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Built of Cermet Layer Using Thermal Plasma Spraying (APS)

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Abstract

The technology of thermal plasma spray take an advanced position among different coating technologies, because of it`s allowing to use a wide range of engineering materials depending on it`s melting point, to get a super mechanical, electrical, and thermal properties in comparing with other thermal spray methods. So it is improves the properties of metals, ceramics, and plastics parts which are used in industry at all.

Introduction

Composite coatings of metal and ceramic mixtures or alternate layers of ceramics and metals have been developed for many thermal, chemical, electrical and mechanical application. It can be prepared by multigun spraying or with a single gun using multifeed powder injection system or by using a premixed powder blend in a single-hopper feed system. The simplest and least expansive method is to use premixed powder blends [1].

Thermal spraying is an important coating technique uses Thermal Plasma, Oxyacetylene flame, and Electric arc power.

In this paper atmospheric plasma spraying was used Fig. (1). Plasma spraying has the advantage over combustion processes, whereby it can spray very high melting point materials such as refractory metals like tungsten and ceramics like zirconia.plasma sprayed coatings are generally much denser, stronger and cleaner than the other thermal spray processes with the exception of HVOF and Detonation processes [2]. This technique enables us use a wide range of materials depending on their melting point to obtain a super mechanical, electrical, and thermal properties comparing with other thermal spraying methods [3], it is used to approve wear, oxidation, corrosion resistance of surfaces, and so to increase mechanical properties of engineering materials [4]. Materials like ceramic, glass, refractory metals, ordinary metals, low melting point metals, and polymers may sprayed using plasma spraying system, many industrial applications comes true because of high density, excellent bonding strength, and low oxidation content of coated layer as effect of using Argon, Nitrogen, Hydrogen, and Helium gases [1, 5].

In the Rockwell micro hardness test, both the shape of indenter and the load are specified, the hardness number depends only on the depth to which the indenter penetrates the specimen [6].

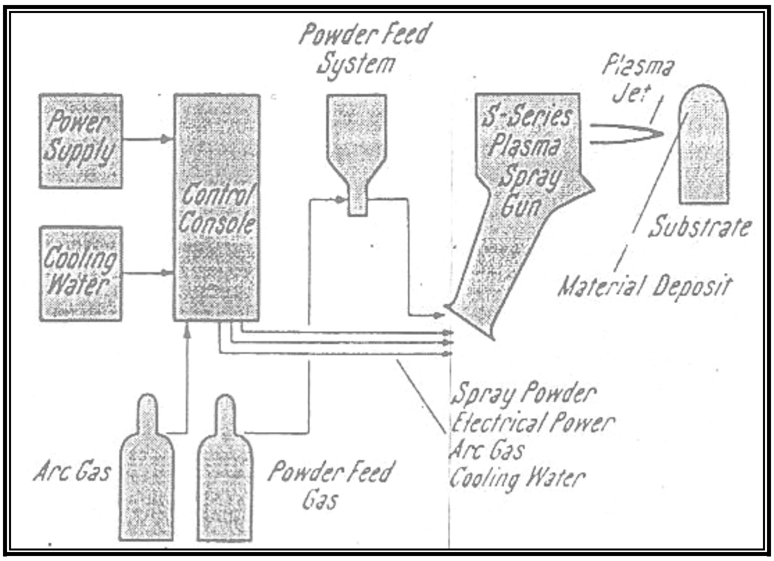

Fig.(1) Atmospheric Plasma Spray System (APS).

Experimental part and Materials

In this work Aluminum powder was used (produced by Metco corporation with code (54NS)), to be metallic part of cermet, it is examined by X-ray diffraction Fig.(2), and particle size distribution by Laser Fig.(3). Gray alumina was used here also from Metco corporation with code (101) to be a ceramic part of cermet, it is checked by x-ray diffraction Fig.(4) and laser particle size distribution Fig.(5).

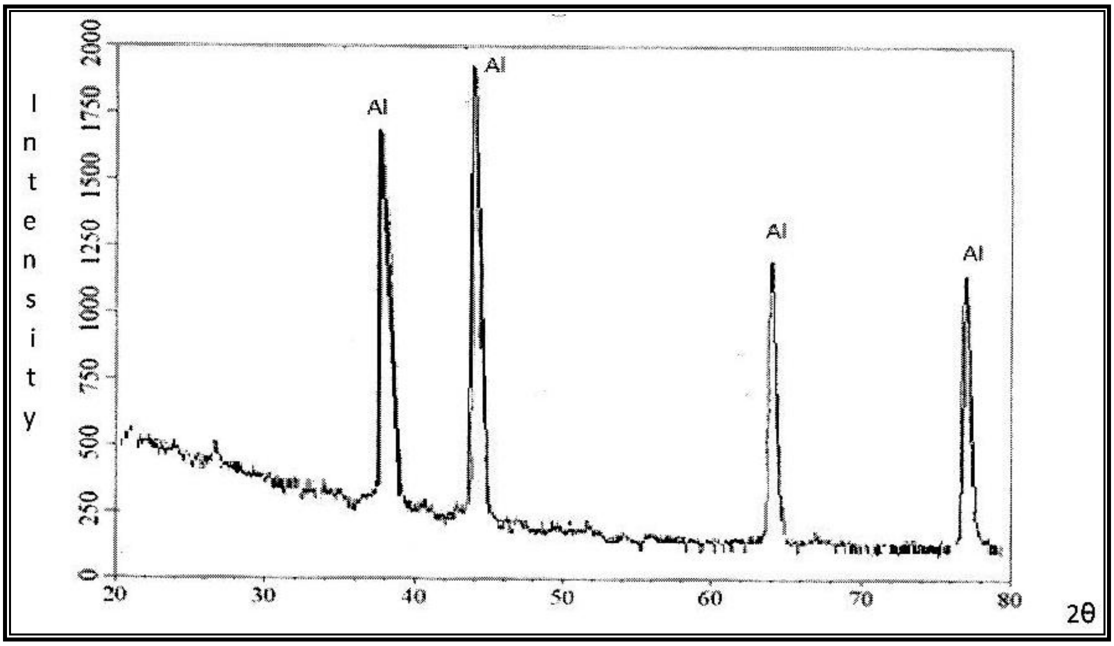

Fig. (2) X-ray diffraction pattern of Aluminum powder.

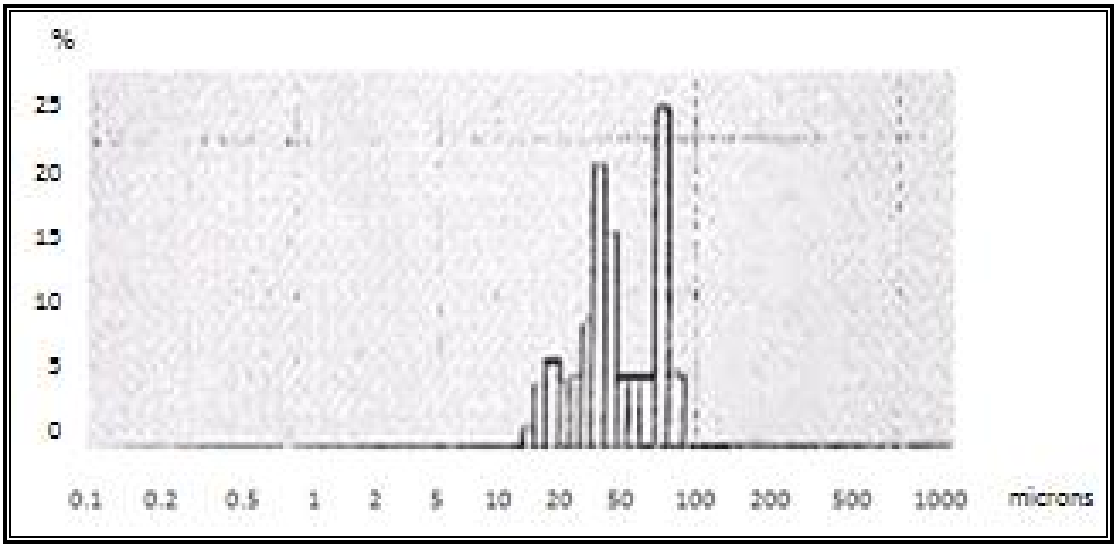

Fig.(3) Particle size distribution of Aluminum powder .

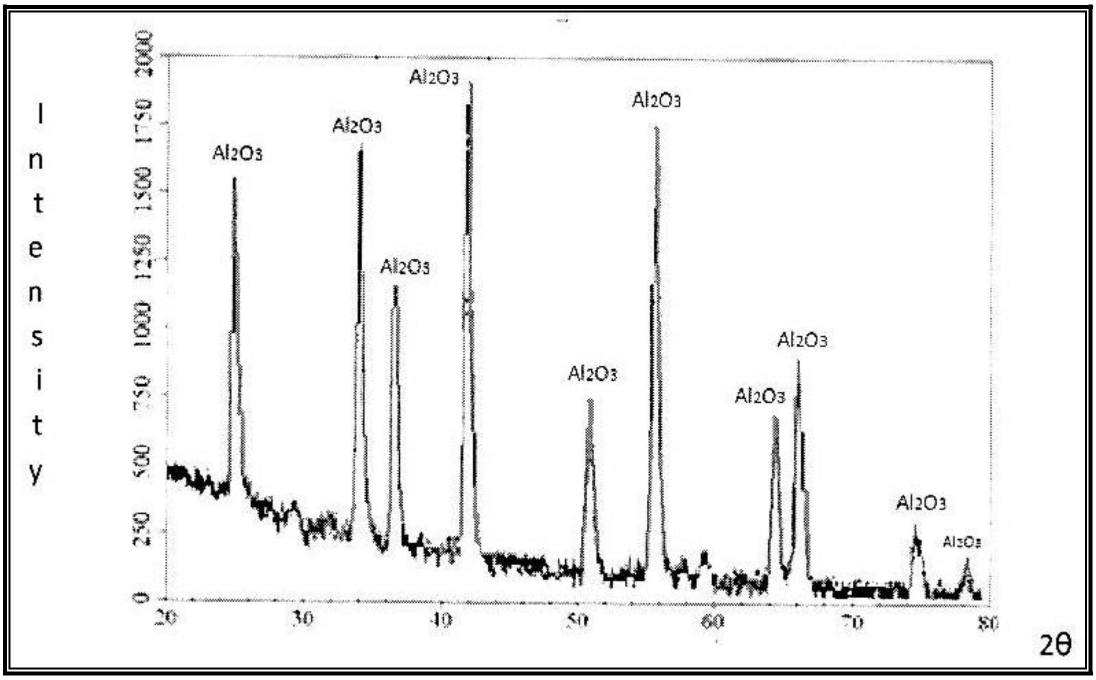

Fig.(4) X-ray diffraction pattern of Alumina powder.

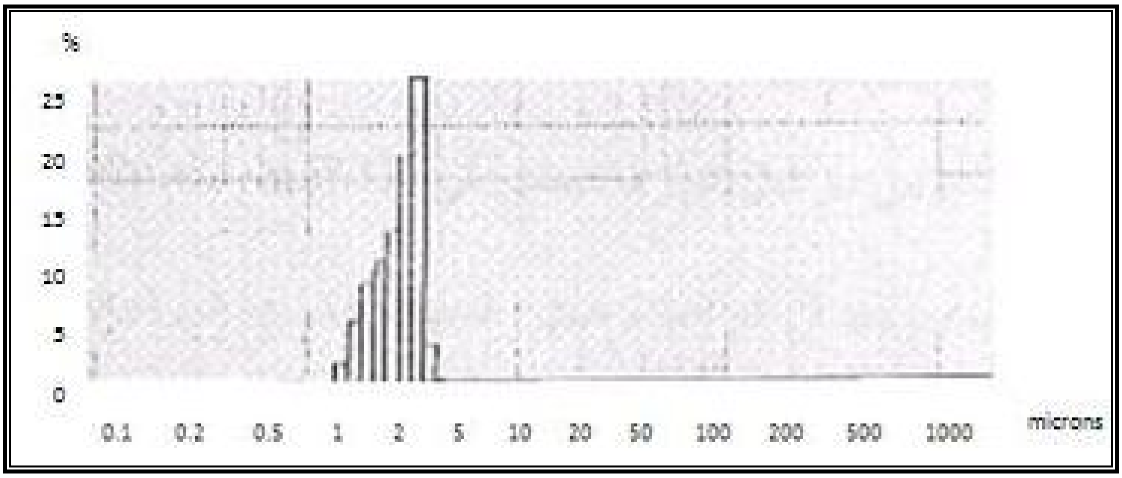

Fig.(5) Particle size distribution of Alumina powder.

Because of wide range of engineering application of Al-Cu alloy (planes, cars, space technology, etc.), it is used here to be a substrate of coating to improve the wear resistance which is so important in these applications, Table (1) explain the chemical composition of this alloy [7].

Table (1)
Chemical composition of substrate alloy.

Cu%	*Fe%*	*Mn%*	*Zn%*	*Si%*	*Mg%*	*Al%*
4.432	0.698	0.744	0.000	0.128	0.251	rem.

A cylindrical samples were prepared with 2 cm length, 1 cm diameter and the upper face was conducted by grit blasting using silicon carbide particles with sizes from 0.5 mm to 2 mm for 30 s, then air blowing [8].

Table (2)
Grit blasting parameters.

Blasting distance	*Blasting angle*	*Blasting pressure*
20 cm	90°	5 bar

Different ratios of Al_2O_3 and Al were used as listed in Table (3), and mixed by three dimensions mixer (Turbula three dimensions mixer) for 3 hours, then thermal spraying has been done using Plasma system (PlasmaTech A3000 system) in air (Atmospheric Plasma Spray APS) with spraying parameters as shown in Table (4).

Table (3)
Alumina to Aluminum ratios.

Samples ¾ ®	*1*	*2*	*3*	*4*
Alumina	5%	10%	15%	20%
Aluminum	95%	90%	85%	80%

Table (4)
Plasma spraying parameters.

The gun		*Powder feeder*		*Plasma arc*	
speed	100 mm/s	Disc speed	35 r.p.m.	Ar	45 *l*/min
distance	14 cm	Mixer speed	60 r.p.m.	H_2	5 *l*/min
		Carrying gas	Argon	power	43 Kw
cycles	2	Carrying gas flow	3.5 *l*/min	current	600 Amp

Discussion

After completing spraying process, a composite layer (cermet) Fig.(6) was obtained with thickness 200 µm as average (Using optical microscope), Fig.(7) shows its x-ray pattern.

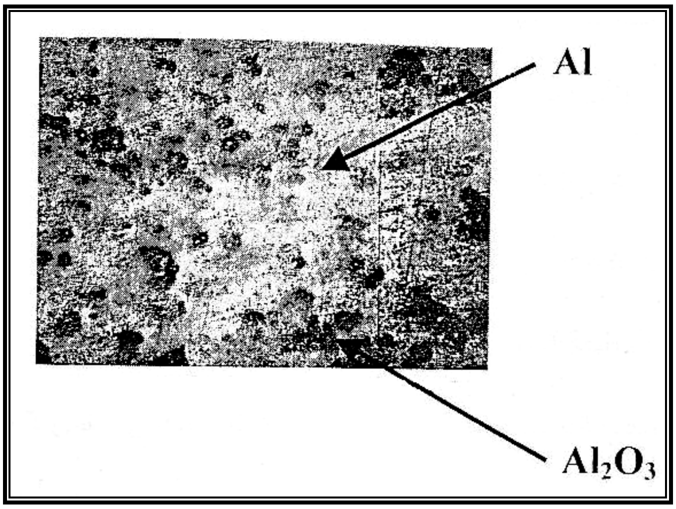

Fig.(6) Profile of cermet layer surface.

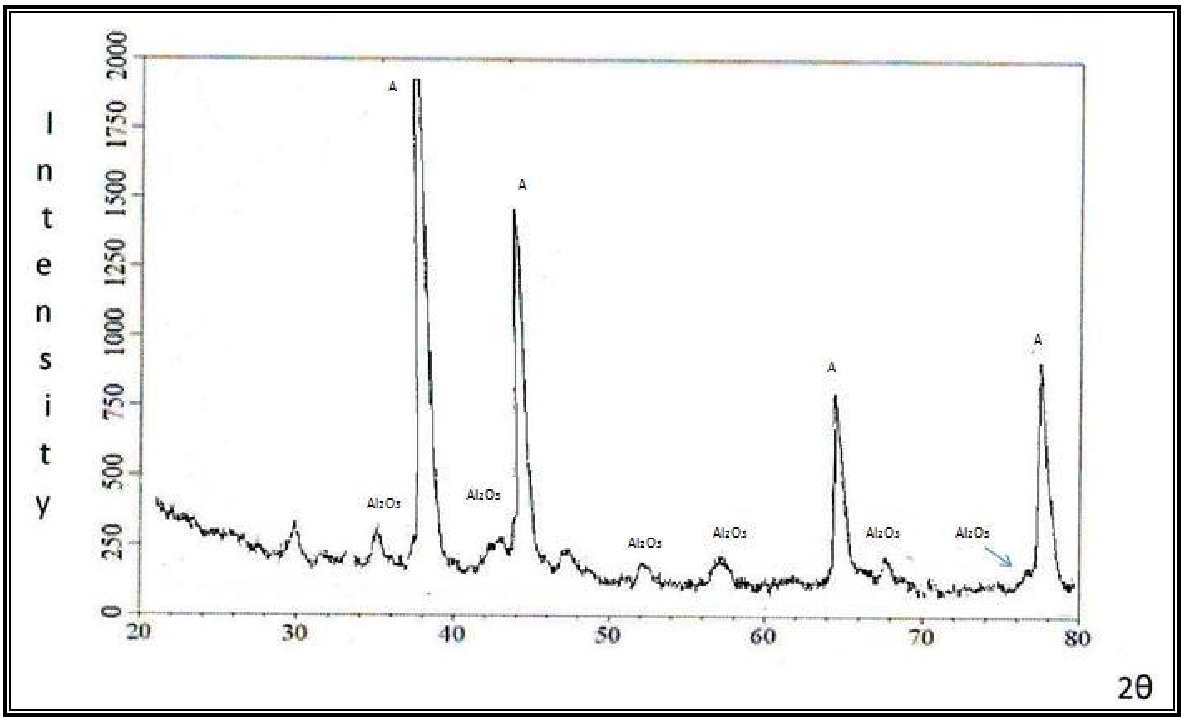

Fig.(7) X-ray pattern for cermet layer.

To study the effect of ceramic: metal ratio, two tests were done here:

- First, is the test of hardness using Rockwell scale (Wilson 500, 15 Kg, 10 s).
- The second, is the test of porosity as shown below:

Table (5) shows that the hardness value is increases with adding more alumina, because of increases of alumina particles distribution in unit area of coated layer, we can see at Al 95%:Al_2O_3 5% the hardness is 38.1 HRT and at Al 80%: Al_2O_3 20% it is increases to 50.2 HRT.

Table (5)
Results of hardness test.

Al_2O_3 wt%	***Al wt%***	***Hardness HRT***
5	95	38.1
10	90	46.25
15	85	48.5
20	80	50.2

The porosity test is obtained using Archimedes way [9] as explain below:

$$p\% = \frac{w2 - w1}{w2 - w3} * 100\ \%$$

Where:
w_1: dry coated layer weight.
w_2: water saturated coated layer weight.
w_3: weight of coated layer when it is suspended in water.

From the above equation, one can noticed that the porosity is decreases with increasing of alumina, because the coated layer becomes more dens as a result of falling the close pores with fine particles of alumina (3 μm as average). Table (6) shows this corresponding between them

Table (6)
Results of porosity test.

Al_2O_3 wt%	Al wt%	Porosity %
5	95	7.5
10	90	6.6
15	85	6.2
20	80	5.8

Acknowledgment

We would like to acknowledgment the APS system which was destroyed at the war of 2003, and we hope to have another one to discover more relations between coating parameters and properties of coated materials.

Reference

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الخلاصة

احتلت تقنية الرش الحراري مكانة متقدمة بين تقانات الطلاء المختلفة، إذ تسمح باستخدام مدى واسع من المواد الهندسية اعتماداً على نقطة الانصهار للحصول على خواص ميكانيكية، كهربائية و حرارية فائقة مقارنةً بطرق الرش الحراري الأخرى، ومن استخداماتها تعزيز خصائص الاجزاء المعدنية والسيراميكية والبلاستيكية المستخدمة في الصناعة بكافة مجالاتها.