

ABSTRACT

In the recent years, a lot of research has been conducted for preparing new materials possessing high strength and better workability. Aluminium and its alloys have gained much importance in the recent times, due to its good strength to weight ratio, high thermal stability and good specific strength. Aluminium alloys are less in weight and have many economic advantages. For enhancement the mechanical and tribological aspects of aluminium, it was reinforced with strengthening materials to form composites. For enhancement of the life and workability of the composite materials during tribological interactions, lubrication has been used. To reduce the dependence on conventional petroleum-based lubricants, investigations have been carried out by using vegetable oils, which are easily bio degradable and do not harm the environment. Additives are being used in the bio lubricants for enhancing the lubricating properties of the vegetable oil during tough working conditions.

In this research, an attempt has been made to conduct tribological investigations on AA6082 Aluminium Matrix Composites. AA6082 was chosen as the matrix material as it had good strength to weight ratio and excellent resistance to corrosion. It was reinforced with Titanium and Graphene, using vegetable oil incorporated with nano particles as lubricant. By using stir casting method, Aluminium Metal Matrix Composites were prepared. Six series Aluminium Alloy such as AA 6082 was used as the matrix material. For reinforcements, Graphene powder and Titanium powder were used. The purpose of using Graphene was to enhance its structural and mechanical properties. Titanium reinforcement was done to improve the hardness and wear resistant properties of the composites.

The mechanical and tribological characteristics of the Aluminium Matrix Composites were evaluated by identifying the feasible limit for incorporation of the Graphene and Titanium particles. Aluminium Matrix composites were prepared by reinforcing Graphene and Titanium each from 1%

by wt. to 5% by wt. The prepared Titanium reinforced Graphene based AA6082 Aluminium Matrix Composites were subjected to mechanical tests such as tensile shear failure test, surface micro hardness testing, corrosion, fatigue and dry wear tests, to identify the effect of Graphene and Titanium reinforcements. On evaluation, AA6082 reinforced with 3% by wt. of Graphene and 3% by wt. of Titanium was found to exhibit better mechanical and tribological properties, as it possessed higher tensile strength of 347 MPa, better fatigue life of 2.36×10^6 NCF, low wear mass loss of 2.3 grams in tribo wear mass loss and more positive E pitt value of -427 eV.

Tribological aspects of the Titanium reinforced Graphene based AA6082 Aluminium Matrix Composites were evaluated by conducting pin on disc tribo wear tests using natural oil lubricants such as Pongamia, Jatropha, Palm, Brassica, Neem oil and they were compared with petroleum-based SAE 20W40 Engine oil. By using a stainless-steel disc, the AMCs in the form of pins were wear tested using loads varying from 20N to 80N at 1000 rpm disc rotational speed for a wear duration of five minutes. The fluctuations in the specific wear rate and coefficient of friction upon using different vegetable oil lubricants, on increasing the loads were identified. Out of all vegetable oils, under the existing conditions, Jatropha Oil was found to have better lubricating properties. In Jatropha oil, three different powders such as Ag Nano particles, Copper Oxide (CuO) powder and Titanium Oxide (TiO₂) particles were added and they were used as lubricant in the Titanium reinforced Graphene based AA6082 Aluminium Matrix Composite tribo wear tests. The specific wear rate and coefficient of friction for the tests conducted using Nano particle incorporated Jatropha oil were observed. On addition of the three Nano powders, the variations in kinematic viscosity were observed by using viscometer and thermal conductivity was measured by using Transient Hot wire method. Out of the three, Ag nano particles incorporated Jatropha oil was found to exhibit superior lubricating properties. For evaluation of tribological environment and conditions in which the overall quality and workability of AA6082 AMCs

reinforced with Graphene and Titanium, the important tribo wear process parameters were optimized. By using a central composite design model, twenty different combinations were formulated using tribo wear disc speed, pin load and wt. % of Ag Nano particle addition in Jatropha oil. Accordingly, twenty experiments were conducted and on conducting each experiment, the wear test mass loss and surface roughness was measured. The purpose was to reduce the wear mass loss and surface roughness. Empirical relationships were developed in between the tribo wear test process parameters and the responses.

Using Analysis of Variance, the significance of the developed tribo wear mass loss reduction model and surface roughness reduction model were ascertained. Optimization was done using Response Surface Methodology. Response Surface Methodology has been regarded as a mathematical and statistical evaluation technique, for prediction of desired response with minimal trial and error experiments. The objective of optimizing the tribo wear process parameters is to achieve minimum possible tribo wear mass loss and surface roughness. Using validation experiments, the significance of the developed optimization model was ascertained. Using interaction and perturbation plots, the tribo wear process parameters which affected the output responses were ascertained. The tribo wear tested specimens were subjected to X-Ray diffraction Spectroscopic evaluation, for identification of the elemental compounds present in the AMC surface. Using Energy Dispersive X-Ray Spectroscopy, the fluctuations in the surface chemistry were observed. The grain modifications in the tribo wear tested surface was evaluated using Scanning Electron Microscopy, and the wear mechanisms and surface degradations were identified.