cutting speed - v_c = 350 m. min^{-1}, feed - f = 0.2 mm, cutting depth - a_p = 0.6 mm

3.1. Evaluation of wear of plate cutting

In the evaluation of wear of the cutting plate a micrometer method was selected. The method consists of a direct measurement of wear of the cutting plate. The evaluation criterion was chosen width of wear of the cutting plate on the back of VB and the depth of the groove at the forefront of the cutting plate KT (**Figure 3**).

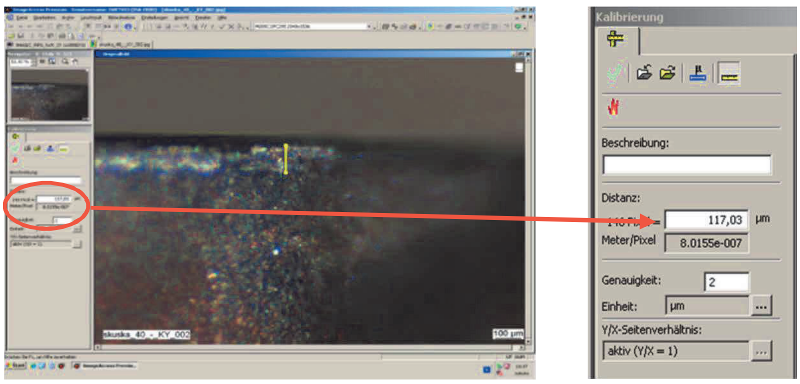
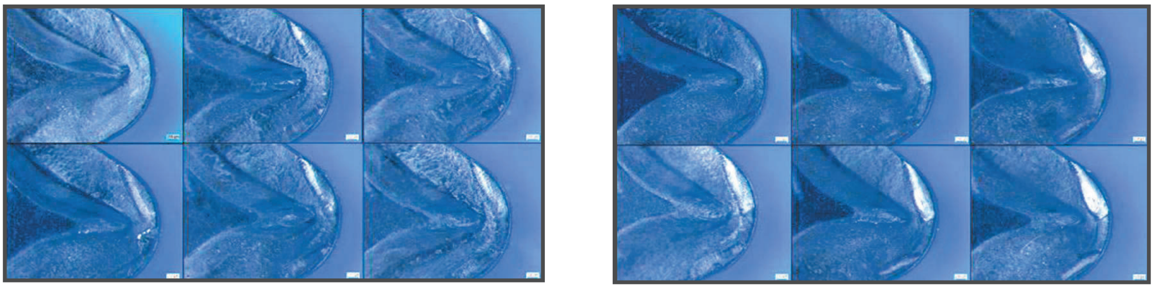


Figure 3 Measurement of wear in the VB environment Image Access

Assessment of wear of cutting plate

On cutting plates there is visible abrasive wear after machining of the both materials (**Figure 4**). This wear is caused by a presence of hard parts in the workpiece. In the case of material 100Cr6 we speak of the presence of carbides and in case of C56E2 of the presence of pearlite in a lamellar form. In the photographs of the cutting plate damages can be observed also outside a zone of wear. The damage is caused by leaving chips. These defects are irregular which could be considered as they are produced by reeling chips. The 100Cr6 material is softer than the material C56E2 and reeling of chips may occur during machining on the knife. Reeling is not suitable for machining, but it can be removed with correct setting cooling. Setting of cooling can regulate outgoing chips in a desired direction.

Due to high hardness of the material C56E2 leaving of chips from the cutting place proves to be better, but wear is still significant. Outgoing chips are irregular because of the geometric shape of the workpiece. During one operation different profile diameters and outer orbit are turned. In the figures one can observe different wear during a production of 50 units.



a) b)

Figure 4 Progressive wear of cutting plate of material a) 100Cr6 and b) C56E2

From the measured values were set up graph (**Figure 5**) of a wear course of cutting plates in machining of the both materials.

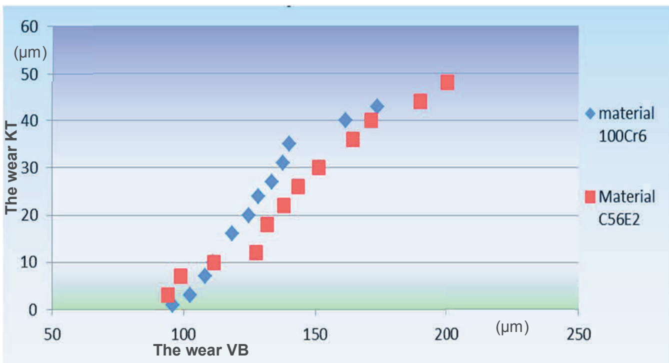


Figure 5 The course of dependence wear VB and KT

From the graphs of the measured values it is evident that the cutting plate is a subject of a higher level of wear when machining the material C56E2 in the both measured parameters (VB, KT) than the cutting plate in case of the machined material 100Cr6. Even after turning the first 25 units there were obvious signs of wear. After a completion of 200 pieces a difference in wear increases. Because of this reason, we conducted an experiment in production, a monitoring of wear of the cutting plate was completed by the end of service life of the cutting plate set by the technology department. A continuation of the experiment after the end of service life would be very risky in terms of quality and a damage caused by the production of non-conforming parts would be high due to the high price of one piece.

3.2. The evaluation of roughness

For comparison of machinability of materials 100Cr6 and C56E2 was studied course roughness of produced parts (**Figure 6**). Measurements were made on the Form Talysurf PGI device manufacturer Taylor Hobson.

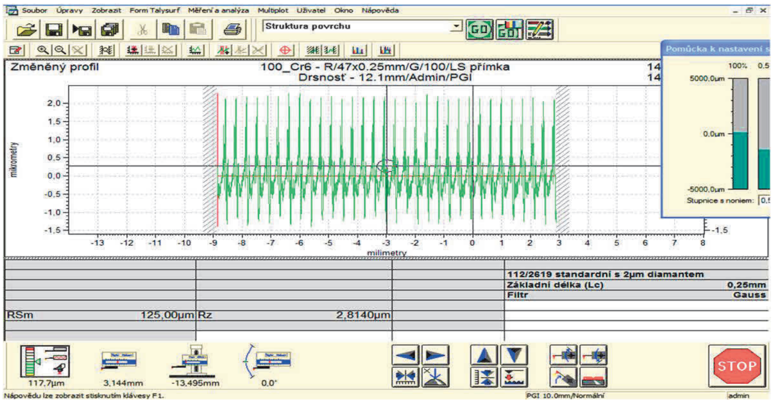
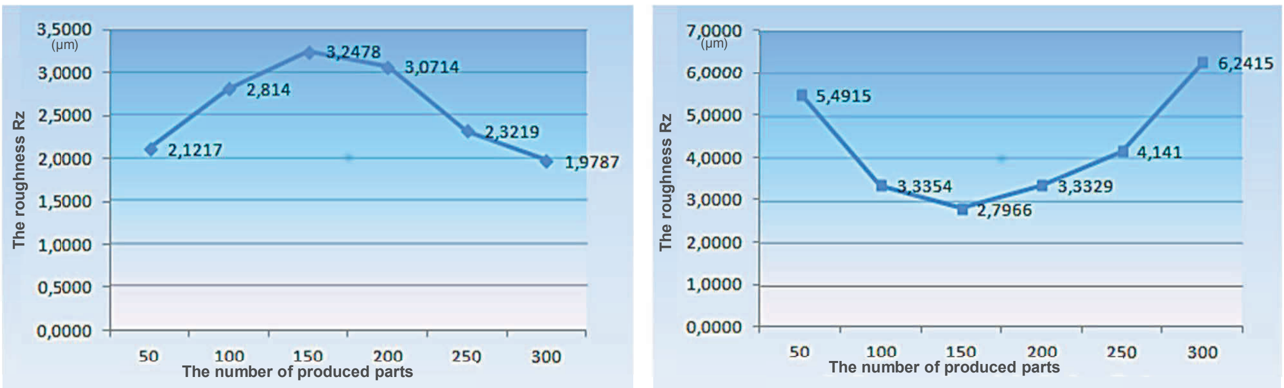


Figure 6 Environment Programme Taylor Hobson ultra V4.6.95

During the life of the cutting plate set up by technology there were roughness elements within the limits prescribed of the required drawing values. Even after a service life results had a very good value when they did not even reach the drawing value of Rz = 25 µm. The course of the measured data (**Figure 7**) observed for the both materials is opposite, a modification of the measured surface roughness of machined parts occurs due to plate wear and creating an increase and their breaking off. For a measurement of maximum height of the roughness profile Rz we decided due to an indication of this parameter in the drawing of a produced unit.



a) b)

Figure 7 The course of roughness when machining material a) 100Cr6 and b) C56E2

3.3. The evaluation of microstructure - see Figure 8

Figure 8 Prepared specimens for evaluation of microstructure

The material 100Cr6 is standardly evaluated in the enlargement of 1000:1. In the microstructure we observed dark carbides in a bright ferritic matrix (**Figure 9**). On the sample, a size of carbides is evaluated and its closest etalon is 2.1 - 2.2, which is a prerequisite for a relatively fine structure. Etalon standards vary by a number of carbides larger than 400 microns. By the assessment of the structure of the material 100Cr6 we exclude the presence of lamellar pearlite. The quality is also affected by a distribution of carbides in the material, which is even. The material C56E2 is evaluated at a magnification of 100:1, respectively 500:1. The proportion of ferrite in the sample has the measured value of 2 - 6 % due to larger secondary grains compared against correlation standards. In the material C56E2 there is a visible presence of lamellar pearlite. In case of bearing steels, the demand is for low volume of non-metallic inclusions. They are the materials that break off under heavy pressure and there also originates pitting.

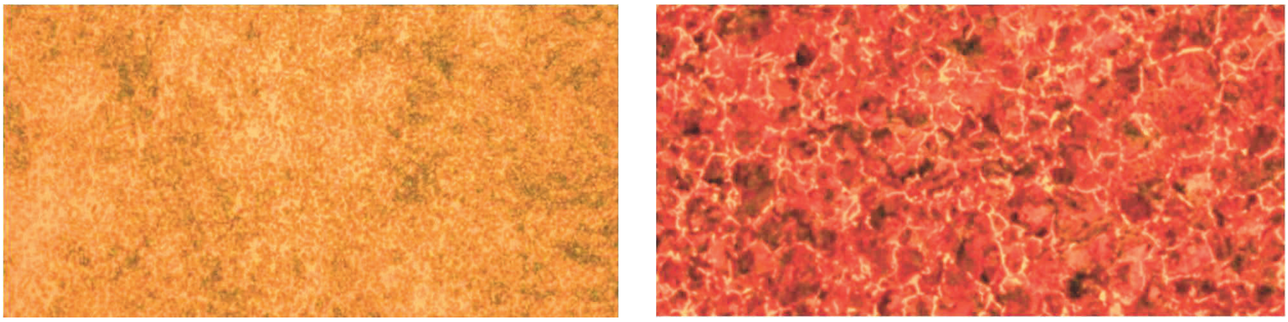


Figure 9 The structure of the material 100Cr6 (magnification 1000:1) and C56E2 (magnification 100:1)

3.4. The evaluation of the cutting force

For a correct measurement we calibrate the device, which consist of a loading of the dynamometer weight in all three axes. After instrument calibration we set a required material removal and after a performance of measurements we removed the layer a_p = 0.4 mm (**Figure 10**). The measured signals were transformed into components of cutting forces in the settings of software Dasy Lab. For the measurement we used the same cutting plates. Cutting parameters were not modified.

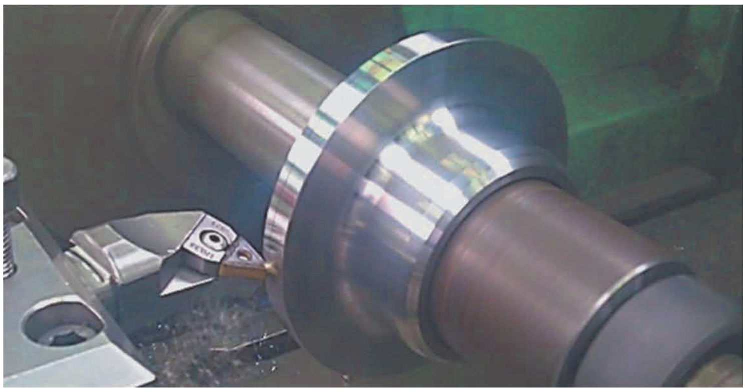
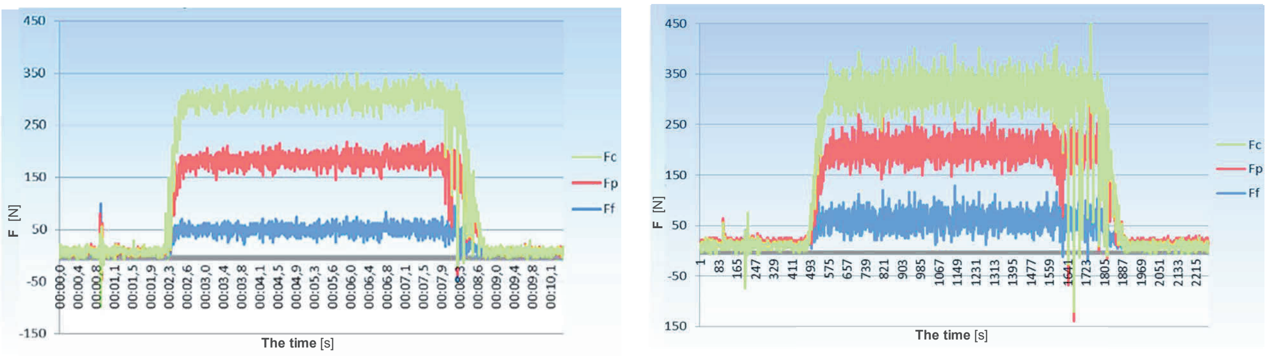


Figure 10 The measurement of cutting forces on the flange

Measured values, (**Figure 11**), show that the cutting forces of both materials differ only slightly, but the stability of the cutting process set by the size of the deflection of measured values of cutting force components from the central value is worse in the C56E2 material. This instability is related to higher value of ultimate strength of the material. The large fluctuation at the end of the cutting process is noticeable and scattered measurements in graphs is associated with an intermittent cutting of a place that is recessed and indicates the batch of material by letters due to an identification of units.



a) b)

Figure 11 The course of cutting forces during machining of material a) 100Cr6 and b) C56E2

4. CONCLUSION

By experimental methods we found out that the material C56E2 is more demanding in terms of machining, which we confirmed the hypothesis No.1. Wear of the cutting plate material during machining C56E2 was stronger than wear in case of the machining of the material 100Cr6. After a service life of cutting plates after machining of the both materials, the cutting plates were capable to cut the required quality but in case of increased wear of the cutting blade when machining the material C56E2, one can expect faster weakening of the cutting wedges and thus a related higher risk of a fracture of cutting edge plates. The course of roughness changed due to the bluntness of plates at the beginning of cutting and a formation of scraps and their breakage off. Roughness differences were minimal and by far they did not reach the value of the drawing. We supposed higher roughness on parts made of the material C56E2, according to the hypothesis 2, however, we also assumed its constant improvement, which was excluded by the measurement.

The presence of lamellar pearlite in the material C56E2 is a cause of higher abrasive wear of the cutting plate. Lamellar pearlite in the material 100Cr6 is excluded. The practical verification of hardness of the materials confirms us the higher hardness of the material C56E2 compared to the100Cr6 material. By measuring the time required to produce one unit we found out that the time to produce one unit on a lathe is 14.51 seconds. The period of the next drilling operations of the center is 16.98 seconds. From the measured periods it is clear that the operation of turning has still a time reserve. Therefore, by a slight decrease in feed of the machining material C56E2 the service life of the cutting plate can cope or even increase.

At a time when in the engineering world-wide people look for ways to save, the maximal production of lines still remains a priority. By means of a more sensitive evaluation of all aspects of the manufacturing process we can optimize a process under conditions to maintain its stability and reliability.

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