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TRIBOLOGICAL CONSIDERATIONS ON RWL 34 TOOLS STEEL

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Abstract: *The paper presents an analyze of the tribological testing on the RWL 34 tools steels in diffrent stages: untreated, hardened and hardened and tempered. The wear tests were made by ball on disk, which is an oscilating sliding method. Two types of materials were used for the counterbody balls, namely: steel (100Cr6) and alumina (Al2O3). The coefficients of friction, worn track sections, worn cap diameters and samples wear rates at diffrent loads (4 and 6 N) were measured. A comparation between all three stages of the material and parameters of the wear tests was made.*

Keywords: *tool steel, heat treatment, micro hardness, coefficient of friction, wear rate, worn track section*

1. INTRODUCTION

For grinding tea plants, knives of different shapes and sizes can be used. Metallic materials used in the manufacture of knives from milling mills have high carbon content to ensure adequate hardness. So we have a tool steel that has alloying elements such as chrome, molybdenum, vanadium, silicon, manganese, etc.[1]

To cut the dried plants, the knife has a high rotational speed and the cut of the knife from the grinder is strongly required. Due to the high rotational speed of the die knives and the permanent contact between the tool cutter and grinding material, the wear resistance of the cutter knife must be high. It is known that wear resistance is high hardness on the parts analyzed, so a high carbon content and a structure with high hardness.

Taking into account the working conditions, the grinding material, it is necessary that the hardness of the material from which the knife is made is as great and the resilience and ductility as possible. This is possible if the structural component is martensitic. It requires a very fine martensite, and this can be achieved by applying a heat treatment applied to the mill knife after being brought to shape and size.

The final heat treatments are applied to the products in order to obtain the necessary mechanical characteristics for use in service. Final heat treatments can be volumetric when heating and cooling takes place throughout the workpiece volume, or may be superficial when heating and cooling takes place to a certain depth [2].

In the case of mill knives analyzed due to the small dimensions, in particular the thickness, the heat treatment is in the volume (volumetric).

In Fig. 1 are presented the shapes of the mill blades from which were taken samples for this study.

Figure 1. The shapes of the mill blades analyzed

The final thermal treatment applied to obtain the martensitic structure is the martensite hardening and the annealing. Martensitic hardening applies to most steels can be applied to non-ferrous alloys or cast iron. The aim of heat treatments for martensite hardening is to obtain the martensitic structure that is a non-equilibrium constituent.

Annealing is necessary to reduce the tensions in the material even if hardness and resilience could decrease, increase ductility. The main purpose of heat annealing is to decompose the constituents out of balance, as martensite, into constituents closer to equilibrium such as annealing martensite. With structural transformations, partial and total internal tensions are also eliminated [4,5].

2. MATERIALS AND EXPERIMENTAL DETAILS

The material used for the research is sintered steel RWL34 with the composition presented in Table 1.

Table 1. Concentration in chemical elements

C [%]	Cr [%]	Mo [%]	Si [%]	Mn [%]	V [%]
1	13	4	0.5	0.5	0.2

According to the manufacturers of this steel, the heat treatment chart shows three important temperatures [6-11]:

- Austenitizing, temperature between 1050-1080^0 Celsius;
- Fast cooling, temperature between -16 and -18^0 degrees Celsius;
- Anneling treatment, temperature between 150-200^0 Celsius

The austenitization and cooling time below zero degrees Celsius is of the order of a few minutes and the anneling time of about 2 hours.

For the tribological tests a CSM Instruments tribometer was used and were set up the following parameters: method: ball on disk; material of the balls: 100Cr6 and Al_2O_3; diameter of the ball: 6 mm; acquisition: linear mode; amplitude: 6.00 [mm]; max lin. speed: 12.00 [cm/s]; normal load: 4 and 6 [N]; stop condition: 50.00 [m]; acquisition rate: 10.0 [hz]; temperature: 25.00 [°C]; Atmosphere: Air; humidity: 30.00 [%]. In order to study the worn track section and the worn cap diameter were used a Surtronic 25+ profilometer and a Nikon MA100 microscope equipped with NIS ELEMENTS software.

3. RESULTS AND DISCUSSIONS

In Fig. 2-13 are presented worn track sections respectively worn cap of the counter ball. All the microscopic images were at 75x magnitude.

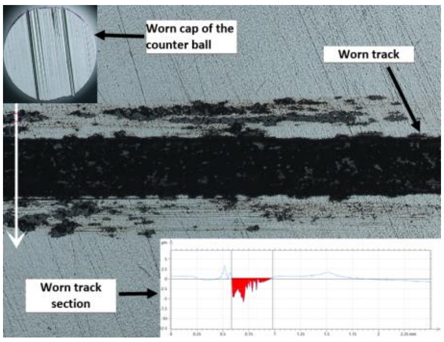

Figure 2. Tribological results of the RWL 34 steel against 100Cr6 ball (F=4N, untreated)

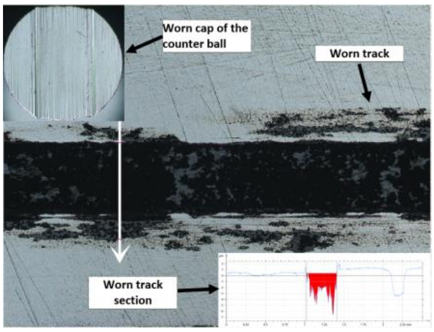

Figure 3. Tribological results of the RWL 34 steel against 100Cr6 ball (F=6N, untreated)

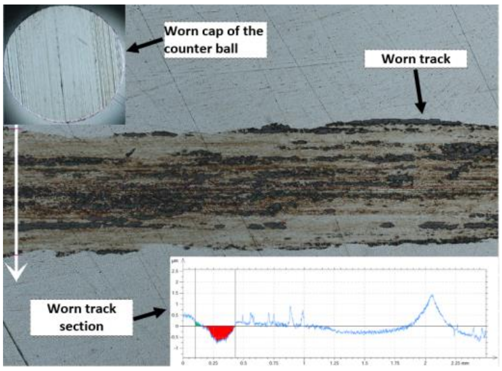

Figure 4. Tribological results of the RWL 34 steel against 100Cr6 ball (F=4N, hardened)

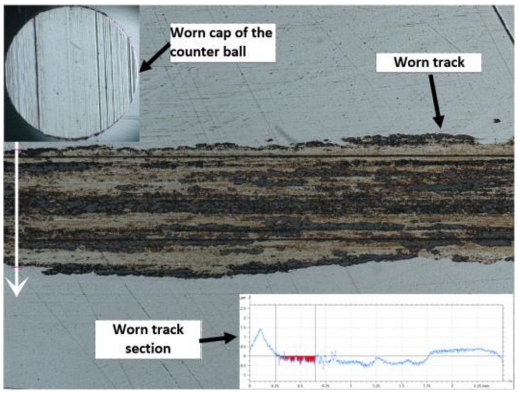

Figure 5. Tribological results of the RWL 34 steel against 100Cr6 ball (F=6N, hardened)

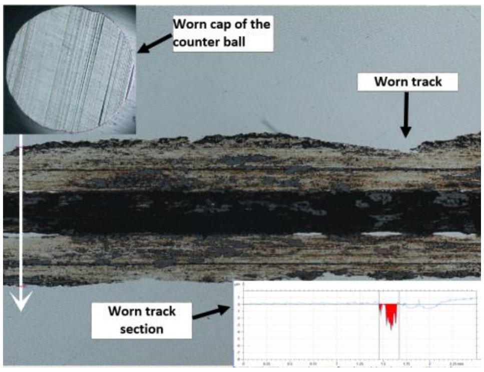

Figure 6. Tribological results of the RWL 34 steel against 100Cr6 ball (F=4N, hardened and tempered)

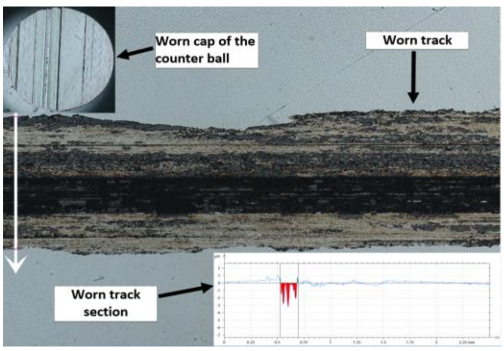

Figure 7. Tribological results of the RWL 34 steel against 100Cr6 ball (F=6N, hardened and tempered)

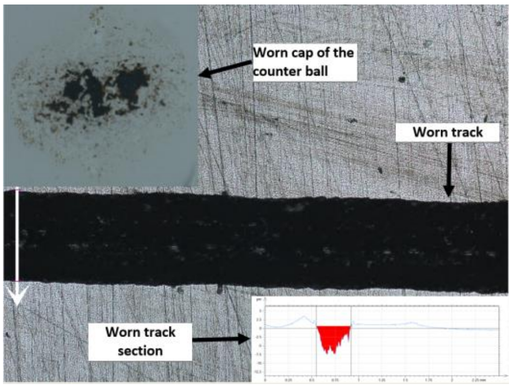

Figure 8. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=4N, untreated)

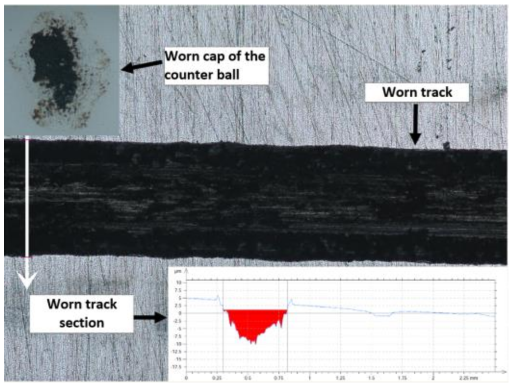

Figure 9. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=6N, untreated)

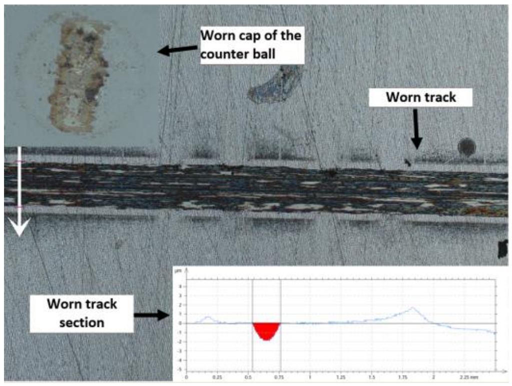

Figure 10. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=4N, hardened)

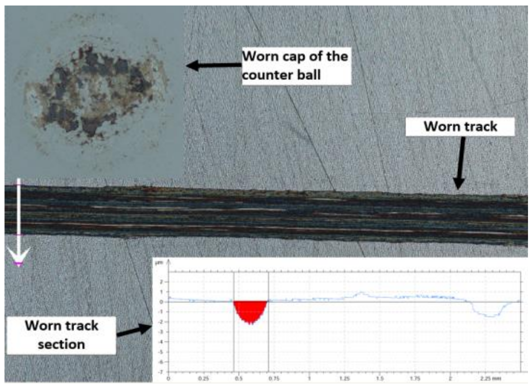

Figure 11. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=6N, hardened)

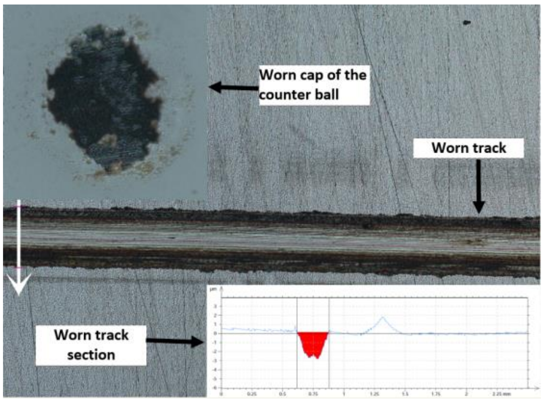

Figure 12. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=4N, hardened and tempered)

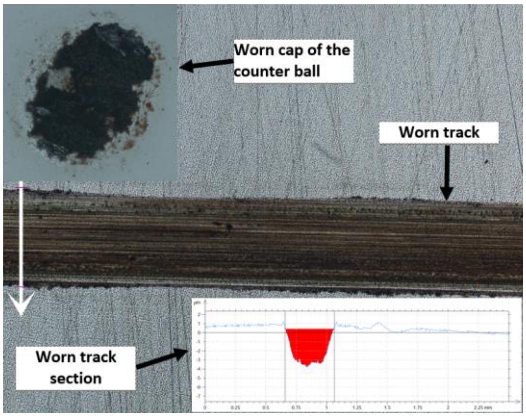

Figure 13. Tribological results of the RWL 34 steel against Al_2O_3 ball (F=6N, hardened and tempered)

In the Table 2-5 there are presented the values of the tribological parameters of the samples using the two types of the counterbody balls.

Table 2. Evolution of the worn track sections

Sample	Force [N]	Worn track section [µm^2]	
		100Cr6	Al_2O_3
untreated	4N	876.4	2088.8
	6N	1125.2	3181.4
hardened	4N	60.4	345.6
	6N	57.32	412
hardened nd tempered	4N	304.8	520.2
	6N	132.54	1143.8

Table 3. Evolution of the coefficients of friction

Sample	Force [N]	Coefficient of friction	
		100Cr6	Al_2O_3
untreated	4N	0.348	0.476
	6N	0.332	0.471
hardened	4N	0.320	0.466
	6N	0.297	0.462
hardened and tempered	4N	0.355	0.490
	6N	0.317	0.533

Table 4. Evolution of the wear rates of the samples

Sample	Force [N]	Wear rates [mm^3/n/m] *10^{-5}	
		100Cr6	Al_2O_3
untreated	4N	2.6290	6.2660
	6N	2.2500	6.3620
hardened	4N	0.1812	1.0370
	6N	0.1146	0.8239
hardened and tempered	4N	0.9143	1.5600
	6N	0.2651	2.2870

Table 5. Evolution of the wear rates of the counterbody balls

Sample	Force [N]	Wear rates of the ball[mm^3/n/m] *10^{-6}	
		100Cr6	Al_2O_3
untreated	4N	8.3530	0.7070
	6N	6.3090	0.8832
hardened	4N	6.5410	0.1215
	6N	4.9950	0.1049
hardened and tempered	4N	8.3610	0.2017
	6N	5.6820	0.3015

As it can be seen from fig.2-13, the worn track sections of the samples using Al_2O_3 as counter body ball are more clearly comparative with those were was used 100Cr6 counterbody ball. It is an advantage in the process of measure the worn track section with the profilometer. Also, the width of the worn obtained with Al_2O_3 balls are lower and uniform comparative with the worn obtained with 100Cr6 ball, which is irregular and present material debris from the ball. After the tribological tests, the counterbody balls made from 100Cr6 present a flat surface due to the scraping by the sample material, which is the cause of the high width of the resulting worn track section of the sample.

The forces used in the tribological tests influence the wear parameters and the higher value for the coefficient of friction was attained for the sample hardened and tempered, tested with a force equal to 6N and Al_2O_3 counter body ball. As it can be seen in Table 5, the wear rates of the Al_2O_3 ball are increase with the increasing of the load.

4. CONCLUSIONS

The experimental research leads to the following conclusions:

- The characteristics of the material used for milling knives after the heat treatment applied are in accordance with the expectations;
- Due to the presence of the debris which act as a counterbody, the values of coefficients of the friction are irregular in the case of 100Cr6 ball;
- In this moment milling knives subjected to the heat treatments from the present paper are in exploitation and will be monitored for an eventually modification of the heat treatment parameters or heat treatment cycle.

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