

Microstructure and Crystallographic Texture of Aluminium Composite

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Abstract
The objective of the present work is to study the hot deformation behaviour of Al alloy-SiC Composites and to analyze the microstructure and crystallographic texture. Dispersing finer size hard particles in Al alloys restricted the flow of grains and tends to alter the texture. Al composites were homogenized and subjected to compression test using universal testing machine at various strain rates and temperatures. The deformed microstructure was studied under microscope paying particular emphasis to understand the mechanism of material flow. The crystallographic texture of the deformed samples was found out using x-ray diffactometer. The results depict that Al composites can safely be deformed at 400 ^{o}C and at 0.01 /s strain rate and the microstructure shows dynamic recrystallization as the predominant mechanism of material flow. It was also observed that at higher strain rate (10/s) of deformation, the interface decohesion between the metallic matrix and ceramic phase was observed. Adiabatic shear bands (localized flow) were observed when the materials deformed at room temperature (30 ^{o}C) and at strain rate of 0.01/s. The texture measurement of Al composites, at the safe region, shows the components of (011) [100], (001) [1-10], (010) [101]. This study indicated that Goss and cube texture are favorable for the easy deformation of Al composite.

1.0 Introduction
Al alloy based composites are finding considerable interest in automobile and aerospace sectors because of their interesting combination of properties such as higher specific strength and specific modulus, higher hardness, low coefficient of thermal expansion and improved wear resistance in addition to lightweight. Dispersion of ceramic particles like SiC in aluminium matrix extends the specific properties of ductile metallic matrix considerably. In the last two decades, considerable research is being carried out to develop cast Al composites [1]. However, the work towards the development of Al composites for structural application is limited. An Al composite for structural application requires deformation of the composites by secondary processing technique such as rolling, extrusion, forging etc [2-8]. The effect of thermomechanical processing on the microstructure and texture is investigated to a limited extent [9 -11]. Poudens e.t. al. [12] studied the texture in extruded Al–SiCp composites. Their results found that the deformation texture in the composites are composed of <111> and <100> fiber texture. After annealing, <320> texture component is existed in addition to the two fiber texture. Al-SiCw (8%) cold rolled composite showed, deformation texture of {100} <011> and recrystallization texture {100} <013>.
In the present paper, attempts are being made to study the hot deformation behaviour of Al alloy composite under compression. Further, the microstructure and texture measurement of the samples are carried out to ascertain the mechanism for material deformation.

2.0 Experimental Details
In the present study AA2014 Al alloy (chemical composition: Cu-4.5 wt %, Mg: 0.5 % and rest is Al) was used as matrix material. Stir casting technique was used to disperse 10wt% SiC (particles size: 10-40 µm) in the Al alloy melt. The homogenized samples were subjected to compression test using a universal testing machine at strain rates of 0.01/sec to 10/sec and temperatures 30˚C to 400˚C. The deformed microstructure is studied under scanning electron microscope. The crystallographic texture of the deformed samples was found out using x-ray diffactometer.

3.0 Results
3.1 Stress-Strain Diagram
The true stress – true strain plots of the Al-SiC composite at various strain rates and temperatures are shown in Fig.1. The stress increased with strain to a peak value and then attained a steady state value with a further increase in strain. Also, the peak stress decreased with increasing test temperature (Fig 1a) and increased with strain rate (Fig.1b).

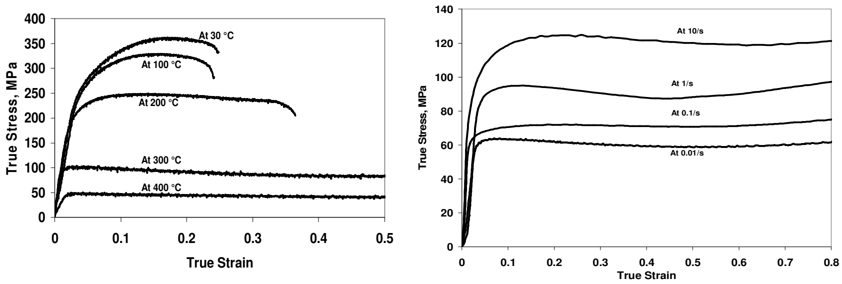


Fig1: Al-SiC Composite (a) at 0.01/sec (b) at 400°C

3.2 Microstructure

The deformed Al-composite samples were observed under scanning electron microscope in order to understand the mechanism of deformation Fig (2). Figure (2a) shows a typical microstructure of the Al-SiC composite deformed at 30˚C and at a strain rate of 10/sec. It depicts that SiC particles are distributed in the alloy matrix and restrict the flow of grains and flow localization is observed. During the flow of material, the interface between the particle and the metallic matrix plays an important role. Figure (2b) shows a typical microstructure of the Al composite deformed at a temperature of 400˚C and at a strain rate of 0.01/s.

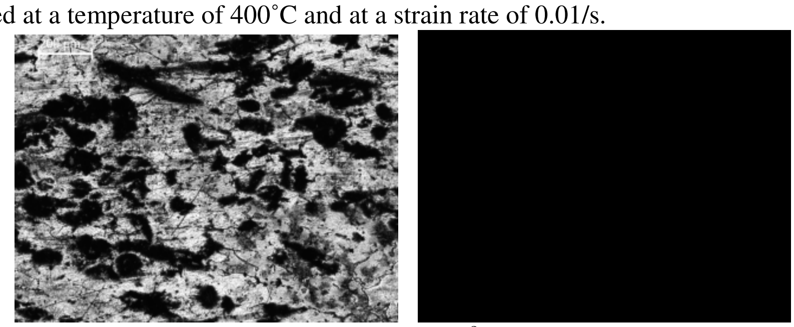
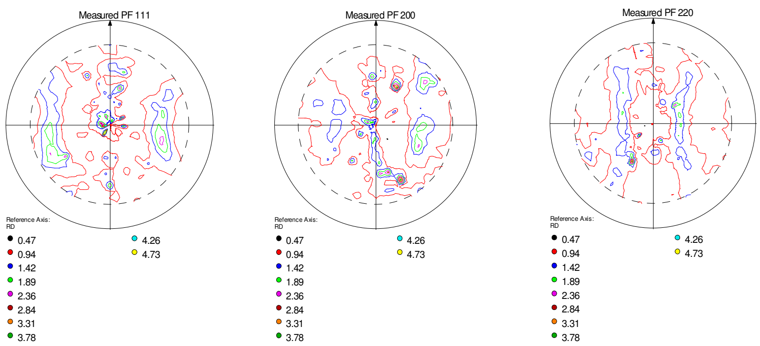


Fig (2) Microstructure of Composite (a)At 30°C, 10/sec (d) At 400C , 0.01/sec

3.3 Texture

Texture was found out by X-ray diffraction technique. The pole figure of Al-SiC composite corresponding to (111) (200) and (220) planes are shown in Figures (3). The orientation distribution function (ODF) of AA2014 -10% SiC composite was calculated from three pole figures (111), (200) and (220) using the harmonic method [14]. Texture measurement in Al - SiC composite contains {011} Goss as well as some amount of {101} Brass and {001} Cube component. But the intensity of these components varies with test conditions.



(a) (b) (c)

Fig (3) Pole figures of (111), (200) and (220) planes at 400 C, 0.01/sec (AA2014-10% SiC Composite)

4.0 Discussion

The true stress – true strain diagrams of Al-SiC composites, at various strain rates and temperatures are shown in Figs (1a & b). It is seen that the true stress is increased with true strain to a peak value and then the stress becomes constant with increase in strain. It is observed that flow stress increases with increasing strain rate and decreases with increasing temperature. Microstructure of the deformed Al composite at room temperature shows flow localization and adiabatic shear band. The reason for the formation of shear bands is mainly due to insufficient time available for the deformation at higher strain rates and at low temperature. The microstructure observed at 400 ˚C and at low strain rate showed recrystallized grains in Al-SiC composites. The elongated grains depict easy flow of Al alloy matrix. At higher temperature say at 400˚C and higher strain rate (10/s) deformation, the microstructure shows interface decohesion between Al and SiC particle and in some instances particle fracture is also observed.

The texture index values obtained from the measurement at a temperature of 400˚C and at a strain rate of 0.01/sec 1.23 for Al-SiC composites. In the case of Al –SiC composites, the deformation at 400 C and 0.01/s strain rate, the texture components found are Goss and cube with the intensities 3.33 and 2.49 respectively. However, at room temperature and 0.01/s strain rate, the texture components such as Goss {011} <100>, brass {101} <1-21>, and cube {001} <100> are found with the intensities of 1.65, 1.05 and 0.82 respectively. In addition, other texture components such as {111} <1-21> and {223} <1-10> are observed with intensities of 1.65 and 0.82 respectively. This clearly depicts that deformation at low temperature and low strain rate, texture components are of mixed in nature. While carrying out deformation of Al composites, a range of texture components are found. The orientation of grains is not of a particular type. It is inferred from the above study that Goss and cube textures are the preferred texture components for defect free deformation. Hansen and Jensen [15] have also reported that in the case of recrystallization texture of Al, Goss and Cube are the dominant texture components.

Conclusions

1. The true stress-true strain curves suggest that on increasing temperature the flow stress decreases and increases with increasing strain rates.
2. At high temperature (400˚C) and low strain rate (0.01/sec), microstructure suggests dynamic recrystallization, whereas at low temperature and low strain rate, flow localization and shear bands were observed.
3. The texture analysis shows the Goss {011} <100> and Cube {001} <100> components for successful deformation and easy flow of matrix material at higher temperature and lower strain rate.
4. Random texture components are found at lower temperature and at low & high strain rate which corresponds to the instable region .

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