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THERMAL DIFFUSIVITY AND CONDUCTIVITY AT LAYER $ZrO_2/20\%Y_2O_3$ SPRAYED WITH ATMOSPHERIC PLASMA SPRAY

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Abstract: *The method of deposition atmospheric plasma spray (APS) is famous among the methods usually used for coating layer thicknesses on surfaces with different degrees of complexity. One of the most delicate issues in the case of thermal barrier applied to the turbine blades is to determine the causes of exfoliation of the ceramic layer due to the large number of thermal cycles.*

The present paper presents a new concept of thermal barrier layer. The novelty is delaminating prevention and consists of a sprayed layer adherent Ni Mo Al (05-05-90) filed by electric arc and a layer of $ZrO_2/20\%Y_2O_3$, deposited by plasma spraying specimens of Ni base super alloys, which aircraft turbine blades are manufactured of. Samples were subjected to heat treatment at 1150°C in order to study the behavior of these metal layers during heating.

These layers we have chosen to spray induce a low thermal diffusivity and conductivity. The reason for this test is just that, to prove the thermal insulation of the ceramic layer.

Scanning electron microscope was used to observe the morphology and microstructure of phases. X-ray diffraction analysis was performed in order to notice the change of diffraction curves, and to observe the new phases obtained after the heat treatment.

Keywords: *SEM, XRD, thermal diffusivity, thermal conductivity.*

1. INTRODUCTION

The desire to improve the performance of aircraft motors led to the rising temperatures of the hot sources.

By rising the operating temperature can significantly improve performance and other important functional parameters of a heat engine. Turbine blades are the most stressed components of a jet engine both thermo-mechanically and chemically.

Because of rotational speed, the blades are exposed to tensile forces which can cause the lengthening of the blades. Creep blades should be avoided because of the elongation of the blade, this can reach the motor casing and destroy it. Because the super alloy the turbine blades is made of has maximum operating temperatures near to 1000°C value the idea of using ceramic materials was foreseen.

Ceramic materials have excellent refractory properties and are used to cover with a protector coating for all the metal components of the jet engines. Ceramic materials, unlike metals, are more complex crystalline cell, this explains the low mobility of crystal defects (dislocation in especial).

Due to the structure and ion type interatomic bonds can explain many of the properties of these materials such as low thermal conductivity and diffusivity.

Thermal conductivity is an important physical property of ceramic, which define their ability to transmit thermal energy by their mass, as determined by the crystallographic structure of the phase components and structural arrangement.

Thermic diffusivity, is the ratio between thermic conductivity and specific heat at constant volume of material.

Zirconium oxide, appears as monoclinic, tetragonal and cubic crystals. The product as total stabilized (FSZ) or partially stabilized (PSZ). This oxide has the following excellent properties mechanical and technological:

- good resistant to bending and traction;
- low thermal conductivity;
- oxygen ion conductivity;
- Young modulus of steel.

Because of these properties of zirconia ceramics are preferred for high demand components of mechanically.

However these properties of ceramic products depends on: processing parameters such as nature and continuity link between crystalline ceramic granules, presence and amount of impurities, sintering parameters and conditions, presence and volume of pores, etc..

This paper presents the study of structural properties by multilayer coatings $ZrO_2/20\%Y_2O_3$. SEM analysis is used to measure porosity coatings, deposited layer thickness determination and structural analysis of the layers. X-Ray diffraction is used to determine the phase and constituents of the deposition structure. Was performed thermic diffusivity to determine the influence of ceramic layer as the base material have a low thermal diffusivity and conductivity.

2. EXPERIMENTAL PROCEDURE SPRAYING EQUIPMENT AND MATERIAL POWDER

Thermal barrier coatings were obtained by atmospheric plasma spraying deposition (APS). Samples were sprayed with ceramic powder $ZrO_2/20\%Y_2O_3$ using SPRAYWIZARD 9MCE by Sulzer Metco.

The bond coating was sprayed with Ni Mo Al powder on rectangular specimens with electric arc using Sulzer Metco Smart Arc 350, on super alloy specimens of Ni base, cleaned in an ultrasonic bath with acetone and sand blasted with electro corundum. The size of the specimens is 8x30x2 mm.

The characterization of samples submitted to surface treatments by plasma spray deposition was performed morphologicaly (determination of the layer thickness, determination porosity, adherence and absorption of the layer) and compositionaly (determining the chemical composition of the layer).

To highlight the results, analysis were performed using electron microscopy with electron microscope QUANTA 200 3D DUAL BEAM. X-Ray diffraction was performed using an X' Pert PRO MRD equipment. Thermo physical properties of materials were analyzed with the device 457 LFA Micro Flash. Samples were subjected to a heat treatment in furnace Chamber Furnaces with Gas Heating at the temperature of 1150°C.

Deposition parameters for atmospheric plasma spray (APS) are presented in Table 1, and intermediate layer parameters with NiMoAl deposited by arc are shown in Table 2.

TABLE 1. TECHNICAL PARAMETERS FOR THE DEPOSITION

Cooling water debit	8,7 bar
Velocity of rotation	55 rot/min
Electrode voltage (U)	60 V
Plasma gas intensity A)	600 A
Composition of plasma	46,1%Ar/13,51%H_2
Spraying distance	120 mm
The cooling pressure of the water	14-17 I/min (3,7-4,5 gal/min)

TABLE.2. SULZER METCO SMART ARC 350

U	31V
I	200A
Air pressure	60 PSI

3. EXPERIMENTAL RESULTS

3.1. Atmospheric plasma spray (APS)

Thermal spraying is a group of processes designed to achieve thin layers, in which fine powders, metallic or nonmetallic, shall be deposited, melted or semi-melted, to form a coating.

The particularity of this process is it's capacity for deposition of metallic, ceramic – metallic (named "cermets"), ceramic and polymeric layers with a thickness from 100 µm to 1 mm, for a various industrial applications.

The layer is totally created when a big number of powder particles are covering each other. These particles are related to substrate mainly with mechanical links. A common characteristic for all types of layers obtained with this process is given by the lenticulare or lamelare structure of the grains, obtained after a quickly solidification of the powder particles after the impact with the substrate, which has a smaller temperature. If powders are not produced

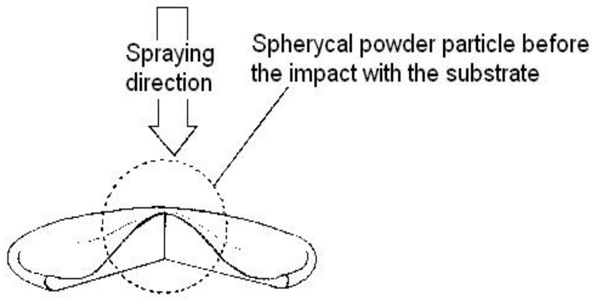


Fig. 1. Schematic representation of a spherical particle sprayed onto a plate substrate

3.2. Particle size distribution

Particle size is an important variable that influences coverage characteristics. To ensure the powder's melting in the plasma spraying, for a given set of parameters, the spraying powder's size should be checked.

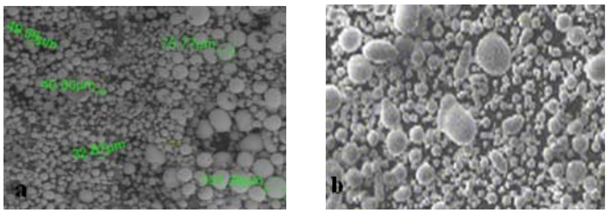


Fig. 1. Powder morphology used in thermal spraying: a) ZrO_2/20% Y_2O_3 and b) Ni5Mo5Al

3.3. Micro structural characteristics

In SEM images of the surface layer small cracks, with diameter of 200 µm, can be observed (Figure 2.a.).

Heat treatment at a temperature of 1150°C for 100 hours, has led to a compaction of layer deposited (Figure 2.b.), only a few separate particles can be seen, resulting in a good compact layer.

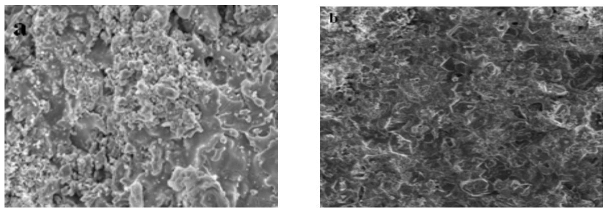
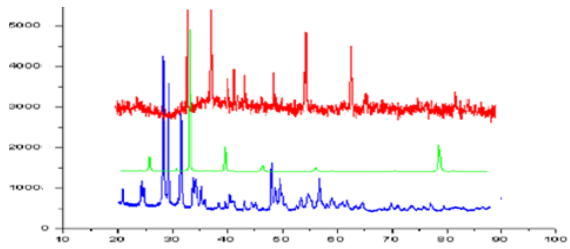


Fig. 2. SEM images of the layer obtained by plasma spray deposition of powder ZrO_2/20% Y_2O_3: a) before heat treatment at 1000X, b) after heat treatment at 1000X

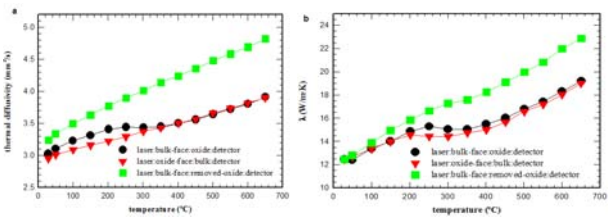
4. X-RAY DIFFRACTION

With XRD analysis observations will be made on constituents and phases of the layer deposited by thermal spraying. With the help of x-ray diffraction we could see the modification of the diffraction curves before and after thermal treatment, thus highlighting the phases obtained after sintering.



5. THERMO PHYSICAL PROPERTIES OF MATERIALS ANALYSIS

This study describes the experimental results of thermal diffusivity, specific heat at constant pressure, and thermal conductivity of porous 20 mol% yttria-stabilized zirconia (YSZ).



6. CONCLUSIONS & ACKNOWLEDGMENT

With this APS technique, almost any material can be deposited, provided it can be melted or become plastic during the spraying process.

Particle size is an important stage in the metallization process that influences coating characteristics. For this reason, in certain sets of parameters the size of the spray powder should be taken into account.

After heat treatment at a temperature of 1150°C for 100 hours deposited layer compaction can be seen. You can see very few separate particles, resulting in a great compact layer.

After X diffraction analysis and heat treatment at 1150 ° C we found areas devoid of peaks characteristic of the solid solution obtained after heat treatment, which shows a very specific complete and ordered structure close to amorphous layers.

Improving the thermal conductivity and diffusivity is possible to increase the entrance temperature of gas turbines and improve performance.

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