

COATINGS PROPERTIES OBTAINED BY THERMAL DEPOSITION USED IN GEARS APPLICATIONS

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Abstract: *Gears tooth are subjected to fatigue and bending. In operating, on the tooth flanks gears appears a wear type pitting. The geometry, can't be modified that is why we decided to modify the contact surface by thermal deposition of an addition material. We made a detailed study of the literature and we decided to use an usual steel which we coated with powder by electro spark process. We have chosen the OLC 45 steel and we coated it with WC. After we obtained the samples, we subjected them to bending tests in order to determine the bending stress and the elasticity modulus. On SEM analysis we obtained the image and the quality of the coatings. The results showed how the coating increases the properties of the basic material.*

Key words: *bending, elasticity modulus, SEM, coating.*

1. Introduction

The Electro-Spark Deposition (ESD) uses energy stored in capacitors that transfer to a consumable electrode of carbide (W, Ti, Cr, etc.), stainless steel, inconel, aluminium etc. for a long duration short of 1/1000 seconds. spark at the electrode tip temperature is between 8,000 and 25000 °C, the material (electrode) ion is transferred to the substrate surface, producing an alloy with a deposit more than this and allied interface electrode - substrate. Plant material applied to the electrode by spark deposition process.

electrode under the action of spark, it consumes the substrate surface, but due to very high temperature, melt layer of workpiece material and allies with the electrode, resulting in an alloy of two layer-substrate material at the interface. Thus the material is deposited both on the surface of the substrate, as well as its depth.

Thermal deposition have been made under normal conditions of temperature, pressure and humidity.

We have made rectangular samples with dimensions 25x10x2. After that, cleaned and degreased them to be later covered.

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After we coated the steels, we analyzed them in order to establish their characteristics. We accomplished the materials analysis both qualitatively and quantitatively.

2. Experimental

The experiments described in this paper have been accomplished in order to determine coatings properties used in gears applications.

2.1. Bending Test

For Bending Test, we used the device named Deben Microtest Materials Tensile/Compression/Bending 2KN/5KN testing, showed in Figure 1.

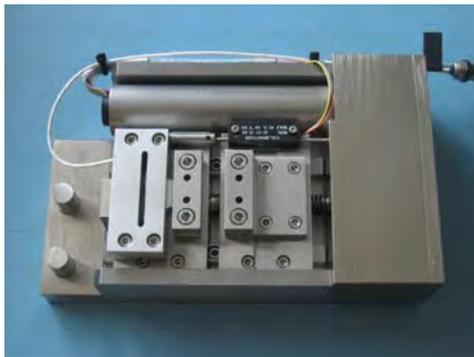


Fig. 1. *Deben Microtest*

Deben Microtest facility and also three / fourpoint bending, have an important role in understanding and estimating the mechanical properties of materials.

Deben Microtest modules is specifically designed to allow real time observation of the high stress region of a sample with an SEM, optical microscope, AFM or XRD system. In our analysis we used a stereomicroscope with a magnification of 50x.

Computer's software is setting the drive parameters and displays on the computer

screen the variation of the strain with the load, the stress/strain curve live.

Loadcells from 2N to 5KN cover most applications, with extension rates from 0.005 mm/min to 50 mm/min. All stages have linear scales for elongation measurement and optical encoders for speed control. Options include three and four point bending clamps, fibre clamps and microscope mounting adaptors. All modules are controlled from Microtest tensile testing software.

2.2. SEM analysis

The microstructures, have been taken by Electronic Microscope SEM Quanta 200 3D, which works with double electron and ion beam and it maximum magnification is 3000000x. The electronic microscope has 3 detectors of secondary electrons, optimized for each way of vacuum, 2 spread electrons detectors, optimized to work on all pressure domains, and one spread electrons detector for special experiments, which involves sample warming until 1000°C. It provides simultaneous presentation of secondary electrons images and of spread electrons on every way of work.

SEM Quanta 200 3D has an EDAX module with the possibility of EDS analysis and crystallographic recognition, and is shown in Figure 2.



Fig. 2. *SEM Quanta 200 3D*

3. Results and discussion

To have a live observation of the material's microstructure, we mounted the Deben Microtest device under the stereomicroscope objective.

We have done all the parameters settings and we started the test, with a careful attention on the stereomicroscope in order to stop the device when the first crack appears.

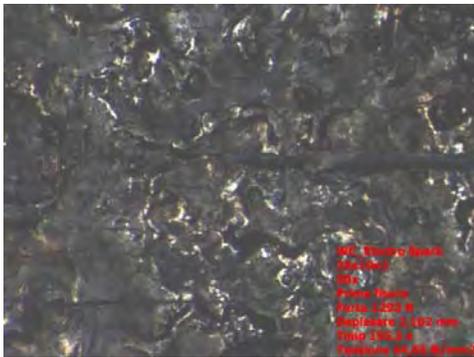


Fig. 3. WC coating microstructure, at 50x, when the first crack appeared

We were observing the microstructure modification under the bending strength, and when the first crack appeared, we have stopped the device, and we have taken a picture of the coating microstructure, shown in Figure 3. Deben Microtest software, showed us automatically on the computer, that the force was 1293 N and the material's stress was 64.65 N/mm^2 .

Electro-Spark Deposition (ESD) uses a consumable electrode of W carbide which is ionized and transferred to the substrate surface, producing an alloying with the it.

In Figure 4, could be observed WC coating microstructure, at the end of Bending Test, when the force is 265 N and the material's stress was 13.45 N/mm^2 .

The crack propagation is bad, in a very short time, the sample destroyed, as it is shown in Figure 5.

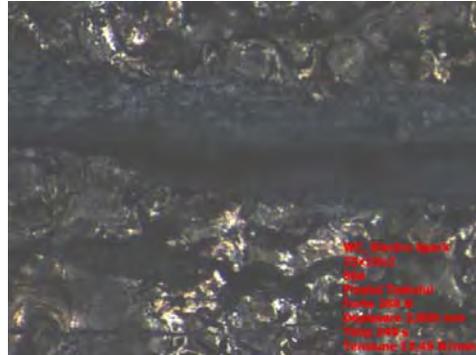


Fig. 4. WC coating microstructure, at 50x, at the end of Bending Test

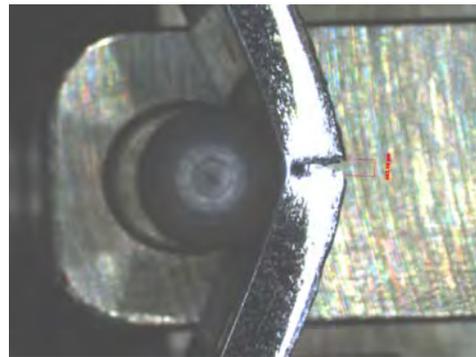


Fig. 5. WC coating transversal microstructure, at 50x, at the end of Bending Test

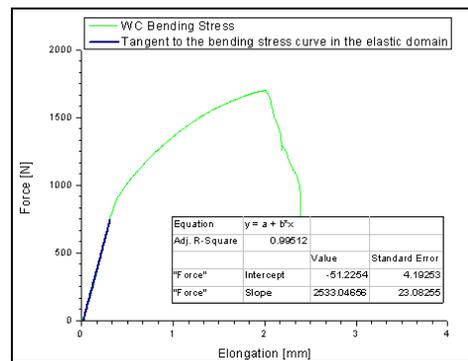


Fig. 6. Mo coating Bending Stress

Result of Mo coating Bending Test is a Hooke type curve, shown in Figure 6.

$$E_{Mo} \approx 253 \text{ GPa.}$$

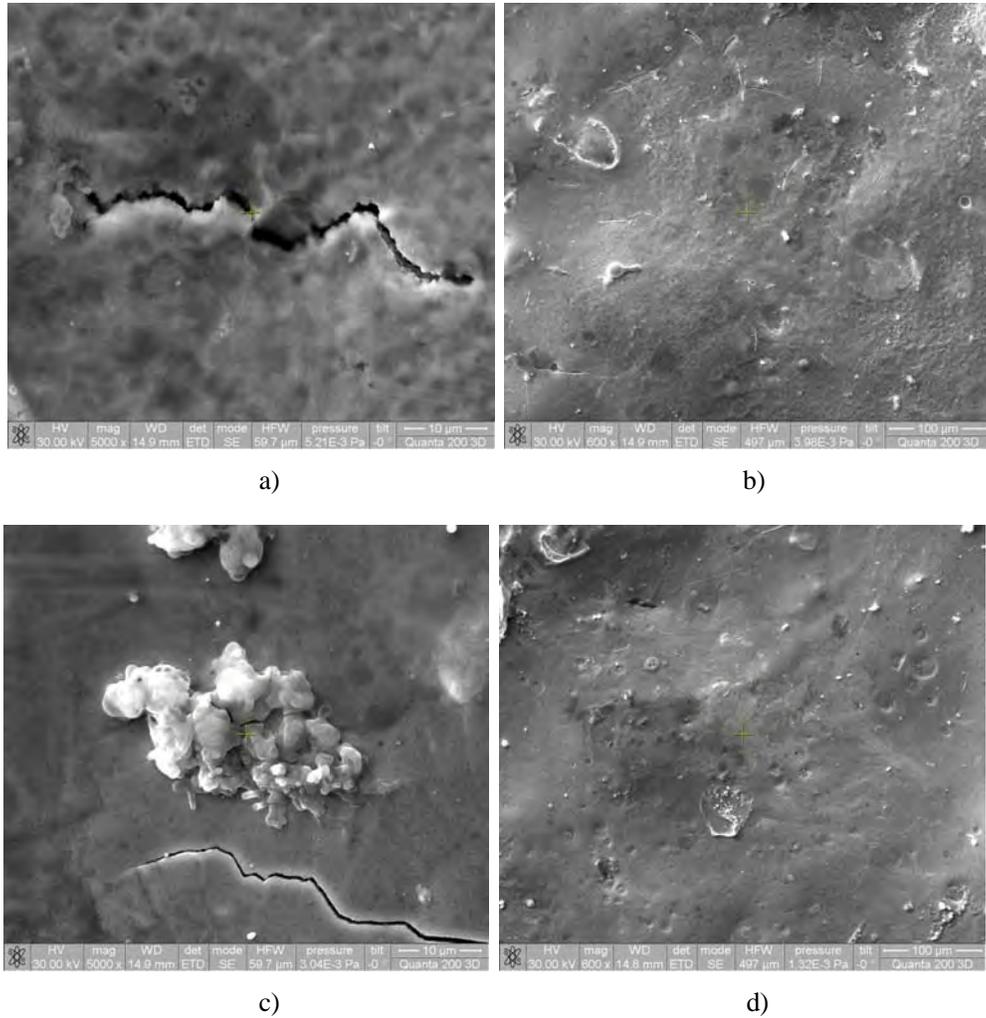


Fig. 7. WC coating SEM microstructure before bending

In Figure 7, could be observed the SEM microstructures of WC coating obtained by SEM Quanta 200 3D before bending test.

WC coating has the best adhesion with the basic layer because the interface between two materials of alloying occurred between them.

In Figure 7 a), could be observed a microcrack in the coating, appeared most likely in the deposition process due to heat

transfer. In Figure 7 b), c) and d) could be observed some unmelting particles due to electrode material transfer.

Microstructure of surface coating is dense, compact, but has some unmelting particles. Coating was not achieved with multiple passes, therefore, microstructure is very dense compact.

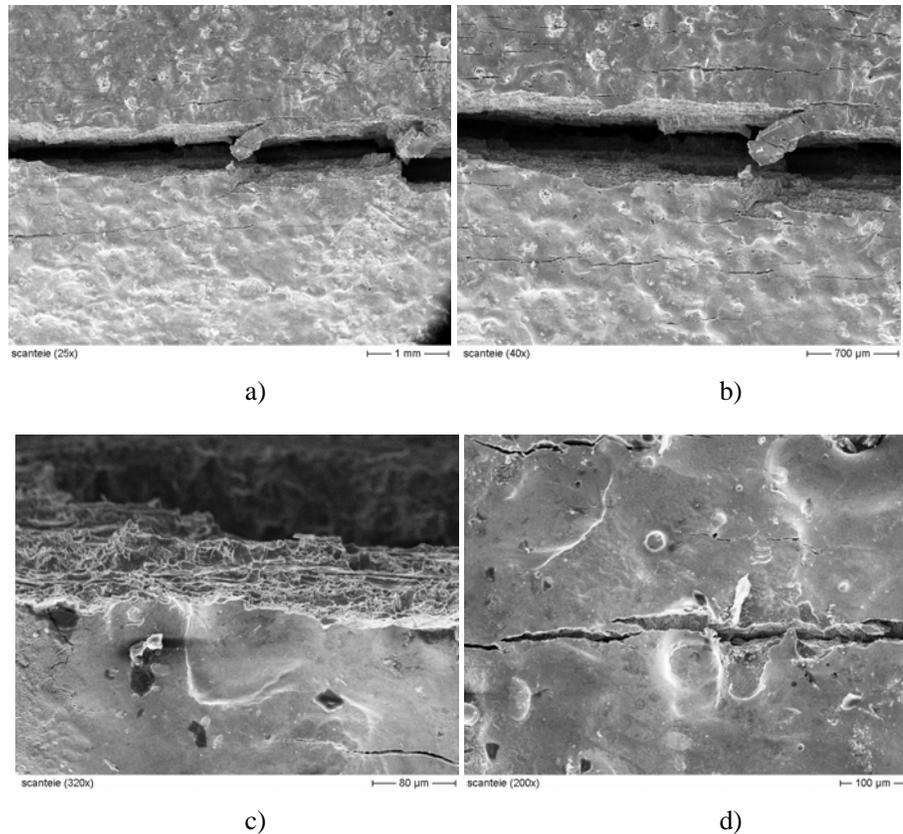


Fig. 7. WC coating SEM microstructure after bending

The addition material is applied on the substrate by spark deposition process. The electrode under the spark action, it consumes on the substrate surface, but due to very high temperature, is melting the superficial layer of the substrate which allies with the electrode's material, resulting an alloy of them at the interface.

Thus the material is deposited both on the surface of the substrate, as well as its depth.

In Figure 7, could be observed the SEM microstructures of WC coating after bending test. Figure 7 a) we could observe the crack with some fragments of material, which gives us the information that the material is fragile. The crack propagation in sectional area is very high, because the

material is hard. We can say that the stresses propagation are higher in cross-section of the coating, because the sample destroyed.

We focused on material and we have taken pictures at diferent magnifications, showed in Figures 7 b), c) and d), where the detailes are relevant.

4. Conclusions

In this paper we have studied the WC coating on steel substrate, obtained by ESD process used in gears applications.

The results of Bending Test showed that the bending stress's curve is type Hooke, so we can say that the basic material (steel) is the one who dictates the behavior at this

type of request.

Steel has the elasticity modulus of 210 GPa, but the coating, increased it until the value of 253 MPa.

We can conclude that the material is harder and stronger than the steel, but when it fails it destroys completely.

We obtained an elasto-plastic material, which can resist to a force of 1293 N and a stress of 64.65 N/mm².

On SEM analysis we observed that the coating is homogeneous, but has some unmelted particles due to the deposition process. Even in this case, after Bending Test, we realized that the material has a good behaviour until almost 1300 N and after that it destroys, because the crack propagation is in coating depth.

Acknowledgements

This paper was financially supported by EURODOC project, "Doctoral Scholarships for research performance in Europe", financed by the European Social Fund and the Romanian Government.

References

1. Munteanu C, Lorenz P, Bărbîntă C-I, Pipa G-R, Bistriceanu I, A-C and Axinte C: *Using X-Ray diffractometer to determine the rail breaking causes*. In: MODTECH Proceedings 2011.
2. Bărbîntă C-I, Munteanu C, Pipa G-R, Lorenz P, Chicet D, Bărbîntă A-C and Axinte C, *A railway rail fracture expertises using the electronic microscopy*. In: MODTECH Proceedings 2011.
3. C Axinte, D-L Chicet, I-L Bistriceanu si C Munteanu, *Materials specific to gears used in automotive industry*. In: Bulletin of the Politechnic Institute of Iasi (2010).
4. I-L Bistriceanu, D-L Chicet, C Axinte si C Munteanu, *Wear test and SEM analysis for CP-Ti air oxidised samples*. In: Bulletin of the Politechnic Institute of Iasi (2010).
5. D-L Chicet, I-L Bistriceanu, C Axinte si C Munteanu, *APS coating used to improve life of bearings*. In: Bulletin of the Politechnic Institute of Iasi (2010).
6. C Axinte, C Munteanu, A-C Bărbîntă si E-S Bârca, *Gears materials analysis in order to establish the mechanical properties*. In: ROTRIB'10 Proceedings, Bulletin of the Politechnic Institute of Iasi (2010).
7. C-I Bărbîntă, C Munteanu, C Axinte, D-L Chicet si A-C Bărbîntă, *The influence of the metallographic characteristics of R7T steel on railway wheels durability*. In: ROTRIB'10 Proceedings, Bulletin of the Politechnic Institute of Iasi (2010).
8. Munteanu C, Rusu I, Susan M, Pelicuda M, *Dimensional ununiformities and electric resistivity variation in amorphous ribbons from Fe80-xSmxB20 and Fe(80-x)GD(x)B(20) systems*, In: Journal of materials science engineering and technology, 1997.
9. Munteanu C, Rusu I, Luca D, Ciofu AM, *Studies concerning the mobility of the magnetic domains structures from the metallic amorphous ribbons from Fe37.5Ni32.5-xCr5CoxB15Si10 system*. In: Journal of materials science engineering and technology, 1997.
10. Munteanu C, Rusu I, Jianu A, Apachitei I, Ciochina C, *Properties using metallic amorphous ribbons from (Fe-Co-Ni)metalloid system, obtained by melt-quenching*. In: Journal de Physique IV, 1993.