Notification No- 510/2022 **Notification Date: 30-03-2022**

Abstract

Student Name: **Manoj Kumar Yadav**
Supervisor Name : **Prof. Arshad Noor Siddiquee**
Co Supervisor Name: Prof. Z. A. Khan
Topic : Some Studies on Surface modification using Hybrid Friction Stir Processing Approach
Department of Mechanical Engineering Faculty of Engineering and Technology
Jamia Millia Islamia, New Delhi-110025

Keywords:

Agglemoratation, Aluminium, ANOM, ANOVA, Friction Stir Processing

The need for the enhancement of mechanical properties is one of the most crucial fields. The engineering society needs more versatile materials that may be more economical and having more strength even under severe thermal conditions. The development of new alloys for strategic sectors like energy is the current demand of the industries. It is always better to improve the properties of existing materials to save time, cost and other resources. In the energy sector, the turbine blades get deteriorated significantly owing to creep-fatigue loadings. Many kinds of research have been done, like the coating of the blade, fabricating single-crystal blades with cooling holes, use of ceramic tiles and many more. The use of high-cost superalloys is also an option to reduce creep fatigue failure. Several works have been performed to make MMCs/ SCs on aluminium alloys to replace the superalloys. Several methods like selective laser melting (SLM), friction stir process (FSP), welding etc., can be used for surface modification. Mechanical Alloying (MA), a solid-state method, is used to produce reinforcement that can be used with the method mentioned above of SCs' fabrication. MA is a very cost-effective process. Another advantage of the process is that the alloyed particles fractured up to the nano sizes, making the alloyed intermetallic powder more useful for future assignments and applications. The efforts were done to enhance the properties of AA1050 by using different methods but reported very acutely. The surface modification is possible by developing metal matrix composites (MMCs)/ surface composites (SCs).

The present work endeavoured to take on this gigantic challenge to investigate the strength enhancement task through the fabrication of SCs using a hybrid FSP route. The roadmap of this task comprised of the meticulous mining of the latest literature on the core and fringe areas of the issue. A set of more than 300 research papers was thoroughly studied, and an infallible methodology was devised. The fabrication and characterization of Al-Ti with different variables and process parameters were thoroughly investigated. Further, a filtered and focused research review of surface modification of AA1xxx series through FSP and the optimization of process parameters using single response and multi-response methods were performed. After a critical literature review, it was found that the synergic effect

of the formation of Al-Ti reinforcement using MA is scarcely reported. Few pieces of literature reported the use of mechanical alloyed reinforcement of Al60Ti40 (an intermetallic finds high-end applications) in Aluminium metal matrix. Al60Ti40 deposition on AA1050 can improve its performance in adverse conditions. Systematic studies on MA as well as FSP parameters is poorly reported. Major work for grain refinement was reported under multi-pass FSP, which can cause coarsening of grains due to higher heat addition and may result in strength reduction. So, it requires to report a clear understanding of the hybrid process that can surpass the ill-effects of the previously reported works.

A planetary ball mill was developed to develop the reinforcement by the mechanical alloying process. The pilot study was conducted to decide a window for the experimentation. The parameters like ball powder ratio (BPR), Process Control Agent (PCA), process cycle interval, and ball size were fixed. After the completion of experiments of MA, it was decided to change only the milling time. The samples after 20, 40 and 60 hours were collected for further investigations. The next step was the fabrication of SCs using FSP, for which an indigenously adapted heavy-duty, robust vertical milling machine was employed. Major process parameters and significant fixed process parameters, their range and levels were explicitly established. To perform the FSP process, a new tool with a scrolled shoulder and plain cylindrical pin was designed and developed. The tool design resulted in an efficient stirring and an adequate distribution of reinforcement in the metal matrix. The novel approach in this study is the hybridization of two processes, one is MA, and the next one is FSP.

For FSP, three variable process parameters, namely shoulder diameter, tool rotational speed and tool traverse speed, were selected after rigorous pilot experimentation. Three sets of values selected for each parameter and their respective level was designated. The range of shoulder diameter, tool rotational speed and tool traverse varied between 16-20 mm, 450-710 rpm and 31.5-50 mm/minute, respectively. AA1050 BM plates having dimensions of 200 mm × 70 mm × 8 mm was chosen to fabricate SCs. A rectangular slot in the centre and along the length of 160 mm × 2.5 mm × 1.5 mm sized plates were machined on these plates in which the MAed Ti-Al reinforcement was filled and compacted. The compacted slots were covered by employing a pin-less tool of 12 mm diameter. The surface modification and fabrication SCs was performed using single-pass FSP experiments according to Taguchi's L_{27} orthogonal arrays (OA).