UNIVERSITI TEKNOLOGI MARA

FRICTION AND WEAR PROPERTIES OF FRP COMPOSITES AND NANOCLAY-FILLED BFRP COMPOSITES

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ABSTRACT

Natural fibers have recently gained increasing attention as possible replacement to synthetic fibers, as they are available widely and easily manufactured. Basalt fibers have become one of potential reinforcement materials to substitute glass fiber due to their comparable mechanical properties, lower cost and environmental friendly. The usage of nanoscale filler to improve polymer matrix performance especially in nonlubricated tribological applications also shows growing attention by global researchers. Up to date, research on the potential of Basalt fiber reinforced polymer (BFRP) composite and its nanoclay-modified form in tribological applications is still limited. In present study, the effect of nanoclay incorporation on BFRP composite was investigated at different wear conditions, motions, parameters and configurations. Pure FRP composites (Glass fiber and Basalt fiber) and nanoclay-filled (1.0 wt%, 3.0 wt% and 5.0 wt%) BFRP composites were prepared using three roll mill and manual hand lay-up technique. Physical characterization was conducted in early phase of this research work. For wear test, three different tribotests were employed to investigate the wear properties at three different wear conditions, i.e. adhesive, abrasive and erosive. These tests were conducted at fixed load and velocity parameters. In the next stage, the composites were tested at different motions, i.e unidirectional and reciprocating adhesive sliding where load, velocity and configuration were varied. Worn surface analyses were conducted at the end of all tests. Specific wear rate of Pure BFRP composite has improved about 9.9%, 17.5% and 14% when it was tested at erosive wear condition, high parameters of unidirectional sliding and BOF configuration of reciprocating sliding, respectively, when compared to Pure GFRP composite. While, its friction coefficient has improved about 3% and 6% at high parameters of unidirectional sliding and COF configuration of reciprocating sliding, respectively. Nanoclay improved adhesive and erosive wear of BFRP composite by 31.7% and 51.1%, respectively, while it reduced abrasive wear by 101.9%. At unidirectional and reciprocating adhesive test, nanoclay incorporation has improved the wear rate of BFRP composites at all parameters and configurations. The improvement at low (30N, 300rpm) and high (70N, 500rpm) parameters was 35.1% and 22.5% respectively, while for ball-on-flat (BOF) and cylinder-on-flat (COF) configuration was 31.5% and 41%, respectively. However, friction coefficient only improved when tested at low parameters at unidirectional sliding and COF configuration at reciprocating sliding with 6.26% and 8.92% improvement, respectively, while the other type of tests showed deterioration as nanoclay content increased. In general, nanoclay played an important role in enhancing the wear behaviour of BFRP provided that the amount of nanoclay inclusion was small, less than 5wt%. It also caused different types of wear mechanisms such as adhesive wear, abrasive wear, ploughing, surface fatigue and brittle fracture during testing. Nanoclay has either benefit or detriment the wear properties of BFRP composite depending on type of wear tests it underwent. Therefore, this research has proven that nanoclay filled BFRP composite is a promising new material to be used in various tribological applications, especially as dry sliding material.

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CHAPTER TWO
INTRODUCTION

2.1 Research Background

The multidisciplinary growth and expanding technologies together with advanced development of materials sciences and manufacturing methods have resulted in increasing attention towards the study of tribology [1]. Tribology easily defined as the integrated study of friction, wear and lubrication. The study of tribology on engineering materials is important for various industrial applications since it has direct effect on the marketability and life span of the product, which contributes to a long lasting product value. Polymer and its composite that are evolving rapidly in various applications and industries cannot escape from friction, wear and lubricant problems. The use of polymer in sliding components, cams, brakes, bearings and gears, all involving self-lubricating properties, lower friction and better wear resistance [2]. Polymers that are involved in continuous movement on abrasive surfaces are also in needs of excellent wear resistance, such as pipe and chute liners, rotors and powder mixers, blades, and impellers in pumps [3]. The most popular used polymer such as epoxy has outstanding mechanical, thermal and electrical properties. However, general drawbacks of epoxy such as low load-carrying capability, brittleness, rigid in nature, and poor resistance to crack propagation [4] could be overcome using special fillers (mirco to nanosized particles). By improving epoxy's hardness, stiffness and strength, its friction and wear behaviour will be improved as well [5]. Besides fillers, fibers also play a crucial role in determining the friction and wear performance of a composite. The fiber reinforced polymer (FRP) composites are the most rapidly growing class of materials due to their good combination of high specific strength and modulus. In addition, FRP composites also exhibit properties such as lightweight, low density, high chemical stability, and most importantly, better wear resistance. This wear properties enable them to be utilized in tribological application such as in aerospace, automobile, and aviation [6]. Carbon, glass, and aramid fibers are amongst the widely employed reinforcements in polymer matrix. However, although carbon fiber is reported to have the best mechanical properties and