Materials and Design 63 (2014) 384–388

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Technical Report

Compressive behaviour of SiC/ncsc reinforced Mg composite processed through powder metallurgy route

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ARTICLE INFO

Article history:
Received 20 January 2014
Accepted 17 June 2014
Available online 25 June 2014

ABSTRACT

In this present work nano coconut shell charcoal (ncsc) and silicon carbide (SiC) particulates were reinforced with AZ31B Mg alloy and suitable magnesium composite was developed by using the powder metallurgy technique followed by hot extrusion. Density measurement of the Mg composites revealed that the addition of ncsc significantly improved the density of the composites and porosity measurement showed minimal porosity. The microstructure of the composites showed even distribution of the ncsc in the AZ31B/3SiC Mg composite. The compressive and impact behaviour of the samples were characterized, the results showed that on increasing the weight percentage of ncsc in AZ31B/3SiC/0.5ncsc Mg composites the mechanical properties such as ultimate compressive strength, 0.2% yield strength, ductility and impact strength decreased. The scanning electron microscope (SEM) analysis of fractured surface of AZ31B Mg alloy and AZ31B/3SiC/0.5ncsc Mg composites showed quasi-cleavage fracture. The presence of ncsc above 0.5 wt% composites revealed mixture of quasi cleavage planes and some dimples.

1. Introduction

The density of Mg is 1.74 g/cm^3 when compared to Al it is 35.6% lower. Because of its low density Mg based materials find their applications in automobile and aerospace industries [1]. The Mg alloys that are named as AZ alloys have been used extensively in industries. Various grades of AZ alloys are AZ31, AZ61 and AZ91 [2]. Low ductility, toughness and stiffness are the main drawbacks of magnesium based materials when compared to aluminium based materials. In recent studies it was reported that the work of fracture and ductility of magnesium can be increased by using reinforcements [3]. Among various reinforcements used like SiC, Al_2O_3, coconut shell charcoal is one of the low density reinforcement available in large quantities. Coconut shell contains 33.61% cellulose, 36.51% lignin, 29.27% pentosans and 0.61% ash as organic constituents [4]. When compared to ingot metallurgy process, powder metallurgy technique can eliminate reinforcement segregation [5]. In [6] pure Mg is reinforced with 10 vol%SiC and the composite is processed through powder metallurgy and microwave sintering, the particle size of SiC used is 25 μm. The ductility and 0.2% yield strength decreased on increase in vol% of SiC. In [7] pure Mg is reinforced with 4.8, 10.2 and 15.4 wt% of SiC and processed through disintegrated melt deposition technique, the particle size of SiC used is 0.6 μm. This chemical composition of Mg/4.8SiC showed improved results. In [8] pure Mg is reinforced with SiC of 50 nm and Al_2O_3 of 50 nm processed through powder metallurgy and microwave sintering. The chemical composition of Mg/0.3 vol%SiC/0.7 vol%Al_2O_3 showed improved 0.2% yield strength and Mg/1.0 vol%SiC showed improved ductility. In [9] pure Mg is reinforced with SiC of (45–55 nm) processed through powder metallurgy and microwave sintering. The chemical composition of Mg/1.8 wt%SiC showed improved ductility and 0.2% yield strength when compared to Mg/0.65 wt%SiC and Mg/0.92 wt%SiC. In [10] AZ31B Mg alloy is reinforced with 1.50 vol%Al_2O_3, 1.11 vol%Al_2O_3 and 0.66 vol%Al_2O_3 processed through disintegrated melt deposition, the particle size of Al_2O_3 is 50 nm. AZ31B Mg alloy showed improved 0.2% yield strength when compared to Al_2O_3 reinforced composite whereas AZ31B/1.50 vol%Al_2O_3 showed improved ductility. In [11] AZ31B Mg alloy is reinforced with 10 vol% CNT and processed through disintegration melt deposition, the particle size of CNT is (40–70 nm). When compared to pure AZ31B Mg alloy the mechanical properties such as 0.2% yield strength and ductility showed significant improvement. In [12] AZ31B Mg alloy is reinforced with 3.3 wt%Al_2O_3/1 wt%Ca, 3.3 wt%Al_2O_3/2 wt%Ca and 3.3 wt%Al_2O_3/3 wt%Ca and processed through disintegrated melt deposition technique. The particle size of $Al_2O_3$is 50 nm. On increase in Ca content, the ductility decreased and 0.2% yield strength increased. In [13] AZ31B Mg alloy is reinforced with a bimodal size SiC particle (micron and nano) processed through semi solid stirring assisted ultrasonic vibration method, the particle size of SiC is 10 μm and 60 nm. The ultimate tensile strength and 0.2% yield strength of the nano and

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http://dx.doi.org/10.1016/j.matdes.2014.06.040
0261-3069/

micro combined bimodal size magnesium composites showed improved results when compared to other compositions. In [14] AZ31B Mg alloy is reinforced with $3.3Al_2O_3$/10Cu and $3.3Al_2O_3$/18Cu processed through disintegrated melt deposition technique, nano Al_2O_3 is used as reinforcement. The chemical composition of $3.3Al_2O_3$/18Cu showed improved 0.2% compressive yield strength and ultimate compressive strength, whereas AZ31B Mg alloy showed improved ductility. In [15] AZ31B Mg alloy is reinforced with three volume fractions (3, 5 and 10) of sub-micron SiC particles (~0.5 μm) were fabricated by semi solid stirring assisted ultrasonic vibration method. In this AZ31B/10 vol%SiC showed improved ultimate tensile strength and 0.2% yield strength, whereas AZ31B Mg alloy showed improved ductility. In this present work an attempt is made to utilize the abundantly available coconut shell charcoal as reinforcement in addition with SiC ceramic particle in AZ31B Mg alloy to improve the compressive and impact properties.

2. Experimental details

The chemical composition of AZ31B Mg alloy is (Al 3 wt%, Mn 0.6 wt%, Zn 1.0 wt%) and the particle size of materials used in this study is Mg 63 μm, Al 50 μm, Zn 45 μm, Mn40 μm, SiC0.5 μm and ncsc (30–50 nm).The micron sized metals and ceramic powders were purchased from MEPCO metal powder company, India. The coconut shell charcoal was ball milled to nanosize using UK PM100, RETSCH planetary high energy ball mill. The powder metallurgy technique was used to synthesize AZ31B Mg alloy, AZ31B/3SiC, AZ31B/3SiC/0.5ncsc, AZ31B/3SiC/1ncsc and AZ31B/3SiC/1.5ncsc Mg composites. The powders were homogeneously mixed with the respective weight percentage of SiC and ncsc powder using suitable powder mixture set at a rotational speed of 350 rpm for 1 h. The homogenised powder mixture of AZ31B Mg alloy, AZ31B/SiC and AZ31B/SiC/ncsc Mg composites were then compacted at a pressure of 690 MPa to form billet of 50 mm diameter and 30 mm height. In order to reduce the reaction of composite with oxygen present in the atmosphere, the compacted billets

Table 1
Shows density and porosity measurement result.

Materials	Theoretical density ρ (g/cm^3)	Experimental density ρ (g/cm^3)	Porosity (%)
AZ31B Mg alloy	1.773	1.772 ± 0.02	0.05
AZ31B/3SiC	1.7878	1.7871 ± 0.02	0.41
AZ31B/3SiC/0.5ncsc	1.7875	1.7873 ± 0.02	0.12
AZ31B/3SiC/1ncsc	1.7871	1.7868 ± 0.02	0.13
AZ31B/3SiC/1.5ncsc	1.7867	1.7863 ± 0.02	0.19

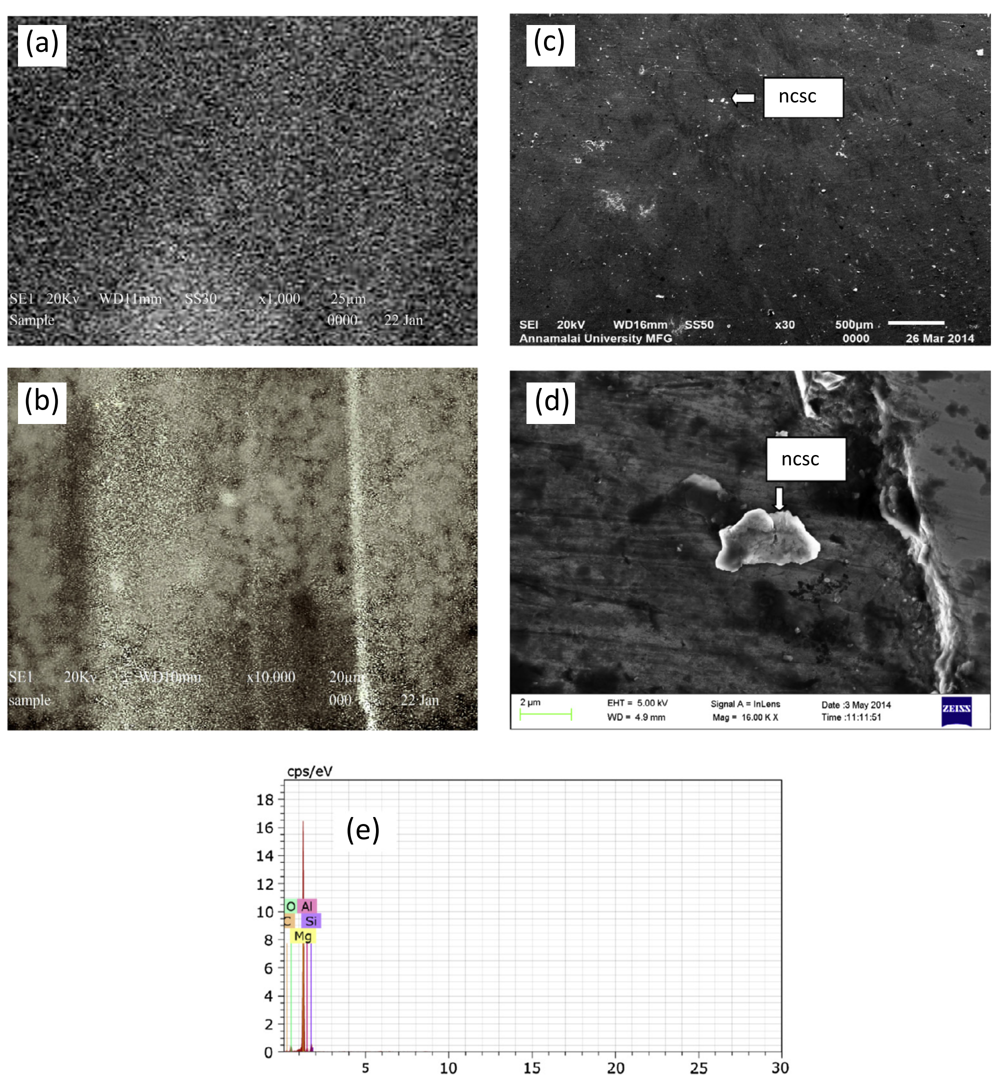

Fig. 1. SEM micrograph of (a) AZ31B Mg alloy, (b) AZ31B/3% SiC composite, (c) AZ31B/3%SiC/1%ncsc composite, (d) AZ31B/3%SiC/1%ncsc composite and (e) EDX of AZ31B/3%SiC/1%ncsc composite.