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Optimization of Magnesium Metal into Commercially Pure Aluminium

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ABSTRACT
The present investigation, involve development of Al-Mg systems by addition of magnesium into commercially pure aluminium. The amounts of magnesium added into commercially pure aluminium are of 1 and 2 wt%. The recoveries of magnesium are around 85-90%.Remaining Mg react with oxygen and float on the liquid aluminium. Presence of magnesium creates two phenomena. One is solid solution hardening and other is intermetallics formation. Both the phenomena checked by microstructural changes and by measuring the electrical conductivity values. By increasing the Mg, content mechanical properties (hardness and tensile strength) increases and electrical conductivity decreases.
Key words: Al-Mg system, Solid Solution, Microstructure, Tensile strength, Hardness, Electrical conductivity

I. INTRODUCTION

The automobile industries needs the development and production of new die casting alloys in the present situation to reduce the fuel consumption and to increase the performance of vehicle needs improvement in field of aluminium industry. Al alloy has high strength, stiffness, lower density, good electrical conductivity etc. Extensive studies done on Al-Mg systems (wrought 5xxx, 6xxx and cast LM5 andLM10). The Al-Mg system has highest corrosion resistance, good machinability & bright surface finish. It is generally used in transportation, structural plates, large tanks for petrol, milk, grain, pressure vessel & architectural component [1,2,3]. The presence of Mg & Si leads to convert alloy as heat treatable alloy[4]. Thermal conductivity reduce by Mg to values approximately 1/2 at 5% to 6% Mg and 1/3 at 15%Mg. Electrical resistivity increases almost linearly with percentage of Mg in solution to reach value of 10 to $11x10^{-8}$ Ohm m at solubility limit(17.4% Mg). Mg is one of the few elements that lower the modulus of elasticity of Al that decreases linear so that 15% Mg alloy has modulus of 58 GN/m^2. Damping capacity also reduced. Mg additions are very effective in reducing a rate of creep. Mg have tendency to segregate at grain boundaries and sub-boundaries. Mg addition leads to Mechanical twining. The Al-Mg_2Si alloy divide into three group first group having amount of Mg+Si <1.5%, second group normally containing Mg+Si>1.5% and third group contain amount of Mg_2Si overlapping first two but with excess Si. Excess Mg is beneficial at low Mg_2Si content because Mg lower the Solubility of Mg_2Si.[5]

II. EXPERIMENTAL WORK

The commercially pure grade of aluminium used for this experiment. The alloy melted in a graphite crucible by using resistance-heating furnace. The solid magnesium metal added into the liquid commercially pure melt at 700˚C. The amount of solid magnesium addition was 1 and 2 wt% respectively. The melt poured into a permanent metallic die. The microstructures of samples characterize by using a Neophote 2 optical microscope and Jeol JSM 5610 LV scanning electron microscope. The static tensile test carried out using a Monsanto tensile testing machine with 0.05 strain rate. Averages of three reading considered as a result. The Brinell hardness tester used to measure hardness. An average of six reading consider as final hardness value [6,7,8].

III. RESULT AND DISCUSSION

3.1 Chemical analysis of all system:

Chemical analysis of raw material and developed system observed by spectrometer and SEMEDS represent in following Table 1. It indicates the recovery of magnesium in both systems is around 85-90%.

Table 1. Chemical analysis of developed system and commercially pure aluminium

System	**Al%**	**Mg%**	**Si%**	**Mn%**	**Fe%**	**O%**
C pure Al	98.17	0.63	0.**630.80**	0.44	0.13	0.00
Mg source	_	96.25	-	-	-	3.75
Al-1%Mg	94.96	0.95	0.83	0.59	0.02	2.65
Al-2% Mg	95.79	1.89	0.84	0.59	-	0.89

3.2 Microstructural Characterization of Al-Mg Alloys by Optical Microscope:

Following figure 3 indicates the microstructure of Al-Mg alloys. It is unetched microstructure so that formation of phases can easily observe and locates in the microstructure.

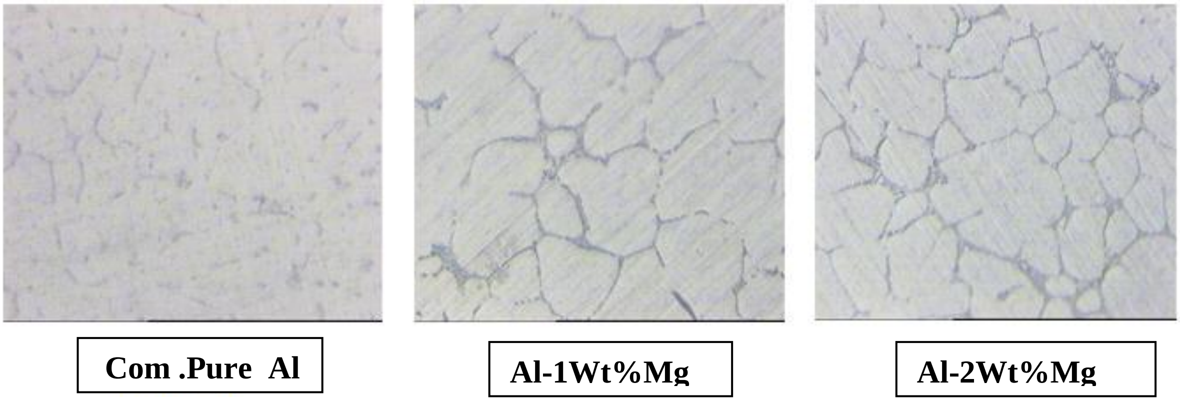


Fig.3 Optical micrograph of various Al-Mg alloys at 200X

In 1wt% Mg-Al system indicate the presence of Mg in the form of dark small circle and some excess Mg present at the grain boundary. In 2wt% Mg-Al system more amount of Mg are observed compare to 1wt% Mg-Al system. More network of Al-Mg rich intermetallics generated and located at the end of the α-aluminium grain. The grains size also decreases compare to Al-1wt% Mg.

3.3 Microstructure analysis various Al-Mg alloys by SEM (BSE Mode):

The following figure 4 indicates the SEM analys, teis study of developed system.

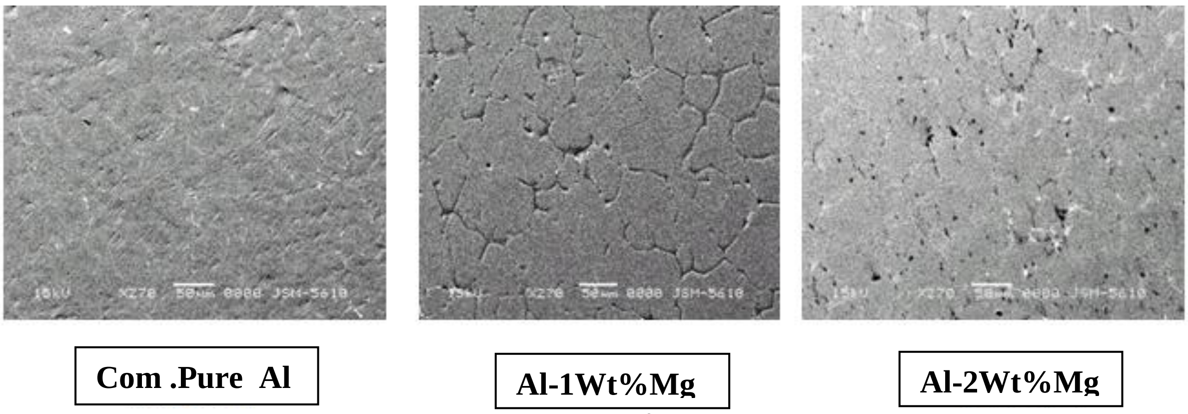


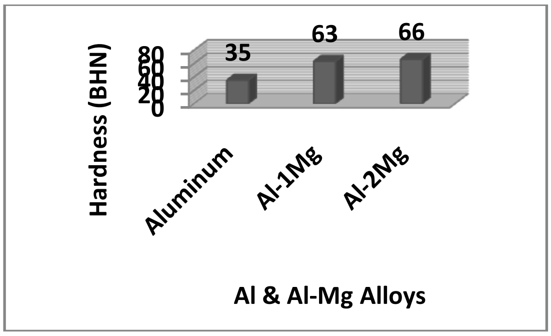
Fig.4 SEM (BSE MODE) micrograph of various Al-Mg alloys at 270X

The SEM in back scattered mode (BSE) micrograph indicates the presence of Mg in the form of dark lines into the grey colour aluminium matrix. By addition of magnesium, formation of grain boundary appears and by further addition, it appears as in the forms of precipitates .The Al-2wt% micrograph indicate the precipitates as dark black dots into the aluminium matrix. The commercially pure aluminium has some impurities and its presence also checked by SEM (BSE) back scattered image. It indicate the presence of the heavy element distribution like Fe, Mn, Si etc as shiny white lines or dots.

3.4 MECHANICAL TESTING

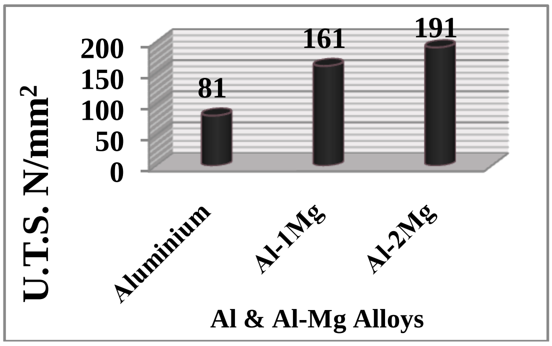
3.4.1 Hardness & tensile testing

Following graph, indicate the hardness value of various systems developed after Mg additions. With increase in Mg content hardness value increases because of solid solution strengthening effect and due to sub grain boundary effect. It increases from 35 to 66 BHN.



Graph.1 Hardness test plot of Al & Al-Mg alloys

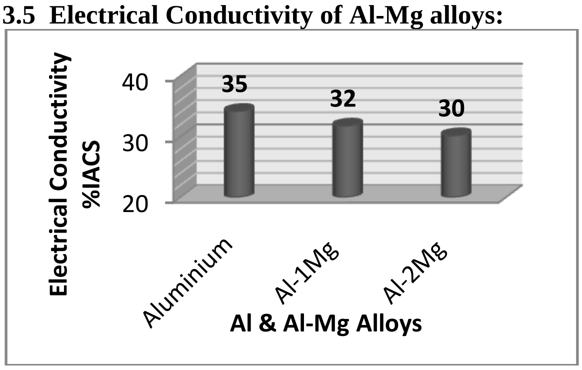
Tensile testing of Al and Al-Mg alloys



Graph.2 Tensile strength plot of Al &Al-Mg alloys

Graphs No 2 indicate the tensile strength of Al and various Al-Mg alloys The tensile strength values depend on the distribution and location of phases in to the structure. The Mg enriched intermetallics phase and Mg_2Si phase increases the tensile strength by restricting the movement of dislocations.[5] .

3.5 Electrical Conductivity of Al-Mg alloys:



Graph.3 Electrical conductivity plot of Al & Al-Mg alloys

The graph 3 helps to check the effect of addition of Mg and formation of phase's electrical conductivity is the quick method, which decreases the electrical conductivity by alloying compare to pure metal. As weight percentage of Mg increases the conductivity decreases from 35 %IACS to 30 %IACS.

IV. CONCLUSIONS:

- Mg have tendency to segregate at grain boundary & sub grain boundary which give solid solution strengthening effect and act as network former to increase the mechanical properties of various Al-Mg systems.
- As the weight percentage of Mg in commercially pure Aluminium increases (1 wt% to 2 wt%) hardness value also increases from 63 BHN to 66 BHN.
- The optimum value of tensile strength (191 N/mm^2) is attaining in Al-2 Wt% Mg system.
- Electrical conductivity decreases with increasing percentage of magnesium in commercially pure aluminum (35 %IACS to 30 %IACS).

V. ACKNOWLEDGEMENT

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REFERNCES

[1] Dr Ashok Sharma, Some aspects for production of clean Al casting, *Indian foundry journal 50th Indian foundry congress*, 279-285(2002).

[2] P.T. Pushp, Studies on y-Al_2O_3 particle reinforced, Al-Mg alloy cast composites, 51 *Indian foundry congress*, 124-129 (2003).

[3] D. Apelian (ed), NACDA Aluminium Cast alloys: Enabling tools for Improved Performance, 9 (2009).

[4] ASM Handbook, Volume 4 Heat treating, 1861 (1991).

[5] L.F. Mondolfo, Aluminium Alloys: Structure and Properties, The butter worth group, published ISBN 408 70680 5, 311-317. (1976).

[6] M Nagaral, V Bharath and V Auradi Effect of Al2O3 Particles on Mechanical and Wear Properties of 6061al Alloy Metal Matrix Composites *Journal Material Sci. Eng,* vol 2 issue 1 1000120 (2013)

[7] Chong Li, Yuying Wu,Hui Li and Xiangfa LiuX.Microstructural formation in hepereutectic Al-M2Si with extra Si , *Journal of alloys and compounds vol.477 Issue 1-2 27May pp 212-216* .(2009)

[8] 8A.A.Hamid, P.K. Ghosh, S.C. Jain and S. Ray, Processing, microstructure, and mechanical properties of cast in-Situ Al(Mg,Mn)-$Al_2O_3(MnO_2)$ composite *Metallurgical and Material Translations A,* Issue 8,vol.36A, 2211-2223(2005).