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Effect of Silica-Based Wastes on Wear Rate and Hardness Properties of Epoxy Composites as a Construction Material

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Abstract. In this study, polymer composites were manufactured with epoxy-based resin and wastes as a mineral additive. The wastes including a high content of silica (Silica fume, glass and fly ash) powder were used as fillers for an epoxy adhesive to improve its wear resistance properties. They were supplemented to mixes in various ratios via substituting the resin from 0 to 20% by weight. Tests of wear rate and hardness were conducted upon all-polymer composites at all fillers ratios. Results indicated that the epoxy hardness increased with increasing the filler addition. Consequently, the addition of wastes that include silica raised the wear resistance of polymer composites; nevertheless, it caused the composites harder materials. The wear rate decreased with increasing the silica fume, glass, and fly ash addition. In the case of fly ash addition, the minimum wear rate was at 15%, and after this percentage, the wear rate increased. However, in the case of glass addition, the minimum wear rate was at 10%, and after this percentage, the wear rate increased.

Introduction

Composites have been broadly utilized in engineering uses owing to their high strength-to-weight ratios [1]. Presently, the polymer composites combine unique characteristics; high deformation and strength properties, and concurrently, the low specific weight being extensively implemented in the industry [2]. The particle fraction and size influence on the mechanical and wear behaviors of polymeric composites was studied, and it was reported that the abrasion withstanding of composite reduces with the increment of the particle volume percentage, instead of an associated increase in the modulus of elasticity and hardness. The particle reinforced polymer composites can be used in many applications due to their low cost, isotropic properties, and easy manufacturing process [3].

Epoxy resins being broadly utilized as a matrix in numerous reinforced composites; they are a thermoset materials class of specific attention to the structural engineers due to the truth that these materials offer a sole balance of the mechanical and chemical characteristics that combined with an extensive processing versatility [4–7]. The epoxy resin possesses a vigorous cohesive force effect due to the presence of the Ester and Ether keys and the epoxy resin. Also, the epoxy resin possesses a vigorous cohesion of the molecular structure compact, thus the mechanical characteristics of the epoxy resin being better than the unsaturated phenolic resin and poly vinegar [8]. Some kinds of stiff inorganic particulate fillers have been investigated for improving the mechanical characteristics of epoxy composite, like alumina, nano clay, silica, etc. Among many epoxy fillers, Silica is the highest one utilized commercially as filler [9,10].

The particles of silica are normally utilized for enhancing the stiffness of epoxy owing to their high elastic modulus and vigorous adhesion with the matrix of epoxy. This adhesion limits the molecular mobility and the deformation of the matrix of epoxy at the interface area. The strengthened interface area enhances the transfer of load and the epoxy/silica stiffness [11]. Due to the incorporation of micro silica into the matrix of epoxy, the thermal and mechanical characteristics, as well as the dimensional stability of the neat epoxy regime, were enhanced through its method of