Reducing the Particle Fracture in Dissimilar Friction Welds by Introducing Silver Interlayer

P. Kannan, K. Balamurugan, K. Thirunaavukkarasu

Abstract: The present work discusses about the introduction of silver interlayer in dissimilar friction welding process. The characteristics of silver interlayer influenced friction weld are compared with the silver free dissimilar friction welding process. Particle fracture occurs commonly in welding process. It leads to poor quality of welds and decreases the strength of the weld. The introduction of silver interlayer reduces the particle fracture. Hence, the friction welding process with silver interlayer produces more efficient welds.

Keywords: Dissimilar Friction Welding, Particle fracture, Silver interlayer

I. INTRODUCTION

The effect of silver interlayer on particle failure is investigated in the present work and also it is compared with the observed dissimilar MMC/AISI 304 stainless steel welds produced without interlayer. This interlayer material affects the coefficient of friction, plastic deformation in the substrate materials and particle failure. The processes that occur during initial heating period of the friction welding operation are also investigated by examining changes in size and distribution of reinforcing particles in MMC base material immediately adjacent to the joint interface.

During initial heating period of friction welding, the physical situation is mostly similar to that in sliding Wear testing. In sliding Wear testing of aluminium-based alloy A356/20 vol% Sic base material, strains as high as 30 MPa are produced near the contact interface and particle fracture occurs when the applied load exceeds the fracture strength of the reinforcing material [1]. It is possible to modify the particle fracture frequency by modifying the loading conditions at the contact surface.

The probability of the particle fracture decreases during tensile testing temperature above 200º C because the matrix flow strength decreases and the local stresses are not high enough to break the reinforcing particles [2]. Consequently there is a transition from the particle to particle void nucleation at the ends of particles and in the region between particle clusters when the temperature of testing rises. It is convenient to observe particle fracture for short friction times as the temperature rises with friction time in the case of friction welding process.

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II. EXPERIMENTAL PROCEDURE

The dissimilar friction welds were made by using 15-mm bars of 6061-T6 base consisting of 10 vol% of reinforcing Al2O3 particles. The main work is to predict the influence of silver interlayer in the particle fracture of the dissimilar friction welds. The required quantity of silver interlayer is electrodeposited over the stainless steel substrate, which is already coated with a nickel strike layer. This nickel strike layer plays as a base for all subsequent coatings and it is commonly used in dissimilar friction welding and diffusion bonding process. For this experiment 3μm thick nickel strike is applied when the electroplating of stainless steel with chromium, zinc and silver takes place at the process [3,4].

The process of electroplating consists of surface degrading and cleaning in 10 Vol% NaOH for 90 seconds and followed by deposition of 6 μm thick Nickel layer in a nickel chloride bath for 240 seconds. The current and temperature was about 450 A/m2 & 23º C. The average thickness of the silver interlayer is 16 μm.

All the joints were polished and sectioned perpendicularly to the joint surface. Using Global Lab SP0550 image analyzer ad SEM microscopy the dimensions of the silver & nickel interlayer and the reinforcement particle characteristics at the half radius locations in the test joints were evaluated. During this image analysis process the magnification was X200 and the measurement involved examining 0.128 mm2 fields at 0.268 mm up to 5 mm from the dissimilar joint interface.

Scanning Electron Microscope was used to examine the frequency of fractured reinforcing particles and the aspect ratio of reinforcing particles at and close to the bondline. These parameters were examined in 0.232 mm2 areas at the joint interface. The procedure deduced by Lewis and Withers was referred as an outline for evaluating the aspect ratios of the reinforcing particles [5]. In this procedure, the particles are modeled as cylinders. In this case the particle diameter d is related to measure width w, by a factor 4/π refer to the below given equation (Eq.1). Once the diameter d is obtained the volume of each particle can be calculated and therefore the accumulated particle volume in a particular volume in a particular location.

$$d = (4 \div \pi)\, w$$

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(1)

The average radius of each particle is considered as half the square of the mean of the particle cross-sectional area was observed using the Global Lab SP0550 image analyzer. When the short term friction welding tests were examined and all the measurements were made at the half radius locations in these joints.

III. RESULT AND DISCUSSION

During the mechanical testing of wrought MMC base material, it is commonly observed that three particle failure modes exist. They are namely cracking, shattering and debonding which is seen in fig 1.

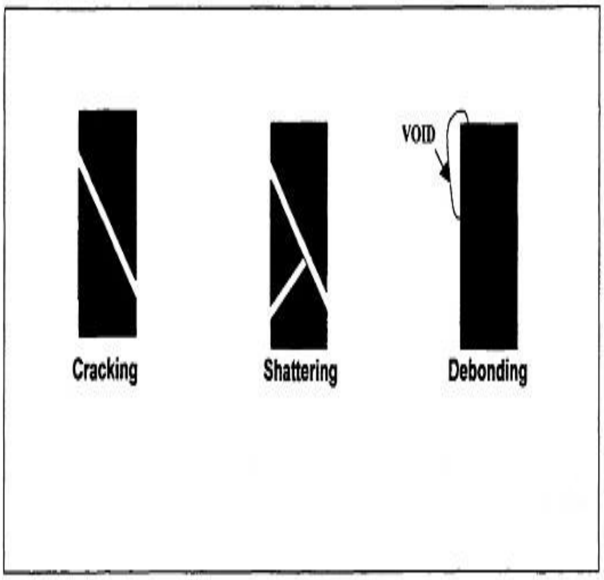

Fig 1: Modes of particle failure observed during mechanical testing of a Particulate reinforced metal matrix composite material

It is possible to have particle shattering but it is difficult to observe because large plastic strains are produced close to the friction weld interface and the broken large might have moved apart and separated in such a way that even the evidence of this particle failure mode may have been obliterated.

By the addition of silver interlayer between the MMC and AISI 304 stainless steel substrates affects the particle fracturing process. The percentage of reinforcing particles in the MMC/Ag/AISI 304 stainless steel joints ranges from 5.2 to 2.2% is taken from fig 2.

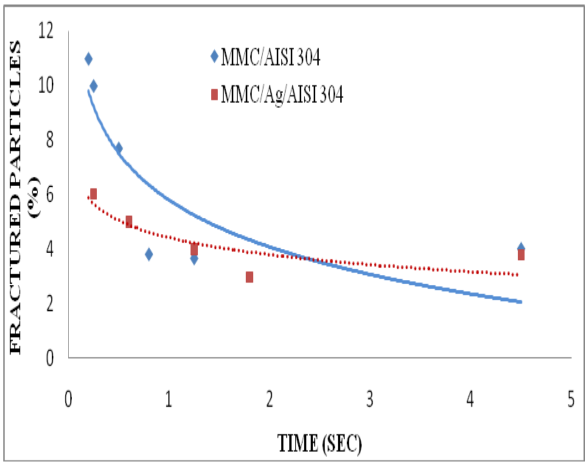

Fig 2: Effect of friction time on the percentage of fractured particles in MMC/AISI 304 stainless steel and MMC/Ag/AISI 304 stainless steel friction joints.

When comparing this with the dissimilar MMC/AISI 304 stainless steel friction welds ranges from 10.6 to 2.93% particle fracture. It is undoubtedly seen that, the percentage of fractured particles is affected by the addition of silver interlayer during dissimilar MMC/AISI 304 stainless steel friction welding.

IV. CONCLUSION

The dissimilar friction welds with and without silver interlayer is experimented and concluded in the following. The main objective of the paper is to reduce the percentage of particle fracture. The percentage of reinforcing particles in the MMC/AISI 304 stainless steel joints ranges from 10.6 to 2.93% particle fracture. After the introduction of silver interlayer, the percentage of reinforced particles ranges from 5.2 to 2.2% particle fracture. Therefore the introduction of silver interlayer shows 3.06 % decrease in particle fracture when compared to normal friction welding process.

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