Investigation of the WC plate, WC rod and CrC Abrasion Resistant Coatings for Refractory Monolithic Mixer Beaters to Beater Life

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Abstract

A solution for an industrial problem is aimed at this study. Used in refractory industry, the knives of mixers which prepare blends, are exposed to wear problem and therefore cause big economic loss. 3 types of coating is tested to increse wear resistance. As a coating material; CrC, WC plate and WC welding wire is used. The wear of those coated mixer knives are observed approximately for a year.

The wearing behavior is examined in both service and laboratory conditions. SEM and EDX analysis and HV microhardness measurements of the coated materials are done. The optimum results from both the experiments and the materials that are observed in the service conditions are achieved from the plates that were coated with WC. Thanks to the mixing materials which are coated spending 3.780 dollars, a 510.000 dollars production loss is impeded in a year.

1. Introduction

Wear is related to interactions between surfaces and specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface . The need for relative motion between two surfaces and initial mechanical contact between asperities is an important distinction between mechanical wear compared to other processes with similar outcomes.

In this study, a solution for industrial problem is sought. Especially intented for magnesite and similar abrasive mine processes, wear resistant coatings that not only decrease production loss but also lower service cost are worked on. In this study, a solution for industrial problem is sought. Especially intented for magnesite and similar abrasive mine processes, wear resistant coatings that not only decrease production loss but also lower service cost are worked on. In the laboratory conditions, abrasive wear test, vickers micro hardness test were applied. The microstructures of the weared parts were analyzed by SEM, XRD and optical microscope.

2. Experimental procedure

2.1. Substrate materials (Specimens and Mixer Beaters)

Materials in which wear tests and wear conditions in service were performed was applied as coatings on a Fe 0.20%C steel substrates by weldings and soldering techniques. Respectively for wear tests, microhardness measurements, SEM and EDX analysis the 12x12x12 mm sized coated and uncoated samples seen in Fig.1 are prepared by wire erosion cutting method. In Fig.2 coated and non-coated states of mixer knives used in service conditions can be seen

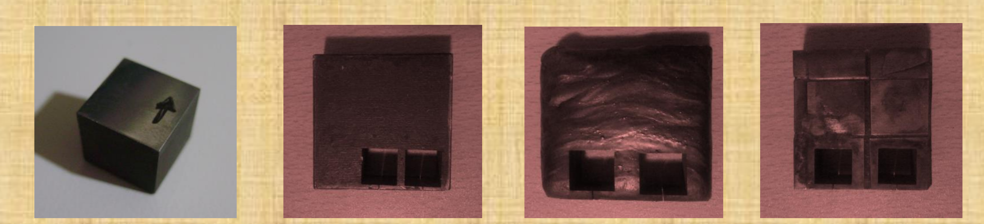

Fig. 1. The states of test samples before coating (at the left 1,2 pictures) and after coating (3,4 pictures).

Fig. 2. The coated and uncoated states of mixer knives used in service conditions.

3. Results and discussion

3.1. Coating characterization

Typical cross-sectional and EDX view of three types of WC plate, WC hard surfacing rod and CrC hard filling coatings are illustrated in Fig. 3,4 and 5, respectively. The coatings appear dense and the coating/substrate interface is clean and without cracks. After wear test, the surface roughness of all coatings are provided in Table 5.

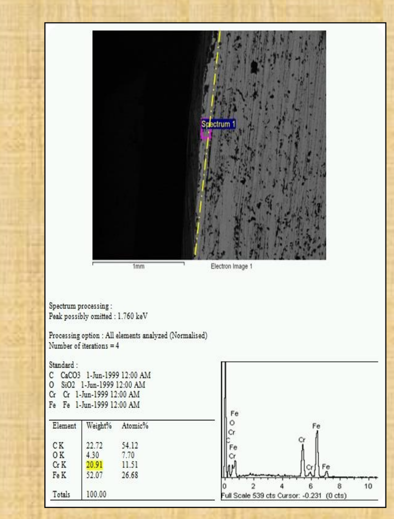

Fig. 3. Cross section and EDX of CrC coating.

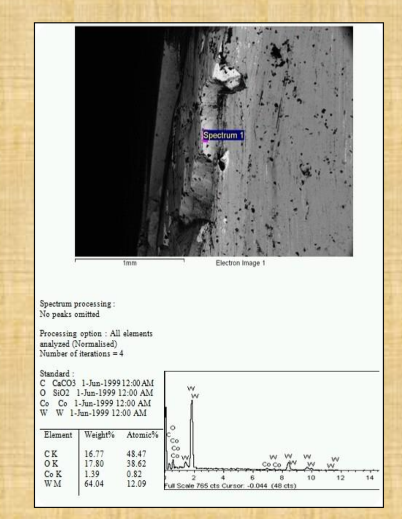

Fig. 4. Cross section and EDX of WC plate coating.

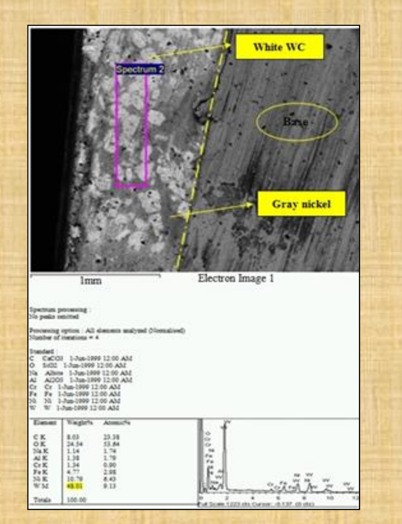

Fig. 5. Cross section and EDX of WC hard surfacing rod coating.

Materials	Ra (µm)	Rz (µm)	Rq (µm)
Sustrate	0,33	2,8	0,43
CrC coating	0,37	8,3	1,61
WC hard surfacing rod	0,23	2,1	0,3
WC plate	0,31	4,2	0,62

Table 5. Surface roughnesses were measured by Mitutoyo SJ 400 perthometer.

3.2. Results of hardness test and wear tests

It is shown in Table 6, the comparison of the hardness results of coatings and substrate specimens, the highest hardness value is WC hard surfacing rod coating, the lowest hardness value is SAE 1020 substrate. At the end of the wear experiments, abrasive wear test results are determined as the weight losses of the samples of untreated substrate; CrC, WC hard surfacing rod and WC plate coatings specimens. Then the wear rates are calculated is shown Fig 6. Also wear rates of 3 types coated mixer beaters are observed aproximatelly 1 year wear life.

Table 6. Hardness values were measured by micro vickers.

Materials	$HV_{0.1}$
Substrate	163
CrC coating	780
WC hard surfacing rod	2260
WC plate	1869

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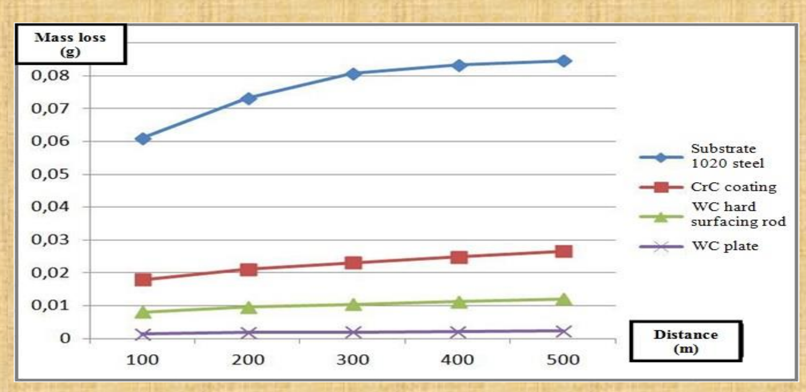

Fig.6. Weight losses were measured after 100, 200, 300, 400 and 500m. sliding distances of wear.

Table 7. The wear life of coated mixer beaters

Date	Wear life (hour)	Wear life (day)	Average Daily working time (hour)	Note
05 / May / 2013	0	0	-	Machine start
30/ September /2013	420	21	20	CrC
30 /December /2013	4763	238	20	WC hard surfacing rod
15 /June / 2014	8111	405	20	WC plate

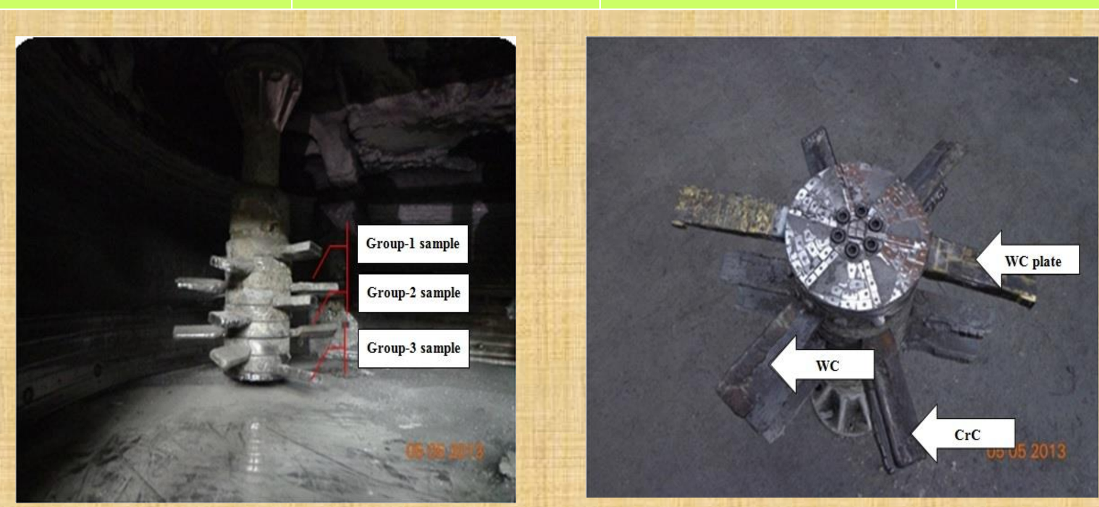

Fig.7. Mixer beaters assembly prepared for the service conditions.

Fig.8. After wear life, CrC coated mixer beaters (on the left), WC hard surfacing coated mixer beaters (in the middle), WC plate coated mixer beaters (on the right) in the service conditions.

4. Conclusions

(1)The wear resistance seen in service conditions are similar in laboratory conditions. The highest wear resistance is observed in the samples and knives which were coated with WC plates. The wear resistance of the ones coated with CrC is the lowest in both service and laboratory conditions.

(2)Hardness, different from wear resistance, has the highest rate in coating made of WC_2 hard filling. The fact that the wear resistance of the coating made of WC_2 hard filling is almost half as much as WC plates' can be described as the metal behavior that the WC_2 hard filling shows.

(3)In this study, the aimed solution of an industrial problem is achieved. The coating made of forming of chrome carbide, only resisted 21 days approximately working 20 hours a day. The coating made of WC_2 hard filling, with 238 days of work, resisted 10 times as much as CrC. WC plate coating, with 405 days of work, maintained a living almost twice as much as WC_2 hard filling.

(4)When unit price of coatings and labor charges are taken into consideration, general cost of the coatings are; CrC 175 dollars, WC_2 hard filling 1478 dollars and WC plate 3780 dollars.

(5)For knive change in the mixer, a shift of clean-up and a shift of mechanic control is needed. The knives in each mixers prepare 20 blends in average shift. Because of the cessation of production, 20 x 2 = 40 blends, cause 30.000 dollars worth unmanufactured refractory tile.

(6)When the production loss for approximately a year is calculated, coating cost turns out to be considerably trivial unlike the production loss caused by the knive change. These costs for a year are, for 17 times change needing CrC coated knives 510.000 dollars, for 2 times change needing WC_2 hard filling coated knives 60.000 dollars and for just one change needing WC plates coated knives 60.000 dollars.