АВТОТРАНСПОРТНЫЕ СРЕДСТВА

УДК 629.3.027.5=111

ШУМ КАК КОСВЕННЫЙ КРИТЕРИЙ ОЦЕНКИ КРИТИЧЕСКОЙ СКОРОСТИ АВТОМОБИЛЬНОЙ ШИНЫ ПРИ ГИДРОПЛАНИРОВАНИИ

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***Аннотация**. Рассмотрен альтернативный метод определения критической скорости качения автомобильных шин с различными рисунками протектора при гидропланировании. Данный метод основан на регистрации шумоизлучения шины при движении по мокрому дорожному покрытию.*

***Ключевые слова:** автомобильная шина, шум, критическая скорость, гидропланирование автомобиля, коэффициент насыщенности рисунка протектора.*

ШУМ ЯК НЕПРЯМИЙ КРИТЕРІЙ ОЦІНКИ КРИТИЧНОЇ ШВИДКОСТІ АВТОМОБІЛЬНОЇ ШИНИ ПРИ ГІДРОПЛАНУВАННІ

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***Анотація.** Розглянуто альтернативний метод визначення критичної швидкості кочення автомобільних шин з різними рисунками протектора при гідроплануванні. Вказаний метод базується на реєстрації шумовипромінювання шини під час руху по мокрому дорожньому покриттю.*

***Ключові слова:** автомобільна шина, шум, критична швидкість, гідропланування автомобіля, коефіцієнт насиченості рисунка протектора.*

NOISE AS AN INDIRECT CRITERION FOR EVALUATING THE CRITICAL SPEED OF VEHICLE TIRE AT HYDROPLANING

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***Abstract.** An alternative method for determining the critical rolling speed of automobile tires with various tread patterns during hydroplaning is considered. The critical speed of the car at which the hydroplaning process takes place is determined. This method is based on recording the tire noise emission when driving on a wet road pavement.*

***Key words:** tread of tire, evaluation criterion, performance characteristics, vehicle tire, noise, critical speed, car hydroplaning, saturation coefficient of the tread pattern.*

Introduction

The motorists often face the problem of rational selection of tires for the corresponding vehicle. This is especially true when the road and climatic conditions change greatly. A special place is taken by driving on a wet road. And here, traffic safety largely depends on the tire.

When designing a new tire, compliance with its main performance characteristics should be taken into account, they are as follows:

– coefficient of rolling resistance;
– maximum speed;
– load capacity of the tire;
– internal pressure of the gas filler;
– level of noise emission;
– coefficient of tire traction with the road surface;
– resource for wear of the tread and fatigue failure of the tire elements.

Each of these correspondences requires detailed study. For this purpose, research is conducted using both experimental and theoretical methods. When it comes to experimental methods, researchers develop stands, fixtures and equipment to determine each of the correspondences.
Development of these aids requires a large financial and time-consuming effort. Therefore, there arises the question as for the application of an indirect evaluation criterion – the aggregate index of an automobile tire. One of these criteria may be the level of noise emission produced by an automobile tire.

Analysis of Publications

A number of researchers have resorted to the use of the noise produced by an automobile tire in contact with the road for evaluation of additional tire and road characteristics. So, in work [1] the hypothesis about the possibility of determining the coupling characteristics of the coating by the magnitude of the noise was put forward. The conducted studies show that noise measurements are an effective tool for obtaining information on the properties of the pavement. Experiments show the possibility of assessing the coupling properties of the road surface in terms of the amount of noise generated when the wheel is rotating. In the future, it is possible to obtain information on the smoothness of the coating, and its roughness in terms of noise.

In work [2] the results of noise measurement are presented when using standard tires on the stand. Then, under unchanged conditions, tires fitted with spikes were installed. When analyzing the amplitude-frequency characteristics (AFC) obtained with a studded tire, it was revealed that the signal level in the main part of the spectrum changes insignificantly, however, a certain increase in the high-frequency component of the spectrum is observed. It is concluded that the use of spikes contributes to the formation of an ultrasonic noise component. In other words, according to the results of the noise emission of the tire, one can determine the presence of spikes. The authors emphasize that this information is important, especially when such tires continue to be used outside the winter season.

V. Knoroz [3] proposed a formula for determining the critical speed of automobile tire hydroplaning

$$v_{kp} = 508\sqrt{\frac{G_k}{Bh_B C_r}}\,, \qquad (1)$$

where G_k is the load applied to the wheel; B is the width of the tread; h_b is the thickness of the water layer; C_r is the coefficient of the lifting force of the hydroclin determined experimentally.

This formula is based on the theory of hydrodynamic pressure in the water layer. It is assumed that there is a complete balance between the load on the wheel and the resulting force caused by the hydrodynamic water pressure.

However, the calculated dependence does not describe such important characteristics for hydroplaning as the differences in tire tread patterns. Analysis of literature sources shows that tire noise as an indirect criterion for evaluating its performance characteristics is certainly possible, however, its application is not sufficiently spread yet.

Purpose and Tasks

The purpose of this study is to determine the critical speed of the car at which the hydroplaning process takes place. The task of the study is to compare the noise levels of tires of the same size under the same operating conditions, but with different tread patterns, when driving on a wet road.

Analysis of Research Results

At the Department of Machine Parts and TMM of Kharkiv National Automobile and Highway University the issues of automobile tire noise emission have been dealt with for a long time [4]. In this paper, the authors present analysis of the results that make it possible to estimate the maximum speed of the vehicle corresponding to the hydroplaning process by recording the tire noise as a result of its coupling with the road. It has a generally accepted name – critical speed.

Determination of the critical speed is based on the formation of an extremum in the graphical dependence of automobile tire noise emission on the rolling speed of the wheel. This process is due to the loss of the contact area of the wheel with the road pavement. This speed will be the rate of the hydroplaning process formation.

This article presents the experimental results of noise emission produced by ROSAVA tires (tires 175/70 R13 BC-4, BC-11, BC-43, SQ-201). These tires are of the same size, road pattern tread, but different in appearance. Each tread pattern provides the tire with reliable grip, as well as optimum performance at the operating speed. Longitudinal and transverse grooves with lamellas provide effective drainage of water from the contact zone, and low probability of hydroplaning. But despite this, each of these tires have their own critical speed at which the effect of hydroplaning takes place.

The experiment was performed on a wet asphalt covering with a water film 2 mm thick. Recording of the noise emitted by the tires was carried out using a road method at various speed. This method consists in passing of a car past the microphone with the engine switched off, during which the noise emitted by the tire is recorded. Using the software, one can determine the maximum level of emitted noise. The results of the experiment are shown in Table 1, and in the graphical form in Fig. 1.

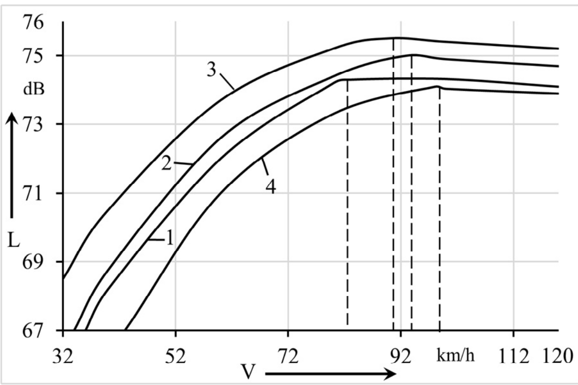
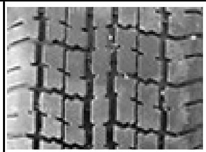
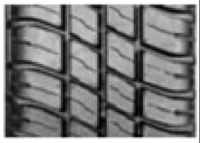
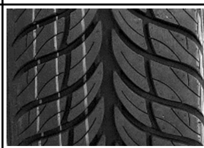


Fig. 1. Graph of dependence of the noise level of tires 175/70 R13 mod.1 – BC-4; 2 – BC-11; 3 – BC-43; 4 – SQ-201 on the rolling speed of the wheel on a «wet» road surface

From the obtained graphical dependences, it is seen that when the critical rolling speed of the wheel is reached, the level of noise emission of a moving automobile tire decreases with a further increase in rolling speed.

Table 1 Results of the conducted experiments

№	Characteristics of the tire	Coefficient of saturation of the tread pattern Кн	Critical speed Vкр
1	 175/70 R13 - BC-4	0,675	90
2	 175/70 R13 - BC-11	0,612	93
3	 175/70 R13 - BC-43	0,750	83
4	 175/70 R13 - SQ-201	0,700	98

The volume of liquid that must be removed from the contact zone increases linearly with increasing velocity and thickness of the liquid film on the support surface. This phenomenon is due to the fact that as the rolling speed of the wheel increases, the fluid moves to the back of the contact spot, and at a speed corresponding to the start of hydroplaning, the water layer extends over the entire area of contact between the tire and the road surface. That, in turn, causes a decrease in the noise emission of the automobile tire with subsequent sound stabilization. The water wedge, which is formed in the front part of the contact of the automobile wheel with the "wet" road surface, increases progressively. The resulting extreme of the sound level corresponds to the required critical velocity at which the hydroplaning of the automobile tire begins. With a film thickness of 2 mm for BC-43 tire, the critical speed corresponds to the speed of movement of 83 km/h, for tire BC-4 – 90 km/h, BC-11 – 93 km/h, SQ-201 – 98 km/h. As it was said above, according to this manufacturer, the treads of these tires are similar in their performance properties. However, the difference in the saturation coefficients and the features of the tread patterns of the tested tires (see Table 1) played a positive role in favor of SQ-201 tire.

The final desired parameter in any method of studying the behavior of a tire on a «wet» road surface is the critical rolling speed of the wheel. Using the methods of high-speed photography [5], or obtaining the coefficient of coupling when the brakes are applied [6] is quite time-consuming and expensive to determine the critical rolling speed of the tire. In turn, the study of hydroplaning with the help of noise emission measurements of tires at different speed allowed to determine the tire with the best indicator of the operational parameter in question, and to determine the critical speed of this effect occurrence.

Conclusion

Using the method of recording the noise of automobile tires of the same size 175/70 (BC-4, BC-11, BC-43, SQ-201), their critical velocities were obtained during hydroplaning. Analysis of the results showed that the tire ROSAVA SQ-201 is the most resistant to hydroplaning.

Thus, the result of study of noise emission of a moving automobile tire on a wet road surface is the proposed method for determining the critical wheel movement speed that does not require expensive equipment and is less labor-intensive.

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