ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume XI (XXI), 2012, NR2

WEAR RESISTANT COATINGS OBTAINED BY THE METHOD - LASER SINTERING

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Keywords: powder, alumina, protective atmosphere, grains surface

Abstract: The essence of process for production of metal powders by aggregation is the formation and sintering operations that cause growth and stabilization of the contact surfaces, together with connections interatomic cohesion between particles.

A body of metal powders is a thermodynamically unstable state due to the smoothness powder, grains surface roughness, form, degree of hardening in deformed areas, surface defects at grain polycrystalline networks (vacations, dislocations), etc.

1. INTRODUCTION

In this paper will be presented several studies on deposition of wear resistant layers on the surface of pieces of ordinary materials, common, a relatively new technology - laser sintering.

Experiments similar to those presented in this paper were described in their previous works, both in terms of the mechanics of obtaining evidence and in terms of observations and interpretation of results [5,6,7,8,9,10].

Concomitantly, I watched with interest and practice of professors from other universities and research centers abroad [2,3,10,11,12,13,14,15]. The results were analyzed and compared with those obtained in my studies, being me often of great use.

In his work Bourell D. L, [1] is representative deposits metal-ceramic materials by laser-sintering. Tolochko N.K, [13] studied deposits in layers, or layers of material deposited over other layers of different material (with intermediate layer deposition).

Such, this paperwill be presented an experiment in hich we obtained some evidence of a material base - OLC 45, which I deposited on the surface of laser-sintering technology, metal powders of Al_2O_3 layers in different thicknesses. The physico-chemical features upper oxide ceramics are determined by low content or absence of vitreous phase, something that is a primary goal in ceramic processing.

Aluminum oxide Al_2O_3 ceramics is the main element and is found in nature as corundum, which may be colorless or colored differently as: ruby (red), sapphire(blue), topaz (yellow). Temperature sintering ceramics based on Al2O3 is between 1550^{o}C and 1650^{o}C.

Descent sintering temperature is achieved by introducing the mixture of raw material composition of mineralized flux, influencing the subsequent processing and product characteristics, the formation of melts which act as binders between alumina particles [1].

Method deposition of layers of materials with a characteristic usually over a base material offers many advantages, the most important is economic.

Alumina Al_2O_3 as high densityand high purity (>99.5%) was the first bioceramic material widely used in various clinical applications.

The combination of excellent properties, corrosion resistance, good compatibility, high wear resistance, outstanding mechanical properties, is used in the following areas:

-maxillofacial reconstruction using Al2O3-based ceramics as bone cavity filling material;

-various plastic surgery to achieve the alveoli of alumina, hydroxyapatite and alumina ceramic composites;

-the construction of various medical devices as sensors, electrodes, pacemakers,etc..;

-replacement of bone segments;

-in dental ceramics, aluminum oxide powder is a primary component in dental porcelain;

-in prosthetic, alumina is used as surface coatings on metal surfaces - as in hip, elbow or shoulder.

2. EXPERIMENTAL STUDY

2.1. THE MATERIALS USED

Deposits were made on flat surfaces of a piece of OLC 45 [2,3]. Rectangular shaped piece dimensions are: h = 4mm, L = 80mm, l = 50mm. Basic material characteristics are presented in Tables 1 and 2 [1].

Table 1. The chemical composition of steel OLC45.

Steel	Chemical composition [%]					Critical temperatures	
	C	Mn	Si	P_{max}	S	Ac_1[^oC]	Ac_3[^oC]
OLC 45	0,42… 0,50	0,50… 0,80	0,17… 0,37	0,040	max 0,045	725	780

Tabel 2. Mechanical characteristics of steel OLC45.

Steel	Delivery status		Heat treatment	Thickness product mm	Mechanical characteristics				Main areas of use
	Normalized	Annealing			Rm	Rp	A5	KCU	
	HB_{max} daN/mm^2				N/mm^2	N/mm$_2$	%	J/cm$_2$	
OLC45	235	207	Călire şi revenire înaltă	<16	700… 840	480	14	59	Parts heat treated, high mechanical strength and toughness average.

Additional layer is made up of a powder of Al_2O_3. Pure alumina (> 99.5%) has been used since the '70s, as material for implants, especially for artificial joints and teeth, due to its good mechanical and biocompatibility with tissues. Al_2O_3 powder characteristics are presented in Table 3 [1].

Table 3. Characteristics of Al_2O_3 powder

Physical properties		Thermal properties	
Density	3,96 [g/cm^3]	Linear expansion coefficient (250°C)	7,4 [μm/(m°C)]
Constant matrix	4,7591 [Å]	Linear expansion coefficient (1000°C)	8,2 [μm/(m°C)]
Molecular weight	101,961 [g/mol]	Thermal conductivity	30 [W/(mK)]
Module Weibull	10	Melting point	2054 °C
Mechanical properties		Boiling point	3000 °C
Hardness (Vickers)	1365	**Optical properties**	

Microhardness (Vickers)	2085	Refractive index	1,761
Tensile strength	300 [MPa]	**Description**	
Elastic modulus	370 [GPa]	Color	White
Resistance to bending	400 [MPa]	Crystalline structure	Rhombohedral
Compressive strength	3000 [MPa]	Grain size	15-20 [μm]

2.2. EQUIPMENT USED

The experiments were run in two stages, purposes to production workshops Phoenix & CO company Sibiu. Because the first attempts were made without a sintering environment - a protective atmosphere, parts could not be obtained to provide the relevant evidence on which to make some measurements

In fact, Figure 1 shows the aspects of such an experiment [1].

Fig. 1. Deposition on the surface of a piece of 4mm thick material OLC45.

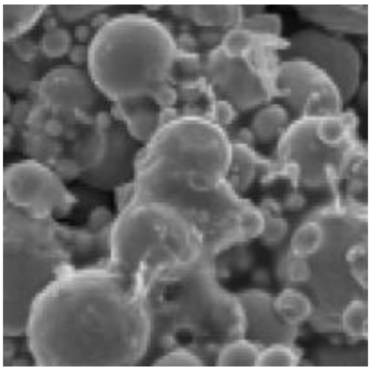

Fig.2. Al2O3 particles (99.5%), sintered by laser beam on the surface OLC45 (electronic1500x).

Therefore, experiments were repeated, this time in the protective environment of gas (CO_2). Sintering was performed at a temperature of about 1550^{o}C. Laser installation was set to an output of 200W. Power density was adjusted to 700W/mm^2 and diameter laser outbreak are reduced to 300μm. In micrography (Fig. 2) shows that sintering in the presence of solid phase, as confirmed by the presence of pores.

2.3. SINTERING MECHANISMS

A body of metal powders is a thermodynamically unstable state due to the smoothness powder, grains surface roughness, form, degree of hardening in deformed areas, surface defects at grain polycrystalline networks (vacations, dislocations), etc. Thermal activation of this system, by heating for sintering, produces transition of a state nearest equilibrium by reducing the free surface [6]. Except these phenomena, same time with the sintering it takes place a process of softening, namely a reduction of the rezistance to deformation of the cristalline grains from the particles, leading to the viscous flow. To the superficial tension of the material of the grains it is opposed a weakened rezistance of the crystalline grains on the contact zones. The value of the superficial tension exceeds the critical tension of flowing – creep tension, at the respective temperature and determines displacings of the gliding plans, therefore a mass transport by the flow in the viscid state of the material.

During the sintering, next to the effect of the body contraction, it is produced the continous reduction of the porosity by the decreasing the dimensions and the form of the eyepores.

Sintering environment (protective atmosphere) occurs in the processes that occur in the superficial layers of materials during sintering. Through judicious selection of these media properties can be obtained so upper and reducing the time and sintering temperature.

Material moves under the influence of surface energy at the convex surface near the concave surface of the material transport mechanisms. Processes of material transport links between particles increases thus generating the phenomenon of shrinkage during sintering.

Mechanisms that contribute to the particles to adhere to each other, that is the formation of necks between grains are the mechanisms of viscous flow. Contact areas between the newly formed powders grains, named intergranular necks or bridges, will have two common crystalline grains originating grain, making their joints. Micrographic seen from the sintering is complete because of implementation bridges between particles, ie intergranular necks.

2.4. SPECIMENS OPTAINED

There have been four samples: the OLC 45 plates with dimensions h = 4mm, L =80mm, l = 50 mm were deposited Al_2O_3 powder layer thickness of 0.2 mm, 0.6 mm, 1 mm or 1.2 mm sintered laser beam (fig.3, fig.4, fig.5, fig.6).

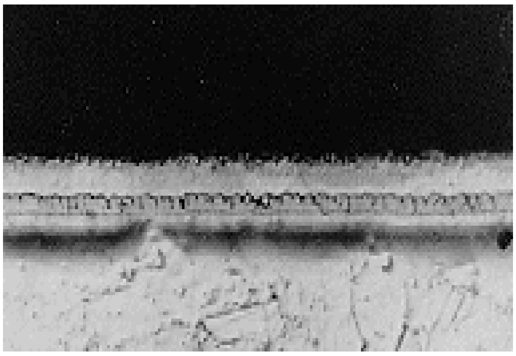

Fig.3. Deposition of powder Al_2O_3 (99,5%) on the support OLC 45 (thickness deposited h = 0,2 mm, optic 100x)

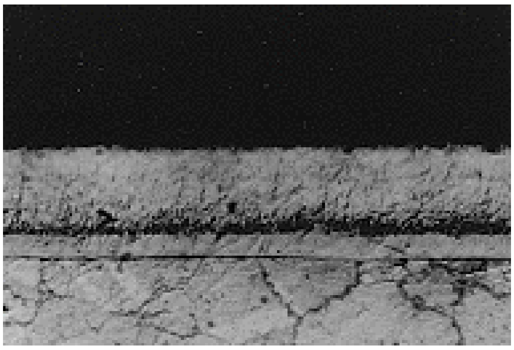

Fig.4. Deposition of powder Al_2O_3 (99,5%) on the support OLC 45 (thickness deposited h = 0,6 mm, optic 100x)

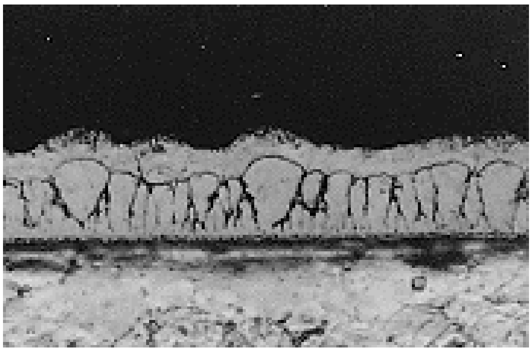

Fig.5. Deposition of powder Al_2O_3 (99,5%) on the support OLC 45 (thickness deposited h = 1 mm, optic 100x)

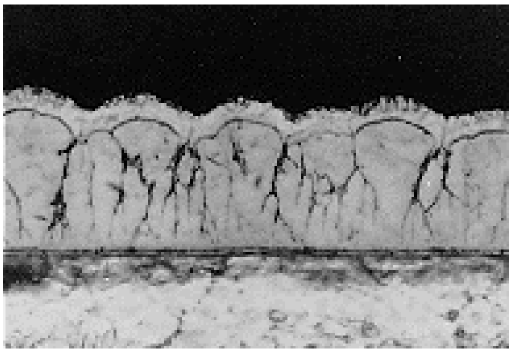

Fig.6. Deposition of powder Al_2O_3 (99,5%) on the support OLC 45 (thickness deposited h = 1,2 mm, optic 100x)

3. MEASUREMENT PERFORMED

To determine the wear resistance using a laboratory bench with the followingfeatures:
Contact type: plan, linear or punctual.
Sliding motion - sliding speeds between 0.000001 and 0.018 m / s.
Contact pressure: 0.1 MPa .... 5 Gpa.
Testing materials and hard and soft layers at low speeds and very small.
Friction regimes: technical dry, old and mixed.
Application:
- tribological experiments on the passport for any material or layer deposited;
- deposited layer thickness determination and adherence to material support;
- parameters determining the movement jerky (stick-slip phenomenon).

Samples were tested for 60 minutes, measurements recorded every 15 minutes. In Table 4 the values registered from testing the base material and values registered and in Table 5 of the test samples with the deposited layers. Each dry friction regime.

Tabel 4. Values of measurements made to determine wear OLC45 sample (uncoatedsubmitted)

Nr. crt.	Proportion Al_2O_3 [%]	Force [N]	Initial mass M_i [g]	Final mass M_f[g]	Mass variation ΔM [g]	Sliding speeds V_a[m/s]	Time [min]				
							0	15	30	45	60
							ΔM_i [g]				
1	0	100	125,62	124,47	1,15	0,01	0	0, 25	0, 53	0,81	1,15

Tabel 5. Valorile măsurătorilor efectuate în vederea determinării uzurii probei Al_2O_3

Thickness deposited [mm]	Proportion Al_2O_3 [%]	Force [N]	Initial mass M_i [g]	Final mass M_f [g]	Mass variation ΔM [g]	Sliding speeds V_a [m/s]	Time [min]				
							0	15	30	45	60
							ΔM_i [g]				
0,2	99,5%	100	128,76	128,37	0,39	0,01	0	0,08	0,18	0,28	0,39
0,6			135,10	134,74	0,36		0	0,08	0,17	0,26	0,36
1,0			141,44	141,13	0,31		0	0,07	0,15	0,23	0,31
1,2			144,60	144,36	0,24		0	0,05	0,11	0,17	0,24

* - with the base material;

4. CONCLUSIONS

Performing results of measurements, we can conclude the following:

-The deadline for submitting, near the base material, wear resistance is considerably higher than the base material itself;

-The modification states that the deposited layer thickness, by increasing its changes, all with increased resistance to wear;

-Loss of mass in the layers are substantially lower than the basic material submitted, proving the wear resistance of alumina;

-Are higher mass-loss limit for submission decreasing thickness layer, proving that a thicker layer provides better wear resistance;

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