REZISTENȚA LA UZURĂ ŞI FRICȚIUNE A AMESTECURILOR COMPOZITE DE POLIETILENĂ DE ÎNALTĂ DENSITATE CU CAUCIUC STIREN-BUTADIENIC

FRICTION AND WEAR PERFORMANCE OF HIGH DENSITY POLYETHYLENE / STYRENE - BUTADIENE RUBBER POLYMER BLENDS

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In the present work, the friction and wear property of high density polyethylene / Styrene - Butadiene Rubber polymer blends was studied. Styrene - Butadiene Rubber addition in the HDPE was 5, 10, 15, and 20 wt%. The result showed that the addition of fillers to the composite changed the friction coefficient and wear rate. All specimen wear loss increases with increasing load and sliding distance; meanwhile the friction (static and dynamic) coefficient increases. Wear rate of all HDPE composites are larger than that of pure HDPE. The results obtained in this study indicate that HDPE / Styrene - Butadiene Rubber polymer applied to the abrasion test indicate that road and load values to increase the effect of wear, but this effect by increasing the rate of Styrene - Butadiene Rubber additives lead to a reduction in wear is observed that value. In the friction test, the coefficients of friction are the rate of increase Styrene - Butadiene Rubber that the friction coefficient increases.

Keywords: *Friction, wear, high density polyethylene, Styrene - Butadiene Rubber, polymer composites*

1. Introduction

Polymeric materials have been replacing metallic materials used as friction wear parts for many years. It is often found that, however, the single unmodified polymer could not satisfy the demands arising from situations where a combination of good mechanical and tribological properties is required. Therefore, it is necessary for improving polymer to provide it with outstanding properties using different methods, including copolymerizing, blending, filling with fibers and/or fillers, etc. [1]

Tribology is the science that deals with design, friction, wear and lubrication of interacting surfaces in relative motion (as in bearing or gears). Composite materials, one of the most rapidly growing classes of materials, are being used increasingly for such tribological applications [2]. A scientific understanding of the mechanism of friction and wear is still lacking, because wear rate is complex phenomenon and its mechanism depends on many parameters like chemical and physical properties of polymer, composition, load, velocity etc. [3].

In recent years, polymer nano-composites have attracted great interest. Nano-composites offer new technological and economic benefits. The incorporation of nanometer-scale reinforcement (e.g., layered silicates clay, nanofiber, nanotubes, and metal nanoparticles in polymeric materials) may dramatically improve selected properties of the related polymer [4]. Wear and friction properties of the polymer composites are investigated in tribological field. These studies presented essential results about of polymer tribological characteristics of polymer composites. Suresha and others, work on the comparative performance of Glass-Epoxy (G-E) composite systems interfaced with graded fillers has been examined. Their study indicates that composite materials were experimentally investigated under varying load and sliding velocities by using a Pin-on-Disc type wear tester. The study results show that the coefficients of frictional values show an increasing trend with subsequent increase in load/sliding velocities. It was observed that the Graphite filled G-E composite shows lower coefficient of friction than the other two composites irrespective of variation in the load/sliding velocities. SiC filled G-E composite exhibited the maximum wear resistance. Further, wear of the matrix, breakage of reinforcing fibers, matrix debris formation and interface separation were observed in unfilled and graphite-filled G-E composites [5].

Briscoe et al. investigated that the wear rate of high- density polyethylene (HDPE) was reduced with the addition of inorganic fillers, such as CuO and Pb_3O_4 [6]. Tanaka et al. concluded that the wear rate of polytetrafluoroethylene

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(PTFE) was reduced when filled with ZrO_2 and TiO_2 [7].

Zhang et al. [8] studied the effect of particle surface treatment on the tribological performance of epoxy-based nanocomposites with silica fillers. It has been found that, unlike micrometre silica, the low volume percent of silica, i.e., 2% showed better wear resistance. Hashmi and co-workers investigated the friction and wear behaviours of the blends of ultra-high-molecular-weight polyethylene with polyphenylene, polyamide, or polyurethane [9]. Tanaka [10] and Bahadur et al. [11] have reported that tribological behaviour of polyamide, HDPE and their composites. They reported that their wear resistance and coefficient of friction are affected greatly by normal load, sliding velocity and temperature. Xianqiang et al. [12] studied the mechanical and tribological properties of the PET / HDPE micro-fibrillar reinforced composites. It has been found that, the wear resistance of HDPE was improved by the formation of microfibrillar composites.

The results of this work shows the tribological behaviour of HDPE / Styrene - Butadiene Rubber polymer composite. Tribological tests were applied for 5, 10, 15 and 20 N load values for wear (at 20, 40, 60 and 80 rpm cylinder rotational speed) and 2, 3, 4, 5 and 7 N load values for friction (at 50, 100, 250 and 500 mm/min sliding speed).

2. Compositions and materials

HDPE and Styrene - Butadiene Rubber polymer were used for polymer blends. Five different polymer blends (given in Table 1) were prepared by using the following material: HDPE, known as Petilen. The blends ratio and their mechanical properties can be seen in Table 1 [13].

In this study, there were used HDPE as YY (I 668 UV) and Styrene - Butadiene Rubber polymer and their compose blends. Its specific gravity is 0.938 g / cm^3, melt flow rate (190 ^oC /5.0 kg) is 1.0 g 10 / min. These were composed at 10 min. 180-220 ^oC at 20-30 bar pressure and a rotation rate of 30 rpm by Micro sanco-rotating twin-screw extruder. The composite dried at 105 ^oC for 24 hours in owen after extrusion. This composite was produced at five different ratio as 10. 20. 30 and 40 of percent of Styrene - Butadiene Rubber fillers. Mechanical properties of HDPE-Styrene - Butadiene Rubber polymer composites injection processing parameters were:

- Processing temperature 180-220 C,
- Pressure 110-130 bar
- Cooling time (after flap open) 10 s. [13].

3. Tribological tests

Static and dynamic coefficient of friction test was done according to the ISO 8295 method with Devotrans friction coefficient measurement equipment. The dimensions of the tested specimens were 80 x 200 x 4 mm and the dimensions of the sled specimens were 63 x 63 x 4 mm. Speed was selected as 100 mm/min.

The static coefficient of friction μs is given by the equation (1) and the dynamic frictional force by the equation (2) [14]:

$$\mu s = FS / FP \quad (1)$$

$$\mu D = FD / FP \quad (2)$$

where μs: static coefficient of friction,
FS: static frictional force (N),
FP: normal force (N),
D: dynamic coefficient of friction,
FD: dynamic frictional force.

4. Wear test

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:

$$Ws = (\Delta m)/\rho.FN.L \ (mm^3/Nm) \quad (3)$$

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

5. Result and discussion

The tribological behaviour of materials has close relations with its mechanical properties.

Wear properties of HDPE / Styrene - Butadiene Rubber Composites

Obviously, the tribological processes involved in this investigation are complex. The

Table 1

Composition of the different polymer blend formulations and mechanical properties.

Samples	Yield Strength (MPa)	Elongation at Break (%)	Hardness (Shore D) (mm^2)	Izod Impact (kJ)
%100 HDPE	25.46	274.132	55.9	17.76
HDPE/SBR (%90-10)	20.042	15.172	53.4	45.78
HDPE/SBR (%80-20)	17.276	16.604	50.7	53.44
HDPE/SBR (%70-30)	15.074	17.336	44	58.06
HDPE/SBR (%60-40)	11.518	18.344	39.8	60.48

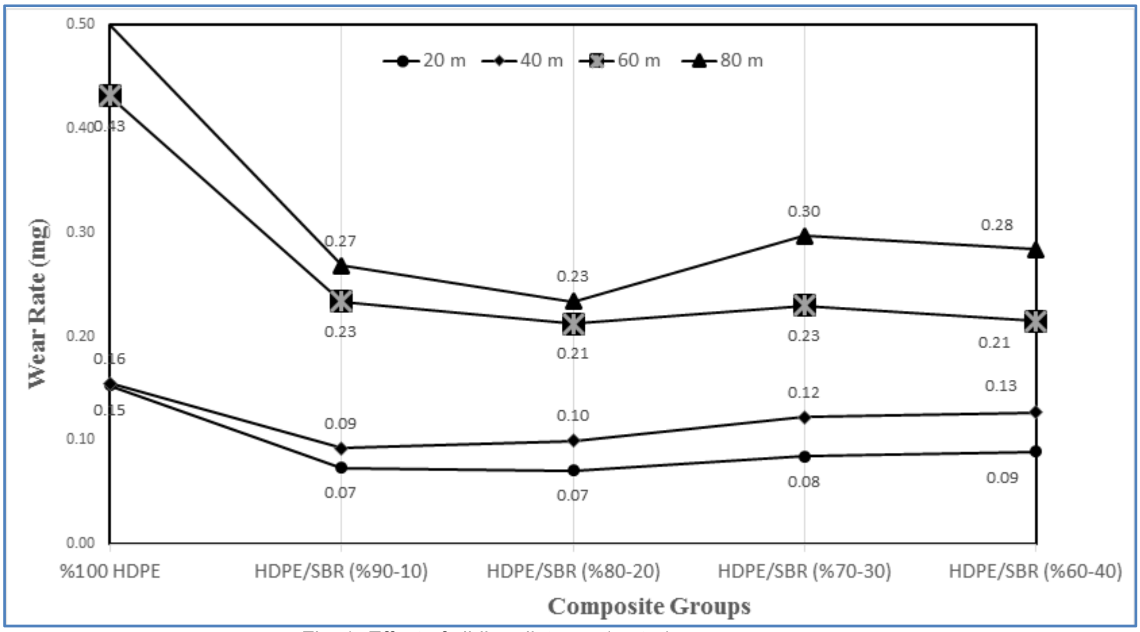

Fig. 1- Effect of sliding distance (meter).

effects of applied load, sliding distance and fillers content on the tribological behaviours of HDPE and its composites were examined. The values of sliding distance-wear loss relationship were obtained and are shown in Figure 1 for the wear loss for various specimens sliding distance against the sand paper (#60) under 10 N load and 0.32 m/s abrasion speed. It can be seen that the wear loss of composites increases with increasing sliding distance and filler content. The same trend is taken on for the applied load-wear loss relationship (Fig. 1).

Figure 1 shows the wear loss for various specimens sliding distance against the sand paper (#60) under 10 N load and 0.32 m / s abrasion speed. The process was more than 40 m and the load more than 10 N, when the wear loss began to decrease slightly. When we examine the Figure 3 which shows wear rate of polymer composite Styrene - Butadiene Rubber contribution has led to decrease wear rate of HDPE. Styrene - Butadiene Rubber contribute has critical load on wear rate of HDPE. HDPE/Styrene - Butadiene Rubber has a low mechanical strength and is easily deformed.

The contact area and wear loss of the counterpart is proportional to applied load. But, on the other side, the less deformation of the composite, the smaller friction force and wear loss of the friction counterpart is, due to the increase, of contact area between the friction counterparts. In general, increasing contribution Styrene - Butadiene Rubber, the wear rate is reduced on the other hand, the increase in corrosion distance causes the deformation of material surfaces. In particular, the deformation rate is increasing significantly on 60 m and over value. This situation continues at 80 meters.

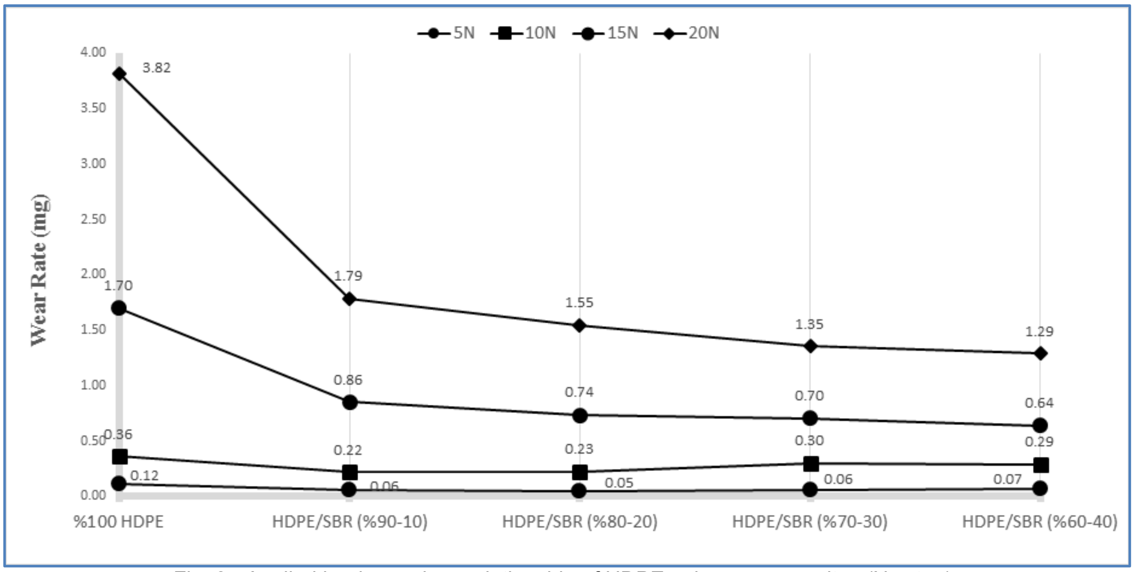

Fig. 2 - Applied load-wear loss relationship of HDPE polymer composites (Newton).

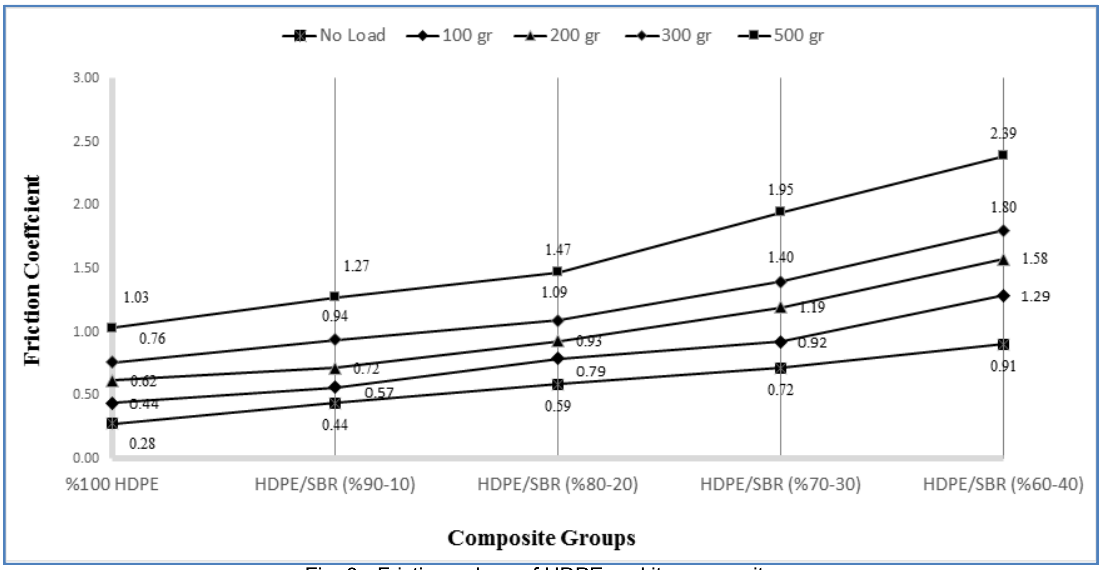

Fig. 3 - Friction values of HDPE and its composites.

It was examined that applied load-wear loss relationship of HDPE polymer composites which is shown in Figure 2. We came across the same behaviour wear rate properties. Styrene - Butadiene Rubber contribute causes the decrease of the pure HDPE, which could be attributed to the good adhesion between elastomers and polymer matrix. The graphic shows that 5 N load had not effect on wear rate for all samples. 10 N loading caused decrease of wear rate. 15 N loading had to increase of pure HDPE wear rate, but the effect was limited because Styrene - Butadiene Rubber contribute failed suddenly this factor. 20 N loading increases to pure HDPE wear rate, this effect peak very high. Styrene - Butadiene Rubber contribute led to an increase, but this ratio rising was not as for pure HDPE. The low level of filler may decrease the hardness of the matrix and bonding strength between the elastomer and polymer matrix. In this Styrene - Butadiene Rubber contribute caused a reduced wear rate. Therefore, Styrene - Butadiene Rubber was suitable for the high load tribological application.

The results of the wear rate of HDPE / Styrene - Butadiene Rubber polymer composites at different loads and sliding distances are given. Styrene - Butadiene Rubber elastomer is soft and polymer with viscoelasticity and very weak inter-molecular forces, generally having low Young's modulus and high failure strain compared with other materials. In these composites, the adhesion would be good on HDPE surface. In this case HDPE / Styrene - Butadiene Rubber blend could increase the wear rate of the composites. So, a high level of the filler led to decrease of wear rate of the composites. Styrene - Butadiene Rubber contribute was suitable for tribological application for HDPE matrix.

Figure 3 shows the friction coefficient for various specimens sliding under load. Load was applied at different speed. It is seen that the static friction coefficients of the HDPE/Styrene - Butadiene Rubber polymer composites were higher than that of the pure HDPE generally. Firstly, when unload force was applied to composite the friction coefficient is increasing. This increase was up with Styrene - Butadiene Rubber contributes. This situation has continued to increase with the increase of load, similarly.

Based on these results the loading had a great effect on the static and dynamic friction coefficient of the composite. As the load increases, the friction coefficient of all types of composites increases. The bonding strengths between the HDPE matrix and Styrene - Butadiene Rubber elastomers fillers changed with the content of the fillers, which accounted for the differences in the tribological properties of the HDPE filled with the varied content fillers.

The tribological properties of HDPE composites blend Styrene - Butadiene Rubber and its variety were studied at different loads and distance under dry sliding. The effects of Styrene - Butadiene Rubber contents on the wear and friction behaviour were discussed. From the above, the following conclusions could be drawn:

a. The toughness of the composites resulted from the strong interfacial adhesion between elastomer contribute and high density polyethylene matrix.
b. The wear loss of HDPE and its composites with decreasing load, force and distance.
c. With the addition of fillers to the composite, the wear rate and friction coefficient significantly and clearly changed. The composites filled with a low level content of fillers showed augment to wear rate. While the composite with a high level content of fillers had lower wear rate.
d. The sliding distance and applied load had a great effect on the wear rate of composites. The applied load is a more

significant parameter than the sliding speed.

e. The bonding strengths between the polymer matrix filler rate and hardness, which accounted for the tribological properties of the composite filled with content fillers were noticed

f. The results showed that the coefficients of friction reduce linearly with the load increase.

6. Conclusion

Friction and wear of polymer and composites are significantly influenced by normal load, sliding velocity and amplitude of vibration, frequency of vibration, direction of vibration and natural frequency. Friction coefficient also depends on duration of rubbing and it is different for different materials. Friction coefficient can be increased or decreased depending on sliding pairs and operating parameters. There are also some correlations between friction/wear and other influencing parameters.

The current trends of these experimental and analytical results can be used in future to design different tribological and mechanical components. The researchers can use these results to innovate some design strategies for improving different concerned mechanical processes. It is expected that the research findings of tribological behavior of polymer and composites discussed in this chapter will also be used for future research and development.

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