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Fabrication of Al7075 / B4C surface composite by novel Friction Stir Processing (FSP) and investigation on wear properties

1. Introduction

A composite material is a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. These unique characteristics of composites provide the engineer with design opportunities not possible with conventional monolithic (unreinforced) materials. The use of composites in the aerospace industry has increased dramatically since the 1970s. In line automotive industry faces many challenges, including increased global competition, the need for higher-performance vehicles, a reduction in costs and tighter environmental and safety requirements. The same has led to development in the field of the composite materials with their unique as said properties.

Many techniques had been reported for fabrication of surface composite (SC), but FSP has been identified as one of the most promising techniques. FSP is developed my Mishra et al[1, 2], which works on the same principle of friction stir welding (FSW). Conventional liquid phase processing techniques suffers from the limitation like, formation of intermediate detrimental phase and porosities due to elevated temperature process conditions, and requires critical control of process parameters to control the solidified structure [2]. To avoid such problems, the process should be carried out at a temperature below the melting point of the substrate as done in solid phase surface modification techniques. As, being one of the solid state surface modification technique, it has been used in the present investigation for fabrication of SC.

First SC has been synthesized via FSP route by Mishra et al.[1]. A composite layer ranged from 50 to 200 nm by reinforcing silicon carbide (SiC) particles in the Aluminum matrix have been obtained. The microhardness of the SC has been reported to be increased by two times compared to the parent metal. Later on many researchers have explored the area of surface composite fabrication using FSP. Among them, Hossein Bisadi et al. [3], has investigated the effects of processing parameters on particle dispersion and hardness in Al7075-alloy reinforced with TiB_2 micro-particles. They have reported 50 % increase in the micro hardness compared to the parent material. Devaraju et al.[4]has fabricated a hybrid SC using Al 6061 as parent material and reinforced the same with different mixture of the powder viz., SiC & Graphite (Gr) and Sic & Al_2O_3. Low wear rate has been observed in the Al–SiC/Gr surface hybrid composite due to mechanically mixed layer generated between the composite pin and steel disk surfaces which contained fractured SiC and Gr. It has been reported that the wear rate was $1/5^{th}$ of the parent material. R. Ramesh et al. [5] has studied the hardness and thereby wear resistance at various combination of rotational speed, travel speed and no. of passes for Al 7075/B_4C surface composite fabricated using FSP. It has been found that the average hardness of friction stir processed surface composite has been 1.5 times higher than base metal. Soleymani et al.[6]reported half volume loss in the wear test of the Al 5083/SiC composite formed using FSP compared to base metal. The increase in hardness and wear resistance have been attributed to fine dispersion of reinforcement particles in matrix and grain refinement of the matrix.

During FSP, particles are wrapped and flow together with plastic metal. Due to difference in the physical properties between B_4C particles and base metal, it is hard for the particles to travel with the trail left by the plastic metal[7]. That’s why B_4C particles cannot be easily dispersed and the agglomeration occurs. So, it is necessary to fabricate SC layer by higher number of passes, which softens the matrix each time & ensures better distribution.

In present work, Aluminium 7075 as being one of the stiffest and strongest aluminium alloy, has been used as matrix phase. Whereas, boron carbide (B_4C), as being third hardest material found on the earth has been used as reinforcement phase. Al 7075/B_4C composite has been formed using various combination of tool traverse speed (TS), number of passes and tool rotation speed (RS). Investigation of microstructure, microhardness and wear properties had been done for the SC formed.