Creative wear of C-Cr-Mo-Nb-W-V surface system

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Abstract: *The paper presents experimental work focused on the wear resistance of clads made with OPEN ARC technology (MOG) and clads with cycled cladding nozzle. The distribution of carbide phases by electron beam was evaluated. The influence of the tempering temperature of the clads on the hardness of the layers was determined. Tests of the resistance of the clads to abrasive wear were carried out.*
Keywords*: CLADDING, PLASMA, CARBIDE, ABRASION, TRIBOLOGY*

1. Introduction

Cladding of abrasive stressed parts is one way of extending their service life [1–4]. Modern MOG tubular wire and plasma welding systems allow the composition of the welding system to be optimised. In this work, the effect of cycling of the winding caterpillars and thus, among other things, achieving an improvement in the morphology of the carbide of the weld will be assessed [5]. Abrasive wear is characterized by the separation of particles from the functional surface by the effect of abrasive particles. Hard mineral particles are formed into the surface of the components when they move relative to each other. When the elastic deformations are exceeded, plastic deformations occur to form microparticles separated from the surface of the body. As the body continues to deform, material loss occurs, up to and including failure of the functionality of the device. It is known from the theory of abrasive wear that the amount of wear is affected by the hardness, grain size of the abrasive. Further, the hardness and structural structure of the worn surface. The body material is characterized by the so-called relative abrasion resistance Ψ, which determines at a plus value the multiple of the abrasion resistance to ethanol. Since carbon ferritic-perlitic steel has low resistance to abrasive wear, these problems are solved by hard martensitic surface coatings based on chromium (e.g. 2% C, 15% Cr) or with the addition of boron. These surfacing systems for extreme abrasive wear, even at elevated temperatures, are now obsolete. Dimensional chromium carbides (or carboborides) are distributed in the martensitic matrix, and these are abraded and broken out by the abrasive in the matrix.

2. Materials for Production of Prototype Parts *Грешка! Източникът на препратката не е намерен.*

In work [6], experiments were carried out, a series of laboratory tests, where the best result was achieved by a coating system characterized by the guideline chemical composition (%) with the designation SKA-45-0, EN ISO 14175, see Table 1.

Table 1. *Chemical composition SKA-45-0, EN ISO 14175 (% in. wt.)*

C	Mn	Si	Cr	Mo	Nb	W	V	Fe
4,7	0,7	0,8	20,5	6,2	6,1	1,8	1,8	Bal.

With hardnesses according to the RD (tubular wire) manufacturer, see Table 2.

Table 2. *Hardness RD (tubular wire)*

20°C	550°C	600°C
63HRc	54HRc	50HRc

When the abrasive is pressed into the austenitic matrix of this system (Table 2), which is reinforced with fine precipitates - carbides NbC, Mo2C, WC, VC, there is no stripping and breaking of the dimensional chromium carbides. The austenitic matrix accumulates a greater amount of energy, it is secondarily solidified (up to 100Hv) by the resulting fine NbC precipitates.

In classical MOG or plasma welding, the deposition of individual caterpillars produces loosened areas of reduced hardness in the overlapping area of the so-called heat-affected zone, acting as wear centers.

Therefore, we have investigated the diverging wire winding, see. Figure 1, where we achieve:

- wider weld caterpillars with less mutual influence
- less mixing with the base material
- improved morphology of the welding carbides
- increased welding productivity

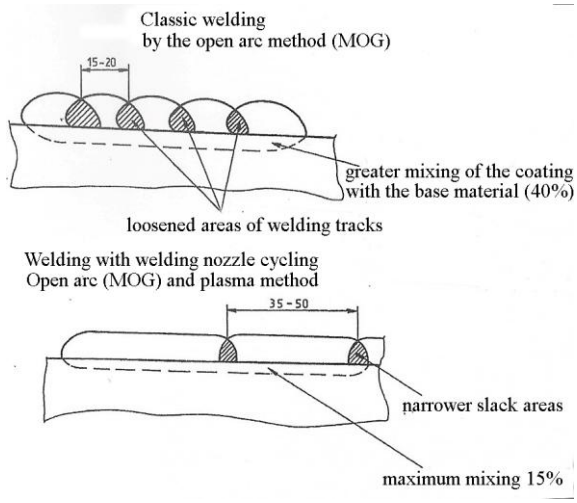

Fig. 1 *Classical cladding with OPEN ARC (MOG) method, cladding with cycling of the cladding nozzle with OPEN ARC (MOG) method or with plasma.*

Cladding with cycling is controlled electronically, the winding head performs a perpen-dicular swing to the winding direction.

3. Results

SEM analysis

The C-Cr-Mo-Nb-W-V based deposit with the specific composition given in Section 2, its SEM analysis was carried out using carbon extraction replicas on a Tesla BS 450 transmission electron microscope, directly from the deposit samples on a JSM-U3 line scanning microscope. The bloom was double layered.

The nature of the excluded carbide phases was monitored (by electron diffraction).

Sample No. 1 was cooked with the MOG system without swaging with A-45-0 tubular wire with a change in ferroniobes ranging from 0.18 to 0.30 mm, which is commonly supplied.

Sample No. 2 was cooked with the MOG system with a swing (cycling) with A-45-0 tubular wire where a ferroniobic grain size below 0,18 mm was required.

The grain structure of both samples is austenitic with the exclusion of dimensional primary chromium carbides, eutectic chromium carbides of M_7Cr_3, Cr_3C_2, and NbC type, see Figure 2.

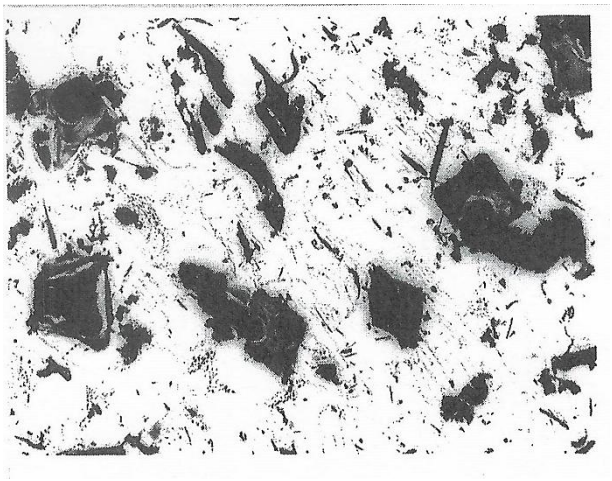

Fig.2 *The grain structure of both samples (1500x mag.)*

The fine carbide phases reinforcing the matrix are mainly composed of niobium car-bides (sample 2), molybdenum, tungsten and vanadium. The nature of the excluded particles - see Figure 3 is mainly Mo_2C and NbC.

For sample No.2, the orientation of the primary chromium and niobium carbides is more favorable.

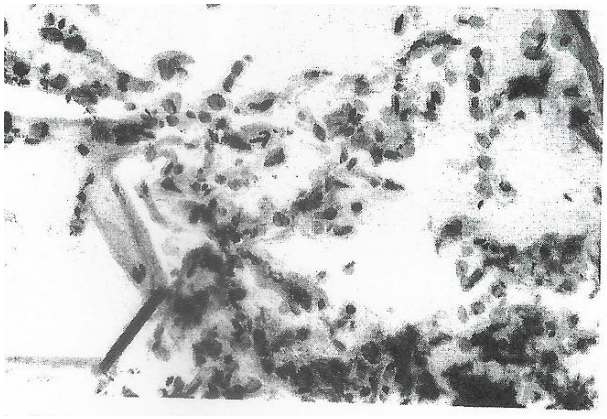

Fig.3 *Detail of chromium and niobium carbide particles in the cladded layers (60 000x mag.)*

The results of the SEM analyses of the evaluated claddings of samples 1 and 2 are presented in Table 3.

Table 3. *Results of the SEM analysis of the claddings of samples 1 and 2*

Filler material type	Type of particles - precipitates determined by electro diffraction and microanalysis	Area fraction of carbide particles %	Resistance to abrasive wear Ψ 2
A-45-0 č.1 cladded without cycling	fine 7,1. 10-5 mm MoC, W_2C,VC medium 5. 10-4 mm Cr_7C_3 large	16,5	3,5
A-45-0 č.2 cladded with cycling	6,3. 10-3 mm Cr_7C_3, NbC fine NbC,MoC, W_2C,VC medium Cr_7C_3, NbC large Cr_7C_3, NbC	35,4	4,4

We also tested resistance to abrasive wear at elevated temperatures.

The measured results of the hardness of samples 1 and 2 are shown in Table 4, with a tempering time of 1h.

Table 4. *Measured results of the hardness of samples 1 and 2*

Samples / layers		Temperature of tempering °C						
		30	300	450	500	600	700	750
Sample No.1	1.Layer Hardness HV10	673	675	670	665	622	724	675
	2.Layer Hardness HV10	821	862	870	874	826	907	807
Sample No. 2	1.Layer Hardness HV10	826	847	841	873	807	947	695

Abrasion resistance tests

The tests of abrasive wear resistance were carried out on a laboratory testing machine type WPM, on a grinding screen according to STN 01 5084.

Conditions: sandpaper Globus 120, dimensions 10x10x12, load 0,2 MPa, sanding path 45m.

For each type of pattern 3 samples were used. The weight losses were measured on an analytical balance with a precision of 10-4 (g).

The so-called relative abrasion resistance Ψ2 was evaluated.

$$\Psi 2 = \frac{\text{Wh etalon}}{\text{Wh sample}} \; x \frac{\gamma \text{ sample}}{\gamma \text{ etalon}} \qquad (1)$$

Etalon structural steel S235

Wh - weight loss (g)

γ – specific weight (g/cm^3)

The measured and calculated values are shown in Table 3.

Evaluation of measured results and requirements for cladding additive

Cladding with A-45-0 tubular wire with the required ferroniob grain size confirmed the electron microscopic findings and the favourable orientation of the primary carbides for the swirl welding by ether tests.

The weld has a favourable austenitic structure reinforced by fine precipitates of carbides mainly MbC and also M02C. This is manifested by an increase in hardness of 12% up to a depth of 0.1 mm.

In this austenitic hardened matrix, the breakage of large primary chromium carbides, niobium. In cycled cladding we have wide areas of good orientation of the primary carbides, which is reflected in an increase in abrasion resistance characterized by an increase in Ψ2 from 3.5 to 4.4. I.e. an increase in abrasion resistance of 25%. tempering curves, the wax maintains a high hardness up to 750°C.

Plasma cladding

Plasma cladding using powder additive materials (PPMs) is advantageous for solving diverse tribological requirements. The advantage over the MOG system with tubular wire, lower heat input and thus less mixing of the filler with the base material and thus the de-sired properties in smaller filler thicknesses.

Therefore, ASKOZVAR s.r.o. purchased a modern plasma welding system type Eutronic Gap 3511 DC with the possibility of applying the welds in a 5-axis environment, rotation and selection of pitch parameters.

Using PPM based on Ni-Cr-C-B-Si + WC + VC, NbC, MoC (2) austenitic matrix, the dimen-sional chromium carbides and borides are protected against delamination by pre-preparation of said carbides by sintering at the required grain size according to the required tribological system. We are currently optimizing the use of PPM for the diverse requirements of the practice.

Fig.3 *Plasma cladding workplace of the company. ASKOZVAR s.r.o*

4. Conclusions

Knowing the tribological conditions of individual friction systems, we can optimize the structure of the welding system by using the MOG system with the use of tubular wires and especially by plasma, where we have wider possibilities of optimizing the welding system. The technological measures - the divergence as mentioned above allow us to minimize the adverse effects of the transition layers between the caterpillar clusters.

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