

## Effect of Reinforcement on Tensile Behavior of Al 7005 Hybrid Composite

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### Abstract:

The aluminum-based composites are progressively used in the transport, aerospace, marine, automobile and mineral processing industries, owed to their enhanced strength, stiffness and wear resistance properties. In the current study, Al 7005 matrix alloy and S-glass + Fly-ash hybrid MMCs with different weight percentage of S-Glass of 1, 3 and 5% and Fly-ash of 2, 4 and 6% were fabricated through stir casting and studied for tensile properties like Yield strength(YS), Ultimate tensile strength(UTS) and percentage of elongation of these hybrid MMCs. The results shows that YS, UTS and percentage of elongation of composites were improved considerably with the addition of S-glass and Fly-ash, also it is noticed that Al 7005 +5% S-Glass+6% Fly-ash hybrid MMCs displayed superior results compared to as cast Al 7005.

**Keywords:** Al7005 alloy; S-Glass; Fly-ash; hybrid MMCs

### 1. INTRODUCTION

Composites have remarkable growth now a days due to its potential in lot of domestic and industrial applications. Combination of two or more reinforcements forms hybrid composites. Aluminium Metal Matrix Composites (AMMCs) are emergent as advance engineering materials due to their high strength, ductility and toughness. Lot of researchers have used ceramics such as SiC, Al<sub>2</sub>O<sub>3</sub>, and Graphene etc., as reinforcements in MMCs [1-5]. Liquid metallurgy route such as stir casting method have been used by several researchers [6-7]. Few reinforcement particles are expensive, and the composites fabricated by using such material may be not be cost effective. In the present work Al7005 alloy is used as matrix material which has various applications such as engine pistons, push rods, cylinders, connecting rods, bicycle frames, forks and pedals etc., [8]. S-glass and fly ash are used as reinforcements due to their better properties and cost effective.

## 2. EXPERIMENTAL DETAILS

In the present study, the Al 7005 reinforced with S-glass and Fly-ash hybrid MMCs were produced using stir casting process. The reinforcements particles size of S-glass and fly-ash are 5-10 $\mu$ m and 25-30 $\mu$ m respectively. The chemical composition of Al 7005 alloy are given in the Table 1.

**Table 1.** Chemical composition of Al 7005 alloy

Element	Cr	Cu	Fe	Mg	Mn	Si	Zn	Others	Al
<b>Weight %</b>	0.20	0.10	0.20	1.8	0.20	0.2	4.5	0.15	Balance

The different compositions of Al 7005 hybrid MMCs are as shown in the Table 2 and as cast Al 7005 alloy was fabricated using stir casting technique. During casting process the reinforcement particles i.e. S-glass & Fly-ash were heated in a furnace upto 400<sup>0</sup>C for 1 Hour to remove moisture content of the particles and these particles were introduced into Al 7005 melt which was heated upto a temperature of 750<sup>0</sup>C and stirred at a speed of 300 rpm for 5 minutes to attain uniform distribution of particles and later poured into cast iron mould to obtain the desired castings [9].

**Table 2.** Designation of Al 7005 hybrid (S-glass + Fly-ash) MMCs

Sl. No	Alloy/Composites	Designation
1	As-Cast Al7005	As-C
2	Al 7005+1% S-glass +2% fly ash	A1
3	Al 7005+1% S-glass +4% fly ash	A2
4	Al 7005+1% S-glass +6% fly ash	A3
5	Al 7005+3% S-glass +2% fly ash	B1
6	Al 7005+3% S-glass +4% fly ash	B2
7	Al 7005+3% S-glass +6% fly ash	B3
8	Al 7005+5% S-glass +2% fly ash	C1
9	Al 7005+5% S-glass +4% fly ash	C2
10	Al 7005+5% S-glass +6% fly ash	C3

### 3. Tensile Test



Fig 1. Tensile Test Specimens



Fig 2. Universal Testing Machine

The tensile test specimens are machined as per ASTM E-8 standards as shown in Fig.1 and the tensile tests are conducted using universal testing machine (Model: TUE-C-400) as per ASTM as shown in Fig.2. Three specimens of each compositions are tested and the average of three values are recorded.

### 4. RESULTS AND DISCUSSIONS

The tensile properties like yield strength, ultimate tensile strength and percentage of elongation for different hybrid metal matrix composites are calculated and results are as follows.

#### 4.1 Yield strength

**Table 3:** Yield strength values for different combination of Al 7005 hybrid MMCs

Sl. No	Alloy/Composites	Designation	Yield Strength in MPa
1	As-Cast Al 7005	As-C	187.20
2	Al 7005+1% S-glass +2% fly ash	A1	199.27
3	Al 7005+1% S-glass +4% fly ash	A2	204.11
4	Al 7005+1% S-glass +6% fly ash	A3	210.02
5	Al 7005+3% S-glass +2% fly ash	B1	201.36
6	Al 7005+3% S-glass +4% fly ash	B2	209.60
7	Al 7005+3% S-glass +6% fly ash	B3	211.52
8	Al 7005+5% S-glass +2% fly ash	C1	205.24
9	Al 7005+5% S-glass +4% fly ash	C2	208.84
10	Al 7005+5% S-glass +6% fly ash	C3	215.49

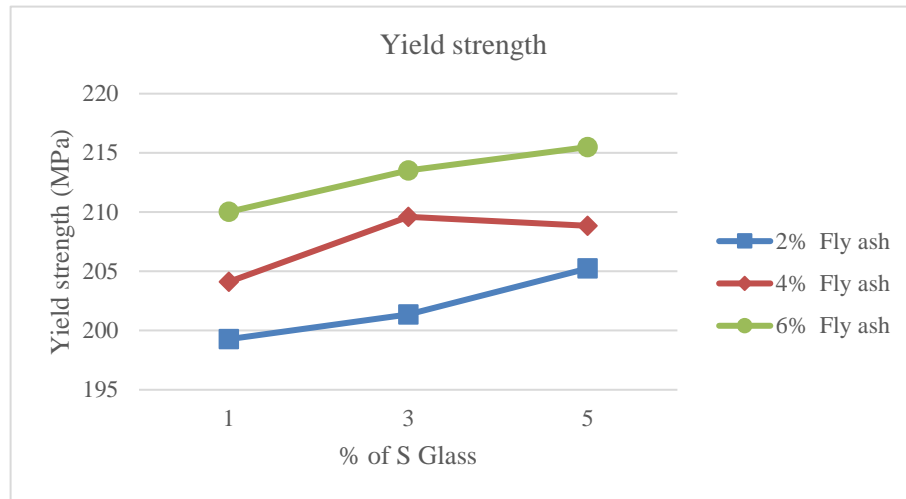


Fig 4 : Variation of yield strength for different combination of Al 7005 hybrid MMCs

Figure 4 shows the variation of yield strength (YS) of different Al 7005 hybrid MMCs. It can be seen that as the weight percentage of S Glass & Fly ash are increases the yield strength increases in all the hybrid composites. It can be found that hybrid MMCs has a better yield strength compared to as cast Al 7005. The composite having 5 % S-Glass with 6% Fly ash gives highest yield strength due to the more percentage of fly ash added in the matrix and good bonding of reinforcement in the matrix material. Also composite having 1% S-Glass with 2% fly ash gives least yield strength due to the addition of less percentage of fly ash in the matrix and poor wettability of reinforcement in the matrix [10].

#### 4.2 Ultimate Tensile strength

**Table 4:** Ultimate Tensile strength (UTS) values for different combination of Al7005 hybrid MMCs

Sl. No	Alloy/Composites	Designation	Ultimate Tensile Strength UTS (MPa)
1	As-Cast Al 7005	As-C	215.18
2	Al 7005+1% S-glass +2% fly ash	A1	226.45
3	Al 7005+1% S-glass +4% fly ash	A2	234.62
4	Al 7005+1% S-glass +6% fly ash	A3	240.62
5	Al 7005+3% S-glass +2% fly ash	B1	231.45

6	Al 7005+3% S-glass +4% fly ash	B2	238.19
7	Al 7005+3% S-glass +6% fly ash	B3	243.13
8	Al 7005+5% S-glass +2% fly ash	C1	233.23
9	Al 7005+5% S-glass +4% fly ash	C2	240.05
10	Al 7005+5% S-glass +6% fly ash	C3	244.88

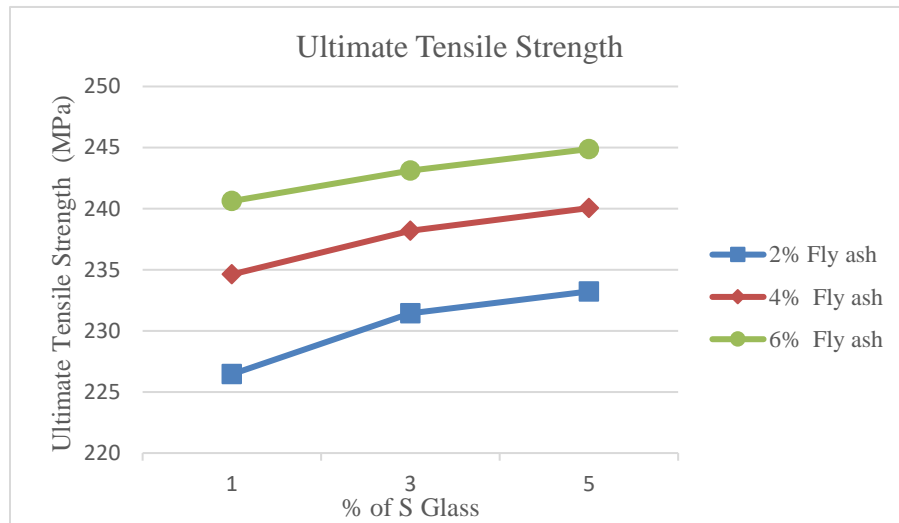


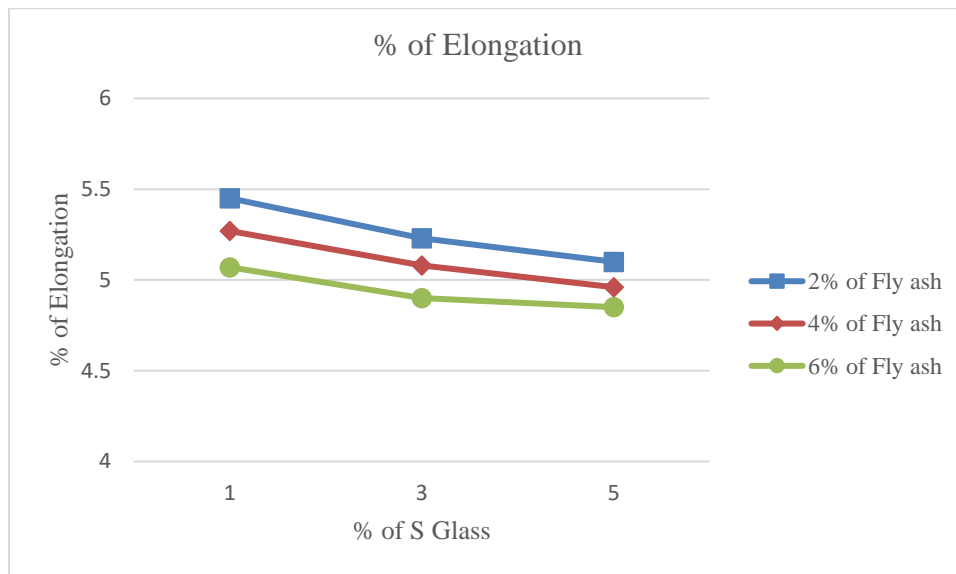
Fig 5: Variation of Ultimate tensile strength for different combination of Al 7005 hybrid MMCs

Figure 5 shows the variation of Ultimate tensile strength values of different Al 7005 hybrid MMCs. It is observed that hybrid MMCs has a better tensile strength compared to as cast Al 7005. The composite having 5% of S-Glass with 6% fly ash gives highest ultimate tensile strength this may be due to the dispersion of hard phases (S-glass and Fly ash) reinforcement in soft ductile matrix (Al 7005) leads to improvement in strength. Also composite having 1% of S-Glass with 2% fly ash least ultimate tensile strength. This may be attributed to large residual stress developed during solidification and generation of density dislocation [11-12].

### 4.3 Percentage of Elongation

**Table 5:** Percentage of Elongation for different combination of Al 7005 hybrid MMCs

Sl. No	Alloy/Composites	Designation	Percentage of Elongation (%)
1	As-Cast Al7005	As-C	7.54
2	Al 7005+1% S-glass +2% fly ash	A1	5.45
3	Al 7005+1% S-glass +4% fly ash	A2	5.27
4	Al 7005+1% S-glass +6% fly ash	A3	5.07
5	Al 7005+3% S-glass +2% fly ash	B1	5.23
6	Al 7005+3% S-glass +4% fly ash	B2	5.08
7	Al 7005+3% S-glass +6% fly ash	B3	4.9
8	Al 7005+5% S-glass +2% fly ash	C1	5.1
9	Al 7005+5% S-glass +4% fly ash	C2	4.96
10	Al 7005+5% S-glass +6% fly ash	C3	4.85



**Fig 6:** Variation of percentage of Elongation for different combination of Al 7005 hybrid MMCs

Figure 6 shows the variation of percentage of Elongation for different Al 7005 hybrid MMCs. It is noticed that hybrid MMCs has less ductility compared to as cast Al 7005. The composite having 5% of S-Glass with 6% fly ash gives least ductility. The ductility reduces from

7.54% to 4.85%. This may be attributed to fact that with increased reinforcement content leads to intrinsically brittle phases and presence of intermetallic phases serves as potential sites for crack nucleation leading to reduction in ductility under quasi-static loading [13-15].

## 5. CONCLUSIONS

It can be concluded that the tensile properties like Yield strength (YS) and Ultimate tensile strength (UTS) of Al 7005 hybrid MMCs shows better results compared to as-cast Al7005 alloy. It is also found that Al7005 +5% S-Glass+6% Fly-ash shows improved YS, UTS properties. The value of YS and UTS increases from 187.20MPa to 215.49 MPa and 215.18 MPa to 244.88 MPa respectively, while the percentage of elongation reduces from 7.54 % to 4.85 %.

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