# The effect of different reinforcements on AA7075: A review

**Amarnath Swami[1], Ranjit Kumar R[2], Satish[3], Basavaraj[4]. Sachin Prabha[5]**
School of Mechanical Engineering. REVA University, Bangalore

## Abstract

Aluminum 7075 alloy with zinc as primary alloying element it has excellent mechanical properties, good ductility, toughness and good resistance to fatigue. It has significantly better corrosion resistance. Aluminum alloys in various applications due to their predominant properties including low thermal expansion, high wear resistance. Aluminum and its alloys are one of the most versatile and economical metallic material for most engineering applications [1]. Their low cost of production and excellent mechanical properties makes them the most potential materials for advanced aerospace and automotive applications. Among various grades of Aluminum alloy, 7075 grade is one of the most prominent and used for fabricating single The addition of $Si_3N_4$ particles improved the strength and micro hardness and wear resistance of the developed AMCs. Silicon Nitride ($Si_3N_4$) is a chemical compound of silicon and nitrogen. It is a white, high melting point solid that is relatively chemically inert. It was chosen as reinforcement due to its ability to resist high temperature wear and nature of chemical inertness [2]. It is one of the most commonly used aluminum alloy for highly stressed structural application, and has been extensively used in aerospace, aviation, marine and automobile.



## INTRODUCTION

Composites are one of the most significant materials known to men. A composite material is a amalgamation of two or more materials that provides better mechanical and tribological properties than those of the individual components used alone. Aluminum metal matrix composites are continuously replacing conventional aluminum alloys in various applications due to their predominant properties including low thermal expansion, high wear resistance. Aluminum and its alloys are one of the most versatile and economical metallic material for the most engineering application. Microstructure analysis of the composite reveals uniform distribution of reinforcement particles in the matrix. The presence of mica and kaolinite in the Al-7075 matrix increases the wear resistance up to 8% of the reinforcement7000 series have higher mechanical properties among other Aluminum alloys. AA7075 is often used in transport applications such as military, marine, automotive, aircraft and aviation [3]. The microhardness showed a decreasing trend with the increase in indentation load and a decreasing trend with the increase in dwell time. The results exhibited that with the increase in silicon nitride reinforcement the microhardness improved [4]. the microhardness and compressive strength shows an increasing trend with increase in wt% of silicon nitride particulates. However wear resistance of the developed composite material was observed to be increasing with increase in normal load conditions [5]. There is an improvement in Ultimate tensile strength and hardness properties with the increase in the weight percentage of reinforcement. Experimental studies invoke

that the 12%wt of $Si_3N_{4ss}$ increases the tensile strength by 7% and hardness values by 8% compared with that of as cast Al7075. Results are evident that there is a decrease in ductility and percentage of elongation with the increase in the percentage reinforcement [6]. The wear and abrasive area properties of MMCs having aluminum as base material exceptionally relies upon the particulate utilized for filler, its size and weight division of particles. If the particulates added for reinforced well to the lattice, the wear obstruction increments with expanding volume division of support materials [7]. Al (7075) alloy and their composites have been successfully developed through the stir casting based liquid Processing route with fairly uniform dispersion of basalt fiber [8]. AA7075 was used as a base matrix material. Aluminum metal matrix composites are continuously replacing conventional and hybrid reinforced composites. Most of researchers reported the micro structural, physical, optical and mechanical characteristics of Aluminum 7075 hybrid composites [9].

**Table.1: Composition of AA7075**

| Constituent | Content (%) |
|---|---|
| Aluminium (Al) | 89.19 |
| Zinc(Zn) | 5.58 |
| Magnesium(Mg) | 2.5 |
| Copper(Cu) | 1.6 |
| Chromium(Cr) | 0.23 |
| Ferrous(Fe) | 0.30 |
| Silicon(Si) | 0.20 |
| Titanium(Ti) | 0.20 |

## 2. Literature review

This review presents mechanical and tribological properties of AMMCs containing single or multiple reinforcements. Fabrication was done by using stir casting method. The effect of silicon nitride reinforcement on microhardness, compression strength has been studied. The influence of $Si_3N_4$ on AA7075 alloy by liquid route compo-casting technique. Five different compositions (0 to 8 wt%) of silica on nitride, which has excellent tribological properties. Five different samples with varying weight percentage (0, 2, 4, 6, and 8) of silicon nitride have been fabricated via stir casting route.The microstructural results showed a grain refinement with the increase in the silicon nitride content. The results exhibited with this review paper increase in silicon nitride reinforcement the microhardness improved there is an improvement in Ultimate tensile strength and hardness properties with the increase in the weight percentage of reinforcement. A fractured surface on the tensile test specimen was investigated to determine the fracture mechanism by using scanning electron microscope. The present scenario demands that, the engineering component should be light weight, wear resistance with high strength. In particulate alloy based metal matrix composite (MMC), alloys acts as base material and reinforcement material is in the form of particles [10]. The tests are conducted are clearly discussed as follows.

## 3. Stir casting method

In a stir casting process, the reinforcing phases are distributed into molten matrix by mechanical stirrer. Mechanical stirring in the furnace is a key element of this process. The resultant molten alloy, with ceramic particles, can then be used for die casting, permanent multicasting, or sand casting. Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement. A major concern associated with the stir casting process is the segregation of reinforcing particles which is caused by the surfacing or setting of the reinforcement particles during the melting and casting process. The final

distribution of the particles in the solid depends on material properties and process and process parameters such as the wet condition of the particles with the melt, strength of mixing, relative density, and rate of solidification. In metal matrix composites by stir casting method some of the factors that need considerable attention are as follows,

- To achieve uniform distribution of reinforcement materials
- To achieve wet ability between the two main substances.
- To minimize porosity in the cast metal matrix composites.

**Figure:1. Stir casting Setup**

**Table.3: Process parameters of stir casting**.

| S.N. | Process parameters | Value |
|---|---|---|
| **1** | Stirring temperature | 800°C |
| **2** | Stirring speed | 400rpm |
| **3** | Stirring time | 10min |
| **4** | Preheat temperature of reinforcement particles | 450°C |
| **5** | Preheat temperature of permanent mould | 300°C |

The present scenario demands that, the engineering component should be light weight, wear resistance with high strength. In particulate alloy based metal matrix composite, alloys acts as base material and reinforcement material is in the form of particles [11]

## 4.Heat Treatment

The composites are subjected to post heat treatment process such as solution heat treatment and artificial ageing after the reinforcement of Silicon Nitride and Fly ash through Stir Casting process. This will eventually improve their mechanical properties. The casted composites are first solution heat treated to 480 °C for 2 hours [12],[13]. Then to achieve the super saturated solid solution state these samples are quenched for about 10 to 15 minutes. Then they are artificially aged by subjecting it to temperature of 120°C for 24 hours. The specimens were cut into 12 pieces and tested for different ageing period 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22 and 24 hours [14]. C. Hardness Measurement: Initially, using carborundum abrasive paper of grade 320 and 400 the specimens were polished. Then the specimens were polished using fine abrasive papers of grade 800, 1200, 2500 and 4000. The carborundum acted as rough emery thereby, helped to attain flat surfaces whereas fine polishing with abrasive papers helps to achieve mirror finish across the

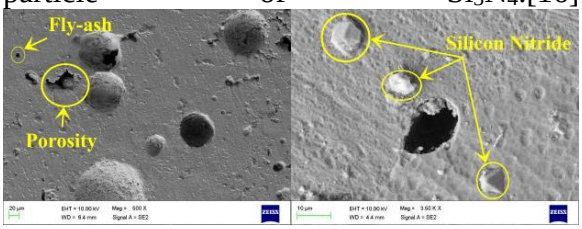
surface. Finally, the micro hardness of polished specimens was measured. The micro hardness of the surface was measured using the MITUTOYO Micro Hardness Tester MVK-H11 machine with an applied load of 300gf for 15 seconds. Hardness measurements of the three variants are done and compared with the base substrate and are reported in the results and discussion section to do a comparative analysis.

### 4.1. Tensile Test:

The Tensile test for the fabricated composites were carried out using computerized Universal Testing Machine (UTM). The samples with 36 mm gauge length and 9 mm diameter rods are prepared as per the ASTM 8 standard to evaluate ultimate tensile strength, percentage elongation and yield strength [15].

### 4.2. Microstructure Analysis:

Using FE-SEM: The microstructure image of AA7075 Hybrid composite is shown in Fig. 4 (a) & (b). The microstructure image shown in Fig. 4 (a) shows the reinforcement particle of Fly-ash along with some porosity and Fig. 4 (b) shows the reinforcement particle of $Si_3N_4$.[16]




**(a) & (b) SEM Images of AA7075-$Si_3N_4$ -FA composite.**

### 4.3. Hardness:

Microhardness of three variants is measured after artificial ageing. The Fig. 6 (a) shows the microhardness of the three variants with an interval of 2 hours. Microhardness is maximum at 16 hours for variant I & II whereas it is maximum for variant III at 12 hours. The maximum hardness of variant I, II & III are 132, 174 & 156 HV respectively. The hardness of composite increases up to 5 wt% reinforcement of Fly ash beyond which it tends to decrease. Similar results were obtained during the fabrication of pure Aluminum powder reinforced with using fly ash powder metallurgy technique [17]. The improvement of microhardness of three variants with respect to base metal AA7075 is shown in Fig. 6 (b). The improvement of microhardness in percentage with respect to base metal for the variants I, II & III are 128, 155 and 93 % respectively. The reason of hardness reduction in case of variant III is due to increased tendency of crack initiation and propagation at the Flyash – metal interface and the increased amount of brittle Flyash particles.[16]

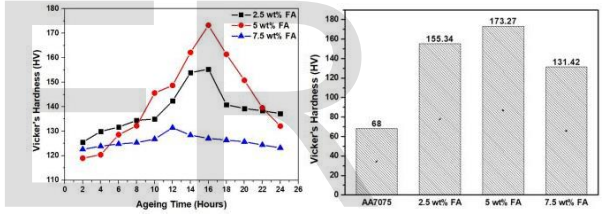



**Fig:6. (a) Microhardness for 24 hours Ageing period. (b) Hardness comparison between base and composite.**

### 4.4. Tribological Properties

Wear is the progressive loss of material due to relative motion between a surface and the contacting substance or substances. The wear damage may be in the form of micro-cracks or localized plastic deformation. Wear may be classified as adhesive wear, abrasion wear, surface fatigue wear and corrosive wear. [17]

## 5. Conclusion

1. In the present review tensile test was been conducted for AA7075 with different reinforcements like Fly

ash, Silicon Nitride, ash, graphite It has been seen with the increasing reinforcement the tensile strength of the composites is increasing.

**2**. The tensile strength of AA7075 reinforced with TaC and Si3N4 gradually increase .This increase in ultimate tensile strength is because of the presence of hard ceramic particles such as TaC and Si3N4 particles in the AMMCs, which in turn increases the strength of AA7075. These hard ceramic particulates impart their strength to the aluminium matrix alloy by their strengthening mechanism the load transfer from reinforcement particles to the matrix material, due to which base material offer more resistance to tensile stress.

**3**. As the wt% of reinforcement of TaC and Si3N4 increases the hardness also increases. Also, the improvement in Vickers microhardness is due to the uniform dispersion of reinforcement throughout the matrix material. Further due to the presence of hard ceramic material in Research the soft aluminium matrix enhances the overall hardness of the matrix material.

**4**. The microstructure of the cast composites revealed grain refinement with the increased content of the $Si_3N_4$ reinforcement. The grain refinement could help in improving the hardness.

**5.** The Al7075-matrix composites found to have high elastic modulus and tensile strength over the base alloys. It was found the Wear rate of composites increases with increasing applied load and speed and also observed highest wear rate is obtained for the lower particle size. [19]

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