Testing the wear on the hardened surface layers

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Macro-microscopic examinations hardness, abrasive wear

1. Introduction

The paper shows the reaction to wear of a hammer mill for grinding coal.

It is demonstrated that in a preparation and coal dust burning there is a reduced operating time because the hammer mill used in grinding wear out quickly.

Crushed cool mill MVC4 is designed to dry and grind coal.

To obtain the desired size coal, mill must operate at optimal technical characteristics which are given for each mill.

The maximum operating time under normal conditions of a hammer was 250 hours.

The life of these hammers is relatively low, and an extension can be made by traditional methods of charging welding the active parties. Among the methods used can be remember MIG-MAG welding, MAG each in several variants.

Cast steels are used for parts requiring high strength and toughness, they are much better in economically and technologically than other types of steels. Non-alloy casting parts contain 0.1 ... 0.6% C, 0.4 to 0.8% Mn, 0.25 to 0.6% and max. 0.04 -0.05% S.

Usually these steels are subject to heat treatment to achieve higher values of mechanical characteristics. Steels are commonly composed of Cr, Ni, Mo, Mn and Co, they are harder to cast with melting and casting temperatures higher and are introduced to streamline added Mn, Si, Cu, V, P. These steels are used for casting parts as a result of heat treatment and recovery or improvement of normalization (quenching plus return) to obtain high mechanical characteristics and well balanced.. In order to complete loading welding technology hammer mill, several options were discussed charging welding technology.

Superalloys are complex alloys, they are based on a major element (Ni, Cr, Mo, etc..) Dissolved in about metallurgical other elements (Al, Ti, Nb, etc.). In order to achieve structural characteristics, mechanical corrosion resistance and / or high wear basic elements both at high temperatures (over 500^{0}C).

Experienced technological variants are made with thermal spraying and welding load.

It is made a thermal plasma jet spraying of powder metal P METCO 450 and after is made a MAG welding process (135) with filler material.

2. Testing and results

In Table 1 have passed the minimum and maximum total thickness of deposits (thermal spraying material and layer deposited alloys) determined by optical microscope measurements MeF2.

Tabel 1. Thickness of deposits

Sample marking	Total thickness of layers deposited [mm]		Average values [mm]
	Minimal values	Maximum values	
Ml	6.79	11.68	9.235
M2	6.47	11.12	8.795

2.1. Macro-microscopic examinations

Macro-microscopic examinations and tests hardness HV5 were made in areas characteristic of the welded joints according to EN 1321.

In establishing the technological variants charge of die active elements is important to choose correctly MVC4 filler material according to the basic materials. Surfaces of the hammer mill were loaded welded on four active areas.

At macroscopic examination can be seen the cross-sectional samples of deposits made in versions 1 and 2.

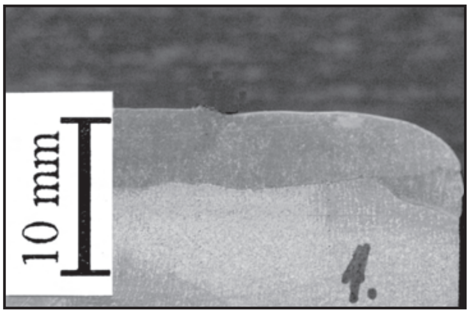

Figure 1. Sample M1 (concentrated ferric chloride attack)

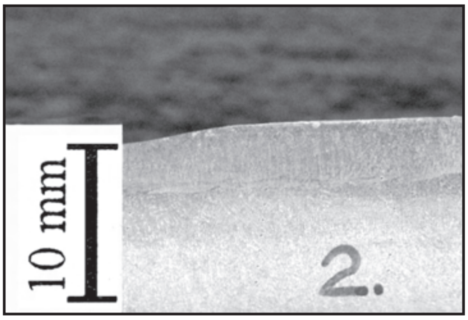

Figure 2. Sample M2 (concentrated ferric chloride attack)

Examinations conducted on both the outer surface of the deposits and their cross section revealed welding defects.

Microscopic examinations on characteristic areas of joints made (MB, ZIT, MD) show the structure:

• In all of the evidence base metals M1 and M2 are perlito-ferritic structure with ferrite grobe and in network (Figures 3 and 4).

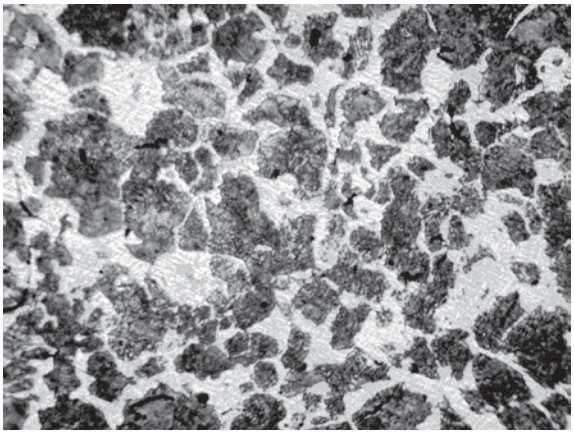

Figure 3. Base metal (MB) (Nital attack 2%, 100 x)

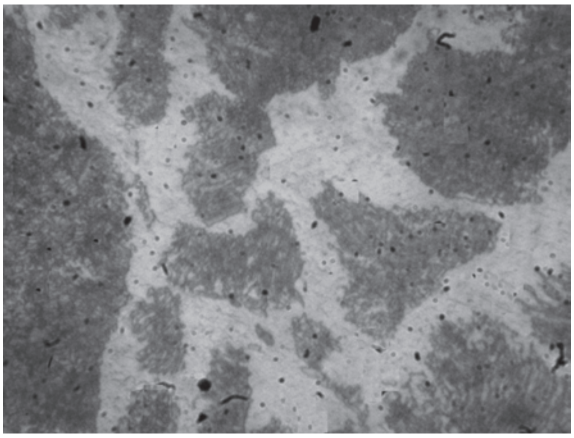

Figura 4. Base metal (MB) (Nital attack 2%, 100 x)

• Deposited metals MD of samples M1 and M2 had a hard martensitic structure with complex carbides (Cr, Mo and V) specific hard alloys and compounds used Ni-Al intermetallic placed uniformly in the matrix hardness (Figures 5 and 6).

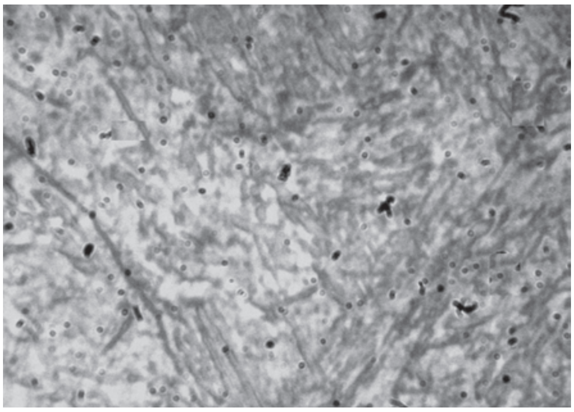

Figura 5. Metal deposited, MD Sample M1
(ferric chloride attack, 500 x)

• The heat affected zones (ZIT) were shifted to all evidence - ferritic structure with ferrite perlito network (Figures 7 and 8).

Hardness values of joints areas M1 and M2 are summarized in Table 2.

Also in Table 2 were passed and calculated values of the estimator of local hardening.

Analyzing ΔHV5 estimator values are found in all samples analyzed that do not exceed 50%, as per the material deposited (MD) and between MB and ZIT no local hardening tendencies and thus possibilities of developing brittle-type fracture, although that the submitted materials appeared very high hardness, as: for samples M1 and M2 variants 1 and 2 made the minimum 549 and maximum 795 HV5;

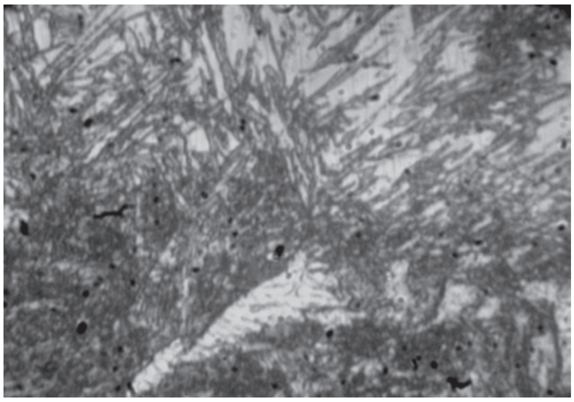

Figura 6. Metal deposited, MD Sample M2
(ferric chloride attack, 500 x)

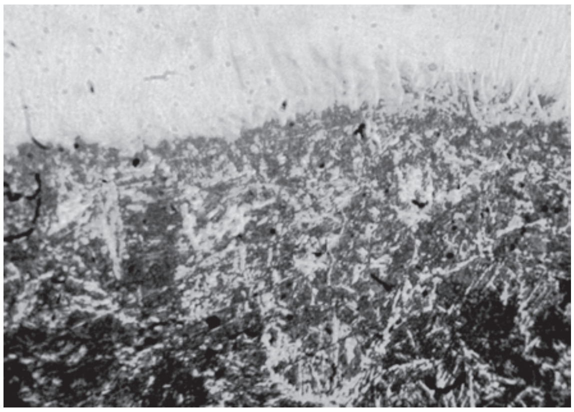

Figure 7. Sample M1, ZIT (Nital attack 2%, 100 x)

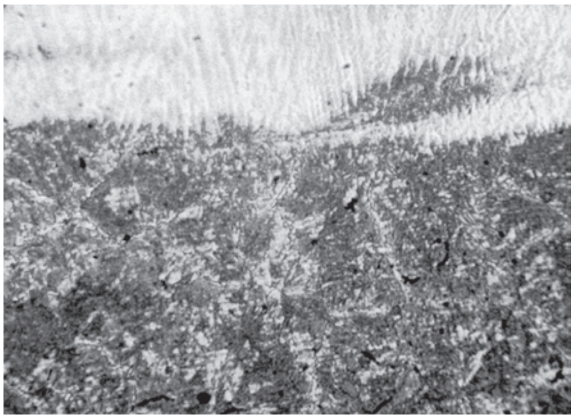

Figure 8. Sample M2, ZIT (Nital attack 2%, 100 x)

2.2. Abrasive wear test of complex alloys deposited hammers is made.

Requests surface that occur during operation of technical systems are due to contact and relative movement between the elements and give rise to surface tension. They determine energy and material losses due to friction, but also changes as a result of wear items.

Abrasive wear of complex alloys deposited hammers to crush coal can be described as a process of destruction of the superficial layer (deposit) to mechanical interaction with other solids (coal), which acts as external load, both bodies have a relative motion.

Because of the high hardness of these samples were water jet cut, cut side have irregular surfaces which they were taken into account in setting their device wear. Also, irregularities deposited layer can influence the balance system during the aging process. For this reason samples tested will be rigidly fixed, resulting in relative motion by rotating the pair element of the car tribological test system MTU. Each test sample was subjected to a process of wear by friction (abrasion) on the abrasive disc.

Tabel 2. Values of the estimator of local hardening

Samples marking	Deposit version	Hardness HV5						Estimator AHV5 [%]	
		MB		ZIT		MD			
		Val. min	Val. max	Val. min	Val. max	Val. min	Val. max	in MD	Between ZIT-MD
M1	1	208	225	227	270	666	785	16.22	22.96
M2	2	204	225	249	317	549	739	25.71	35.64

Tabel 3. Mass loss

	Features pre-trial		Features after the trial					
Samples	Hardness HV5 deposit	Initial mass m_o [g]	stage I		stage II		stage III	
			m [g]	Δm [g]	m [g]	Δm [g]	m [g]	Δm [g]
1.1	223...584	71.183	70.990	0.193	70.9600	0.0300	68.992	1.968
1.2	447...666	61.265	60.455	0.810	60.1957	0.2593	59.724	0.4717
1.3	413...623	77.498	77.033	0.465	76.0451	0.9879	75.684	0.3611
1.4	465...612	70.874	70.654	0.220	70.5102	0.1438	69.949	0.5612
1.5	396...739	70.842	70.312	0.530	70.0764	0.2356	69.900	0.1764
1.6	297...580	68.050	67.361	0.689	66.5865	0.7745	65.465	1.1215
2.1	425...603	72.213	71.836	0.377	71.7251	0.1109	71.607	0.1181
2.2	456...608	65.559	65.385	0.174	65.2824	0.1026	65.176	0.1064
2.3	491...668	61.807	61.678	0.129	61.5699	0.1081	61.444	0.1259
2.4	547...666	64.788	64.603	0.185	64.4720	0.1310	64.416	0.056
2.5	596...610	77.192	76.954	0.238	76.8922	0.0618	76.838	0.0542
2.6	362...480	64.156	63.991	0.165	63.9036	0.0874	63.687	0.2166

Abrasive wear test is based on evidence submitted wear layers tough on a specialized machine and the following stages of testing and evaluation

- Preparation and identification of materials;
- Analyzing and recording the initial state;
- Applying the set of requests;
- Analysis and measurement of parameters after the trial;
- Processing and interpretation of results.

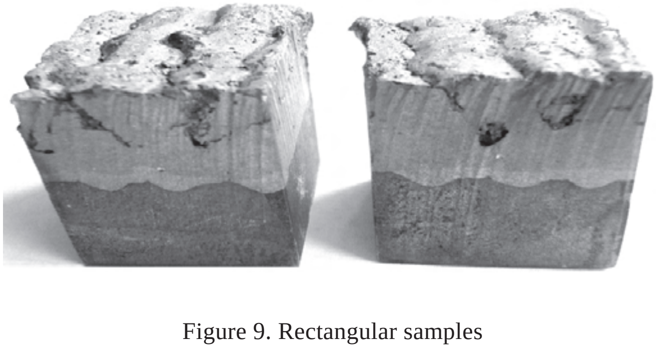

Figure 9. Rectangular samples

Test samples were cut from plates 1 ... 4 taken from hammers to crush coals that were deposited by welding layers of hard technologies established.

Rectangular samples were cut appearance with irregular dimensions approximate 20x20x22mm shown in figure 9.

After each step, we determined the values of mass "m" and loss of "Δm" both in grams.

The tests were made only on the welded cover in different versions. Thermal Spray Research are experimental and have not applied because industrial results are not complete (no abrasive wear tests) and the impossibility of thermal spraying large areas with existing specialized facilities.

The experimental results obtained are inserted in Table 3

Sample marking was as follows: first digit indicates the variant cover and the second number of specimen tested.

For experiments were used hammer mill steel surface alloyed cast steel equivalent OT 60.3 340 - 530W (ISO 3755), which load was applied by welding alloys.

During processing of casting defects were detected, goals that were covered by the welding procedures.

Depositions of metal alloys, super alloys, hardened by dispersion are characterized by tensile strength and higher material yield basic Orowan hardening mechanism due to growth.

The basic material defects were not identified and is ferrito-pearlitic structure.

Given that the evidence submitted in the same variation between subject test to abrasive wear are significant differences in weight loss, Δm, was used an average of Δm average percentage change during the test according to abrasive wear is shown Figure 10.

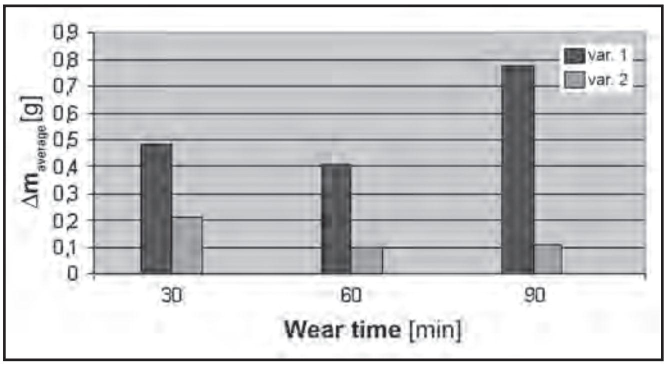

Figure 10.

Analyzing variation of $\Delta m_{average}$ depending on testing time is noted that the average mass loss ($\Delta m_{average}$) have the highest values in variant 1 (max. 0.777 g) and lowest in version 2 (max. 0.113 g) after trying to wear while 90 minutes.

It is considered that the average weight loss of samples subjected to abrasive wear in version 2 are small, so they achieve the hammers to crush coal deposits for optimum endurance to use this option to the detriment of variant 1 (performed with buffer layer) to obtain three homogeneous layers of the same tough alloy complex.

3. Conclusions

One of the important issues of the research is to increase the remaining life time of a hammer mill for grinding coal.

To achieve this issue there is a few methods to obtain high properties in the active surface of the hammer mill. For each method it is made micro and macrostructure analyze and it is measured the hardness.

Analyzing ΔHV5 estimator values are found in all samples analyzed that do not exceed 50%, as per the material deposited (MD) and between MB and ZIT no local hardening tendencies and thus possibilities of developing brittle-type fracture, although that the submitted materials appeared very high hardness, as: for samples M1 and M2 variants 1 and 2 made the minimum 549 and maximum 795 HV5,

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As a future problem there is the implementation of the methods presented in this paper which allow a significant increase in the life of the hammers used in the coal grinding mill.

The problem of increasing resistance to wear hammer is analyzed and partially solved but that is why further research in this area should achieve the following problems:

• research on the evolution of materials deposited in mining, analysis of the cavities or defects arising from the superficial layers;

• further research on the mechanical characteristics of the deposition of metal alloys, super alloys, the existing alternatives or new ones;

• further research of thermal spray deposition, which are currently difficult to make on large areas.

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