THE EFFECT OF MILLING TIME ON MICROSTRUCTURE AND HARDNESS OF THE ALUMINIUM SILICON CARBIDE (Al-10 wt % SiCp) COMPOSITE

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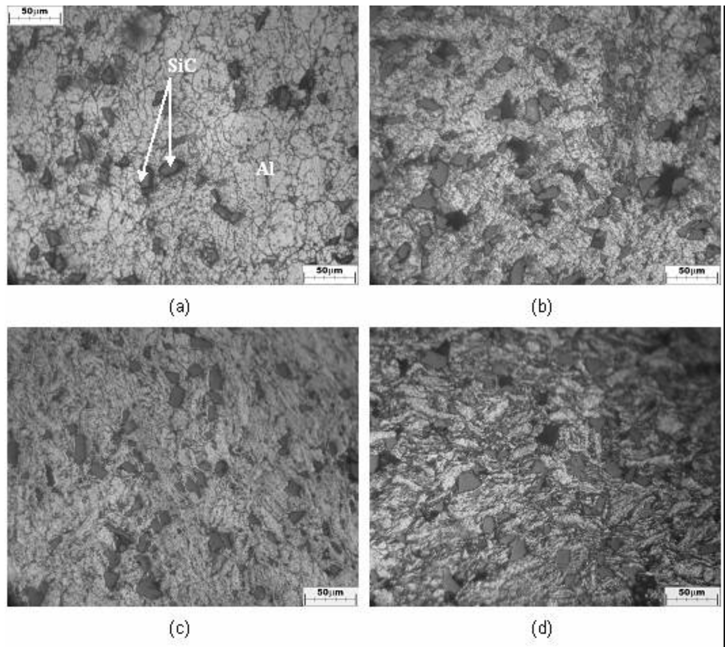
Abstract
The aim of this study is to develop Al – 10 wt % SiCp composite by powder metallurgy technique. Aluminium and SiC powder were mixed by ball milling and it was then sintered at 550˚ C for 5 hours. The parameter to control the microstructure of the composite is milling time. Microstructure and hardness of the composites were investigated. The results showed that hardness of the composite has increased as the milling time increased. The maximum value of hardness can be obtained at 5 hours milling time. After 5 hours milling time, the hardness starts to drop. Microstructure plays important role in controlling the hardness of the composite.

Introduction
Metal matrix composites have been studied since the early 1960s. Initial work on MMCs was stimulated by the high performance needs of the aerospace applications which placed performance ahead of price, at least in developmental programs. MMCs have been produced using a wide range of matrices which include copper alloys, iron based alloys, magnesium alloys, nickel based superalloys, titanium alloys and lead alloys [1,2]. Reinforcement materials should have significantly higher specific stiffness and specific strength compared to the base alloy as well as high melting temperatures. Reinforcement can be classified into continuous or discontinuous fibre, whiskers and particles. The techniques of primary fabrication are the key factors in choosing the reinforcement form and type. Liquid metal techniques are always used to fabricate Al reinforced with continuous fibre reinforcements such as graphite, alumina and SiC [1,2]. For continuous boron fibres, the fabrication method employed is hot pressing. Powder metallurgy techniques are used to fabricate Al reinforced with discontinuous fibres (SiC, Al_2O_3) whiskers (SiC, B_4C) and particles (SiC, Al_2O_3, B_4C, graphite). Metal matrix composites are currently fabricated by powder metallurgy, liquid metal and spray deposition techniques. Each fabrication technique has its own limitations in the size and shape of MMCs which may be produced and also the reinforcement chosen. Fabrication of MMCs is more difficult than the fabrication of the matrix alloy because during the fabrication process (e.g. the liquid metal technique) an interface reaction takes place between matrix and reinforcement to form intermetallic compounds. During fabrication, it is important to control the reactions at the matrix/reinforcement interface in order to produce optimum interface bond strength and avoid reinforcement degradation [3-6]. Ball milling or mechanical alloying is one the powder metallurgy technique to MMCs. Zebarjad et al. [7] have studied the microstructure of Al–Al_2O_3 composite produced by mechanical alloying method. The results showed that increasing milling time caused to make fine alumina powders as well as uniform distribution within aluminum, also in steady-state stage increasing milling time has not significant effect on their size distribution within aluminum. This paper presents the effect of milling time on the microstructure and hardness of Al – 10 wt % SiCp fabricated by ball milling.

Experimental
The materials used were aluminium, silicon carbide and starch. Aluminium fine powder was supplied by Merck, Germany and silicon carbide was supplied by Sigma – Aldrich (M) Sdn Bhd. Aluminium and 10 wt % silicon carbide were cleaned using ethanol before milling them together. Aluminium was soaked into 200 ml of ethanol and ultrasonic using Ultramet 2003 – Sonic Cleaner for 15 minutes. The mixtures were separated by using filter paper. Drying process approximately for12 hours. The steps were repeated for silicon carbide. All powder were mixed and milled in the Planetary Ball Mills, model PM 100. Milling time was varied from 0 hr to 10 hrs. The zirconia balls and the powders were put into the jar with the ratio of 10: 1. Then, the powder was compressed for 600 MPa using hydraulic press to make pellet. After compaction, the pellets were sintered in the tube furnace under controlled atmosphere. Argon gas was applied during sintering process. The samples were ground and polished prior microstructure characterization and hardness test.

Results and Discussion
Figures 1(a) to (d) show the optical micrographs of the composites. For 0 hour, SiC is not fully distributed in the aluminium matrix but the grain structure can be observed clearly. With increasing milling time to 2 and 5 hours, the grain structure starts to disappear may be because of the response from the matrix to the

deformation. The porosity near the silicon carbide particles also can be observed in the sample. When milling time is prolonged to 10 hours, SiC particles start to segregate follow the elongated deformation layered of the matrix due the heavily deformation.



Figures 1 : Microstructure of Al – wt 10 % with milling time (a) 0hour, (b) 2 hours, (c) 5hours, (d) 10 hours

During milling process, the particles are deformed, cold welded and fractured due to high energy collision. Those events may change particle shape and also increase particle size and forming layered structure. Figure 2 illustrates the relationship between hardness and milling time. The result indicates the hardness increases with increasing milling time. At 5 hours of milling time, the microhardness achieves the highest value as nearly double than composite without milling. The maximum hardness appears during 5 hours is may be due to the effect of the response from the matrix to the deformation. During this stage, the deformation may produce lattice distortion in the matrix aluminium, then this lattice distortion creates lattice strain and increase the dislocation which is the main hardening mechanism. After 5 hours milling time, the effect of dislocation is not the main factor because of the major influence controlled by the elongated matrix grain size.

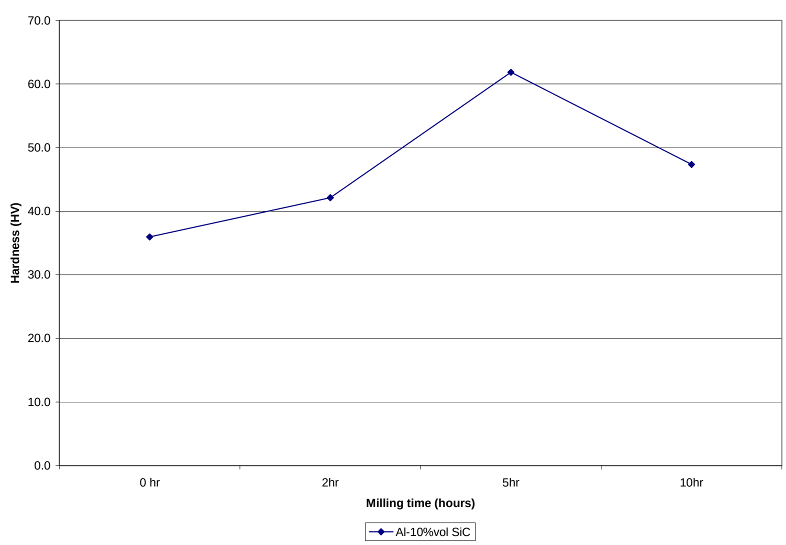


Figure 2: Relationship between hardness and milling time

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