Experimental investigation on enhancement of mechanical properties by coating ceramic material on Al7075Alloy

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Abstract: -

The practice of coatings on conventional metals and their alloys is now widespread universally in manufacturing industry for lowering production cost and enhancing productivity, all of which are very crucial if industry is to endure economical competition. The materials may get failed because of their poor mechanical properties like strength and hardness. These essential properties of the materials to sustain for longer servicing life can be improved by applying a suitable coating over the material. The durability of the material depends on the proper choice of coating materials, propositioning and curing. The Ceramic coatings can transform an ordinary metal into a high-performance surface. The fabrication of a ceramic coating on the metallic substrate is usually applied to achieve the improved performance of the material. Plasma electrolytic oxidation (PEO) is one of the most promising methods to reach this performance, mostly wear and corrosion resistance. Traditional PEO is carried out in an aqueous electrolyte. However, the current research work concentrated on the characterization of Al7075 coated by Zirconium Oxide using Spraying method to avoid disadvantages of system heating-up and the formation of undesired elements in the coating. The effect of Zirconium coating on the mechanical characterisation of Aluminium alloy Al7075is presented in the paper. From this Experimental investigation, an enhancement in Tensile strength, Impact strength and hardness of aluminium alloy Al7075 is observed by applying zirconium coating.

Keywords: *- Coating; Spray Coating Process; Tensile Strength; Impact Strength; Hardness;*

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I. Introduction

The exceptional range of properties owned by aluminum and its alloys made aluminum one of the multipurpose, cost-effective, and attractive metallic materials for a broad range of uses—from soft, highly ductile wrapping foil to the most challenging engineering applications.Properties of aluminium (Al) and its alloys can be improved to a great extent by incorporating micro/ nano sized carbonaceous materials while keeping its light weight properties intact. Various carbonaceous filler materials explored by researchers for the fabrication of Al-based composites include graphite, graphene, graphene nano sheets/platelets (GNPs) and carbon nanotubes (CNTs)[1–5].Current industry commonly put on the fabrication of different ceramic coatings on metallic substrates to attain essential properties.Plasma spray coating is a different type of thermal spraying methodology which is extensively used for making dense and smooth coating [6–9].Through previous few years thermally sprayed copper and copper alloy coatings have been examined by numerous investigators for variety of applications such as boiling heat transfer [10-12], antimicrobial constituents [13,14] and so on. Recently Xiao et al. [15] equipped Cu–15- Ni–8Sn coatings on 304 stainless steel plates by means of atmospheric plasma spraying process and analysed microstructure, tribological and mechanical properties of the coatings. They have found that for dry sliding condition, delamination along with spalling is principal wear mechanism for coatings.Commonly, metals and metallic alloys are realized for wear and corrosion resistance. Nowadays, aluminum is the utmost promising metal since it is a keysubstance to substitute iron-based materials in various industrial applications. Al7075 alloy, one of several aluminium alloys, is a high strength alloy with mechanical characteristics closely similar to many varieties of steel. Al7075 is appropriate as aircraft fixtures, shafts, and gears, valve apparatuses, and someadditional structural parts. Though, this alloy has lesser corrosion resistance compared to other categories of Aluminium alloys. This problem may be addressed by the deployment of a coating on the Al substrate.

Moreover,coatings are intended to shield structural materials from deprivationdue to surface attack such as corrosion, erosion and wear or to reduce the temperature of materials. Therefore, the optimization of their proportions and construction is principallyfocusedin the direction of these exact tasks. Other significant properties of anelement, i.e., bulk properties for instance mechanical strength or integrity, are customarilyassumed by the applicable bulk property of the structural material. This property yet again is a consequence of optimization of composition and structure. Accordingly, the chemical composition and microstructure of coatings and structural materials might differ from one another, as well as key mechanical and/or physical characteristics including Young's modulus, yield strength, creep, and fatigue. Theincongruity of properties may result in coating-substrate reactions which may impact the behaviour of a coated constituent and its life span.Hence, mechanical properties of coated structures, as well as their prime catastrophic mechanisms, will be administrated by the appropriate considerate property of the substrate or the coating or both, based on the geometric state and loading conditions.

II. Materials

Aluminium, the second greatest abundant metallic component on the planet earth, turn out to be economic competitive in engineering applications as recently as the end of 19th century.Factually, all main technologically advanced nations established their own standard designations for aluminum and aluminum alloys, based on chemical symbols. These are all now being categorized under the systems of the American National Standards Institute, the International Organization for Standardization and the European Committee for Standardization.

A four-digit numerical designation code is used to recognize wrought aluminium and aluminium alloys. The designations Systems are presented in the Table 1.

Table 1: Designation of Aluminium and Aluminium Alloys

Alloying Element	Designation
Aluminum	1xxx
Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Magnesium & Silicon	6xxx
Zinc	7xxx
Other elements	8xxx

From the table of designations, Zinc is the prime alloying component in the series starting with the number 7. The subsequent alloy is heat-treatable and very strong. Significant alloys are 7050 and 7075, both used in the manufacturing of aircraft structural components.

In this present experimental study, the Al7075 alloy is coated with Zirconium oxide (ZrO2). Zirconium oxide is the most sophisticated technological ceramic with the highest fracture toughness is. It is ideal for medical and specific wear applications due to its toughness, mechanical characteristics, and resistance to corrosion. It is the perfect plunger for use in a steel bore since its thermal expansion coefficient is extremely similar to that of steel. Its characteristics are the result of an extremely exact phase composition. The material may become unstable due to certain environmental factors, losing its mechanical qualities. Its considerable weight and relatively moderate hardness also restrict its widespread use in wear applications.

The mechanical behaviour of Al7075 alloy coated with zirconium oxide is studied under tensile, impact loads and the hardness is also observed experimentally.

III. Experimental Setup

To evaluate the enhancement in the properties of coated al7075 alloy the following mechanical tests were conducted on both coated and uncoated specimens.

Tensile Test

Tensile strength is a quantity of the force required to pull something to the point before it breaks. Tensile test was done using Universal Testing Machine (UTM). The Specimen used is prepared as per the ASTM E8 standard. The specimens made of aluminium Al7075 and zirconium coated aluminium Al7075 both were tested on UTM. The dimensions of the specimen are shown in figure 1.

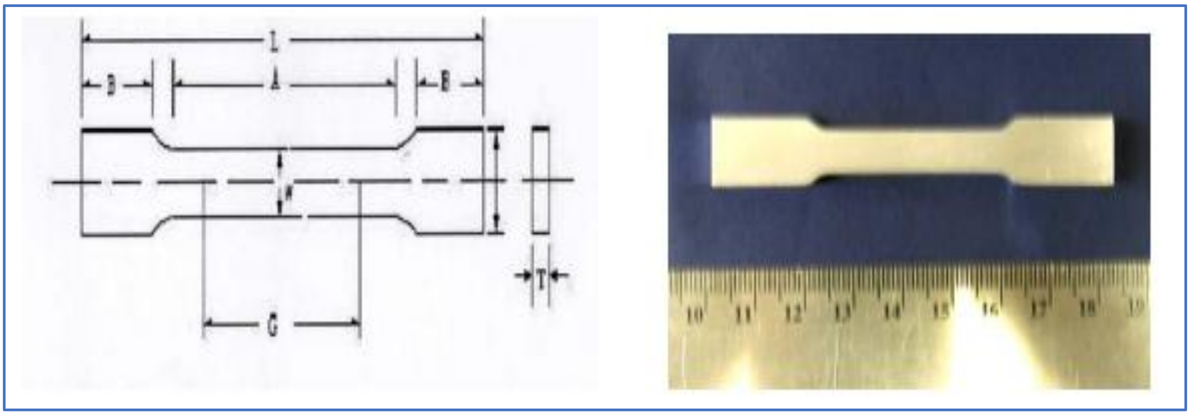

Figure 1: The dimensions of the specimen used for tensile test on UTM.

Impact Test

Impact test, Test of the ability of a material to endure impact, used by engineers to forecast its behaviour under actual conditions. Several materials fail abruptly under impact, at flaws, cracks, or notches. Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition. The impact test is being conducted on the Impact testing machine to on both coated and uncoated specimens.

Hardness Test

Hardness is the ability of the material to resist penetration by another material. The hardness of the zirconium oxide coated and uncoated specimens are experimentally found by using Rockwell hardness tester.

IV. Results

The experimental results on the mechanical behaviour of Aluminium alloy 7075 and Aluminium alloy coated with zirconium oxide are presented here in the table 2 to table 4.

Table 2. Comparison of Tensile strength values of coated and uncoated Al7075

Specimen	Tensile Strength
Al7075	501Mpa
Al7075 coated with Zirconium Oxide	527 Mpa

Table 3. Comparison of Rockwell hardness Number of coated and uncoated Al7075

Specimen	Rockwell Hardness Number
Al7075	57
Al7075 coated with Zirconium Oxide	82

Table 4. Comparison of Rockwell hardness Number of coated and uncoated Al7075

Specimen	Fracture Toughness
Al7075	30
Al7075 coated with Zirconium Oxide	36

V. Conclusions

- The effect of coating zirconium oxide on mechanical properties of Al7075 is practically studied by conducting tensile test, hardness test and impact test.
- The Zirconium oxide coating was applied on the Al7075 by means of thermal spraying process.
- An appreciable enhancement in the tensile strength of the Al7075 is observed by coating Zirconium Oxide.
- It is also been observed that the hardness of the Aluminum Alloy 7075 is improved by adding a ceramic coating.
- Similarly, the Impact strength is also been increased appreciably by ceramic coating on Al7075.

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