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FAILURE ANALYSIS OF CHAIN BRACKET

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Keywords
- bulk material
- conveyor
- chain bracket
- hardening zone
- cracks

Abstract

In spite of numerous and expensive research in the field of fatigue and fracture and regular control of end products, cracks occur every day in all fields of human activity. This paper describes failure analysis of chain brackets, used in conveyor systems for cement production. Chain type bucket elevators utilize chain brackets for joining segments of chain as well as for attaching brackets for bulk material transport. The contact zone between chain link and bracket is one of the most stressed in this elevator system. During regular maintenance, cracks are found on used and new brackets in the case hardened zone. Case hardening of the chain bracket is performed due to requirements for increased wear resistance of the chain link contact. The occurrence of cracks in new brackets raised the question regarding the origin of cracks and it is the main subject of this paper. This paper also suggests a solution for avoidance of cracks on chain brackets.

Ključne reči
- rasuti materijal
- konvejer
- spojnica lanca
- otvrdnuta zona
- prsline

Izvod

Uprkos brojnim i skupim istraživanjima u oblasti zamora i loma kao i redovne kontrole gotovog proizvoda, prsline se javljaju svakodnevno u mnogim oblastima. Ovaj rad opisuje analizu otkaza spojnice lanca korišćene u konvejeru za transport cementa. Lančasti elevatori sa kašikom koriste spojnice za spajanje segmenata lanca i za vezivanje kašike za transport rasutog tereta. Površina kontakta između karike lanca i spojnice predstavlja jedno od najopterećenijih mesta na celom elevatoru. Tokom redovnog održavanja na upotrebljenim i novim spojnicama lanaca uočene su prsline u otvrdnutim termički obrađenim zonama. Radi povećanja otpornosti spojnica na habanje one se u oblasti kontakta sa karikom lanca termički obrađuju. Pojava prslina u novim nekorišćenim spojnicama pokrenula je ispitivanja sa ciljem da se utvrdi poreklo prslina na novim spojnicama. Pored ispitivanja uzroka nastanka ovih prslina u radu su navedeni predlozi mera za sprečavanje njihovog nastanka.

INTRODUCTION

Bucket elevators can be found in almost all bulk material processing industries. They are used for conveying all types of bulk material in the following industrial sectors: cement and building material works, potash, salt and soda works, power stations, the chemical industry, the iron and steel industry, port facilities, gravel works and quarries, fertilizer works. Chain bucket elevators provide advantages for following applications:

- Wherever extremely robust traction mechanisms are required.
- Charge fluctuations can be expected.
- The traction mechanism could run off.
- The materials being handled can be expected to have high temperatures.
- The material handled can be expected to have large individual feed sizes.

METALLURGICAL FAILURE ANALYSIS

This paper describes failure analysis of chain brackets, Fig. 1, used for joining segments of chain as well as for attaching brackets for cement transport, from a domestic cement plant. After detection of cracks on in-service chain

brackets, all unused chain brackets are tested by magnetic particle method. On several new chain brackets, cracks are found at the same zone as in-service brackets, Fig. 1. This has raised the question regarding the hidden production of flaws and the remedy for this type of cracks. These types of cracks are characteristic for one shipment only and another bracket shipment is replaced due to wear.

The contact zone between chain link and bracket, Fig. 1, is one of the most stressed zones in this elevator system, and in that zone fracture has occurred, Fig. 2. The fracture surface indicates that the bracket operated at the unidirectional bending at low nominal stress. The chain bracket is produced by forging with small flash line i.e. excess metal that extends out from the body of bracket. Sulphur print, Fig. 3 reveals that carburized depth is approximately 2 mm, in chain contact zone, with hardness profile shown in Fig. 4.

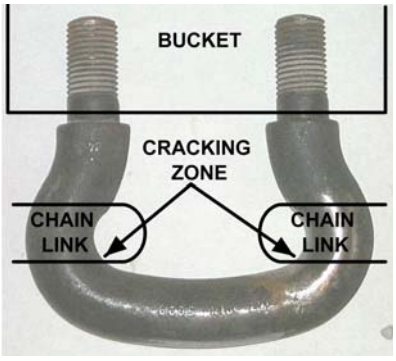

Figure 1. Chain bracket with schematic connection of bucket with chain links.
Slika 1. Spojnica lanca sa shemom veze sa kofom i sa karikama

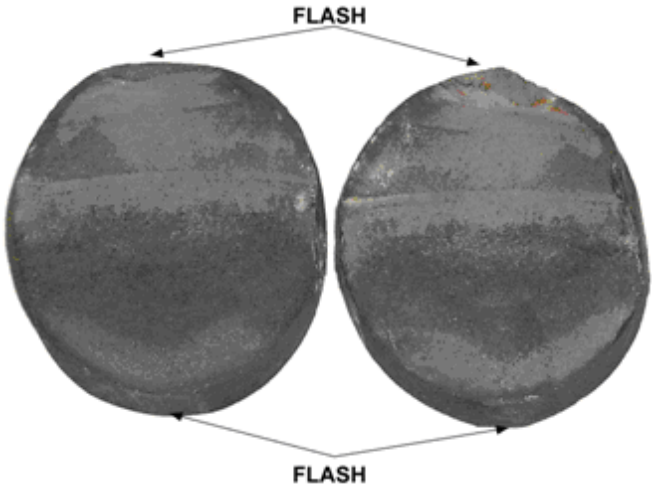

Figure 2. Fracture surfaces of chain bracket.
Slika 2. Površine preloma spojnice lanca

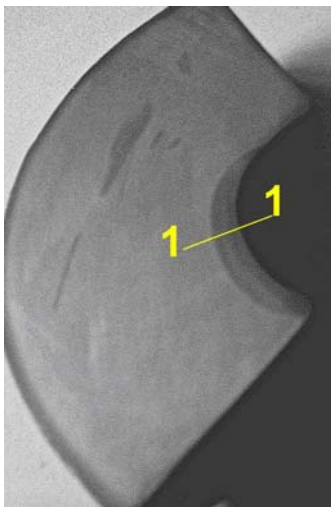

Figure 3. Carburized zone of chain bracket.
Slika 3. Cementirana zona spojnice lanca

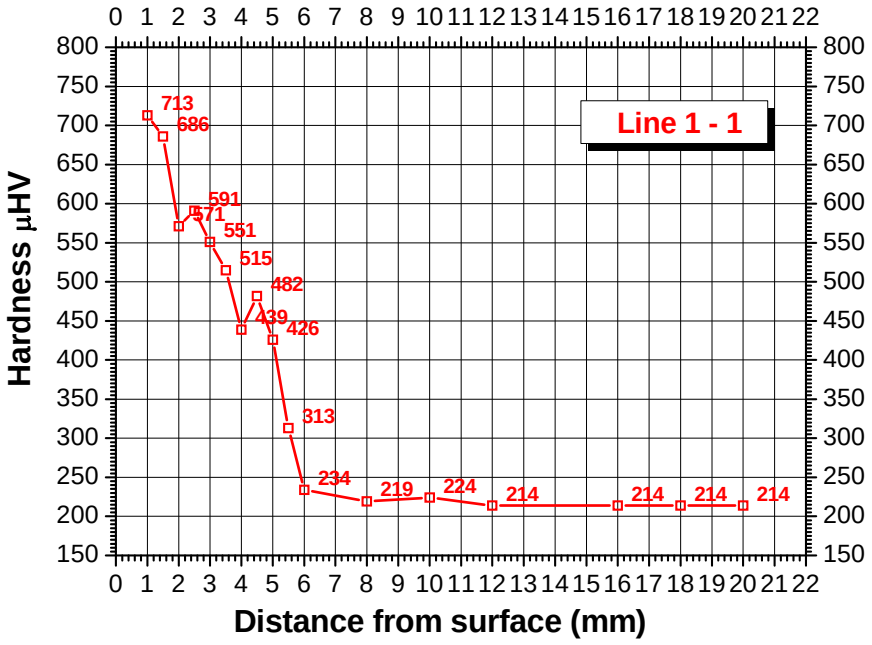

Figure 4. Hardness profile of carburized zone in Fig. 3.
Slika 4. Profil tvrdoće cementirane zone sa sl. 3

Chemical composition and mechanical properties match with steel 14CrNi6 (1.5919). Average impact toughness at room temperature is above 180 J, where 25% of absorbed energy is crack initiation and the rest is crack propagation.

The cross section of bracket can be divided into three microstructural zones: carburized zone (Fig. 5), transition zone (Fig. 6), and basic microstructure of the chain bracket forging (Fig. 7).

SEM analysis, from crack presented in Fig. 5, shows significant presence of oxide on crack surfaces, Fig. 8. Fatigue striations are shown in Fig. 9.

Figure 5. Carburized zone with the crack, hardness values between 600 and 700 HV.
Slika 5. Cementirana zona sa prslinom, vrednosti tvrdoće između 600 i 700 HV

Figure 6. Transition zone, hardness values between 300 and 600 HV.
Slika 6. Prelazna zona, vrednosti tvrdoće između 300 i 600 HV

Figure 7. Fine grain ferrite–pearlite microstructure of chain bracket forging, average hardness value 220 HV.
Slika 7. Finozrna feritno perlitna struktura otkovka spojnice lanca, prosečne tvrdoće 220 HV

DISCUSSION

The fact that cracks are found in new, unused chain brackets, shift focus on production path and possible weak point of production process of chain brackets.

Chain bracket are produced from bars, hot bended before forging, which leads to wrinkling of material in zone 1-1, in Fig. 3. After cooling, small initial cracks, as a result of wrinkling, remain on surface. Subsequent forging, with distinct flash, and thermal cycles as a result of heat treatment only help propagation of those initial cracks. The storage of chain brackets during shipment disables moisture and oxidation. The environment where the chain bucket elevator is in-service is very dry, because cement is a highly hygroscopic material, so it is plausible to conclude that the oxide found in Fig. 8, is from production. The fact that operating stress is low combined to the high impact toughness of forging, has prevented the catastrophic failure of the chain bucket elevator.

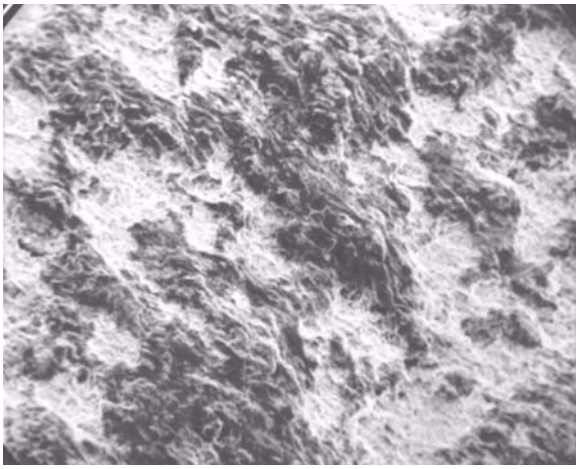

Figure 8. Oxide layer on fractured surface, ×50.
Slika 8. Oksidni sloj na prelomnoj površini, ×50

Figure 9. Fatigue striations on fractured surface, ×5000.
Slika 9. Linije zamaranja na prelomnoj površini, ×5000

CONCLUSIONS

The origin of cracks on new and in-service chain brackets is found in the production process, as a result of wrinkling of the material during hot bending. Simply a low-cost operation, after hot bending, the grinding in zone of further carburization could prevent the occurrence of cracks in chain brackets.

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