

Development of Aluminum-Zinc Alloy by Adding Zn Solid and Zn Powder

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Abstract

Aluminum is most versatile material for various application like Aerospace, Marine and Transport industry due to high strength to weight ratio. Aluminum is alloyed with various element like copper, magnesium, zinc and silicon to obtain desired properties among which 7xxx (Al-Zn) series exhibits outstanding properties. This paper present idea to developed Al-Zn alloy by adding Zn in solid as well as powder form. Aluminum is doped with 1%, 3% and 5% Zinc by weight percent in both form. We get highest recovery in case of solid. Addition of Zn is also evaluated by hardness, tensile strength value and electrical conductivity. Superior properties are obtained in case of Zn solid.

Keywords: Aluminum, Aluminum- Zinc Alloys, Recovery, Hardness, Tensile Strength

I. INTRODUCTION

Aluminum is second most plentiful element. It is third most abundant element after silicon and oxygen from earth's crust. It is light metal and density of aluminum is one third of the steel. Aluminum became a common structural material because of unique combination of properties. It is light material, having density one third of the steel. It finds application to reduce the weight of components and structure, particularly connected with transport, especially with aerospace. High strength to weight ration can be achieved in certain alloys [1,2]. It has a good electrical and thermal conductivity. It can be easily cast, rolled to any desired shape due to good ductility and also it has high metallic luster so used for photographic reflector. It has high resistance to atmospheric corrosion due to thin, continuous aluminum oxide layer on the surface [3,4].

Aluminum and its alloys are used in a variety of cast and wrought form and condition as well as heat treated condition. To meet various requirement, aluminum is alloyed with copper, manganese, magnesium, zinc, nickel and silicon as major alloying element. These alloying addition improves the properties of aluminum when added in desire percentage [5]. Aluminum-Zinc alloy is first commercial alloy which has highest mechanical strength among all heat treatable alloys due to high strength to weight ratio & widely used in aerospace industry. From all alloying element Zinc have highest solid solubility in Aluminum which is 66.4 atomic weight percent so it will improve strength by solid solution strengthening and addition of magnesium makes alloy age hardenable. Thus strength and hardness of alloy increasing as zinc content [6,7].

II. MATERIALS AND METHODS

The pure aluminum is melted in graphite crucible by using resistance heating furnace. Zinc is added in to liquid aluminum around 660-700° C temp. The amount of addition is 1%,3% and 5% Zn in solid as well as powder form. The Zinc added is melt, poured in to permanent metallic die. Energy dispersive spectroscopy is done for chemical analysis. The static tensile testing is carried out by Monsanto tensile machine with stain rate 0.05. The Brinell hardness tester used to measure hardness. An average of six reading are taken in to consideration for final hardness value. Electrical conductivity test were performed to check the variation of Zn concentration.

III. RESULTS & DISCUSSION

A. Chemical Analysis of Raw material

Following table 1 indicate chemical analysis of all raw materials like commercially pure aluminum, Zinc solid & Zinc powder.

Table – 1
Chemical analysis of raw material

<i>Chemical composition (%)</i>	<i>Pure Aluminum</i>	<i>Zn solid</i>	<i>Zn Powder</i>
<i>Aluminum</i>	95.92	78.91	89.81
<i>Oxygen</i>	2.60	21.09	10.19
<i>Magnesium</i>	0.43	-	-
<i>Zinc</i>	0.08	-	-

Silicon	0.64	-	-
Iron	0.33	-	-
Total	100	100	100

Above table indicate that pure aluminum have 0.08% Zn and others impurities in the range of 2-4% from which 2.5% is oxygen. Zinc solid have around 79% Zinc and remaining 21% is oxygen. Zinc powder have 90% Zinc and remaining 10% is oxygen.

B. Chemical Analysis of Developed Alloy

By the addition of Zinc 1%,3% and 5% in Zinc solid and powder form six system are developed. Following table 2 indicate chemical analysis of developed system.

Table – 2
Chemical analysis of developed alloy

Chemical analysis	Al+1% Zn Solid	Al+3% Zn Solid	Al+5% Zn Solid	Al+1% Zn Powder	Al+3% Zn Powder	Al+5% Zn Powder
Aluminum	83.01	80.92	78.93	92.13	92.24	89.85
Oxygen	14.40	15.15	15.61	6.65	5.50	6.80
Magnesium	0.30	0.30	0.32	0.21	0.18	-
Zinc	0.71	2.11	3.52	0.63	1.87	3.12
Silicon	1.18	1.11	1.18	0.22	0.21	0.22
Iron	0.40	0.41	0.43	0.16	-	-
Total	100	100	100	100	100	100

Recovery of Zinc is higher in case of Zn solid compare to Zn powder. In all cases of Zinc solid we get recovery around 70% and in all cases of Zn powder recovery is around 62%. Recovery of Zn increases as we increase Zn content in both forms.

C. Mechanical Properties of Developed Alloy

Following Table 3 indicates changes in tensile property of developed alloy by changing amount of Zn and Source of Zn (Solid & Powder Form)

Table – 3
Mechanical properties of Developed alloy

Sr.No	Developed alloy	Tensile strength (N/mm ²)	Hardness (BHN)
1	Pure aluminum	90	45
2	Al+1% Zn Solid	132	44
3	Al+3% Zn Solid	139	47
4	Al+5% Zn Solid	158	49
5	Al+1% Zn Powder	133	43
6	Al+3% Zn Powder	135	46
7	Al+5% Zn Powder	145	48

Above Table 3 indicates variation in tensile strength and hardness with addition of Zn solid and Zn powder in different fraction. In case of Al+5% Zn Solid we get highest tensile strength 158 N/mm² which is 40% higher compare to pure aluminum and hardness is 49 BHN. Zn will improve strength of alloy by solid solution strengthening mechanisms and hardness also.

D. Electrical Conductivity of Developed Alloy

To check the presence of Zn electrical conductivity measurement was done and computed in table 4.

Table – 4
Electrical conductivity of Developed alloy

Sr.no	Developed alloy	Electrical conductivity (% IACS)
1	Pure aluminum	47
2	Al+1% Zn Solid	42
3	Al+3% Zn Solid	40
4	Al+5% Zn Solid	34
5	Al+1% Zn Powder	42
6	Al+3% Zn Powder	41
7	Al+5% Zn Powder	38

Table 4 indicates reduction in electrical conductivity. It is highest in case of Al+5% Zn Solid which is 28% lower than pure Al.

IV. CONCLUSION

- Maximum Zn recovery we get in solid form & hence successful alloying done in case of Zn solid.
- As Zn content increases tensile strength and hardness increases.
- As Zn content increases electrical conductivity decreases.

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