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COATING PROPERTIES OBTAINED BY THERMAL DEPOSITION USED IN CAMS/CAMS FOLLOWERS APPLICATIONS

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Abstract: *High inertial forces which occur in the distribution mechanism and certain operating regimes leading to deficitary lubrication can cause wear of contact in mechanism cam / cam followers. In this paper we present a new concept of thermal deposition of a 40Cr130 wear resistant material on a 18MnCr11R50 steel through a electric spark process. Friction and wear tests were performed using the CETR UMT-2 tribometre. To highlight the obtained results scanning electron microscopy analyzes were performed by using the QUANTA 200 3D DUAL BEAM electron microscope. To determine the profile and roughness of the wear trace the Form Talysurf I50 was used.*
Keywords: *CETR UMT-2 tribometre, friction, were, roughness, 40Cr130*

1. INTRODUCTION

Cams followers are components which insure the mechanical transmission of motion to the valve or to the drive rod as well as the takeover of the lateral forces produced by the cam. The cam followers used in current engines have a flat contact surface, for this reason they are called flat cam followers. In the gas distribution system the pourpose of the camshaft is to drive the valves through the cams motion in accord with the engine thermal cycle for every cylinder. The forces acting on the camhaft lead to bending, torsion and squeeze tensions at the cam level. The pourpose of applying a ceramic coating on cams is to reducing the coefficient of friction between the cam and cam followers significantly reducing the contact wear. The thermal deposition through a electric spark process leads to the possibility of obtaining layers with different thickness composition and surface quality.

2. EXPERIMENTAL PROCEDURE

This paper presents a new concept of thermal deposition which consists of a 40Cr130 deposited layer by electric arc using the Smart Arct 350 from Sulzer Metco. This layer has the pourpose of increasing the wear resistance especially the pitting, surface distress, delamination and spalling.
The QUANTA 200 3D DUAL BEAM electron microscop was used to highlight the obtained resultes. After each test cycle, the samples were removed, cleaned with a special solution in ultrasonic bath.
Electric arc deposition parameters are presented in Table 1.

Table 1: Technical parameters

Smart Arc 350	40Cr130
U	28V
I	252A
Air pressure	60PSI

3. EXPERIMENTAL RESULTS

The two samples were mounted on the device shown in Figure 1. The tests were performed in dry and in lubricated conditions with SAE 5W-30 Audi Original oil, with a viscosity of 51.7 mm^2/s at 40°C in according to the ASTM D-445 standard.

Figure 1: The way how the sampled is mounted on the CETR UMT-2 tribometre:
a) the samples subjected to friction wear without lubrication;
b) the samples subjected to friction wear lubrication.

The experimental tests were performed with CETR UMT-2 tribometer with a pin-disc test system [1]. We used a pin with a diameter of 6,3 mm and a disc sprayed with 40Cr130. At a radius of 10 mm from the center of the disc a normal pressures forces with a value $F_z = 10$ N was applied through the pin, for a period of 10 minutes. Tests were performed both under dry friction wear and lubrication conditions.
Since the deposited layer surface roughness is very important, it was measured before and after the abrasion test to estimate all the wear resulting from friction [2]. In Figure 2 is presented the mounting of the sample in order to determine the roughness of the layer.

Figure 2: The mounting of the sample on the stand to determine the roughness of the profile

In Figure 3 is presented the mounting of the sample in the working room of the microscope [3].

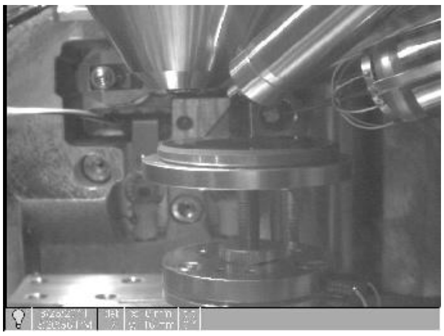


Figure 3: The mounting of the sample in the working room of the microscope

Images were acquired with the microscope on used samples in different areas, including on the wear trace. The microscope worked in the High Vacuum module, with a pressure of $5.33 \cdot 10^{-3}$ Pa, using the ETD (Everhardt - Thornley Detector) and an accelerating tension of the electron beam of 20kV. The magnifying power of the microscope was in the range of 80X - 5000X, with a working distance (the distance between the sample and the electron cannon) of 15 mm. Apart of the SEM images there also EDS elemental chemical analyses were made, for the pourpose of evaluating the state of the coating wear due to the friction test.

3.1. The analyses performed on the samples subjected to gry friction wear

In the figure 4-a it can be noticed that the width of the running track is between 685 µm - 731 µm, and in the Figure 4-b is observed that in the surface layer changes occur in the meaning of pitting traces. In Figure 4-c its shown the pitting wear trace, at the magnifing power of 5000X [6].

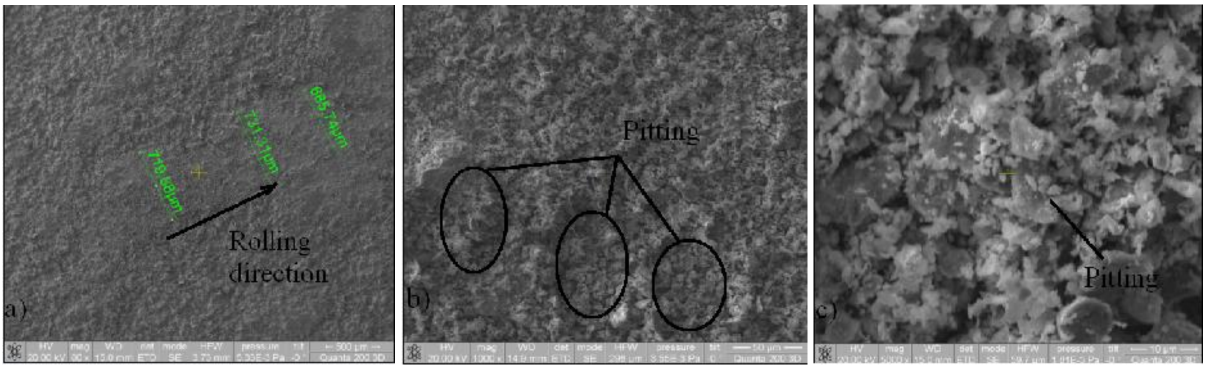
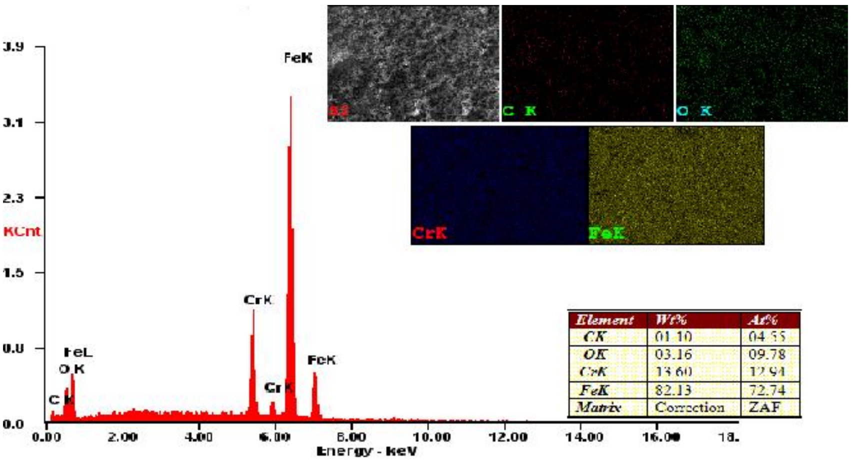


Figure 4: The appearance and dimension of the wear trace resulted after dry friction test:
a) 80X, b) 1000X si c) 5000X

In the distribution map from Figure 5 it can be seen that besides the wear produced on the sample, on its surface there are present traces of iron, this happens because of the particles resulting from the wear of the pin which adhere on the samples surface.



Element	Wt%	At%
CK	01.10	04.55
OK	03.16	09.78
CrK	13.60	12.94
FeK	82.13	72.74
Matrix	Correction	ZAF

Figure 5: Map distribution of the elements and EDS analyses of the wear trace

In the Figure 6 it's presented the variation of the friction coefficient under dry frictrions conditions with a apllied normale force of 10N. In the begining of the test the friction coefficient has a accelerated downward tendency down to a value of 0,17, then has an upward tendency until it reaches the value of 0,3, at which it stabilizes, and in the final part of the test it rises to the value of 0,42 [3].

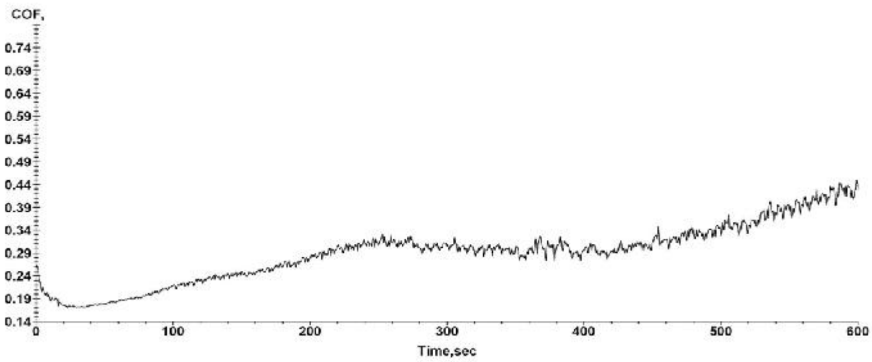


Figure 6: The variation of the friction coefficient from the pin-disk test with dry friction conditions

Figure 7 presents the scanned tested sample after the dry friction test. A wear depth of 80 µm can be observed in the picture.
The shape of the channel due to wear is achieved with the Login Form Talysurf 50 profilometer, produced by Taylor Hobson, England.

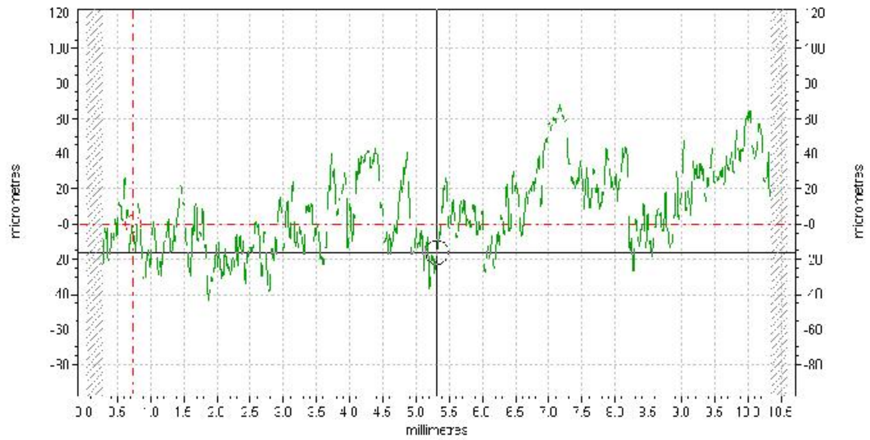


Figure 7: The shape of the wear trace under dry friction condition

Figure 8 shows the roughness analysis on a LS-Line profile. The arithmetic mean deviation of the roughness profile Ra is evaluated to 12,4745 µm. The standard deviation of the assessed roughness profile Rq is 15,2887 µm and the average height of the roughness profile is measured to Rz = 70,1730 µm [6].

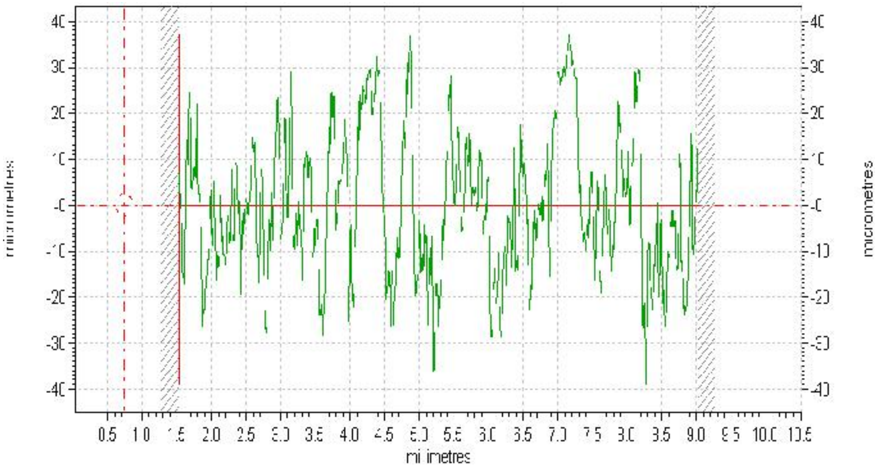


Figure 8: The roughness values of the sample in dry friction condition

3.2. The analyses performed on the sample subjected to lubricate with ester-containing oil sae 5w-30 audi original

In Figure 9-a is observed that the width of the wear track is between 336 µm - 374 µm, but on the surface of the layer, shown in Figure 9-b, a smoothing appears. In Figure 9-c it can be seen that the layer has ompacted as a result of the wear test. There are no traces of pitting on the layer [6].

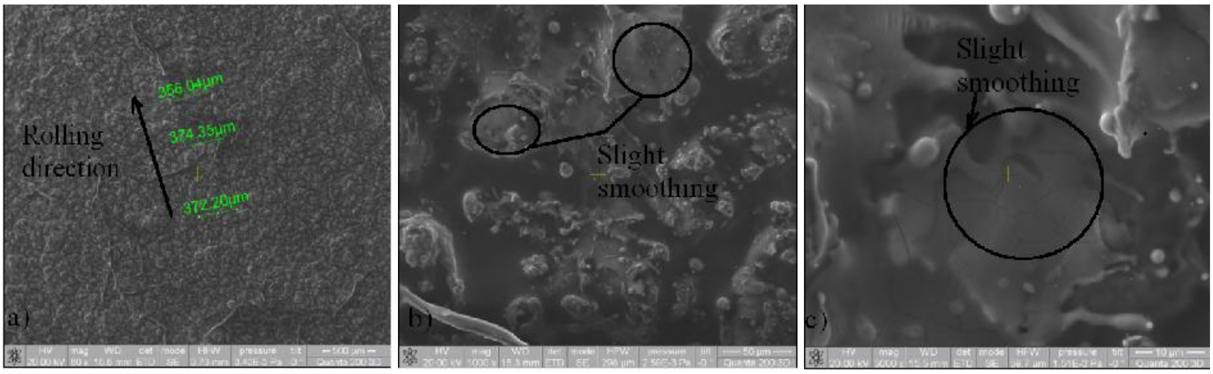


Figure 9: The appearance and dimension of the wear trace resulted after lubrificated friction test:
a) 80X, b) 1000X si c) 5000X

The fact that wear didn't occur in the deposited layer is also shown by the EDS chemical analysis presented in Figure 10, in which the presence of Cr, O_2, C and Fe in the analyzed areas can by observed. The distribution map presents a uniform distribution of elements. Also this time in the surface of the deposited layer traces of iron are present, this is due to the fact that particles resulting from wear of the pin adhered to the sample surface.

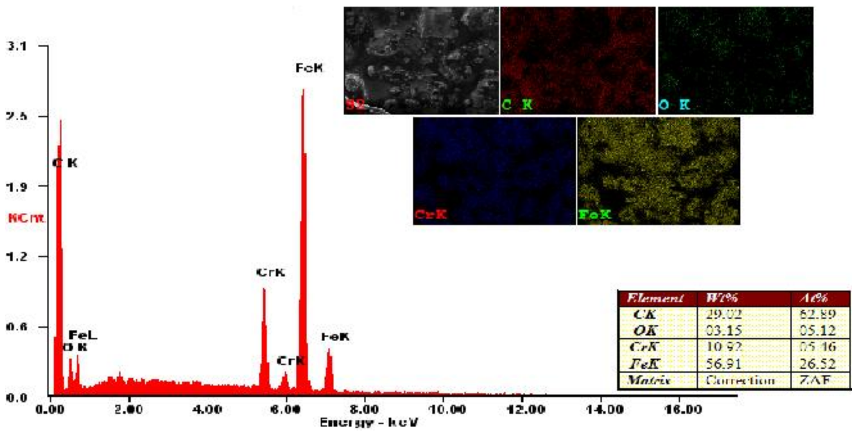


Figure 10: The distribution map of the chemical elements and the EDS analyses

In Figure 11 can be seen the evolution of the coefficient of friction during the friction test in the presence of lubricant. The friction coefficient presence a downward tendency in the beginning of the test from the value of 0,16 to 0,13, after this value it is approximately constant until the end [3].

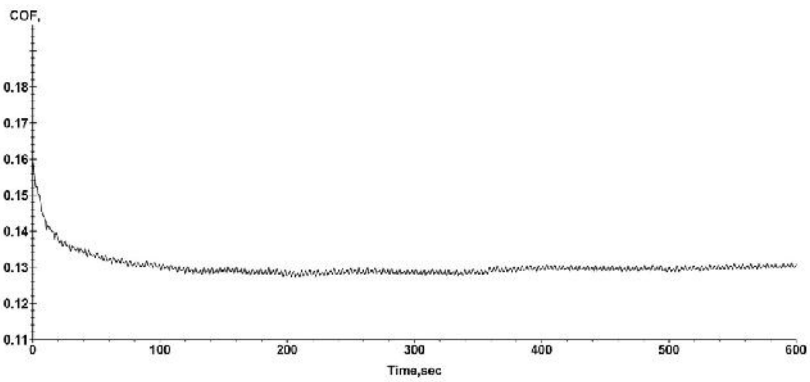


Figure 11: The variation of the friction coefficient from the pin-disk test in lubricant friction conditions

In Figure 12 is presented the scann of the tested sample. In the case of the sample subjected to friction with lubricant in the contact area the depth of the wear trace is very low, fact that is show in the profilometry. Wear depth is only 60 µm. Compared with the shown in Figure 7 a very good adherence and stability in presents for the layer tested with lubricant. The depth of wear is reduced by half.

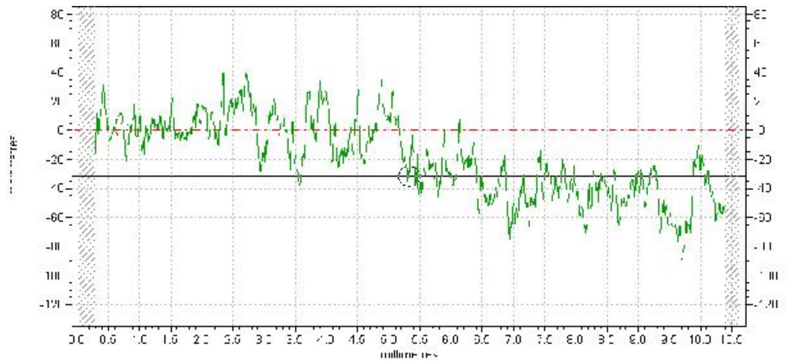


Figure 12: The shape of the wear trace under lubricant friction condition

Figure 13 shows the roughness analysis of a LS-Line type profile. The arithmetic mean deviation of the roughness profile R_a is evaluated to 11,3891 µm. The standard deviation of the assessed profile roughness R_q = 14,0036 µm and the average height of roughness profile is R_z = 67,1976 ìm.

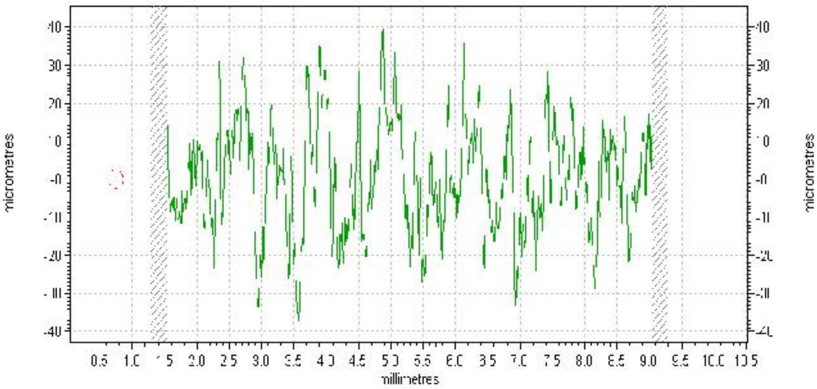


Figure 13: The roughness values of the sample in lubrificant friction condition

4. CONCLUSIONS

In the case of dry friction pitting wear had occurred with the thickness of the wear trace between 685 µm - 731 µm. For the sample subjected to friction in presents of the SAE 5W-30 Audi Original lubricant with a viscosity of 51,7 mm^2 /s at 40°C, the wear on the surface is present but has a very small value.
From the elemental chemical analyses and the distribution map performed on the sample in cam by concluded that in both cases wear did occurred and material from the pin adhered to the layer.
The variation of the friction coefficient is higher for the sample subjected to dry friction at the beginning of the test with a downward trend accelerated up to a maximum value of 0,17, and has a tendency to rise to around 0.3 at which is stable. In the last part of the test the coefficient of friction increases to around 0,42. In the case of friction with lubricant the friction coefficient tends to decrease rapidly from 0,16 to 0,13, and then remains constant around this value.
Following the performed tests it can be concluded that the samples subjected to friction in the presence of a lubricant behaved very well to wear, hence we conclude that a coating based on 40Cr130 deposited on the camshaft would lead to an improvement in its functioning in terms of contact wear due to the friction to the cam follower.

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