WEAR PERFORMANCE OF HDPE/ ZnO – SiO_2 - $CaCO_3$ – $Mg(OH)_2$ NANO-FILLER POLYMER COMPOSITES

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Abstract: Polymer technology is developing products for diverse needs. However, the expected properties of materials are rapidly increasing. Many new products have been developed using nanotechnology in the development of polymer production. These products can be illustrating change properties as physical, structural, morphological, electrical and mechanical properties when compared to the microstructure. Detection of these changes can be determined by an examination of these materials. In this study, the investigation of the effect of high-intensity polyethylene is filled by zinc oxide, magnesium hydroxide, calcium carbonate and silicon dioxide. The experiments show that It varies according to the tribological properties of nano contribution rates. High density polyethylene with zinc oxide, magnesium hydroxide, calcium carbonate and silicon dioxide have been mixed at % 5, %10, %15 and % 20 proportion. After the mixing activity the dehydrated materials have been changed into granule.
Key Words: Wear Performance, Nano powder, HDPE

INTRODUCTION

In recent years micro-and nano-fillers have attracted great interest, both in industry and in academia, because they often exhibit remarkable improvement in materials properties when compared to conventional composites made by using macro-fillers. These micro-/nano-composites can be made with very low loading of micro-/nano-fillers as compared with macro particle sized fillers (Ray, 2003). High density polyethylene (HDPE) is widely used as a commodity polymer with high-tonnage production due to its distinctive mechanical and physical properties. Because of its low toughness, weather resistance, and environmental stress cracking resistance as compared to engineering polymers, its application in many areas has been limited. To improve these disadvantages, HDPE has been reinforced with fillers [Wang, 2009; Rothon, 1995-1999; Ersoy, 2012). Wear is defined as the loss of materials at the rubbing surfaces. Wear rate on the type of material, to the shape of the rubbing surfaces of the friction conditions and depends on the chemical effects of the environment. Maintained a certain period of effect of a given force to the test parts for wear reduction in the amount or size reduction by weight or volume are measured (Ersoy, 2015).

Determined by the literature and the results of similar studies have been examined. Dhoka et have examined the effect of the addition of nano ZnO on silicone modified alkyd- based coatings with water based on the mechanical and heat resistance. In this study, nano- ZnO was added in different proportions. Contribute to the increase of the rate of increase has caused the wear rate (Shailesh, 2009).

In a study conducted; PP - Mg $(OH)_2$ which size is 50 nm were mixed. Mixing ratios caused the reduction of wear. The change in the wear rate of the material has been found to be associated on hardness value. (Saçaklı, 2012).

In another study performed on mechanical and wear behavior of vinyl ester resins investigated the effect of nano silica filler. In this study, vinyl ester resin was mixed SiO_2. This abrasion test was applied to the obtained material. Results of an increase in contribution rates indicate that the wear rate increases. Another study on the ZnO nano-composites and aluminum were also examined and compared with SiO_2 and their wear rate comparison with other samples and their result values were found to be better than other nano-materials filler composites (Elansezhian, 2011).

Experimental Details

High-density polyethylene (HDPE) Was supplied by Petkim (Izmir-Turkey). Specific gravity is 0,970 g/cm^3. Melt flow rate is 5.2 g/10 min (190^o C–2.16 Kg). Yield strength is 28,0 MPa and notched Izod impact (23^o C) is 12 kJ/m^2. Zinc oxide nano powder was supplied by MK nano. Particle size is ≤50 nm and white powder. Its purity is 99.9 %. Magnesium hydroxide nano powder was supplied by MKnano. Its purity is 99 %. Particle size is 50 nm. Calcium carbonate (calcite- CaCO3) Nano powder was supplied by Cales de Llierca. Its purity is 98 %. Particle diameter is 50 nm (Ersoy, 2012)

SiO_2, ZnO and $Mg(OH)_2$ were dried in a Vacucell VD 55 vacuum oven at 105ºC for 24 hours before being blended with HDPE. Mechanical premixing of solid compositions was done using a blender for 15 min. Samples with various proportions of HDPE/SiO_2, HDPE/ZnO and HDPE/$Mg(OH)^2$ polymer composites were produced between 180-220 oC at 20-30 bar pressure, and a rotation rate of 30 rpm, with a co-rotating twin-screw extruder. L/D ratio is 30, Ǿ: 25 mm. To prepare the samples for thermal and mechanical tests, the following injection conditions were used: Injection temperature was 180-220 ºC, injection pressure was 110-130 bar, dwelling time in mold was 10 s, and screw rotation was 25 rpm, Polymer composites were also dried in vacuum oven at 105 ºC for 4 hours after extrusion (Saçaklı, 2012).

METHODS

Wear rate that the fragment of material is determined by counting the amount by mechanical rubbing, scraping and erosion. The cylinder is wearing to polymer without overheating wherein the force applied is 10N. Test, according to the type of the sample, 10, 20 and 40 are made according to one of meters. The result of this operation indicates deliver the ratio of the wear resistance. This value is expressed as volume loss or abrasion (ASTM D638). Figure I. shows operating principle of the abrasion tester. The device has TS EN 12770 as a reference number which is containing the abrasion test method that used in the standard [6]. The device used in the assay is Devotrans brand. This device is located at Marmara University Faculty of Technology and Metallurgy Laboratory. Test samples have 4 mm thick and 16 mm diameter. The weight of the test sample is determined. Samples should be in full contact with the abrasive system as TS EN 12770 and TS 11007.

Figure 1. The abrasion test device

The device reaches 40 meters by 84 cycles. Thereafter the test stops and the part is ejected. And then the weight of the sample is determined. This process is repeated for 5 samples which is TS 1731. The wear tests were done according to the DIN 53 516 method with Devotrans DA5 (Devotrans, Istanbul-Turkey) abrasion test equipment. The friction coefficients and wear rates reported in the present study were the averages of three measurements. The thickness of the test specimens was 7.0 mm and diameter was 15.5 mm. The mass loss of the specimen was measured after the wear test, in order to calculate the specific wear rate by the equation:

$$Ws = \frac{\Delta m}{\rho\ .Fn.L}\ (\mathrm{mm^3/Nm}) \qquad (1)$$

where Δm: mass loss,
ρ: density (0.958),
FN: normal load,
L: sliding distance

RESULTS

The abrasion test result values are presented in this section. The results indicate that wear rate value of pure HDPE was identified as 0.000172 cm^3/Nm as reference value. All these measurements compose on this reference. Material increase in the contribution rate caused by corrosion of the values were determined.

HDPE - ZnO nano-composite examination of the wear rate values which is 5% ZnO reinforced materials was 0.00018 cm^3 / Nm. This corrosion rate is seen that an increase in value arrive 4.6%. ZnO wear rate 10% contribution values has led to an increase of 16.3% (0.00020 cm^3 / Nm). 15% ZnO contributing which is metal-based materials was studied and the wear rate determined 0.00021 cm^3/Nm, it increase 22.1% on wear rate ratio. Contribution of 20% ZnO grew by 27.9% in value of the wear rate 0.00022 cm^3 / Nm is. It was observed that the wear rate increases. Contribution of 20% ZnO grew by 27.9% on value of the wear rate (0.00022 cm^3/ Nm)

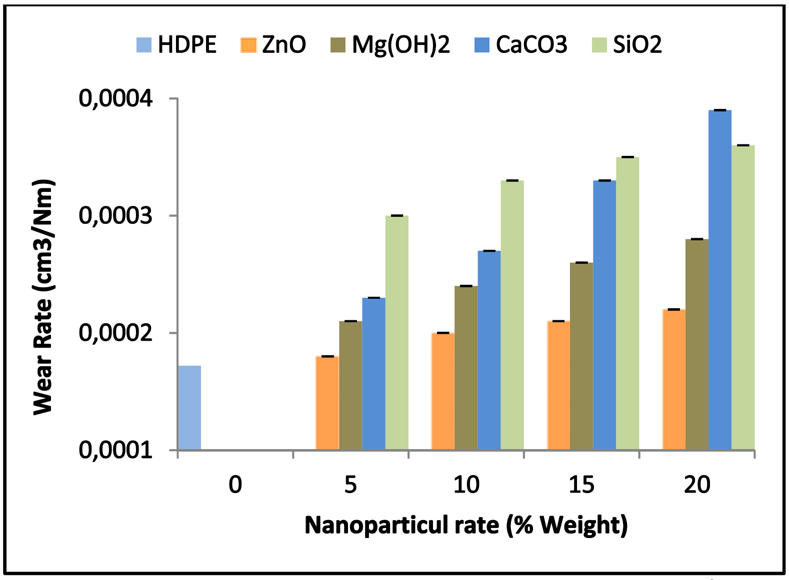

Figure 2. The wear rate as a result of abrasion test values (cm^3/Nm)

Metal materials such as ZnO, which class of Mg $(OH)_2$ addition of HDPE nano-composite wear rate values are examined, depending on the surface roughness increased wear rate. Examined the contribution of 5% of this value, the wear rate of 22,1% was observed with the increase in 0.00021 cm^3/Nm. Additives 10% ZnO, the increase in wear rate is 39.5%. The wear rate of 15% ZnO increased 0.00026 cm3/nm value (51.2%). In 20% of the additive reaches 0.00028 cm^3/ Nm seen.

Organic materials such as $CaCO_3$ and SiO_2 were found to contain high increase in the wear rate. HDPE - $CaCO_3$ contributing 5% of nanocomposite was determined as 0.00023 cm^3/ Nm, where in wear rate increased 33.7% by reference values of HDPE. Wear value with 10% fill rate increased by 57% and reached 0.00027 cm^3/ Nm. Contribution rate of 15% $CaCO_3$ on the wear rate is 0.00033 cm^3/ Nm (91.9% increase). 20% $CaCO_3$ additive caused an increase in the rate of 127%. Here the value of wear rate cm^3 / Nm 0.00039. HDPE - SiO_2 by mixing additives with the HDPE increases were observed very high in wear ratio. 5% SiO_2 added increased wear rate value 74.5% (0,00030 cm^3/Nm). Wear value contribution of 10% SiO_2 was determined to be 0.00033 cm^3/nm. Here increase in wear values as 91.8%. Attrition values of 15% of additives identified as 0.00035 cm^3/nm. This indicates an increase in the rate of 103.5%. Contribution rate of 20% indicate that increase wear value as 109.3% (0.00036 cm3/nm).

Additives used in the study of the ZnO and Mg $(OH)_2$ depending on the contribution rates of nano-powders of the wear rate is understood that a linear increase. $CaCO_3$ and SiO_2 nano powder additives for wear rate was determined at the highest level in test groups.

SEM - EDAX

Nano- powder were conducted in order to determine the content by EDAX analysis. The data obtained are presented in Figures.

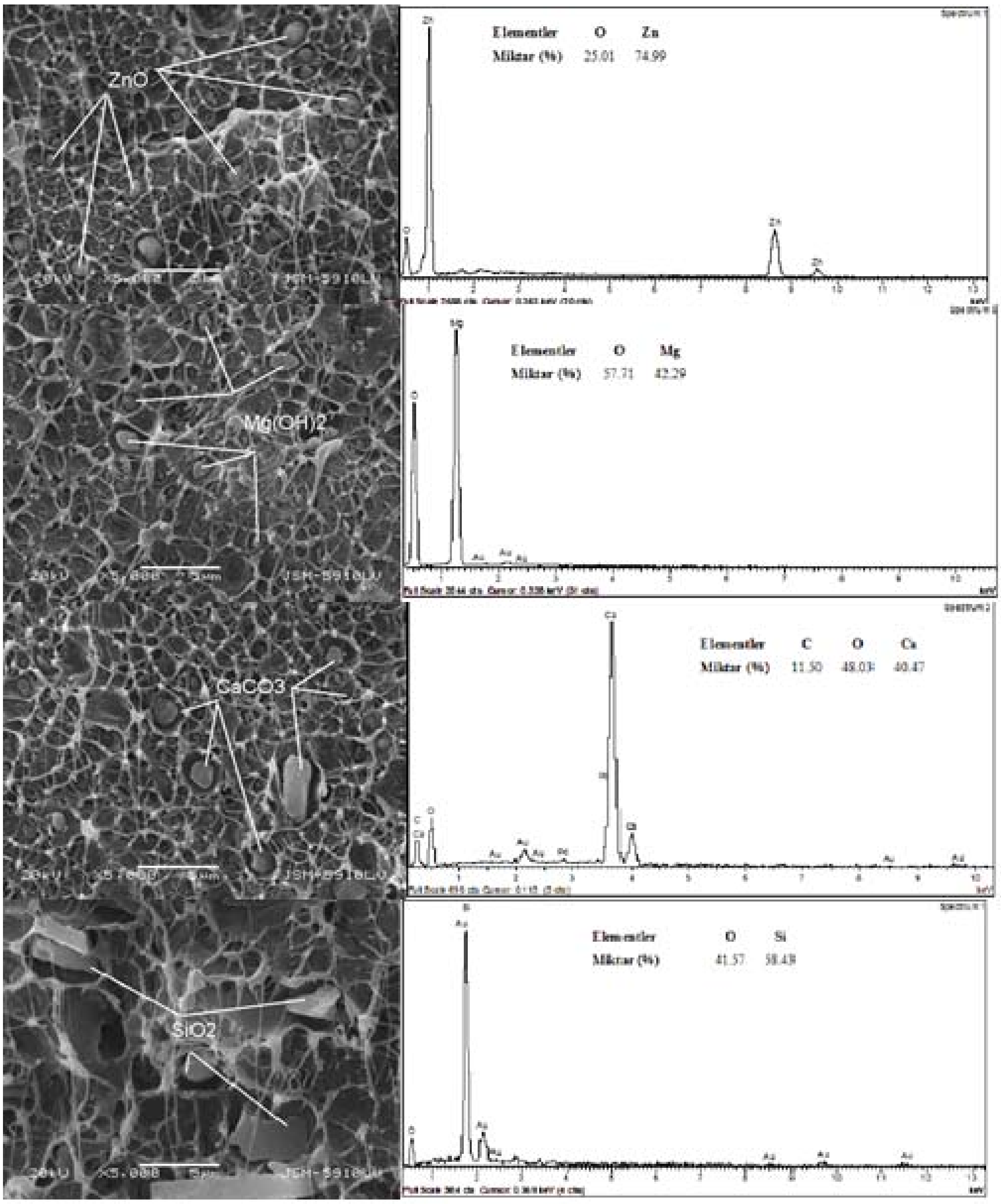

Figure 3. EDAX analysis results for ZnO, $Mg(OH)_2$, $CaCO_3$and SiO_2

CONCLUSION

Wear is the loss of material from the rubbing surfaces and its calculate quantity, by weight or volume or size reduction. Wear is the loss of material from the rubbing surfaces and it can be calculated quantity, weight and volume or size reduction. In this study; high density polyethylene incorporated nano powders were found to improve wear rate. Contribution rates have increased abrasion values. All material contribution rate, the highest values were observed in the highest wear. ZnO - HDPE composite materials for wear values increased about 20%. This increase was determined at Mg $(OH)_2$ at 27%, 109% in the addition of SiO_2, 126% of $CaCO_3$ filler respectively. Finally, it seen that wear rate of SiO_2 did not change at %20. It is understood that the SiO_2 nano-fill is not effective after this at 15%. After this work, researcher can work on filled new rate and their statistical analyses.

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