Characteristics Structural and Physical Properties of the System Cermet [Basalt - (Ni-Al)] Using Thermal Spray Flame Technology

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Abstract

The powder technology of important technologies in the manufacture of advanced materials technology and the number of pieces because of its great influence, has been in the current research use material Cermet of basalt and (Ni-Al) With metal bonding material, where taking different proportions of powder metal bonding material (Ni-Al) and percentages by weight the amount of (50, 35, 25, 10) % and added to the powder material base of basalt. After that process has paint spraying method powders and different flame spaces spray it has also been a different thermal treatment of the samples. The tests were conducted physical and synthetic included both (X-ray diffraction, Electron microscope scanner SEM, Porosity truth), Where he explained the results of X-rays that the material used is basalt and material strengthening of the installation of (FCC) metal bonding material is (Ni-Al) The results of scanning electron microscope showed that the thermal treatment (1100 is a great influence on the homogeneity and consistency of the sample between substances and high thermal treatment negatively affects on the physical properties of the samples either the results of the real porosity found that it begins to decline gradually, the more this distance, so we get to the lowest porosity which is when spraying distance (15 cm) and then begin to rise again.

Key Words: Powder Technology, Polymer Material Composites (PMCS), Cermet.

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Introduction

Known as (Composite Materials) As the materials that arise from combining two or more phases, and together they produce high properties that include increased durability and light weight, so the direction to the production of composite materials to be a substitute for traditional engineering materials (metals, alloys, polymers and ceramic [1]. The properties of composite materials are affected by the properties of its constituent materials, which include the basis of Article and developed Reinforcing Phase it is also affected by surface interface formed between the eccentric and the basis of article. Article represents the basis for the continuous phase in the composite material, working on the cohesion of elements and materials strengthening and connecting parts together to form a coherent compositional system that can withstand external forces. [2] Relay tools working to strengthen the basic material, and these materials are either ceramic or metal or polymer, and are of different forms, as they may be in the form of fibers or scales or powders [3]. Classified as composite materials, depending on the type of base material to metal-based composite materials (Metal Material Composites (MMCS)) and other relevant based polymer (Polymer Material Composites (PMCS)) and composite materials are based on ceramic (Ceramic Material Composites (CMCS)) [4].

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The improvement of the properties of composite materials in general mainly depends on the methods of manufacturing such material, whether in a way plumbing (Casting) or Powder Technology or the modalities of paint (Coating), as the manufacturing method significantly affect the microscopic structure variables (Microstructure) and therefore It will affect the physical properties of mechanical and composite materials. The composite materials consisting of oxides with high degrees of ceramic materials fusion consisting of elements such as magnesium, Yttrium, aluminum and zirconium with additions of metal materials called (Cermet). In recent years, scientists have made a great effort to use this material composed widely in many electrical applications.

The thermal properties of dielectric that require good temperature at high temperature ranges, due to the good resistance to thermal excellence shocks without any deformation under thermal conditions used then. Composite materials are used (Thermal Barrier Coating) in gas turbines and jet engines as well as marine engines [7,6,5]. These materials are also working to protect the base metal from oxidation as silencers exhaust sound [8]. The current research aims to study the structural properties of basalt powder and the binder represented by nickel and aluminum.

The Practical Part

1. The Raw Materials Used in the Research

The use of basalt rock and the site of the president is a rock state of Germany (Rhineland-Palatinate). After cleaning the rock and dried and then grind first normal for reducing the volume of the rock of the appropriate size to granules by less than 8mm almost then grind by special type (Mortar Grinder RM 200) German-made. Where he was grinding the rock for a period of 48 hours when the size of granular ≤ 100µm.

2. Method of Preparation

It was prepared cermet material from taking different ratios of powder metal bonding material (Ni-Al) and percentages by weight of (50, 35, 25,10) % and added to the powder material of basalt. After that, the mix of material mixing with the base material Association well through the use of an electric mixer with balls of Teflon for (2hr) And for the purpose of obtaining a homogeneous mixture. Then a preliminary heat treatment was conducted for the powders of composite cermet materials before painting process at a temperature of $150c^0$ for (2hr) and using the oven type (Carbolite) English origin containing a controlled thermal type (Eurotherm). Figure 1 shows the powders used.

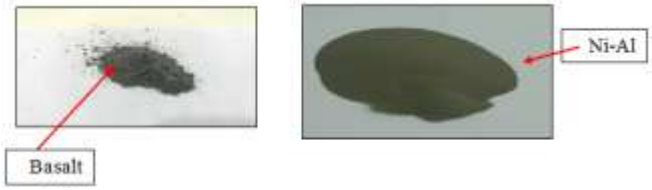


Figure 1. Using powders in paint

The purpose of the transaction before the thermal coating process is drying powders particles from the effect of moisture, and thus will be particles in good condition plasticity, be eligible for the production of coatings with good strength jowl with the base material. The accreditation to add powder metal bonding material (50%), so as to increase the porosity ratio of surface defects when adding a binder by higher or lower than (50%), which gave the mechanical properties of weak layers of paint cermet as a result of the non-proliferation and homogeneity of particles metal bonding material with Ceramic oxide particles are fine.

Tests and Measurements

First: X-ray Diffraction Examination (XRD)

In order to identify the phases consisting of elements of the spray materials used metaphase transformations that occurred after the spraying process. The device used (X-ray Diffraction) product from a company (Philips) located at the Sharif University of Technology/ Iran. Where the Target user in the X-ray tube is copper with a wavelength (Cukaα) which is equal to $1.542A^0$).

By knowing the wavelength (λ) and measuring the diffraction angle (2θ), obtained the values of the distance between atomic levels (d), using the equation given Barak following the relationship [9]:

$$n\lambda = 2\, d \sin\theta \quad (1)$$

Where

θ: angle of diffraction

n: is an integer and is equal to 1

λ: is the X-ray wavelength and is equal to $(1.542A^0)$.

d: is the crystal interplant distance.

It was identified phases formed through a

comparison of the values of the spacing between the interplant distance and intensity of the scan interplant through standard tables of American (ASTM).

Second: Porosity Study

The physical tests represented in the real porosity were performed by following the Archimedes rule according to the international standard (ASTM C373 - 88) using the sensitive electrode accuracy (0.0001 g) according to the following steps:

- Models dried for one hour using an electric oven at a temperature ($150C^0$) and leave to cool inside the oven, and then weighed the form after it out of the oven, and this is called dry weight (W_d).
- He samples are placed in boiled distilled water for period of (5) hours. The samples are then transferred to a container containing distilled water at room temperature for 24 hours. After models are removed, only suspended surface water is removed. The models are then weighed and this weight represents the saturated weight (W_S)
- The model is weighed while suspended and immersed in distilled water by a sensitive suspension scale and this weight is the suspended weight (Wi).

And then the truth is Porous Account (T.P.) using the relationship below [10].

$$T.P. = \frac{T.D. - B.D.}{T.D.} \times 100\ \% \quad (2)$$

As:

T.P: The ratio of total porosity of the body sintered

B.D: Body density sintered process (Bulk density) (g / cm^3).

Third: Scanning Electron Microscope test

The scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a high-energy beam of electron for resolution imaging of surface. The signals that derive from electron-sample interaction reveal information about the sample including external morphology, chemical composition, crystalline structure, and orientation of material making up the sample [11]. The electrons are produced by a thermal emission source, such as a heated tungsten filament or by a field emission cathode. The energy of the incident electron can be as low as 100 eV or as high as 30 KeV depending on the evolution objectives [12]. The electron is focused into a small beam by a series of electromagnetic lenses in SEM column as shown in figure (2).

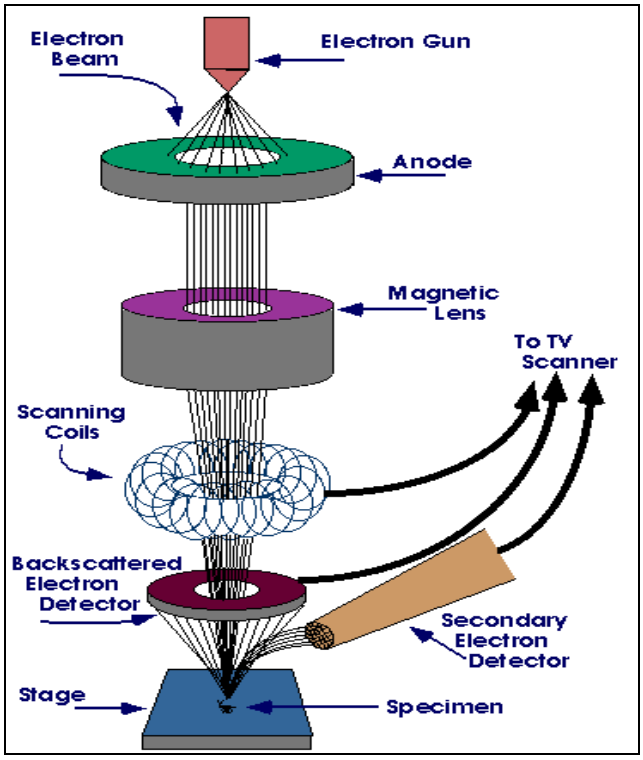


Figure 2. Electron beam interaction diagram. [11]

The fundamental principle of scanning electron microscopy is that the accelerated electrons in an SEM carry signification amounts of kinetic energy, and this energy is dissipated as variety of signals produced by electron-sample interactions when the incident electrons are decelerated in the solid sample. These signals include secondary electrons (that produce SEM image), backscattered electrons (BSE), diffracted backscattered electrons (EBSD that used to determine crystal structures), photons characteristic X-ray that are used for elemental analysis. Secondary and backscattered electrons are commonly used for imaging sample: secondary electrons are most valuable for illustrating contrasts in composition in multiphase samples [12]. This process was also carried out in Iran.

Results and Discussion

Results of X-ray Diffraction Examination

The study of research samples by X-ray is an important means of identifying the nature and composition of the material used in the process of thermal spraying first and observing the phase changes that occur on it second. And Figure (2) represents the results of X-ray diffraction of the

basalt powder material before coating. Through the figure, we find that the type used in the thermal spraying process was basalt from Albite ($AlNaO_8Si_3$).The structure (Triclinic), and from Dmisteinbergitei ($Al_2CaO_8Si_2$) is hexagonal. By comparing the results with the American Standard Tables (ASTM).

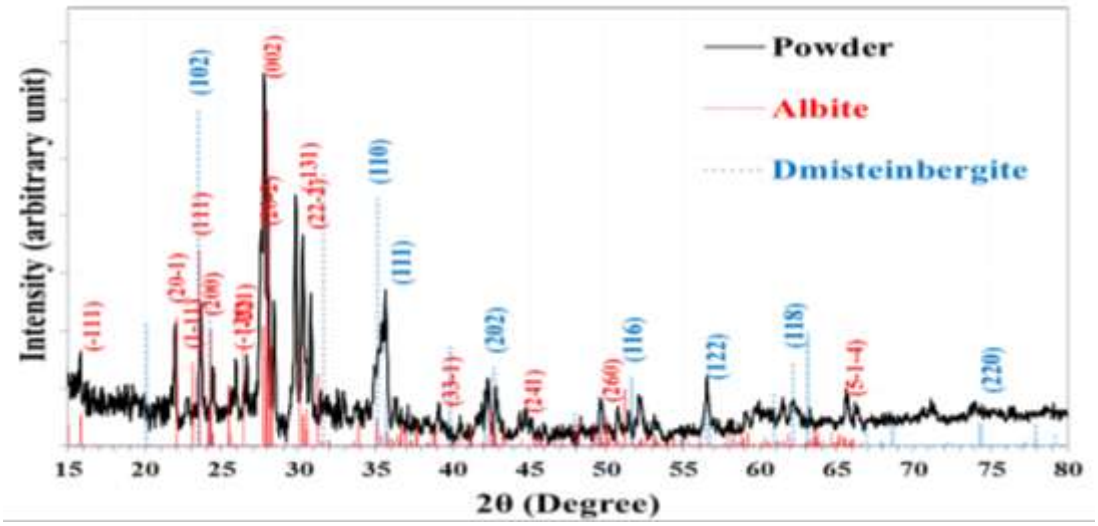


Figure 3. X-ray diffraction powder basalt before painting process

The Figure 4 represents the results of X-ray diffraction of the material Association (Ni-Al) a powder before the paint process, with notice that the type of material Association be of aluminum, nickel and phase cubic FCC (cubic) for both elements and by comparing the results with standard tables US (ASTM) [13, 14].

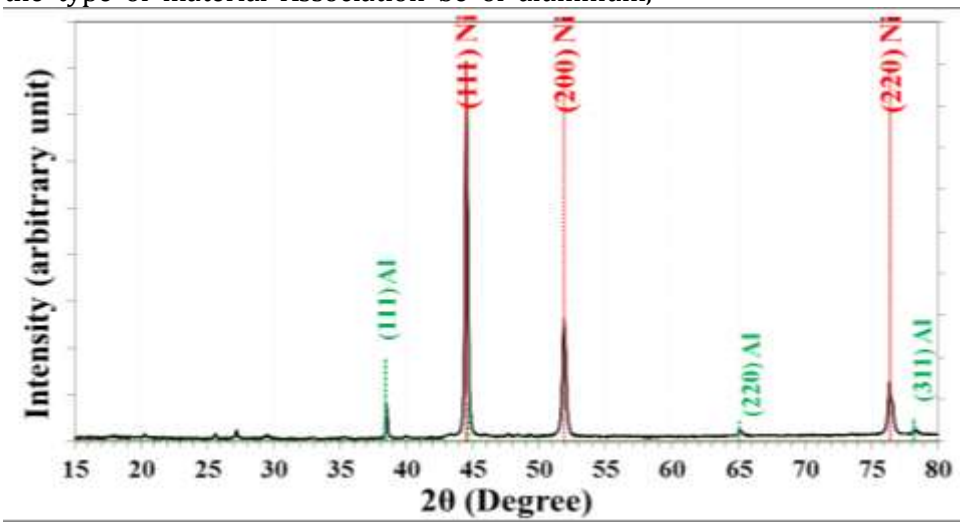


Figure 4. X-ray diffraction of the material Association (Ni-Al) prior to the coating process.

Either through (Figure 5) When a paint process samples blended by (50-50) for each article League and basically any at room temperature (RT) coated sample only note the appearance of nickel (FCC) are clearly at (111) and (200) and (220) as well as the emergence of Albait ($AlNaO_8Si_3$) at (112) and (002) which represent the primary components of the materials used to improve the properties was conducted thermal treatment of the samples at a temperature ($750C^0$) note appearance ($Al_2CaO_8Si_2$) denote the beginning crystal growth began at the corner site ((2θ = 35.4513) in (FCC) [15], which indicates that at the beginning of the removal of stress and lack of porosity and probability .The presence of agglutination between the layers of paint, which is believed to contribute to the improvement of the properties of layers of paint either when increasing the temperature to $950C^0$ and 1100 C^0 note the homogeneity of the paint layers for each of the ((NiO when developed (FCC) and ($AlNaO_8Si_3$) phase (Triclinic), and note also the emergence of Diopside)) phase

(monoclinic) and free of defects and the emergence of a new addition growth trends to remove most of the defects and surface stress and that this leads to an improvement in the physical properties of the layers of paint and indicates that the best thermal treatment is (1100C^0).[15]

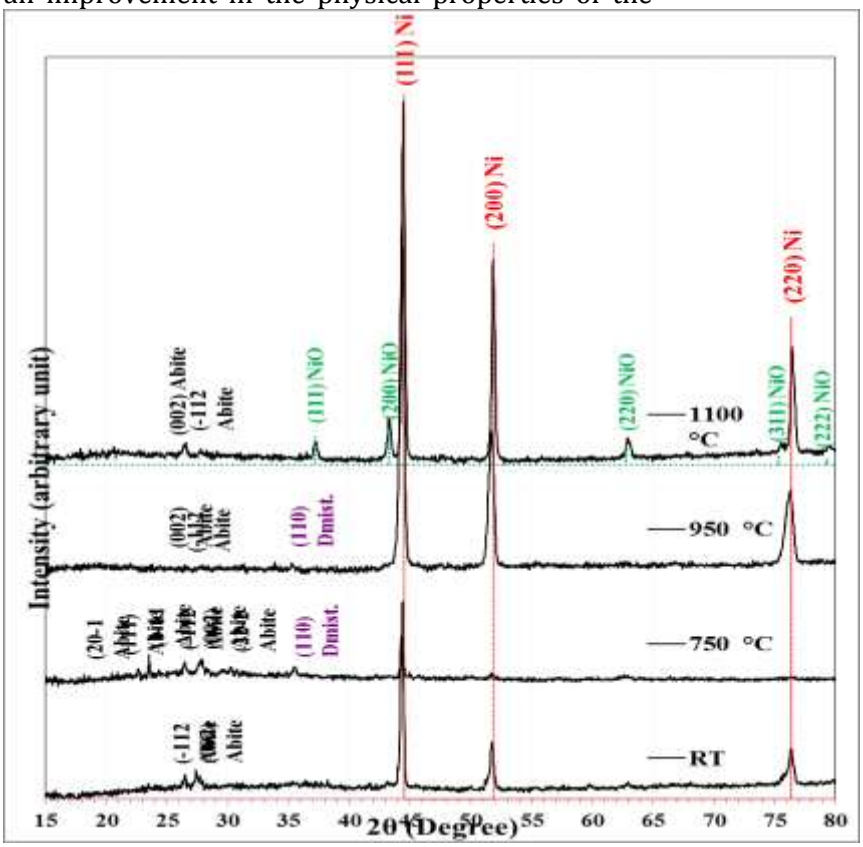


Figure 5. X-ray diffraction of imbricated (Basalt-Ni-Al) coating process after conducting various thermal transactions

Third: Results of the Scanning Electron Microscope (SEM)

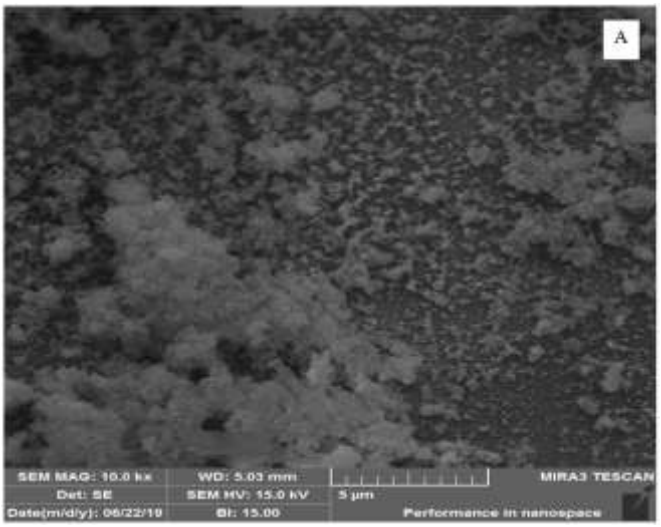
Showing images scanning electron microscopy (SEM) shown in Figure (5) compound ((Basalt+Ni-Al When (5mμ), and strongly enlarge 10KX)) for all standard samples, we note what is coming:

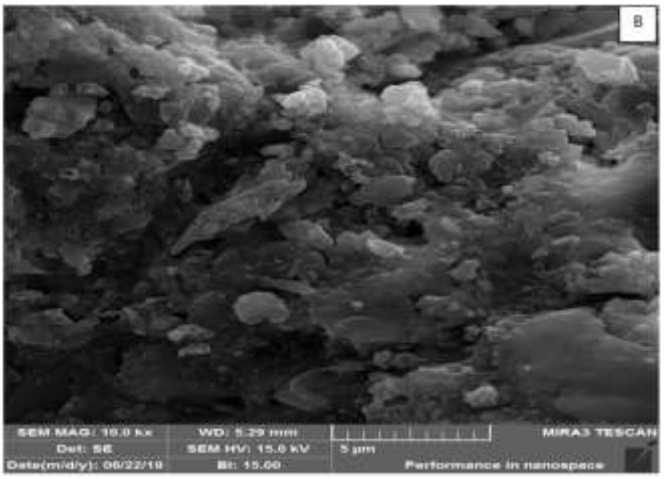
In Figure (5 \ A) before heat treatment (sintering) note that the correlation between the components of basalt and metal bonding material homogeneous random bit but the effect of paint heat and clear through the cohesion of the granules with each other with the spread of some defects somewhat surface with pores in the microscopic structure . It also noted the presence of low density areas and other high-density led to the spacing elements from each other and heterogeneity.

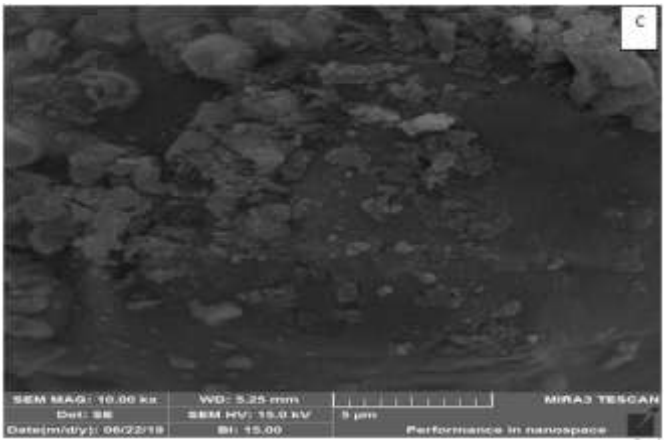
The figure (5 \ B) and after thermal treatment (750 C^0) is observed from the microscopic structure as more homogeneous with stronger coherence and the biggest result of aluminum merger and nickel with the components of basalt compared with the model in (5 \ A) and that there is an overlap between the particles for both the downtrodden , also notes that there are clear to some of the pores phenomenon through the surface of the sample.

The figure (5 \ C) and after thermal treatment (950C^0) note a significant breakdown of the material Association This is evident through the spread of a clear-grained on the surface and coherent with each other made - up metal mesh with a few interspersed with pores.

The figure (5 \ D) and after heat treatment b (1100 C^0), we find the increase in the proportion of fusion between grained basalt and granulated material supported with The improved bond structure of the microscopic and the process of filling the pores by it. We find also a clear effect on the distribution and melting material full bond between the compounds Basalt with a clear disappearance of the pores and lack of surface defects, any re-crystallization ((re-crystallization of the grains of the material bond between the oxides of basalt eight, especially when strengthening (50%) if we note a significant homogeneity between the grains [15].







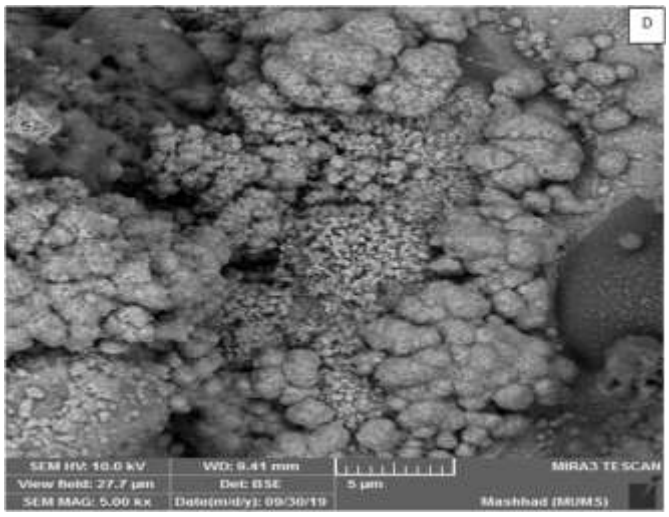


Figure 5. Scanning electron microscopy (SEM) of the compound (Basalt+Ni-Al) When (5µm), and strongly enlarge (10KX) for all standard samples

Effect of Heat Treatment on the Porous Coating Al-cermets

The results of measurements trial has shown the porosity emergence of different ratios of pores in the coating material depending on the different sedimentation rates four adopted in our research which is% (50,35, 25,10) of Article Association (Ni-Al) with the corresponding material basalt. Where we find that the pores ratio ranged between 12.6% ratio 35% (Ni-Al) + 65% (Al2O3) [and between 6% ratio (Ni- Al) + 50% (Basalt)] 50% [When optimal spray 15cm distance].

Figure(6) illustrates the porosity relationship with different distances spray when using different ratios of binding material (Ni-Al) , has been observed that the lowest porosity be at the rate of precipitation 50%, where porous borders (6%).

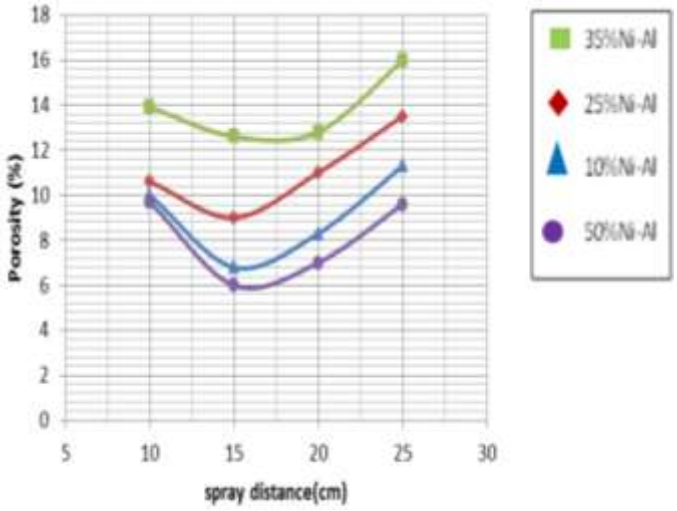


Figure 6. Shows porosity values with spray distance without heat treatment

The figure(7) shows above also that the porosity of the proportions of all add-used generally be very high when they are a few spray distance, and begin to decline gradually, the more this distance, so we get to the lowest porosity, when spraying distance ((15 cm, after which rise again , said that this was due to the lack of distribution of minutes molten material emerging from the spray gun regularly on the base surface [15, 16], It is the speed and temperature of minutes when spraying the molten center rather than at the edges, and thus harden the particals of the fusible before arriving at the base in the rims area, leading to the formation of voids or pores..

For the purpose of reducing the proportion of porosity in the coating material Al-cermets the resulting thermal treatment of the samples with specifications and standard when best-conducted spraying distance ((15cm, being the specifications then recorded the lowest value of porosity before the thermal treatment. Thermal treatment was conducted in an oven heat is vacuum, and at temperatures thermography, different °C (750, 950, 1100, 1200), and time (1.5hr) has observed a significant change in the proportion of porosity, as its value fell to 2.6%)), the lowest-value when thermal treatment (1100C^0) as shown in the form (4-4)). This change in the value of the porosity is due to the formation of areas of interdependence between the layers of paint Al-cermets because of sintering processes and the spread of atoms through the movement of atoms among them, and attempt to close the pores when you perform a thermal treatment. As the thermal treatment of a significant impact on increasing both hardness and density of samples [16].

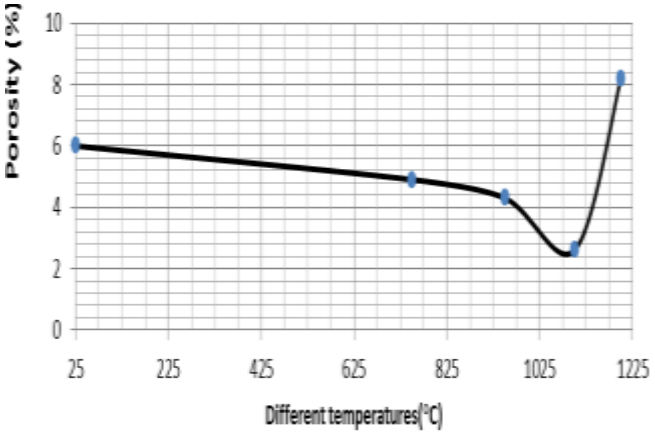


Figure 7. Shows the porosity values after the different thermal treatment of 50% Basalt + (50%) Ni-Al

Conclusion

The most important conclusions that can be obtained from the current research is the possibility of spraying the thermal flame of Basalt is the presence of a binder helps cohesion and link the powder during the paint, as was obtained less porosity is possible and at the optimum conditions of Sintering (1100C^0) and distance spray (15cm) and mixing ratio (50%), reaching a value of 2.6%)) as the least value of the porosity,. The results of scanning electron microscope, we find the increase in the proportion of docking between the grains and basalt granules material reinforced with improved microscopic structure of the Association and the process of filling the pores by it. We find also a clear effect on the distribution and melting material full bond between the compounds of basalt with apparent disappearance of the pores and lack of surface defects, any re-crystallization ((Recrystallization of the grains of the material bond between the oxides of basalt eight, especially when strengthening (50%) if we note a significant homogeneity between the grains. The X-ray diffraction and when a paint process samples blended by (50:50) for each article League and basically any at room temperature (RT) only coated sample note the appearance of nickel (FCC) are clearly at (111) and (200) and (220) as well as the emergence of Albait (AlNaO8Si3) at (112) and (002) which represent the primary components of the materials used.

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