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Methods of Assessing the Influence of Operational Factors on Brake System Efficiency in Investigating Traffic Accidents

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Abstract

The article is devoted to investigation of some operational factors affecting the response time of a brake system and substantiation of the need for their consideration in reconstructing and investigating traffic accidents. The aim of this article is to publish proposals for improving the traffic accidents (TA) assessment methodology by considering extra operational factors that increase the braking time and the length of stopping distance of a vehicle fitted with a hydraulic brake drive. Experiments have proved that there is regularity in influence of the braking fluid boiling temperature on the total braking system response time. A coefficient has been calculated and substantiated that takes into account this influence on designed braking time values and vehicle stopping distance.

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Keywords: Vehicle, traffic accident investigation, hydraulic drive braking system, braking system condition, braking process, braking efficiency.

1. Introduction

According to statistics, braking process is the reason in most of traffic accidents. The main goal of each judicial motor vehicle expert is to establish, as truly as possible, the real cause of a traffic accident and determine the driver’s technical capability to prevent it. However, in carrying out the traffic accident investigations there are still methods

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which are not considering a number of operational factors impacting the efficiency of a braking system response [Borovsky et al. (1984), Evtyukov and Vasilyev (2012), Domke et al. (2009), Ilarionov et al. (1989), Judicial Motor Vehicle Investigation (1980)]. Analysis of the main designed dependencies related to determination of the vehicle travel speed (V_a), time (t) and braking distance (S_o), used by motor vehicle experts in the process of assessment of traffic accidents, showed that they ignored such operational factors as actual strength of the braking effort on the brake pedal, front and rear axles and the brake pad wear. The need to consider these factors and the methods of correcting the designed dependencies taking into account their influence on the expert's final conclusion concerning the driver's ability to prevent the accident are discussed in articles [Podoprigora et al. (2012/2013), Evtyukov and Podoprigora (2012)].

The aim of this article is to publish the results of investigations and proposals for improving the methods of traffic accident assessment methodology by considering such additional operating factor which causes the increase of the brake time and stopping distance of a vehicle fitted with hydraulically driven brakes as the actual condition of the braking fluid.

2. Main part

The authors have investigated the technical condition of a vehicle fitted with disc brakes and hydraulic drive, which made it possible to evaluate the influence of the qualitative composition of braking fluid characterized by its boiling temperature (T) on the braking system's total response time (t_r).

The braking fluid, as a functional element of the braking control system, must meet all the requirements applied to its operating quality, one of which is boiling temperature. This is an essential indicator that determines the braking system workability in conditions of maximum permissible operating temperature of the brake hydraulic drive elements. In most of modern braking fluids the boiling temperature comes down in operation due to high hygroscopic property when water comes into the system because of the moisture condensation from the air. Therefore, during operation, in addition to the boiling temperature of the "dry" braking fluid, the boiling temperature is also measured of "humidified" fluid, i.e. the temperature at which the fluid will "boil" following a certain period of operation (from 1.5 to 2 years).

The investigations have shown that in case of urgent braking the brake pad temperature may rise over 600°C, while the braking fluid can heat up over 150°C. High temperature in braking mechanisms, together with hygroscopic property of the fluid, may result in «watering» and lead to pre-timely aging. These phenomena adversely impact the condition of rubber cup-type seals of the braking cylinders and contribute to metal components corrosion.

The biggest danger in braking system malfunctions is formation of gas and vapor bubbles in braking fluids. They are formed in case of overheating of braking mechanisms to high temperatures or because of the low boiling temperature of the fluid itself as well as due to its heightened water content. When the braking control mechanism is activated the bubbles are compressed. As far as the volume of the main brake cylinder is normally 5–15 ml, even more intensive pushing of the brake pedal may not result in the pressure growth in the system to the required level. In this case the brake system doesn't respond instantly because of vapor plugs in the system. The beginning of a vapor phase formation in brake fluids during heating and, as a consequence, formation of vapor plugs in the brake system's hydraulic drive occur at a temperature of 20–25°C below fluid boiling temperature. This fact is taken into consideration in determining the brake fluid quality indicators [Bukharin, Prozorov and Shchukin (1965), Gurevich and Melamud (1978), Ilarionov et al. (1966), Kruze et al. (1947)].

According to international standards, the boiling temperature of "dry" and "humidified" braking fluid must be, respectively, no less than 205 and 140°C for vehicles in their normal operating conditions; and no less than 230 and 155°C for vehicles operated at high speeds or with intense braking. It is also known that on a parked vehicle, after intensive braking mode, the fluid temperature may rise for some time due to intense heat emission of the brake pads when they are not cooled by incoming airflow.

In order to evaluate the impact of braking fluid boiling temperature (T) on the braking system's total response time (t_r), a method has been developed for experimental investigations that takes into consideration the above mentioned standards and circumstances. The objects of investigation were category M1 motor vehicles having the technically maximum permissible weight of no more than 3.5 tons. Based on these vehicles, tests were carried out on the efficiency of the braking system response on braking testing bench of the MAHA IW2 Eurosystem the instrumental control and