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INVESTIGATION OF WEAR PROPERTIES AND STRENGTH OF POLYMERIC MATERIALS USED IN TENSION PULLEYS WHICH IS REINFORCED WITH GLASS FIBER AND GLASS BEAD

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Abstract: *In this study, materials which are used in plastic pulleys of the tension rollers is investiagted. The materials for tension pulleys have produced by using various polymers (POM, PE, and PA6.6) and material reinforcements (glassfiber and glass bead). Special abrasion test machines have assayed those produced tension pulleys. In these test machines, pulleys abrasion values have obtained on a stable temperature at variated loads. Mechanicaland physical tests are also applied to the produced composite materials. In the light of obtained data, high wear resistance and durability are aimed.*

Keywords: *Tension Roller, Composite Materials, Pulley abrasion*

INTRODUCTION

Composites are one of the engineering materials which are used in many industrial areas such as automotive industry[PH Thornton, RA Jeryan, (1988); D Puglia, J Biagiotti, JM Kenny, (2005)]. Composite materials, which used to take advantage of the best properties of their components, have formed by macro level of materials in different levels.[Asi, D. (2008)]. Composite materials consist of two parts called matrix and reinforcement element.The composite material has classified according to the type of matrix material.One of these types is polymer matrix composites.Purpose of production of polymer composites is as strong as steel and is as light as possible within high temperature resistance[Bulut, M.(2014); S.J.V.Frankland (2003)]. Due to these advantages, they can be used instead of steel in the automotive sector. The most important features of polymer composites compose of high resistance to corrosion, an easy machinability, a lightweight material and high load carrying properties.

Mechanical properties of materials are the behaviors that have shown under mechanical loads. To gain better mechanical properties of composite materials, their internal structure of the material canbe altered. [Ozsoy, N. (2015); David L. McDanels (1984)]. The changing in the internal structure of the material may be in the matrix and the reinforcement element. In this study, polymer matrix composites will be used as matrix material. Polyamide (PA), Polyethylene (PE) and Polyacetal (POM) materials are called thermoplastic.[Ayparcasi,Z. (2014)]. Another component forming the composite material is the reinforcement element. The reinforcement element in this study has used as glass bead and glass fiber. The most important properties of fiber-reinforced composites are their high modulus of elasticity, their hardness and their resistance to corrosion [Y.Wang and oth., (2006)]. The most important characteristic of glass fibers is that their tensile strength per unit weight is higher than the steel.

The biggest disadvantage of plastic materials is that they cannot have melted and re-used as they are in steel. It is not easy for researchers to make inferences about the tribological behavior of their plastics. Therefore, specific test devices are manufactured according to system conditions are modeled and all of these results have been tried to be interpreted. Franklin in his scientific study has investigated the effect of sliding speed, an abrasive surface roughness on abrasion and friction behaviors using PA-66 (PA-66 + 30% CE) with 30% glass fiber reinforced POM (POM + 30% CE) with 20% PTFE impregnated POM (POM + 20% PTFE), PA-66 with 30% glass fiber reinforced ÇYMAP. At low surface roughness, an increasing the rate of wear for PA-66,POM + 20% PTFE and POM + 30% polymers have increased in shear rate, wheras the rate of wear for POM, UHMWPE and PA-66 +%30 CE polymers have decrased shear rate. It has obtained that the POM + 30% CE and PA-66 + 30% CE polymer composites have decreased whereas the wear rate of the additive POM polymer has increased with increasing surface roughness[S.E Franklin (2001)] .

Wear, which is a common problem of all plastics, is also one of the biggest issues of the tension roller. Friction and heat cause to the wear of the tensioner due to the operation of the belt on the pulley. The most important factor affecting this abrasion is undoubtedly the material of the tensioner. A wear rate depends on the material of the tensioner pulley. In Figure 1, the surface of a tensioner pulley is visible.

Figure 1:Worn Tensioner Pulley

EXPOSITION

Materials and Methods

Table 1 shows the general properties of the raw materials.

Table 1: General Properties of Raw Materials

Test Sample	Density	Melt Flow Rate	Moisture Absorption	Melting Temperature	Heat Deformation Temperature	Vicat Softening Temperature
Condition		(2.16kg, 270°C)	% 50 RH, 23°C	10 K/min	0.45 MPa	50N
Standart	ISO 1183	ISO 1133	ISO 62	ISO 11357	ISO 75	ISO 306
PA6.6	1.14 g/cm3	-	%2,7	262°C	210°C	-
PA6.6%15 GB	1,20 g/cm3	-	%1,9	262°C	-	-
PA6.6%15 GF	1,23 g/cm3	-	%2,3	262°C	250°C	250°C
PA6.6%30 GB	1,35 g/cm3	-	%1,9	262°C	210°C	245°C
PA6.6%30 GF	1,36 g/cm3	-	%1,9	262°C	260°C	255°C

POM	1,32	-	%0,2	165	-	-
POM %15 GB	1,45	-	-	165	-	-
POM %15GF	1,47	-	%0,2	165	-	-
POM %30GB	1,52	-	-	165		-
POM %30GF	1,54	-	0,2	165	-	-
HDPE	0,96	-	-	130	-	-
HDPE%15GB	1,05	-	-	130	-	-
HDPE% 15GF	1,05	-	-	130	-	-
HDPE%30GB	1,15	-	-	130	-	-
HDPE% 30GF	1,15	-	-	130	-	-

Tensile tests have carried out on a Zwick Roell brand-testing device. ISO 527 standard has applied for a tensile test. The technical drawing has shown in figure 2. Each experiment has been repeated five times and average values have been obtained. Experiments have been performed at a rate of 4 mm / min. Tensile strength, elongation, elastic modulus and yield strength values are obtained from tensile tests.

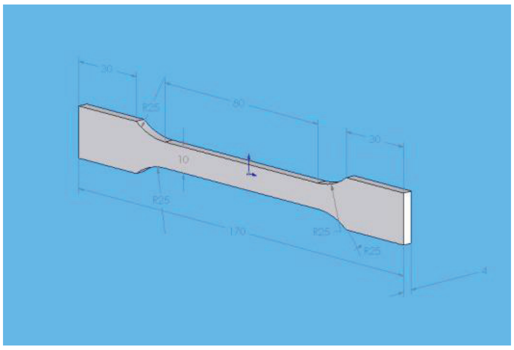

Fig 2: Tensile Test Sample

Impact tests are performed on the AOB brand-testing device. ISO 180 / 1A is applied to the notched impact test whereas ISO 180 / 1U is applied to the unnotched impact test. Impact tests are carried out according to the isod impact method. The samples are positioned vertically. Initially, the lowest energy hammer is tested. If this hammer does not break the sample, it will be retried with a hammer with an upper energy source. Figure 3 shows the technical drawings of the impact sample. Izod impact strength values have obtained with notched and unnotched in the impact tests.

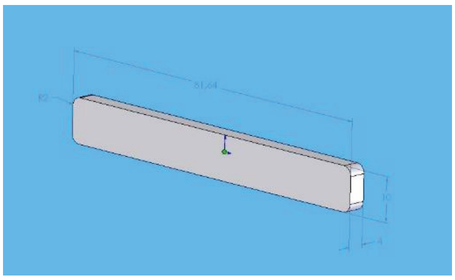

Fig 3: impact test sample

The abrasive samples that are previously made of plastic injection moldshave produced in the Haitian brand plastic injection-molding machine. The temperature and pressure values have shown in Table 2. The produced test sample is shown in Fig 4.

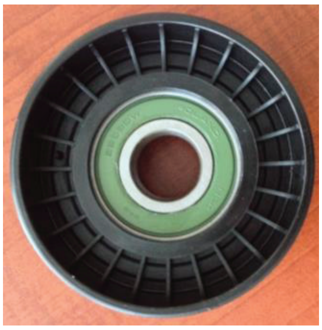

Fig 4: Test Sample Produced in Plastic Injection Machine

Table 2: Process Temperature and Pressure Values

Test Sample	Drying	Processing Temperature	Mold Temperature	Hold Pressure	Injection Speed
PA6.6	80°C	270-290°C	50-90°C	50-100 MPa	Medium-Fast
PA6.6%15 GB	80°C	270-290°C	70-110°C	50-100MPa	Fast
PA6.6%15 GF	80°C	270-290°C	70-110°C	50-100MPa	Fast
PA6.6%30 GB	80°C	270-290°C	70-110°C	50-100MPa	Fast
PA6.6%30 GF	80°C	270-290°C	70-110°C	50-100MPa	Fast
POM	100°C	170-210°C	60-80°C	80-100 MPa	Medium-Fast
POM %15 GB	80°C	200-220°C	80-100°C	40-80MPa	Medium-Fast
POM %15GF	80°C	200-220°C	80-100°C	40-80 MPa	Medium-Fast
POM %30GB	100°C	190-230°C	60-120°C	80-100 MPa	Medium-Fast
POM %30GF	100°C	190-230°C	60-120°C	80-100 MPa	Medium-Fast
HDPE	-	180-210°C	20-40°C	40-80 MPa	Low-Medium
HDPE%15GB	-	180-210°C	20-40°C	40-80 MPa	Low-Medium
HDPE% 15GF	-	180-210°C	20-40°C	40-80 MPa	Low-Medium
HDPE%30GB	-	200-240°C	20-60°C	40-80 MPa	Low-Medium
HDPE% 30GF	-	200-240°C	20-60°C	40-80 MPa	Low-Medium

A wear device has specially designed and manufactured to make abrasion tests of the produced composite materials. Figure 5 shows the wear test device.

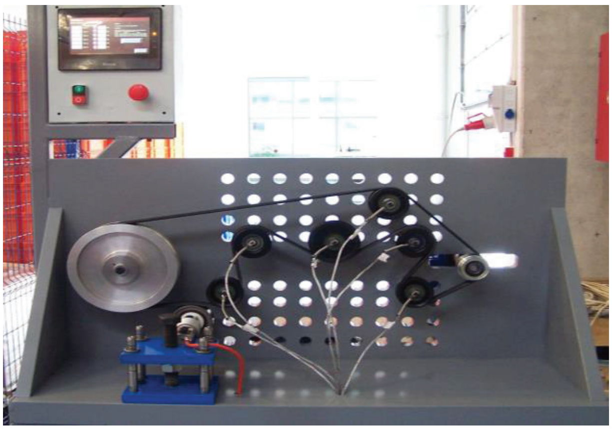

Fig 5: Wear Test Device

The test procedure used in the abrasion tester has carried out as shown in table 3. The tensioner pulley has fixed and connected to the test machine. The Test Samples have tested under three different forces (50N-80N-100N) by applying different durations at variable speeds. The average speed of the test setup is 90 km / h.

Table 3.Applied Cycles and Times

CYCLES (RPM)	3250	2500	1500	650	5500	4500	3750
TIME (SECOND)	34	15	10	5	5	10	20

Weights are measured on a 0.0001 precision scales instrument before the samples are subjected to abrasion testing device. The precise scales are shown in figure 6. The samples that are subjected to the abrasion test, are measured again after their surfaces are cleaned and dried with an alcohol. The abrasion quantities are found in terms of weight.

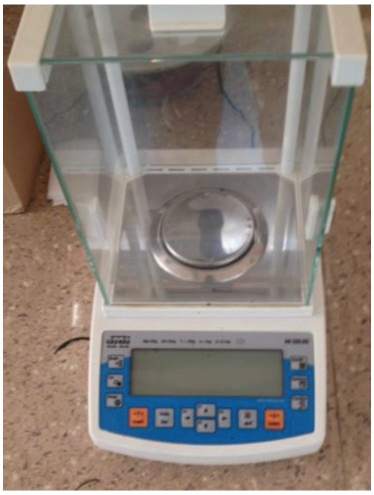

Fig 6: Precision Scales used in tests

Results and Discussion

Tensile test results are shown in Table 4. Impact test results are shown in Table 5.

Table 4. Tensile Test Results

Test Sample	Stress at Break	Strain at Break	Tensile Modulus	Yield Strenght	Standart	Condition
PA6.6	-	-	3200MPa	85MPa	ISO 527	+23°C
PA6.6%15 GB	80 MPa	-	4250 MPa	-	ISO 527	+23°C
PA6.6%15 GF	130 MPa	%3	6250MPa	-	ISO 527	+23°C
PA6.6%30 GB	85 MPa	-	4500Mpa	-	ISO 527	+23°C
PA6.6%30 GF	185 MPa	%3	10000MPa	-	ISO 527	+23°C
POM	-	-	1100MPa	50MPa	ISO 527	+23°C
POM %15 GB	50Mpa	%12	2500MPa	-	ISO 527	+23°C
POM %15GF	90MPa	%4	4500MPa	-	ISO 527	+23°C
POM %30GB	50Mpa	%10	3500Mpa	-	ISO 527	+23°C
POM %30GF	120Mpa	%2,5	8000MPa	-	ISO 527	+23°C
HDPE	20MPa	%2,0	800Mpa	-	ISO 527	+23°C
HDPE% 15GB	25MPa	-	1000MPa	-	ISO 527	+23°C
HDPE% 15GF	45MPa	%2,1	3250MPa	-	ISO 527	+23°C
HDPE% 30GB	25MPa	-	1250MPa	-	ISO 527	+23°C
HDPE% 30GF	50MPa	%1.5	5250MPa	-	ISO 527	+23°C

Table 5. Impact Test Results

Test Sample	Izod Impact, notched	Izod Impact, notched	Izod Impact, un-notched	Izod Impact, un-notched
Condition	+23°C	-30°C	+23°C	-30°C
Standard	ISO 180/1A	ISO 180/1A	ISO 180/1U	ISO 180/1U
PA6.6	5kJ/m^2	4kJ/m^2	-	-
PA6.6%15 GB	4kJ/m^2	3kJ/m^2	-	-
PA6.6%15 GF	7kJ/m^2	6kJ/m^2	50kJ/m^2	45kJ/m^2
PA6.6%30 GB	6kJ/m^2	5kJ/m^2	30kJ/m^2	25kJ/m^2
PA6.6%30 GF	13kJ/m^2	11kJ/m^2	80kJ/m^2	70kJ/m^2
POM	16kJ/m^2	14kJ/m^2	-	-
POM %15 GB	5 kJ/m^2	-	-	-
POM %15GF	6 kJ/m^2	5kJ/m^2	-	-
POM %30GB	5kJ/m^2	4kJ/m^2	-	-
POM %30GF	7kJ/m^2	6kJ/m^2	-	-
HDPE	3 kJ/m^2	-	-	-
HDPE%15GB	4kJ/m^2	-	-	-
HDPE%15GF	7kJ/m^2	6kJ/m^2	-	-
HDPE%30GB	4kJ/m^2	-	-	-
HDPE%30GF	7kJ/m^2	-	-	-

The relationship between the cycle of test samples and the time has shown in table 6.

Table 6. Sample Cycle and Time

TIME (HOUR)	CYCLE (RPM)
00:00:00	0
39:05:00	3250
55:00:00	3750
82:10:00	1500
168:00:00	3250

The results of the post-wear weight measurement of the test specimens have shown in Table 7.

Table 7. Weight Measurements of Pre- and Post-Wear of Test Samples

TEST SAMPLE	INITIAL WEIGHT	LAST WEIGHT	DIFFERENCE	LAST WEIGHT	DIFFERENCE	LAST WEIGHT	DIFFERENCE
Applied Force		50 N		80 N		100 N	
PA6.6	91,7748g	91,5737g	0,2011g	91,5296g	0,2452g	91,5055g	0,2693g
PA6.6%15GB	93,3833g	93,2289g	0,1544g	93,1819g	0,2014g	93,1622g	0,2211g
PA6.6%15 GF	94,1876g	94,0397g	0,1479g	94,0021g	0,1855g	93,9872g	0,2004g
PA6.6%30GB	97,4048g	97,2663g	0,1385g	97,2370g	0,1678g	97,2056g	0,1992g
PA6.6%30 GF	97,6729g	97,5471g	0,1258g	97,5319g	0,1410g	97,4943g	0,1786g
POM	96,6005g	96,3343g	0,2662g	96,9059g	0,3054g	96,2762g	0,3243g
POM %15GB	100,0858g	99,8429g	0,2429g	99,8093g	0,2765g	99,7846g	0,2912g

POM %15GF	100,6220g	100,3823g	0,2397g	100,3576g	0,2644g	100,3518g	0,2702g
POM %30GB	101,9624g	101,7429g	0,2195g	101,7036g	0,2588g	101,7014g	0,2610g
POM %30GF	102,4986g	102,2893g	0,2093g	102,2574g	0,2412g	102,2167g	0,2519g
HDPE	86,1447g	85,8194g	0,3253g	85,7735g	0,3712g	85,7461g	0,3986g
HDPE%15GB	89,3619g	89,0492g	0,3127g	89,0077g	0,3542g	88,986g	0,3759g
HDPE%15GF	89,3619g	89,0595g	0,3024g	89,0167g	0,3455g	89,0078g	0,3541g
HDPE%30GB	92,0429g	91,7562g	0,2867g	91,7307g	0,3122g	97,7032g	0,3397g
HDPE%30GF	92,0429g	91,7638g	0,2791g	91,743g	0,2999g	91,7306g	0,3123g

CONCLUSION

In this study, mechanical and wear properties of thermoplastics which are used in tension pulleys are investigated. Tensile and impact tests are carried out to determine the influence of the ratio and the ratio of additive material on mechanical properties. Friction and abrasion of composite materials have investigated by using a specially produced abrasion tester in order to determine the effects of tribological properties, cycle, charge, additive ratio. As a result of the experiments, it is aimed to compare the performances of the samples produced in composites (Ozsoy, N. 2015).

As a result of these comparisons;

-PA6.6% 30 GF is the least abrasive composite. Resistance to wear isrespectively in the form of PA6.6, POM and PE.
- PA6.6% 30 GF and PA6.6% have observed to be more abrasive comparing with 30% GB. As a result, the fiber additive has found to less worn than the filler additive.
-PA6.6, PA6.6 15% GF, PA6.6% 30 GF samples have been compared, abrasion rate is inversely proportional to the fiber ratio. As the fiber ratio increases, the amount of wear decreases.
-PA6.6, PA6.6% 15 GB PA6.6% 30 GB samples have been compared, it is seen that abrasion rate is inversely proportional to the bead ratio. As the ratio of beads increases, the amount of wear decreases.
-Compared to POM sample, PA6.6 sample has found to be more resistant to wear.
- It has been observed that POM30% GF is more abraded comparing with POM 30% GB. As a result, the fiber additive has found to beless worn than the filler additive.
- When POM, POM 15% GF, POM 30% GF specimens were compared, it was seen that the abrasion rate is inversely proportional to the fiber ratio. As the fiber ratio increases, the amount of wear decreases.
- When the samples of POM, POM 15% GB and POM 30% GB have been compared, it is seen that the wear rate is inversely proportional to the bead ratio. It has observed that the amount of wear decreases as the ratio of balls increases.
-POM sample has found to be more resistant to wear than PE sample.
- When the samples of PE %30 GF and PE %30 GB have been compared, PE 30% GF is less abraded. As a result, the fiber additive has found to be less worn than the filler additive.
- PE, PE 15% GF, PE 30% GF sampleshave been compared, the wear rate is inversely proportional to the fiber ratio. As the fiber ratio increases, the amount of wear decreases.
- PE, PE 15% GB PE 30% GB samples have been comparedthat the wear rate is inversely proportional to the ball rate. It has observed that the amount of wear decreases as the ratio of bead increases.

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