Effect of Aluminum oxide nano coating on microstructural & mechanical properties of tempered Aluminum (7175) alloy

Vijayakumar M R , B.N. Sarada
Department of Mechanical Engineering
B. M. S. Collegeofengineering
PB 1908, Bull Temple Road, Bengaluru – 560 019

Abstract

In this present study AA7175-T7351 Aluminum alloy heat treated to T7351 condition is selected as raw material. This alloy finds application on aerospace industry, for managing passive thermal control on spacement. Generally these components are coated. For the present study Aluminum oxide nano coating is selected as coating material and coating is carried out by plasma spraying technique. XRD/ SEM tests are carried out for coating analysis and to measure coating thickness. The effect of coating thickness on mechanical properties is studied. Mechanical properties are studied using Nano indenter. The results are discussed.

.**Keywords:** SEM, XRD,Nano indenter

1. Introduction

Aluminum has a mixture of varied properties. It's one among the lightest metals of the world: it's nearly thrice lighter than iron however it's terribly sturdy, very flexible and corrosion resistant as a result of its surface is usually coated in a particularly terribly thin and however very sturdy layer of oxide film. It doesn't magnetize, it's a nice electricity conductor and forms alloys with most of all metals [1].Characteristics of 7 series of Aluminum alloy: Alloying element for this series is zinc. These have the highest strength among alloys in the series. These have varying tensile which is between 450-500 MPa & it may exceed 600 MPa. They may stress corrosion, when they are welded[2].Different coating methods include powder coating, anodizing, special surfaces and mechanical surface treatment[3].Nano technology manipulate the structure of matter into tiny variety of nanometers, understood by totally {different completely different} folks at different times as which means something from zero.1 nm (controlling the arrangement of individual atoms) to one nm or additional (anything smaller than micro technology [4]Nano technologies contain the design & the assembly of objects at a minute scale that range from one hundred nano meters or less. Nano materials are utilized in the assembly of tubes, rods or fibers. The nano materials find it's usefulness in health care, textiles, cosmetics, electronics, environmental protection & info technology. The smaller size of nano materials makes their Present technology for assessing nano particle is suits for individual & to monitor the area, can be used continuously or intermittently. The characterization can be done at basic levels.usage production difficult [5] Black inorganic anodized Aluminum alloys can be used on optical equipment to manage thermal control due to space influences these characteristics have been studied for 7175-T7351 Aluminum alloy. Theanodization process involves the conversion of the metal surface unlike external coating. The mechanical behavior of AA7175-T7351 is different from other Aluminum alloys as the coating was spongy throughout the volume[6]. Alumina coatings were deposited on polymer substrates to increase the wear resistance y a two-step method uniting plasma spraying & micro-arc reaction. At totally different times the micro minute constructions & stage composition of administered coats has been examined. α Al_2O_3 &γ Al_2O_3 phases were present in the coatings. By conducting the cross sectional EDS analysis it was found that the alumina can be obtained in the inner area of the coatings after 30 min of Micro arc oxidation (MAO) treatment.5.89 MPa is the maximum bond strength reached[7].Frequency Plasma Assisted Chemical Vapour Deposition (FEPACVD) is a hybrid method of (Ti/TiC/a C: H layered on Al-Z alloy 97075) sequences to research the gradient antiwear properties. The test results confirm that the opportunity of placing gradient coats of extraordinary bond to the exterior of Aluminium alloy substrate in one process in an exceedingly two-step aging action, that additionally adds to enhanced opposed wear things[8].Alumina was deposited on polymer substrate to increases the wear resistance by a two-step methodology uniting plasma spraying & small arc reaction. At completely different times the small constructions & phase configurations of the treated coats are inspected. The coatings were found to have porous microstructures consisting of α Al2O3 & γ Al2O3 phases. By conducting the cross sectional EDS analysis, it was found that the alumina can be obtained in the inner area of coatings after 30 min of Micro Arc Oxidation (MAO) treatment 5089 MPa is the maximum bond strength reached[9].Cutting edges of carbide inserts are nano coated which are used for rough re-profile of railway wheel sets. The coatings were formed using a filtered cathodic vacuum are (FCVAD).It has low impact on the surface structure of cemented carbide. The re-profiling machining of railway wheel buggies was successfully done using Ti-TiAlcrN coated carbide inserts as compared to commercially available one. The coated inserts increase the performance, depth of cut & no chipping during machining. The life time also increased for coated inserts.[10].

2. Experimental procedure

2.1. Sample preparation

For plasma spraying experiments, small samples with dimensions 20x20x20mm were cut from commercially available alliminum AA7175-T7351 alloy using abrassive water jet cutting machine.

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The substrates were grit-blasted using a grit blasting unit (Sandstorm equipment, Bangalore) and alumina grits (~45 µm grit size) were used. Grit blasted substrate were ultrasonically cleaned in water and acetone and dried. Grit blasting will improve the adhesion of plasma sprayed coatings on to the substrate.No other surface treatment was used.

2.2.Chemical composition of the raw material checked by XRD techinique was as follows

Table.2.1: Composition of 7175 Aluminum alloy

Composition	%
Aluminum	Balance
Chromium	0.18 - 0.28
Copper	1.2 – 2
Iron	0.2 max
Magnesium	2.1 - 2.9
Manganese	0.1 max
Remainder Each	0.05 max
Remainder Total	0.15 max
Silicon	0.15 max
Titanium	0.1 max
Zinc	5.1 - 6.1

2.2. Powder plasma spraying set-up

Alluminum oxide powders in nonoscale is used for coating. Argon is one of the main gases used in thermal plasma spraying, pure hydrogen gas is mainly used as secondary gas which acts as an anti-oxidant which are used to increase the heat conduction.In present work 80kW (Sulzer Metco 9M) plasma spray systemwas used for plasma spray process.

The parameters used forsolution precursor plasma spraying are listed in table 2.2

	Voltage (V)	**Current (A)**	**Spray Distance (mm)**	**Feed Rate (ml/min)**	**Number of passes**	**Ar gas (nlpm)**	**H2 gas (nlpm)**	**Carrier Gas flow (scfh)**
SS Plate (30kW)	60	500	80	30	1-2	40	7	15

The photographs plasma spray coated coupon are shown in figure.

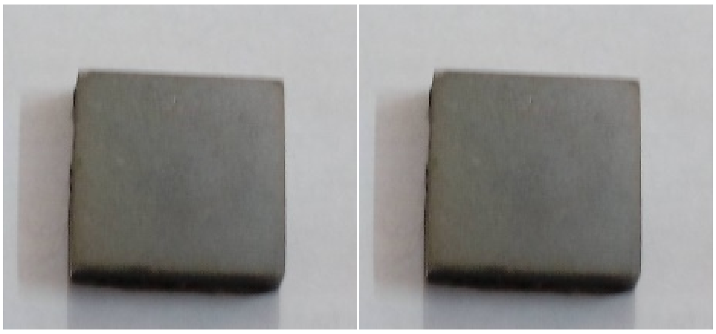

Fig.2.1. plasma coated sample

3. Results and discussion

3.1 **Hardness test using Brinell hardness test**

Brinell hardness test results

Table.3.1 BHN value decreases with coating thickness

Specimen identification	Dia of the indenter, D mm	Dia of the Indentation, d mm	BHN
Raw material	10	2	152
Single pass sample	10	2.1	143
Double pass sample	10	2.2	130

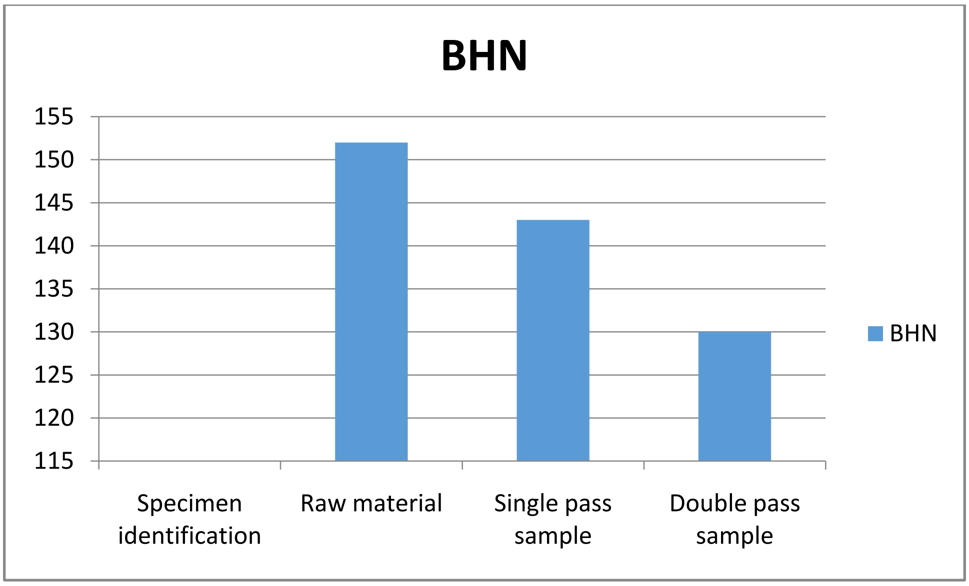

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Fig.3.1 Column chart BHN versus specimen type

We can see from the Fig. 3.1 that the BHN value decreases as coating thickness increases. So, the conclusion is coating doesn't add any hardness to the raw material.

3.2 Hardness test using Nano indenter

Nano indenter test results

Micro hardness of nano coated specimen

Table. 3.2 Hardness values for coated samples

Specimen identification	Hardness at max load (20 kgf) in GPa
One pass	5.471
Two pass	0.447

Micro hardness of coated material decrease with increasing coating thickness. In one pass coating material showing higher hardness than two pass coating material. This would be due to porosity of coated material & improper adhesion between passes.

3.3 SEM studies

Surface morphology studies are presented in the following fig.

One pass sample

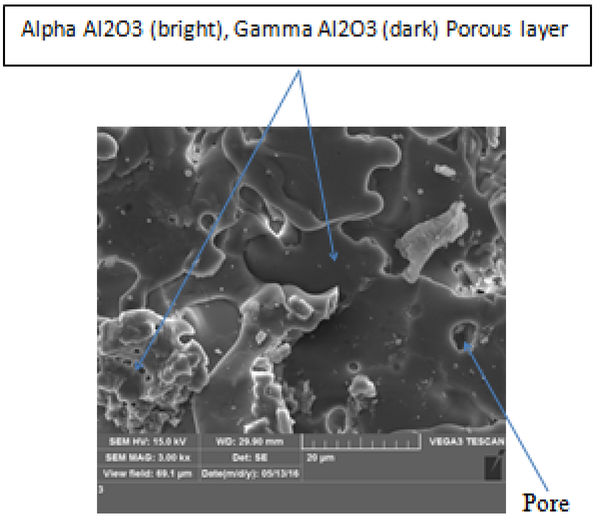

Fig..3.2 Microstructure for one pass sample

Two pass sample

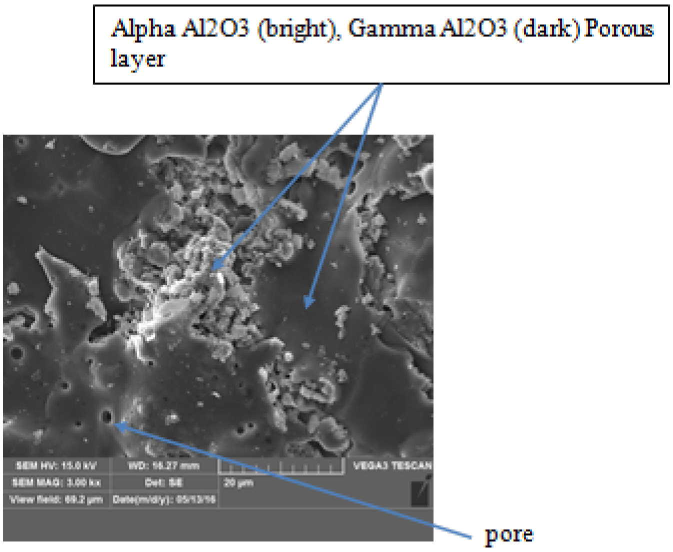

Fig.3.3 Microstructure for two pass sample

The microstructures & phase compositions of one pass & two pass coatings are found to have porous microstructures consisting of α Al_2O_3 & γ Al_2O_3 phases. It is also observed that two pass coated material consists of more α phase with more porosity. The reason could be difference in thermal conductivity of base material & coating material. One pass coating material directly in contact with base material & more alteration after α phase to γ phase is detected. Since thermal conductivity of coating is less phase alteration (from α to γ phase) is detected.

3.4 Coating thickness studies

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From the SEM picture it's clearly visible that the thickness of the one pass sample is 21µm

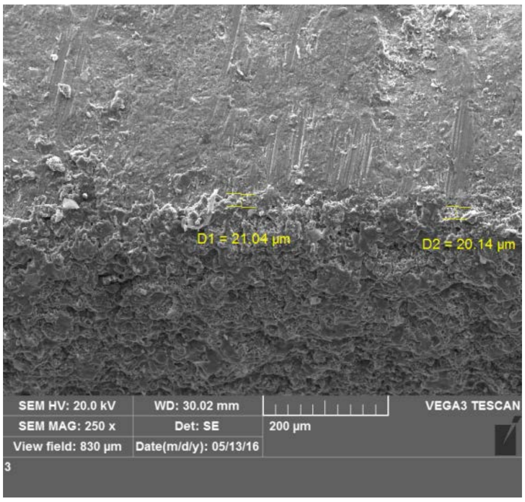

Fig.3.4 Coating thickness of one pass sample

From the SEM picture it's clearly visible that the thickness of the two pass sample is 45µm

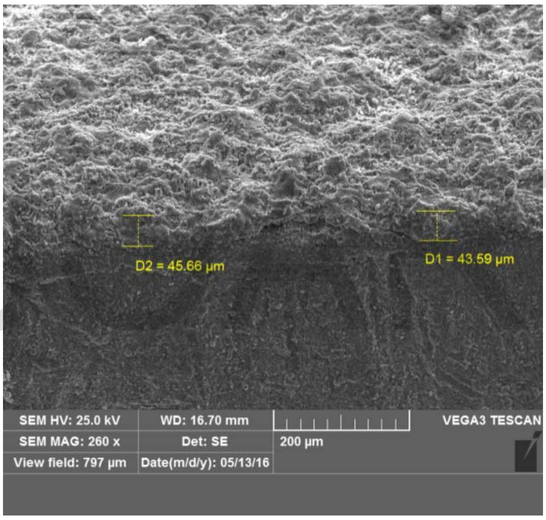

Fig.3.5 Coating thickness of two pass sample

3.5 XRD analysis

XRD analysis of the coated & uncoated area

Uncoated area:

The analysis of the main graphic view shows that the main constituents are Aluminum 88 to 91.4%,magnesium 2.1 to 2.9 %, Zinc 5.1 to 6.1%,copper 1.2 to 2.0%

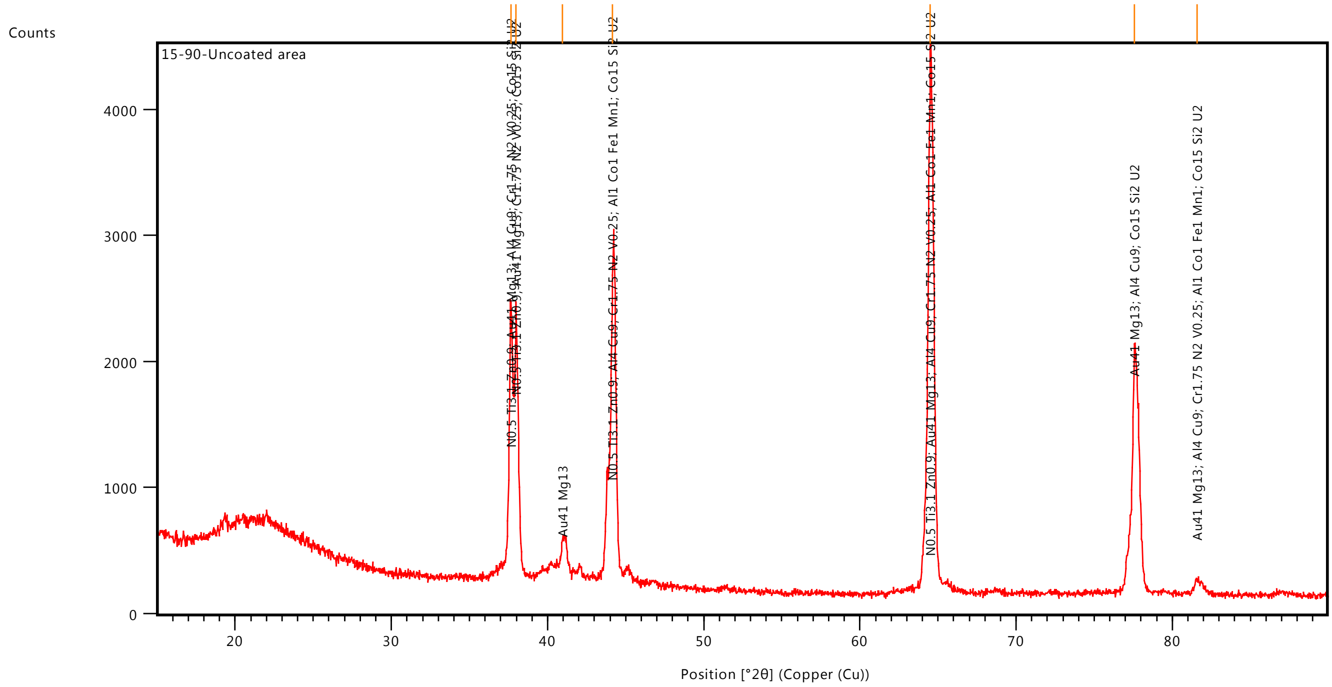

Fig.3.6 XRD analysis of uncoated area of the specimen

Analysis of the coated area

The sharp XRD peaks in the coatings suggest good crystalline quality of the coatings. In the analysis graph 16 peaks have been shown out of which 3 main peaks have taken into consideration which contains mainly the Aluminum oxide which is coating material.

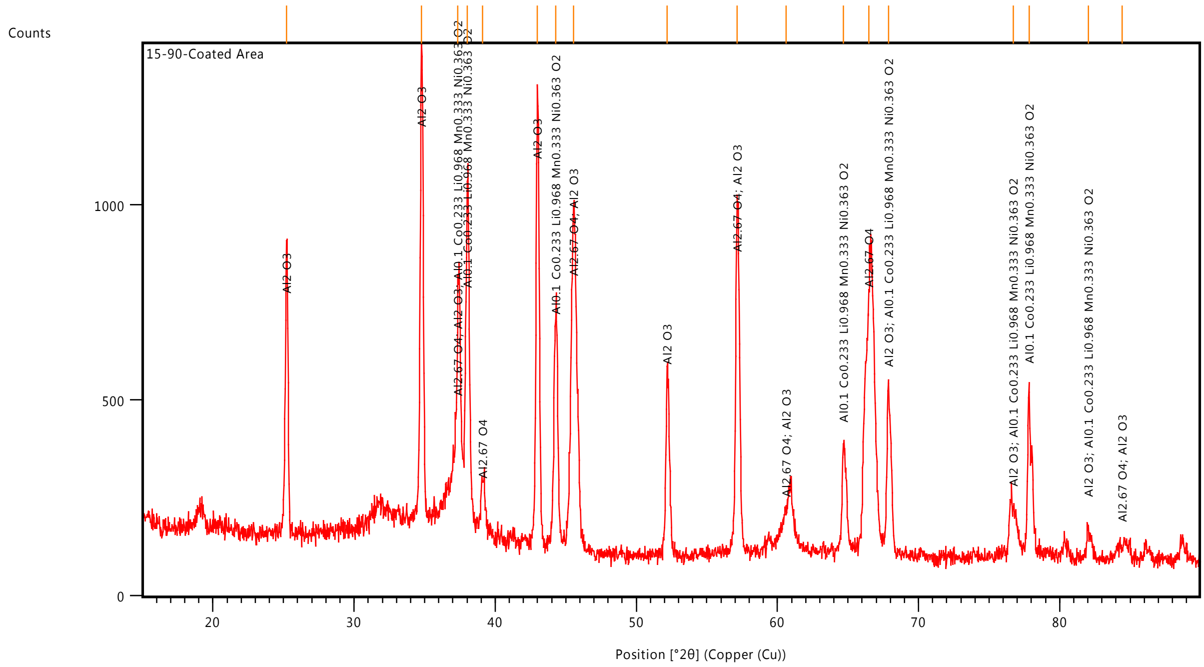

Fig.3.6 XRD analysis of coated area of the specimen

3.6. Nano indenter test results

Table.3.3 Comparison of test results of one pass & two pass samples

Specimen identification	Modulus at max load GPa	Drift correction nm/s	Displacement at max load nm	Load at max load mN
One pass	105.077	0.634	2819.514	193.406
Two pass	28.790	0.732	5545.607	193.406

The modulus at maximum load for one pass is more as compared to the two pass. The drift correction needed is less for single pass as compared to two pass as the indenter penetration is less. The displacement at maximum load is less for single pass in comparison with two pass as the hardness decreased with the increase in coating thickness. The decrease in young's modulus with increase in coating thickness could be brittle behavior of Al_2O_3.

4. Conclusions

Al_2O_3 nano coating was done successfully on Al7175 alloy under T7351 condition by Plasma spray coating Technique. The coating was carried out in one pass and two passes. The layers are analyzed using XRD technique and characterized using scanning electron microscopy (SEM). Mechanical properties and micro hardness were determined using Nano indenter. Coatingdecreased the hardness of base material. Micro hardness measurement of the coating shows one layer Al_2O_3 coating has high micro hardness value as compared to two layers. One layer coating also increased Young's modulus of the base material. The surface morphology of the coated layers shows the deposition of fine grained structures. The microstructures & phase compositions of one pass & two pass coatings are found to have porous microstructures consisting of α Al_2O_3& γ Al_2O_3 phases. It is also observed that two pass coated material consists of more α phase with more porosity.

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