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The Effect of Adding Syria on Microstructure of Nickel-Aluminum Alloy

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Abstract:

In this work, Ni-15%Al alloy with additives of CeO_2 prepared by powder metallurgy method, Nickel and Aluminum Powders were tacking blending and mixing as (Ni-15%Al) then adding CeO_2 powder for different percentage after the mixture was compacting and sintering, then measuring the density and porosity for it. Microstructure analysis by microscope and x-ray diffraction tests which done. Finally we discuss the effect of additives percent on the properties of alloy. We found that there was no significant enhancing in hardness with increasing of additives percent, in spite of; were resistance increased with increasing of additives percent.
Key word: composite material, Ni-Al alloy.

Introduction:

Advanced composite materials (ACMs) are materials tailored to possess exceptional properties (superior mechanical properties, corrosion/ oxidation resistance, thermal, electrical, optical or magnetic properties and wear resistance) by controlling their composition and internal structure. They are subdivided into structural composite materials (wear parts, cutting tools, engine components and biocomposite materials), electrical composite materials (capacitors, insulators, substrates, integrated circuit packages, piezoelectric, magnets and superconductors), ceramic coatings (engine components, cutting tools and industrial wear parts) and chemical processing and environmental composite materials (filters, membranes, catalysts and catalyst supports).

Advanced composite materials (ACMs) are in production for wear parts, cutting tools, bearings, filters, and coatings. (ACMs) are also in limited production in discrete engine components such as turbocharger rotors, glow plugs, and pre combustion chambers. Current military applications in the United States include radomes, armor, and infrared windows.

Experimental work:

Nickel-Aluminum alloy (Ni-Al) was prepared by powder metallurgy with adding CeO_2, Table 1 shows material which used.

After mixing metals powders manually for 5 minutes, powders remixed by ball mill for 30 minutes at rotation speed 750 rpm. The mixing powder were compacted by using tool steel die with 15mm diameter with compacting pressure 174 MPa, 5 samples prepared from each mixing percent.

sintering process dune under Argon, the samples were heated to 250˚C and setting at this temperature for 30 minutes then cooled to room temperature at the furnace, that was the first attempt for sintering process but it was noticed that the temperature wasn't enough to remove all the Novalac from the compacting, for that another attempt was done.

That was the samples were heated to 250˚C and setting at this temperature for30 minutes then heated to 550˚C and setting at this temperature for 30 minutes finally cooling to room temperature at the furnace. The second attempt had given good samples; all samples were then sintered by using this heating cycle.

The samples were cleaned from the waste by dipping it in acetone then using ultrasonic bath for 10 minutes, at last the samples dried in furnace at 100˚C for 30 minutes. Ni-Al alloy was ready to make density and porosity tests.

Tests

In this part there were tests which dune on Ni-Al alloy with and without CeO_2 Nano additives sample

1-Density and Porosity Test.

ASTM D 792 standard reference was used in all density and porosity measurements, which are based on Archimedes principle. The specific gravity of the material is given by equation 1 and the porosity is given by equation 2.the relationship between density and porosity was studied this test repeated for 5 samples from each nanoadditives percent addition, finally the average was tacked as result.

$$Sp.Gr = [W1/ (W1 – W2)]*Sp.Gr.\ of\ acetone \quad ……eq. (1)$$

Where

Sp.Gr = Specific gravity of material

W1= weight of material in air

W2= weight of material suspended in acetone

$$P = (w_3 – w_1)/\{(w_3 - w_2)*Sp.Gr.\ of\ acetone\} \quad ……eq. (2)$$

Where

P= Porosity of material

W3= Weight of Wet material i.e weight of soaked material in air.

2- Scanning Electron Microscopy Test

Ni-Al with nanoadditives samples were characterized by S-4160 Scanning Electron Microscope (SEM) at electrical engineering department, Tehran University, Islamic republic of Iran.

3- X-Ray Diffraction (XRD) test

The X-Ray Diffraction test dune for Ni-Al with nanoadditives samples at

Specialist Institute for Mechanical Industry, Baghdad, and Republic of Iraq.

4- Micro hardness test:
The micro hardness test was dune at metallurgy laboratory/Department of Production and Metallurgy Engineering.

5- Were test:
Test was done at Smelting laboratory/ Department of Production and Metallurgy Engineering.

Results and Discussion:

In this work, pours Ni-Al alloy sample prepared by using Novalac as space holding material with particle size (>500 µm) all samples resulted were good as shown in Figure 5,this could be due to using coarse powder which take its place by substitution with the particles of metal powders. At Sintering process, when Novalac be evaporated there was enough way to the vapor to go out of the compacting, and there wasn't any inside pressure generated in the compacting, as shown in Figure 1.

From figure 2, density decreases with Novalac percent increase ,this could be due to two reasons ,the first is the open porous .the second which could be the main reason, the waste of Novalac which remains in the close pours, this what insured by the porosity results, We can see there wasn't significant changing in porosity, yet the density in general was decreased.

From Figure 3, porosity wasn't enhanced with Novalac present increase; this could be due to two reasons, the first the agglomeration of Novalac particle on the out surface of the compacting. The second is the close pours which contain waste of Novalac which affects the density results at the same time it did not enhance the porosity.

Scanning Electron Microscope (SEM) and XRD:

The CeO2 Nanoparticles were examined with SEM in order to insure that we get CeO2 Nanoparticles and its average diameter was (78 nm), as shown in Figure 8. XRD test dune in order to insure that we get CeO_2 Nanoparticles, as shown in Figure 9 XRD patterns for sample of purified CeO_2 Nanoparticles in the 2ϴ range (20^0-60^0). Figure 4

According to the open pours, it is clear. For the agglomeration, Novalac particles had irregular shape which agglomerates on the out surface of compacting. After sintering process Novalac will evaporate leaving a rough and lumpy surface that means increases in surface area with increases in Novalac addition and the last factor could be the main factor.

Conclusions:

1- Particle size of space holder should be suitable to particle size of

metal powders to prevent samples cracks.

2- The closed pores have negative affecting on the activated porosity (surface area).

3- CeO_2 quantity increased led to increase hardness and wear resistance.

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Table (1): Show chemical composition of samples.

Alloy No.	Al%	Si%	CeO2 NANO%
Alloy 1	88	12	……..
Alloy 2	87.12	11.88	1
Alloy 3	86.24	11.76	2
Alloy 4	85.36	11.64	3

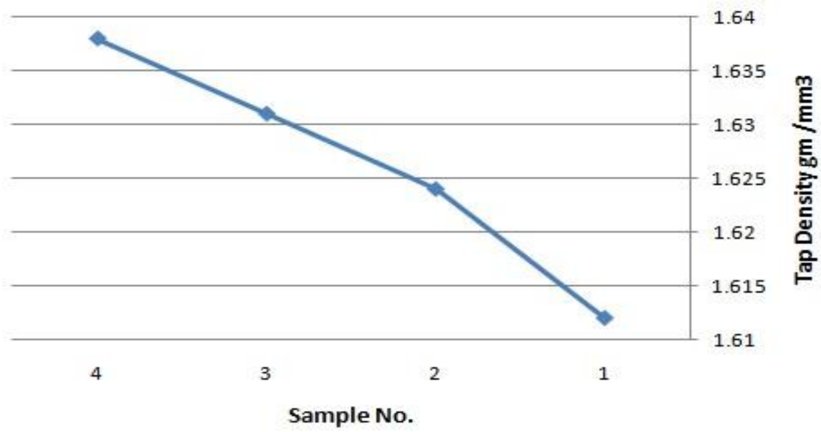

Fig (1): Show the Tap density with alloy no.

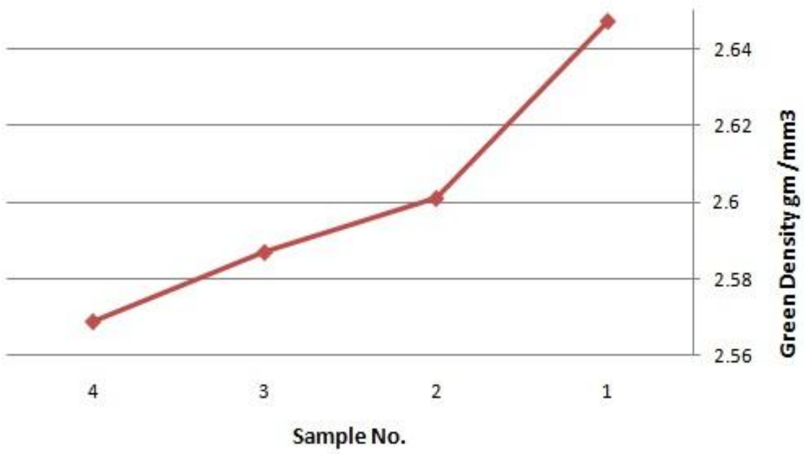

Fig (2): **Show the Green density with alloy no.**

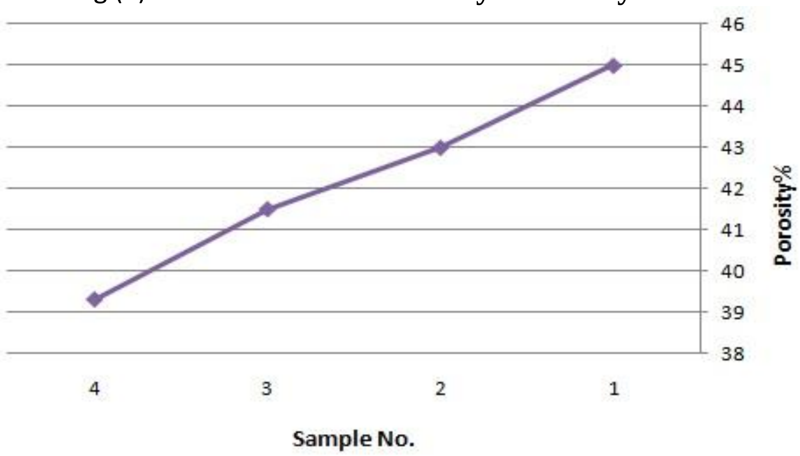

Fig (3): Show effect of additives on porosity percentage.

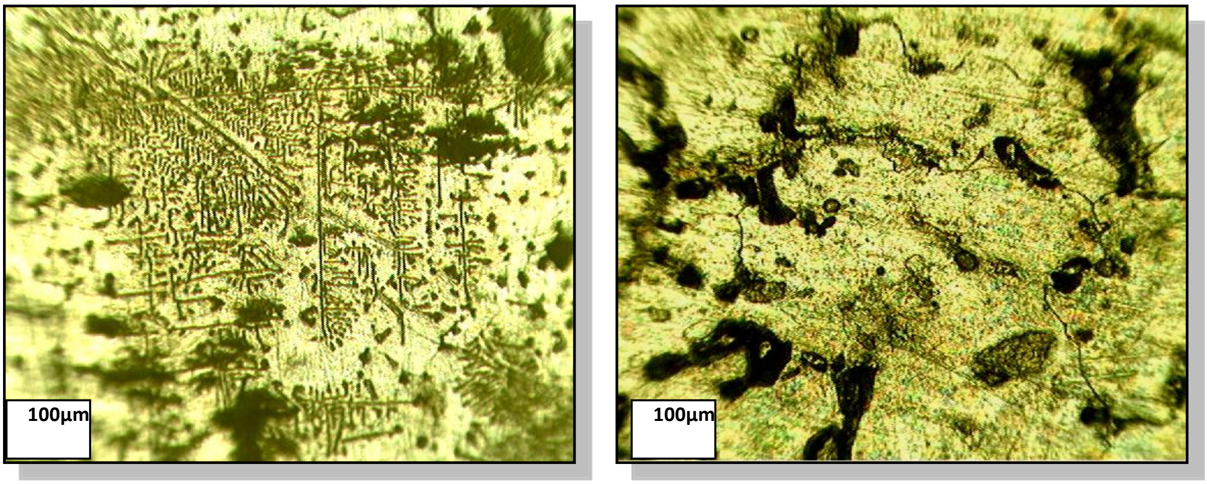

Fig (4): Show alloys microstructure.

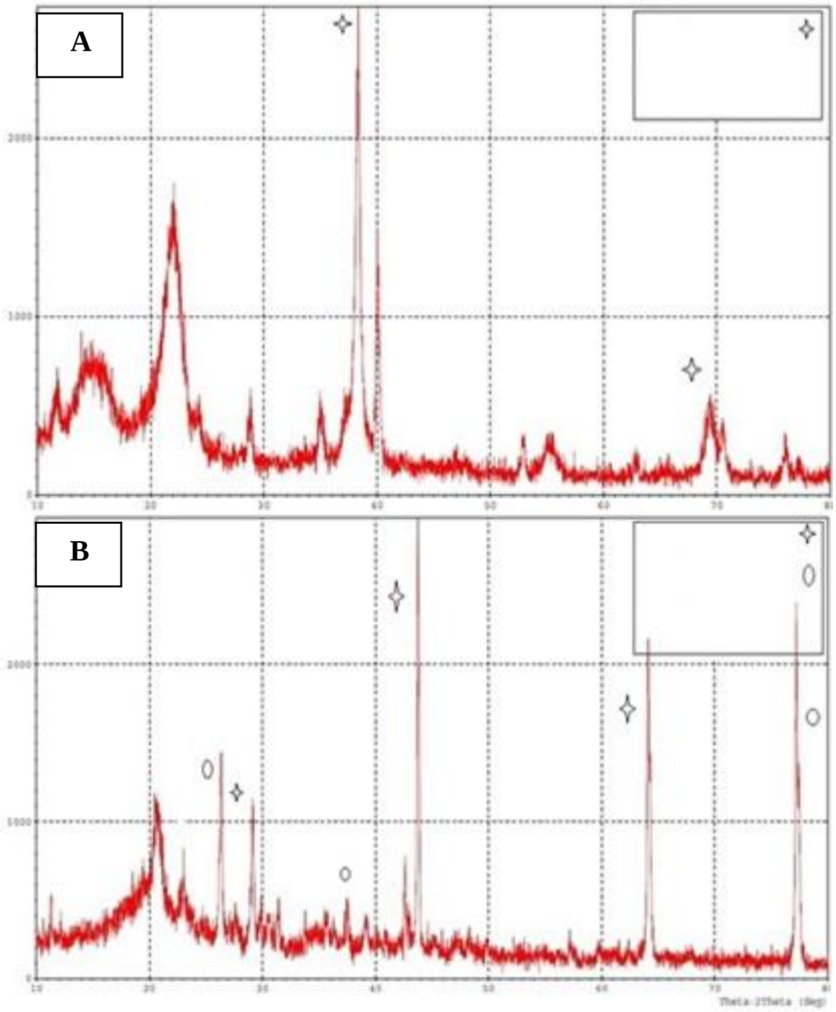

Fig (5): Show the X-ray diffraction (A): before additives, (B): after additives.

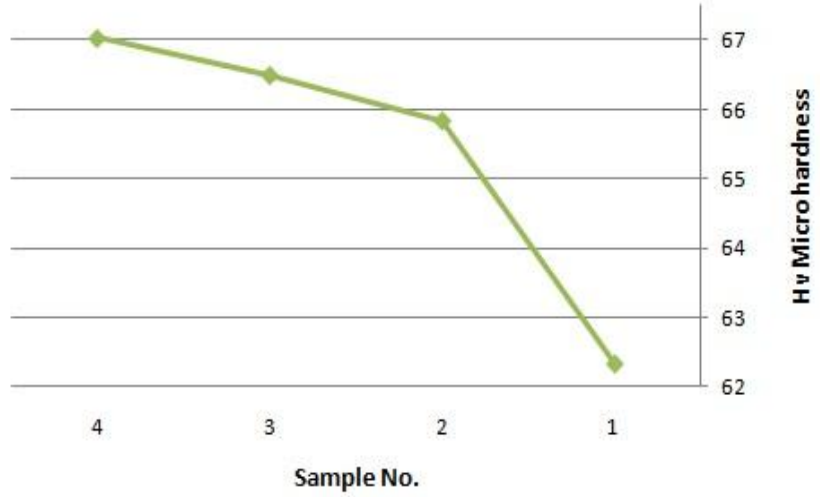

Fig (6): Show the microhardness with alloy no.

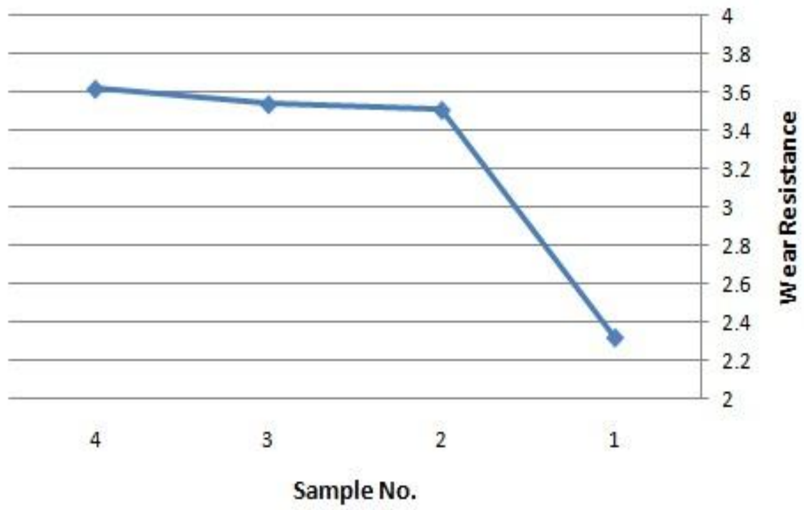

Fig (7): Show the Tap wear resistance with alloy no.

تأثير إضافة السيريا على البنية المجهرية لسبيكة نيكل-ألمنيوم

الخلاصة:

تم في هذا البحث تحضير سبيكة نيكل-ألمنيوم بطريقة تكنولوجيا المساحيق، حيث تم مزج وخلط المسحوقين وإضافة مسحوق السيريا الى المزيج بنسب مختلفة وبعدها تم كبس المخلوط وإجراء عملية التلبيد. تم أخذ المكبوسات لأجراء فحوصات الكثافة ونسبة المسامية والفحص المجهري وصلادة فيكرز وفحص الأشعة السينية، ولوحظ ان قيم صلادة فيكرز تزداد بزيادة نسبة الأضافة.