https://doi.org/10.37434/tpwj2022.06.03

REPAIR OF THE BODY OF CONNECTING ROD OF MOBILE JAW CRUSHER METSO LOKOTRACK LT 120

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ABSTRACT

The paper describes the experience of repair welding of service defects in the body of the connecting rod of mobile jaw crusher Metso lokotrack LT 120, which is a rather rigid honeycomb structure from cast low-alloyed steel of 20GL type with thickness of external walls of 60 mm and of partitions of not less than 45 mm and more than 5 t weight. It was found that the most significant defects — fatigue cracks and cleavage which are incompatible with performance, naturally formed near the structural stress raisers, service damage, caused by contact impact of armour protection, casting defects, as well as in the sites of unsmooth connection of elements, etc. Crack opening displacement is equal to 2–3 mm that is indicative of the start of shape change of the body and need for prevention of further operation in such a state. Rigid structure of the connecting rod body and general state of destruction required special technology of repair welding, which was created and realized by the authors. It included new welding consumables, technological measures and engineering solutions and those verified by our own practical experience of repair of cast structures, as well as high skill and competence of the welders. Practical importance and effectiveness of the performed work on connecting rod repair was confirmed by safe operation of the crusher in the design mode for two years.

KEYWORDS: connecting rod, service defects, design stress raisers, through-thickness cracks, repair-welding technology, rigid framework, weldability, mechanical peening of welds

INTRODUCTION

A large number of foreign highly productive technological equipment, in particular jaw crushers, has been imported into mining, cement and construction industry of Ukraine over the recent decade. The most widely spread are mobile jaw crushers, namely Metso lokotrack LT 120 (Finland). It is designed for primary rock crushing by their compression between flat surfaces called jaws, which are located at a small angle to each other. The operating principle consists in that one of the crushing surfaces is stationary, while crushing is performed due to the mobile jaw moving closer to the stationary one. The mobile surface, which is called the connecting rod, performs reciprocal movements, thus alternatively reducing or increasing the gap between the jaws that leads to high compressive and shear stresses, and, as a result, to the rock breaking up [1]. As the connecting rod operates under variable static loading, its body is made from cast low-alloyed steel with a rather rigid honeycomb structure with 60 mm thickness of the outer walls, not less than 45 mm thickness of the partitions, and more than 5 t weight (Figure 1).

Intensive operation of Metso lokotrack LT 20 jaw crusher at PJSC "Kryvyi Rih Cement" Company for five years resulted in formation of a number of defects on the connecting rod body. Location of the most significant of them, detected by the methods of visual-optical control, is given in Figure 2 and Table 1. Photofixation of cracks Nos 1–4, incompatible with further performance of the rod, is given in Table 2.

As one can see from Figure 2, through-thickness fatigue cracks Nos 1–4 naturally developed from structural stress raisers, service damage, contact impact of armour protection, casting defects, as well as in areas of unsmooth connection of elements, etc. Crack opening is equal to 2–3 mm that is indicative of the start of distortion of the body shape and inadmissibility of its further operation in such a state. Therefore, at the peak of 2002 season crusher operation was interrupted, as there was no spare connecting rod on stock. At mining enterprises repair of such parts by welding is considered to be the main measure for restoring their integrity, and extension of their operation term [2]. The complex nature of destruction and absence of qualified specialists, needed to restore parts by welding, initiated the appropriate plant

Figure 1. Design features of the connecting rod body

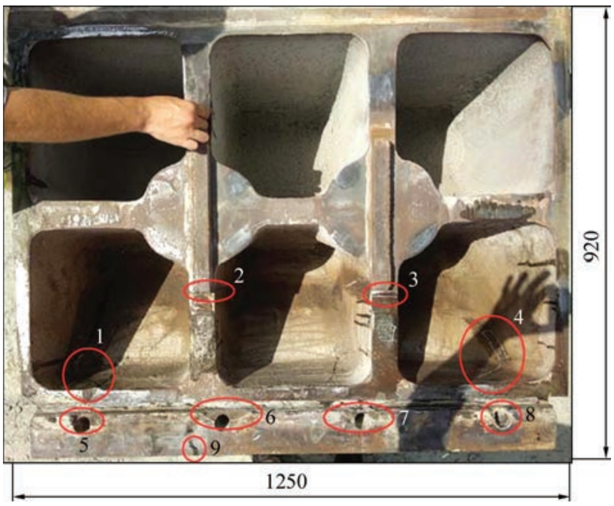


Figure 2. Location of defects Nos 1–9 on the walls and partitions of the rod body

services turning to PWI for technical assistance. In view of the design features, general state, destruction parameters, and operating conditions, PWI specialists came to the conclusion that the connecting rod is repairable in case of application of special repair-welding technology.

The objective of this work consists in development of a repair technology that allows reducing the level of residual stresses in joints, where welding is performed under the conditions of limited deformation, and ensuring their high technological strength and operability under variable static loading.

MATERIALS AND PROCEDURES

In order to develop the respective repair-welding technology, it is necessary to study the chemical composition of foreign cast steel, assess its weldability and technological strength, select a welding process and welding consumables, and to develop new engineering solutions for restoration of the integrity and load-carrying capacity of the body, as well as technological methods to adjust the welding stresses.

For performance of welding operations, it was considered rational to apply coated-electrode manual arc welding (111) and gas-shielded mechanized welding (135), as well as their combination. Taking into account the chemical composition and potential mechanical properties of the cast steel, and requirements of ensuring high technological strength, low-hydrogen welding electrodes of BOHLER FOX EV 50 grade of 3.2 and 4.0 mm diameter (AWS A5.1 E7018) and welding wire of Bohler DMO-IG grade of 1.2 mm diameter (AWS A5.28M-05) were selected. Proceeding from our own experience at performance of such repairs, it was decided to conduct welding in the modes with lower heat input [3, 4], given in Table 3, which were corrected during work performance, in order to improve the stress-strain state of repair joints of the connecting rod under the conditions of their rigid fastening. Positive results, obtained earlier at combined application of both the methods were also taken into account, for instance, when manual welding was used for facing of the groove, and mechanized process — for performance of the filling layers. Previous practice has shown that welding with facing of the edges of not less than 3 mm thickness promotes formation of a more favourable structure in the metal of welded joint HAZ and prevents appearance of cold

Table 1. Characteristic inadmissible service defects on the rod body surface

Defect number	Defect type	Length, mm
1	Through-thickness crack	370
2		320
3		330
4		270
5	Spallation	50
6		100
7		70
8		75
9	Blowhole	30
10	Surface wear	100 %, depth > 4 mm

Table 2. Location and parameters of defects (through-thickness cracks) Nos 1–4

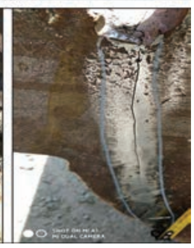
Nos	Three-angle images of defects		
1			
2			
3			
4			

Table 3. Technological characteristics of welding modes

Welding process	Electrode diameter. mm	Kind of current, polarity	Welding current, A	Arc voltage V
111	3.2	Direct, reverse	120–140	24–26
	4.0		140–160	
135	1.2		160–200	26–28

cracks and spallation in it, even in welding alloyed steels [5, 6]. Considering the great thickness of the rod body walls and in order to increase the cold cracking resistance, it was also believed rational to apply preheating up to 80–100 °C in welding [6, 7]. In welding under the rigid restraint conditions, for this repair case it was recommended to apply mechanical peening of weld metal layers, using a special impact tool [8]. Before the start of welding operations, baking of electrodes in electric furnaces at the temperature of 300–350 °C for 1.5 h should be usually performed. To eliminate their moistening, during operation they must be kept in thermal cases at the temperature of 70–80 °C. For manual welding it is necessary to use, for instance, field-proven DC current source VD-306, and for mechanized gas-shielded welding (80 % Ar + 20 % CO_2) — the apparatus of ewm Phoenix Pulse 501 model with built-in semi-automatic machine. The methods of cutting out the damaged metal cracks and edge preparation for welding, used in the work, are well-established and have been applied in our practice for a long time [9]:

- mechanical cutting, plasma and electric-arc gauging by special electrodes of ANR-2 type;
- surface cleaning by an abrasive tool.

Connecting rod preparation for repair consisted in removal of contamination and lubricants from the surface in the welding zone, as well as mechanical cleaning of the surfaces from scale and thorough check for defects using penetrants.

The described experience and recommendations were included into the repair technology of restoration of the connecting rod integrity.

INVESTIGATION RESULTS

As a result of studying the chemical composition, it was found that the content of elements in the metal sample taken from the rod body, is as follows, wt.%:

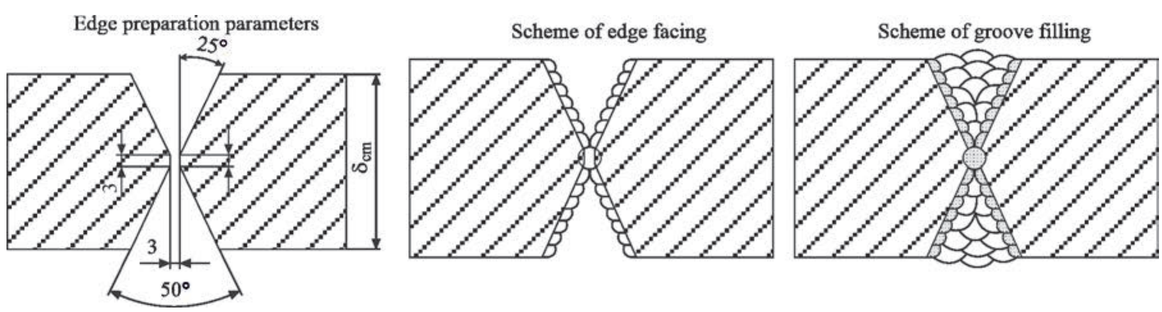


Figure 3. Scheme of repair of defects Nos 1–4

Figure 4. General view of the region of repair of crack No. 1 on the front wall (*a*), after thermal removal of a wall fragment (*b*), after welding (*c*) from the inside and outside, respectively

Figure 5. General view of repair of crack No. 2 on the front wall after mechanical edge preparation (*a*) and after welding (*b*)

C — 0.20, Si — 0.43, Mn — 1.52, S — 0.007, P — 0.023. Such metal is identified as low-alloyed steel, analog of local steel of 20GL grade to GOST 977–88. Its weldability at carbon equivalent C_{eq} = 0.45 is assessed as satisfactory.

Welding technique was as follows: block method, up to 100 mm block size, not more than 10 mm width of individual weld beads.

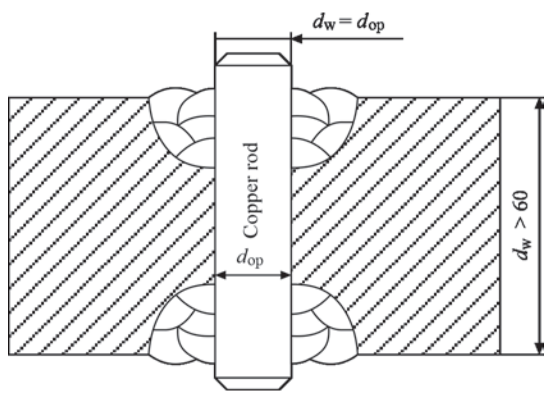


Figure 6. Scheme of repair of defects Nos 5–8

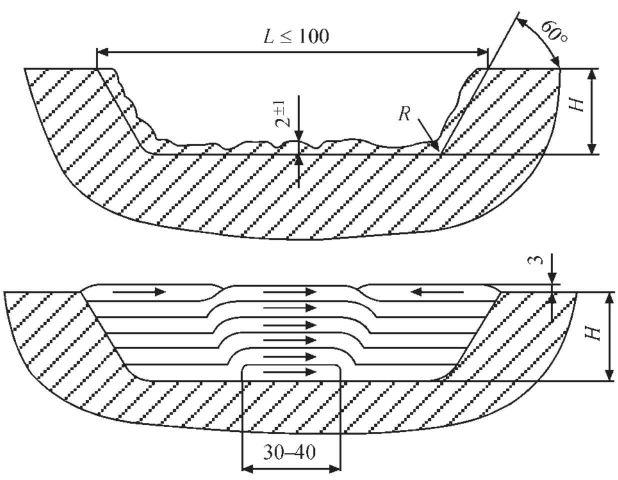


Figure 7. Scheme of repair of defect No. 9

Taking into account the size and diversity of the defects, their repair sequence was as follows: regions with cracks in the walls were cut out and welded first (defects Nos 1–4), openings were repaired in the second turn (defects Nos 5–8), and blowholes were the third to be repaired (defect No. 9). Repair was completed by restoration of the worn surfaces.

Repair of defects Nos 1–4 was performed after crack cutting out, edge facing with electrodes of Bohler FOX EV 50 grade with subsequent mechanized welding up of the groove, using Bohler DMO-IG wire according to the scheme, given in Figure 3. An example of the general view of the region of repair of crack No. 1 on the front wall is given in Figure 4, and that of the crack No. 2 — in Figure 5. When going over to welding of the weld outer side, the weld root cleaning must be performed. During welding mechanical peening of deposited metal layers by an impact tool was performed up to a change of the weld pattern, except for the first layer in the weld root and the facing layer. Weld interpass temperature was maintained in the range of 130–150 °C.

Repair of defects Nos 5–8 was performed after treatment of the inlet channel and installation of the copper rod into the opening. Welding was conduct-

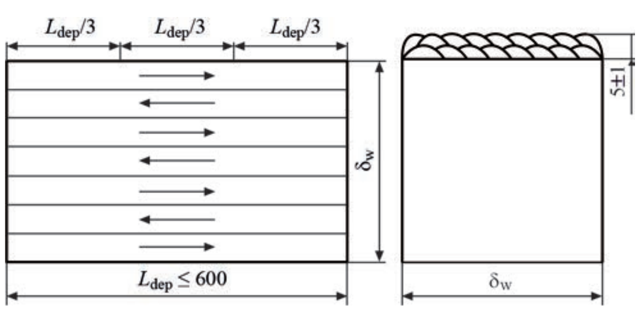


Figure 8. Scheme of restoration of worn surfaces

ed by FOX EV 50 electrodes, in keeping with the scheme, given in Figure 6.

Blowhole repair (defect No. 9) was carried out according to the scheme (Figure 7) with prior grinding to clean metal, using mechanized welding by Bohler DMO-IG wire.

Restoration of worn surfaces was performed with prior removal of the work-hardened layer to the depth of 0.8–1.0 mm and further deposition of longitudinal beads by Bohler DMO-IG wire with 1/3 overlapping in two layers, according to the scheme in Figure 8. Finish grinding was performed to metal level, no blackness was allowed.

At planned breaks or long-term interruptions of the work, as well as after completion of welding, repair joints must be subjected to slow cooling with periodical heating by gas-oxygen flame up to the temperature of 120–150 °C with covering by thermal insulation materials.

Welding operations support provided by our specialists during the entire period of their performance showed that the proposed technology ensures the high technological strength of the repair joints and is professionally realized by qualified welders without any problems. After performance of visual-optic control the restored connecting rod was transferred to the enterprise with guarantee period of 12 months. Two years have passed since putting it into operation up to now. During this time, the enterprise did not make any claims as to the quality of the provided service.

CONCLUSIONS

It was clarified that inadmissible service defects on the connecting rod body made its further operation impossible, and required repair by a special technology, which would take into account the design features of the repaired object, the state of its damage and need for welding under the conditions of limited deformation. Custom-designed technology includes new welding consumables, technological measures and engineering solutions and those tried out by our practical experience of repair of similar cast structures, as well as high skill and competence of welders. Practical importance and effectiveness of its application has been confirmed by the rod operation in the design working mode of the mobile jaw crusher Metso lokotrack LT 120 for two years.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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SUGGESTED CITATION

V.D. Poznyakov, O.A. Gaivoronskyi, Yu.V. Demchenko, A.M. Denysenko, G.V. Zhuk (2022) Repair of the body of connecting rod of mobile jaw crusher METSO LOKOTRACK LT 120. *The Paton Welding J.*, **6**, 17–21.

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https://pwj.com.ua/en

Received: 18.05.2022

Accepted: 15.08.2022