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RESEARCH OF STRENGTHENED PLOUGH POINT BY PLASMA TRANFERRED ARC WELDING

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Abstract: Experiment based on strengthened plough point which produced from boron micro-alloyed steel. Cutting edge and front surface of plough point covered by plasma transferred arc welding (PTAW). This welding method creates relatively low thermal treatment of plough point steel and welded layer content has high tungsten carbide concentration which creates high wear resistance of working surface and cutting edge. This strengthening process increased working time of plough parts.
Keywords: plough point, plasma transferred arc welding, wear

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INTRODUCTION

High abrasive content in soil creates high wear of agricultural equipment parts. It creates huge material losses. The main material of agricultural machines which working in soil is boron micro-alloyed steel. This steel is tempered and takes 40–50 HRC hardness, but abrasive particles in soil has 4,5–9,5 GPa hardness (SiO_2, granite and etc.) which create intensive wear.

High wear losses of agricultural equipment require a lot of researches to avoid it [1–5]. There are a lot of investigations about agricultural equipment surfaced by plasma, laser or manual arc welding methods. Durability of agricultural can be increased by hardening, tempering, cementation, borizing, surfacing by WC or other hard alloys particle mixing in various matrixes.

The research object is to analyze wear of plough point hardened by plasma transferred arc welding method in field conditions.

EXPERIMENTAL

Reversible plough points (FRANK ORIGINAL No. 94609, Germany) surfaced by plasma transferred arc (PTA) welding method in JSC “Dangų inžinerijos centras“. During this method was used powders Fortecoat 15560 with 60% of WC (rest Ni alloy matrix, 55 HRC) to create 2 mm height and 16 mm width strip. Plough point has 12 mm thickness. The plough points were mounted in reversible, 4 furrows plough Overum Xcelsior CX pulled by a Case-IH Puma tractor. Working speed 9 km/h, depth 20 cm. One furrow working width 45 cm. Field test made in J. Kairys farm (Marijampolė district, Lithuania) in August and September 2017. Dominant type of soil was loamy. Soil hardness in 20 cm depth 1,79±0,26 MPa, moisture 26–30% measured by penetrometer PENETROLOGGER SN (EIJKELKAMP). The last furrow is working under the soil pressed by tractor left wheels. In that place soil hardness is 2,23±0,55 MPa. This effect we eliminate by replacing plough points every measuring.

2 of 8 reversible plough points (1 left and 1 right) was tampered in manufacture (35±5 HRC) and not surfaced (fig. 1 – I), 2 of them was surfaced on rear side cutting edge (II), 2 of them surfaced on rear and front cutting edges (III) and 2 surfaced on rear and front cutting edges with two additional strips on front side (fig. 1 – IV). Used plough points are reversible, but during experiment plough points worked on one side, their direction was not changed.

Plasma thermal influence reduced hardness: II type plough points has 24±3 HRC, III type – 25±3 HRC and IV type – 24±4 HRC hardness.

Wear of plough points evaluated in various ways. During experiment was measured mass, thickness, length of diagonals and total length of plough points. Measuring processes made with dial thickness gauge, balance and caliper.

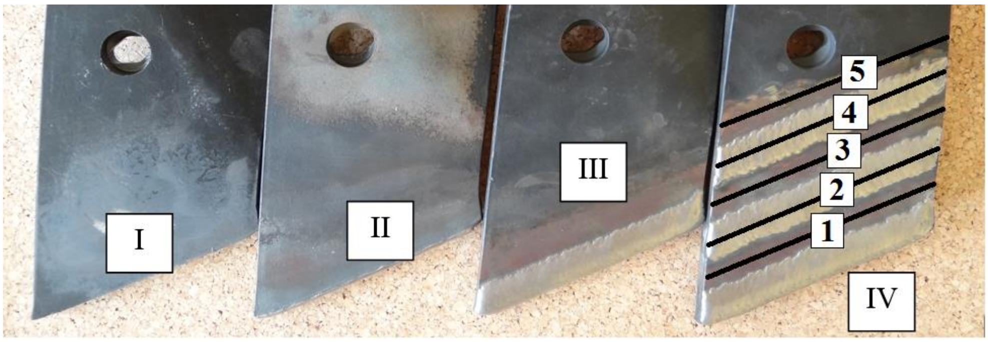


Figure 1. Non-hardened (I) and hardened (II-IV) front sides of plough points (II plough point surfaced on rear side). Lines 1-5 showing thickness measuring of IV plough point.

RESULTS AND DISCUSSION

Analysis of results, after 280 km working distance, showing that plough points surfaced on rear surface edge has the highest wear (fig. 2-II). This plough point lost 54% of his mass, surfaced on rear and front surfaces edge (III) – 50%, not surfaced plough point (I) lost 42% and surfaced with additional strips (IV) – 37% of itself mass.

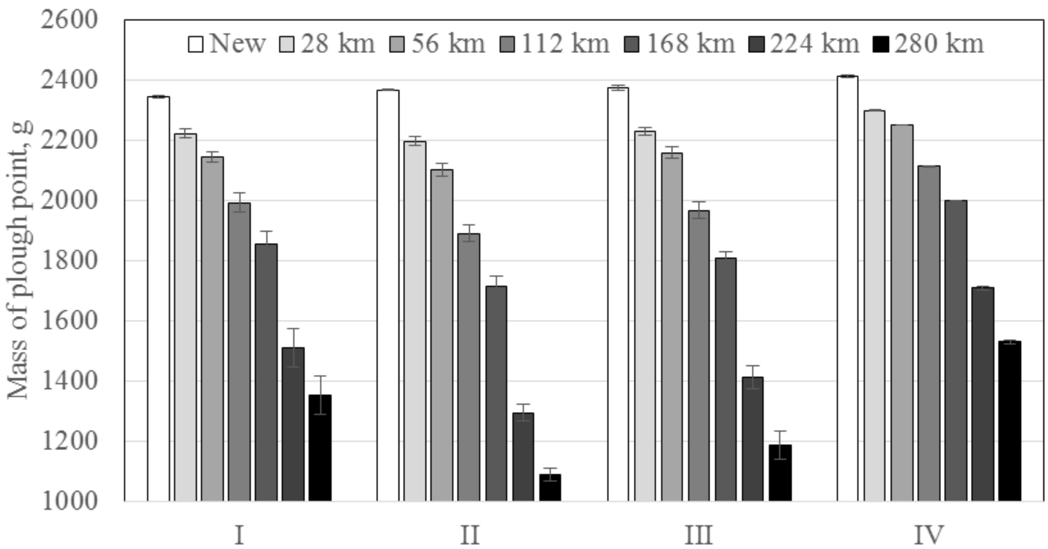


Figure 2. Change of mass of plough points: new and after 28, 56, 112, 168, 224 and 280 km working distance.

III type plough point has weld bead on rear and front surface edge. Weld bead has high hardness, but metal near bead is annealed and has lower hardness. Due to this process soil remove metal near bead and create groove. The same situation with IV point. Between welded strips on front surface clearly visible grooves made by soil.

In this research was estimated length of plough point (fig. 3). Initial length is different because weld bead on cutting edge has various width. Length measured in parallel to side edge of plough point in 8 places every 8 mm. Results in fig. 3 shows that hardened points has higher shortening resistant after 280 km, because cutting edges is protected by higher hardness weld bead. I and II plough points lost 7,5% and 8,9% of their length. Minimal changes of plough point showed III – 4,1%. IV plough point lost 6,7% of its length. After 280 km working distance was clearly visible that on II and III plough points rear surfaces welded layer was removed and it increased shortening of point length.

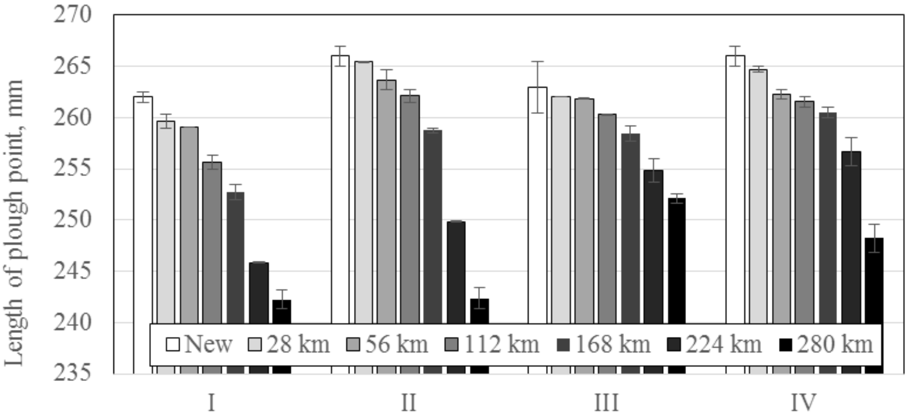


Figure 3. Change of length of plough point: new and after 28, 56, 112, 168, 224 and 280 km working distance.

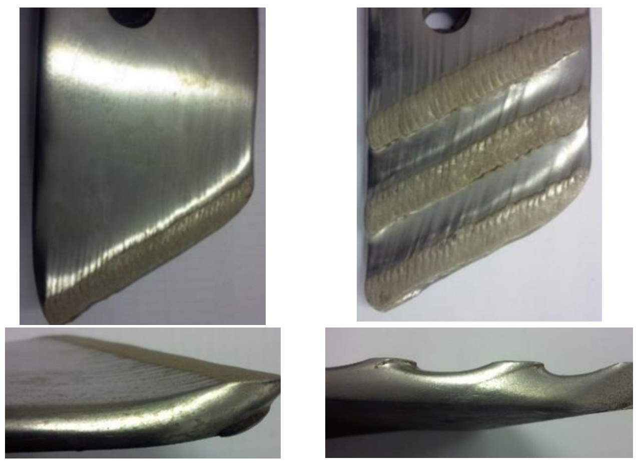
Variation of plough points thickness given in Table 1. Thickness is average of measured thickness at 9 points in 4 (IV plough point 5) lines (fig. 1). Measured data showing problematical places after surfacing. Soil movement swilled out metal and create grooves across plough point (fig. 4).

Table 1. Thickness of new plough point after 28, 56, 112, 168, 224 and 280 km working distance.

Working distance, km	I point				II point				III point				IV point				
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	5
New	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	13,6	12,0	13,6	12
28	11,7	11,6	11,7	11,5	11,9	11,2	11,2	11,3	11,6	11,3	11,4	11,4	11,6	13,4	11,8	13,5	11,8
56	11,2	11,1	11,2	11,2	11,1	10,5	10,8	11,1	10,7	10,7	10,8	11,1	11,5	13,3	11,7	13,4	11,6
112	10,1	10,2	10,2	10,3	8,3	8,8	9,1	9,5	10,4	9,6	9,5	9,7	10,8	13,1	11,2	13,2	10,6
168	9,5	9,5	9,4	9,5	7,9	8,2	8,4	8,7	9,8	8,5	8,4	8,6	10,6	13,1	10,7	13,0	10,6
224	7,8	7,8	7,6	7,6	5,4	5,8	6,2	6,7	8,0	7,6	6,6	6,7	10,3	12,9	10,5	12,9	10,1
280	6,5	7,0	6,3	6,9	3,7	4,8	5,4	5,5	7,6	7,0	5,6	5,8	9,5	12,8	10,5	12,8	9,5
II and III plough point weld bead get worn more quickly than plough point without hardening. On IV plough point front surface between welded beads clearly visible grooves made by soil (fig. 5).																	

The most stable thickness of plough point has IV point. Welded strips lost only 5,8%, while based metal thickness between strips reduced 12,5–21% of their thickness. II plough point has highest wear of surface. It lost 54–69% of thickness. I and III plough points lost 42–47,5% and 20–53% of their thickness.

I II



III IV

Figure 4. I, II, III and IV plough points after 140 km working distance. Soil swilled out based metal and made grooves between surfaced strips (IV).

Measurement of diagonals (fig. 5) represents rounding of plough point corners. This dimension is important to perform ploughing deep. Plough points protect main frame parts of furrow. High wear of point corner can damaged these frame and it can create more losses. Table 2 gives values of plough points after various working distances.

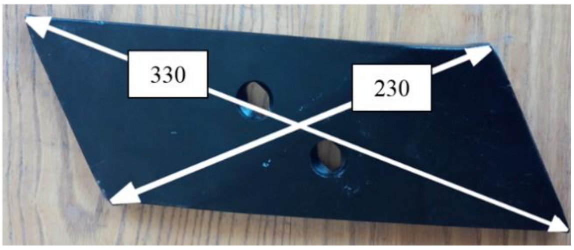


Figure 5. Measurement of diagonals of plough point: longer diagonal – 330 mm, shorter – 230 mm length.

Length of diagonal of new plough point is 330 and 230 mm. After 280 km working distance the best result showed III plough point. Longer diagonal reduced 12%, shorter – 11% of their length. II plough point diagonal length decreased 18% and 17% of their length. I plough point diagonal length diminished 13% and 12%. All plough point longer diagonal worn out 1% more than shorter, except IV plough point. This plough point has higher wear of shorter diagonal – 13%, while longer diagonal – 12%.

Table 2. Length of diagonals of new plough point and after 28, 56, 112, 168, 224 and 280 km working distance.

Sample code	New		28 km		56 km		112 km		168 km		224 km		280 km	
I point	330	230	326	224	321,5	221	315,5	218,5	308,5	215	295	205,5	287	202,5
II point	330	230	326,5	228	323,5	224,5	317	219	308,5	216	286	204,5	270	201
III point	330	230	326,5	228,5	324	222,5	320	221,5	316	221,5	302,5	209	290	205
IV point	330	230	326,5	227	323,5	224,5	318,5	220,5	315	216,5	303,5	208,5	290,5	200

Plough points after 224 and 280 km working distance given in fig. 6. It is clearly visible that initial shape maintain I and IV plough points. Surfaced cutting edge on rear surface was worn after 224 km working distance. This was the main reason why wear increased.

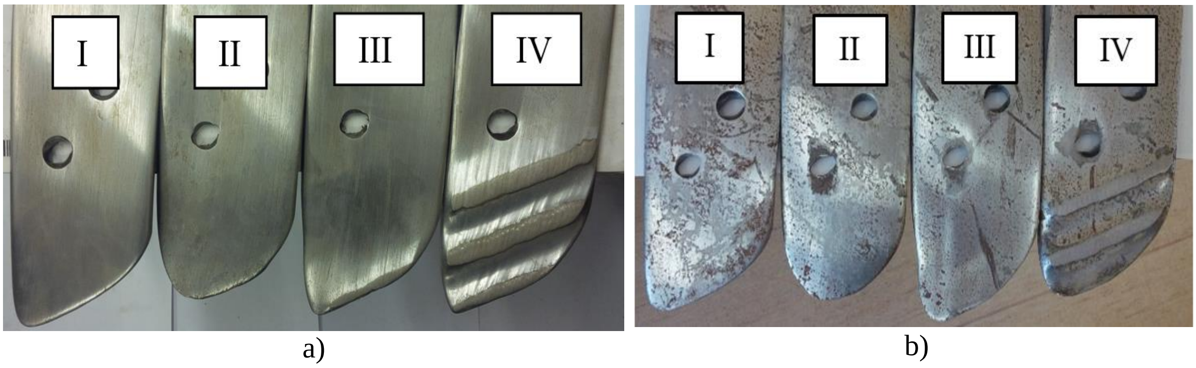


Figure 6. Plough points after 224 and 280 km working distance.

III plough point remain initial shape but results of thickness showing very thin material 5,6 mm (initial thickness12 mm). This thickness is dangerous on contact with stone and plough point can be damaged. This effect created by surfaced cutting edge. Plough points fixed by two bolts. During ploughing from 224 till 280 km was extremely for first bolt. Thickness of plough point was too small to protect it.

CONCLUSIONS

- Strengthened plough point field test result in loamy soil (moisture content 25–30%, soil hardness 1,79±0,26 MPa, working distance 280 km) can be summarized in following conclusions:
- The biggest mass losses was plough points welded on rear cutting edge surface (II) and welded on rear and front cutting edge surfaces (III) 54 and 50% of their mass, respectively. Lowest mass losses was plough point surfaced on front surface with additional strips (IV) and original (I) 37 and 42% of their mass, respectively.
- The minimal length variation of plough point has III and IV (surfaced cutting edge on both sides) 4,1 and 6,7% of their length, respectively. Original (I) and surfaced on rear surface of cutting edge worn faster 7,5 and 8,9% of their length, diagonal length decreased 12%. It is 6% lower wear than surfaced on rear cutting edge surface (II).
- Surfaced IV plough point front surface stops reducing of plough point thickness - welded layer (60% WC in nickel matrix) reduced only 0,8 mm, while plough point surfaced on rear side (III) 6,5–8,3 mm. For future researches, to improve wear resistance at this working condition, on plough points front surface should be welded 1,5 mm thickness and 3–4 additional strips from hard alloy.
- Estimation of given results showed that it is useful to make investigation at dry conditions.

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