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Laser Alloyment of Regeneration Layers upon the Surface of Steel Cylinders

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The article shows the results of laser alloying the „BoroTec" regenerative powder upon the elements of steel cylindrical elements. The layers have been put on a screw line with different grades of covering in each layer. It shows the preparations to alloyment and the process of alloyment. It presents the results of measurement made on the metallographic specimen of exposed elements. It analyzes the influence of covering the screw line on the geometrical parameters of the layers obtained, their structure and distribution of microhardness inside the layers.

Keywords: king pin, laser alloyment, Boro Tec powder.

1. INTRODUCTION

Many of vehicles elements which are used up during the exploitation, can be regenerated by putting so called „regenerative powders" on the used surfaces. The powders are commonly alloyed by flame method. It allows to obtain layers with rather big thickness and high hardness.

The disadvantage of powder layers put on different elements by flame is their low adhesion with the substratum which comes from mediocre melting of the surface layer during heating with the gas torch. As the research conducted at Poznań Politechnic University proves, this disadvantage can be eliminated by alloying powder by the laser beam, which enables to melt powder and properly melt the surface layer of the material on which the powder is being put [1, 2].

On the research there have been trials made to create the single tracks of the „BoroTec" powder melted on the surface of the flat steel specimens; the powder contains among others boron. The tracks have had quite a small breadth: about 2 mm, caused by the small diameter (= 2 mm) of the used laser beam. In practice there will be a need for alloying the powder on the surfaces much wider than the beam diameter. The research has been started to check the possibilities of creating the continuous layers of significant measures by alloying many contacting tracks of melted „BoroTec" powder by laser. The woks presented below are about possibilities of producing such layers on the cylindrical steel elements.

2. EXPERIMENTAL PROCEDURE

The research was made upon the king-pin of the van car. The king-pin of 24 mm diameter was made of construction carburizing steel (according to Polish Standards marked by symbol 2OH: 0.19 % C, 0.8 % Cr, 0.6 % Mn). Such king-pins are surface hardened in the production to the depth of 1 mm, with hardness of 50 ÷ 52 HRC.

The BoroTec regenerative powder Nr 10009, containing 15 % Cr, 4.4 %Si, 3.2 % B and 7 % Ni [3] was used in the research.

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The first stage was to put the regenerative powder on the ready to exposure surface. The most effective methods to put the powder on is using metal spraying gas torch. During the process the parameters of the heater were correlated to obtain the „glued" layer of unmelted powder on the surface of the king-pin, keeping the most uniform thickness without melting the surface of the king-pin (adhesive connection). It allowed to obtain the powder layer with the equal thickness of 0.5 mm.

The prepared king-pin was exposed to the beam of Trumpf 2600 T CO2 laser. Three series of tracks were exposed, differing from one another in the grade of interference of the following tracks (the tracks were exposed in screw line, series of four each).

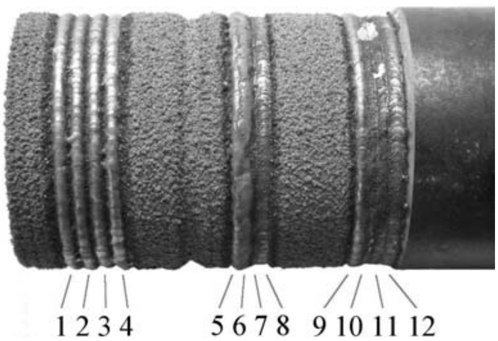

Fig. 1. The king-pin after exposure to the laser beam with parameters: laser beam power P = 1310 W, laser beam diameter d_w = 2 mm. The grade of tracks interference: s_n = 0.5 mm for 1 ÷ 4 tracks s_n = 1.25 mm for 5 ÷ 8 tracks and s_n = 1 mm for 9 ÷ 12 tracks

The parameters of the exposure were: laser beam power P = 1310 W, laser beam diameter d_w = 2 mm, the grade of tracks interference s_n = 0.5 mm for 1 ÷ 4 tracks s_n = 1.25 mm for 5 ÷ 8 tracks and s_n = 1 mm for 9 ÷ 12 tracks. There was no added layer enlarging the laser absorption used. The king-pin with the tracks exposed and their numbers are shown in Fig. 1.

After the exposure the king-pin was cut through the middle and metallographic specimen was made. The specimen allowed to observe the shapes and structures of zones emerged after the exposure (using Epiquant metallographic microscope) and the geometric measurements of the zones were taken along with the HV0.1 microhardness measurements (using Zwick 3212 harness tester).

3. RESULTS AND DISCUSSION

Fig. 2, 3 and 4 show the zones obtained after exposure of another track series. In all the tracks there is a light zone visible, containing melted regenerative powder (with dendritic structure – Fig. 5) and underneath it is the dark zone of core material with structure changed because of the heat during the exposure (it is the fine martensite structure). The zone of „BoroTec" powder is melted into the zone of basic material with changed structure, there is no physical mixing of the zones yet.

After the structural observation was made, the measurements of thickness in zones obtained in exposure was made. The measurement were of:

- maximum thickness of BoroTec powder in the track places (measure marked h_b);
- thickness of the zones in the king-pin material with the structure changed in the exposure (under the BoroTec layer) in the track places (measure marked h_m).

The results are shown in the Table 1.

Table 1. Thickness of the zones obtained after putting BoroTec powder on the king-pin

Track number	h_b, mm	h_m, mm
1	0.84	0.34
2	0.85	0.35
3	0.83	0.37
4	0.87	0.30
5	1.3	0.51
6	0.88	0.34
7	0.35	0.50
8	0.51	0.27
9	0.90	0.37
10	0.57	0.31
11	0.55	0.31
12	0.51	0.28

As the shown Fig. 1 and measurements prove, in the case of small interfering of the tracks it was impossible to obtain the continuous layer of the melted powder. In this case the zone is created of separate tracks with the uniform maximum thickness of both melted BoroTec and the zones in the material of king-pin, with the structure changed after the exposure.

The use of 0.1 and 1.25 mm interference resulted in obtaining the uniform layer of the powder, yet the thicknesses of the layer are visibly different in the length of the cut. In the both degrees of interference there is hb thickness of the melted Boro Tec powder layer in the tracks which were exposed first visibly grater than in the others. Hb thicknesses are more uniform for other tracks if the lower degree of interference was applied (9sn = 1 mm) In this stage of research it is difficult to find an explanation for such a shaping of the layers. Probably the reason can be the fact that the first tracks of each layers were exposed on the cool material and the others were exposed on the material partially heated by the laser beam, which melted the previous one. But this speculation needs to be proved in separate research.

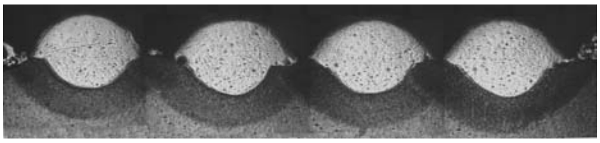

Fig. 2. Cut of the melted BoroTec powder zone, obtained after exposure of the tracks 1 ÷ 4. Grade of tracks interfering s_n = 0.5 mm

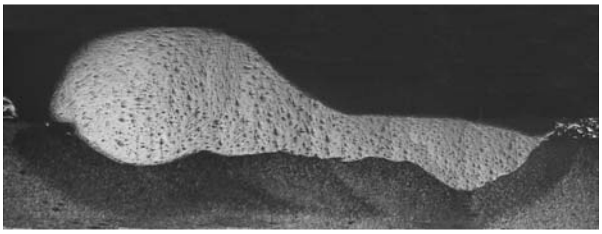

Fig. 3. Cut of the melted BoroTec powder zone, obtained after exposure of the tracks 5 ÷ 8. Grade of tracks interfering s_n = 1.25 mm

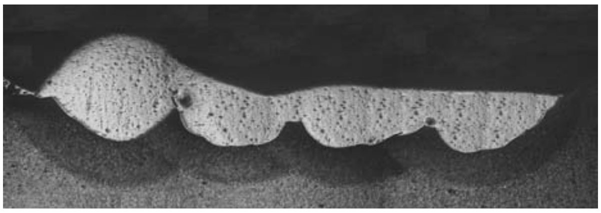

Fig. 4. Cut of the melted BoroTec powder zone, obtained after exposure of the tracks 9 ÷ 12. Grade of tracks interfering s_n = 1.0 mm

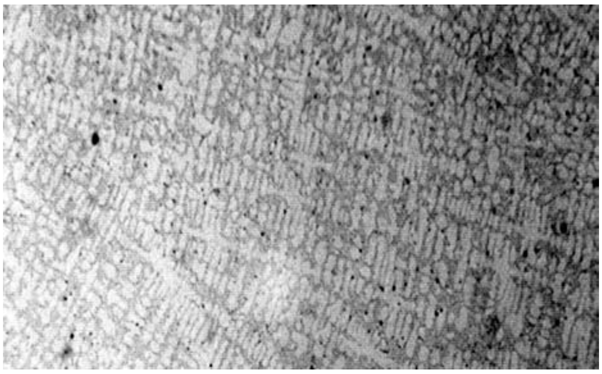

Fig. 5. Dendritic structure of BoroTEc melted powder zone. Magnification ×500

The next stage of research was to measure HV0.1 microhardness in the obtained zones. The measurements were made:

- on the surface of each track through the melted BoroTec layer, the king-pin material with the changed structure down to the core material - the measurements were made where the thickness was the biggest.
- parallel to the surface of the king-pin on the whole length of the layer (all tracks in the layer) in the depth

of half of a medium thickness of the melted BoroTec layer.

The distribution of microhardness HV0.1 for tracks 5 ÷ 8 and 9 ÷ 12 is shown in Fig. 6 – 9.

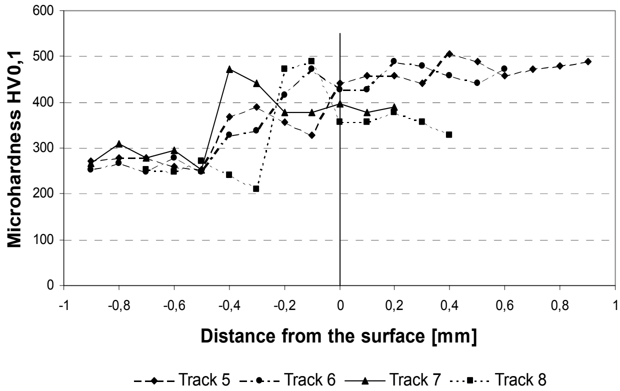

Fig. 6. Distributions of HV0.1 microhardness from the surface of the melted BoroTec layer to the core of king-pin for tracks 5 ÷ 8 [4]

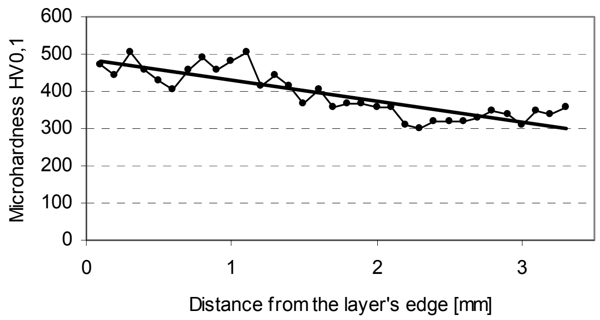

Fig. 7. Distribution of HV0.1 microhardness parallel to the surface of the king-pin in half of a medium thickness of the melted BoroTec layer for tracks 5 ÷ 8 [4]

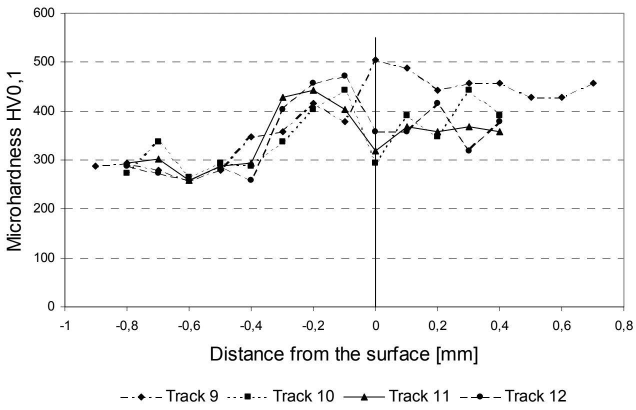

Fig. 8. Distributions of HV0.1 microhardness from the surface of the melted BoroTEc layer to the core of king-pin for tracks 9 ÷ 12 [4]

„0" value is the surface of the king-pin. The negative values are into the king-pin direction and the positive values are towards the surface of BoroTec layer.

As the pictures show, the microhardness into the layers of melted BoroTec powder is distributed evenly. The average HV0.1 microhardness for the layer of tracks 5 ÷ 8 was 433 ± 51 HV0.1 and for the layer of tracks 9 ÷ 12 397 ± 57 HV0.1.

The measurements of the tracks across the melted powder showed the tendency to a slight drop of value in the exposed zones. It can be explained by the smaller intensity of heat abstraction from the track under exposure in the material partially heated by the warm absorbed from the already exposed tracks.

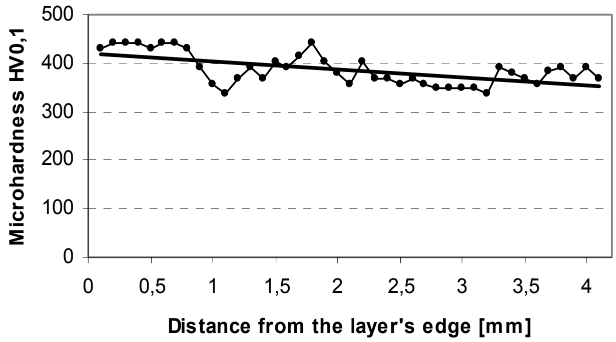

Fig. 9. Distribution of HV0.1 microhardness parallel to the surface of the king-pin in half of a medium thickness of the melted BoroTec layer for tracks 9 ÷ 12 [9]

As the figures show, the microhardness of the layers of melted BoroTec powder is distributed evenly. The average HV0.1 microhardness of the layer of tracks 5 ÷ 8 was 433 ± 51 HV0.1 and of the layer of tracks 9 ÷ 12 397 ± 57 HV0.1.

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The average microhardness values in the zones of king-pin material with the structure changed after the exposure under the BoroTec layer were practically the same for the both layers and were 402 ± 58 HV0.1 for 5 ÷ 8 tracks and 401 ± 42 HV0.1 for 9 ÷ 12 tracks.

4. CONCLUSIONS

1. The exposure of the consecutive, close zones on the surface of the steel cylindrical elements covered with BoroTec powder by the laser beam enables to create continuous layers of the melted powder on the elements. Value and uniformity of the zones thickness seems to be dependent vitally on the grade of interference of the tracks exposed. Too small interference does not allow to obtain the uniform layer while too big interference seems to cause significant uneveness of thickness in the obtained layers.
2. Layers of melted BoroTec powder, obtained in laser alloyment of the steel elements seem to be better connected with the substratum than in the classic flame alloyment. Additional research is needed to acknowledge it.

3. The layers of BoroTec powder obtained in the research have rather uniform hardness in the whole volume. The values of hardness are rather low (about 400 HV0.1). Some premises and results of preliminary studies show that to obtain the higher hardness the amount of boron in the powder should be increased. Acknowledgement of this assumption needs further research.
4. It is needed to continue research upon influence of parameters of the laser beam used to alloy the regenerative powder on the geometric measures and microhardness values in the uniform layers of the BoroTec powder, obtained after the exposure of parallel and partly interfering zones.

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