11th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2007, Hammamet, Tunisia, 05-09 September, 2007.

EXPERIMENTALLY INVESTIGATION OF POLYURETHANE MATERIALS USED AS DUST BOOT IN TIE ROD ENDS

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ABSTRACT
Tie rod ends generally deteriorate earlier due to the lack of dust boot. Polyurethane materials, which show excellent properties as abrasion resistance, flexibility and needle pressure stability, can be used as dust boots in tie rod ends. So in this study flexibility, abrasion resistance and needle pressure stability are investigated by changing the hardness of polyurethane materials. In the experiment materials, named as Elastollan-C 60A and Elastollan-C 70A, are used as dust boots. During physical tests to be applied to the dust boot are as followed; hardness, tensile strength, elongation at break, recovery, compression set at 70 ^{0}C/24h, density, volume, weight, adhesive resistance, internal diameter, external diameter and outer diameter. During the aging tests, following steps are applied; change of hardness, change of tensile strength, volume change, change of weight, change of friction, internal diameter, external diameter and outer diameter at 100 ^{0}C/70h in the lithium grease and circulating air test. Finally those polyurethane materials, used as dust boots, are applied according to the criteria of ASTM, and DIN in order to preserve tie rod ends from outer factors for a long time. As a result, physical and aging values of these to polyurethane materials are assessed.
Keywords: polyurethane, hardness, tie rod end, dust boot, ball joint boot.

1. INTRODUCTION
Tie rod is one of the most important components in vehicles [1]. Figure 1 shows the tie rod ends. Dust boots of the tie rod loses its elasticity in the course of time also eroding and tearing of them can occur. Rod connection to steering system can slack due entrance of water dust and foreign particles in the tie-rod bearing [2, 3]. Therefore it is seen that skid tendency increase in rotation. Figure 2 is shows schematic of the tie rods connection to steering balance rod.

Correct material selection for the dust boots should be required the fact that tie rods can provide safety in all weather and road conditions in automotive sector dust boots shouldn’t loose their properties in the temperature range from -45 ^{0}C to 80^{0}C.
The features that are demanded for dust boots can be listed as below;
- Durability for fuel, lubricants and grease.
- Long term resistance to mood and dust.
- High friction resistance
- Ozone resistance

- Durability to lower and higher temperatures (etc -45 ^{0}C, and 80^{0}C)
- Higher aging resistance
- Higher wearing resistance
- Higher fatigue resistance
- Lower gas permeability
- Compression set is good

All these features should be required in dust boots to protect them against external factors for a long time [2-4].

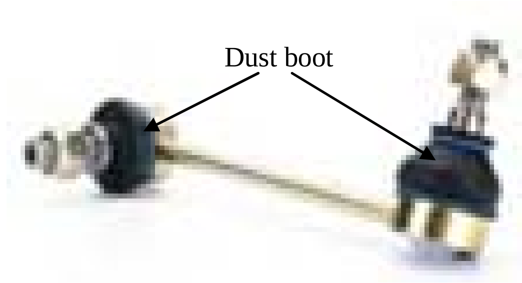

Figure 1. The tie rod end

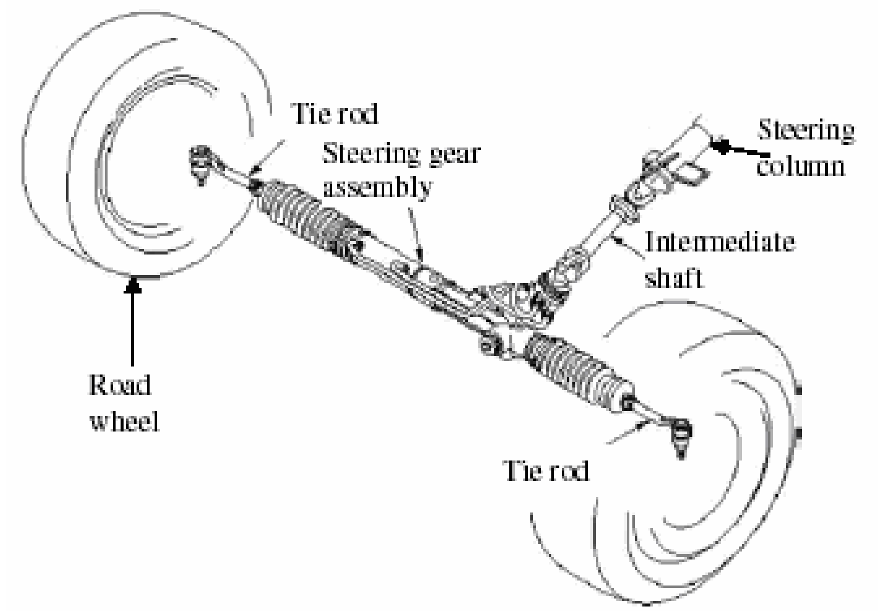

Figure 2. Schematic tie rods connected to steering balance rod.

2. EXPERIMENTAL WORK AND RESULTS

In the experimental study, polyurethane material, used as dust boots are underwent to plasticity fatigue, physical, and aging tests and are investigated from the viewpoint of the problems occurred in the dust boots. Also in the experimental study two different hardness types (60 and 70 share A) of a polyurethane material are used.

In the plasticity wearing test system, test specimens which are produced as the thickness of practical dust boots, are placed in the plasticity wearing test device. The medium parts of the specimens are punctured then breaks life tests are applied to specimens by stretching them as %300 vertically.

Table 1. Aging tests

STATE	(TEMP-TIME)			*Require ment*	*Elastollan C 60A*	*Elastollan C 70A*
Circulating Air Test	100h in 70°C	DIN 53505 SHORE A	Change of Hardness	+3*	64	72
		DIN 53504 MPA	Change of Tensile str.	≥ 12	28	36
		DIN 53504 %	Change of Elong. at break	≥ 350	885	650
		DIN 53479 gr/cm3	Change of Density	---	1.149(%+0.142)	1.16 (%+173)
		DIN 53521 %	Change of Volume	---	6.773(%-0.645)	8.85 (%-0.427)
		%	Change of weight	---	7.78(%-0.256)	10.27(%-0.3)
		DIN 7168	Change of internal diameter	---	33.49(%-0.238)	42.34(%+7.86)
		DIN 7168	Change of external diameter	---	24.87(%-1.923)	28.7(%-0.864)
		DIN 7168	Change of outer diameter	---	25.87(%-0.5)	26.57(%-0.263)
Lithium Grease	100 h in 70°C	DIN 53505 SHORE A	Change of Hardness	- 5*	67	69
		DIN 53504 MPA	Change of Tensile str.	≥ 10	27	31
		DIN 53504 %	Change of Elong. at break	≥ 350	870	640
		DIN 53479 gr/cm3	Change of Density	---	1.157(%+1.048)	1.16(%+0.173)
		DIN 53521 %	Change of Volume	± 10*	5.896(%-13.51)	8.173(%-8.077)
		%	Change of weight	± 7*	6.81(%-12.692)	9.47(%-8.06)
		DIN 7168	Change of internal diameter	---	31.98(%-4.736)	41.07(%-2.24)
		DIN 7168	Change of external diameter	---	24.01(%-5.323)	28.09(%-2.971)
		DIN 7168	Change of outer diameter	---	(%-4.385)	25.92(%-1.051)
Hydrolysis Distilled Water	10 day in 80°C	DIN 53505 SHORE A	Change of Hardness	± 8*	66	70
		DIN 53504 MPA	Change of tensile str.	≥ 8	24	30
		DIN 53504 %	Change of elong. at break	≥ 250	920	750
		DIN 53479 gr/cm3	Change of density	---	1.138 (%-0.61)	1.15(%-0.6)
		DIN 53521 %	Change of volume	---	6.82 (%+0.044)	8.985(%+1.057)
		%	Change of weight	+ 25*	7.79 (%-0.128)	9.47(%+0.485)
		DIN 7168	Change of internal diameter	---	33.53 (%-0.12)	41.83(%-0.428)
		DIN 7168	Change of external diameter	---	25 (%-1.42)	28.61(%-1.174)
		DIN 7168	Change of outer diameter	---	25.91 (%-0.35)	26.74(%+0.375)

* According to *Physical Tests in Table 2*

Usually polyurethane materials have perfect resistance against breaking, tearing and wearing between –30 ^{0}C and 100 ^{0}C. Also they have good resistance against air, ozone, mineral oils and grease. Especially they are used as high pressure impermeability element for the mentioned above in the experimental studies Elastollan C 60 A and Elastollan C70A are used.Physical, aging, and life tests should be made according to standards while dust boots material is chosen. Physical and aging test results are given in Table 1 and 2. When Table 1 and Table 2 are investigated, it is seen Elastollan-C60A and Elastollan-C70A used in dust boot in the tie rod end are shown good properties in physical and aging tests conditions. In addition that elasticity of Elastollan C 70A is lowed due to the fact that the hardness arises. The same material is hold -40^{0}C/24h, and then bended it is seen cracks on material. On the other hand, Elastollan C 60A was ruptured in cycle of 10528 but Elastollan C70A was ruptured in cycle of 7852 at plastic fatigue test.

Table 2. Physical tests

INITIAL VALUES	***Standard***	***Unit***	***Requirement***	***Elastollan C 60A***	***Elastollan C 70A***
Hardness	DIN 53505	Shore A	$\geq$ 50	62	71
Tensile Strength	DIN 53504	Mpa	$\geq$ 12	30	39
Elongation at Break	DIN 53504	%	$\geq$ 350	820	690
Compression Set at room temperature	DIN 53517 (ISO 815)			22	15
Compression Set (24 h in 70ºC)	DIN 53517 (ISO 815)	%	$\leq$ 17	30	25
Temperature Resistance (24 h in -40ºC) Cold resistance for 2x bending 180° around 10mm axle	TS 4709	No Cracks	No Cracks	No Cracks	Cracks
Tear strength	DIN ISO 34-1	kN/m	---	41	40
Abrasion loss	DIN 53516	mm^3	---	28	35
Ozone resistance 170 pphm 48h in 21 °C	ASTM D 1149	No Cracks	No Cracks	No Cracks	No Cracks
Density	DIN 53479	gr/cm^3	Sample	1.14	1.155

4. CONCLUSION

In this experimental study, it is aimed to make comparison between Elastollan C 60A and Elastollan C 70A which are offered as dust boots used in tie rods which have connections to steering system and the results are achieved as below.

- It's seen that there isn't any crack in elastollen-C7060A material when it is bended 180^0 around in the situation of –40^{0}C/24h.
- In the some conditions it is seen that a big crack is occurred in elastollen-C70A. Elastollen-C70A has lower elasticity according to elasollen-C60A.

5. ACKNOWLEDGEMENT

This study has been supported by Foreign Trade Branch of KAVSAN Ltd. in Turkey.

6. REFERENCES

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