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INVESTIGATION OF THE SITUATION OF TIE ROD ENDS FAILING PREMATURELY DUE TO DUST BOOT FAILURE WITH SOFT PVC AND NEOPRENE

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ABSTRACT
Dust boot is the part which prevents entering the foreign bodies (such as water, dust etc.) in to the tie rod ends. Dust boot can lose its elasticity according to working condition. The boot fails and contaminants, resulting in corrosion and wear and causing excessive deflection in the socket assembly, loose steering and alignment to angle changes. Increasing trends in the problems of difficulty in control on the road curve, and skid due to the looseness in the connecting points to the steering system can be seen. In this study physical tests are applied to the dust boot. These are; hardness, tensile strength, elongation at break, recovery, compression set at 70 ^{0}C/24h, density, volume, weight, adhesion resistance, internal diameter ,external diameter and outer diameter. In the period of aging tests, following tests 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. Soft PVC and neoprene materials are used in dust boot and it is applied according to the criteria of ASTM and DIN in order to preserve tie rod ends from outer factors in a long time. Physical properties and aging values are compared.
Keywords: Neoprene, tie rod end, dust boot, ball joint boot, soft PVC.

1. INTRODUCTION
Tie rod is one of the most important components in vehicles. Dust boots of the tie rods 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 bed. Therefore it is seen that skid tendency increase in rotation [1].
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 [2];

- 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.

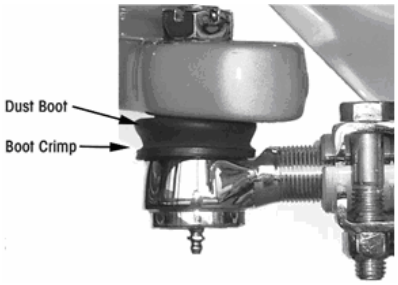

Figure 1. Dust boot should protect the rods, from dust water, Grease and foreign particles.

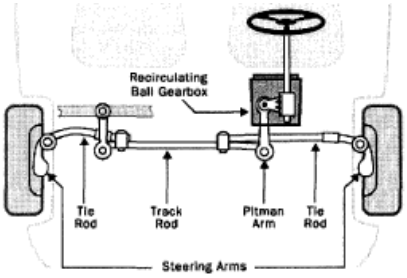

Figure 2. The tie rods connection to steering balance rod.

Figure 3. Plastic fatigue test machine

2. EXPERIMENTAL WORK

Neoprene (CR) and soft PVC materials are used in experimental studies. We face some problems are occurred in dust boot and investigated the problems by applying physical tests and aging tests.

Table 1. Physical Tests

INITIAL VALUES	***Standard***	***Unit***	***Require ment***	***Soft PVC RESULT***	***CR RESULT***
Hardness	DIN 53505	Shore A	≥ 50	67	52
Tensile Strength	DIN 53504	Mpa	≥ 12	11	15
Elongation at Break	DIN 53504	%	≥ 350	250	577
Recovery	DIN 53517 (ISO 815)	%	---	60	94.2
Compression Set (24 h in 70ºC)	DIN 53517 (ISO 815)	%	≤ 17	30	12.3
Temperature Resistance (24 h in -40ºC) Cold resistance for 2x bending 180° around 10mm axle	TS 4709	No Cracks	No Cracks	Cracks	No Cracks
Rebound Resistance	DIN 53512	%	≥ 35	18	45
Ash	TS 336	%	---		4.23
Ozone resistance 170 pphm 48 h in 21 °C	ASTM D 1149	No Cracks	No Cracks	Cracks	No Cracks
Adhesive resistance V=500 mm/min	DIN 53515	N/mm	≥ 14	17	73
Density	DIN 53479	gr/cm^3	Sample	1.188	1.339
Friction	KV.02	N	≤ 5	10.2	2.441

2.1. Experimental Materials

In the experimental study Neoprene (CR) and Soft PVC are used. Soft PVC is used commonly as non-originally for the reason of its production easiness and low cost. On the other hand Neoprene (CR) is very resistant against to breaking, tearing and wearing between -45 ^{0}C and 100^{0}C. Also it is resistant to flame, silicon lubricant grease and alcohol. Therefore it is used in the places where the resistance is required against lubricant and atmospheric conditions simultaneously [3-5].

In plastic fatigue set, test samples are manufactured equivalent to thickness of dust boot which is placed to test equipment. Fatigue life test is applied to holed center of test samples for making flexible vertically %300.

3. EXPERIMENTAL RESULTS

Soft PVC used as dust boot costs lower. But Table 1 and 2 shows soft PVC is deformed more quickly. The tie rod end should change if deformation or tearing occurs in dust boot. Therefore soft PVC has not very efficient properties for used as dust boot.

Table 2. Aging Tests

STATE	**(TEMP-TIME)**			***Require ment***	**RESULT (CR)**	**RESULT (PVC)**
Circulating Air Test	100h in 70°C	DIN 53505 SHORE A	Change of Hardness	+3*	53.8	75 (+8 ShA)
		DIN 53504 MPA	Change of Tensile str.	≥ 12	14	8
		DIN 53504 %	Change of Elong. at break	≥ 350	450	200
		DIN 53479 gr/cm3	Change of Density	---	1.346	1.184 (-0.337%)
		DIN 53521 %	Change of Volume	---	11.689	10.191 (-0.276%)
		%	Change of weight	---	15.65	12.09 (-0.083%)
		DIN 7168	Change of internal diameter	---	31.94	20.84 (-0.84)
		DIN 7168	Change of external diameter	---	38.8	45.00 (+0.06)
		DIN 7168	Change of outer diameter	---	22.35	30.00 (+0.55)
Lithium Grease	100 h in 70°C	DIN 53505 SHORE A	Change of Hardness	- 5*	49.5	80 (+13 ShA)
		DIN 53504 MPA	Change of Tensile str.	≥ 10	12	6
		DIN 53504 %	Change of Elong. at break	≥ 350	378	170
		DIN 53479 gr/cm3	Change of Density	---	1.268	1.184 (+2.106)
		DIN 53521 %	Change of Volume	± 10*	12.743	8.619 (-0.154)
		%	Change of weight	± 7*	16.49	10.48 (-0.133)
		DIN 7168	Change of internal diameter	---	33.25	20.38 (-1.3)
		DIN 7168	Change of external diameter	---	40.37	41.64 (-3.3)
		DIN 7168	Change of outer diameter	---	39.78	28.14 (-1.31)
Hydrolysis Distilled Water	10day in 80°C	DIN 53505 SHORE A	Change of Hardness	± 8*	47	90 (+23 ShA)
		DIN 53504 MPA	Change of tensile str.	≥ 8	10	5
		DIN 53504 %	Change of elong. at break	≥ 250	265	140
		DIN 53479 gr/cm3	Change of density	---	1.28	1.22
		DIN 53521 %	Change of volume	---	13.06	9.05
		%	Change of weight	+ 25*	17.2	11.52
		DIN 7168	Change of internal diameter	---	34.	21.02
		DIN 7168	Change of external diameter	---	41.2	42.12
		DIN 7168	Change of outer diameter	---	40.1	28.5

* According to *Physical Tests in Table 1*

When Table 1 is investigated, soft PVC used as dust boot bended 180^0 in the condition of -40^0C/24h, small cracks have been seen. Moreover, soft PVC used as dust boot has lost its features due to heat at aging test (from 67 Shore A to 90 shore A) and it hast lost its elasticity. This state is showed in Table2.
On the other hand, when neoprene and soft PVC materials are used as dust boot in the condition of -21^0C/48h in ozone resistance tests, small cracks have been seen on soft PVC. But, they have not on neoprene material. So, neoprene showed a good performance as used a dust boot and if it is used in the tie rod end it can good properties.
When Table 1 and 2 are investigated, soft PVC used as dust boot, friction value of 10,2N isn't suitable and friction value is increased to 15.1N after aging results.

4. CONCULUSION

In tie rods connected to steering system, following results are obtained from experimental study by compare Neoprene (CR) and PVC used as dust boot;

- When soft PVC used as dust boot bended in the condition of -40^0C/24h, small cracks have been seen.
- Soft PVC used as dust boot has lost its features due to heat at aging test (from 67 Shore A to 90 shore A) and it hast lost its elasticity.
- Soft PVC used as dust boot, Friction volume of 10,2N isn't suitable and friction volume is increased to 15.1N after aging results.
- Soft PVC used as dust boot has lost its features in aging test. Neoprene (CR) has fracture in cycle of 5905 soft PVC has fracture in only cycle of 157 at plastic fatigue test.
- In physical and aging tests, neoprene (CR) used as dust boot has maintained its features.

5. ACKNOWLEDGEMENT

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6. REFERENCES

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