Experimental Study on Aluminium Based Alloys with Dispersed Intermetallic Compound (Al_2CuMg) for Industrial Applications

Rakesh Kumar and Varinder Sahni

***Abstract*—The intermetallic compound (Al_2CuMg) has been prepared with aluminium, copper and magnesium metals taken by their atomic weights. The TIG welding heating source at the desired temperature is used to melt the materials and stirring manually for five minutes. The results have been analysed using techniques of XRD and obtained 55.5% of Al_2CuMg intermetallic compound and by XRF obtained 44.87% Al_2O_3, 35.21% CuO and 19.24% MgO. The intermetallic compound has been further synthesized by 5 wt% proportions mixed with aluminium metal and casted sample heat treated at 140oC for five hours to enhance material properties. The tensile and hardness test were performed on the new material which has yielded high end values of the aluminium alloy.**

***Index Terms*—Aluminium alloys, intermetallic compound, inert space.**

I. Introduction

The two or more pure metal produces new materials with its own properties in known as intermetallic materials. Some researcher had worked out with different metals to help the present experimental work.

To analyse the morphology and composition of complex microstructure of the intermetallic phase in AlSi1Mg alloy at a cooling rate 2 ° C/min, the complex binary, ternary and quaternary eutectic structure in the solidified zone were also observed [1].

The dissolution of Al_2Cu in two Al-Si-Cu-Mg aluminium alloys was investigated by calorimetric analysis and metallographic measurements.

Both alloys had similar compositions but very different microstructures. The Al_2Cu phase was fine and the particles had very high aspect ratios that favored faster dissolution in the matrix. About 0.5 h was enough for this alloy [2]. A ternary Al-8Si-5.1Cu (in wt. %) alloy was rapidly quenched from the melt at cooling rates between 10^6 and 10^7 K/s using the melt spinning technique. Micro hardness value of the melt-spun hypoeutectic Al-Si-Cu alloy is 201 kg/mm^2 [3]. The influence of Cu content on the microstructure and hardness of near eutectic Al-Si-*x*Cu (x = 2%, 3%, 4% and 5%) was investigated. It is found that increasing Cu content from 3% to 5% increases the hardness from HB 55 to HB 118 [4]. It has been demonstrated that the strength of an Al–Si–Cu alloy is maximized by high-temperature solution treatment at 807 K, which is approximately 16 K higher than the ternary eutectic temperature. This study has provided visual evidence for both the positive and negative effects exerted on the mechanical properties of an aluminium alloy by a high-temperature solution treatment.

We conclude that the positive effects can outweigh the negative effects even above the eutectic temperature. As a result the maximum strength is realized at a relatively high temperature with a significant reduction in the time required for solution treatment [5], [6] The effect of β-iron intermetallic and porosity on the tensile properties in cast Al–Si–Cu and Al–Si–Mg alloys were investigated for this research study, The T7 heat-treated alloys display lower hardness values than those which were T6 heat- treated [7]. The mechanical properties of aluminium-silicon casting alloys containing Cu and Mg are known to be improved by heat treatment. Artificial ageing of Al-Si-Mg alloys anywhere in the temperature range 170-210 ° C gives the same peak yield strength, while Cu-containing alloys show a decrease in peak yield strength with increasing ageing temperature. Several precipitation sequences are possible in Al-Si-Cu-Mg alloys and it is unknown which parameters determine the actual sequence which takes place [8]. The influence of solidification rate on the solution treatment response for an Al-8Si-3.1Cu alloy has been investigated. The alloy was cast using the gradient solidification technique to produce samples with three different solidification rates. The samples were solution treated at 495 ° C for various times between 10 min and 10 h .The time needed for solution treatment is strongly dependent on the coarseness of the microstructure. For a very fine microstructure a short solution treatment for 10 min is sufficient to achieve dissolution and homogenisation, while for a coarse microstructure more than 10h is needed [9]. The T6 heat treatment is commonly used for gravity cast Al-Si-Cu-Mg alloys. The influence of the alloying elements Cu and Mg and the artificial ageing temperature on the age hardening at 170 ° C and 210 ° C .The Al-Si-Mg alloy has a better combination of yield strength and elongation to fracture than the Al-Si-Cu-Mg alloy when the required yield strength is below about 300 Mpa [10].

It is evident from literature survey that the intermetallic compound plays a great role for industrial application. It is understood the present problem play a great role for industrial application and experimental study of aluminium, copper and magnesium was used as per their atomic weight to form intermetallic compound Al_2CuMg, which was used to study the mechanical properties of aluminium alloy. Initially 5%weight percentage of intermetallic compounds has been used to check the effect on aluminium material.

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II. Mathematical Analysis

In the Table I, The chemical composition was obtained with spectrometer and it has found in the base material, the aluminium percentage was 97.28 and remaining Cu-0.3, Mg 0.35, Si 0.4, Mn 0.5, Ni 0.031, Zn 0.15, Pb 0.08, Sn 0.025,Ti 0.04 percentage respectively. The same result represents in the Fig. 1. The graphical representation in between elemental composition of Al alloy and percentage amount in Al alloy. The highest peak showed aluminium percentage and remaining miscellaneous.

III. XRD Analysis

The X-ray diffraction (XRD) is a versatile, nondestructive analytical method to analyze material properties like phase composition, structure, texture and many more of powder samples or even liquid samples. The tests were performed to find out formation of wt. percentage of intermetallic compound.

From the Fig. 2, the height peak count at 55.5 wt. percentages has shown the intermetallic compound and44.5wt. percentage of miscellaneous material obtained in partial inert space. The 100 mesh size compound was used to test in the powder form.

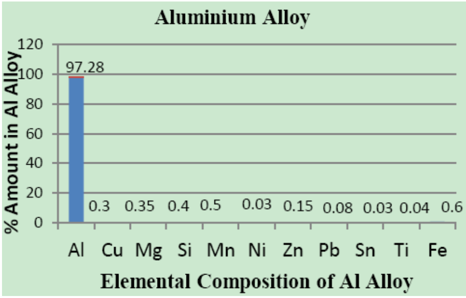

Fig. 1. Chart for chemical composition of base metal (Aluminum alloy).

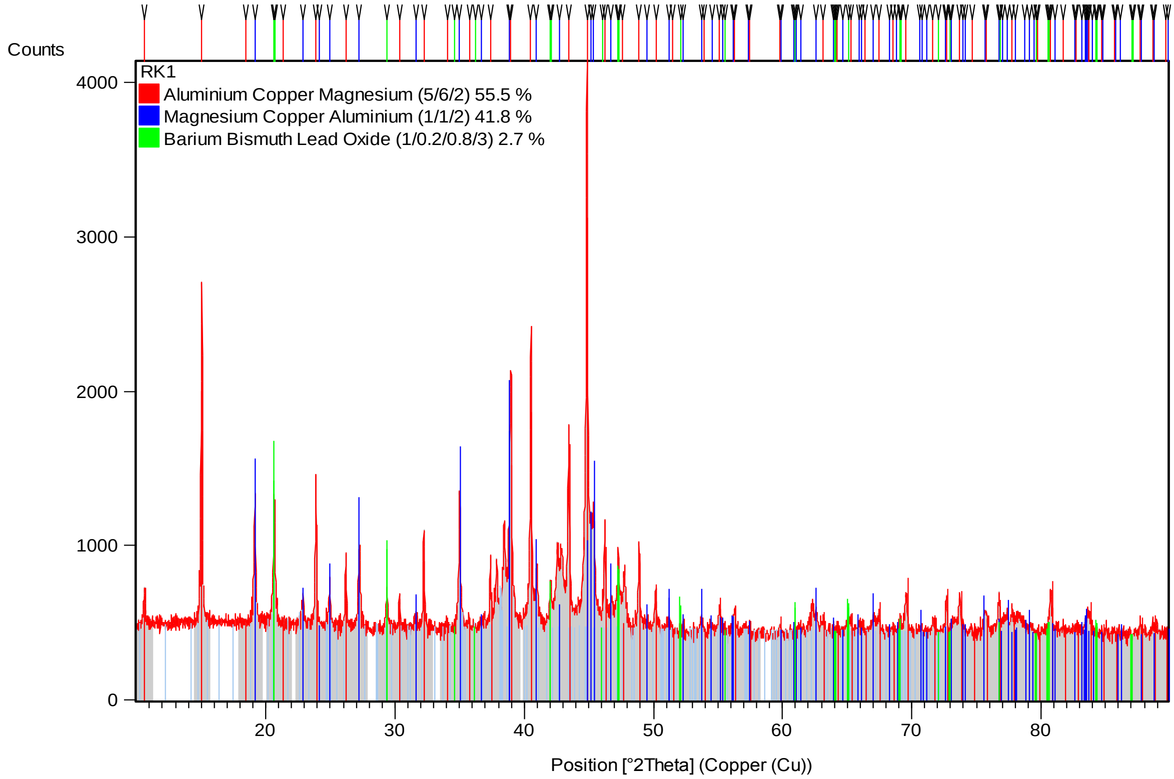

Fig. 2. The XRD pattern of Al_2CuMg.

TABLE I: Chemical Composition of Aluminum Alloy

Al	Cu	Mg	Si	Mn	Ni	Zn	Pb	Sn	Ti
97.28%	0.3%	o.35%	0.4%	0.5%	0.031%	0.15%	0.08%	0.025%	0.04%

IV. XRF Analysis

The X-ray fluorescence analysis (XRF) is one of the best analytical techniques to perform elemental analysis. The X-ray Fluorescence Analyser (XRF) tests were performed to find different compounds available in the intermetallic material.

The Table II, showed Al_2O_3 44.87, CuO 35.21, MgO 19.21, Fe_2O_3 0.29, SiO_2 0.24, HfO_2 0.03, Cr_2O_3 0.03, MnO 0.02 and Pb_2O_5 0.02 percentage respectively. The highest Al_2O_3 44.87 percentage obtained in the compound.

In Fig. 3, the graphical representation shown for various compounds tabulated in the Table II. The highest peak obtained Al_2O_3.

TABLE II: Elemental Composition of Al_2CuMg

Al_2O_3	CuO	MgO	Fe_2O_3	SiO_2	HfO_2	Cr_2O_3	MnO	Pb_2O_5
44.87 %	35.21 %	19.21 %	0.29 %	0.24 %	0.03 %	0.03 %	0.02 %	0.02 %

TABLE III: FOR TENSILE & HARDNESS TEST

Material for study	Diameter of specimen, mm	Gauge Length, mm	Area, mm^2	Ultimate Force, N	Ultimate Stress, MPa	Total Elongation,%	Hardness HV
Base Material	9.22	30	66.8	6570	85.0	24.84	31.8
New Material	9.22	30	66.8	6570	98.5	48.3	48.7

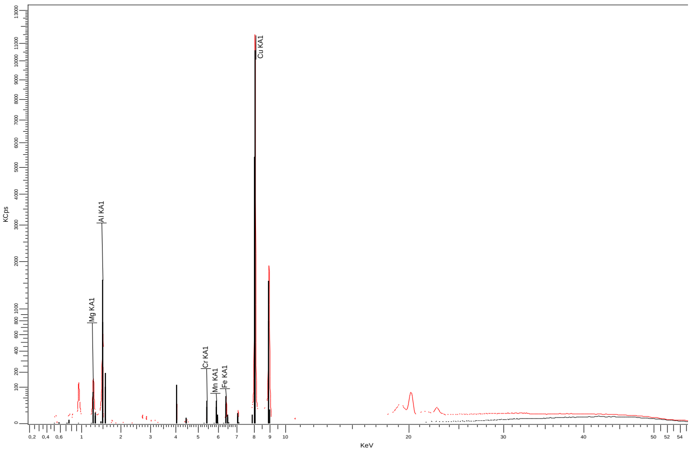

Fig. 3. The XRF pattern of Al_2CuMg.

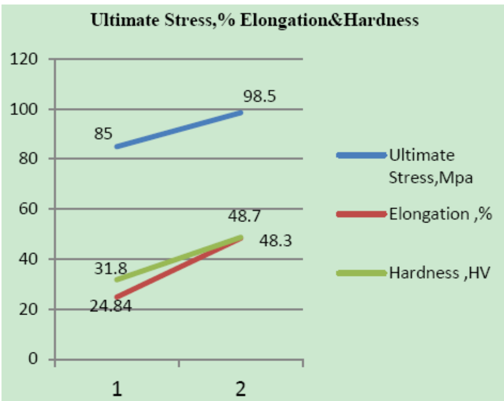

Fig. 4. Graphical representation of ultimate stress, % elongation and hardness.

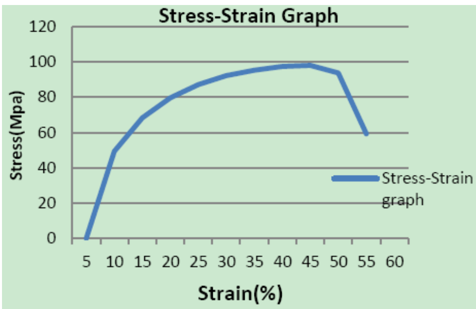

Fig. 5. Graphical representation in-between stress and strain.

In the Table III, the tensile test specimen with specifications as diameter 9.22mm, gauge length 30 mm, area 66.8 mm was used for analysis the ultimate tensile stress, % elongation test performed at tensile testing machine and compared with base material and new material and hardness test were performed at Vickers hardness tester on base material and new material as value find out31.8 and 48.7 respectively with improved results. The Vickers test provides a good continuous scale for hardness from soft to hard materials without change of indenter for different ranges.

The Fig. 4 showed the graphical representation for ultimate stress, elongation and hardness values.

In the Fig. 5, the graph plotted for stress and strain values. The maximum value of stress for base material is 85 Mpa and for new material is 98.5 Mpa, this is a good improvement with using intermetallic compound. The maximum elongation obtained 24.84 percentage for base material and for new material value obtained 48.3percentage. The new Material has obtained good strength and ductility. These improved results will be beneficial for industrial application.

V. RESULT AND DISCUSSIONS

The tensile and hardness test were performed to find out suitable improvements as shown in the Table III. The XRF patterns of Al2CuMg clearly indicate elemental proportions of composite material with packing of aluminium in substance. This property achieved by virtue of coareness and synthetization of materials at controlled temperatures for longer durations makes the material suitable for industrial applicaions. The hardness has shown marginal enhancement over base material.

VI. CONCLUSION

In the experimental work, the tensile strength properties improved 13.7 Mpa % and the hardness value improvement is 34%. The new material has shown significant improvement in tensile strength and hardness properties of the material over the base material. The relationship between stress to strain has expressed vulnerability of these type of composite materials to weathering conditions.

VII. FUTURE SCOPE

The present studies have given us overall idea about change in innate characteristics of the composite material. In the experimental study to prepare intermetallic compound in partial inert space using TIG welding heating sources now, we are trying to develop 100 wt. percentage intermetallic compounds for further study. The materials thus developed will find abundant scope in commercial use in industrial applications.

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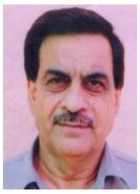

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