Annals of Agrarian Science

Journal homepage: http://journals.org.ge/index.php

Analysis of the impact of the main factors affecting the pattern of tire depreciation

P.A. Tonapetyan, A.G. Avagyan

National Agrarian University of Armenia, 74, Teryan str., Yerevan, 0009, Republic of Armenia

Received: 15 August 2018; accepted: 04 October. 2018

A B S T R A C T

This study investigates the optimal internal tire pressure affecting the maximum tire usageof a particular minibus operating on a particular route in Armenia.Regression equations were developed that show the dependence of the tire usage on the internal tire pressure and wear.The results of operational and stand tests reveal the nature of the impact of the tread sipe density on tire usage. The analysis of the study shows that among the most influential factors affecting automobile tire usage are the density of tire tread sipes and the internal tire-pressure.

Keywords: Tires, Mileage, Weight, Internal tire pressure, Depreciation pattern, Tread height.

*Corresponding author: Pargev Tonapetyan; E-mail address: tonapetyan.pargev@mail.ru

Introduction

It is important to understand that the tires used in Armenia are imported from Russian manufacturers in Russia and the recommended maintenance values for optimal usage may be different for road, climate, and usage conditions in Armenia. Our study provides recommendations as to the optimal tire pressure and usage conditions required for maximum usage of tires in Armenia for important long arterial routes between major cities. This study shows most influential factors affecting automobile tire usagewere the density of tire tread sipes and the internal tirepressure [1-9].

Experiments were carried out for 215/75R16C radial model tires include tire tread pattern wear, both with the application of relevant stands and in real operating conditions.

Objectives and Methods

During stand testing, tire weight and tread height were measured for different mileage values; while during actual operation, the weight of the front and rear tires were measured for the same mileage values.The stand tests were carried out using "CTWIST" stands.The results of the stand tests are summarised (Tables 1 and 2).

Table 1. *The tread height of 215/75R16C Radial model tires depending on the mileage for different air pressure values*

Number of tests	Mileage, L	Tread height, h,mm		
		P=2.8	P=3.0	P=3.2
1	12000	8.984	8.671	8.898
2		8.880	8.800	8.740
3		8.778	8.930	8.584
average		8.881	8.800	8.741
1	36000	5.997	5.003	4.998
2		5.212	5.477	4.864
3		5.600	5.200	4.930
average		5.603	5.227	4.931
1	60000	2.263	1.739	1.693
2		2.090	1.870	1.810
3		1.920	1.999	1.925
average		2.091	1.869	1.809

Table 2. *The weight of 215/75R16C Radial model tires depending on the mileage for different air pressure values*

Number of tests	Mileage, L	Weight, m,kg		
		P=2.8	P=3.0	P=3.2
1	12000	23.420	23.352	23.062
2		23.324	23.241	23.159
3		23.230	23.130	23.258
average		23.325	23.241	23.160
1	36000	21.842	21.368	21.430
2		21.550	21.611	21.210
3		21.700	21.486	21.322
average		21.697	21.488	21.321
1	60000	20.401	20.121	20.168
2		20.280	20.170	20.088
3		20.155	20.220	20.006
average		20.279	20.170	20.087

The tests were carried out using the experimental planning method. Bк-type composite plans were used to process experimental data.

In statistical approach, the mathematical model of an object or a process is presented in the form of a two-dimensional second-order polynomial equation which has the following appearance [3,4,10-15].

$$Y = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i,j=1}^{k} b_{ij}\ x_i x_j + \sum_{i=1}^{k} b_{ii} x_i^2 , \quad (1)$$

where` b_0 is the free term, b_i is the linear impact coefficient, is b_{ij} double (pair) interaction coefficient, b_{ij} is the coefficient of the square term, k is the number of factors.

The vehicle mileage (L) and air pressure in tires (P) were chosen as free factors (x).Tire tread height(h)and weight (m) were chosen as optimizing factors (Y).

Factor levels and transformationintervals are given in Table 3.

Experiment planning matrix was developed to determine actual tread height and weight of215/75R16C Radial model tiredepending on vehicle mileage (L) and air pressure in tires (P) (Tables 4 and 5).

Table 3. *Factor levels and transformationintervals*

Factor level and transformationinterval	Factors studied	
	Pressure, P	Mileage, L
Code naming	X_1	X_2
Zero level, $x_i = 0$	3	36000
Transformation interval, Δx_i	0.2	24000
Lower level, $x_{min} = -1$	2.8	12000
Upper level, $x_{max} = +1$	3.2	60000

Table 4. *Experiment planning matrix determining actual tread height of 215/75R16C Radial model tires depending on vehicle mileage (L) and air pressure in tires*

N°	True value of factors		Coded value of factors		Tread height, h, mm
	P	L, km	X_1	X_2	$\overline{h_i}$
1	2	3	4	5	6
1	3.2	60000	1	1	1.809
2	2.8	60000	-1	1	2.091
3	3.2	12000	1	-1	8.741
4	2.8	12000	-1	-1	8.881
5	3.2	36000	1	0	4.931
6	2.8	36000	-1	0	5.603
7	3	60000	0	1	1.869
8	3	12000	0	-1	8.800
9	3	36000	0	0	5.227

Table 5. *Experiment planning matrix determining actual weight of 215/75R16C Radial model tires depending on vehicle mileage (L) and air pressure in tires*

N°	True value of factors		Coded value of factors		Weight, kg
	P	L	X_1	X_2	$\overline{m}$
1	2	3	4	5	6
1	3.2	60000	1	1	20.087
2	2.8	60000	-1	1	20.279
3	3.2	12000	1	-1	23.160
4	2.8	12000	-1	-1	23.325
5	3.2	36000	1	0	21.321
6	2.8	36000	-1	0	21.697
7	3	60000	0	1	20.170
8	3	12000	0	-1	23.241
9	3	36000	0	0	21.488

Results and analysis

As a result of mathematical processing of experimental data results, regression equation coefficients were determined and the following equations were developed:

- for determining tread height of 215/75R16C Radial model tire

$$m(X) = 21.641 - 0.122X_1 - 1.532X_2 + 0.208X_2^2 \quad (2)$$

- for determining weight of 215/75R16C Radial model tire

$$h(X) = 5.328 - 0.182X_1 - 3.442X_2 + 0.112X_2^2 \quad (3)$$

The adequacy of regression equation was verified by Fischer criteria[3,4,10-15].

Usingthe equations (2) and (3), a group of graphs showing the change of tread height and weight of 215/75R16C Radial model tires weremade depending on vehicle mileage and air pressure in tires (Figure1 and 2).

Under real operating conditions the vehicle tire interacts with the road pavement, and is subjected to surface irregularities including cutting and sharp objects found on the road.As a result of this interaction, as well as tire gyration, braking and acceleration; the tire tread sipes are worn unevenly. Therefore, the measurement error of the sipe height may exceed the permissible limit during road tests. By taking the circumstance into account, instead of using the tread height, it is advisable to weigh the tire and determine the weight loss caused by tire wear. Internal tire air pressure was measured on a daily basis maintain the stability of the internal air pressure. Tire pressures were measured and it was measured on a daily basis after the minibus was retired at the end of the day and was brought to the recommended pressure less 4%.In addition, the impact of the temperature increase on the internal pressure due to tire operation was not considered during the tests.

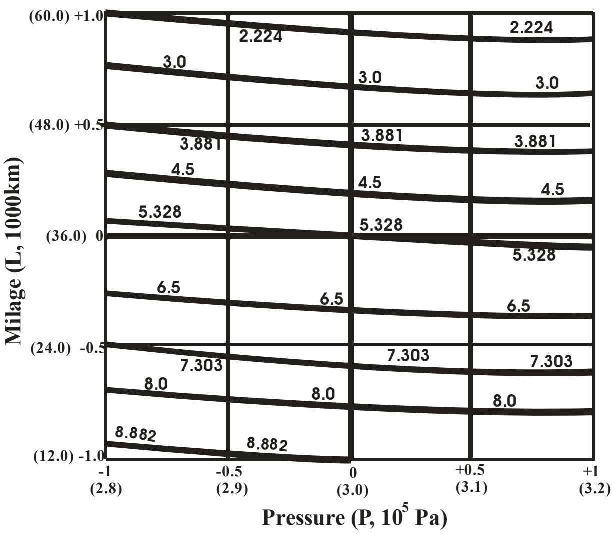

Fig. 1. *A group of graphs showing the change of tread height of 215/75R16C Radial model tiredepending on vehicle mileage (X_1)and air pressure in tires (X_2)*

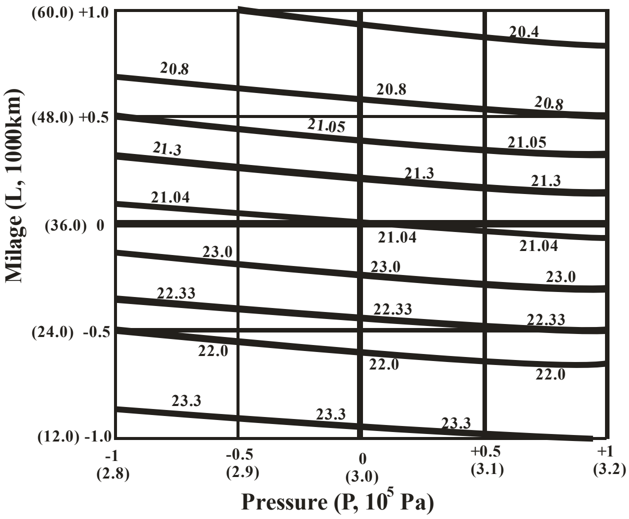

Fig. 2. *A group of graphs showing the weight change of 215/75R16C Radial model tiredepending on vehicle mileage(X_1)and air pressure in tires(X_2)*

The following regression equations (4 and 5) were developed as a result of the mathematical processing of the results obtained from measurements taken during mini bus operation:

- For measuring weight of rear tire

$$m(x) = 21.446 - 0.114X_1 - 1.418X_2 + 0.589X_2^2 \quad (4)$$

- For measuring weight of front tire

$$m(x) = 21.286 - 0.168X_1 - 1.579X_2 + 0.529X_2^2$$

(5)

Usingequations (4) and (5), a group of graphs showing the weight change of front and rear tireswas made depending on vehicle mileage and air pressure in tires (Fig. 3 and 4).

Conclusion

Operational testing of minibus tires shows that the vehicleswill have maximum mileage under optimal pressure conditions.For example, when the tire inner pressure is within recommended limits, the weight of rear tire is 21.872 kg in case of 36000 km, while in case of 48000 km, the weight is 21.496 kg (the height of the tread is within limits of 5.2 mm, hence the tire tread wear is 2.8 mm), so tire tread wear tends to be minimal under optimal pressure conditions.The comparison of stand and operational testing results shows that the difference in tire weight loss is 3 to 7%, while the average tire tread wear in comparison is within 5%.

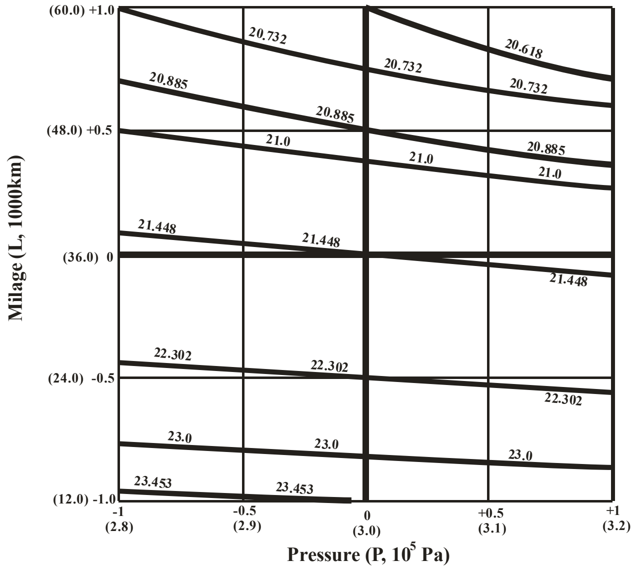

Fig. 3. *A group of graphs showing the weight change of rear tiredepending on vehicle mileage (X_1)and air pressure in tires (X_2)*

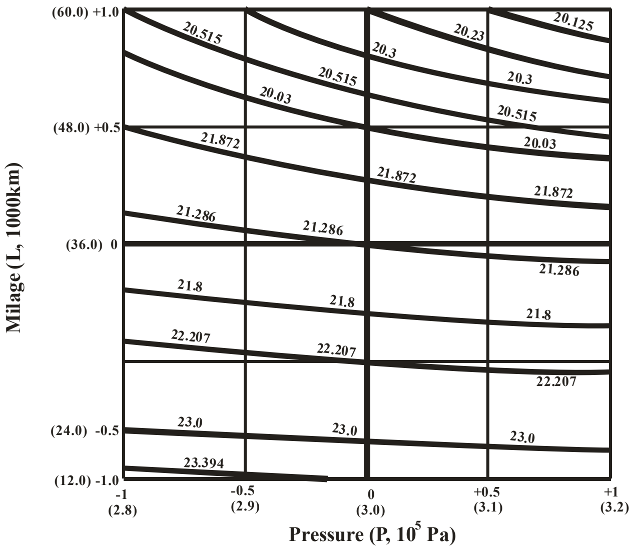

Fig. 4. *A group of graphs showing the weight change of front tiredepending on vehicle mileage (X_1)and air pressure in tires(X_2)*

The analysis of regression equations, developed by this study in both stand accelerated and real operating conditions visualised with the graphs indicates that the tire tread wear is more intense in the middle of the tire compared to the rims, and more pronounced when measuring between 24000 to 36000km of travel. The maintenance internal pressure of the tire (optimal value) maximizes the tire usage.

References

[1] Avagyan A.G., Factors affacting automobile tire resource and the evaluation of their Impact, NUACA,Collection of Scientific Works, Vol. III (46), Yerevan, 2012, pp. 69-74 (in Armenian).

[2] Avagyan A.G., Development of The method of evaluation of minibus tire resource based on the results of accelerated yests, Dissertation, Yerevan, 2016 (in Armenian).

[3] Grigoryan Sh.M., Tarverdyan A.P., Khachatryan A.Ts.,Petrosyan D.P.,Elements of Mathematical Statistics and Theory of Experimental Planning, Asoghik, Yerevan, 2001 (in Armenian).

[4] Spirin N. A., Lavrov V. V., Planning Methods and Processing of Engineering Experiment Results. Yekaterinburg, 2004 (in Russian).

[5] Shokouhfar, Shahram Moustafa, Development of a rolling truck tyre model using an automatic model regeneration algorithm. International J. of Vehicle Systems Modelling and Testing, (2016) 52-62.

[6] Hamad Sarhan Aldhufairi, Oluremi Ayotunde Olatunbosun Developments in type design for lower rolling resistance: a state of the art review. Proceedings of the Institution of Mechanical Engineers, Part D: J. of Automobile Engineering (2017) 96-104.

[7] Y.Nakajima, Application of computational mechanics to tire design -yesterday, today, and tomorrow. Tire Science and Technology: December, vol. 39, no 4 2011, pp. 223-244.

[8] Jinn-Tong Chiu and Chau-Rung Shui Analysis of the Wet Grip Characteristics of Tire Tread Patterns. Tire Science and Technology: January-Marchvol. 46, no 1, 2018, pp.2-15.

[9] Dmytro A. Mansura, Nicholas H. Thom, and Hartmut J. Beckedahl A.Novel Multiscale Numerical Model for Prediction of Texture-Related Impacts on Fuel Consumption. Tire Science and Technology: January-March, vol. 45, no. 1, 2017, pp. 55-70.

[10] Barabashyuk V.I., Kredentser B.P., Miroshnichenko V.I., Planning an Experiment in Engineering, Kiev, 1984 (in Russian).

[11] 11.Ermakov S.M., Zhiglyavsky A.A., Mathematical Theory of Optimal Experiment. Nauka, Moscow, 1987 (in Russian)

[12] Zazhigaev L.S., Kishyan A.A., Romanikov Yu.I., Methods of Planning and Processing the Results of a Physical Experiment, Atomizda, Moscow, 1978 (in Russian).

[13] Montgomery D.K. Experiment Planning and Data Analysis, Shipbuilding, Lion, 1980.

[14] Statistical Methods of Empirical Data Processing. Recommendations, Publishing House of Standards, Moscow, 1976 (In Russian).

[15] Kovel A.A., Pokidko S.V., Mathematical planning of an experiment when developing electronic devices, Izv. Universities Instrument making, 51, № 8 (2008) 13 -18. (in Russian).