

# Wear behaviour of Polyurethane Coated Aluminium Alloy (7075) with the influence of Multi-walled Carbon Nanotubes

Aravind B<sup>1</sup>, Jacob Preetham R<sup>2</sup>, Mohamed Yazzir J<sup>3</sup>

U.G. Students, Department of Mechanical Engineering, Christ College of Engg and Tech., Puducherry, India<sup>1,2</sup>

Associate Professor, Department of Mechanical Engineering, Christ College of Engg and Tech., Puducherry, India<sup>3</sup>

**ABSTRACT:** This paper predicts the life of a aircraft machine covering utilizing high quality precipitation solidifying 7000 series aluminium alloy, for example, AA7075 which is utilized for the most part in aeronautic trade. The aim of defensive covering is to spare the Aluminum alloy 7075 metal surface from weatherability and, in the meantime, to get the required level of cosmetic finish for the object. This covering material is normally involved of a Primer layer and a Topcoat layer. One was "Epoxy polyamide-Multiwalled Carbon Nano Tubes" as Primer layer and other was the "Polyurethane-Multiwalled Carbon Nano Tubes" as Topcoat layer of covering through traditional spray coat on aluminum alloy 7075 substrates. The reason for mixing MWCNT's with the covering layer is that, it increment the mechanical property, which tends to increment in the wear resistance property. Epoxy polyamide is useful binders for aircraft coating. Best coats have additionally been readied, yet polyurethane is still the decision for airship coating. The capacity of the polyurethane covering is to prevent corrosion and weatherability relies on upon its anti-corrosive pigments and its adhesion to the substrate. All these factors are widely variable with the geographic area and season, for example, temperature, wind, oxygen and environmental poisons. The impact of auxiliary and process variable on wear resistance of the covered examples are examined to decide the most extreme wear rate.

**KEYWORDS:** Polymer nanocomposite, Polyurethane, AA7075, CNT, Wear, Coating Layers.

## I. INTRODUCTION

Polymer and covering solidness contemplates have been progressing research for around 120 years. Polyurethane coatings give erosion insurance to a wide range of structures, for example, stockpiling tanks, oil and gas funnelling, water and wastewater pipelines, scaffolds, ships, and other marine offices. The items have been viable as a result of their exceptional future and execution, imperviousness to forcefully destructive situations, high scraped area resistance, and low temperature curing ability, solid attachment, high film manufacture, quick application, and consistence with the most thorough directions on unpredictable natural compound (VOC) discharges. Nonetheless, the choice, application, and assessment of a polyurethane covering can be a troublesome assignment in view of different qualities, including covering science, covering properties, surface readiness prerequisites, application parameters, and imperviousness to ecological assault, financial matters, and labourer security. Substantial painted aluminum parts experience significant dimensional changes because of warming and cooling. The covering must be adequately flexible to withstand these dimensional changes without breaking or losing bond. In air ship coatings, the preliminary gives assurance against erosion by the vehicle of attractive particles and atoms to the substrate. The top-coat limits or hinders the vehicle of undesirable particles, for example, chloride, and gives toughness and shading. In this article, the significance of the portrayal of PU covering on AA7075 at particular microns level is managed to concentrate their most extreme wear resistance of the covering layers by differing the MWCNT from 0 to 4 rates.

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Routine air-worked splash firearms work at high weight (ordinarily 50 - 70 psi) which atomizes coatings to offer outstandingly fine completes favoured by experts and genuine do-it-without anyone's help for top notch paint employments on autos, armada vehicles and other metal surfaces, paint application by method for the shower is in no way, shape or form another procedure. To comprehend the craft of showering and to wind up distinctly a productive administrator, it is basic that the standards included ought to be gotten a handle on. The achievement of the procedure relies on the surge of paint or other sort of gets done with being appropriately atomized, or, as it were, separated into a fine fog. This state must be acquired by two conditions working in congruity with each other-the stream of air from the gun and the consistency of the material which is being connected. On the off chance that the compel of the air is inadequate to separate the paint into fine particles, then, rather than an even film of paint being kept upon the surface, blobs will be spurted out, and this will happen likewise if the paint is excessively strong or stodgy.

Aluminum is covered by polymers since extensive painted aluminum parts experience impressive dimensional changes because of warming and cooling. The covering must be adequately flexible to withstand these dimensional changes without breaking or losing bond. In flying machine coatings, the groundwork gives insurance against erosion by the vehicle of attractive particles and atoms to the substrate. The top-coat limits or blocks the vehicle of undesirable particles, for example, chloride, and gives strength and shading.

## II. LITERATURE SURVEY

[3] The exploration anticipate the life of an air ship covering utilizing high quality precipitation solidifying 7000 arrangement aluminum combinations, for example, 7075 which is utilized widely in airplane business. The expectation of defensive covering is to spare the aviation aluminum amalgam 7075 metal surface from weatherability and, in the meantime, to acquire the required level of corrective complete for the protest. The groundwork utilized for this covering is Epoxy Polyamide and the top coat is Polyurethane. Wear tests were performed on polyurethane PU sliding against a gentle steel bar utilizing an under various burdens, speeds and separation. The surface morphologies found that the surface of polyurethane is clearly secured over the segment, worn surfaces and garbage arrangement demonstrated that the wear systems are because of rough wear by the development of longitudinal scratches and glue wear.

[5] The Multiwalled Carbon Nanotubes and the polyurethane composites were set up by method for in-situ polymerization and arrangement throwing approach. By filtering electron magnifying instrument, a homogeneous scattering of MWCTs all through the polyurethane network broke surface. The resultant conclusion from this is a solid interfacial attachment is seen between the MWCTs and the PU grid, and it is demonstrated by method for the softened however firmly inserted MWCTs up the network which is positive for the anxiety exchange from the polymer framework to the Nanotubes. The mechanical tests, for example, ductile test and element mechanical investigation were occurred. It is clear from these tests that the Young's modulus and elasticity of the composites are enhanced to 90% with consolidating just 1% of MWCTs when contrasted and the unadulterated Polyurethane.

[7] In The multiwall carbon Nanotubes/polyurethane nanocomposite is readied. The warm properties demonstrate that including carbon Nanotubes would enhance the warm debasement properties by 26oC (from 315 to 341oC) when carbon Nanotubes substance was 2.5 phr in covalent holding framework. After the surface adjustment, carbon Nanotubes can be scattered viably, and enhance the interfacial quality amongst it and waterborne polyurethane network. The Mechanical property tests demonstrated that including multiwall carbon Nanotubes would enhance the elastic properties essentially (an expansion of 370% in tractable anxiety and 170.6% in ductile modulus).

[10] In this exploration paper the dry sliding grating and wear conduct of epoxy half and half composites fortified with glass strands and a fluctuating measure of potassium titanate stubbles (PTWs) manufactured by a vacuum hand layup technique were examined. Encourage the impact of ordinary load, sliding speed, and hair content on both grating coefficient and particular wear rate was researched on a stick on-plate machine. The rubbing coefficient and wear resistance of the mixture composites were observed to be enhanced with the bristle content and were additionally incredibly impacted by ordinary load and sliding speed. Relationship between's dry sliding wear practices of composites with wear parameters was gotten by different relapses. The well used out surface of chose tests was seen under checking electron magnifying lens (SEM) to distinguish wear instruments.

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## III. PREPARATION METHOD

The coating system used in this study was epoxy polyamide and with a high gloss Polyurethane topcoat and both the materials were purchased from *Macromol Products*, Chennai. The blending material for the coatings was Multi-Walled Carbon Nano Tubes (OD: 30-50 nm, Length: 10-30 nm), which was purchased from *H.Chandanmal & Co*, Chennai. The coating substrate was AA7075-T6, which was purchased from *Perfect Metal Alloy Company*, Bangalore. The 7075aluminium alloy was machined as per the requirement of coating process in the shape of cylindrical pin (8mm dia×30mm length) for wear test. The entire Aluminium surface was cleaned with Acetone for degreasing surface from moist, oil, and grease.



Fig. 1 Sample preparation requirements (a) Multi-Walled Carbon Nanotubes OD 30-50 nm (b) Epoxy Polyamide-Primer (c) Polyurethane-Top Coat (d) Aluminium alloy compatible to coat and test wear (e) Various coated samples of differed compositions

The key components required for the overall preparation process are Multiwalled Carbon Nanotubes (a), which is used to blend with Epoxy polyamide (b) and Polyurethane (c) for coating, (d) The Machined Aluminium alloy 7075 rod compatible for coating by hanging method and testing wear by Pin-on-Disc method. The final figure (e) is the collection of different composition of coated samples which is ready to move for testing.

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The MWCNT's were blended with Epoxy polyamide and Polyurethane separately for different proportions (1%, 2%, 3% and 4%) with the help of Mechanical stirrer for 30 minutes at an atmospheric pressure and room temperature. The primer was Epoxy polyamide – CNT nanocomposite which was first coated as a base layer on the AA7075 substrate with the help of Conventional spray gun at the pressure not exceeding 35bar. Then the primary layer was dried for 8 hours with the atmospheric conditions. The top coat was Polyurethane – CNT nanocomposite which was coated on the finished surface of the primary layer (Epoxy polyamide). The coated samples are dried under same conditions for 10 hours. This process is repeated for all the samples and then they are moved for testing.

**Table 1** Composition of the samples

Sample No.	Primer	Top coat
S1	EP only	PU only
S2	EP+1%MWCNT	PU only
S3	EP+2%MWCNT	PU only
S4	EP+3%MWCNT	PU only
S5	EP+4%MWCNT	PU only
S6	EP only	PU+1%MWCNT
S7	EP only	PU+2%MWCNT
S8	EP only	PU+3%MWCNT
S9	EP only	PU+4%MWCNT
S10	EP+1%MWCNT	PU+1%MWCNT
S11	EP+2%MWCNT	PU+2%MWCNT
S12	EP+3%MWCNT	PU+3%MWCNT
S13	EP+4%MWCNT	PU+4%MWCNT

The table shows the various compositions of coated samples on the AA7075 substrate namely 13 samples by varying the percentage of MWCNT in Primer and Top coat from 1% to 4% respectively. Epoxy polyamide nanocomposite primer film thickness was approximately in a range of 30-55  $\mu\text{m}$ , while the top-coat of the polyurethane nanocomposite was in the range of 35-60  $\mu\text{m}$ .

## IV. EXPERIMENTAL TESTING & CHARACTERISATION

### Wear Test Pin-On-Disk Wear Testing

This test method has been widely used as a laboratory procedure for determining the wear of materials during sliding with a help of pin-on-disk apparatus. For the pin-on-disk wear test conducted in this research, the specimens are in pin shape with a circular tip, which is fixed perpendicular to a flat rounded disk. The sliding path is a circle on the sample surface. Here the pin is the coated sample pressed against the disk with applying load (N), sliding velocity (m/s), and sliding distance (m). The Wear rate and Coefficient Of Friction can be calculated by the following equations.

$$\text{Wear Rate} = \Delta w / 2\pi r N t \text{ gm/cm}$$

Where,

$\Delta w$ , mass loss of the sample in gm; r, track radius in mm; N, sliding speed in rpm; t, sliding time in min

### Micro Hardness: Vickers hardness test

The Vickers hardness test technique comprises of indenting the test material with a precious stone indenter, as a pyramid with a square base and an edge of 136 degrees between inverse confronts subjected to a test constrain of in the vicinity of 1gf and 100kgf. The full load is regularly connected for 10 to 15 seconds.

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The Vickers test can be utilized for all metals and has one of the vastest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness (DPH). The hardness number can be changed over into units of Pascals, however ought not be mistaken for weight, which likewise has units of Pascals. The hardness number is dictated by the heap over the surface zone of the space and not the zone ordinary to the compel, and is thusly not weight. The HV number is then controlled by the proportion  $F/A$ , where F is the constrain connected to the jewel in kilograms-compel and An is the surface zone of the subsequent space in square millimetres. i.e.

$$Hv = \frac{F}{A} \sim 1.8544 * \frac{F}{d^2}$$

Where,

F is in kgf; d is in millimetres

**Surface roughness:** Average roughnesses of the coated samples were identified using Mitutoyo SU-210 surface analysing device. Here the top coat nanocomposite determines the roughness of the overall sample. **Wear morphology:** Optical microscope was used to study the worn out surfaces of some selected samples between 200x and 400x using. Worn structure of the polymer-nano coats were studied to reveal the effect of maximum sliding conditions on dry sliding wear of composites. Optical Microscope can produce high-resolution image of a surface, revealing details about less than 100µm in size.

## V. RESULTS AND DISCUSSION

### Wear rate – Pin on disk wear testing

For all the experiments, each sample was weighed before and after the test using digital weighing. Here the applied load 5N, sliding velocity 1m/s, and sliding distance 1000mm. Mass loss was then recorded at the end of each test, then converted to wear rate using the formula detailed before. Brief studies are made for the best three samples, which were compared to the pure coating samples. The best samples are in which the weight loss is minimum, which was the coated samples with maximum wear resistance.

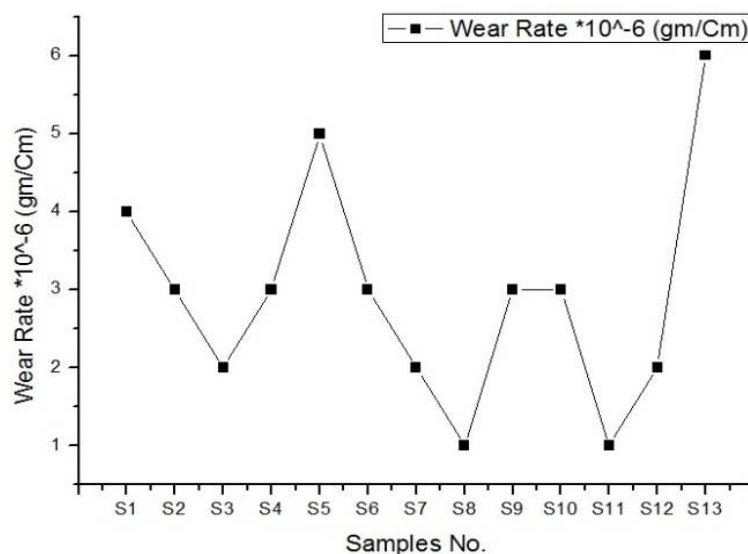


Fig.2 Represents the Wear rate of the Samples

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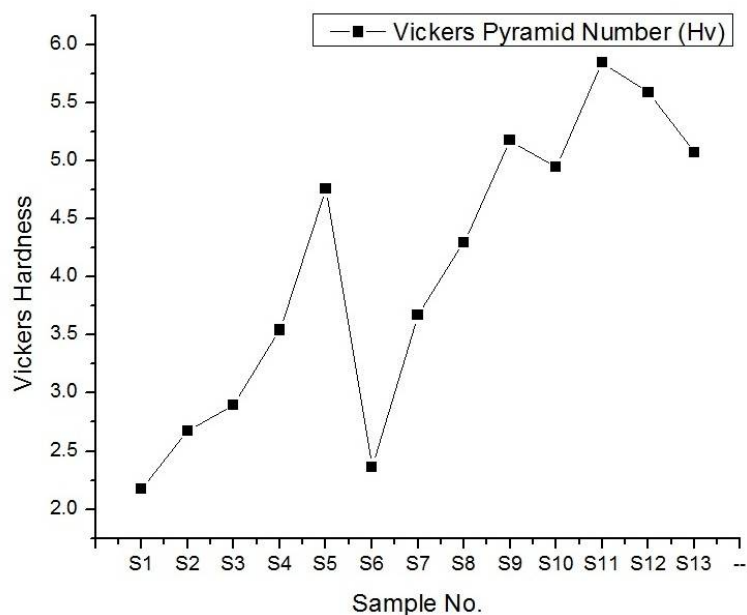
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The above graph illustrate the mass loss for each samples, using the formula for calculating wear rate, the wear rate for each samples were calculated in terms of gm/cm. And further using the curves the best samples were selected and found to sample S8 and Sample S11.

### Micro-hardness by Vickers Hardness test

The Micro-hardness of the samples is done by the Vickers Hardness test, and the hardness values are obtained for each sample. The hardness values vary depending upon the thickness of the coating done over the surface of the substrate. The lowest hardness unit obtained is by the Sample 1 which is of EP only and PU only. The highest hardness unit obtained is by the Sample 11 which is of EP + 2% CNT and PU + 2% CNT. A graph is generated and displayed below by means of the values obtained by the Vickers Test to determine the micro-hardness for the samples. The graph depicts the Vickers Pyramid Number (Hv) with respect to the respective sample.

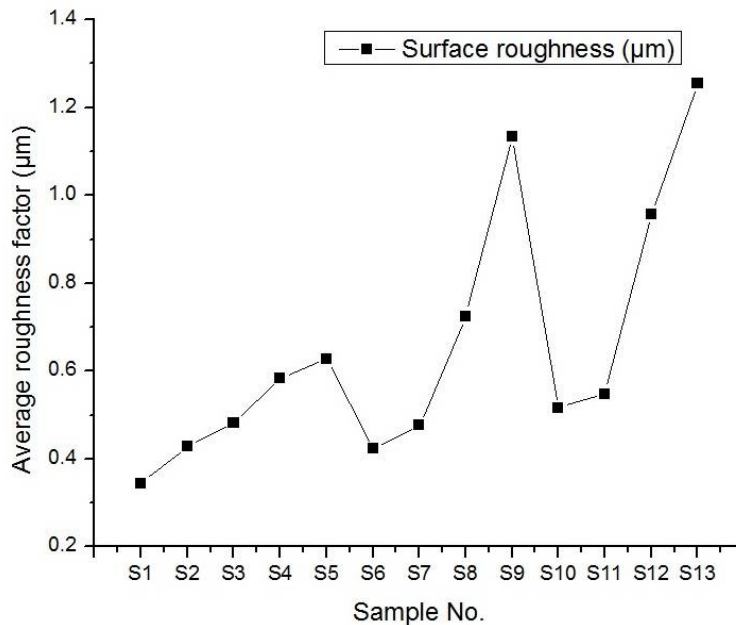


**Fig.3** Vickers Hardness with respect to the samples

The graph depicts how the Vickers hardness number (Hv) varied with respect to the thirteen samples. In Fig.3 S5, S9, S10, S11, S12 and S13 noted as high hardness. After this the samples are moved for the examination of Surface roughness and wear morphology.

### Surface roughness:

The surface roughness of the sample was identified by the Mitutoyo SU-210 surface analysing device. Obviously the sample 13 will have the highest surface roughness because it has the higher composition of the polymers coated over it. With a total quantity of EP + 4% CNT & PU + 4% CNT coated over the substrate. The graph is generated for the average roughness factor to the number of samples coated. The surface roughness of the sample determines the strength of the coat and up to which the coat can withstand the wear. When compared with the roughness factor of S1 and S13, it is clearly evident that the coating possesses a higher range of variability.

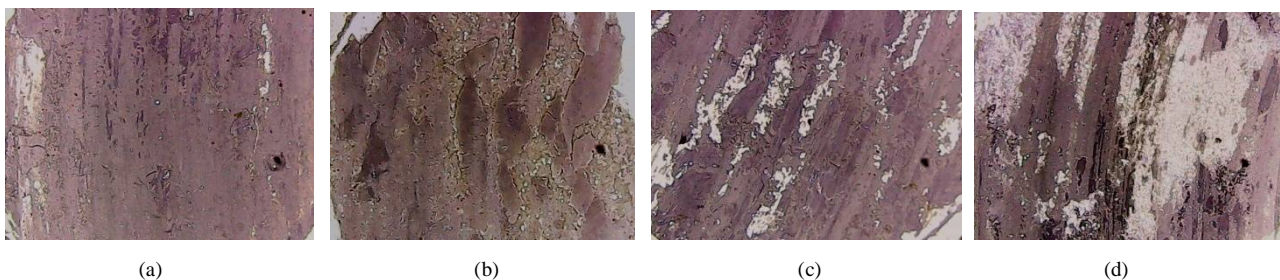


**Fig.4** Surface Roughness for each sample

The graphs depict how the Surface roughness varied with respect to the thirteen samples. In Fig.4 except S8, S9, S12 and S13 most samples gives the good range of surface roughness. Comparing with Fig.3 S5, S7, S10 and S11 comes the safer side and when compared to wear rate S7 and S11 are chosen for further analysis. After this the samples are moved for the examination of wear morphology by optical microscope and the best composition is identified with the reasons obtained on the worn surfaces.

**Wear morphology**

Optical magnifying lens was utilized to concentrate the well used out surfaces of some chose tests in the vicinity of 200x and 400x. Worn structure of the Nano composites coats were considered to uncover the impact of most extreme sliding conditions on dry sliding wear of composites. Optical Microscope can create high-determination picture of a surface, uncovering insights about under 100µm in size. Wear morphology of worn surface are observed in four samples namely S1, S3, S8 and S11 respectively as shown in the figure below.



**Fig. 5** Wear morphologies (a) worn surface of sample S1 (b) worn surface of sample S3 (c) worn surface of sample S8 (d) worn surface of sample S11

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From the optical micrographs shown in Fig.5 for some selected samples, the worn out surfaces were captured using camera with the help of optical microscope. (a) It was the S1 composition of sample, used to compare the other samples for which the wear resistance is higher. (b) It was the S3 composition of sample it observed the slight increase in visibility of primer over the surface compared to the S1 sample. Hence, 2% of MWCNT with epoxy has more wear resistance. (c) It was the S8 composition of sample, in this morphology, it was observed the increase in coverage of the top coat on the substrate and mostly primer is covered by the top coat. Hence, 3% of MWCNT with Polyurethane has more wear resistance. (d) It was the S11 composition of sample with maximum wear resistance. The primer and top coat covered most of the area with high wear resistance. Hence, 2% of MWCNT with Polyurethane and Epoxy has more wear resistance.

## VI. CONCLUSION

Aluminium 7075 was coated with epoxy polyamide –MWCNT nanocomposite as primer and polyurethane – MWCNT nanocomposite as top-coat. Wear tests were performed on polyurethane PU sliding against a mild steel bar using a under 5N load, 1m/s velocities and 1000mm distance. Wear rate was calculated for all samples and morphological study was done on the best samples. Further while analysing the surface morphologies it is found that the surface of polyurethane (topcoat) is obviously covered over the portion, worn surfaces and debris formation showed that the wear mechanisms are due to abrasive wear by the formation of longitudinal scratches and adhesive wear. Hence, it was found that 2% of MWCNT with Polyurethane and Epoxy has more wear resistance.

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