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INVESTIGATION OF ABRASIVE WEAR RESISTANCE OF ELECTROSPARK DEPOSITED (ESD) COATINGS FOR DRUM MOWER BLADES

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Electrospark deposition method creates thin coatings with high hardness. This property of coating is very useful for abrasive wear resistant material. For our research the coatings produced with the help of three different electrodes were used for laboratory and field tests. Laboratory test was made by ASTM G65-94 standard method. Field tests were performed with drum mower. For these test we covered mower blades in the same electrodes and conditions as laboratory test. During field test it was found that blades covered only on back side has lower wear than covered only on front side. Also it was found that blades covered on back side has sharper cutting edge.

Key words: electrospark deposition, abrasive wear, drum mower.

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Introduction

Electrospark deposition is micro welding process. During this process electrode (anode) material is placed on substrate (cathode) material. This process is used for creation of a coating with very high hardness which is effective for abrasive wear resistance. In India was tested wear characteristics of rotavator blades (Chelpuri R. 2016). Experiments made with soil where is extremely abrasive and accompanied with impact wear what requires very thick and not brittle coating. Fodder preparation requires a lot of hectares cutting by mower. At the cutting moment, mower blade has a contact with straw. But sometimes blades has contact with molehill or other various irregularities of filed surface. This contact reduces sharpness and mass of blade. We didn't found any literature about using of ESD coatings in abrasive wear conditions.

The aim is to investigate resistance of electrospark deposition coatings for abrasive wear in laboratory and field conditions

Materials and methods.

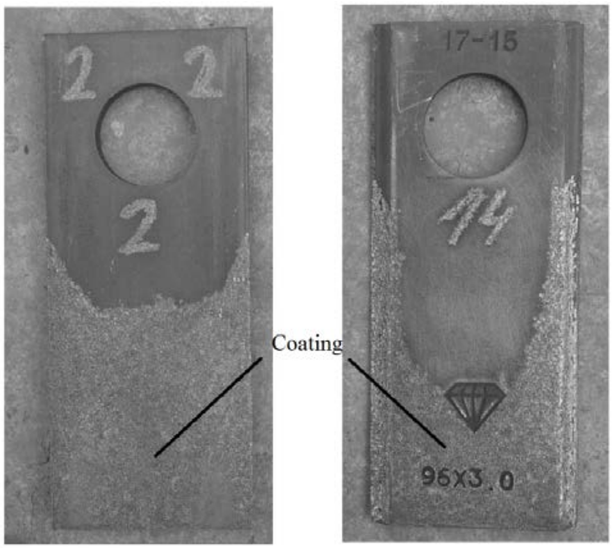
Laboratory and field experiments made with T15K6, BK6 and 12C2 electrodes coatings. Chemical content of electrodes showed in table 1. These coatings created by ЭФИ-10M device with vibrating electrode movement. Coatings thickness created by electrode T15K6 is 60– 80 µm, by BK6 is 35–50 µm, by 12C2 is 35–45 µm. Substrate material for laboratory test "Hardox 400" (80×40×5 mm). Current was 1,5 – 2 A, processing time 2,5 min·cm^{-2}. Processing time was used to control quality thickness of coatings. Longer processing time doesn't create thicker layer (Michailov V.V. *et al.*, 2013).

Table 1. Chemical composition in *wt. %* and hardness of electrodes.

Electrodes	WC	TiC	Co	Ni	Si	Cr_3C_2	Fe	Hardness, GPa
T15K6	79	15	6	–	–	–	–	9,4
BK6	94	–	6	–	–	–	–	7,8
12C2	–	–	–	12	2	15	71	6,7

The laboratory test made by ASTM G65–94 standard with a rubber disc at the following parameters: the diameter of rubber disc was 229 mm, the rotation rate was 200 min^{-1} (2,4 m·s^{-1}), the load was 10 N. Abrasive quartz sand of SiO_2 was 800–1100 HV, grain size was 250–400 μm, the flow rate was 300 g·min^{-1} and the duration of the test was 90 s (68,7 m). Wear lost was measured by weighting: before and after test by KERN ABJ 120–4M scale (accuracy 0,1 mg).

Field experiments was made on July in 2016. During these experiments was tested wear resistance of ESD coatings of drum mower blades. Blades made by PBL France (hardness 32±2 HRC). Blades were covered by electrodes materials (table 1.) in the same conditions as for laboratory test. In field conditions one part of tested blades was covered on front side, other part on back side (fig. 1).



a *b*

Fig. 1. Blades covered by T15K6 electrode on back (a) and front (b) side.

Covered blades was mounted into drum mower "Mewa 1,65" (Poland), working width 1,65 m. The kinematic scheme of mower is shown in Figure 2. Mower was aggregated by tractor "T-25" (Kharkiv, Ukraine), working speed 5 km·h^{-1}. At one time in mower are working 6 blades. Three blades are mounted into drum every 120° (fig. 3). Drums are rotating to contrary directions to create windrow of grass: drum on left by clockwise, drum on right counterclockwise.

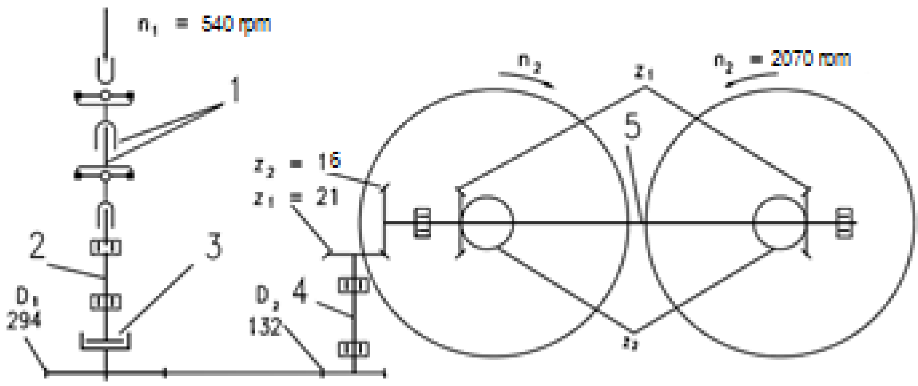


Fig. 2. Kinematic scheme of drum mower: *1* – PTO (power take off) shaft; *2* – head drive shaft; *3* – slip one way clutch; *4* – drive shaft of the main frame; n_1 and n_2 – rotation of PTO shaft and drums; D_1 and D_2 – diameters of pulleys; z_1 and z_2 – number of tooth on gear (Drum mower manual, 2006).

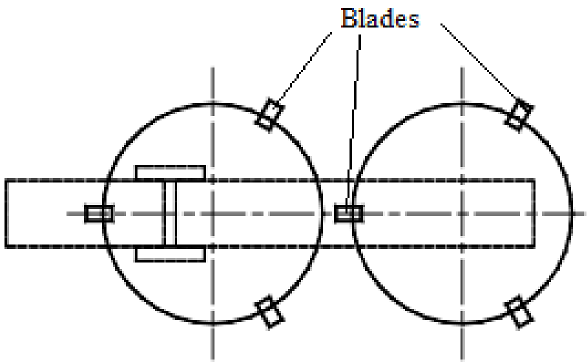


Fig. 3. Blades position in mower.

Experiment was made in 6 ha area and divided into three parts by 2 ha. The first set of two hectares was for testing T15K6, BK6 coatings on front side and without coating blades. During the second test was tested coatings of 12C2 on front and back sides and blades without coating. The third set was for T15K6, BK6 electrodes covered blades on back side and blade without coating. Wear resistance measured by weighting covered blades before field experiments and after 2 ha working.

Results and discussion

Laboratory wear resistance test duration was 90 s because longer time remove ESD coating. These coatings thickness can be 40–80 µm. Results of wear testing are shown in Fig. 4. Coating created by electrode T15K6 has lowest wear of all coatings because it has the highest hardness. 12C2 coating has lowest hardness of created coatings and wear results are worst.

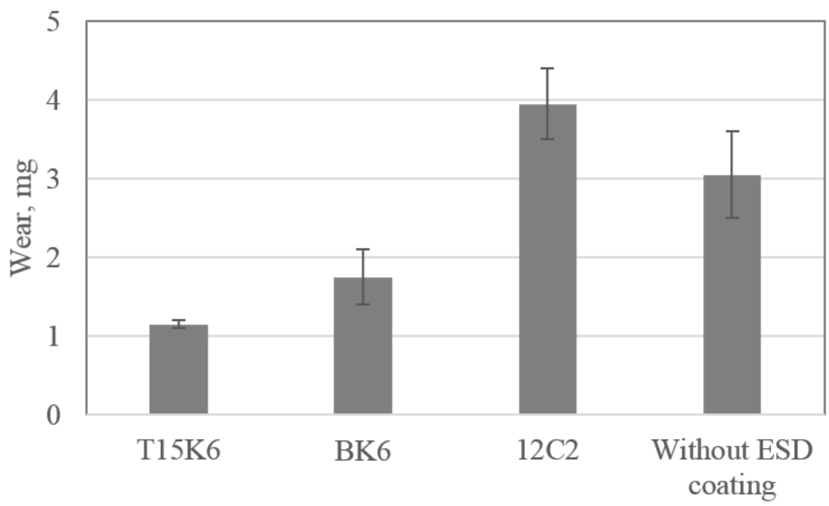


Fig. 4. Wear results of ASTM G65–94 test

Field test showed (fig. 5) that coating made by electrode T15K6 has 1,2 time lower wear than usual blade without coating. Blades covered by BK6 and 12C2 electrodes has 1,5 and 1,9 times respectively higher wear than blade without additional coating. Results calculated grams per hectare, to understand what the weight loss of blade was. Bright columns is wear results coatings covered on back side of blades, grey – wear results of front side. During test one blade covered by 12C2 electrode, due to the contact with stone, was lost and the corresponding result is shown without the error bar.

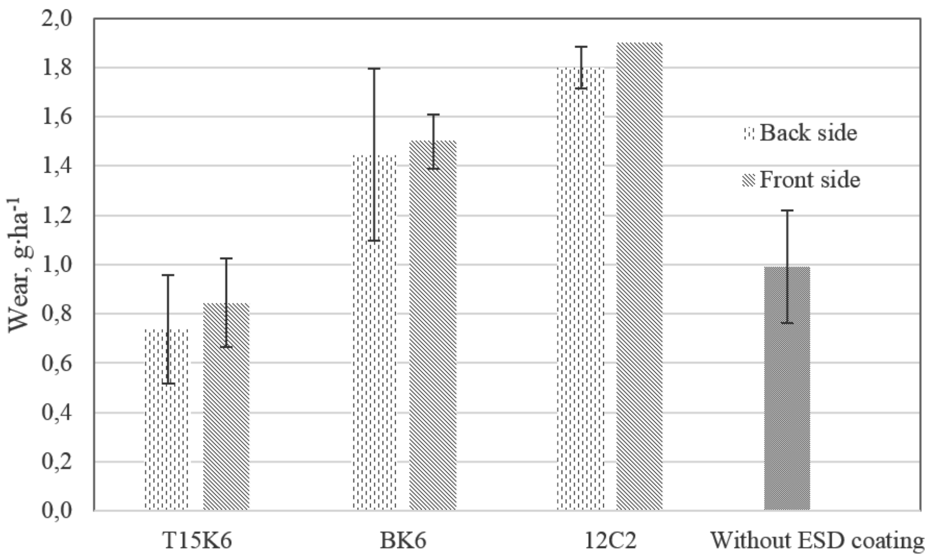


Fig. 5. Wear of ESD coatings after field test.

Coatings on back side of blade has lower wear than coatings on front side on every electrode. Electrode T15K6 has 1,3 time lower wear covered on back side. Other electrodes coatings differences are a little bit less. After cutting moment, grass turns on front side of blade. Drum and blade are removing grass over the mower and creating windrow. Due to often contact with grass, front surface of blade wear more than back surface.

Before working, mower blades need to be sharp because it reduces power consumptions and improves requirements of stubble. After experiments noticed that blades covered on back and front sides has different sharpness of cutting edge. Fig. 6 shows blades placed on each other.

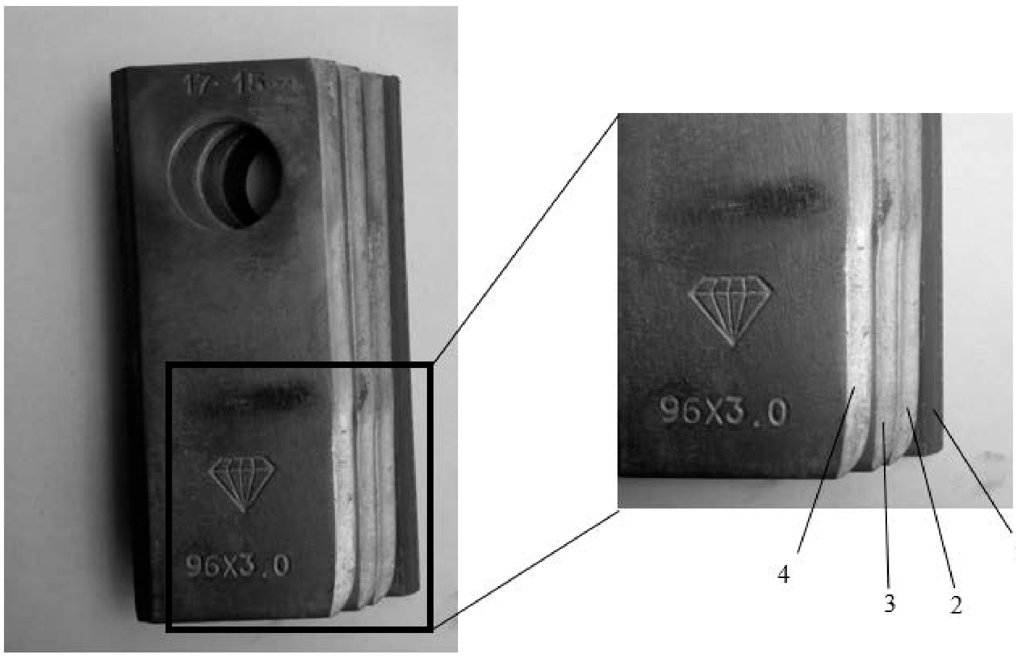


Fig. 6. Worn mower blades after 2 ha working area: *1* – new blade; *2* – blade covered on back side; *3* – blade covered on front side; *4* – blade without coating.

The unused blade is indicated by 1 (Fig. 6). Other three blades are after 2 ha working area. *2* is blade covered on back side, *3* – covered on front side and *4* blade is without coating. From image is possible to see that most worn part is corner of blade. These corners have largest contact during cutting moment. The coating on front side of blade was removed quite quickly comparing with surface on back. During this process coatings working like an additional sharp edge which helps for cutting process. This effect was not studied during the current research work, however it might be very useful for practical application of ESD coatings.

Conclusions

After laboratory and field test analysis following conclusions can be carried out:

1. Laboratory test results shows that two types of electrodes (T15K6 and BK6) coatings has 2,6 and 1,7 respectively, times better wear resistance characteristic than surface without ESD coating;
2. Field test results shows that only surface covered by electrodes T15K6 has 1,2 time better results than without ESD coating;
3. Blades covered ESD coatings on back side has lower wear than covered on front side;
4. Blades covered ESD coatings has longer sharp edge than blades without coating.

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