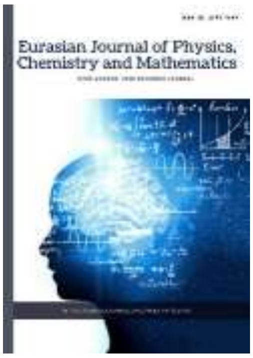

Evaluate Results of the Structural and Mechanical properties for composite (Al-WC) by using Thermal Spray

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ABSTRACT

In the current article, a model of oil pipes with dimensions of 1 centimeter was cut for the purpose of coating them with a system consisting of composite aluminum-tungsten carbide and with different reinforcing values of carbide (5,10,15,20,25) % and after performing the coating process by the method of thermal spraying with flame. Samples were heat treated at 1000°C for a time of only 2 hours. Then the test of hardness, porosity, adhesion strength and scanning electron microscope were conducted, and the results showed that the highest hardness was 222Hv, and the highest adhesive strength was 46 MPa, while the lowest porosity was 7%, while the electron microscope gave clear images of the coated samples in which the amount of consistency appeared crystal and mechanical interlocking.

Keywords: Composite Material, Coating, Oil pipeline, Aluminum

Introduction

Thermal spray technology has occupied a wide range of development in various industries in terms of treating corrosion and rust in many devices and equipment that are used in many applications, and one of the most important of these applications is the turbo spray that suffers from cracks and fractures during work, which in turn weakens the production of those turbo sprays. Thermal spraying with flame can also be used in the treatment of external verification of oil pipelines that extend for very long distances. Thus, it is not possible to replace a long-term oil pipe with another due to the material cost and stress. Thus, the replacement is replaced by a local treatment by mixing many materials that may be of a mineral basis represented in (Al, Ni, Cu, Mn) or a ceramic base, including Y_2O_3, Al_2O_3 ,ZrO_2 ... etc. It is possible to use different carbides WC, B_4C, SiC, etc. [1,2,3]. Mixing these materials produces An alloy painted to a steel-based base (st.st316L), which represents the metal of which turbine blades, oil pipelines, or even various pontoon bridges are made [4]. All applications that can activate the process of thermal spraying with flame, plasma, or any method of thermal spraying with flame, they need to be of low economic cost, light weight and aesthetic in terms of surface topography and cohesion of the atoms of the materials that make up the single alloy[5]. The coating process has differed from one method to another with many advantages and variables of coating that can be used to suit the application to be worked on, as we find that the process of coating by the method of thermal spraying with flame is easy to work, which in turn gives a good coating cover and meets the available industrial purposes [6]. The advantages of this method are the high hardness of the prepared samples as well as the low porosity that contributes to increasing the durability of the coating as well as excellent adhesion force and this also depends largely on the spraying distances that can be used which were generally found through multiple experiments (10,12, 14,16,20). These are the distances that separate the thermal spray gun and the models to be painted, which have proven through many experiments to be effective [7]. It can be industrially applied to many different devices and equipment, which in turn reduces the cost and returns the device or the turbine blade to work again, which contributes to creating an excellent applied industrial difference [8]. And the aim of the current research is to treat cracks in the outer surfaces of the turbine blades and oil pipelines by the method of thermal spraying with flame, which enables through the results of experience to prove the importance of the application in terms of hardness, porosity, density, adhesion strength and dysfunctional structural examinations.

Raw Material:

Was used (Al-Ni) powder (80%Al with (20%Ni) as a binder between the alloy to be painted, as well as the steel base (st.st) manufactured by the Japanese company Metco), and Aluminum metal Al manufactured from German Riedel - De haen AG seelze - Hannover company, with a particle size of 90μm and 99.8% purity, as the basis material, and it was reinforced using WC tungsten carbide manufactured by Changsha Santech Materials Co., Ltd. of China, with a particle size of 200 μm with purity of 99.8%

Experimental Methods:

In the current work, the flame thermal spray method was used for the purpose of producing coated models of the (Al-WC) system with different weight ratios of carbide, where the device consisting of two oxygen acetylene bottles was used, where the proportion of oxygen was (4 bar) while the proportion of acetylene was (0.7bar). A special powder was used to be installed within the spray gun in order to put the powder mixed in it after it was ground for two hours by a homemade mill that has steel balls. The powder was placed in the granules designated in the spray gun, and after turning on the torch and taking the distance designated for painting, the granules of the powder were opened and the powder began to descend to the previously roughened base by denting method for the purpose of increasing the adhesion strength between the molten drops and the coating base that was used from an out-of-service Turbine feather according to table (1)) shows the chemical analysis of the alloy used as a coating base. The type of gun used in coating is (GH - 4/h, China) of Chinese origin, and figure (2) shows a schematic image of the device used, after The prepared models tend. Those models suffer from some weakness in the outer coating, which requires a great deal of heat treatment, which was conducted for the models through a furnaces type (KSL 1200X) of American origin and at a temperature of (1000 °C) and for a period of only two hours, so that the samples are ready after this is to perform various laboratory tests, table 1. Show the results of Parameter coating (Al-%WC)

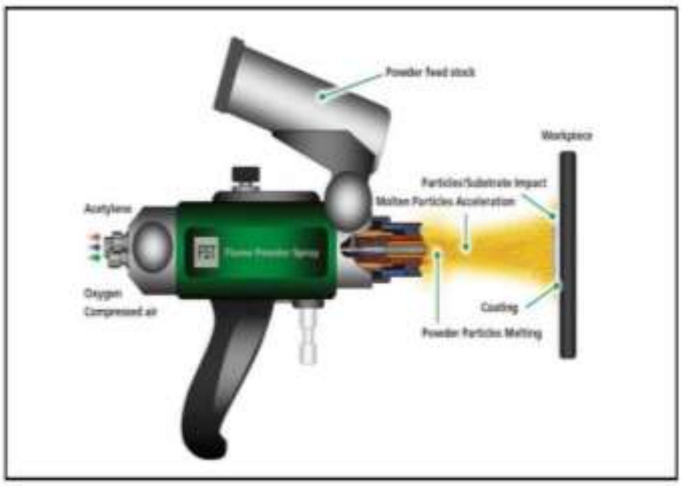

Figure (1) Layout of the thermal spray system

Table 4.1. The results of Parameter of coating (Al-%WC)

Sample	Material
1	(95%Al-5%WC)
2	(90%Al-10%WC)
3	(85%Al-15%WC)
4	(80%Al-20%WC)
5	(75%Al-25%WC)

Tests used:

1- Hardness Test

The property of hardness is the resistance of the surface of the material to the permanent plastic deformation that occurs through indentation, cutting, wear and scratching, penetration and machinability. The hardness of the material depends on the type of bonding force. Between molecules or atoms, surface type, high temperature and heat treatment. The Vickers micro hardness test was carried out in a hardness apparatus (METKON), of French origin, which consists of the penetration device, which is a tapered microscopic head in the shape of a square-base diamond pyramid whose levels intersect at the top at an angle of 136°, where the sample is fixed under this instrument for that. The samples were cut with a length of 1 cm, a width of 1 cm, and a thickness of 1 cm, applying a load of 50N and a time of 20sec. The Vickers number for the hardness is calculated by measuring the lengths of the two diagonals (d2, d1) and their average value (D) and then applying the relationship [9]:

$$HV = \frac{2P\sin\frac{136^\circ}{2}}{d_{av}} = \ldots\ldots\ldots\ldots(1)\quad HV = 1.854\,\frac{P}{d_{av}}$$

Where: Hv: Vickers hardness, f: shed load (N), dav: mean impact diameter.The hardness was measured in several different areas of the sample, where the hardness was taken on the edges and in the center and collected to get an approximate value of the hardness rate.

2- Porosity Test

Porosity is one of the most important physical tests in terms of calculating the number of pores present within one model, and thus the percentage of the number of pores on the surface of the paint, which is directly proportional to the hardness. Archimedes, where the weight of the paint was calculated, which is (W1), then the painted model was immersed in distilled water for (24) hours, and then the weight was calculated after immersion (W2), then the painted model was suspended inside the distilled water and the third weight was calculated (W3) After that, the following law was applied, as the Immersion Method method was used [10].

$$\text{Porosity} = \left(\frac{W_2 - W_1}{W_2 - W_3}\right) \times 100\% \ldots\ldots\ldots\ldots(2)$$

3- Adhesion Test

The painted model represents the main part of the work. Thus, the adhesive force must be calculated, which represents the adhesive force between the base that represents the oil pipe or the turbine blade and the coating of the system (Al-WC). The adhesion force is measured using a microcomputer Controlled Electronic Universal Testing Machine.) with specifications (Time Group lnc. It is measured in units of mica pascal (MPa), where a coated sample and an uncoated sample is taken and an adhesive substance is placed between the two samples and pressure using the device for a period of 24 hours, then the above device is used for the purpose of drawing between the coated sample and the other coated and when the two samples are separated from each other, the device will record the maximum adhesion force in pascals.[11], and as shown in Figure (2).

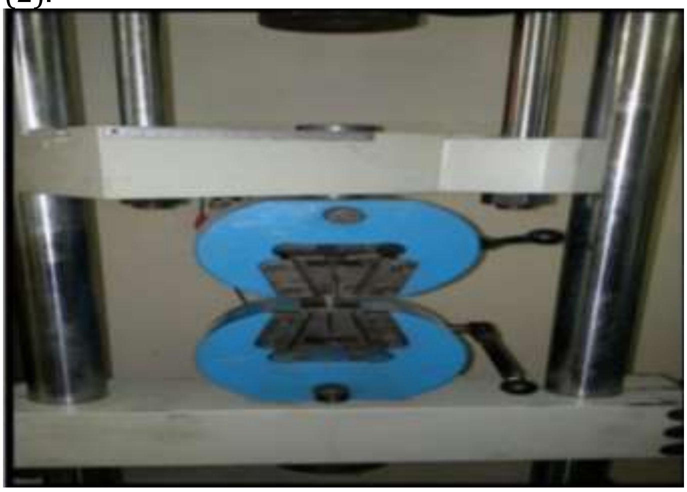

Figure (2) shows the adhesive force device

4- Scanning Electron Microscope

The surface topography of the resulting samples was studied after sintering in order to know the outer surface of the resulting samples and how they are cohesive. A scanning electron microscope was used for this purpose, because of its great advantages that give a distinctive description of the external surface structure and with a magnification of thousands of times of optical microscopes, the type of microscope used is (TESCAN) with a model (MIRA3) of French origin.

Results and discussion:

1. Effect of adding tungsten carbide on Vickers hardness:

We note through Figure (3), which gives the relationship between the percentage of tungsten carbide and the hardness before and after sintering by 1000°C. We reach the highest hardness at 20% reinforcement and hardness 178Hv to start decreasing after that, which is attributed to the fact that the resulting agglomeration of the reinforced material works negatively on the hardness, which in turn hinders the process of mechanical entanglement between the atoms of the two base and reinforcement materials [12]. After sintering, we find a significant increase in hardness with the addition ratios, and it also reaches a maximum at 20% WC with a hardness of 222Hv. Agglomeration of WC carbide [13].

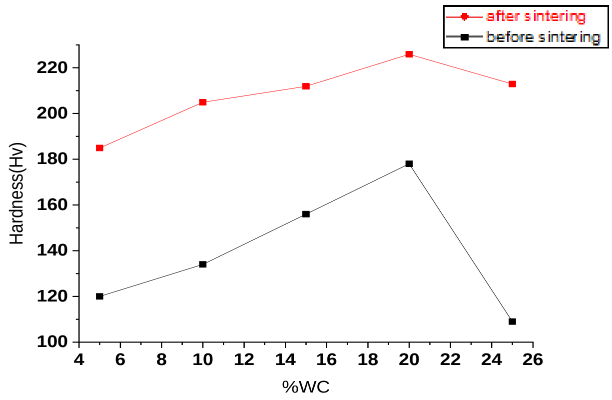

Figure (3) gives the relationship between tungsten carbide and hardness before and after sintering.

2. Effect of adding tungsten carbide on the porosity of the coating:

The porosity of the coating is one of the important measurements of the coating, which in turn gives a clear indication of the strength and hardness of the coating, as we note through Figure (4), which gives the relationship between the percentages of tungsten carbide added and the porosity of the coating before and after the thermal sintering process at 1000°C, as we note that there is a strong correlation Between the porosity and the hardness, and by increasing the time ratio of reinforced tungsten carbide WC, the porosity ratio decreases until it reaches the lowest value before sintering about 20% of the reinforcing material, which is 7%. The same reasons that were mentioned in the hardness, meaning that the porosity is an inverse relationship with the hardness, and the lower the porosity, the higher the hardness, in addition to the porosity after sintering decreases because the distances between the atoms are less than it was before sintering, which arose due to the different materials used in coating as well as freezing Molten droplets before reaching the base of the coating [14].

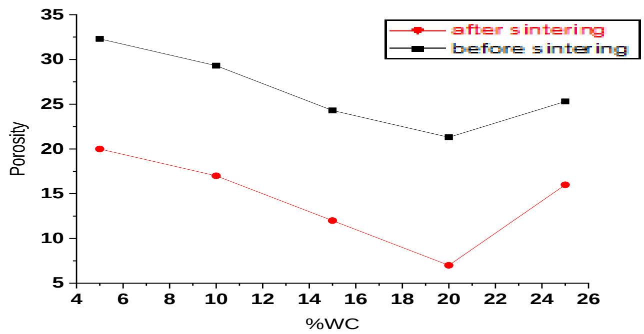

Figure (4) The relationship between the ratio of tungsten carbide and the porosity before and after sintering.

3. Effect of adding tungsten carbide on the adhesive strength of the coating:

The adhesion strength test was conducted for the resulting coating after thermal spraying as a measure of the adhesion strength of the coating to the base, which in turn is a mechanical measure of the strength of the coating between the reinforced material and the substrate, as we note through figure (5) the relationship between the adhesion strength and the percentages of added tungsten carbide from 0-20 % before and after sintering, and we find that increasing the additive increases the adhesion strength between the base and the coating until we get the highest adhesive strength after sintering which is 46MPa and at a 20% reinforcement rate, and then the adhesion strength weakens, and the reason is attributed to the fact that the increase in carbide ratios will lead to the melting of the powder completely, which leads to the appearance of agglomeration inside the paint and weakens the bonding between the coated components and this is what happened in the hardness and porosity, as the distance between the heat spray gun and the base of the coating has a great role to increase and decrease the adhesion strength and increasing the distance leads to freezing of the drops, which reaches the drops It melts to the base of the coating and causes a weak adhesion force [15].

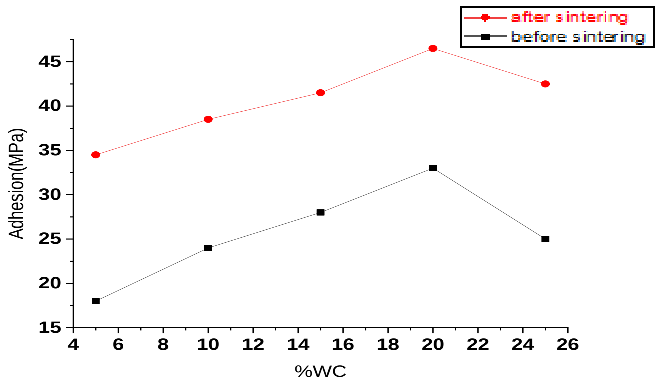

Figure (5) The relationship between adhesive strength and percentages of tungsten carbide added before and after sintering.

4. Effect of adding tungsten carbide on the coating topography:

The surface topography of the samples sprayed by the thermal flame spray was studied. Figure 4.19 explains the scanning electron microscope with a depth of (10μm) and enlargement (5.00KX) to the samples model after conducting the thermal sintering at 1000°C with different reinforcement ratios of Tungsten Carbide. Image (a) explains the reinforcement ratio of 5%, and we can realize the success of the coating process, but there is a randomness in distributing the nickel atoms during the surface of the sample; image (b) clearly explains the existence of reinforcement material spread through the nickel with very few quantities, randomness on the surface with reinforcement of 10% while the reinforcement ratio in the image (c) is 15% and we can find that it is a beginning to the surface regularity with apparent homogeneity and dimension between the nickel and Tungsten Carbide. In image (d) and with a reinforcement ratio of 20% of the Tungsten Carbide, we find the beginning of the crystal growth because of the temperature and apparent homogeneity between components. In comparison, we realize that an apparent and consistent surface was obtained in the image (e) with a 25% reinforcement ratio. There is a distinctive crystal tangle between each base and reinforcement material with Tungsten Carbide distribution with all the surface components. This is consistent with the hardness, porosity, and adhesion force results. So, we can find that the surface consistency and metallic interlocking between the coated material components have a high effect on the components of the coated material and highly increase the physical and mechanical properties (McMullan, 1995).

Figure 6 shows the scanning electron microscope to the model of samples at different reinforcement ratios and after the thermal sintering.

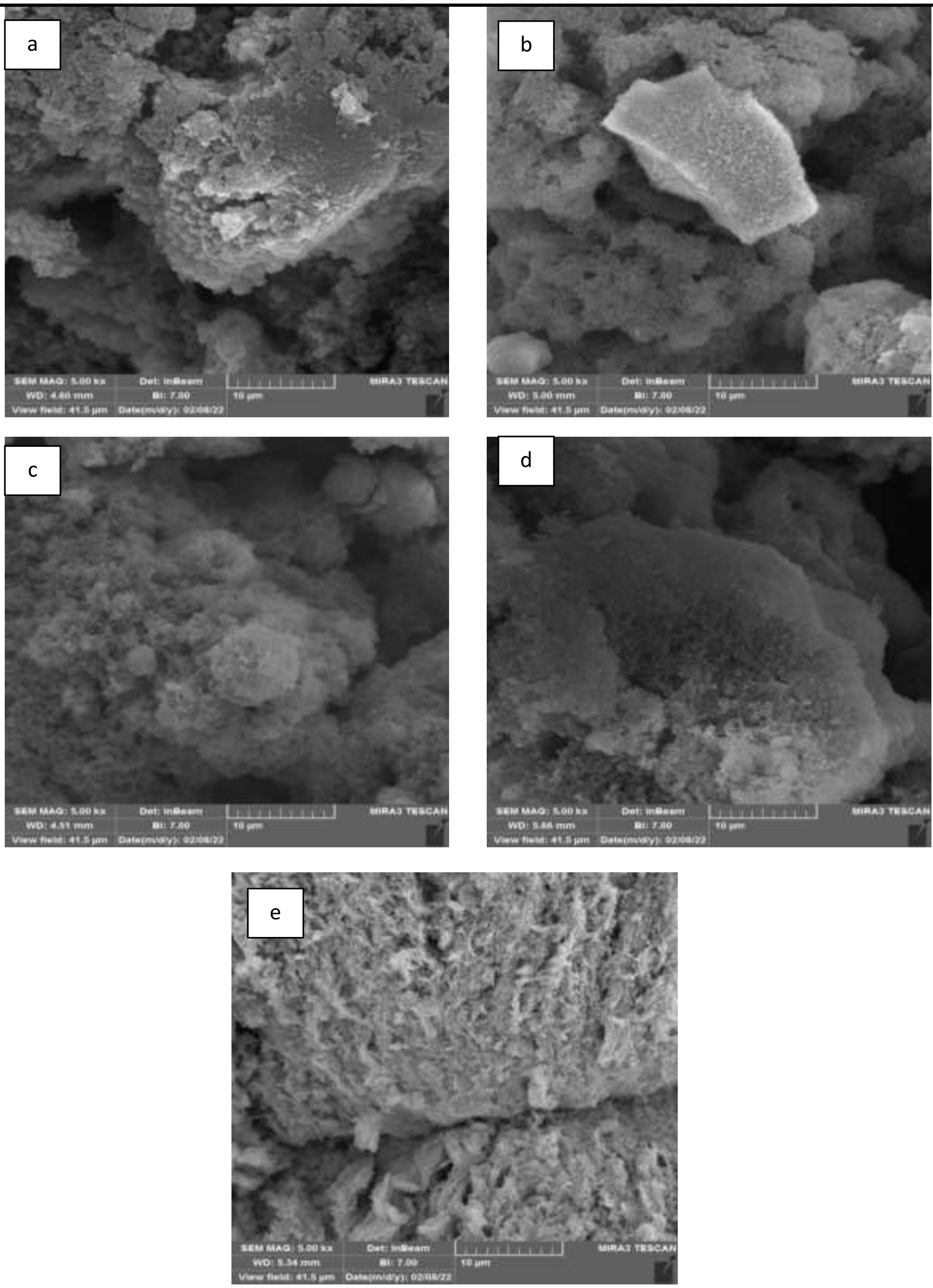

Figure (6) Scanning Electron Microscope (SEM) of samples at different reinforcement ratios and after thermal sintering.

Conclusion:

The important conclusion from the current article is the possibility of using flame thermal spray coating for the system (Al-WC). The hardness, porosity and adhesion strength were examined, in addition to the scanning electron microscope examination of the samples prepared after and before thermal sintering, and after thermal sintering, the best value of the hardness was obtained. It is (222Hv), while the lowest value for porosity was (7%), and the adhesive force reached the value (46MPa), and all results were at the best 20%WC reinforcement ratio. As for the scanning electron microscope, it gave a topographical description of the coating surfaces, which was the best is at 20%

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