# AGEING RESPONSE OF $SiC_p$ ADDITION IN Al-7Si-0.3Mg ALLOY

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**Abstract** Al–SiC metal matrix composites of different weight percent (5%, 10% and 15%) were produced by a stir casting method. The samples of 10cm cube were prepared from the three composites and from the unreinforced Al alloy for the ageing treatment. The samples were solution treated at $500\pm2^0$C for 5 hours and followed by water quenching at $15\pm5^0$C. Then the samples were aged at temperature $175\pm2^0$C for periods ranging from 1 to 7 hours. Peak ageing time was determined by the measurement of microhardness of the matrix alloy of composites. The hardness of the matrix alloy increases with the increase of ageing time, and reaches to a maximum after ageing of a certain period and then the hardness drops again. It was also found that the peak ageing time become shorter with the increase of particle content in the composites.

*Keywords: Metal matrix composites, ageing, precipitates and microhardness.*

## INTRODUCTION

Metal matrix composites are significant as advance materials due to their high strength, specific modulus, low coefficient of thermal expansion, good wear resistance and better high temperature properties [Oh *et al.*, 1989]. Al alloys are more attractive among all other metals as matrix materials of metal matrix composites for their light weight property as well as for precipitation hardenability. The ageing effects of a wide range of aluminium alloys were well studied before [Ashby and Jones, 1988; King, 1987]. Some efforts have been made on the effect of ageing kinetics of aluminium alloys composites in presence of ceramic particles. There has been a clear effect on the ageing behaviour of matrix alloy in presence of SiC particles [Suresh *et al.*, 1989; Christman *et al.*, 1988; Rack, 1989]. During ageing of age hardenable Al alloys, precipitates are nucleated at the defect sites in crystals, such as dislocation populated areas, vacancies etc. In Al-alloy matrix composites, dislocation density increases in the vicinity of the particle matrix interface, which encourages the nucleation of precipitates [Arsenault *et al.*, 1986]. The increased dislocations density in matrix aluminium alloy is due to the difference of coefficient of thermal expansion between the ceramic particles and the matrix alloy [Chawla *et al.*,1972; Arsenault *et al.*, 1986]. Chawla *et al*. studied the effect of ageing behaviour of $SiC_p$/Al2014 composite at different temperature and time. They found that the kinetics of ageing of Al2014 matrix is highly sensitive on the ageing temperature. The reinforced material peak aged much faster than the unreinforced alloy. But the ageing effect of matrix alloy with the increase of ceramic particles content is quite limited. This study has therefore been undertaken to investigate the ageing behaviour of matrix alloy with the increase of $SiC_p$ content in Al-7Si-0.3Mg alloy.

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## MATERIALS AND EXPERIMENTAL

Three SiC reinforced aluminium alloy matrix composites viz. 5%, 10% and 15 wt.% were made by the stir casting route. The matrix Al alloy (Al- 7Si- 0.3 Mg) was also used with three composites for the comparison of ageing study. Cubical samples of 10×10×10 cm in dimensions were prepared from the four materials for the ageing treatment. The samples were solution treated at 500±2°C for 5 fours and followed by water quenching at 25±5°C. Then the samples were aged at 175±2°C for periods ranging from 1 to 7 hours. After ageing treatment, the samples were stored in the refrigerator at -15°C. The heat treatment cycle is shown in Fig.1. The microhardness measurements were taken from unreinforced Al alloy and in the matrix of the Al–$SiC_p$ composites. The measurements were carried out on well polished samples at room temperature using Shimadzu microhardness tester at 100gm load.

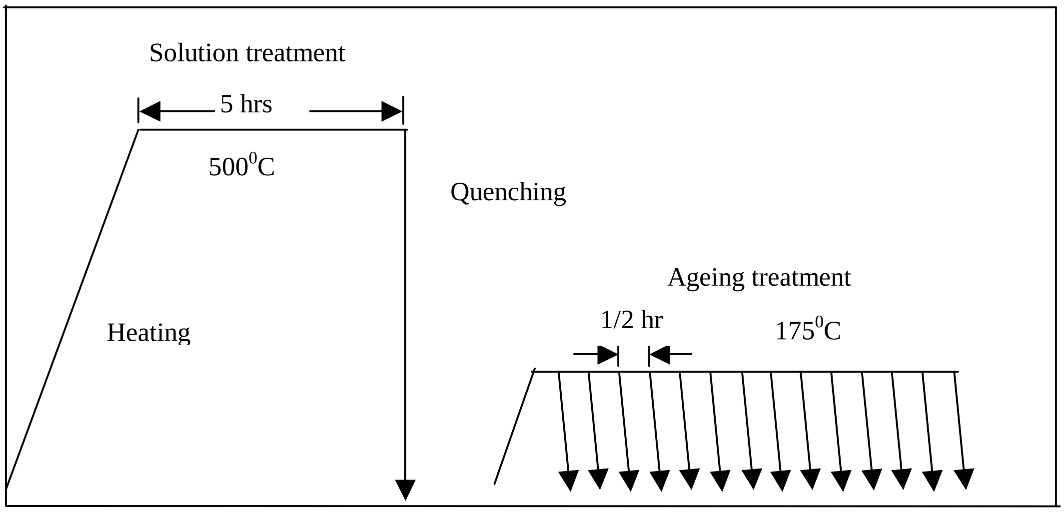


**Fig. 1 Heating Cycle of unreinforced and SiC reinforced aluminium alloy composites**

## RESULTS AND DISCUSSION

The microhardness measurements taken from the matrix of all three composites and unreinforced alloy, have been plotted in Fig. 2. It is clear from the figure that with the increase in ageing time the hardness gradually increases up to a maximum value and then decreases. The time to reach the maximum hardness is referred to as peak ageing time. From previous study [Rashid, 1993] it has been reported that at relatively high temperature of solution treatment the alloying constituents dissolve in the aluminium matrix to form a saturated, or nearly saturated solid solution. When the metal is quenched, the alloying constituents remain in solid solution, but the solution is unstable and decomposes slowly at the ageing temperature, the alloying constituents being precipitated, initially in a non-equilibrium form. These transitional-precipitates, known as GP (Guinier-Preston) zones, are coherent or partially coherent with the matrix. Hence strain fields are set up in the precipitates vicinity with the ability to prevent dislocation glide and thus resulting in the observed hardening. The size of precipitates in aluminium alloy increases with increase of ageing time and turns to coherent from partial coherent. At this stage aluminium alloy shows the maximum hardness. After this stage, the size of the precipitates increases continuously with ageing time. Dislocation can glide easily through these large precipitates and results low hardness in matrix alloy.

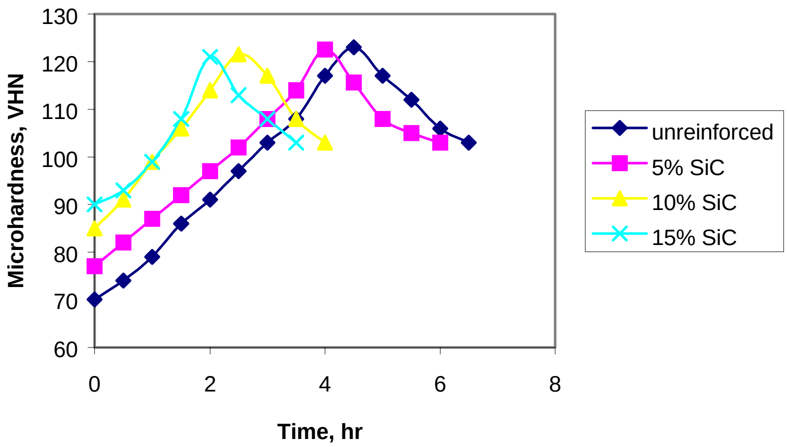


**Fig. 2 Effect of ageing on the microhardness of matrix material**

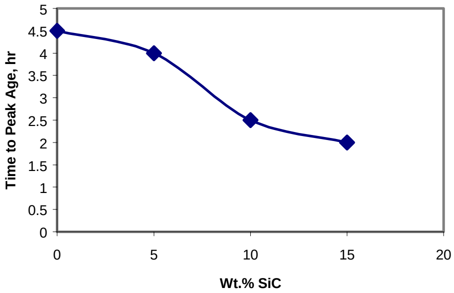


**Fig. 3 Effect of ageing on the time to peak age of matrix material**

It is clear from Fig. 2 that at peak age hardness of the matrix of all aluminium composites and aluminium alloy do not change appreciably due to the addition of the reinforcing particles. It is, however, noticeable that the time required to peak age is decreased with the addition of SiC particles (Fig. 3). Upon quenching, the soft matrix of the composite undergoes plastic deformation due to a substantial thermal stresses resulting from the differences in the coefficient of thermal expansion of the matrix alloy material and the reinforcing particles (SiC) (Chawla *et al*., 1991). The plastic deformation of the matrix introduces a large number of dislocations and vacancies that act as nucleation sites for precipitation and accelerate the ageing kinetics of the matrix by precipitating rapidly. It is thought that the thermal stress is the highest in the matrix of composite containing 15 wt.% of SiC and thus the time to reach peak age is the shortest. The high thermal stress yielding the high hardness with the increase of SiC at quenched condition is also evident from Fig. 4.

## CONCLUSIONS

The hardness of matrix alloy of all four material increases with the increase of ageing time up to a certain limit and then decreases. At quenched condition the 15% SiC reinforced composite has the highest microhardness. Peak ageing time becomes shorter with the increase of the SiC content in the aluminium alloy matrix

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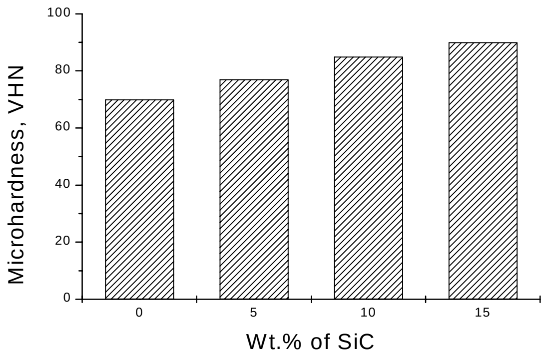


**Fig. 4 Microhardness of reinforced and unreinforced Al alloy at quenched condition**