# Study of Tensile Properties of Al-17%Si Alloys by Addition of Phosphorous

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***Abstract***- **Hypereutectic Aluminum-Silicon alloys have been widely investigated because of their excellent properties, which Include excellent wear and corrosion resistance, high temperature strength, low coefficient of thermal expansion, good cast performance, and high specific strength. Therefore, the hypereutectic Aluminum-Silicon alloys are widely used in aeronautic, astronautic, and automobile industries. It has been documented extensively that the microstructure of hypereutectic Aluminum-Silicon alloys, prepared by conventional casting routines, usually consist of a coarse primary silicon phase in a fibrous eutectic matrix. The brittleness of coarse Silicon crystals (both eutectic and primary silicon) is the main reason responsible for the poor properties of Aluminum-Silicon alloys because coarse silicon crystals leads to premature crack initiation and fracture in tension. In order to refine and modify the primary silicon, many methods have been carried into execution, such as high-pressure casting, rapid solidification technique, and melt overheating treatment. In the present study; the effect of phosphorous and titanium on the complex modification and refinement of hypereutectic Aluminum-Silicon alloys will be conducted. The influences of Phosphorous and Titanium on the microstructure and mechanical properties of hypereutectic Aluminum-Silicon alloys will be investigated**

## I. INTRODUCTION

High wear resistance, high strength-to-weight ratio, low coefficient of thermal expansion, high thermal conductivity, high corrosion resistance, excellent castability, hot tearing resistance, good weld ability etc. make hypereutectic aluminium silicon alloys very attractive candidate in aerospace and other engineering sectors. These applications demand the study of techniques to improve the wear properties of these alloys. For this purpose, many researches had been done to enhance their wear properties. Most common applications of aluminium silicon alloys are components like connecting rods, pistons, engine blocks, cylinder liners, air conditioner compressors, brake drums etc. The improvement in the tribological properties depends on number of material-related properties like shape, size and size distribution of the secondhase particles in the matrix and microstructures in addition to the operating conditions such as sliding speed, sliding distance, temperature, load etc. With the development of automobile industry, the need of hypereutectic Al-17%Si alloys is increasing greatly. Al-17%Si alloys containing more than 13 wt% silicon are known as hypereutectic Al-Si alloys. The high wear resistance is mainly attributed to the presence of hard primary silicon particles distributed in the matrix. Due to the presence of the hard primary silicon phase, these alloys have serious machinability problems. In order to obtain the best machinability and low wear rate, the size of silicon phase must be controlled through melt treatment. Wear rate of the material decreases with increase in hardness of the material. It should be noted that it is the hardness of the contacting asperities that will improve the wear resistance [1]. Wear resistance in Al-Si alloys is primarily due to the presence of silicon in the aluminium matrix. Increasing the silicon content in Al-Si alloys increases the wear resistance and strength at the expense of machinability. Aluminium silicon alloys can be strengthened by adding small amount of Cu, Ni or Mg and the presence of silicon provides good casting properties. It has been documented extensively that the microstructure of hypereutectic Al-20Si alloys, prepared by conventional casting routines, usually consist of a coarse primary silicon phase in a fibrous eutectic matrix. The brittleness of coarse Si crystals (both eutectic and primary silicon) is the main reason responsible for the poor properties of Al-20Si alloys because coarse silicon crystals leads to premature crack initiation and fracture in tension. In order to refine the primary silicon, many methods have been carried into execution, such as high-pressure casting, rapid solidification technique, and melt overheating treatment in the present study [2]; the P complex modification of hypereutectic (17%Si,)alloys were conducted. The influences of P, Tensile properties of hypereutectic Al-17%Si alloys were investigated.

## II. EXPERIMENTAL DETAILS

A. Preparation of Specimens: Al -Si will be prepared via foundry technique .Calculated quantities of commercial Purity aluminums (99.7Wt%purity) and A1- Wt% Si master alloy are melted in Resistance furnace under a cover flux (45% NaCl +45% KCL + l0% NaF). The melt is held at 720˚C ± 50˚C. After degassing the melt with solid hexacloroethane ( C2Cl6) , CuP chips duly packed in the aluminium foil will be added to the melt for grain refinement . The melt will be stirred for 30 seconds with zircon coated iron rod , after the addition of grain refiner. After which no further stirring will be carried out. Melts will be poured after holding for about 5 minutes into cylindrical graphite mould (25 mm dia and 100 mm height) surrounded by fire clay brick with its top open for pouring. The so prepared samples will be taken for macro analysis ,micro analysis , hardness test and tensile test.

Fig.1

Fig.2

B. Preparation of Tensile Specimen

After thorough literature survey the variables for preparation of samples for mechanical properties have been decided. Al 0,1, 2, 3, 4, 5, 6, 7, 8, 9, and 10% Ai alloys were prepared using commercial purity and Al-Si master alloy and commercially available Al-Si alloys were used for comparison. Melting of alloy was carried out in a resistance furnace (kanthal) and melt was held at 7200C. after degassing with solid hexachloroethane(C2Cl6), the melt was poured into graphite mould (25mm dia, 100mm height) surrounded by fire clay brick with stop open for pouring(for microstructural studies) and also melt was poured into split type graphite mould(12.5mm dia, 125mm height) for preparing tensile specimen.

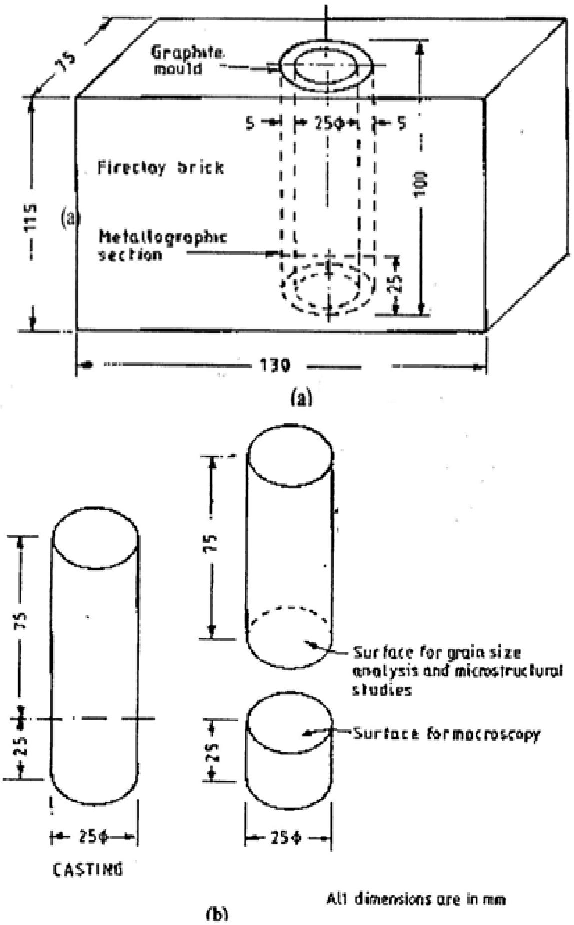


Fig.3

Fig.4

## III. RESULT AND DISCUSSION

Tensile Test for Al-17%Si

| Composition Wt % | UTS(MN $m^{-2}$) |
|---|---|
| Al-17Si | 175.8 |
| Al-17Si+0.01 | 175.2 |
| Al-17Si+0.02 | 176.2 |
| Al-17Si+0.03 | 178.8 |
| Al-17Si+0.04 | 177.5 |
| Al-17Si+0.05 | 179.2 |
| Al-17Si+0.06 | 181.6 |
| Al-17Si+0.07 | 173.2 |
| Al-17Si+0.08 | 173.8 |
| Al-17Si+0.09 | 174.6 |
| Al-17Si+0.10 | 175.2 |

From the above table it is very much clear at optimum addition of phosphorous i.e at 0.06%P the tensile of the specimen is 187.6 MN m-2. The tensile strength increases from 175.8 MN m-2 to 181.6 MN m-2.

## IV.CONCLUSIONS

The complex modification of P can obviously modify the primary silicon and the refinement effect of P on the primary silicon is more distinct. The edges and angles of the silicon are passivated .The size of primary silicon decreases with increasing P content but the optimum addition of P lies between 0.02% P To 0.12% P for the alloys considered for study. Excess P is unfavorable to the refinement of primary silicon as average particle size increases with addition of Phosphorous. The mechanical properties of hypereutectic Al-17%Si alloys are improved obviously with the addition of P. Due to the decrease in hardness the optimal combination of strength and plasticity are obtained.

Specific conclusions can be drawn for each alloy and are listed as below.

- Optimum addition of Phosphorous for Al-17%Si. Which in turn increases plasticity and hence tensile strength from 175.8 MNm-2 To 181.6 MNm-2
- Tensile Strength decreases and hardness increases with increase in silicon content for hyper eutectic Al-17%Si alloys.

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