Mechanical Properties of Al-Cy-Mg alloys Micro-alloyed with Sn

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Introduction

The demand in aircraft and space industry for structural materials has resulted in a thrust in development of high strength and light weight alloys especially Al-Cu, Al-Mg-Si, and Al-Cu-Zn-Mg alloys[1]. The recent trend is to improve the mechanical properties of these alloys by micro-alloying with elements such as Sn, Cd, Ag, etc.[1-8]. In the present study, Al–Cu–Mg alloys microalloyed with Sn varying (Sn wt. % varying between 0 to 0.1) were processed by casting technique followed by rolling. The microstructure and mechanical properties of these alloys after heat treatment were investigated and reported.

Experimental Procedures

Six different alloys (having an average nominal composition Al-5.9%Cu-0.49%Mg-0.5%Si-0.49%Fe) with Sn content varying from 0 to 0.1 wt.% were processed by casting technique. The cast samples were preheated at 200 °C for 1 hr and subsequently warm rolled at the same temperature. The rolled samples were subjected (i) homogenized at 510 ^{o}C for 10 hrs and furnace cooled, and (ii) solutionized at 525 ^{o}C for 10 hrs and water quenching followed by age hardening heat treatment at 170 ^{o}C for 24 hrs. The peak aging time of the alloys was established by carrying out by studying the precipitation hardening behavior of these alloys at 170 ^{o}C for various times. Tensile specimen were machined from the rolled strips and tested in a Dynamic UTM (Instron, 8801). The micro structural investigation of the polished and etched specimen was carried out using Optical microscope (Carl Ziess, Axiotech) and Scanning electron microscope (SEM, LEO, 1430 VP) attached an energy dispersive X-ray spectrometer (EDS, Oxford).

Results and Discussions

Table 1 shows the tensile properties of the rolled and homogenized Al–Cu–Mg alloys with different Sn wt.%. YS and UTS of the alloy increased with increase in Sn content up to 0.06 wt.% and with further addition decreased. The percentage elongation of the alloy decreased with increase in Sn content from 0.02 wt.% up to 0.06 wt.%. Further increase in Sn content increased the percentage elongation. *E* of the rolled alloy decreased by 8 % due to the trace addition of 0.04 wt.% Sn. Further increase in Sn content increased the *E* value. Maximum strength among the rolled and homogenized Al–Cu–Mg alloys was observed while microalloying with 0.06 wt.% Sn. YS of the alloy increased by 29 % whereas the ductility reduced by 21 % upon addition of 0.06 wt.% Sn.

Table 1. Tensile properties of rolled and homogenized Al–Cu–Mg alloys

Sn wt.%	Young's Modulus (GPa)	Yield strength (MPa)	Ultimate tensile strength (MPa)	Elongation %
0	67.2	128	182	7.0
0.02	65.0	145	193	9.0
0.04	61.7	147	193	8.6
0.06	62.9	165	205	5.5
0.08	66.9	160	198	7.0
0.1	62.8	134	178	7.5

The mechanical properties of the Al-alloys in the rolled and peak aged conditions are shown in Table

2. YS and UTS of the alloys increased with increase in Sn content up to 0.06 wt.%. The alloy with 0.06 wt.% Sn was observed to have a maximum YS of 371 MPa and UTS of 416 MPa. YS and UTS of the alloy increased by 7 % and 16 % respectively, upon 0.06 wt.% Sn addition. Further addition of Sn resulted in a decrease in the YS and Tensile strength.

Table 1. Tensile properties of rolled and peak aged Al–Cu–Mg alloys

Sn wt.%	Young's Modulus (GPa)	Yield strength (MPa)	Ultimate tensile strength (MPa)	Elongation (%)
0	62.7	347	360	0.8
0.02	58.7	335	365	1.2
0.04	52.6	356	394	0.7
0.06	53.0	371	416	0.6
0.08	56.2	352	393	0.8
0.1	61.2	338	348	0.7

The YS and UTS increased considerably by the precipitation hardening treatment. However, this was achieved at the expense of the ductility. The percentage elongation of the alloy decreased with increase in Sn content from 0.02 wt.% up to 0.06 wt.%. Further increase in Sn content increased the percentage elongation. The total elongation was minimum and maximum for the alloys with 0.06 wt.% and 0.02 wt.% Sn, respectively. Young's modulus of the rolled and peak aged alloys with Sn wt.%. *E* decreased by 16 % upon addition of 0.04 wt.% Sn. Further increase in Sn content increased the *E* value.

Maximum strength with a considerable loss in ductility was observed in rolled and peak aged alloys containing 0.06 wt.% Sn. UTS of the alloy increased by 16 %, whereas, the ductility reduced by 28 % upon addition of 0.06 wt.% Sn. The overall tensile properties were significantly affected by the age hardening treatment. With age hardening treatment, strength was considerably increased but there was a loss in ductility for all the alloys in rolled condition. The UTS of rolled Al-Cu-Mg without zinc content increased by 98 %, while the total elongation decreased by 89 % when peak ageing heat treatment was given.

Conclusions

The strength of the Al-Cu-Mg alloy was increased by addition of trace amounts of Sn. The Y.S. and U.T.S of the Al-Cu-Mg alloy was found to increase with increase in Sn content up to 0.06 wt.%. Precipitation strengthening resulted in achieving higher strengths but at the expense of ductility.

References

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