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Environmentally Friendly Process for Making Ai-Mg Alloys for Structural Usage

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Abstract:
Aluminum magnesium alloys are the ideal material for usage in the aerospace, automotive, and structural industries as well as in composite manufacturing. Al-Mg alloy is created in this instance using a plunger rod and a modified stir casting technique. It can be used to make composite materials and brake shoes. Magnesium loss in this production process is minimal. The outcome demonstrates that more than 90% of the magnesium is recovered, and the alloy's hardness also increases. The mechanical characteristics of Al-Mg Alloys are enhanced by the addition of Mg. Studying the impact of furnace temperature on the production of Al-Mg alloys revealed that 8000C produces the best results.
Key Words: Al-Mg alloy; Furnace temperature; Mg recovery;Hardness

1. Introduction

Materials with a high strength-to-weight ratio are always needed for structural applications. Aluminum-magnesium alloys are the best materials for the applications in this competition. It offers higher production quality and good mechanical strength [1-3]. Due to magnesium's volatility, there is reduced recovery of magnesium during the production of aluminum-magnesium alloys. Thus, the alloys made using the plunger approach have a high magnesium recovery. Magnesium addition boosts alloy strength and improves corrosion resistance while also lowering alloy density, which is highly advantageous in structural applications [4-5]. The alloy preparation method that uses plungers is economical and environmentally beneficial. Plunger technique for alloy preparation makes it considerably simpler and more effective to add the volatile Magnesium ingredient.

In this study, a novel process for preparing aluminum-magnesium alloys—the plunger technique—was employed. Magnesium chips, which are less expensive, are employed here to prepare the alloy. Magnesium has a lower boiling point than aluminium, which affects how much of the element is recovered in the alloy. The goal of the current study was to create a method for producing Al-Mg alloys through casting using inexpensive magnesium turnings [8–9]. In order to get a high recovery of magnesium in the alloy, the plunger approach proved useful in reducing magnesium loss in the liquid route. Despite the magnesium being in the form of turnings, more than 90% of it was retrieved. This method was thought to be useful for adding alloying materials with high volatility and significant density differences. The amount of magnesium recovered in the alloy is significant, which lowers the amount of magnesium lost during alloy preparation [9–11]. The Al-Mg Alloys were created in furnaces heated to 7000°C, 8000°C, and 9000°C, and their hardness was measured.

2. Experimental procedure

The plunger technique apparatus was used to produce the required Aluminum-Magnesium alloys. Here the solid shaft of the stir rod was converted to hollow one as shown in figure(Figure 1), where the required quantity of Magnesium through Plunger rod are introduce to the Aluminum melt. The different percentages of Magnesium i.e. 1, 3, 5, 7, 10 by weight areused for the alloy preparation.

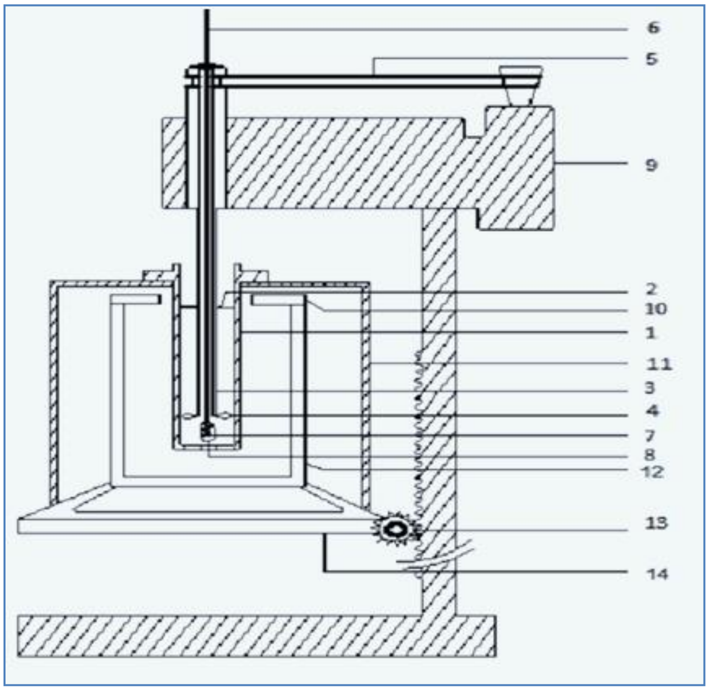

Figure 1: Diagram of Plunger Technique Apparatus to Prepare Aluminium-Magnesium Alloys

1. Heating pot
2. Melt Level
3. Hollow Spindle
4. Impeller Blade
5. V-belt Drive
6. Plunger Rod
7. Capsule
8. Mg turnings Particle
9. Gear Assembly and Motor
10. Split Cover
11. Crucible Holder
12. Electric Furnace
13. Rack and Pinion Arrangement
14. Base Plate

2.1Materials

Commercial Al ingots were used to prepare Al-Mg Alloys, the composition of the Al ingot is tabulated in Table 1.The chemical composition of Magnesium turning is represented in Table 2.

Table 1: Chemical contains of Aluminum ingot

Cu	V	Mn	Si	Fe	Al
0.001	0.006	0.003	0.08	0.15	99.76

Table 2: Magnesium Chemical composition for preparation of alloys

Cu	Mn	Mg	Zn	Ni	Al	Si	Pb	Fe
0.005	0.1	99.68	0.005	0.005	0.05	0.1	0.005	0.05

2.2 Methodology

Aluminium metal matrix as liquid form was taken in a cast iron crucible .A hollow spindle having three stirred blades fixed at the lower end was used for mixing. A screw feeder assembly was introduced through the hollow spindle for delivering the additions below the agitating blades (Figure 2). Mg turnings were taken into the plunger rods to feed it into the Al melts. Aluminum melts at 660^0C, so furnace temperature is maintained above 700^0c and the plunger rod containing Mg particulates wrapped with Al foil are used to feed into the Liquid Al melts. Then the liquid Al-Mg alloys poured into the mould to get the casting. After cooling, samples are collected & cut to size for different sizes for testing.

Figure 2: Photograph of perforated mild steel capsule welded to plunger rod, Mg particles inside the capsule shown wrapped with Al foil

3. Results and discussion

3.1 Magnesium recovery

Prepared alloys samples are collected to get the chemical analysis. Magnesium content was measured to calculate magnesium recovery. ASTM-E-1251-2007 method was followed. The

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results are given in Table 3-5. Magnesium recovery was calculated for percentage of magnesium added.Figure 6show of Mg Recovery versus percentage of Mg added.

Table 3: % of Mg added vs. % of Mg recovery at furnace temperature 700^0C

%of Mg added	1	3	5	7	10
%of Mg recovery	94	93.5	92	89	84

Table 4: % of Mg added vs. % of Mg recovery at furnace temperature 800^0C

%of Mg added	1	3	5	7	10
%of Mg recovery	95	95	94	90	87

Table 5: % of Mg added vs. % of Mg recovery at furnace temperature 900^0C

%of Mg added	1	3	5	7	10
%of Mg recovery	94	93	91	87	84

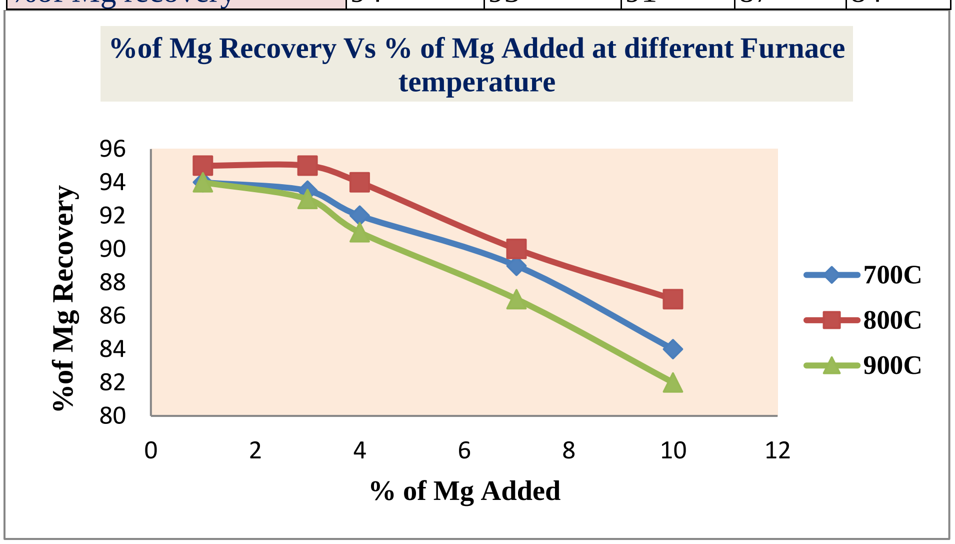

Figure 6: % of Mg Recovery VS % of Mg added

3.2 Hardness

To begin with mechanical strength property indicator, hardness parameter determination was made for laboratory scale and tabulated. The hardness of the casting sample was measured in the middle of the casting. The measured hardness (VHN) data were tabulated in following Tables 6 to 8at different furnace temperature.Figure 7indicates the graphs between the hardness and the percentage of of magnesium added at different furnace temperatures.

Table 6: Hardness of castings at furnace temperature of 700^0C

%of Mg added	1	3	5	7	10
Hardness (VHN)	71.9	73.26	77.13	83.54	86.69

Table 7: Hardness of casting furnace temperature of 800^0C

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%of Mg added	1	3	5	7	10
Hardness (VHN)	74.7	76.59	80.38	86.16	89.04

Table 8: Hardness of casting at furnace temperature of 900^0C

%of Mg added	1	3	5	7	10
Hardness (VHN)	73.25	75.93	78.62	85.36	87.58

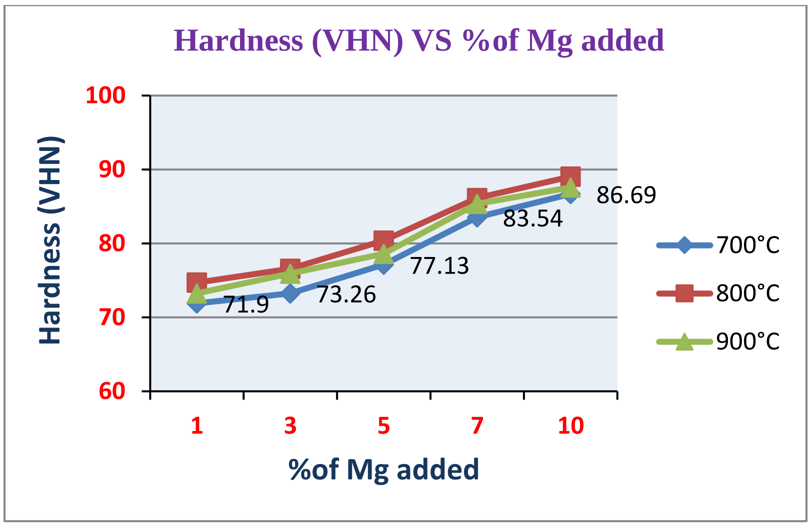

Figure 7: Graph between Hardness and % of Mg added at different furnace temperatures.

4. Conclusions

More than 90% of the magnesium in the cast magnesium alloys produced was recovered using the plunger method. The findings from Fig. 3.1 show that the furnace's temperature has a significant impact on magnesium recovery. Around 8000 c, magnesium recovery is at its maximum. The recovery reduces as the percentage of magnesium addition rises and the furnace temperature rises. Al-Mg alloys offer high percentage recovery of magnesium produced by the plunger method, which is a low-cost and highly efficient method for alloy manufacture. As a result, the hardness value has significantly enhanced as compared to aluminium, a base metal. Figure 3.2 demonstrates that at 8000C in the furnace, the hardness is increased. Additionally, it demonstrates that alloy hardness improves along with alloy magnesium content.

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