Improvement of operation stability of crucial parts and constructions when repairing dredges and other mining machines exploited in conditions of North

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Abstract. The problems of a choice of rational technology and materials for restoring crucial parts and large-sized welded constructions of dredges and other mining machines with use of methods of welding and surfacing are considered. Welding and surfacing occupy a significant share in the overall labor intensity of performing repair work at mining enterprises. Both manual arc welding and surfacing as well as mechanized methods are used, which ensure a 2-4-fold increase in productivity. The work shows examples of using the technology of restoring parts and structures at gold mining enterprises in Irkutsk region. Some marks of welding and surfacing materials are shown, which production is mastered by Irkutsk Heavy Engineering Plant (IZTM)

1. Introduction

The improvement of operation stability of crucial parts and constructions of mining machines is a rather actual task. The practice of machines maintenance in conditions of North shows that the significant part of idle times of machines is connected to the repairs caused by necessity of substitution or restoring of prematurely worn out or dangerous for maintenance parts and constructions. The problem of substitution of spare parts is aggravated by their deficiency and price. Welding and surfacing are widely applied to restoring and hardening parts and constructions of mining machines. In this script, some techniques of restoring by welding and surfacing of crucial parts and constructions of mining machines in gold mining industry are shown [1-3]

2. Details, structures, materials and methods

Dredges. The scooping mechanism of dredges. In modern practice of dredging-and-placer mining, the greatest specific volume of mining is occupied by dredging operations. One of the most crucial and loaded aggregates of a dredge is the scooping mechanism, on which reliable operation, in many respects the productivity, of an operating dredge depends. The analysis of working hours of dredges shows the large losses because of execution of the repair works connected to substitution or restoring of worn out parts of the scooping mechanism: buckets, fingers, upper and lower scooping drums.

The bucket is a complex, massive casting (mass up to 3 tons) made of high manganous steel marked as 110G13L (Russian grade abbreviation), and is used as a cutting organ of a dredge and for transportation of rock for dressing. The dredge works 10 months a year, including low negative temperatures periods, in difficult geological conditions.
During repair of buckets on dredges, the wide use is given to methods of surfacing for restoring worn out and for hardening. The semi-automatic surfacing by powder wires marked as PP-AN170 and alike, electrodes marked as ZN-16, EN-G13M2, T-590, T-620 are applied. Deficiencies of methods of surfacing are the low endurance of a build-up metal or restricted height of a surfacing (up to 40 mm) with satisfactory endurance. It requires a periodically iterated surfacing, which is impossible because of necessity to stop dredges and high complexity of building-up operations [4]. The basic method of restoring buckets of dredges during repair is welding a cutting part of a bucket to a body. Cutting parts are the castings from steel marked as 110G13L, welding is carried out by manual arc using chrome and nickel or highmanganese electrodes marked as NII-48G and EN-G13N4 or semi-automatic welding by a powder wire such as 08X12G15N8. Deficiencies of the given method are low endurance of cutting parts and insufficient reliability of welded connection concerning cheap high-manganese austenite electrode materials.

![Figure 1. The scooping mechanism of a 250-l dredger: a - bucket bottom; b – a 250-l bucket, twice reconditioned by welding a deflector](image)

The electrode materials and technique of weldings ensuring reliability of operation of welded connection are developed. During the research, the elemental composition of metal of a weld varied in limits 0.45-0.85 %C; 3-6 %Cr; 1-2% Nb with the fixed contents of 10 %Mn; 0.3 %Si; 3.5 %Ni; S<0.02%; P<0.025%. A rate of auxiliary properties (value of strength σb, percussion viscosity KCU, relative endurance ε) was carried out by results of trials welded and build-up samples and mathematical treatment of obtained experimental data. Except for auxiliary properties, the rate of technological properties of electrodes, in particular - technological durability of welded connection was carried out. As a result of the carried out optimization of an elemental composition and parameters of a condition of welding for industrial use, during repair of buckets of dredges by welding of a cutting part, the electrodes of the mark EN-G10X4N4B2 are recommended; the production of electrodes is mastered by IZTM.

In cooperation with Kurgan machine-building Institute, the method of hardening of a working area of castings made of highmanganese steels using carbides of titanium is developed. The doping is carried out by introduction of titanium dusts, graphite and aluminum during an embedment of pool metal in the shape. Studies of structure and trials of properties in laboratory conditions revealed that the endurance of hardend samples is 1.3-1.5 times higher than in case of castings from steel 110G13L, emitted using the traditional method. The trials of experimental castings of buckets of 250-liter dredges in conditions of "Lensoloto" and "Primorsoloto" have confirmed data of lab tests.
The restoring of buckets of dredges in "Lensoloto" now is made by complex technique which includes casting of hardend cutting parts and welding by electrodes of EN-G10X4N4B2 type.

The connective finger of dredge bucket is a large cylindrical forged part by a diameter up to 220 mm with side shovel. The fingers are made from steels marked as 37XN3A, 38XN3WA and 34XN3M with consequent thermal handling (quenching and tempering). While in service fingers expose strike and hydroabrasive shock. The life expectancy of a finger makes about 3 months.

For restoring fingers are applied a semi-automatic or manual. The fingers to be restored must have wear which does not exceed 30mm. The surfacing is executed with preliminary heating up to 250-300 °C in board and low tempering at once after a surfacing. If the magnitude of a wear exceeds 10-12 mm a soft underlayer is made with a soft underlayer. The underlayer is executed by electrodes UONI 13/45 or powder wire PP-AN29. The high layers of a surfacing by width 8-10 mm are executed by electrodes ENP-2 or powder wire PP-AN122. The hardness of metal of a surfacing after tempering makes 42-46 HRC. On datas of "Lensoloto" average magnitude of a wear of build-up fingers after three months of maintenance makes 5.7mm, at unbuild-up ones – 32 mm (after common quenching and TVCH). On IZTM the special electrodes of the mark ENP-2 for a surfacing of connective fingers of dredges are developed and produced. An elemental composition of build-up metal is: 0.65-0.7 %C; 4.3-4.5 %Cr; 3.5-4.0 %Mn; 0.3-0.5 %Mo.

Upper bucket drums. The wear of upper bucket drums made of steel marked as 35XML basically occurs at the expense of an attrition of heels executing a role of teeth of an asterisk for migration of bucket chain. The restoring of heels is made by strips made of steel 110G13L. The welding of heterogeneous steels requires different speeds of co surfacing oling, is executed after a liner of edges of strips by austenite materials by electrodes of the mark TMU-21U with local preliminary heating [7].

Concentration equipment of dredges. The sowing sheets of a drum sieve (barrel) are made of steel 50G. During surfacing, in a zone of thermal influence, the structure varies sharply; the plastic properties owing to growth of a grain because of overheating complete or deficient quenching are reduced. There is a hazard of formation of cold fractures in a zone of thermal influence. As the preliminary heating of sheets is practically impossible, the use of conditions of welding ensuring minimum welding of the basic metal is recommended. During semi-automatic surfacing, the powder wires of the marks PP-AN124, PP-AN125 and PP-AN170 are applied. The surfacing is made for an abatement of welding of the basic metal and abatement of a share of the basic metal in the welded-up one with the purpose of heightening antiwear qualities; the welding-up is executed with heightened
embarkation of an electrode. The minimum strain of sheets and abatement of stresses are achieved by building-up welding randomly on all sheet by small sites for uniform heat and cooling of a sheet. The axles with width 20-30 mm are superimposed along an axis of rotation of a barrel. The order of superposition of welds - back-step, distance between axles - 60-80 mm. The surfacing is made at a height of 6-8 mm [4, 8, 9].

*Caterpillar. The links of caterpillar* are made of such steel as 40GNF. The most wearing parts are pin holes, racing track (contact with abutment rollers) and spindle linkage (wear from driving asterisk).

The restoring of pin holes is made by electrodes ENP-2 or powder wire PP-AN122. Racing tracks are build-up welded by welding wires Sv-08A or Sv-08G2C by a stratum of ceramic flux ANK-18 [5].

*Asterisk of a cone* is made of such steel as 35GNF. For a surfacing of teeth of an asterisk, the copper water-cooled gage is used. At a significant wear of teeth, the surfacing of a underlayer is applied by electrode UONI 13/45; high layers are welded by electrodes ZN-16, WSN-6, ENP-2 and ZS-1.

*The finger of a chain* is made of such steel as 45GF. The electrodes of marks OZN-300, OZN-350, ENP-2 are applied. The surfacing is made randomly by zones of width up to 10 mm and length up to 30 mm serially from the opposite sides and back-step way from the middle to edges. The powder wire PP-AN120 under stratum flux AN-348A or self-protective wire PP-АН122 is applied to an automatic surfacing.

*Sleeve of a chain, abutment roller* is made of such steel as 35GF. For surfacing, the same materials are used as for surfacing of fingers.

*The knife of a shovel* is made of such steel as 30GF. The automatic surfacing by a powder ribbon PL-U30Х30G3TJ 45 mm wide under stratum flux AN-348A is applied. The surfacing of the first axle begins at a distance of 1/5 lengths of a knife from a back; the second axle is welded on the opposite side across the entire length of a knife; third - on the left 1/5 lengths of a knife. For a semi-automatic surfacing, powder wires PP-AN124, PP-AN125 are used.

The heightening of reliability and longevity of operation of large-sized welded constructions of mining machines has the important value for heightening the efficiency of engineering use. Application of new materials, such as thermohardened low-alloy steels, including high-strength, the perfecting of designing and technique of manufacture of welded constructions of machines working in difficult geological conditions ensured a significant heightening of reliability of constructions, lowered a number of emergencies owing to their destruction. However, intensive maintenance and insufficient cold resistance of metal, the failures of machinery during manufacture, adjustment and repair frequently result in formation in different elements of constructions fatigue fractures, which development can lead to destruction of constructions. The restoring of constructions is carried out by substitution of an element, in which there is a fracture, or more often the restoring of fracture with application of plasticized welding materials is made. The welding of fractures almost always is rather a labour-consuming operation demanding stopping of maintenance of the machine, unloading of repaired elements of a construction, creations of conditions favorable for welding and quality of welded welds etc. Besides because of formation of a wide zone of thermal influence and significant welding stresses frequently, there is a further development of fractures and formation of new fractures.

In this connection, there is an interesting method of fractures restoring offered IMASCH. The essence of the method is that the welding of fracture is not made, and the delimitation of a location of fracture and surfacing of an axle perpendicular to a direction of fracture development is executed only. Plasticitive qualities of builded-up metal should considerably exceed the qualities of the basic metal that is necessary for braking and consequent stopping of fracture. The localization of fractures allows one to lower essentially the complexity of repair and idle times of machines connected to it, and also ensures creation of a more effective scheme of loading elements of constructions with a minimum value of additional stresses.

The electrodes for localization of fractures are developed and produced, their metal consists of high plasticity nickel alloy such as E-08X2N55W4M5K2D3G2, with the use of which the repair of
Fractures of a series of large-sized welded constructions was executed. For example, some fractures were repaired in the upper (stretched) zone of a bucket frame of a 600-liter dredge. The further development of fractures after two-year maintenance of a dredge is not detected.

The high performance is ensured by application of the low-alloy high-resistance steels with $\sigma_{0.2} \geq 700$ MPa in welded constructions. On Tulun coal open cast, walking excavator ESCH 65/100 is in maintenance, which boom is made of steel 12GN3MF-AJDR-SSCH. The boom is a complex spatial bracing frame, which belts are made of pipes with a diameter from 1220 up to 1420 mm. Three years after the begining of maintenance, in the lower zone of a bracing frame, which has the constructive concentrator of stresses, the transversal fracture was formed, which length made up 700 mm. After the repeatedly undertaken unsuccessful attempts to weld the fracture by electrodes UONI 13/55, a special technique of repair was developed. The repair of a boom was carried out at temperature of -30 $^\circ$C; in a zone of repair, the shelter was installed, inside which the temperature was elevated up to +10 $^\circ$C. The welding was executed with local preliminary heating up to temperature 150-170 $^\circ$C. The welding of fracture was executed with use of a remaining foot block from steel 15XSN, using electrodes of marks UONI 13/55, ANP-6P and EA-395/9. After welding, the low tempering of a welding zone with consequent slow cooling was executed. The observation within two years after repair has not detected a restoration of fracture.

3. Conclusion
The rational technique of restoring welding or building-up welding, the crucial parts and welded constructions of mining machines and use of appropriate welding-up materials by methods allows one to increase considerably life expectancy of machines and efficiency of their maintenance.

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