Usage of Gray Cast Iron for Hardening of Agricultural Machines’ Soil-Tilling Implement

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Abstract. Research of gray cast iron was established to study physical-mechanical properties in microstructure while apply a layer on steel basis of work tool’s soil-tilling. Gray cast iron went through preliminary heat treatment, where gray cast iron hardening with temperature of 750…1050 °C with following water quenching. Research program including: comparison analysis of reference specimen and specimens which were went through heat treatment. Researching material was applied on work tool’s soil-tilling with two methods: arc surfacing and electrosparck surfacing. Microstructure of welding layer after arc welding and electrosparck welding was studied. Therefore was found out that electrosparck method gave opportunity to obtain wear resistant layer for a few run, also structure and basis of gray cast iron doesn’t change. Coarse graining doesn’t spot in pad weld, which is beneficial for properties. Measurement of welding layer’s hardness is bigger than base metal and there is no softening of basis. Field tests of hardened products which have shown that to use effectively gray cast iron with heat treatment for hardening, because quality and coating thickness is meeting the requirements of abrasive resistance and there are no spotted significant changes of geometrical dimension for soil-tilling implement.

1. Introduction
At the present time any manufactory requires availability of more complex equipment which allows obtaining competitive products. Whereby for development of necessary equipment is using different materials – from common and easy of approach to rare and expensive. This is due to the specific conditions of equipment and tool’s exploitation.

In relation to expensiveness of wear-resistant substance, the bases of parts are made of cheap material, but hardening only necessity parts. Usage of this method is exacerbated by the fact that obtaining of wear-resistant layer is fraught with difficulties of applying, if to be exact – there is changes of material structure and (or) its basis, also changing their physical-mechanical properties. This in turn restricts the wide application of given composition because of complexity of technological process and high cost.

Usually wear-resistant substances are using as layers of different thickness, which applying on part surface with different methods. Some parts requires additional machine processing after layer was applied, because it is difficult to achieve uniform thickness.

Parts are abraded to different types of wearing and load during exploitation. More often pars are drift out of geometrical dimension because of abrasive wear.

Operative parts of agricultural machines have more intensity abrade weariness in agricultural production. Operative parts of soil-tiling machines are developing from intermediate-carbon structural steel, which is sensitive to wear abrasion. To improve wear properties of operative parts, there is using of highly-alloyed hard metals, and as for alloying components using chrome, nickel, wolframium and other elements which improve self-cost of developing tool.
Deposit welding can be conducted by electrodes, solid and cored wire, cast-bar, mixture of different powders. At the present time the assortment of materials for welding are very big: sormite, cast tungsten carbide, stalinite, heat-resistant steel, cast iron and others.

During welding of operative parts with abovementioned coats there are following problems: lack of zone of adhesion of welding layer with basic material, overheating of basis, embrittlement of zone of adhesion and basis [1,2], which can lead to generation of micro-cracking with following destruction.

Transition zone (zone of adhesion) is basis which determines quality of weld joining. During analyze of joins obtained with sormite there was no transition section (Figure 1). Moreover there are graphitization zones if transition section after welding with electrodes. Such zones are completed cracks and they will lead to breakaway of layer even with minimum loads. Lack of transition zone and following decrease of properties of welding joins are related to degree of weld metal alloying [1, 2].

Fig. 1. Microstructure of composition steel 65G – sormite 1 using arc welding (x260)

Arc welding give an opportunity to obtain needed layer of welding metal, but such method leads to strong heating of basic metal in fusion zone and generation of coarse structure [2].

Goal of research – studying of physical-chemical properties and microstructure of cast iron which is welding on steel basis of soil-tilling operative parts and subjected to heat treatment, and to study abrasive resistance of current layer.

2. Equipment and devices used in studies
Heat treatment is more available method of changes of physical-mechanical properties and microstructure of electrodes from cast iron for welding. Heat treatment of gray cast iron consists of hardening in range of temperature 700 – 1050°C, heating during 30 minutes with following water quenching and dispatching with 300°C. Also was conducted cycle annealing (20 cycles) with temperature of 950°C with heating during 1 hour.

Obtained cast iron after heat treatment has improved durability 200…250 MPa and perlite-ledeburite structure without graphitizing, in comparison with nontreated reference specimen (σв=125…130 MPa). After dispatching with 300°C hardness of cast iron improves up to HRC 50…55 without generation of following hardening cracks. That is why gray cast iron is the new material for welding of soil-tilling implement.

Wear resistant layer on razor edge of soil-tilling implement for agricultural machines was applied by arc welding and electrospark welding with different electrodes [2], subjected to heat treatment.

With the help of arc welding can be obtained layer with almost every thickness, but electrospark welding give opportunity to obtain needed thickness for a few run [2].

2.1 Results and discussion
Electrodes from formula of gray cast iron (in %): 3,8-4,2 C, 0,75 Si, 0,24 Mn, 0,08 S, 0,08 P, other – Fe, were subjected to heat treatment and had following mechanical properties (Table 1). Electrodes for arc welding were developed with trapezoidal shape, 7 mm section and 200 mm length, for electrospark welding – diameter 25 mm and length 150 mm.
Table 1 – Influence of heating temperature for hardening on mechanical properties of gray cast iron.

| Heat treatment                      | $\sigma$, MPa | $\delta$, % | $\Psi$, % |
|-------------------------------------|---------------|-------------|-----------|
| Without heating                     | 125.0         | 2.0         | 1         |
| Hardening 700°C, water quenching    | 200           | 3.1         | 1         |
| Hardening 750°C, water quenching    | 202           | 1.7         | 1         |
| Hardening 800°C, water quenching    | 214           | 1           | 1         |
| Hardening 850°C, water quenching    | 232           | 1           | 1         |
| Hardening 900°C, water quenching    | 241           | 1           | 1         |
| Hardening 1000°C, water quenching   | 240           | 0.5         | 1         |
| Hardening 1050°C, water quenching   | 251           | 0.5         | 1         |
| Annealing 900°C, heating time 1 hours, 20 cycles | 235           | 0.45        | 1         |

Initial heat treatment of developed electrodes before welding them on work surface gave opportunity to obtain perlite-ledgeburite structure without graphitzing (Figure 2). Current structure also give opportunity to obtain more quality wear resistant layer which will work in abrasive environment.

Fig. 2. Microstructure of gray cast iron after heat treatment: a – hardening 900°C, water quenching; b – hardening 1050°C, water quenching (x300)

Applying of abrasion resistant coating was realized by arc welding in environment of protection gas and without protection.
Structure of welding layer after arc welding represented on figure 3.

Fig. 3. Microstructure of welding layer after arc welding application. (x80)
Arc welding generate composition of wear resistance layer – basic material, herewith thickness of welding layer is enough for work in abrasive environment. But current method leads to strong overheating and increasing of grain effect (Fig. 3). After conduc|

After conduction of literary analysis and established researches to obtain wear resistance layer on surface [1 – 10] there was trial of electrospark welding. Current method gives good bond between layer with part, but not provide enough thickness for working of soil-tilling implement in abrasive environment which is soil itself. Also there is a problem related to permanent oxidation of electrode, during process of electrospark welding. It is requiring permanent stripping of defective layer [2]. Authors are offered way to delete defective layer from electrode’s surface [2], that is why welding of heat treatment gray cast iron was realized with usage of current method. Method of electrospark welding of wear resistance layer are not disturbing structure of basic material, because welding material is quickly cooling and necessary wear resistance are not possible to reach. There was decided to applicate layer for a few run, to solve this problem. After realization of welding there was study of microstructure and evaluation of features of welding part on prepared samples.

Fig. 4. Microstructure of welding gray cast iron by electrospark welding with heat treatment: a – hardening 900°C, water quenching; b – 900°C, hardening, heating time 1 hour, 20 cycles. (x300)

There is lack of graphite insertion in structure of welding metal, which allow to infer of keeping structure of components, which were obtained after heat treatment and electrosparking welding. During the study there is also wasn’t spotted increase of grain effect which is beneficial for features (Fig. 4).

Fig. 5. Influence of electrode’s heat treatment on changes of hardness of hardened layer in sample section
Measurement of hardened layer’s micro-hardness (Fig. 5) shows that surface layer, which is applied by electrodes of gray cast iron and subjected to initial heat treatment, has improved hardness than basic material and it gives an opportunity to infer of higher wear resistance.

Hardened products were subjected to field tests on farms of Kemerovo region, the Russian Federation. Tests showed efficiency usage of hardening with given material for electrospark welding, because thickness and quality of welding layer is meet the necessary requirements of wear resistance. After soil-tilling implements work during one season there was observed insignificant changes of geometrical dimension, which can be recovered by all-known methods.

3. Conclusions
Usage of gray cast iron as welding material, subjected to initial heat treatment with following application on surface of pars with electrospark welding, and working in environmental of abrasive wear, gives an opportunity to increase operational life and decrease purchase costs for new parts.

References
[1] Kurbanova, M.G.; Chernysh, A.P.; Sankina, O.V.; Buziy, O.N., Increasing of wear resistance of functional surface of operative parts and mechanisms of grinding and blending of biogas unit. Achievements of science and technics APK 2013. №5. P.: 79 – 80.

[2] Chibryakov, M.V.; Sankina, O.V., Arc welding and electrospark welding of parts with unalloyed white cast iron. News of international agrarian education academy 2018. Bulletin №39 (2018). P.: 53 – 57.

[3] Shibe Vineet, Chawla Vikas, Characterization of Fe-C-Cr Based Hardfacing Alloys, Transactions of the Indian Institute Of Metals. Volume: 71. Issue: 9. P.: 2211-2220

[4] Martinazzi, Douglas; Lemos, Guilherme V. B.; Landell Renan M.; et al., Preliminary study on effect of rod geometry in FHHP between FE55006 nodular cast iron and SAE 8620 steel, PERIODICO TCHE QUIMICA. Volume: 16. Issue: 31. Published: Jan 2019. P.: 642-649.

[5] Carcel-Carrasco Francisco-Javier; Pascual-Guillamon Manuel; Salas-Vicente Fidel; et al., Influence of Heat Treatment in the Microstructure of a Joint of Nodular Graphite Cast Iron when Using the Tungsten Inert Gas Welding Process with Perlitic Grey Cast Iron Rods as Filler Material , Metals. Volume: 9. Issue: 1. Article Number: 48. Published: Jan 2019.

[6] Reisgen U.; Sharma R.; Wieland S.; et al., Improving the corrosion and wear resistance of grey cast iron components by surface welding with duplex stainless steel using regulated gas metal arc welding; Influence of dilution on corrosion properties, MATERIALWISSENSCHAFT UND WERKSTOFFTECHNIK. Volume: 49. Issue: 12. Published: Dec 2018. P.: 1520-1537.

[7] Winiezenko Radoslaw; Kaczorowski Mieczyslaw; Skibicki Andrzej, The microstructures, mechanical properties, and temperature distributions in nodular cast iron friction-welded joint, Journal of the Brazilian society of mechanical sciences and engineering. Volume: 40. Issue: 7. Article Number: UNSP 347. Published: Jul 2018.

[8] Saraev Y.; Gladkovsky S.; Lepikhin S.; Kamantsev I.; Lunev A.; Perovskaya M., Investigation of the Influence of Energy Parameter of the Covered-Electrode Welding on the Impact Strength Characteristics and Cracking Resistance of the Welded Joints Obtained, Obrabotka metallov-metal working and material science. Volume: 20. Issue: 2. P.: 100-115

[9] Chamim M.; Triyono; Diharjo Kuncoro, Effect of Electrode and Weld Current on The Physical and Mechanical Properties of Cast Iron Welding, International Conference on Engineering, Science and Nanotechnology (ICESNANO) Location: Solo, INDONESIA Date: Aug 03-05, 2016. Book Series: AIP Conference Proceedings. Volume: 1788. Published: 2017.

[10] Ambroza P.; Bockus S.; Kavaliasiene L., Formation of build up layers microstructure by arc automatic overlay welding using secondary raw material powders, Archives Of Metallurgy And Materials. Volume: 58. Issue: 2. P.: 549-553. Published: 2013.

[11] Gabet D.A.; Markov A.M. Study of the influence of alloying elements on the structure and properties of gray cast iron operating under conditions of shock-friction wear. Obrabotka metallov (teknologiya, obrudovanie, instrumenty). Metal Working and Material Science, 2019, vol. 21, no. 1, P.: 70–81.