Microstructure and Mechanical Properties of Al/Fe Micro-laminated Composites Fabricated by Ultrasonic Consolidation

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Introduction

Ultrasonic consolidation technology is a new method for preparing high-performance laminate composite materials. In this paper, it is aimed at Al/carbon steel and Al/Fe laminated composites systems with low cost and multilayer structures, Al-Fe and Al-carbon steel laminated composites were prepared by ultrasonic consolidation, the interface forming mechanism of Al-Fe laminated composites was analyzed, and its mechanical properties were tested. It has a broad application prospect and academic value for studying the fundamentals of multi-layered protective structural systems and their popularization and application.

Experimental

Industrial purity aluminum 1060 and iron foil are placed in alternating layers in all ultrasonic consolidation experiments. The foil Al 1060 and iron have a shear size of 800×20×0.2mm.The obtained Al/Fe laminated composite is selected oriented perpendicular to the direction of the ultrasonic consolidation lamination to standard grinding and polishing, the OM, SEM and EDS was used to study the interface microstructure, Composition distribution and fracture morphology of polished samples, the Vickers Hardness of laminated composites was characterized by microhardness. The electronic stretcher was used to test the tensile properties of the obtained laminated composites.

Results and discussion

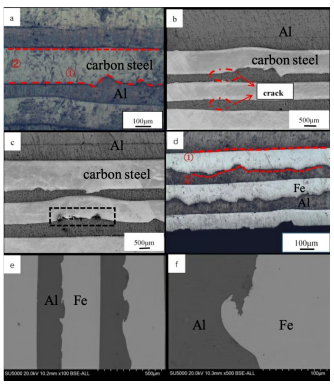

Figure 3. (a)(b)(c) Microscopic image of Al/carbon steel laminated composites (d)(e)(f) Microscopic image of Al/Fe consolidation samples

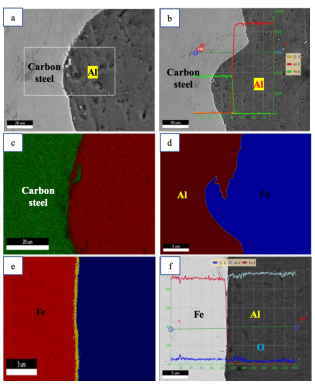

Figure 5. (a)(b)(c) interface surface scan of Al/carbon steel laminated composites (d) toothed interface surface scan of Al/Fe laminated composites
(e)(f) interface surface scan of Al/Fe laminated composites

There are a lot of defects in the interface bonding region of Al/carbon steel consolidated samples, and the "cavity" defects exist, which destroys the interface continuity of materials, the metallurgical bonding region of the laminate materials is not formed in the material interface layer by EDS. But in the laminated composite samples obtained by Al/Fe consolidation, there are "toothed" interface and "straight" interface topography, and Al/Fe consolidated samples generate trace of intermetallic compounds at the straight interface, an elemental diffusion region with a thickness of about 1 micron appears, it is an ideal combination of the laminated materials. It can be clearly found that the concave and convex defects are greatly reduced at the macroscopic interface of the Al/Fe consolidated samples, there are only few micro-defects such as "cavities", and combination effect is better.

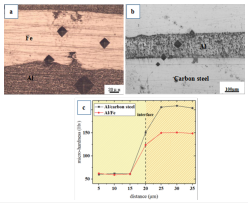

Figure 6. hardness indentation and hardness comparison of Al / Fe and Al / carbon steel laminated composites

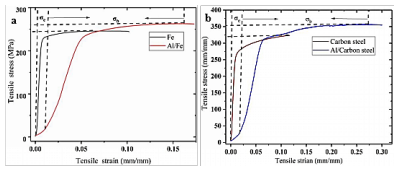

Figure 7. (a) stress-strain curves of Al/Fe laminated composites(b) stress-strain curves of Al/carbon steel laminated composites.

The hardness indentation of each layer of the Al/Fe laminated composites show a significant linear contrast with the material self-property.

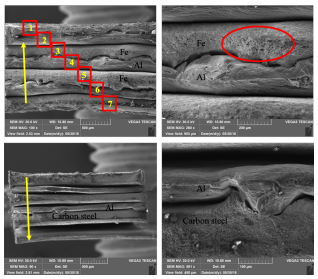

Figure 8. (a) macroscopic morphology of fracture surface of Al/Fe laminated composites (b) "toothed" morphology of Al/Fe interface (c) macroscopic morphology of fracture surface of Al/carbon steel laminated composites (d) "toothed" topography of Al/carbon steel interface.

In the fractured stage: there is no necking phenomenon in Al/Fe laminates and Al/carbon steel laminates, showing brittle fracture. The Al/Fe laminates are more likely to brittle fracture than the pure iron after strengthening. The Al/carbon steel laminates are more likely to brittle fracture than the Al/Fe laminates after strengthening.

The overall fracture morphology shows that the Al/Fe interface and Al/carbon steel interface have completely cracked, there are still "tooth" phenomenon at the interface. The fracture of aluminum layer is prior to the fracture of iron layer. The fracture interface of aluminum rolling on iron is the toothed surface, while the fracture interface of iron rolling on aluminum is straight and cracked.

Conclusion

The interface analysis of the two groups of experiments shows that the Al/Fe laminated composites prepared by the ultrasonic consolidation have better bonding effect, and the interface of the Al/Fe laminated composites is straighter than the interface of the Al/carbon steel laminated composites.

It is indicated that the mechanical properties of materials after lamination consolidation can be greatly improved, and the effect of Al/Fe laminated composites is better than the Al/carbon steel laminated composites.

By analyzing the fracture morphology of the two groups, it is found that the coordination of Al/carbon steel consolidated samples is obviously inferior to that of Al/Fe consolidated samples.

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