# Wear Characteristics of Unalloyed and alloyed LM25-Aluminium casting

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**Abstract:**

Alloys A-356(LM25) is being universally used for alloy wheel rims of luxury as well as for other types of cars. Globally 40% cars are running on aluminium alloy wheels.

In this research 0.2% Cu has been added in ternary system of Al-Si-Mg alloy to increase mechanical properties of existing alloy. The alloy was cast in to metal mould and was solution treated at 540$^o$ temperature for 4 hrs, water quenched and precipitation hardened for 12 hrs at 180$^0$C. Wear characteristics of the material were observed under Wear testing using K93500 Pin-On-Disc Tester ASTM G99 test standard. This test was carried out under during dry condition using 2.5kg and 3.5 kg load, at 300 rpm of disc speed for 15 min. The microstructural characteristics of worn surface of alloys have been investigated using scanning electron microscopy_SEM. All intermetallic compound formed during solidification has been investigated through XRD.

***Key word:*** *LM25, SEM, Pin-on-Disc, XRD.*

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## INTRODUCTION:

Cast aluminum–silicon alloys have widespread applications, especially in the aerospace and automotive industries. These foundry alloys have an excellent combination of castability and mechanical properties, as well as good corrosion resistance and weldability. It is used in nuclear energy installations and for aircraft pump parts. LM25 may be superior for castings, particularly in gravity dies, which are difficult to make to the required standard of soundness.[1] Wear of a material is controlled by the material characteristics as well as operating parameters such as applied pressure, sliding speed, environment and the type of sliding interaction. Material characteristics including metallurgical and mechanical properties of alloy significantly affect their wear resistance [2]. Both hypoeutectic and hypereutectic Al-Si alloys have been used for tribological components in dry and lubricated contacts for a long time. One typical application of the hypereutectic alloy is in the form of pistons in automobile engines possibly because of such advantages as lightness, high thermal conductivity and low cost. Addition of silicon, apart from reducing the coefficient of thermal expansion, produces an Aluminium alloy with good wear, casting, machining and corrosion characteristics. A number of hypoeutectic alloys are in general use which are by no means simple binary systems but have alloying additions of copper, magnesium and nickel together with trace amounts of iron, manganese and zinc.[3] A356 (Al–7Si–0.35Mg) is a hypoeutectic alloy in the Al–Si–Mg system that has widespread applications especially in the aerospace and automotive industries. It is a heat-treatable casting alloy which can be strengthened by precipitation of $Mg_2Si$ after T6 treatment. Addition of copper to Al–Si alloys causes to form $CuAl_2$ phases and other intermetallic compounds, which increase strength of casting parts. Copper also increases heat treatability of the alloy.[4]

**EXPERIMENTAL WORK:**

Fresh ingots of LM25 of about 600 gms weight were melted in crucible type electrical resistance furnace. Melting was carried out under cover flux.

Just prior to pouring N2 was used as degaser. Lime coated clean iron tools were used. The molten metal was stirred by graphite rods and was poured in metal mould to 200° C in order to overcome chilling effect. Finally metal mould casting was obtained. Then after Solution treatment was carried out at 540+5°C for 4 hours.

Samples were quenched in water and ageing was carried out at 160°C for 12 hrs. Wear characteristics of the material were observed under Wear testing using K93500 Pin-On-Disc Tester ASTM G99 test standard. This test was carried out under during dry condition using 2.5kg and 3.5 kg load, at 300 rpm of disc speed for 15 min. of time. A fixed track diameter of 60mm was used in all test. Cylindrical pins of tested materials with 5mm in diameter and 30mm in length were used as wear test specimens. Microstructure of wear samples were studied under Scanning Electron Microscope at different magnification.

**RESULTS:**

**XRD Observation:**

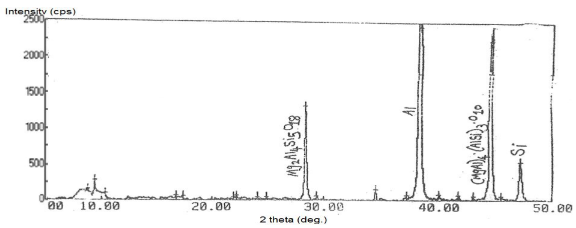


Fig 1: XRD results of Unalloyed A356 w/o heat treatment

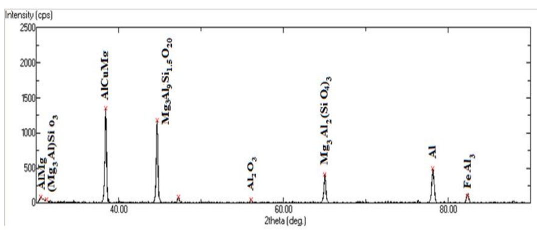


Fig 2: XRD results of Unalloyed A356+0.2%Cu w/o heat treatment

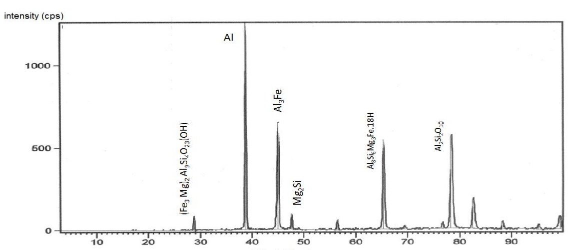


Fig 3: XRD results of Unalloyed A356 after heat treatment

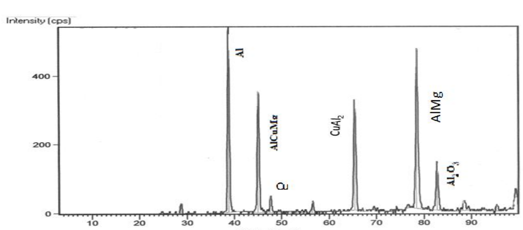


Fig 4: XRD results of Unalloyed A356+0.2%Cu after heat treatment

**Wear test Observation:**

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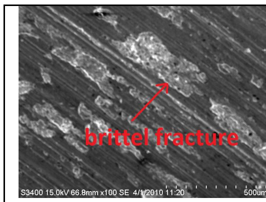
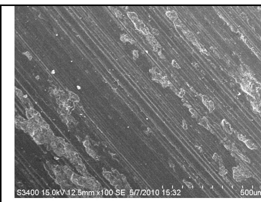
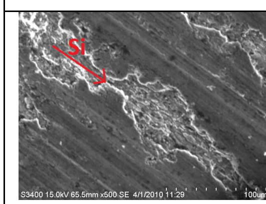
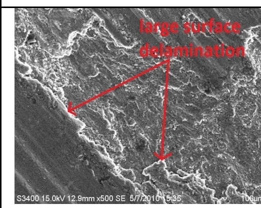
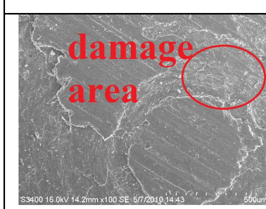
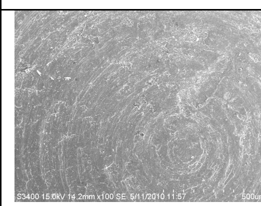
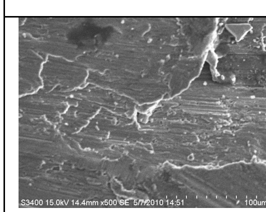
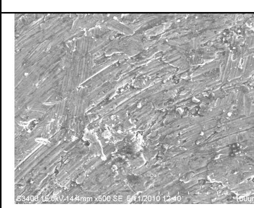
|   fig.5: A356 as cast, 2.5kg,100X |  fig.6: A356+o.2%Cu, 2.5 kg load,100X |
|   fig.7: A356 as cast, 2.5Kg,500X |   fig.8: A356+o.2%Cu, 2.5 kg, 500X. |
|   fig.9: A356 as,12 hrs,ageing,2.5kg100X |  fig.10:A356+0.2%Cu, ageing,2.5kg,100X |
|  Fig.11:A356 ,12 hrs, ageing,2.5kg,500X |  fig.12:A356+0.2%Cu, 12 hrs, |

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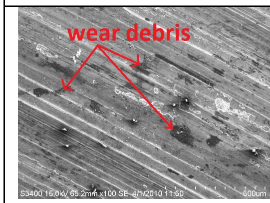
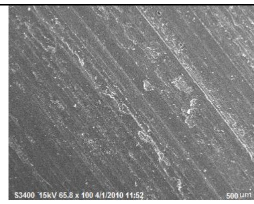
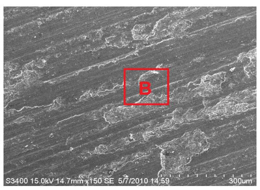
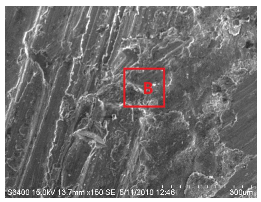
| | ageing,2.5kg,500X |
|   fig.13:A356as cast, 3.5kg,100X |  fig.14:A356+0.2%Cu, 3.5kg, 100X |
|  fig.15:A356,12hrs, ageing,3.5kg, 150X |  fig.16:A356,+0.2%Cu 12hrs ageing, 3.5kg,150X |

**Results Discussion:**

XRD result show (fig.1) formation of $Mg_2Al_4SiO_{18}$ (inclusion oxide) and $(Mg\ Al)_4(AlSi)_3O_{10}$. $(Mg\ Al)_4\ (AlSi)_3O_{10}$ can also termed as cluster of $Mg_2Si$. As indicate in Literature survey Cu is distribution in Al-Si matrix (fig 2) with Cu addition in A356 without heat treatment indicate formation of AlCuMg.after heat treatment there is formation of $CuAl_2$.(fig.13) XRD result show formation of AlMg, $(Mg_3Al)Si\ O_3$, AlCuMg, $Mg_3Al_9Si1_{.5}O_{20}$, $Al_2O_3$, $Mg3Al_2(Si\ O_4)_3$, Al, $FeAl_3$. Fig 3 show formation of $Mg_2Si$ as well as $Al_8Si_6Mg_3Fe18H$, $Mg_2Si$ consider as a final precipitate whose formation may impart better hardness compared to as cast unalloyed sample. XRD results show (fig 4) formation of AlCuMg and $CuAl_2$. $CuAl_2$ which may increase strength of casting parts.

Mechanical parameters such as amount of massive silicon particles, eutectic silicon, morphology of silicon crystal (fig.7) and bonding of these particles with soft aluminium matrix are important factor which should be considered in analysis of wear behavior of these alloys. In case of cast unalloyed sample, the presence of acicular eutectic silicon in microstructure may lead to stress concentration at silicon matrix interface due to dislocation. Spheriodisation of silicon needles may be attributed to reduction in wear rate with increases in ageing temperature as spherical morphology would discoverage the crack nucleation and their growth at particles matrix interface.[5] Microstructure at high magnification (1000 X) indicate that extent of damage is maximum in case of 0.2 % Cu+A356 (fig.8).

There is increase in weight loss when load is increased to 3.5 kg. Maximum weight loss in case of unalloyed A356. This is observed by SEM image since maximum damage is observed in Unalloyed A356 (fig.9,14). The wear surface shows formation of continues wear grooves and same damaged regions. Wear debris (fig.12) are generated when materials rub against each other and their quantity, dimension, composition shapes, morphology feature and structural characterisation are closely related with wear mechanism. All wear debris exhibits irregularly profile and unequal dimension so that the grainy wear debris can be attributed to as abrasive microcutting effect (fig.13,15).[6]

Copper addition to A356 alloy decreases melting point significantly, hence solidification range increases which facilitates porosity formation.

**CONCLUSION:**

The present investigation shows:

1. Wear capacity of unalloyed A356 and 0.2 % Cu+A356 improved after heat treatment process as compare to unalloyed.
2. More wear found in unalloyed Aluminum during different loading condition as compare to addition of o.2wt% of cu with LM25.

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