UNIVERSITY OF KRAGUJEVAC

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL CONSTRUCTIONS AND MECHANIZATION

IRMES KRAGUJEVAC 2019

9TH INTERNATIONAL SCIENTIFIC CONFERENCE - IRMES 2019

RESEARCH AND DEVELOPMENT OF MECHANICAL ELEMENTS AND SYSTEMS

BOOK OF ABSTRACTS

Editor: Nenad Marjanović

5-7 September 2019, Kragujevac

Book of Abstracts for the 9th International Scientific Conference [on] Research and Development of Mechanical Elements and Systems, IRMES 2019

ISBN 978-86-6335-061-8

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Editorial assistant:	Nenad Kostić, Faculty of Engineering, University of Kragujevac
Technical editor and graphic design:	Nenad Petrović, Faculty of Engineering, University of Kragujevac
Publisher:	Faculty of Engineering, University of Kragujevac, Department for Mechanical Constructions and Mechanization, Sestre Janjić 6, 34 000 Kragujevac, Serbia
For Publisher:	Vesna Ranković, Vice dean, Faculty of Engineering, University of Kragujevac
Printed by:	InterPrint, Jurija Gagarina 12, 34000 Kragujevac, Serbia
Circulation:	200 copies

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The publication of this Proceedings was supported bz Ministry of Education, Science and Technological Development of the Republic of Serbia

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IRMES KRAGUJEVAC 2019

9th International Scientific Conference
Research and Development of Mechanical Elements and Systems
Kragujevac, Serbia, September 5-7 2019

REPARATORY SURFACE WELDING OF THE FRACTURED TOOTH OF THE BUCKET-WHEEL EXCAVATOR GIRTH GEAR

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Key words: reparation, surface welding, fracture, tooth, bucket-wheel excavator, girth gear.

Frequent premature damages and fractures of components or the whole structure of bucket-wheel excavators at open-pit mines occur in exploitation. That is explained either by inadequate design and construction or by insufficient knowledge of the material properties, welded joints or oversights in manufacturing. Besides the direct losses due to damage or fracture of the excavator, the disruption in the power production and supply can cause significant indirect losses. The considered bucket-wheel excavator was employed for 5000 hours, when the fracture of the tooth of the girth gear, which enables the circular motion of the excavator's upper structure, occurred. The gear was made of the cast steel GS 40 MnCrSi3 V. To predict the cast steel resistance to crack propagation, the fracture parameters were calculated, namely the critical value of the stress intensity factor – the facture toughness K_{Ic} and the critical crack length a_{cr}, based on the obtained values of the material's impact energy and the yield stress, according to the Barsom-Rolfe model. The calculated value of the critical crack length was 61.9 mm. After the necessary calculations, the reparatory surface welding technology of the fractured tooth has been proposed. Due to the complex construction solution of the girth gear and its function in exploitation, it was necessary to precisely define a large number of details and carefully consider and execute all the operations in the methodology of manufacturing the new tooth. This was an imperative in order to ensure the safety of the repaired girth gear exploitation, since the smallest oversight, underestimate or improper execution could cause serious problems in

operation of the BWE as a whole. This is the reason why the preparation procedure for the hard-facing technology is presented, as well.

First, the weldability of the cast steel was determined by using various equations. According to equivalent carbon formula of the International Welding Institute, for maximal value of the chemical elements composition of the GS 40 MnCrSi3 V, the limiting value for the good weldability of this material is greater than 0.45. The value obtained by the Ito-Bessyo formula also surpasses the limiting value for the good weldability of 0.30. Based on the obtained results, it was concluded that this steel is prone to cold cracks appearance, what prompted the necessity for the hard-facing of the broken tooth to be performed with preheating and controlled cooling. In addition, according to formula for the Hot Cracking Sensitivity (HCS) it was established that this material is prone to appearance of the hot cracks, as well, since the obtained value for the HCS is less than 4, which is the limiting value for this type of steels with tensile strength of about 700 (MPa). After the detailed investigation of weldability, the hardfacing procedure was proposed, as well as all the preparatory and depositing operations. Due to the girth gear construction (dimensions and mass) and conditions of the hard-facing execution without the heat treatment, for the filling volume greater than 500 (cm3), the recommended preheating temperature is within range 100 to 150 ºC. Depositing of the first layer was executed by the austenitic electrode E 18 8Mn B 22, while the second layer was deposited by the basic electrode E 1-UM-300 (DIN 8555). After the hard-facing, machining of the gears to measures defined by the coordinate measuring device was performed in accordance with clearances (tolerances) prescribed by the excavator manufacturer's documentation.

Reparation of the girth gear tooth of the bucket wheel excavator SRs 2000×32/5.0 by the presented methodology was executed in 2013. The time gap of about 5 years, from the performed reparatory hard-facing to preparation of this paper, appeared due to the fact that the repaired girth gear's behavior was monitored in exploitation. Considering that the new tooth fractured after only a year in operation and that the repaired excavator is still in operation at the open pit mine "Kostolac" (Serbia), it can be concluded that the reparation was successful. It should be emphasized that in this way the large financial effect was realized as well, since the construction of the new girth gear would cost over 500.000 €. If the time, needed for manufacturing the new girth gear, which is about 6 to 9 months, would also be included in this calculation, as well as effect of the electric power that would not be produced in such a long period, the total positive financial effect is about 8.000.000 €.

The presented methodology of the reparatory hard-facing, as well as the welding procedure, can be applicable, with necessary adjustments, for recovery of other parts and structures of the bucket wheel excavator at open pit mines.

Acknowledgments. This research was partially financially supported by the Ministry of education, science and technological development of Republic of Serbia through grants TR 35006 and TR 35024 and by the project of Operational Program Research and Innovation: "Research and development activities of the University of Žilina in the Industry of 21st century in the field of materials and nanotechnologies", No. 313011T426, co-funded by European Regional Development Fund.