PUBLISHED PAPER 1

Study the Influence of MnO_2 and $MnCl_2$ on Microstructure and Mechanical Properties of Pure Magnesium

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Abstract

Manganese is an important major addition for many magnesium alloys. It eliminates the Fe impurities responsible for poor corrosion properties of Mg alloys. In this study, six different magnesium systems were developed by the addition of MnO_2 and $MnCl_2$ at 750°C, 800°C, 850°C temperatures to check the solubility of manganese in pure magnesium. Solubility of manganese was highest in Mg-MnO_2 system at 850°C temperature (0.85%) compare to other. Optical photographs revels the grain refinement of pure Mg due to presence of Mn. Hardness of these samples was examined via micro vicker's hardness tester at 100 gms. Around 40% of hardness and ultimate tensile strength of the pure magnesium was increased by the addition of <1% manganese. There was no major difference observed in hardness value in MnO_2 and $MnCl_2$ samples.

Keywords: Pure magnesium, MnO_2, $MnCl_2$, Solubility, Grain refinement, Hardness, UTS

1. INTRODUCTION

Magnesium alloys are being increasingly evaluated for applications in automotive components due to their outstanding properties such as low density, high specific strength, castability, machinability at high speeds, and weldability under controlled atmospheres. The automobile industry is already utilizing cast magnesium alloys due its extra ordinary properties [1].

Magnesium alloys have an excellent combination of properties which includes excellent strength-to-weight ratio, good fatigue and impact strengths, and relatively large thermal and electrical conductivities [1–3] and excellent biocompatibility [4, 5]. This makes magnesium alloys one of the most promising light-weight materials for automotive [6], aerospace, consumer electronic (computer, camera, and cell phone), and biomedical applications due to its biodegradability. The addition of manganese is usually strategic and aimed at lowering the effect of the iron (Fe) impurity content in order to control the overall corrosion of Mg-Al alloys [7, 9]. Mn also plays an important role in the control of the microstructure. For example, it influences the crystal grain size in the solidification structure and the grain refining response, such as superheating, and prevents abnormal germination, which occurs during solution heat treatment [10]. Manganese is generally added in the quantity of 0.34% to transform the iron and other heavy-metal elements into relatively harmless intermetallic compounds, is in the area surrounding the nodules [8]. This paper focuses on the effect of addition of different sources of Mn like MnO_2 and $MnCl_2$ in pure magnesium at 750°C, 800 °C and 850°C temperature. Mg-MnO_2 and Mg-$MnCl_2$ systems were developed at 750°C, 800°C and 850°C temperature. Microstructure of followed systems was observed in optical microscope. Hardness and tensile properties were evaluated by micro vickers' hardness at 100 gm load and UTM respectively.

2. EXPERIMENTAL WORK

Fig. 1 Steps involved in experimental work

PUBLISHED PAPER 2

Effect of Various Forms of Manganese and Its Recovery in Pure Magnesium Metal

Sonam M. Patel and Vandana J. Rao

Abstract Manganese solubility in magnesium mainly depends on temperature, manganese sources, and the presence of other alloying elements. In this study, five different Mg–Mn systems were developed by the addition of different sources of manganese. To check the recovery of manganese in pure magnesium, each alloy was developed by adding the same weight% of the manganese-containing source (5 wt%) at the same temperature (850 °C). Among all manganese sources, the recovery of manganese was highest in the case of electrolytic manganese flakes containing system. Optical pictures of all developed systems revel the grain refinement of pure magnesium because of the presence of manganese. Hardness and ultimate tensile strength of magnesium were increased by the addition of all sources of manganese. Maximum ultimate tensile strength and hardness were achieved in electrolytic manganese flakes containing system. However, % elongation decreases as the wt% of manganese increases like in the case of electrolytic manganese flakes containing system.

Keywords Mn sources · Mg–Mn alloy · Grain refinement · Hardness · Ultimate tensile strength · Elongation

1 Introduction

Magnesium alloys are broadly used as structural materials, as a result of their low density, good damping capacity, high specific strength, and castability [1–3]. This all characteristics of magnesium alloys are make it ideal to use in the automotive and aerospace industry to fulfill weight reduction and higher fuel efficiency requirements

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 929
S. K. Acharya and D. P. Mishra (eds.), *Current Advances in Mechanical Engineering*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-33-4795-3_86

PUBLISHED PAPER 3

IOP Publishing Mater. Res. Express 8 (2021) 116503 https://doi.org/10.1088/2053-1591/ac30b2

Materials Research Express

CrossMark

OPEN ACCESS

RECEIVED
31 July 2021

REVISED
14 October 2021

ACCEPTED FOR PUBLICATION
18 October 2021

PUBLISHED
15 November 2021

PAPER

Synthesis and characterization of magnesium melting fluxes

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Keywords: magnesium melting, covering flux, decomposition temperature, surface morphology, weight loss

Abstract

Magnesium and its alloys are extremely susceptible to oxidation and fire due to their reactivity with oxygen. Therefore, special care should be taken while melting them. In this research, different types of fluxes were used to protect the molten magnesium from oxidation. These fluxes cover the molten magnesium surface and refine it. In this research, nine magnesium melting and refining fluxes were studied. Dow fluxes compositions were taken as a base to prepare five fluxes and another four fluxes were developed by varying the content of chlorides, fluorides, and oxide. The main purpose of this research is to increase the recovery of magnesium metal by melting in normal atmospheric conditions and develop a low-cost conventional melting practice. Decomposition behavior, mass change, and melting of these nine fluxes were studied by TG/DTA technique. After fusing, the surface morphology of these fluxes was studied by visual observation and scanning electron microscope. Magnesium was melted using these nine fluxes and for each flux, the weight loss of magnesium was calculated. From a thermal analysis study, it was confirmed that all the fluxes were fused before magnesium melting. Based on the flux layer which was generated during the melting and the weight loss analysis, flux 9 (250) was the best flux compared to other fluxes. The highest purity was obtained by using flux 2 with the highest tensile strength value.

1. Introduction

Magnesium alloys are widely used in numerous applications, from automotive to electronics, due to their unique characteristics. Magnesium shows high potential to substitute conventional materials such as iron and aluminum in specific applications where damping resistance is important [1–4]. Magnesium is a relatively low-cost metal with low density and machinability. All these properties make it an excellent candidate as a structural material [5, 6].

Molten magnesium has a high tendency to oxidize. So, to protect it from oxidation and burning, surface care should be taken. If the oxidation of magnesium is not controlled, a porous, non-sticky MgO layer is formed on the surface of the molten metal. This layer cannot be prevented, so it creates a passage of oxygen into magnesium melt. As a result, the liquid metal burns and forms more oxide. In addition, magnesium and its alloys evaporate easily, so the extremely fine powder will form around the cold areas of the melt. This magnesium dust easily ignites due to the high surface-to-volume ratio. Therefore, to prevent the melt from oxidation and control magnesium from evaporation is very crucial [7–10].

Magnesium has a tendency of oxidizing and contaminating with non-metallic inclusions. So, casting is done by fluxing technique or flux-less technique (in presence of gas or vacuum) [11]. Non reactive gases, such as nitrogen, argon and oxide film modifiers like sulfur hexafluoride (SF_6), sulfur dioxide (SO_2) are used in the fluxless method. Sulfur hexafluoride is an effective cover gas due to its ability to form a dense film containing magnesium oxide (MgO) and Mg fluoride (MgF_2) on the molten magnesium surface. This film prevents further oxidation and evaporation of magnesium. However, SF_6 is very expensive and an extremely powerful greenhouse gas, with a 100-year global warming potential which is estimated at 23,900 times that of carbon

PUBLISHED PAPER 4

IOP Publishing Eng. Res. Express 4 (2022) 045035 https://doi.org/10.1088/2631-8695/aca9a8

Engineering Research Express

PAPER

CrossMark

RECEIVED
4 October 2022

REVISED
23 November 2022

ACCEPTED FOR PUBLICATION
7 December 2022

PUBLISHED
16 December 2022

Effect of Mn on microstructure, mechanical properties, and corrosion behaviour of Mg-Ni alloys

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Keywords: Mg-Ni alloy, Mg-Ni-Mn alloy, microstructure, mechanical properties, corrosion behaviour

Abstract

Previous research on Mg-Ni alloys focused on the mechanical characteristics and damping behaviour in the presence of Zn and rare Earth elements. There has not been much research on the Mg-Ni-Mn alloy's microstructure, mechanical properties, and corrosion behaviour. The present research work fulfills this gap by concentrating on the microstructure, mechanical, and corrosion characteristics of Mg-Ni-Mn alloys. Here, different Mg-Ni-Mn alloys were developed by varying the nickel and manganese content. The microstructure of the developed alloys was studied using an optical microscope and scanning electron microscope. Ultimate tensile strength and microhardness of all alloys were performed on a tensometer (room temperature), and Vickers hardness tester respectively. The corrosion rate of Mg-Ni and Mg-Ni-Mn alloys was measured at 3.5 wt% NaCl solution by immersion test. The result shows that the nickel and manganese presence refine the grain size of magnesium. XRD analysis confirmed the presence of α-Mg and Mg_2Ni phases in Mg-Ni alloys. Along with these phases, the Mn phase was observed in Mg-Ni-Mn alloys. Mechanical properties such as ultimate tensile strength and hardness of pure magnesium were increased in the presence of Ni and Mn. However, the presence of manganese in Mg-Ni alloy shows an adverse effect on corrosion behaviour. The corrosion rate of the Mg-Ni alloy was accelerated in the presence of manganese.

1. Introduction

The demand for magnesium alloys in automobiles, industrial sectors, and aerospace industries is increasing day by day due to their low density, high specific strength, good castability, good machinability, and excellent damping capacity. However, along with these excellent properties, magnesium is also known for its reactive nature. It is prone to a higher rate of corrosion. Thus, it is necessary to study the mechanical properties as well as the corrosion behaviour of magnesium alloys [1–8].

As per available literature, the presence of elements like Cu, Fe, Ni, and Co rapidly increases the corrosion rate of magnesium. If nickel presents more than 0.004 wt%, it increases the corrosion rate drastically. This detrimental effect of nickel limits its use in industrial fields [9, 10]. Since the fact that nickel precipitates in magnesium alloys as Mg_2Ni, which is more cathodically active than $FeAl_3$ and Fe, nickel in magnesium alloys has a higher cathode activity than iron in pure magnesium and magnesium alloys [11]. However, Hassan *et al* reported that the formation of Mg_2Ni intermetallic increases room temperature yield strength and ultimate tensile strength [12]. X S Hu *et al* investigated the damping capacities of Mg-Ni alloys. They observed excellent damping capacities in hypoeutectic Mg-Ni alloys. They found that less than 12.1 wt% Ni-containing Mg-Ni alloys possess high damping values [13]. Niu *et al* developed Mg-4Zn-xNi alloys. According to their findings, the compressive strength and microhardness value increased with increasing nickel content. The presence of the Mg_2Ni phase in the Mg-Zn series alloy aggravates galvanic corrosion and increases the degradation rate [14, 15].

It has been reported that Mn is added to many magnesium alloys to enhance corrosion resistance. It also improves the ductility and tensile properties of magnesium alloys. In addition, the Mn addition reduces the

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Action	Manuscript Number	Title	Initial Date Submitted	Status Date	Current Status	Date Final Disposition Set	Final Disposition
Action Links	MATPR-D-23-02420	Microstructure, Mechanical Properties and Corrosion Behaviour of Mg-Cu and Mg-Cu-Mn Alloys	Mar 15, 2023	Jun 19, 2023	Completed - Accept	Jun 19, 2023	Accept

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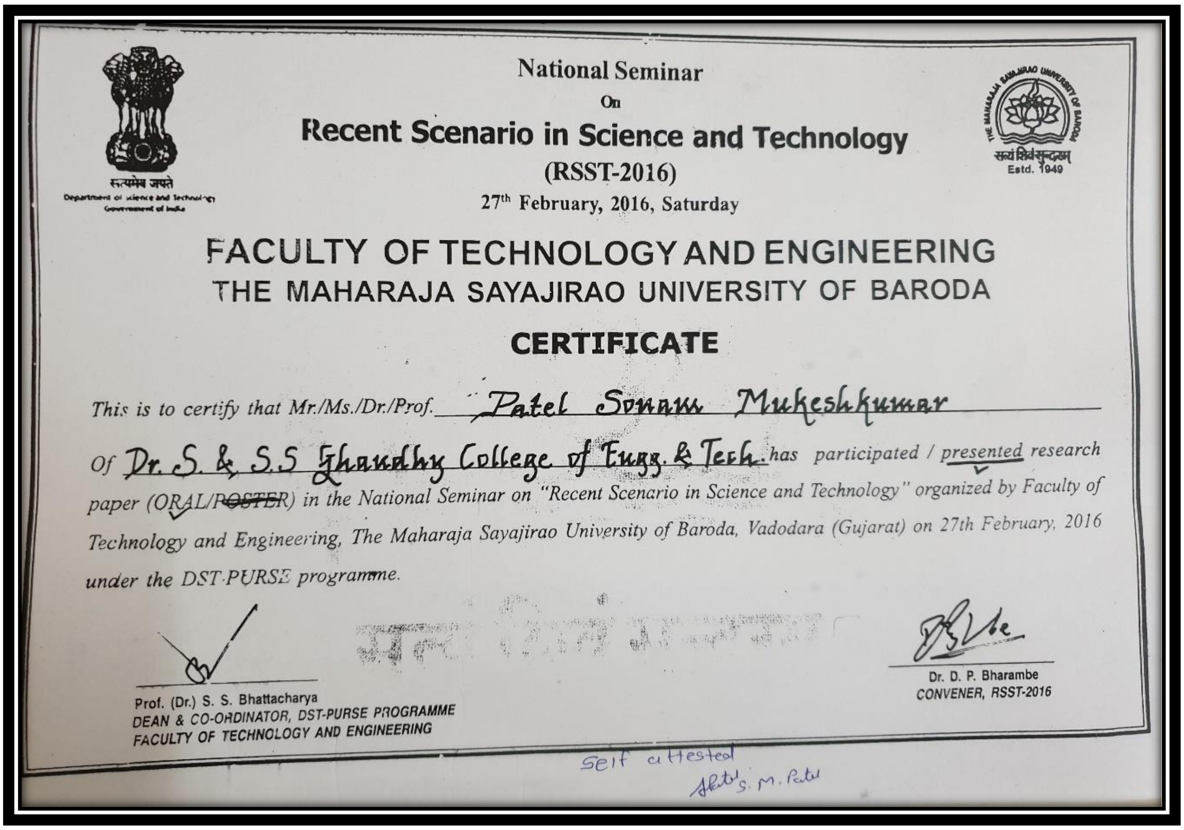

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BEST PAPER AWARD

Paper ID & Title of the paper
CCM 6057 - Microstructure, Mechanical Properties and Corrosion Behaviour of Mg-Cu and Mg-Cu-Mn Alloys

Author(s)
Sonam Patel, Vandana Rao

Date & Session of presentation
10.02.2023 & ME 04

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