Influence of Ambient Temperature on the Intensity of Tread Wear of Large Tires

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ABSTRACT

The article presents the results of an experiment conducted on the tires of technological vehicles operated in the Amantai quarry. During the year in a quarry, the dynamics of changes in ambient temperature was studied and its effect on the intensity of tire tread wear was calculated. As a result, on hot days (above 30^0C), tire operation beyond the capacity of heat dissipation inevitably leads to the formation of internal delaminations, mainly in the shoulder area of the tires.

Keywords: Tire resource, ambient temperature, technological transport, tire wear intensity, technological road, oversized tires.

Introduction. Reducing transport costs in road transport, efficient use of material resources, as well as the choice of trucks and tires that are adaptive to specific operating conditions has always been an urgent task. In this regard, in the field of road transport it is very important to determine and control the consumption of fuel, spare parts and tire life [1 – 4].

The cost of open pit mining significantly depends on the productivity of mining trucks, which is directly related to the durability of pneumatic tires [2 – 3].

In recent years, in the quarries of Uzbekistan with different climatic and mining and geological conditions, various models of imported large-sized tires have been tested in operating modes. An analysis of the results of the HF showed that the main criterion for their performance is the heating temperature of the carcass, sub-groove and tread, which reaches 120-130°C under standard operating conditions of dump trucks, which leads to thermal destruction of the material [4 – 8].

The main causes of failures of pneumatic tires of mining dump trucks in operation are [2 – 7]:

- mechanical damage (cuts, punctures, chipped lugs and others);
- fatigue and thermal failures (delamination of the tread, sidewalls, delamination of the cord, etc.);
- natural tread wear;
- manufacturing defects that were not detected during the final inspection of tires at the manufacturing plant.

It has been established that the greatest amount of heat is released in the middle of the tire breaker layer and at its edges, and the total amount of heat generation in the tire is

distributed over its main elements as follows [2 – 3]:

- protector - about 50%;
- frame - from 12 to 33%;
- breaker layer - from 7 to 15%:
- sidewalls and the board adjoining them - from 5 to 25%.

Publication analysis. The authors [2 – 3] found that the tire at an ambient temperature of 20…25^{0}C cools down in about 10 hours of a dump truck standing. At the same time, in the first 4 hours of the dump truck's sludge, the tire cooling rate is 10 ... 12^{0}C/hour, and then it decreases to 5.0 ... 6.7^{0}C/hour.

The ambient temperature has a significant effect on tire wear [5, 6]. The temperature on the friction surface should be attributed to the main indicator of the intensity of rubber wear and its destruction. The temperature of the tire during its operation increases under the influence of friction force and due to deformation.

Petrov A.I. [6] suggests the following dependence of wear rate on temperature and load on the tire:

$$U_{\text{cp}} = I_0 + C_1 \cdot \left(\left(t_{\text{cp}} - t_0\right)^2 + \delta_t^2\right) + C_2 \cdot S_{\text{cp}} + C_3 \cdot \frac{1}{D}, \quad (1)$$

where I_0 is the minimum wear rate realized under ideal conditions; C_1 is an indicator of the sensitivity of tires to a change in t according to the intensity of their wear; C_2 is an indicator of the sensitivity of a change in wear intensity to a change in G_{cp}; C_3 is an indicator of the sensitivity of a change in the wear rate to a change in D; t_{cp} is the average ambient air temperature for the period under consideration; t_o is the optimum ambient temperature; δ_t^2 is the dispersion of the ambient air temperature; D is a generalized indicator of road conditions; S_{cp} is the average tire load over the lifetime.

Based on the analysis of experimental studies of the operation of mining dump trucks in a real operating condition, we will choose the following as the main factors that determine the thermal state of large tires to the greatest extent:

- the average radial load on the tire for the transport cycle;
- operating speed of a dump truck;
- ambient air temperature;
- the degree of rock strength.

We will not consider the influence of the average load on the tire and the operating speed of the dump truck, since this is a completely controllable factor. In this experimental study, we investigate the effect of air temperature on the intensity of tire wear [8 – 17].

The following dump trucks are operated in the Amantai quarry of the Navoi Mining and Metallurgical Combine: BelAZ-7555B, BelAZ-7513, BelAZ-75310, CAT 773E and Komatsu HD 465. These dump trucks use tires of sizes 24.00R35, 33.00R51, 37.00R57, 40.00R57 and 46.90R57.

Compliance with the requirements of building codes and regulations (BC and R) technological roads of the Amantai quarry, where mining dump trucks are operated, was studied:

- longitudinal slope of the tracks, on average 5 – 6%;
- the width of technological roads is on average 16 – 18 meters, and the turning radius is on average 26 – 30 meters;
- the hardness of the rock is within 8 – 10 on the scale of M. M. Protodyakonov;
- the number of turns at a distance of transportation up to 6;
- the time of passage by dump trucks of one cycle is 0.6 – 0.8 hours.

Based on these data, we can classify the Amantai quarry as a medium severity category [18 – 21].

Experiment. Experimental studies of the effect of ambient temperature on the wear rate of tires of technological vehicles were carried out in the open pit conditions of Navoi MMC JSC.

The purpose of the experiment is to evaluate the effect of ambient temperature on the intensity of tread wear in each season.

The experiments were carried out in the Amantai quarry, for this, qualified drivers and 5 CAT 773E dump trucks, manufactured in 2019, were selected. On November 30, 2021, new 30 tires 24.00R35 MICHELIN XTRA LOAD GRIP A4 TL E4 were installed on dump trucks. The tread

height of these tires is 73 mm, the load index is 20,000 kg, the speed index is 50 km/h, the recommended tire pressure is 750 kPa, tonne kilometer per hour (TKPH) is 503. CAT 773E dump trucks have a load capacity of 55.5 tons.

Methodology. The internal pressure in the tires was 750 kPa, which was controlled and checked by the drivers. The load applied to the tire was controlled within ±5% of the recommended one. Average daily air temperatures were recorded and average weekly temperatures were calculated. Once a week, the distance traveled by the dump truck, the residual height of the tire tread and the intensity of tread wear were recorded and analyzed.

It is planned to install new tires on dump trucks every season. If possible, at the beginning of spring, that is, on February 28, the tires of the 3 dump truck were completely replaced, and before the summer, on May 30-31, the tires of the 4 dump truck were completely replaced. In the remaining seasons, the experiment was carried out by completely replacing the tires of all 5 dump trucks. MICHELIN XTRA LOAD GRIP A4 TL E4 tires were always used during the experiment.

Each time the measurement work was included in table 1.

Table 1

№	Make and number of dump truck	Tire model	Initial tread height, mm	Tire installation date	Measurement date 7.12.2021 y.				
					Average temperature per week, day/night	Dump truck mileage since the beginning of the experiment, km	Average tread height when measured, mm	Tire wear intensity, mm/thousand km	Truck mileage in the interval, km
1	CAT 773E, 651	MICHELIN XTRA GRIP A4 TL E4.	73	29.11.2021 г.	3.8/-1.5	2412	70.8	0.912	2412
2	CAT 773E, 655			30.11.2021 г.		2038	71.1	0.932	2038
3	CAT 773E, 656			30.11.2021 г.		2430	70.8	0.905	2430
4	CAT 773E, 657			29.11.2021 г.		3076	70.2	0.91	3076
5	CAT 773E, 658			30.11.2021 г.		2603	70.6	0.922	2603
Average					**1.4**	**2511.8**	**70.2**	**0.92**	**2511.8**

The results of each weekly measurements were entered in table 1. Based on these tables, which included the results of the experiment, a summary table 2 was compiled.

Table 2

№	month	Average mileage of dump trucks per month, km	The average temperature per month, according to the experiment, ^{0}C	Average temperature per month, according to the Internet site [22], ^{0}C	Average tire tread intensity per month, mm/thousand km	Average intensity of wear in a season, mm/thousand km
1	December	9834	1.1	1.9	0.91	0.913
2	January	10122	0.6	0.5	0.89	

3	February	10247	3.4	1.7	0.94	
4	March	9879	8.6	9.4	1.02	1.087
5	April	9212	18.8	16.0	1.08	
6	May	10751	24.1	24.9	1.16	
7	June	9783	31.7	30.5	1.43	1.48
8	July	10758	**36.6**	**31.1**	1.48	
9	August	9875	30.6	29.5	1.39	
10	September	10751	23.5	22.9	1.14	1.046
11	October	10023	**14.8**	**11.4**	1.03	
12	November	9273	6.4	3.4	0.97	

Based on tables 1, 2 with the results of the experiments, the following graph (fig. 1) and diagram (fig. 2) were built.

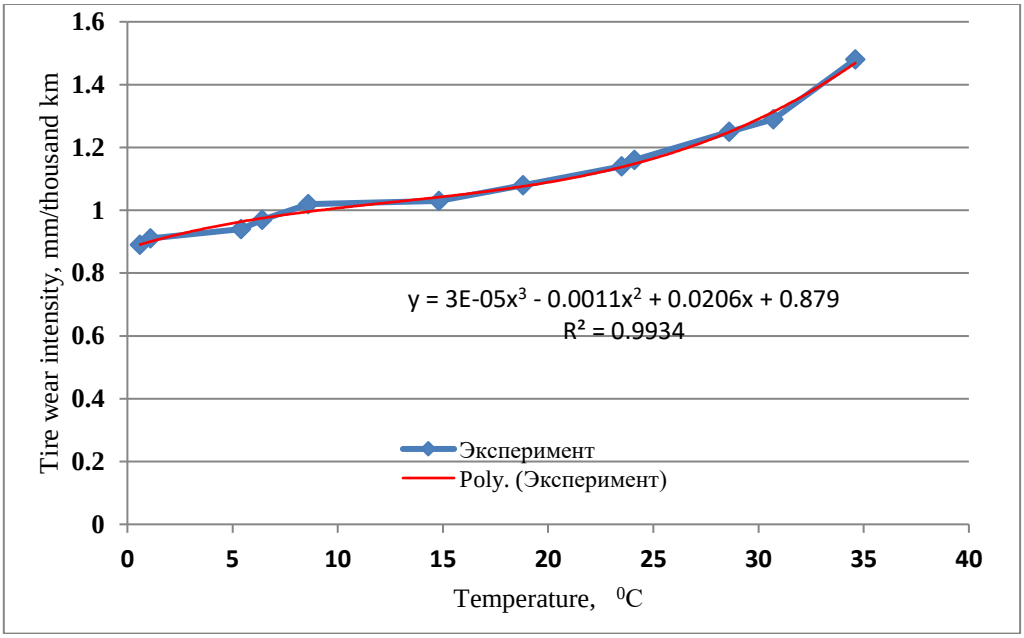

Fig.1. Influence of ambient temperature on the intensity of tire wear.

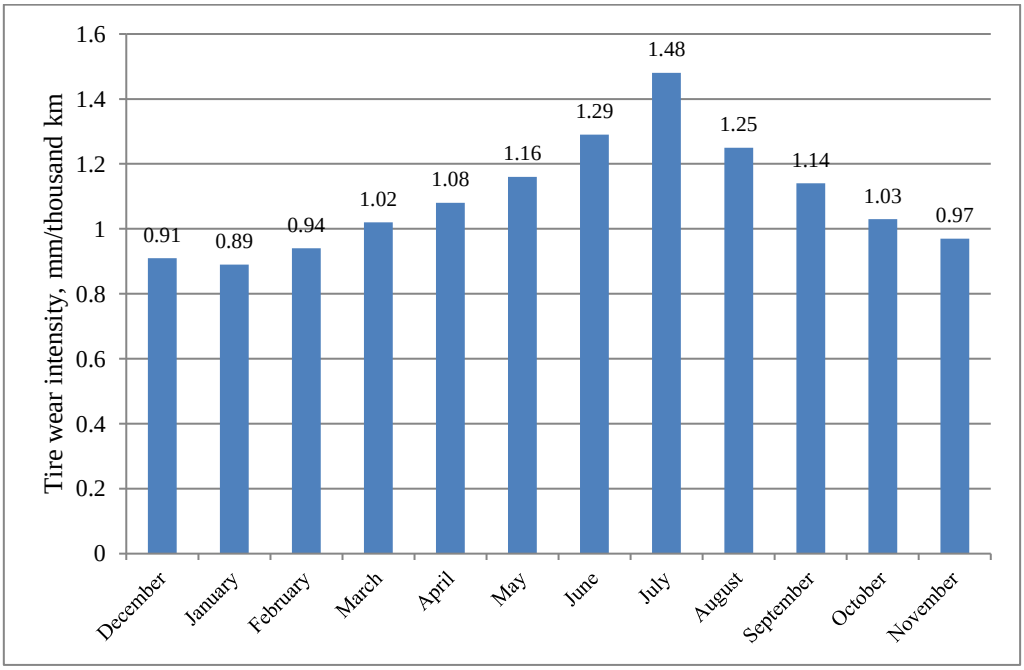

Fig.2. Tire wear rate by month

Conclusion

1. During the summer season, the intensity of tire tread wear increased by about 1.5 times compared to other seasons.

2. In winter, the lowest intensity of tire wear was observed in January and amounted to 0.89. The highest intensity was observed in July and amounted to 1.48.

3. You can see from Figure 1, the optimum ambient temperature for tires 24.00R35 MICHELIN XTRA LOAD GRIP A4 TL E4, 8 – 18^{0}C. The average operating speed of the dump truck was 17 km/h.

4. When comparing the air temperature in the quarry, measured during the experiment, with the information presented on the site [23], the air temperature in July and October differed by up to 20%. In other months, the air temperature difference did not exceed 3 – 5%.

5. Cool weather from October to April (up to 15^{0}C) was observed to compensate for the internal heating of the tires and did not lead to thermal delamination.

6. On hot days (above 30°C), running tires beyond their ability to dissipate heat inevitably results in internal delamination, mainly in the shoulder area of the tire.

Literature

1. Skornyakov E.S., Kvasha E.N., Homenia A.A., Boikov V.P. Operation and repair of oversized tires / - M .: Chemistry, 1991. p. 128.
2. Goryunov S.V., Sharipov V.M. Forecasting the operating temperature of pneumatic tires for dump trucks // Forests of Russia and the economy in them. 2013. No. 1-2(42-43). p. 32-34.
3. Goryunov S.V., Sharipov V.M. Study of the thermal state of pneumatic tires for mining dump trucks // Journal of Automotive Engineers. 2015. No. 3 (92). p.6-10.
4. Gudkov V.A., Kubrakov V.P., Tarnovsky V.N. Influence of wheel rolling mode on car tire tread wear. Design questions. and car research. - M., 1989 - p. 99 - 104.
5. Gudkov V.A., Tarnovsky V.N., Kubrakov V.P. Factors affecting the intensity of tire tread wear. Business guides. - M.: TsNIITE Neftikhim, 1986. No. 47.
6. Petrov A.I. Influence of operating conditions on the durability and failure-free operation of automobile tires: Dis... cand. tech. Sciences. - Tyumen, 1999. - 222 p.
7. Topalidi V.A., Yusupov U.B. Rationing of the resource of tires of typical cars in quarry conditions. Automotive industry. Moscow, 2019. - No. 11. p. 27 - 29.
8. Yusupov U.B., Kasimov O.K., Narziev Zh.Sh. Rationing of tire mileage for NefAZ shift buses in the conditions of AGMK. International, scientific, electronic journal. - Tashkent, 2019. "Transport of the Silk Road" No. 3 - 4. p. 94 - 101.
9. Topalidi V.A., Yusupov U.B., Babaev A.M. Wear resistance of specialized vehicles tires on quarry roads. International journal of mechanical and production engineering research and development (IJMPERD); ISSN (online): 2249-8001. Vol-10, Issue-5; Edition: Oct-2020, p. 643 – 658.
10. Topalidi V.A., Yusupov U.B. Wear resistance of tires of specialized vehicles, depending on the category of the fortress of quarry roads. Automotive industry. Moscow, 2020. - No. 12. p. 20-22.
11. Umidbek Yusupov, Omil Kasimov, Akhmadjon Anvarjonov. Research of the resource of tires of rotary buses in career conditions. ICPPMS-2021. Tashkent, 2021 y. June 10-11. Cite as: AIP Conference Proceedings 2432, 030072 (2022); https://doi.org/10.1063/5.0089587. Published Online: 16 June 2022.
12. Valeriy Topalidi, Umidbek Yusupov, Samad Allaberganov. Improving the efficiency of transport logistics support. ICPPMS-2021. Tashkent, 2021 y. June

10-11. Cite as: AIP Conference Proceedings 2432, 030073 (2022); https://doi.org/10.1063/5.0089590. Published Online: 16 June 2022
13. Yusupov U.B. Tire resource rationing in quarry conditions. Rail transport: Topical issues and innovations. Tashkent, 2021. - No. 3. p. 35 – 42.
14. Topalidi V.A., Yusupov U.B. Wear resistance of tires of specialized vehicles in quarry conditions. Monograph. Tashkent, 23.09.2021y. Publishing house "Avtomsan". ISBN 978-9943-4906-9-7. p.132.
15. Topalidi V.A., Yusupov U.B. Analysis of the mileage of oversized tires of heavy dump trucks operating in the Kalmakyr mine. Scientific journal of vehicles and roads, Tashkent 2022. No. 1. p. 73 - 81.
16. Yusupov U.B., Otamurotov F., Baratov I. Road studies of wear resistance of large tires. Scientific journal of vehicles and roads, Tashkent 2022. No. 1. pp. 36 - 46.
17. Yusupov U.B., Topalidi V.A., Anvarjonov A.A. Development of coefficients for correcting the mileage of tires of specialized vehicles, taking into account work in career conditions. Journal of Hunan University Natural Sciences. ISSN: 1674-2974. Vol. 49. No. 02. February 2022. p. 276 – 286.
18. Yusupov U.B., Anvarjonov A. Rating of the operational massage of the tires of large-loaded mining dump trucks operating at the objects of the Almalyk mining and metallurgical combine. Galaxy International Interdisciplinary Research Journal (GIIRJ). ISSN (E): 2347-6915. Vol. 10, Issue 1, Jan. (2022). p. 36 – 40.
19. Yusupov U.B., Urinboev K.U. Analysis of the results of theoretical and experimental studies on the wear resistance of tires for specialized vehicles. “Oriental renaissance: Innovative, educational, natural and social sciences (ORIENS)”. ISSN 2181-1784, (www.oriens.uz) Vol. 2, Issue 1, January 2022. p. 1216 – 1224.
20. Umidbek Yusupov, Akmal Muxitdinov, Feruz Otamuradov. Rationing of tire mileage in the operating conditions of the Kalmakyr quarry. International Jounal of Multidisciplinary Research and Analysis" (IJMRA). ISSN(print): 2643-9840, ISSN(online): 2643-9875. Volume 05, Issue 05, May 2022. p. 929-934. DOI: 10.47191/ijmra/v5-i5-07.
21. Yusupov U.B., Narziev J., Zafarov K. Особенности эксплуатации крупногабаритных шин для технологического транспорта. Oriental Journal of Technology and Engineering. ISSN : 2181-2837. Vol. 2, Issue 1, May 2022. p. 20 – 29. DOI: https://doi.org/10.37547/supsci-ojte-01-01-04.
22. https://global-weather.ru/archive/zarafshan