EVALUATION OF SELECTED CHARACTERISTICS OF HVOF COATINGS

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Abstract

Thermal spraying technology today belongs to manufacturing technologies that significantly reduce production costs while achieving high utility performance. The paper focuses on the methodology of testing of selected technological tests, especially bending and twist tests, metallography and porosity analysis of layers made by HVOF technology. The above tests are used by standard for the quality control during production. Proper implementation and evaluation are key to detecting possible imperfections during production and the possibility of repairs. Sprayings samples were based on WC-Co, Cr_3C_2-NiCr, Stellite 6 made by HVOF technology on JP 5000, JP 8000 equipment's.

Keywords: HVOF, bending test, twist test, metallography, porosity

1. INTRODUCTION

The high velocity oxy fuel (HVOF) process is reported to be versatile technology and has been adopted by many industries due to flexibility, cost effectiveness and the superior quality of coating produced. Due to the high impact velocity of particles the coating shows a high adhesive strength, high cohesive strength of individual splats, high density and low porosity [1-3]. Many thermal and thermo-chemical surface treatment techniques are being used to modify the surface of the material with desired properties for various applications in service. Nowadays, high velocity oxy-fuel (HVOF) spray is being widely used in industrial applications due to its ability to produce a high-quality coating with required hardness and low oxide content due to its high velocity impact inherent in the process. Porosity and hardness are two important coating properties for wear and corrosion related applications, and they play a significant role in the service life of the components.

2. MATERIALS AND TECHNOLOGY USED

The experiments were provided on the HVOF sprayed hard metal coatings. For experiment were used three typical commercial HVOF coatings WC-Co, Cr_3C_2-NiCr, Stellit 6 produced by Praxair. The coatings were sprayed by HP/HVOF JP-5000®, JP-8000® (TAFA) spraying technology with standard preparation procedure on the grit blasted substrate of carbon steel (S355). To design the set of the spaying parameters, the parameters recommended by the powder producer was used as a reference. The chemical composition

Table 1 Chemical composition WC-Co 88/12

W	Co (%)	C (%)	Fe (%)
base	10.5 - 13	5.2 - 5.6	0.20

Table 2 Chemical composition Cr_3C_2-NiCr 75/25

Cr (%)	Ni (%)	C (%)	O (%)
base	18 - 22	9 - 11	max. 0.60

Table 3 Chemical composition Stellite 6

Co	Cr (%)	C (%)	Si (%)	W (%)	Other
base	26.5 - 29.5	0.9 - 1.4	0.5 - 1.5	3.0 - 5.0	Fe, Ni, Mo, Mg

3. MECHANICAL TESTING

Mechanical operation tests are very important for quality control. These tests can be detected during the production of disagreements in spray parameters. The actual execution of the test should be performed repeatedly before the start of production. A typical number of samples is three for each test. If larger coating thickness or several coating types are used, it is necessary to adjust the test parameters for both the bending mandrel diameter, bending angles and torsion angle.

3.1. Bending test

For bending testing, it is used three 150 x 25 x 1,5 mm samples shall be coated in order in perform the bend test. The coatings thickness shall be 0.15 mm. The samples shall be subjected to a bending of an angle between 180° on a 12.5 mm diameter spindle. The bending shall be performed in a period of time between 2-5 seconds. Coatings cracking's to the parallel to the bending axes are acceptable unless the coating comes off the base materials. **Figure 1** shows a bend test. The results of all the tests were without cracks and unacceptable defects.

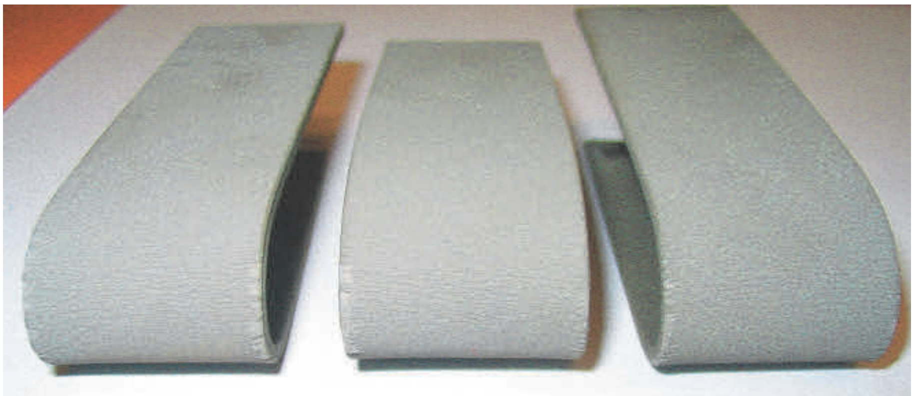

Figure 1 Bend test samples WC-Co 88/12

3.2. Twist test

Three test samples shall be coated with 0.15 thickness of coating on one side. Sample sizes were the same as for the bend test. One coupon shall be twisted along the long dimension to plus 90 degrees and then twisted back through 0 degrees to minus 90 degrees. The coatings may have uniform fine cracking or crazing, but shall not exhibit sign of chipping, spalling, or flacking when examined at 10x magnification. The other coupons will be twisted if there are any discrepancies with first piece. **Figure 2** and **Figure 3** shows a results of twist test. The results of all the tests were without cracks and unacceptable defects.

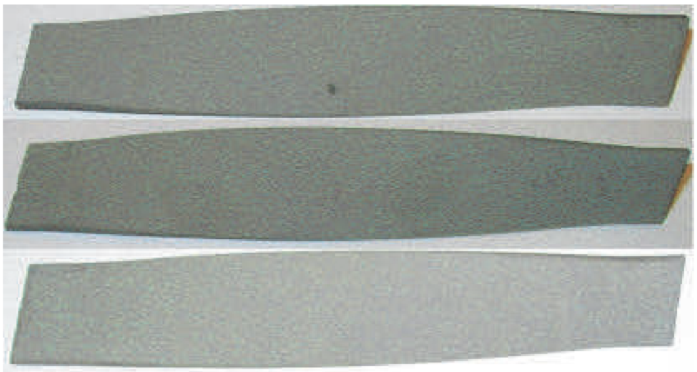

Figure 2 Twist test samples WC-Co 88/12

Figure 3 Surface samples after twist samples (Enl.20x)

4. METALOGRAPHY TESTING

The metallographic examinations are amongst the most basic methods of assessment. Unlike operating tests, both the bending and twist test is significantly more objective and time consuming. For the evaluation of the microstructure, either a prepared sample with an equilateral coating or a part of the coated article can be used. Thermal coatings are susceptible to porosity due to insufficient fusion between spraying particles or the expansion of spraying gases. Determination of porosity of the surface is important in order to monitor the effect of the variable parameters of the hot-dip coating process and the suitability of the coating for the intended purpose. Very important is the preparation of samples, where a number of recommendations and methodologies can be used [4,5]. The ASTM standards give guidelines for test procedures but it is the user's responsibility to fix details and evaluate the whole procedure. Many details, especially concerning specimen preparation cannot be standardized and very much depends on the experience of the metallographic staff. The results of porosity analysis are shown in **Figure 4** - **Figure 9**. In **Table 4** are shown value of porosity tested samples.

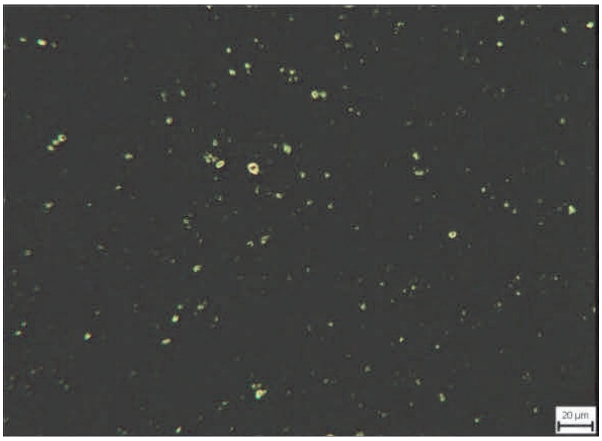

Figure 4 Porosity analysis-dark field WC-Co 88/12

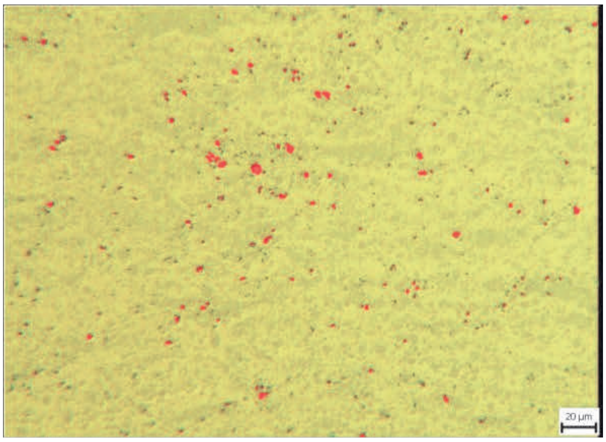

Figure 5 Porosity analysis-pore designation WC-Co 88/12

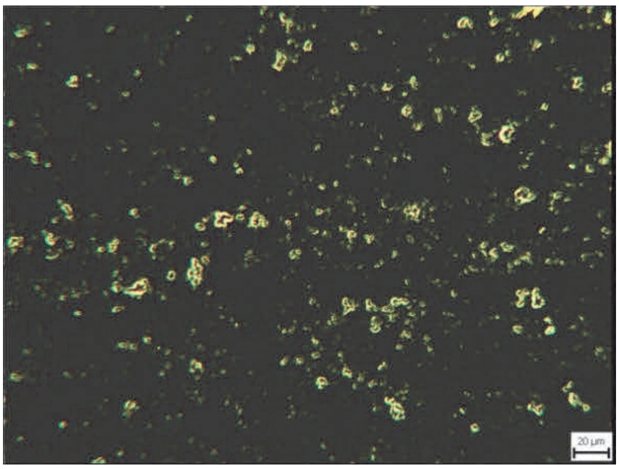

Figure 6 Porosity analysis-dark field Cr_3C_2-NiCr 75/25

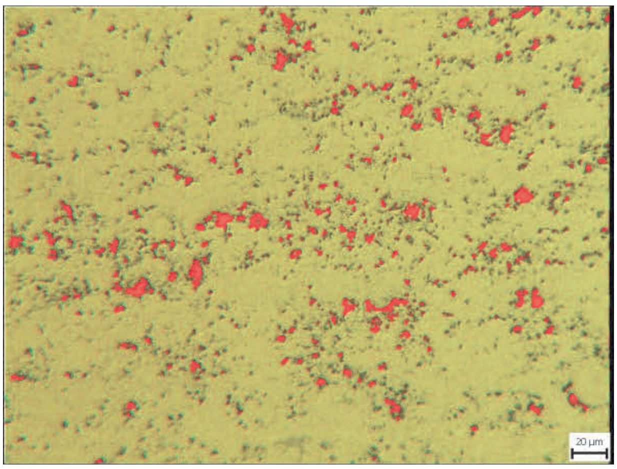

Figure 7 Porosity analysis-pore designation Cr_3C_2-NiCr 75/25

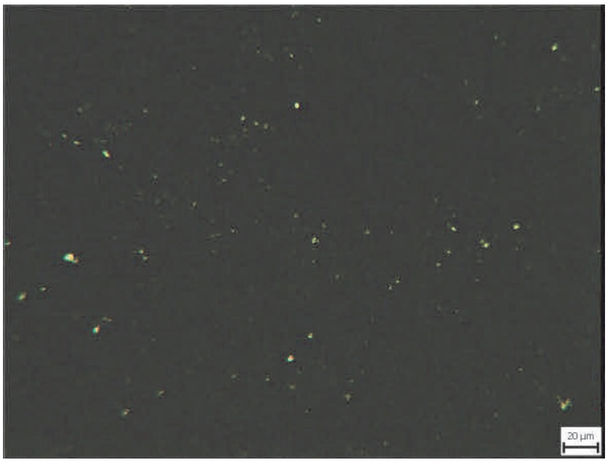

Figure 8 Porosity analysis-dark field Stellite 6

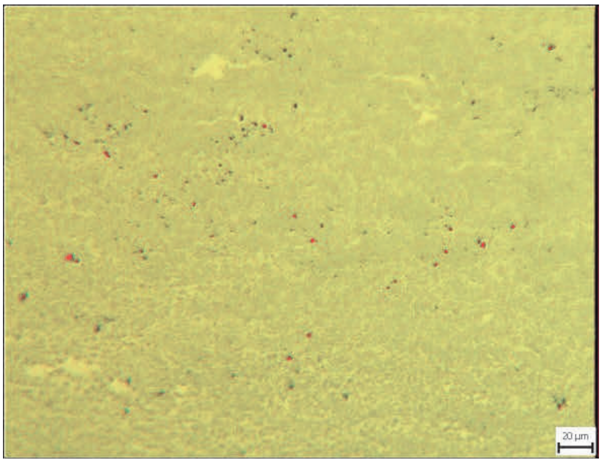

Figure 9 Porosity analysis-pore designation Stellite 6

Table 4 Value of porosity tested samples

Coatings	Porosity (%)
WC-Co 88/12	0.31
Cr_3C_2-NiCr 75/25	1.69
Stellite 6	0.3

5. CONCLUSION

The article shows the results of testing the selected properties of thermal spraying coatings. A detailed description of the course of two technological tests, namely bending and twist tests. These tests can very quickly detect an inappropriate spraying parameter before it is sprayed. The last test described is porosity testing. Porosity values are often limiting for a given application. As it turns out, it is very important to prepare the test sample (fine grinding) to avoid misinterpretation of the results.

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