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Mechanical and dry sliding wear behaviour of hot rolled hybrid composites produced by direct squeeze casting method

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Abstract

Aluminium Copper alloys reveals several specific and attractive properties that qualify them to be used in many automotive and aeronautical applications. Aluminium matrix composites have good mechanical and physical properties, when reinforced with SiC and fly ash particle. In the present work, the number of cast samples of Al-Cu/fly ash/SiC composites was prepared by combination effect of stir and squeeze casting followed by hot rolling. The percentage inclusions is fixed for 4%fly ash and varied SiC from 1 to 6wt%. The composites prepared with a stirring speed of 400 rpm and squeeze casted at 750ºC with a pressure of 120MPa. The results showed improved hardness and tensile strength. Wear resistance is superior for higher percentage of reinforcement with increase in pull out of rolling. Higher weight percentage of reinforcements with higher reduction results in shrinkage cavities and particle cracking during rolling. Consecutive hot rolling process resulted in declining void and the agglomeration clusters and thus superior mechanical properties are achieved.

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Keywords: Stir and squeeze casting;hot rolling; microstructure; hardness; tensile properties;

1. Introduction

Nowadays production of light weight, low cost, high performance aluminium has undergone significant evolution. However, more the changes introduced around processing, more the based composites challenges faced because of higher number of critical parameters [1-6]. The SiC is commonly used reinforcement in almost all Al-alloys and proved better mechanical properties [7-12]. Production of composites by reinforcing fly ash and SiC to Al-Cu alloy by stir cast method enhances hardness, tensile strength compression and impact strength [13, 14].

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Squeeze cast technology in comparison with stir cast are advantages for obtain higher hardness and structure homogeneity with minimum possible porosity levels, good interface bonding, uniform distribution of reinforcements with refining microstructure [15-18]. An earlier study [19] has shown that Al-4.5Cu/fly ash/SiC composite can be made through squeeze cast route and gives interesting properties. Many researchers have carried out research work on secondary process for the mechanisms of high temperature deformation of composites. Compared with some exclusive and costly methods such as forging, extrusion, rapid solidification, and equal channel angular pressing (ECAP), rolling process was a common way that can fabricate large dimensioning products [20-22]. I. G. Siddhalingeshwar et al. [23] rolled Al-4.5Cu-5TiB2 composite to a reduction of 7.5 -10% reductions and stated increase tensile and micro hardness with increase in extent of rolling. Mohamed A Taha et al. [24] rolled stir cast Al-Cu/SiC composite and concluded that workability of Al-MMCs is better in case of rolling. Sajjad Amirkhanlou et al. [25] reported that rolling Al-SiC composites to 95% reduction increases tensile strength and decreased porosity level with increase in reduction of rolling. Also research is not extended for hot rolling of composites produced by fly ash and SiC particulates as reinforcement using squeeze casting technique. Hence, in the present work Al-Cu alloy reinforced fly ash and SiC composite using squeeze casting method is carried out to obtain castings. A further objective is to investigate the effect of extend of hot rolling reduction on the microstructure and mechanical properties of the produced MMCs.

2. Experimental procedure

Squeeze casting system was constructed in the present experimental work to produce specimens. The Al–4.5Cu alloy was chosen as matrix alloy and composites were produced by introducing fly ash and SiC particulates with 4wt.% fly ash and 1, 2, 3, 4, 5 and 6wt.%SiC to the Al–4.5Cu matrix. The density of fly ash and SiC measured is 2.09g/cm3 and 3.2g/cm3 respectively with the particle size varying between 10 and 25μm. The squeeze casting method is explained in detail by the G.N.Lokesh et al [26] with a constant pressure of 120MPa for a period of 120 to 180 seconds. Composites prepared by squeeze casting with different weight percentage of reinforcement are shown in Table 1.

The rolling samples were prepared for a dimension of 180mm length, 25mm width and 25mm thickness. The samples were successively hot rolled with a temperature of 410°C and the thickness reduction of 0.25mm per each cycle into different final reductions of 8%, 16% and 25% with intermediate heat treating process shown in Fig.1 (a). The rolling mill with a loading capacity of 15tons is used for rolling the samples as shown in Fig. 1(b).

Table 1. Measured composition of squeeze cast samples (wt.%)

Sample		Composition
Sample 1	Matrix alloy	Al-4.5wt%.Cu alloy
Sample 2	Composite 1	4wt%Fly ash, 1wt%. SiC, reinforcements
Sample 3	Composite 2	4wt%Fly ash, 2wt%. SiC, reinforcements
Sample 4	Composite 3	4wt%Fly ash, 3wt%. SiC, reinforcements
Sample 5	Composite 4	4wt%Fly ash, 4wt%. SiC, reinforcements
Sample 6	Composite 5	4wt%Fly ash, 5wt%. SiC, reinforcements
Sample 7	Composite 6	4wt%Fly ash, 6wt%. SiC, reinforcements

The roll diameter was 85mm and roller speed was set to 30rpm. Hardness measurements were performed using a Brinnel hardness tester with a load of 10kgf as per ASTM-E10-01. Tensile test samples having 6mm diameter with a gauge length of 25mm, were prepared for testing in tensometer as per ASTM E-8 standards (Fig. 2). Wear tests were carried out using a computerized pin on disc wear testing machine under room temperature on specimens for normal load of 10N, and track velocity of 2m/sec. The wear tracks were observed under a scanning electron microscope to examine the effect of the percentage of particulate on the wear behaviour of the MMCs