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RECOVERY AND HARDENING OF WORN PARTS FROM STEEL 25L FOR GRINDING EQUIPMENT

Abstract. The main fuel of thermal power plants is pulverized coal. Grinding of coal is carried out by hammer crushers, the working bodies of which are beaters made of steel 110Г13Л. They fail prematurely mainly due to wear from impact-abrasive action. Increasing the service life of beaters is becoming an urgent task.

The paper analyzes the methods of electroslag surfacing and equipment used to restore worn parts. The technological capabilities of the electroslag surfacing of the bits have been investigated.

The technology of restoration and hardening of worn bits by automatic electroslag surfacing with wear-resistant carbon alloys has been developed. It is shown the expediency of conducting the process by non-consumable lamellar electrode with powder filler material feeding. The cladding material, resistant in the conditions of shock-abrasive wear, was chosen.

To restore and harden the worn bits of coal grinding mills a special installation was developed that allows the slag bath to be applied by a non-consumable electrode, and the electroslag surfacing process by a fusing electrode. High durability of clad bits was noted.

Electro-slag metal is characterized by extremely high density and homogeneity, absence of any defects of shrinkage and liquation origin. It is practically as good as the forged one and considerably exceeds the cast one. The expediency of conducting the process by a non-consumable plate electrode with the supply of powdery filler material is shown.

Key words: Beads, electroslag surfacing, electrode, hardening, arc discharge, slag bath, filler material.

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ҰНТАҚТАУ ЖАБДЫҒЫНА АРНАЛҒАН 25Л БОЛАТТАН ТОЗҒАН БӨЛШЕКТЕРДІ ҚАЛПЫНА КЕЛТІРУ ЖӘНЕ БЕРІКТЕНДІРУ

Аннотация. Жылу электр станцияларының 70%-дан астамы ұнтақталған тас көмірді жағу арқылы жұмыс істейді. Көмір ұнтақтауды жұмыс органдары 110Г13Л болаттан жасалған ұрғыштар (било) болып табылатын балғалы ұсақтағыштар жүзеге асырады. Олар өте тез тозып (300...350 сағат арасында) істен шығады. Сол бөлшектерінің мерзімінен бұрын істен шығуы негізінен олардың соққы-абразивті әсерінен тозуына байланысты болады. Ұрғыштардың қызмет ету мерзімін арттыру өзекті міндетке айналуда. Бастапқы өлшемдерді қалпына келтіру және жұмыс бөлігінің тозуға төзімділігін арттыру қажет. Бірақ қалпына келтірудің технологиялық процесі ұрғыштар бетінің біркелкі емес тозуымен қиындайды. Жұмыстың мақсаты көмір диірмендері ұрғыштарының жұмыс бөлігін қалпына келтіру технологиясын жасау. Қалпына келтіру әдісі әдебиеттерді шолу және патенттік іздеу негізінде анықталады. Тозған бөлшектерді қалпына келтірудің және қатайтудың ең тиімді әдісі электрод металын сұйық қожбен өңдеу және бөлшекті үстемелеу кезінде металдың кристалдануы нәтижесінде өнімділігі жоғары, шөгілген металдың жоғары сапасына ие электр қожбен үстемелеу болып табылады. Ол тозған бөлшектерді қайталап қатайтуға мүмкіндік береді. Бұл жұмыста тозуға төзімді көміртекті қорытпалармен автоматты электр қожбен үстемелеу әдісі әзірленді. Әдісті жүзеге асыру үшін қож ваннасын тұтынылмайтын электродпен индукциялауға мүмкіндік беретін арнайы қондырғы әзірленді, ал электр қожбен үстемелеу процесі – тұтынылатын электрод. Үстемеленген ұрғыштардың төзімділігі жоғары. Шөгілген металдың өте жоғары тығыздығы мен біркелкілігі бар, шөгу мен

ликвация ақаулары жоқ. Сапасы бойынша электр қожды металл соғылған металға ұқсайды және құйылған металдан айтарлықтай жоғары.

Түйін сөздер: ұрғыш (било), электрқожды үстемелеу, электрод, беріктендіру, толықтырғыш материал.

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ВОССТАНОВЛЕНИЕ И УПРОЧНЕНИЕ ИЗНОШЕННЫХ ДЕТАЛЕЙ ИЗ СТАЛИ 25Л ДЛЯ МЕЛЮЩЕГО ОБОРУДОВАНИЯ

Аннотация. Основным топливом тепловых электростанций является измельченный пылевидный каменный уголь. Размол угля производится молотковыми дробилками, рабочими органами которых являются била из стали 110Г13Л. Срок службы бил в среднем составляет всего 300…350 часов. Преждевременный выход из строя деталей углеразмольного оборудования происходит, главным образом, из-за их износа от ударно-абразивного воздействия. Повышение срока службы бил становится актуальной задачей. Необходимо восстановить первоначальные размеры и повысить износостойкость рабочей части. Но технологический процесс восстановления осложняется неравномерностью износа поверхности бил. Цель работы – разработка технологии восстановления рабочей части бил углеразмольных мельниц. Метод восстановления определен на основе обзора литературы и патентного поиска. Наиболее эффективным способом восстановления и упрочнения изношенных деталей является электрошлаковая наплавка, имеющая высокую производительность и обеспечивающая высокое качество наплавленного металла. Она также позволяет повторные упрочнения изношенных деталей. В данной работе проанализированы методы электрошлаковой наплавки и оборудование, используемое для восстановления изношенных деталей. Исследованы технологические возможности электрошлаковой наплавки поверхности износа. Предмет исследования – била из стали 25Л. Для восстановления и упрочнения изношенных бил углеразмольных мельниц разработан способ электрошлаковой наплавки их торцевой горизонтальной поверхности с поперечными колебаниями неплавящегося графитового электрода и подачей порошкового присадочного материала, не обладающего ферромагнитными свойствами, на поверхность шлаковой ванны по обе стороны электрода. Для реализации способа разработана специальная установка, позволяющая производить наведение шлаковой ванны неплавящимся электродом, а процесс электрошлаковой наплавки – плавящимся электродом. Стойкость наплавленных бил высокая. Наплавленный металл имеет исключительно высокую плотность и однородность, дефекты усадочного и ликвационного происхождения отсутствуют. По качеству электрошлаковый металл практически не уступает кованому и превосходит литой металл.

Ключевые слова: била, электрошлаковая наплавка, электрод, упрочнение, присадочный материал.

Introduction. One of the serious technical problems of the present time is increase of reliability and durability of machines. More than 70% of thermal power plants operate on hard coal, which is burned in furnaces of boilers in a pulverized state. Grinding is carried out by hammer crushers, the working bodies of which are beats. These parts are made of J91109 (ASTM) steel, and their average service life is 300...350 hours.

One of the main reasons of premature failure of parts of the coal milling equipment is their wear due to shock and abrasion.

Consequently, increasing the service life of the rolls is an urgent task. In this regard, and there is a need for their strengthening (Kuskov et al., 2001). At restoration of rollers it is expedient not only to provide the original dimensions, but also to increase wear resistance of the working part. One of the rational ways to increase the service life of such parts is cladding their working surfaces with wear-resistant materials. However, due to the unevenness of the beaded surface wear, the technological process of restoration is difficult.

Research Material and methods. The aim of the presented work is to develop the technology of restoring the working part of the coal mill rollers. Carbon mill bits made of C1025, C1035, J91109 .(110G13L) steels are subjected to the most intensive wear (Fig.1).

The service life of the new cast U-shaped mill bits made of 25L steel, applied in mills of MMT-1500 type, is 600...800 hours. The working part of the mill bits made of 25L steel wear out for 600 hours of operation at the average by 80 %, which corresponds to the reduction of their mass by 3...4 kg (Figures 1 and 2). The service life of new cast U-shaped bits made of 25L steel with 8...10 mm thick hardfacing on the impact face by flux-cored wire PP-An125 or flux-cored tape PP-AN 101 is 1000 ... 2000 hours. The character of the worn surface is represented in the form of extruded and cut scratches.

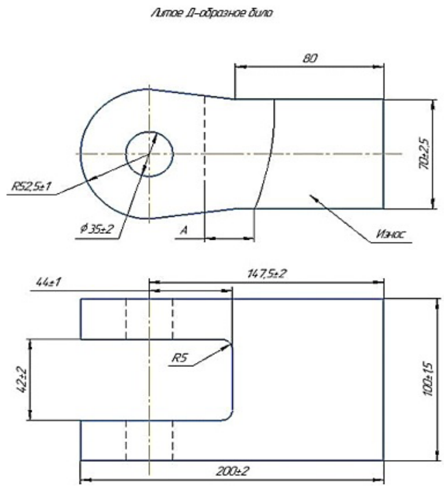
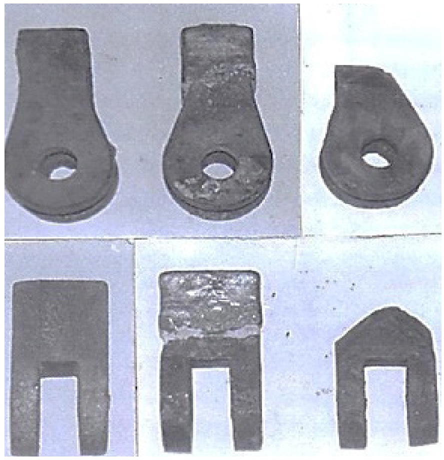


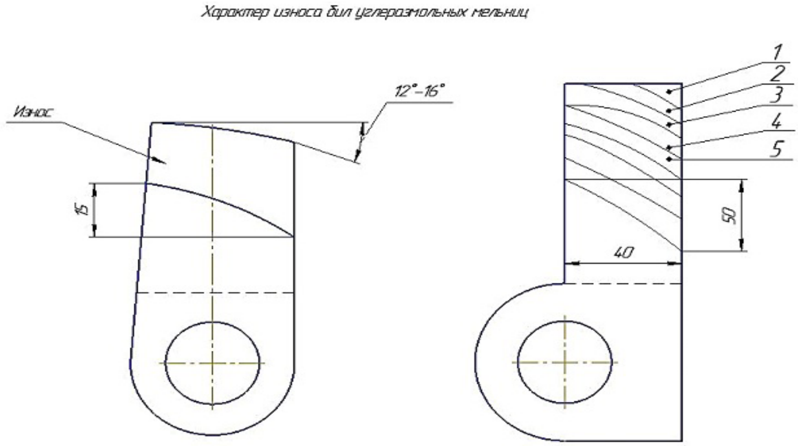
Figure 1. Cast D-shaped beater



a b c

Figure 2. U-shaped beams of HEC
(a – new bit; b – restored beater; c – worn beater)

In spite of the fact that the main impact energy is perceived by the bit surface B (Fig. 3), the surface A wears 5...7 times faster due to intensive abrasion. Wear of the blades occurs in several stages (Fig. 3, b). In the course of wear the shape of rounding of bit surface changes (stages 1, 2...5, Fig. 3, b). In particular, the degree of wear of coal grinding mills' jars is significantly affected by the rock content in hard coal and the temperature mode of their operation. Thus, when grinding the coal mass, the gas with the temperature of 400 ... 500°C is supplied in the crushing zone, and it results in heating the working surfaces of the mill parts up to 200 ... 300°C and in their intensive wear. There are no data on the temperature mode of the beater in the literature. It can be assumed that the temperature in the crushing zone is significantly higher. At the same time the destruction and abrasion of materials leads to additional heating of parts. To increase the service life of the parts of crushing and grinding equipment and, in particular, of the mill rollers, cladding them with wear-resistant alloys has been widely used (Shimanovsky et al., 2018, Popov V.S., 2006, Paton B.E. 1980). The effectiveness of this method is due primarily to the fact that the wear-resistant material hardens only the working surfaces of parts, while the bulk of the part can be made of cheap structural steel. After the working surface is worn, the part can be hardened again by surfacing.



a b

Figure 3. Wear pattern of coal mill rollers

Arc surfacing methods are usually used for hardening working surfaces of new cast bits or bits subjected to wear to a depth not exceeding 5...10 mm, whereas the latter is reasonable to use for applying layers of great thickness.

New bit blanks are cast from steel C1025 with a recess for surfacing of wear-resistant layer. The surfaced surfaces are cleaned from scale, burnt-in and other impurities. Welding is carried out in a special turning device equipped with three water-cooled casings arranged radially at an angle of 120°. The surfacing process is carried out at the first position, the second position is used for metal crystallization and cooling of the surfaced bit, and the third position is used for removal of the surfaced beaters. When installing a workpiece for surfacing, the gaps between the workpiece and the walls of the casting should be filled with asbestos. Oscillating movements of the electrode are combined with stopping in extreme positions for the time required to move the electrode by one step. Limitation of the surfacing length is carried out by means of limit switches and stops.

The duration of the surfacing process is set by the program which includes the surfacing process. Rate of current is 900 ... 1000 A, voltage is 30 ... 32 V, the oscillation speed is 45 ... 50 m/h, the unit travel speed is 50 ... 60 m/h, deposition rate is 12 ... 14 mm.

Overlay welding is carried out with powder tape PL-AN101 (2.3-3.1% C; 22.0-28.0% Cr; 1.3-3.6% Ni; 2.5-5.0% Si; 0.5-2.5% Mn; no more 0.04% S; no more 0.04% P; rest of the iron) at direct current of reversed polarity. Facing time of a bead is 3 minutes, during this time 1.5 kg of alloy 300Cr25C3Ni3Mn are hardfaced. The capacity of one plant is 80 ... 100 beads per shift. Hardfacing with a flux-cored tape allows using welding current of up to 1500 A without worsening of the hardfacing process and formation of the deposited layer. At the same time the productivity of the process increases by 25...40%.

Taking into account simplicity and reliability of the surfacing process and operating experience of the A-1004 M cladding unit at the E.O. Paton IES, the U-877 cladding unit was designed, which enables surfacing of 150...160 bits per shift [1]. The durability of small bits weighing up to 10 kg clad with PL-AN101 is 800...1000 hours which is 1.5...1.7 times longer than durability of the bits clad with flux-cored wire. Durability of large rollers weighing up to 18 kg cladded with flux cored wire PL-AN101 is about 2000 working hours.

The most effective way to restore and harden worn parts is electroslag surfacing, which has high productivity, high quality of the deposited metal due to treatment of electrode metal with liquid slag and metal crystallization as the part is surfacing (Medovar et al., 1963, 1982, Paton, 1981, Ivochkin et al., 1974, Zaitsev et al., 1976, Yuzvenko et al., 1972, Zorin, 2008).

Since the wear of the rollers of coal mills reaches a significant value - 50...70 mm - in this case it is most expedient, especially for the restoration of worn parts, to use electroslag surfacing (Melnikov et al., 1974, Glebov, 1938, Popov, 1973).

A large range of alloys alloyed with carbon, chromium, nickel, boron, etc. is used for surfacing parts subjected to abrasion and shock-abrasion. (Fateev, 1973, Zorin et al., 2029, Artemiev et al., 2009, Luzin, 1968).

The electroslag method allows to obtain the most advantageous form of the working surface by changing the shape of the crystallizer, i.e. to achieve an increase in the wear resistance of the rolls by improving their structural forms.

Electroslag welding and surfacing installations containing, in addition to the fusing electrode, an additional non-fusing electrode are of considerable interest. The installation provides the technology of electroslag surfacing on the side surface of the part, which requires certain technological methods to maintain a given depth of penetration of the base metal on the height of the surfacing.

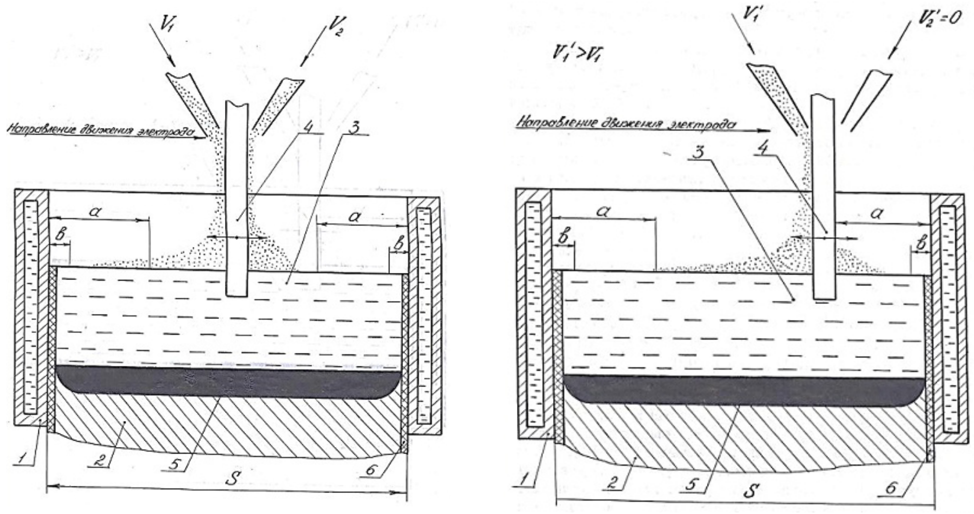
To restore and harden the worn bits of coal grinding mills a special installation has been developed that allows the slag bath to be applied by a non-consumable electrode, and the electroslag surfacing process - by a fusing electrode. High durability of the cladding bits was noted (Dudko et al., 1965, Padar, 1985).

Electro-slag metal is characterized by extremely high density and homogeneity, absence of any defects of shrinkage and liquation origin. It is practically as good as forged metal and is considerably superior to cast metal (Medova et al., 1982, Paton et al., 1981, Ivochkin et al., 1980, 1971, Rakitin, 1978). In addition, electroslag surfacing is characterized by low cooling rates, which allows the surfacing of wear-resistant alloys, prone to the formation of hot and cold cracks in arc surfacing, of any layer height without formation of defects in the form of cracks.

As a result of the analysis of existing methods of electroslag welding and cladding (Medova et al., 1982, Ivochkin et al., 1974, Ermantraut et al., 1978, Mikheev et al., 1984, Padar et al., 1981) and the conducted experimental research on the technology of cladding carbon mill bits the method of electroslag cladding was developed (Medova et al., 1982). Electro-slag surfacing on the face horizontal surface of the rollers with transverse oscillations of a non-consumable graphite electrode and powder additive material without ferromagnetic properties on the slag bath surface on both sides of the electrode was adopted. The developed method allows to exclude accumulation of powdered filler material on the slag bath surface between the mold walls and the electrode moving to them, excludes excitation of arc discharge and shorting of welding circuit between them and, consequently, increases service life of the molds, reliability and safety of the process. Schemes of the electroslag surfacing process according to the developed method are shown in Figure 4, a, b.

In the melting space formed by the walls of water-cooled forming crystallizers 1 and part 2, a slag bath 3 of size S is induced by a known method, for example, with a non-consumable electrode.

The non-consumable electrode 4 is lowered, shorted to the part 2, and an arc discharge is excited. The electrode is communicated by reciprocating motion along the surfacing with specified frequency and amplitude. Flux is supplied to the surfacing on both sides of the electrode in equal streams. Dosing device spigots are fixed on the electrode holder and move together with the electrode. When the electrode approaches the wall of the mold at a distance “a”, feeding of flux into this area stops and increases its feeding from the opposite side of the electrode, which continues its movement, and when the electrode approaches the wall of the mold at a distance “c”, the electrode stops and begins to move in the opposite direction. When the electrode moves away from the wall of the mold at a distance “a”, the flux is again fed in equal streams to both sides of the electrode. Thus, formation of non-electrically conductive interlayers of solidified slag, in the areas adjacent to water-cooled crystallizers is excluded. But there is an increased heat dissipation, especially since in the initial period of the heating process the thermal power reserve is small. Accumulation of non-electrically conductive interlayers of solidified slag does not allow for heating and melting of the peripheral parts of the part surface by the heat of the arc of the non-consumable electrode, reduces the quality and reliability of the fusion zone of the base metal with the clad metal. Further accumulation of slag layers leads to electrode fracture and termination of the process, which requires disassembly of crystallizers and cleaning the part from slag.



a b

1 - mold; 2 - billet beater; 3 - slag bath; 4 - non-fusing electrode; 5 - metal bath; 6 - slag crust;
- powder filler material

Figure 4 - Schematic diagram of the electroslag surfacing process

The heat of the non-consumable electrode arc heats, melts and smoothes the surface of the part to be clad, and melts the flux. As the flux melts, the arc process changes to an electroslag process and a slag bath is initiated. The slag bath process takes place.

After setting the slag bath required volume on the surface of the slag bath on both sides of the electrode 4 are fed powdered filler material and flux, in the amount required to compensate for slag consumption for the formation of a skull 6. In this case the electrode 4 is reported reciprocating movement with a given amplitude and frequency.

Particles of powder material, immersed in a slag bath, are heated and melted, forming a metal bath 5. Flux, getting on the surface of the slag bath, is heated and melted, replenishing its volume.

Result and discussion. Getting on the surface of the slag bath with speed V1 = V2, the powder material sinks in the slag bath not instantly, but stays on its surface for some time and moves ahead of the electrode in the direction of its movement. On the opposite side of the electrode the powder material remains on the surface of the slag bath. The lower layers of the powder particles which are in direct contact with the slag bath get heated and sink in it. New portions of powder with the speed V1 = V2 are supplied to the areas of the slag bath which are adjacent to the electrode on both sides and therefore connected to the movement of the electrode. Therefore, always in front of the moving electrode on the surface of the slag bath there is a hill of powder material, and from the opposite side of the electrode a plume of powder is drawn on the surface of the slag bath. As the electrode approaches the wall of the mold at the distance “a”, the feeding of new portions of powder material into this area is stopped and its feeding from the opposite side of the electrode is increased, which continues to move to the wall of the mold. The pile of powder material in front of the electrode gradually heats up and sinks in the slag, cleaning the surface of the slag bath between the electrode and the wall of the mold. This eliminates the accumulation of metal powder in this area, eliminating the shorting of the welding circuit between the electrode and the mold. In addition, all the filler material enters the slag bath, since when the electrode approaches the mold wall at a distance of about 10...20 mm, the filler material is not fed into this zone, but is fed from the opposite side of the electrode. This makes it possible to reduce its losses. When the electrode approaches the wall of the mold at a distance “c”, the electrode is stopped and moved in the opposite direction. When the electrode moves away from the wall of the crystallizer to the distance “a”, the powder material is fed on both sides of it with the speed V1 = V2. Then the cycle repeats. The distance “c” is chosen as minimum and is determined by the absence of arc charge between the electrode and the crystallizer through the liquid slag. At normal accuracy of electrode fabrication and crystallizer assembly this distance is about 10...12 mm. Theoretical calculation of the distance “a” is connected with the holding time of the powder material particles on the slag bath surface and presents some difficulties connected with temperature, heat capacity, thermal conductivity, density and viscosity of slag, convective flows in a slag bath, granulation and density of powder material, surface tension on the slag-metal interface, formation of garnish on powder particles. However, in each specific case, the distance “a” can be easily determined experimentally.

Conclusions. In the work:

- The character of wear and possibilities of hardening of coal grinding mill rolls by means of automatic electroslag surfacing have been determined;
- The analysis of electroslag surfacing methods and equipment used for restoration of worn parts has been made;
- Technological advantages of the electroslag surfacing of the rollers were studied;
- The technology for restoration and hardening of the worn bits by automatic electroslag surfacing with wear-resistant carbon alloys is developed;
- Expediency of conducting the process by non-consumable lamellar electrode with powder filler material feeding is shown.

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