EFFECTS OF Cu ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF Mg ADDED Al-Si-Cu (A319) ALLOY

S.Meinathan[1] and Nitin.VR[2]

[1]Assistant Professor, Department of Mechanical Engineering, Shree Venkateshwara Hi-Tech Engineering College Othakuthirai, Gobi, India.
[2] Post Graduation Student, Department of Mechanical Engineering, Shree Venkateshwara Hi-Tech Engineering College, Othakuthirai, Gobi, India.

---***---

Abstract - *The third mostly seen element on the earth's crust is Aluminium. Versatility and strength to weight ratio are its important characteristics. The mechanical properties can be improved through alloying. It has lighter weight, , corrosion resistance and mechanical properties that makes that attractive for wide usage. Al-Cu, Al-Mg, Al-Si, Al-Zn etc are different types of cast Al alloys are available . Among these, Al-Si alloy is take for detailed study because of their excellent properties like good cast ability, high strength to weight ratio, better wear and corrosion resistance. Strength of Al alloys will improve by addition of Mg by forming precipitates. Increasing the copper content in Al-Si-Cu alloy and in Al-Si-Cu-Mg alloy will improve strength.*

Key Words: (Aluminium, A319 alloy, influence of mg and cu on A319 alloy.

1.INTRODUCTION

The third mostly sen element on the earth's crust is Aluminium. Versatility and strength to weight ratio are its important characteristics. The mechanical properties can be improved through alloying. It has lighter weight, corrosion resistance and mechanical properties that makes that attractive for wide usage. Aluminium is mostly alloyed, which improves its properties. It is used in pure for when importance is given for corrosion resistance than strength and hardness. The major alloying elements are copper, zinc, magnesium, manganese and silicon. it is very useful in automotive application because the fuel efficiency can be improved because Al has a density one third to that of steel. Al-Cu, Al-Mg, Al-Si, Al-Zn etc are different types of cast Al alloys are available. Among these, Al-Si alloy is take for detailed study because of their excellent properties like good cast ability, high strength to weight ratio, better wear and corrosion resistance. Strength of Al alloys will improve by addition of Mg by forming precipitates. Increasing the copper content in Al-Si-Cu alloy and in Al-Si-Cu-Mg alloy will improve strength. This alloy is used in the manufacturing of automobile engine components. Strength of Al alloys will improve by addition of Mg by forming precipitates. Increasing the copper content in Al-Si-Cu alloy and in Al-Si-Cu-Mg alloy will improve strength. Evaluation of the properties of alloy we taken for study were conducted by mechanical testing methods.

1.1 Aluminium

Aluminium Al is a silvery white lightweight metal, soft, non-magnetic, ductile metal.it has an atomic number 13 and std atomic weight 26.98gm, with density 2.7gm/cc and melting point is 660.32. The Young's modulus is 70 N/mm, Shear modulus is 26 N/mm, Bulk modulus is 76 N/mm.

1.2 Al-Si System

About 80% of the Aluminium casting alloys major alloying element is Aluminium silicon alloy due to their high fluidity, high resistance to the corrosion, better weld ability, shrinkage reduction and low coefficient of thermal expansion. Because of this reasons they are widely used in the automobile and space industries. This study focuses on Al-Si system with Cu and Mg.
The Al-Si-Cu alloy has good response towards heat treatment which makes it with greater practical importance.

2. OBJECTIVES

In these years A319 alloys are used in automotive sector because of increasing demand for automobiles with more power and less weight. Several studies has been suggested that addition of Mg up to 0.5% will have a positive influence in increasing mechanical properties by forming of precipitates. The main pourpose of this research is to understand the combined effect of Mg and Cu on strength.

3. RESULTS AND DISCUSSION

The chemical composition of the 319 alloy ingot used in the present study is given in table 2. The wt% of Cu is lower than standard limit of 3 to 4%. In order to bring Cu level to required level Al-33%Cu master alloy is to be added. Other elements are found to be within standard limits of A319 alloy.

Table -1: Composition of A319 alloy

	Si	Mg	Cu	Fe	Ni	Zn	Mn	Sn	Ti	Al
Wt%	5.5-6.5	0.1 max	3-4	0.1 max	0.35 max	0.1 max	0.1 max	0.05 max	0.25 max	Bal

3.1 Chemical Composition

The chemical composition of the alloy castings were analyzed using optical emission spectrometer. The composition analyses confirm that main alloying elements are present within the specified limits

Table -2: chemical composition of ingot

	Si	Fe	Cu	Mg	Sr	Ti	Al
Wt%	5.34	0.037	1.825	<0.00010	0.00026	0.0068	Bal

3.2 Hardness

Hardness measurements were performed on all heat treated samples. Samples were subjected to varying ageing temperatures and time. All samples were solutionized at 500^{0}C for 8 hrs and subjected to natural ageing for about 12 hrs at room temperature. With incrrease in copper content keeping ageing parameters constant the hardness value is found to be increasing. This due to the fact that the amount of Cu above solubilits limit in the alloy leads to the formation of large of hard precipitates. Similarly addition of Mg also improves hardness value.

3.3 Tensile Properties

3.3.1 Ultimate tensile strength

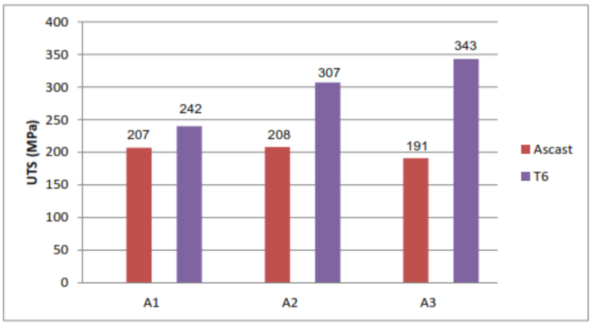

Chart -1: Variation of UTS with Cu & Mg content

Table -3: Ultimate Tensile Strength Of As- Cast And T6 Peak Aged Condition

Alloy	*As- cast condition*	*T6 peak aged condition*
	UTS(MPa)	UTS(MPa)
A1	207	242
A2	208	307
A3	191	343

These results conclude to the better ageing response of alloy A2 & A3 due to the combined effect of Cu and Mg. The Mg added alloy with 4% Cu has higher strength of about 343MPa. In comparison with base alloy the UTS in Mg added alloy with 3% and 4% Cu exhibits approx. 27% and 42% increment respectively.

3.3.2 Yield strength

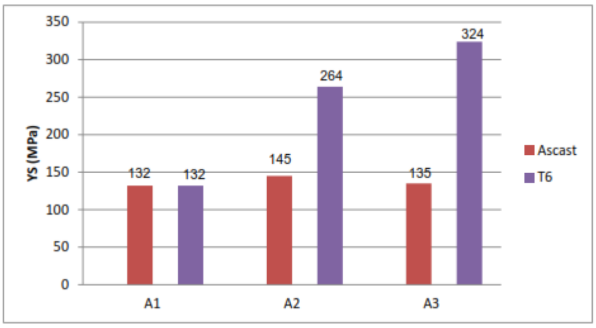

Chart -2: Variation of Yield Strength with Cu & Mg

Table -3: Yield Strength of As- Cast and T6 Peak Aged Condition

Alloy	*As- cast condition*	*T6 peak aged condition*
	YS(MPa)	YS(MPa)
A1	132	132
A2	145	264
A3	135	324

The yield strength also exhibit similar behavior as that of UTS with variation of Cu and Mg. But the exception is that variation of Cu and Mg affect yield strength much greater than any other property. In Mg containing alloy raising Cu content improve YS by large amount. But with constant Mg content increase in Cu reflect in a greater enhancement in UTS. Raising the Cu level to 4% causes YS to improve by approximately 2.4 times that of as-cast strength as well as strength of base alloy. Due to the combined effect of Cu and Mg, both Mg containing alloy shows better ageing response specifically alloy with 4% Cu.

3.4 Wear

Wear resistance is proportional to weight loss so wear resistance is expressed as a function of weight loss. The trend shows that at different loads, Mg added samples are showing improvement in wear resistance. This improvement in wear resistance is caused by the enhanced hardness of the alloy with presence of Mg2Si. The presence of an additional intermetallic phase aids in improving the wear resistance. Increasing Cu causes decrease in weight loss which means wear resistance is increased.

3.5 Microstructure

The mechanical properties of a material are determined by its phase constituents and their morphology. The as-cast microstructure of three alloys consists of α-Al with dendritic structure and eutectic silicon embedded inthe α-Al matrix. Silicon exhibits a fibrrous morpholoogy in all castings instead of acicular in unmodified. This is one of the factors that improve ductility. Due to the low solubility of Cu in Al at room temperature majority of Cu added is accumulated to a large connected network of hard intermetallic phase. Decreasing of mechanical properties will be the result. Addition of Mg leads to the formation of additional precipitate Mg2Si (dark black) which is the main in hardening constituent in Al-Si-Cu-Mg alloy. In addition to that increasing Mg content leads to formation of an extra phase a grey colored bulky phase represented as Q phase with composition Al5Mg8Si6Cu2.

3.6 X-Ray Diffraction Analysis

The main precipitates formed are identified using XRD analysis. The XRD image of base alloy identifies the presence of precipitate Al2Cu. Mg added alloy with 3% and 4% Cu respectively, confirms the presence of Mg2Si. Also another phase called Q phase is detected made it clear that some amount of Mg added is attracted to form Q phase instead of Mg2Si.
XRD analysis of base alloy shows same precipitates even after heat treatment. The XRD image alloy with various contents of Cu and Mg shows the presence of main strengthening phases like Al2Cu & Mg2Si even after heat treatment which explains improvement in the strength. Also analysis confirms the presence of Al5FeSi plates even after heat treatment. Thus it reveals that Al5FeSi plates are more or less stable during solutionising. It remains as it is in the as-cast state without morphological change causing decrease in ductility.

4. CONCLUSIONS

Copper have profound influence in Mg added 319 alloy. Results prove that increasing copper would increase strength remarkably at the expense of ductility. Maximum strength is obtained for Mg added alloy with 4% Cu due to high density of precipitate Al2Cu in microstructure. For application of 319 alloys that it need high strength 0.4-0.45% Mg added A319 alloy with 4% Cu is suitable. Addition of 0.4-0.45% Mg to A319 alloy will increase strength tremendously by cooperative precipitation of Mg2Si and Al2Cu. Also Mg added alloy exhibits greater ageing response compared to that without Mg. Strength in Mg added 319 with 4wt% Cu increases by 42% from 242MPa to 343MPa compared to base alloy for a drop in ductility by 74% to 2.3%. In Mg added alloy increase in Cu content result in more fraction of Cu in matrix. This leads to the formation of Al5Mg8Si6Cu2 reducing the available Mg in matrix for the formation of Mg2Si.
Even though the Cu is increasing, the strengths obtained were low due to segregation of alloying element in as-cast condition. In order to improve properties, uniform distribution of hardening phases is essential that makes heat treatment necessary. Evaluation of mechanical properties shows that increase of Cu content in Mg added alloy would improve UTS & YS by a large amount. Wear resistance was found to increase with increasing Cu content. Increasing Cu content by keeping Mg level

constant shows surprising improvement in ageing response. Yield strength is greatly influenced by ageing

REFERENCES

[1] AM Samuel, J Gauthier, FH Samuel, Microstructural aspects if the disolution and melting of Al2Cu phase in Al-Si alloys during solution heat treat ment-Metallurgical and Materials Transactions A, 1996

[2] JE Gruzleski, BM Closset, The treat ment if liquid aluminum-silicon alloys - 1990

[3] JY Hwang, R Banerjee, HW Doty, MJ Kaufman, The effect of Mg in the structure and the properties of type 319 aluminum casting alloys- Acta Materialia, 2009