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# EROSION PROTECTION OF PULVERIZED BOILER COAL PREPARATION EQUIPMENT

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## ABSTRACT
*Problem of boiler component erosion is a very complex and present in practically all fossil fuel power plants burning low heating value coals irrespective of their particular design and operating characteristics. Major fly coal erosion accelerating factors are large amounts of abrasive components in the air-coal mixture and its high velocity. In general terms, there is a trend of implementation of appropriate erosion protection in critical place of pulverized boiler coal preparation equipment. In this paper are presented results of erosion tests provided on samples with different erosion protection materials. Erosion damage profiles of different protection materials were investigated and analyzed on tested samples.*
**Keywords:** Erosion, Protection, Fossil Fuel Power Plants

## 1. INTRODUCTION
Erosion of different components of thermal power plants burning lignite of very low heating value and containing a high concentration of residual mineral material in the ash, is presented in the units for feeding, preparation and burning of fuel considerably shortens the equipment lifetime. The solution of this problem requires consideration of the erosion conditions and erosion resistance of material. For modern and competitive thermal power systems in the world, the protection of equipment components is realized with a great success using thermally sprayed coatings that is metallization.
The aim of this work is microstructural characterization after erosion test of two types of materials deposited on the substrate by selected thermal spraying method and one type of material deposited by weld overlay method.

## 2. EXPERIMENT
Cold spraying was selected as the metallization method. Cold metallization is a process whereby the small solid state particlees (1-50 μm) accelerated at high velocity (300-1200m/s) forms on substrate (base material) a coating by impact [1-3]. For the purpose of this work, a low-carbon structural steel (0.17%C-max 0.05%P-max 0.05%S-0.00%N – Č0361, JUS) was selected as the base material - substrate for coating deposition. The steel samples with dimensions 150x150 mm$^2$ were cut using plasma cuter and polished to obtain flat surfaces. On two sample the coating was deposited by arc spraying of a wire ARC 502 as well as wire ARC 595 using EuTronic Arc equipment whereas for the third sample the coating was realized using CDP - "CastoDur Diamond" material deposited by weld overlay method.

*Table 1: Materials used for deposition*

| Material | | Characteristics | | | |
|---|---|---|---|---|---|
| Type | Description | Hardness, HV | Spec. bond. stren., MPa | $T_{max\ wor.}$ °C | $d_{layer}$, mm |
| ARC 502 | Fe, Cr, C, Co and Ti alloy for erosion protection at elevated temperatures | 570 | 35 | 600 | 1 |
| ARC 502 | Fe, Cr, C, Co and Ti alloy for corrosion/erosion protection at elevated temperatures | 1200 | 40 | 600 | 1 |
| CDP | Alloy contain matrix hardened by Cr, Nb and W carbides | matrix:750-800HV carbides: 2400 HV | | | 4 |

*Table 2: Cold spray parameters*

| Voltage | Current | Air pressure | Distance from working piece | Deposition velocity |
|---|---|---|---|---|
| 40V | 280A | 3,5bar | 180mm | 6kg/h |

Erosion test was done using sand blasting equipment, Fig. 1, with parameters given in Table 3.

Table 3: Erosion test parameters

| Parameter | Characteristics |
|---|---|
| Type of erodent | quartz ($SiO_2$) |
| Erodent granulation | up to 1 mm |
| Velocity of erodent particles | 40m/s |
| Carrying gas | air |
| Pritisak kompresora Compressor pressure | 3,5 bar |
| Erodent velocity * (mean value) | 25 m/s |
| Nozzle diameter | 8 mm |
| Angle of erodent attack | 45° |
| Distance between nozzle and sample | 370 mm |
| Erosion test duration | 10 min |
| Temperature | 23°C |

*Figure 1. Erosion test*

**3. RESULTS**

The macro view of the samples of selected materials before and after erosion tests are shown in Table 4 whereas the weight loss following the erosion tests are given in Table 5.

*Table 4: Macro view of investigated samples before and after erosion test*

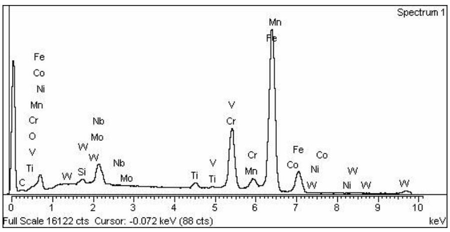
| Č0361 | Č0361+502 | | Č0361+595 | | Č0361+weld overlay | |
|---|---|---|---|---|---|---|
| After erosion test | Before erosion test | After erosion test | Before erosion test | After erosion test | Before erosion test | After erosion test |
|  |  |  |  |  |  |  |

The macro view of the damage following erosion tests has an elliptic shape with clearly visible edges in the samples with the metallization deposited coatings. In the samples with a welded layer, the damage zone has an irregular shape and uneven dimples most probably as a result of geometry of welded layers. Considering that the testing conditions for all three samples were the same, the observed difference in the damage features can be correlated with the coating density, cohesion strength between the grains as well as the erosion mechanism itself.

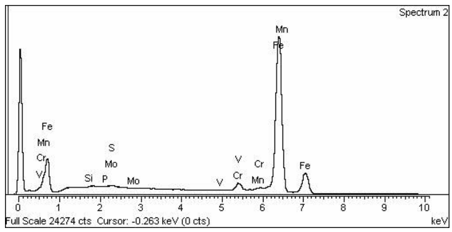
*Table 5: Weight changes of investigated samples after erosion test*

| Material | Sample weight before erosion test, g | Sample weight after erosion test, g | Weight loss, g |
|---|---|---|---|
| Č0361 | 1225 | 1200 | 25,35 |
| Č0361+502 | 850 | 805 | 45,00 |
| Č0361+595 | 805 | 770 | 35,00 |
| Č0361+CDP | 830 | 805 | 24,80 |

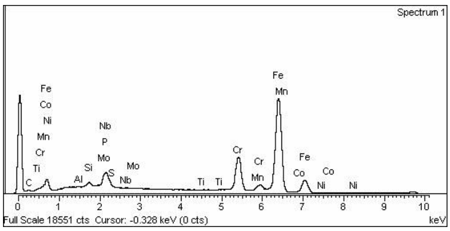
For the given testing conditions, the weight loss in the unprotected metal and the weld overlay samples are lower than in the samples with metallization protection. Based on these results, it should not be concluded that the metalized layers are of not so good quality characteristics, but rather that for the given erosion parameters the higher density materials have the advantage in erosion resistance.
Figures 1-3 depict the EDAX analyses of the samples with the 502 and 595 coatings, that is, with the welding overlayers. In all cases it is apparent that in the micro zones the presence of a complex type of material in the sense of chemical composition with numerous carbide-forming elements is noted.




*Figures 1. EDAX analyse of 502 metallized layer*



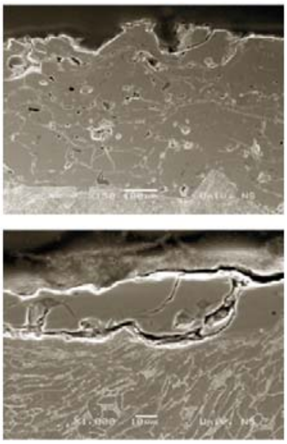

*Figures 2. EDAX analyse of 595 metallized layer*



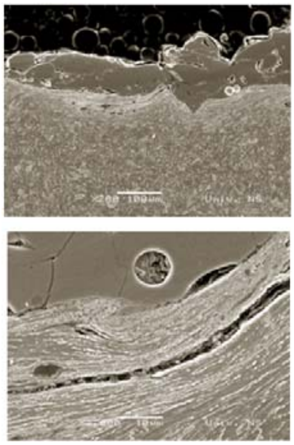

Figures 3. EDAX analyse of welding overlay (CDP)

## 4. MICROSTRUCTURAL CHARACTERIZATION

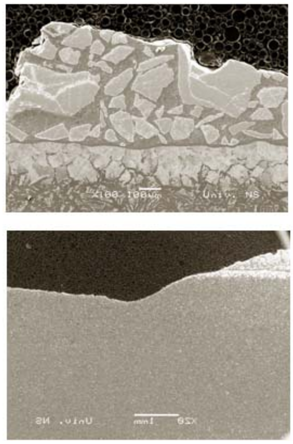
Microstructural characterization was carried out on the sample cutted from the erosion affected zones. All samples were prepared in the same manner, by grinding, polishing and etching followed by gold coating used to improve the quality for structural examination with the Scanning Electron Microscope (SEM).
Based on the microstructure of the metalized samples Figs. 4-9, it can be concluded that a very good bonding quality between the substrate and coating was attained. This is an indication that the cold spaying deposition parameters with a wire are properly selected. The coating microstructure is characterized with fine polycrystalline lamellar grains with thickness in the range 10–20μm and very low oxide inclusions and undeformed grains as well as satisfactory porosity in the range 3 – 6.5% depending of selected area. The hardness of metallized coatings is in the range 62–69HRC. Also, the deformation of surface layers of the base material are noted following the erosion tests. The thickness of deformed layer is in the range 10 - 60 μm. During the erodent action, the cold sprayed material grains are fractured and the bond between the particles is lost resulting in their separation from the substrate.



*Figures 4-5. Cross section of 502 sample before and after erosion test*



*Figures 6-7. Cross section of 595 sample after erosion test*



*Figures 8-9. Cross section of CDP sample after erosion test*

From the SEM images of the CDP sample with a weld overlay shown in Figs. 8-9 it is clear that there are 3 distinguished regions: base material, heat affected zone and weld overlay. Even with this type of protection, the materials removal is not uniform due to the presented phases (matrix and carbides) with different hardness values and thus erosion resistance.

## 6. COMMENT

Considerable economic savings, reduced outages and extending the repair time of damaged equipment can be realized using modern methods of erosion protection of thermal power equipment. It is clear, however, that the same process of erosion protection cannot be applied with the same degree of success to different types of equipment since neither the equipment nor the operating conditions are the same. Therefore, erosion testing are essential in order to determine what equipment and operating conditions can be used to achieve the best results for the specific type of erosion protection. In this work are presented partial results of a much wider testing efforts dealing with the erosion behavior of three types of deposited materials: cold spray method used on two samples and weld overlay method on one sample. For the given testing conditions, the material sample protected by weld overlay showed the best erosion resistance.

## 7. REFERENCES


[1] Braunovic, M., Sijacki Zeravcic, V., Bakic G., Djukic M at all., Boiler Tube Erosion in Power Plants, CEATI Report N$^{o}$ T052700-0122, CEA Technologies Inc., Canada, 2006

[2] Joachim Rosler, Mechanical Integrity of Thermal Barrier Coated Material System, Adv. Eng. Mat. Communic. 2005, 7, No. 1-2, pp 50-54

[3] F. Gartner, T. Schmidt, T. Stoltenhoff, H. Kreye, Recent Developments and Potential Applications of Cold Spraying, Adv. Eng. Mat. Reviews DOI: 10.1002/adem. 200600048, pp 611-618