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THERMAL SHOCK BEHAVIOR OF THE COATS DEPOSITED BY PLASMA SPRAYING OF THE TiO_2

Maria Laura BENEA

"Politehnica" University of Timişoara, Engineering Faculty of Hunedoara, ROMANIA

ABSTRACT

For the coats made by using the TiO_2 powder (type Metco 102) on a martesitic stainless steel substrate, the thermal shock testing conditions consist in: fast heating to 800°C (or 500°C) (10s) and water cooling without maintaining to maximum temperature. After 20 cycles to a maximum temperature of 800°C we noticed the appearance of pattern fine cracks, which is developed along the next 20 cycles but with no scorching. For a maximum temperature of the 500°C of the thermal shock, after 180 cycles we not observed the appearance of the scorches on the coats surface.

KEYWORDS

Thermal Shock, TiO_2 coatings, plasma deposition

1. INTRODUCTION

Plasma spraying of materials such as ceramics and non-metallic, which have high melting points, has there fore become well established as a commercial process. Such coatings are increasingly used in aerospace, automobile, textile, medical, printing and electrical industries to impart proprieties such as corrosion resistance, thermal resistance, wear resistance, etc [1,2].

One of the most important characteristics of thermal barrier coatings is the ability to undergo fast temperature changes without failing; the so called thermal shock resistance.

The thermal shock resistance is defined as the number of thermal shock a thermal barrier coating withstands without failing.

This paper describes the results of tests conducted to determine the thermal shock behavior of the coats deposited by plasma spraying of the TiO_2.

2. EXPERIMENTAL PART

2.1. Experimental conditions at the TiO_2 coatings spraying in plasma

The substrate is the martensitic stainless steel Z12CNDV12.

The powder used is Metco 102, with 99% TiO_2 and particle size between 7,8 and 88 μm.

The coatings have been made using plasma generator GPPR-400 equipment.

There have been working using the following parameters:

- intensity of the current at the generator: 500 A;
- voltage: 70 V;
- spraying distance: 50 mm;
- plasma gas flow: 36,6 l/h;
- coating thickness: 0,3 mm;

Thermal shock testing

For the coats made by using Metco 102 powder on a martensitic stainless steel substrate, the thermal shock testing consist in: fast heating to 800°C or 500°C (10 s) and water cooling (600°C/s) without maintaining to maximum temperature.

3. RESULTS AND DISCUSION

Some results of the experimental determination are shown in table 1. Figure 1 shows some images for the coats made using Metco 102 powder, in a different moments of the determination.

Samples were examined by optical microscopy using a stereo microscope

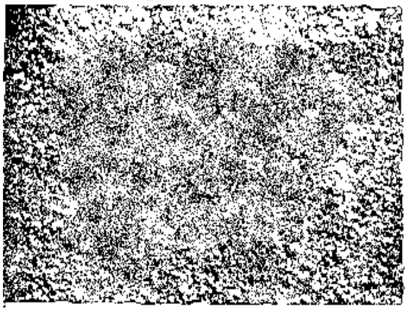
As was expected, the evidence submitted TiO_2 have a reduced resistance to heat shock at 800°C (25 cycles).

TABLE 1. RESULTS OF THE THERMAL SHOCK DETERMINATION

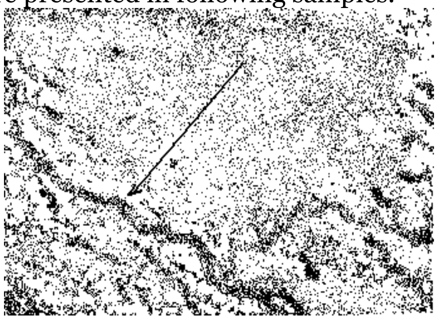
Cod sample	The number of thermal cycles	The maximum temperature cycle [°C]	Cooling medium	Observation
48	20	800	water	The appearance of scorches
50	30	800	water	The appearance of scorches
54	25	800	water	The appearance of scorches
Medium		59		
3	180	500	water	No cracks, No scorches

Layers, in its original state, have a characteristic ceramic deposition, with a pronounced roughness without visible cracks to the naked eye or to the optical microscope at low zoom. The images in Figure 1 reveals the fact that a smooth network of cracks is formed after the first set of 22 set of cycles. The cracks increase is fast, showing in this way the extended cracks and the exfoliations detected on the sample number 54.The breaking surface is highlighted by the glossy appearance of the detachment surface limits. The observed cracks have the propagation way perpendicular to the longitudinal axis of the sample, highlighting the direction with maximum stretching tensions during the experiment. Also, the cracks orientation on the layer thickness is from the substrate towards the deposit surface determed by the tensions in the substrate during the experiment.

Because the treatment chose in the first step was considered excessively harsh for the ability of TiO_2 to take thermal shocks, the experiment was resumed on a new set of samples covered in the same conditions at a maximum temperature of the thermal cycle 500ºC with a cooling speed of 600ºC/s. After running 180 cycles do not show any exfoliations. The network of cracks appears to form at a higher number of cycles (54) and extends slowly, increasing the number of cycles. The number of cracks expands significantly at over 135 cycles. At the limit of 180 cycles the apparition of the first dislocation of the coverage layer on the limits of the cracks can be notified. Images for the coats made by using the Metco 102 powder at the thermal shock are presented in following samples.

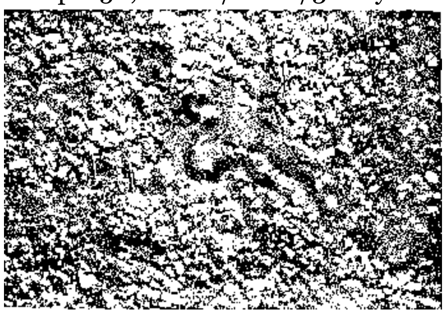


Sample 50, 40x, Initial state

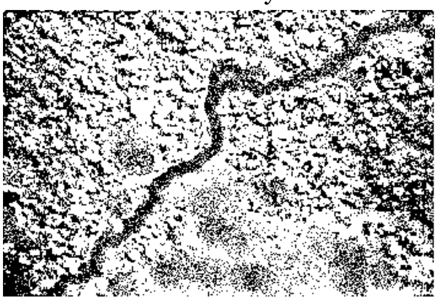


Sample 50, 800°C/water/322 cycles Cracks

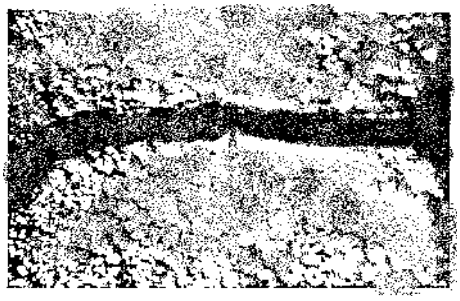
Sample 50 (70x), 800°C/ water / 19 cycles
Detachment layer



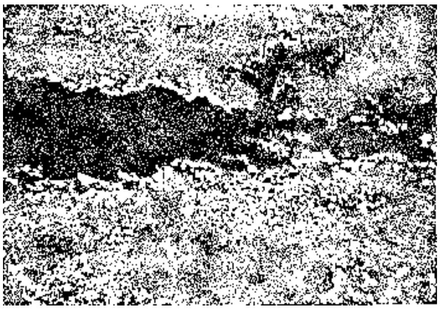
Sample 50 (70x), 800°C/ water / 31 cycles
Cracks



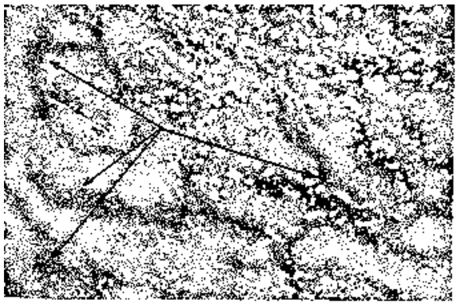
Sample 54 (70x), 800°C / water / 25 cycles
Cracks



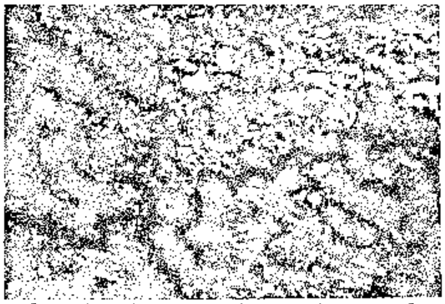
Sample 54 (70x), 800°C / water / 31 cycles
Detachment layer



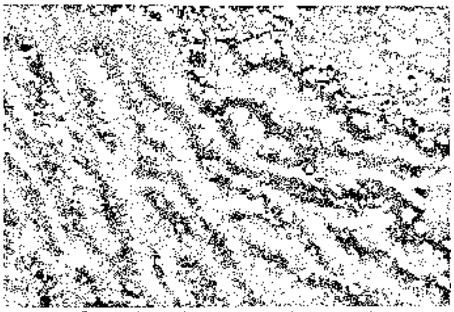
Sample 54 (70x), 800°C / water / 31 cycles
Detachment (per section)



Sample 3 (70x), 500°C/water/104 cycles
Cracks



Sample 3 (70x), 500°C/water/130 cycles
Cracks



Sample 3 (70x), 500°C/water/156 cycles
Network of cracks

Sample 3 (70x), 500°C/water/180 cycles
Cracks and layer displacement

4. CONCLUSIONS

Conclusions that results from analyzing the results of determination the resistance to thermal shock of the TiO_2 layers are:

- The TiO_2 samples have a low resistance at thermal shock at 800°C (25 cycles);
- It has already formed a network of cracks after the first set of 22 cycles performed at 800°C;
- The growth of cracks is rapid, revealing the extended cracks and the exfoliation uncovered on the sample number 54;
- The breaking surface is highlighted by the glossy limits of the detachment surface;
- The cracks that have been seen have the sense of propagation perpendicular to the longitudinal axis of the sample attempted at 800°C, highlighting the maximum stretch tension during the experiment;
- The orientation of the cracks on the coating layer thickness tested at 800°C is from the substrate to the surface the deposit, this is determined by the tension of substrate during the experiment;
- Particularly in the first stage of the experiment is considered over harsh for TiO2's capacity to take heat shock;
- At a maximum temperature of thermal cycle of 500°C and a cooling of 600°C/s after running a number 180 cycles, no samples presented peeling;
- The network of cracks is formed from a larger number of cycles and expands slowly when increasing the number of cycles;
- The maximum temperature of thermal cycle of 500°C, the cracks are not extending significantly at more than 135 cycles;
- The apparition of the first displacement of coverage layer on the edge of the cracks is notified at the limit of the 180 cycles with the maximum temperature of 500^{o}C.

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