Characterization Of Cerment Composite Coating Al2O3-Ni System

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Abstract. This paper report on the possibility used new technique method by thermal spray coating to produce ceramic-metal coating of nano Al2O3-30% Wt. Ni samples. In this process nano crystalline cermet powders with grain size below 50nm were obtained by mechanical alloying. The steel substrates were degreased and grit blasted with SiC particles to get a mean roughness of 5µm. Experimentally the coating used under the best spraying parameters were deposited on steel substrate with thickness around 1.85mm. This powder and thick coating layers have been characterized by using XRD, SEM, EdS and hardness techniques. The X-ray results show that cerment coating consists a lot of phases such as ɤ-Ni, α-Al2O3 and ɤ-Al2O3 phases. The results also found that the wear resistance is superior, under high load conditions. The improved wear is attributed to the higher values of hardness. Results also show that Nickel was attractive for achieving good self-bonding with ceramic Al2O3 particles for all cerment samples.

Keywords: Thermal spray coating, Al2O3, Ni, Engineering materials, Structural properties.

1. Introduction:
Cermet coating composite of Al2O3-Ni are an attractive combination of physical and mechanical properties, including high hardness, high melting temperature and good corrosion resistance[1]. Researchers as self-binding metals such as Ni, Al or Co have been considered during the last 30 years, not only as bulk materials, but also as layer coating [3]. The important useful of the nickel also on reaction which work as a self-bonding coating with the Ceramic materials such as WC , ZrO2, TiO2 and Al2O3 , in order to improve the adhesion force of the deposited coating layers [4,5]. Thermal spray by flame (TSF) is the most important method to deposit thick coating for several application such as high temperatures corrosion, wear properties and also for electrical and biomedical properties[6]. In this work, TSF of Al2O3 mixed with Ni powders was investigate by mixing powders in mechanical alloying of planetary mill getting Particles nano fine size of Al2O3 - 30% Wt.

2. Experimental Work:
The powder containing α- Al2O (4µm) , Ni (50µm) were made to nano- composites by using high energy attrition milling (mechanical alloying). Typical particle size distribution of Al2O3 - Ni 30-40 nano composite were Prepared. The substrate was 304 L stainless-steel (0.02C – 18.18 Cr -8.1Ni – 0.31 Si – 1.33 Mn- 0.53 Mo Rem. Fe Wt. %). The circular substrates were first clean and
degrees in acetone and grit blasted with SiC (220 mesh) to roughen the surface to $R \approx 38 \mu m$ before Spraying. The flame thermal sry (FTS) parameters are given in Table 1. Nano Composite ($Al_2O_3 - 30Ni$) with thick $1.59 \pm 0.04$ mm reached.

Table 1: process parameters used for (FTS) coating of $Al_2O_3 - 30 Ni$.

| parameters               | value            |
|--------------------------|------------------|
| Pure Fuels $O_x + C_xH_y$| 17 cm            |
| Spray distance           | 100              |
| Gun traverse (m/min)     | 150              |
| Powder fed rate (gm/min) | 0.85             |

Structures of the sprayed Coating and powder morphologies characterized using SEM microscope (Philips XL 30). Hardness and bond strength of the samples were investigated in order to evaluate mechanical behavior and to find Correlation between macroscopic properties (Hv) was measured at average of five measurements from the cross section of coating. Bond strength was determine in at ensile pull test as an average of three measurements. The coating samples was glued between two rods. Comperd results have been done as spraying coating and after heat treatment at (750, 950, 1050, 1250) $^oC$ at rate of 10 $^oC / min$. Finally, XRD diffraction was used filtered CuKα radiation($\lambda=1.542\AA$).

3. Results and Discussion:

The focus point of this search was to produce thick spray coating around 1.59 mm . dense with low porosity level. Fig(1) shows that a good interface between the nano cerment coating ($Al_2O_3 - Ni$) after mixing and before spraying, which so clean and void less. Fig( 2 ) shows the cerment coating after heat treatment at 950 $^oC$ (10 $^oC /min$) rate. The over coating after heat treated. The particles are high deformation between elements leads to get high adhesion coating layers the coating structures are visually also dense wit out pores the high velocity impact throw the substrate as shown in figure (3). At 1250 $^oC$ treatment show particles are highly flattened due to the change to high level of plastic deformation as Shown in figure(4). It shows also weak interfaces at the layer surface. High dislocation density indicates high plastic strain causes slip planes with probably some of pores not detectable. The fracture and deformation in this figure 4 shows also that the bonding between $Al_2 O_3 - Ni$ particles are not me interface goes to the brittle and ductile surface shape. The result of Vickers hardness Hv as sprayed coating and heat treated states shown in table 2 . The high hardness indicating a goes strength of surface and hardening. This high hardness coating by increasing the heat temperatures. Cleary detected maximum at 1100 $^oC$ due to the hardifying surface structure reinforcement between cerment coating.
Figure 1: Surface morphology (SEM micrograph) of Al$_2$O$_3$-Ni Spherical powders.

Figure 2: Interface between the nano cerment coating (Al$_2$O$_3$-Ni) and substrate (SEM) at 950 °C.
Figure 3: The effect of heat treatment 1100°C (3hr.) on the nano composite coating.

Figure 4: The effect of heat treatment 1250°C (3hr.) on the nano complete coating.
The bond strength result of nano composite Al$_2$O$_3$ – 30Ni coating cases, the bond strength occurred at the interface between coating layers and steel substrate until 1100 °C heat treated. These bond strengths range as shown in table 3 are reasonable, in dictating a good bonding between the coating layers and substrate. Above 1100 °C at rate of 10 °C/min the result show that high plastic deformation occurred with fracture and some cracks. The reduction value of bond strength are very clear at heat treated of 1250 °C indicating the weak self-bonding between the coating and substrate.

### Table 3: The bond strength nano composite Al$_2$O$_3$ – 30Ni after heat treated

| Heat Treatment °C | Bond strength MPa |
|-------------------|-------------------|
| 750               | 287               |
| 850               | 30.72             |
| 950               | 36.64             |
| 1100              | 40.11             |
| 1250              | 30.33             |

X-ray diffraction result were examined RT and after heat treatment for several temperatures at constant 3hr length of time and air cooled inside furnace to room temperature the results are shown in Fig.(5). The presence of (α-Al$_2$O$_3$) and (ɣ-Al$_2$O$_3$) phases are observed at all temperatures chosen. In addition so peaks corresponding to FCC structure of Ni phase. The result also shown that all phases are very clear at heat treated at 1100 °C for α and phases of Al$_2$O$_3$ and α-Ni with highest intensity compared with other temperature. No change the shape of the peaks or angle position (2θ) during the variable temperature of heat treatment this is due to stability of phases which are observed.
4. Concluding Remarks:

Flame thermal spraying (FTs) coating enables to production of over dense coating of nano cement coating structure around 1.55 mm thickness. In this work, the optimized Powder spraying parameters taken. Substrate high strength force of layers. Coating due to the self-bonding metal-ceramic was observed after heat treated and as spraying. The results show that best values at 1100 °C at constant 3 hr. length of time inside furnace then slow cooling. Also the hardness Hv show that after heat treated the heating at 1100°C show a good results, but above this degree high plastic deformation occurred with fracture and some cracks. SEM results show that a good surface layer gives full dense coating with low porosity coating with the optimal combination of ceramic-metallic. High plastic deformation with weak mechanical properties have been observed above 1100°C (3hr.) due to the fracture and some cracks. The nano composite deposits examined by XRD without and after heat treatment. The results shows presence of different phases such as $\alpha$-Al$_2$O$_3$, $\gamma$-Al$_2$O$_3$, and $\alpha$-Ni. No any change of angle position of 2θ during the variable temperatures.

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6. References:

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