3rd International Brazilian Conference on Tribology – TriBoBR 2018
Florianópolis, Brazil, 3-5 December 2018

Microabrasion Resistance of Laser Clad Cobalt-based Alloy Coatings

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1. Introduction

Cobalt superalloys are materials applied in severe conditions which may involve high temperatures and different types of wear [1].

These conditions are found, for example, during the production of second generation ethanol, in which sugarcane biomass is processed at high temperatures in the presence of solid particles [2]. This work investigates the tribological behavior of cobalt superalloys in microabrasion.

2. Experimental method and materials

Randomized microabrasion wear tests were performed with commercial microabrasion tester Plint TE66, with a fixed spherical configuration. Abrasives of SiO_2, Al_2O_3 and SiC with slurry concentration of 0.1 g/cm^3 were used. The test load was 0.3 N.

Samples of cobalt superalloys were produced by the laser cladding technology with powders from Stellite alloys 1, 6 and 12. These alloys were deposited on a cast substrate of Co30Cr19Fe alloy. Table 1 shows the chemical compositions of the powders used and the substrate material.

Optical microscopy (OM) and scanning electron microscopy (SEM) were used for microstructural characterization and investigation of micromechanisms.

Table 1 – Chemical composition of the samples (% weight)

Materials	Co	Cr	W	Mo	C	Fe
Stellite 1	Bal	30	13	<1	2,5	<2
Stellite 6	Bal	28	4,6	<1	1,2	<2
Stellite 12	Bal	30	8,5	<2	1,4	<2
Co30Cr19Fe	Bal	30	0,2	0,3	0,2	19

3. Results and discussion

3.1. Microstructure

The sample Co30Cr19Fe, fig. 1a, is composed of a cobalt matrix with Cr and Fe atoms in solid substitutional solution, with coarse grains and dendritic structure. The sample coated with Stellite 1, fig. 1b, is formed by chromium-rich primary carbides, probably of the M_7C_3 type, dispersed in a eutectic matrix containing secondary carbides. The samples coated with Stellites 6 and 12, Figs. 1c and 1d, respectively, present similar microstructures, formed by primary cobalt dendrites surrounded by eutectic carbides precipitated in the interdendritic regions.

The cast sample Co30Cr19Fe had the lowest average hardness, 248 ± 12 HV_{10}, among the materials. The sample coated with Stellite 1 showed the highest average hardness, 678 ± 33 HV_{10}, followed by Stellite 12 with 522 ± 12 HV_{10} and Stellite 6 with 458 ± 6 HV_{10}.

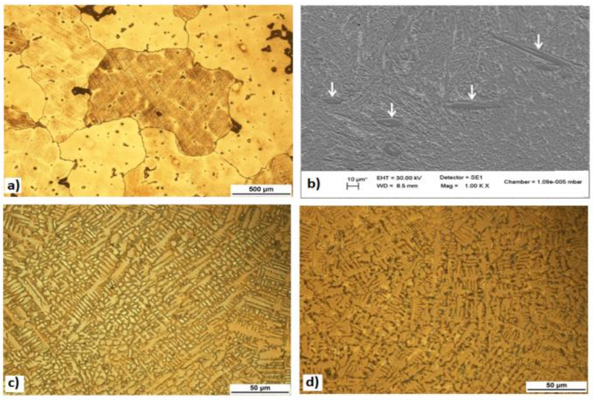

Fig. 1 – Microstructure of the samples. a) Co30Cr19Fe (OM), b) Stellite 1 (SEM), c) Stellite 6 (OM), d) Stellite 12 (OM).

3.2. Microbrasion tests

Table 2 shows the values of the dimensional wear coefficients (k) obtained in the tests.

Table 2 – Dimensional wear coefficient [$m^3(Nm)^{-1}x10^{-13}$]

Samples	SiO_2	Al_2O_3	SiC
Co30Cr19Fe	17,5 ± 0,6	38,7 ± 2,3	31,3 ± 1,2
Stellite 6	12,2 ± 0,5	33,0 ± 1,4	23,6 ± 0,9
Stellite 12	9,4 ± 0,7	31,9 ± 0,9	25,7 ± 0,5
Stellite 1	6,9 ± 0,3	29,6 ± 3,1	23,0 ± 0,9

The results of the tests were statistically evaluated through analysis of variance. In general, higher wear coefficients were achieved when using the Al_2O_3 abrasive, followed by SiC and SiO_2. The material used as substrate showed higher wear coefficient regardless of the abrasive. This alloy presents the lowest amount of carbides and, therefore, less hardness. Among the coated, an increase in the wear resistance with increased carbon content is observed for the tests carried out with SiO_2 and SiC. The predominant wear micromechanism was grooving, except for samples coated with Stellite 6 and 12 and tested with SiC, which presented mixed and rolling mechanism, respectively.

4. Conclusions

The coating with Stellites alloys, by the laser cladding process, promoted an increase in microabrasive wear resistance of the samples evaluated. The sample coated with Stellite 1 presented higher resistance to wear between materials.

5. References

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[2] Marques, F.P., Bozzi, A.C., Scandian, C., Tschiptschin, A.P. *Microabrasion of three experimental cobalt-chromium alloy: wear rates and wear mechanisms*. Wear, vols. 390-391, pp. 176-183, 2017.