TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2011, 11A, 121-128

TIRE LIFE ADJUSTMENT ON THE COEFFICIENTS OF OPERATIONAL AND ROAD CONDITIONS

Alexander Kravchenko, Olga Sakno

Volodymyr Dahl East-Ukrainian National University, Lugansk, Ukraine

Summary. The article investigates the problem of adjustment of tire life from the coefficients of working conditions and road conditions. On the basis of a methods the actual tire life for trucks of the enterprises of Donetsk region is corrected. The decision under the detailed analysis and specifications of factors which influence indicators of operating life, working capacity and wear rate of tires during operation of wheeled vehicle is offered.

Key words: tire life, factor correction, wheeled vehicle, road conditions, norm of an average of tire life, operational factors.

INTRODUCTION

Tires are an element which influences many operational factors of vehicles. Tires are expensive, disturbance of their condition considerably raises operating costs [1, 2, 3, 4]. The important role is occupied by questions of normalization of tire life which it is has to revise because of used new materials, operating conditions [5, 6, 7, 8].

The norm is a caused by changes in the area of activity for which these norms are established. Therefore normalization of use of resources includes following stages: working out of norms; updating and revision of norms which operate; the statement and finishing to industrial subsections [8, 9].

The existing methods of calculation of tire life in Ukraine does not always produce positive results. Research of tire life in enterprises of Donetsk region [10, 11, 12] found that more than 95% of design life is less than actual. This leads to several negative consequences: increased stockpiles of tires, part of working expenses are derived from turnover, quality of tires in storage inevitably deteriorates. Consequently, the design procedure of tire life on correction coefficients has got the greatest prevalence, which is based on statistical processing of run of many models of tires in various road conditions in practice.

RESEARCH OBJECT

To improve methods of correcting of tire life on coefficients of operational and road were conducted observation of work of truck Volvo FM 400 and KAMAZ 6520-61 the Donbas's company: limited company "DISK-SERVICE" and limited company "DISK-CONCRETE" (Donetsk), Structural subdivision "Avtobaza" State enterprise "Ordzhenikidzeugol" (Enakievo).

According to [11, 12, 13] two final correction factor is formulated for dump trucks and concrete mixing machine. In view of the constancy of the routes trucks within the organization, plan routes vehicles is analyzed in the work with instructions of run on roads of population aggregate and behind them, with instructions of a condition of a pavement in experiment carrying out on route sites.

Since the Donbas refers to the central climate region, we are guided by the corresponding data [11, 12, 14]. So, 80% of dump trucks route runs along the roads of asphalt carpet in satisfactory condition, and 20% - on roads with similar cover in unsatisfactory condition. Moving through a career in all three cases doesn't exceed one kilometer.

RESULT OF RESEARCHES

Rationing of tire life in Ukraine is arisen on the basis of operational norms of an average life of pneumatic tires of wheeled vehicle and special vehicles which are executed on wheel chassis [9]. As appropriate, the norms correct for actual operating conditions that differ from normal or especial conditions by following equation:

$$N = N_{NC} \cdot k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_6, \quad (1)$$

$$N_{NC} = N_{SC} \cdot k_3 \cdot k_5, \quad (2)$$

where: N_{NC} – the norm average life of pneumatic tires for normal operating conditions, thousand km (motor-hours); N_{SC} – the norm average life of pneumatic tires for special application conditions, thousand km; k_1 – the correction coefficient depending on traffic and climatic conditions of operation; k_2 – the correction coefficient depending on operation rate of pneumatic tires; k_3 – the correction coefficient depending on service life of pneumatic tires; k_4 – the correction coefficient depending on load-carrying capacity use; k_5 – the correction coefficient for pneumatic tires of tractor-lorry-trailer combination which are constantly used with trailers; k_6 – the correction coefficient depending on the ratio of kilometres travelled in the city to the kilometres travelled outside the city.

Norms are corrected by means the coefficients $k_1 - k_6$, which are established for normal operating condition, the coefficients k_3 and k_5 norms for special application conditions. Apply only the correction coefficients which relate to certain operating conditions, and it is certain by these Norms (the use of all the coefficients are not necessarily). If all the features of the actual operating conditions can not be taken into account, using these coefficients, the temporary regulations are being developed for the average life of pneumatic tires.

The correction coefficient k_1 of the norms depending on traffic and climatic conditions of operation determined as:

$$k_1 = k_{11} \cdot k_{12} \cdot k_{13}, \quad (3)$$

where: k_{11} – the correction coefficient of norms by the type of road surfacing; k_{12} – the correction coefficient of norms by the longitudinal inclination of road; k_{13} – the correction coefficient of norms by the degree chemical pollution.

The values of the correction coefficients are presented in tab. 1.

Table 1. **The correction coefficients of norms depending on traffic and climatic conditions of operation**

Climatic zone	The correction coefficient of norms by the type of road surfacing in satisfactory (unsatisfactory) technical state (k_{11})			The correction coefficient of norms by the longitudinal inclination of road (k_{12})			The correction coefficient of norms by the degree chemical pollution (k_{13})		
	asphalt-concrete	cement-concrete	stone block, sledged stone	no more than 40 %	from 40 to 60%	over 60 %	I	II	III, IV
North	1,0 (0,96)	0,88 (0,80)	0,84 (0,76)	1,0	0,98	0,96	1,0	0,98	0,96
Central	1,0 (0,96)	0,88 (0,80)	0,84 (0,76)	1,0	0,98	0,96	1,0	0,98	0,96
South	0,95 (0,90)	0,79 (0,76)	0,76 (0,73)	1,0	0,98	0,96	1,0	0,97	0,95
Mountain	0,97 (0,93)	0,82 (0,78)	0,80 (0,76)	1,0	0,98	0,96	1,0	1,0	1,0

The correction coefficient k_2 of norms depending on operation rate of pneumatic tires defines by the table 2.

Table 2. The correction coefficients k_2 of norms depending on operation rate of pneumatic tires

Operation rate, thousand km (motor-hours) / month	The coefficient k_2
from 1,0 (0,04) to 1,5 (0,06)	0,95
over 1,5 (0,06) to 3,0 (0,12)	0,98
over 3,0 (0,12)	1,0

If the operation rate wheeled vehicle characterizes the average monthly run of less than one thousand kilometers (40 motor-hours to an operating time) which answers the period of operation of the tire over 5 years, for each of following after the fifth year of operation the coefficient k_3 is: for the 6th, 7th, 8th, 9th and 10th years of operation, respectively: 0,96; 0,92; 0,88; 0,82; 0,75.

The correction coefficient k_4 depending on load-carrying capacity use defines by the table 3. Intermediate values, if necessary, determine the interpolation.

The correction coefficient k_5 norms for tractor-lorry-trailer combination determine on conditions that k_5 = 0,9 in the case of 100% of the first run with single trailer and k_5 = 1,0 – when run carried out without the trailer.

Table 3. **The correction coefficients k_4 of norms depending on utilization factor load-carrying capacity k_l wheeled vehicle**

Wheeled vehicles	Value of utilization factor load-carrying capacity k_l (seating capacity k_s)								
	to 0,4	0,4	0,5	0,6	0,7	0,8	0,9	0,95	1,0
	The coefficient k_4								
Truck vehicle-borne, trailers, bolster-type tractor, semitrailers	1,03	1,03	1,0	1,0	1,0	0,98	0,98	0,97	0,97
Dual-purpose vehicles	1,03	1,03	1,02	1,0	1,0	1,0	0,98	0,98	0,97
Dump trucks	1,04	1,04	1,03	1,03	1,0	1,0	1,0	1,0	0,98

Dependence of coefficient k_6 depending on the ratio of kilometres travelled in the city to the kilometres travelled outside the city defines by the table 4. Intermediate values, if necessary, determine the interpolation.

Table 4. **The correction coefficients k_6 of norms depending on the ratio of kilometres travelled in the city to the kilometres travelled road public network**

The ratio of kilometres travelled of road public network in the city to total kilometres travelled, %	0	20	40	60	80	100
The coefficient k_6	1,04	1,02	1,00	0,99	0,98	0,97

This methods has showed oneself to good advantage and it has been continuing to improve, for instance the work [15, 16].

In compliance with methods we will calculate for dump truckVolvo FM 400 8x4 and concrete mixer vehicle model KAMAZ 6520-61:

$$\mathrm{k}_{11_{Volvo}} = 1{,}0 \cdot 0{,}8 + 0{,}96 \cdot 0{,}2 = 0{,}992\,;\ \mathrm{k}_{11_{KAMAZ}} = 0{,}76 \cdot 0{,}2 + 1{,}0 \cdot 0{,}8 = 0{,}95\,.$$

According to data obtained during the investigation:

$$\mathrm{k}_{12_{Volvo}} = 0{,}98 \cdot 0{,}7 + 0{,}96 \cdot 0{,}3 = 0{,}974;\ \ \mathrm{k}_{12_{KAMAZ}} = 0{,}98\,.$$

The Donetsk region is one of the most ecologically adverse and chemically contaminated regions of Ukraine. Because of this factor k_{13}, corresponding to III and IV levels of chemical contamination, is k_{13} = 0,96.

At the time of the experiment, monthly kilometres travelled of dump truck Volvo FM 400 8x4 varied from 3,5 to 8 thousand km and concrete mixer vehicle model

KAMAZ 6520-61 - 1200...3000 km. On this basis, we take the largest value of the coefficient k_2, according to table 2: $k_{2_{Volvo}}$ = 1, $k_{2_{KAMAZ}}$ = 0,98.

The enterprise operation life of tires on trucks not exceeding five years, because the correction coefficient k_3 takes exactly one, k_3 = 1,0.

By controlling the weight of data it is known that the loading of dump trucks ranging from 26 to 30 tons at the nominal weight of cargo that is transported 26 tons and critical weight is 32 tons. Consequently, it is advisable to take k_l = 1,0, then $k_{4_{Volvo}}$ = 0,98. The coefficient of utilization load-carrying capacity for concrete mixer vehicle depends mainly on the type of concrete. Prescription composition and the density depend on the type of mixture. In most cases, the company produces and transports the mixture, in which the coefficient of utilization load-carrying capacity is 0,8 ... 0,95. In this case, taken $k_{4_{KAMAZ}}$ = 1,0.

Trucks carry the entire run without a trailer. Therefore, k_5 = 1,0. Guided by the data on the route of dump trucks Makeyevka-Red liman-Makeyevka the percentage of run makes 36%; Makeyevka-Prosjanoe-Makeyevka - 26%; Makeyevka-Telmanovo-Makeyevka - 17%. Thus, the average ratio of runs is 23%. We establish by interpolation method $k_{6_{Volvo}}$ = 1,017. About 90% tire life concrete mixer vehicle carried out within the city limits. According to the data of table 4, it is calculated:

$$k_{6_{KAMAZ}} = 0,97 \cdot 0,9 + 1,04 \cdot 0,1 = 0,977.$$

Concluding correction coefficient for trucks:

- Volvo FM 400 8x4 tires Michelin models XZY-2 and XDY-3

$$k_{xzy,xdy} = 0,992 \cdot 0,974 \cdot 0,96 \cdot 1,0 \cdot 1,0 \cdot 0,98 \cdot 1,0 \cdot 1,017 = 0,924;$$

- concrete mixer vehicle model KAMAZ 6520-61 tires model ID-304 Y-4 is

$$k_{ID\text{-}304} = 0,95 \cdot 0,98 \cdot 0,96 \cdot 0,98 \cdot 1,0 \cdot 1,0 \cdot 0,977 = 0,86.$$

According to [17], tire model ID-304 Y-4, which are installed on concrete mixer vehicle model KAMAZ 6520-61, the base average tire life is 80 thousand km. For tires Michelin [18] models XZY-2 and XDY-3, which are mounted on trucks Volvo FM 400, the base average tire life is 65 thousand km. Guided by this data, we calculate the tire life with a glance real-time use.

Dump truck:

$$N_{xzy,xdy} = N_{NC_{xzy,xdy}} \cdot k_{xzy,xdy} = 65000 \cdot 0,924 = 60060\text{km}.$$

Concrete mixer vehicle model KAMAZ 6520-61:

$$N_{ID\text{-}304} = N_{NC_{ID\text{-}304}} \cdot k_{ID\text{-}304} = 80000 \cdot 0,86 = 68800\text{km}.$$

Let's check up a methods for the tires XZY-2 and XDY-3, following the norms of firm Michelin [19]. We accept, in accordance with recommendations of the manufacturer, middle wear rate equal 0,1 mm / 1000 km. Then, whereas the initial height of protector XZY-2 - 18 mm, and protector XDY-3 - 25 mm, will calculate a height, to the limiting wear, if height of protector, at which a tire is subject to decommissioning is 1,6 mm:

$$h_{xzy} = 18,0 - 1,6 = 16,4\text{mm}; \quad h_{xdy} = 25,0 - 1,6 = 23,4\text{mm}.$$

Knowing the height of protector which wears out to attainment of critical value, the base tire life is calculated:

$$N_{xzy} = \frac{16{,}4}{0{,}1} \cdot 1000 = 164000 \text{km}; \quad N_{xdy} = \frac{23{,}4}{0{,}1} \cdot 1000 = 234000 \text{km}.$$

Then, in accordance with correction coefficients, calculated before, will get:

$$N_{xzy} = 164000 \cdot 0{,}924 = 151536 \text{km}; \quad N_{xdy} = 234000 \cdot 0{,}924 = 216216 \text{km}.$$

The results of calculations for different tire life are offered in a table 5 and fig. 1.

Table 5. **The results of calculations for different tire life**

Model of tire	State guidelines, km	Guidelines of producer, km
Michelin XZY-2	65000	164000
Michelin XDY-3	65000	234000
ID-304	80000	-

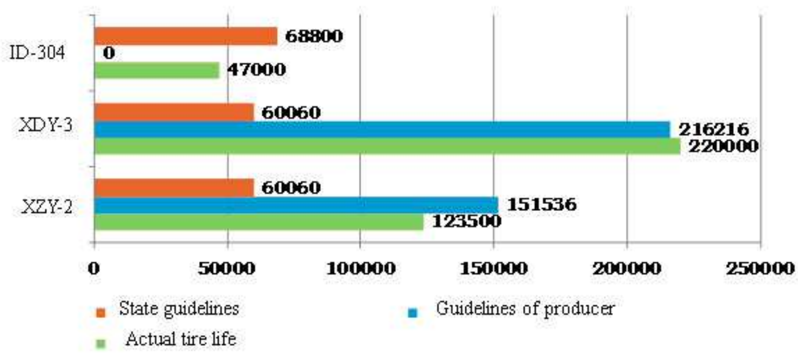

Fig. 1. Charts of tire life after state and actual data, km

The results of calculations show that tire life to writing off does not correspond to the facts, under the recommended [17] standards, as the tire foreign and domestic production. According to the data received during the experiment, tire Michelin XZY-2 which are installed on operated axes of dump truck Volvo FM 400, by the time of writing-off on the average overcome 123,5 thousand km, and Michelin XDY-3 that are installed on leading axes of the same dump trucks, to writing off overcome 220 thousand km.

Tires model ID-304 Y-4 which are installed on all axes concrete mixer vehicle model KAMAZ 6520-61 leave operation after overcoming, on the average 47 thousand km.

CONCLUSIONS

Having analysed the above-stated, it is can conclude following:

1. To this effect necessary to design high-quality tires and norms the average tire life.

2. It is necessary to consider in details factors which influence indicators of reliability of automobile tires. The main factors note that influence the tire life.

3. For real operating conditions wheeled vehicles it is necessary to consider norms average tire life and their correct.

4. Mathematical models concerning calculation wear rate of tires do not consider the real conditions in which the wear process of tire wheeled vehicles is taking.

5. Design procedure of run of run of tires of wheeled vehicles from the correction coefficients is the most practical and based on statistical data of tire in specific conditions.

6. The mentioned facts indicate the need to revision the adjustment factors for all models of tires.

7. It is necessary to improve system concerning control over elements of suspension mechanized of wheeled vehicles.

REFERENCES

1. Ellis D.R., 1975.: Controllability of the vehicle. - Moscow: Mechanical engineering. – 216 p.
2. Larin A.N., Chertok E.E., Yurchenko A.N., 2004.: Wheel components of modern cars. - Kharkiv: “S.M.A.”. – 206 p.
3. Litvinov L.S., 1971.: Controllability and stability of the vehicle. - Moscow: Mechanical engineering. – 416 p.
4. Levine A.A., Fufaev N.A., 1989.: The theory of rolling of a deformable wheel. - M.: Science. - 370 p.
5. Rules of operation of automobile tires. - Moscow: Chemistry, 1983. - 37 p.
6. Kovalchuk V.P., 1972.: Operation and repair of tires. - M.: Transport. - 256 p.
7. Larin A.N., 2003.: Pneumatic tires. - Kharkov: HNADU. - 137 p.
8. Evretsky V.G., 1986.: Material standards for motor transport: Development and evaluation of the use / V.G. Evretsky, V.A Tregubov. – Moscow: Transport. – 128 p.
9. Norms of fuel consumption for cars, norms of tire life and accumulators / [has made Kuznetsov]. – X. : Factor, 2009. – 528 p.
10. Kravchenko A.P., Sakno O.P., 2010.: On the analysis of the reliability of tires // Visnik of the Volodymyr Dal East Ukrainian National University. Scientific Journal. – Lugansk: ENU of the V. Dal. – № 6 (148). – P. 218 - 222.
11. Kravchenko A.P., Sakno O.P., Lukichev A.V., 2010.: The comparative analysis of the norms and the actual resource tires of vehicles in the Donbas's conditions // Visnik of the Volodymyr Dal East Ukrainian National University. Scientific Journal. – Lugansk: ENU of the V. Dal, – № 7 (149). – P. 110 - 114.
12. Zakharov S.V., Kravchenko A.P., Sakno O.P., 2010.: Before the analysis of reliability of motor-car tires in the conditions of the operation // Journal of the Zhytomyr state technological university / Technical sciences. – Zhytomyr: ZSTU. – № 2 (53). – P. 52 - 57.
13. Yurchenko A.N., 2003.: Tyres (requirements, maintenance, depreciation). - Kharkov: DP HMZ "FED". - 115 p.

14. Sakno O.P., Hnatiuk M.I., Lukichev A.V., 2010.: Influence of operating factors on a resource and reasons of refuses of pneumatic tires of vehicle // Energy-efficient and resource-saving technologies at operation of cars and the equipment : theses of the second Annual Inter-University Scientific Conference Donetsk Institute of Railway Transport (December 2–3, 2010, Donetsk: DonURT). - Donetsk: DonURT. - P. 59 - 61.
15. Sidelnikov G.V., 2007.: Development of a technique rate setting of tire life buses of city bus: dis. … k. t. s.: 05.22.10. – Moscow. – 177 p.
16. Savchugov V.I., 2005.: Adjustment guidelines of tire life of special cars: dis. … k. t. s.: 05.22.10. – Tyumen State Oil and Gas university - Tyumen. – 180 p.
17. About the statement of Operational norms of an average tire life wheeled vehicles and special machines carried on a wheeled chassis Order of the Department of Transportation and Communications of Ukraine from May 20, 2006. - № 488.
18. Michelin truck tire service manual / aug. 2009. – 150 p.
19. Michelin truck tire data book. Mexico. 2010. – 250 p.

КОРРЕКТИРОВАНИЕ РЕСУРСА ШИН ПО КОЭФФИЦИЕНТАМ ЭКСПЛУАТАЦИОННЫХ И ДОРОЖНЫХ УСЛОВИЙ

Александр Кравченко, Ольга Сакно

Аннотация. В статье рассмотрен вопрос корректирования ресурса шин по коэффициентам эксплуатационных и дорожных условий. На основе методики скорректирован фактический ресурс шин для грузовых автомобилей предприятий Донецкой области. Предложено решение по детальному анализу и уточнения факторов, которые влияют на показатели долговечности, работоспособности и на интенсивность износа шин в процессе эксплуатации транспортных средств.

Ключевые слова: ресурс шин, коэффициент корректирования, колесно-транспортное средство, дорожные условия, норма среднего ресурса, эксплуатационные факторы.