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Friction Performance Analysis of Waste Tire Rubber Powder Reinforced Polypropylene Using Pin-On-Disk Tribometer

Sivaraos[a]*, T.C. Yap[b], Qumrul[a], M.A. Amran[a], T.J.S Anand[a], R. Izamshah[a], A.A. Aziz[a]

[a]*Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100, Durian Tunggal, Malaysia*
[b]*Faculty of Engineering and Technology, Multimedia University, Jalan Ayer Keroh Lama, 75450, Melaka, Malaysia*

Abstract

Waste tire rubber powder reinforced polypropylene composites were established with different set of compositions ranging from 0% to 40%, where coefficient of friction for each of them was analyzed by pin on disk tribometer. The tribological effect between the pin-disk reveals of how the reinforcement plays a vital role in enhancing the coefficient of friction as compared to virgin polypropylene. This paper also elaborates in detail of how the matrix, reinforcement, specimen and test were prepared and conducted via critically designed methodology. A specially designed non-metallic parted line mold was used to ease specimen removal. SEM micrographs provides clearer view of what actually happens between the inter layer bonding of matrix and reinforced materials. The promising findings not only save the environment by utilizing waste tires which are often difficult to be disposed, but it also significantly enhanced the coefficient of friction for pure polypropylene which is highly potential to be used in engineering applications. The correlation between these materials was found towards routing an alternative way of how waste tires could be utilized to engineer new composite materials.

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Keywords: Friction performance; pin on disc; wear test, waste tire rubber powder; WTR powder polypropylene composite; coefficient of friction

1. Introduction

The waste tires and recycled rubber are known as main adverse effects contributor to the environment which is now addressed as a global issue handled all over the world. There were about 1.5 billion waste tires around the world in May 1997. Thus, about 3.2 million tons of used tires are annually generated in Europe, out of which 2.5 million tons life ended tires are significantly utilized for value recovery. The technologist utilizes devices and machines from the range of simple mechanical devices to sophisticated, complex mechanochemical and thermal set ups to rework or reutilize used tires. Few systems are combined together to operate in tandem to produce desired products [1]. Coefficient of friction and weight losses of epoxy-rubber composites has been investigated by varying

* Corresponding author. Tel.: +60-6-3316505; fax: +60-6-3316411
E-mail address: sivarao@utem.edu.my

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speeds, loads and time [2-3]. It was observed that all the specimens have exhibited very low coefficient of friction and low wear rates under dry sliding condition. Incorporation of silica in PP-NR-RRP composites gave more processing difficulties than carbon black and calcium carbonate filled PP-NR-RRP composites [4-5]. Wear resistant rubber products are being mainly developed on an empirical basis as the scientific understanding of rubber wear is yet to achieve. Therefore, further investigation of the wear mechanism is necessary in order to be able to design rubber formulations and to specify relevant test methods in a rational way, in order to improve the tribological performance of rubber products [6-7].

Maridass Balasubramaniam et al. [8], predicted and optimized the mechanical properties of polypropylene/waste tire powder blend using a Hybrid Artificial Neural Network-Genetic Algorithm (GA-ANN) incorporating various blends of PP and waste ground rubber tire powder with ethylene-propylene-diene monomer (EPDM), and polypropylene grafted malcic anhydride (PP-g-MA) compatibilizer of various concentrations. Four material factors namely WGRT, H-PP, PP-g-MA and EPDM concentration led to 9 trials for optimized recipe with respect to tensile strength, including elongation break, modulus, and hardness. Zhen Xiang Xin et al. [9], investigated the recycling of waste ground rubber tire (WGRT) foaming method using CO2 as the foaming agent in an extrusion foaming process. Multiple samples were prepared with various weight percentage (wt%), but the 20 wt% blend demonstrated as the best cell morphology possessing smaller cell size, better cell uniformity, and higher cell density. The cell density, void fractions generally increased proportionally as the CO2 amount increases.

Expanded Waste Ground Rubber Tire Powder/ Polypropylene Composites has been investigated by [10] using a single screw foam extrusion setup and chemical blowing agent. The relationship between foam structures of foamed PP/WGRT composites was studied. It was claimed via the statistical analysis that, screw speed is the most important factor in determining the cell size and cell density, the blowing agent is the most important factor determining the void fractions. The mechanical behavior of epoxy matrix composites filled with Nano sized silica particles and styrene-butadiene rubber was performed by [11]. The results of the wear test in pin-on-disc mode and hardness test on Rockwell R scale showed that, Nano sized silica particles is able to improve the wear resistance of the epoxy matrix even though the content of the filler is at a relatively low level (1.0-2.0 wt%). This makes it possible to develop novel type of epoxy-based material with improved wear resistance for various applications. A good correlation between mechanical properties and weight contents of the filler materials, hardness and ultimate strength, hardness and wear rate has been observed.

2. Matrix and filler properties

The properties of both, polypropylene (PP) being the matrix, and waste tire rubber (WTR) powder as filler were characterized critically to ensure the reproducibility of the composites. The properties of PP and WTR powder are shown in Table 1 and Table 2 respectively.

Table 1: Properties of waste tyre rubber

Properties	Value
Density	0.9 x 103 Kg/m3
Specific Gravity	0.94
Low Temperature Limit	-18^{o}C – 10^{o}C
High Temperature Limit	70^{o}C – 107^{o}C

Table 2: Properties of Polypropylene

Properties	Value
Density	0.51 x 103Kg/m3
Specific gravity	0.90
Young Modulus	1.3GPa
Form	Pallet

3. Experimental investigation