Statistical means of the assessment of the passive safety of road vehicles

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Abstract. The article discusses the main criteria for assessing the design of vehicles in the field of passive safety. Road safety is influenced by a large number of factors, among the most negative factors are road accidents and their consequences. All categories of the population die and get injured in road accidents, which entails a decrease in the population of the country and the level of health, life expectancy, length of the working period, and distortion of the age pyramid. Existing methods for assessing measures to improve passive safety do not fully allow establishing a correspondence between the characteristics of vehicle structural elements that ensure its passive safety and the severity of the consequences in an accident. This situation is mainly due to the impossibility of assessing the passive safety of the car as a whole, by one indicator, since the applied assessment is based on the requirements of regulatory documents. In this case, the most optimal analysis will be the analysis of the consequences of real road accidents, which allows to identify the most dangerous conditions of road accidents and traumatic elements of the structure of vehicles. The result of the assessment of measures to improve passive safety is an accurate assessment of the severity of human injury in an accident and the risk of an accident. The existing and prospective criteria governing passive safety indicators cover a small number of all types of road accidents. Therefore, expanding the scope of application of safety criteria to the widest possible range of types of road accidents and taking into account the anthropological parameters of a person is the most significant potential way to reduce the number and severity of injuries in road accidents.

1. Introduction

The problem of ensuring the safety of modern passenger cars is of high social and economic importance and is one of the important problems of the country's motorization. Reducing the number of road accidents and the number of people injured in motorization is the main task in the road safety system. Nowadays, the term “Safe System Approach to Road Traffic” has become widespread, which includes the optimization of the transportation system for all road users by identifying and taking into account the vulnerability of road users to serious injuries in road accidents. One of the most important principles of the described approach is the safety of vehicles, aimed at reducing the severity of injury and reducing mortality as a result of road accidents. However, the existing methods for assessing measures to improve passive safety do not fully make it possible to establish a correspondence between the characteristics of vehicle structural elements that ensure its passive safety and the severity of the consequences in an accident. This situation is mainly due to the impossibility of assessing the passive safety of the car as a whole, by one indicator, since the applied assessment is based on the requirements of regulatory documents. The result of the assessment of measures to improve passive safety should be an indicator
of the hazard of an accident. And an accurate assessment of the severity of injuries will determine the limit of the human body's endurance to the effects of shock loads at the time of an accident. Thus, it is possible to influence the evaluation criteria of the vehicle design and minimize injuries in road transport. Analysis of the consequences of real road accidents allows us to identify the most dangerous conditions of road accidents and traumatic elements of the structure of vehicles.\[1,2\]

In the Russian Federation, the national priority is the life and health of people. However, there are objective factors that affect the damage from the loss of a member of society or his temporary retirement from the sphere of production. Socio-economic damage from road accidents has a negative impact on the demographic indicators of Russia, such as: a decrease in the population of the country and the level of health, life expectancy, length of the working period, distortion of the age pyramid. All categories of the population die and get injured in road accidents. Young people between the ages of 15 and 29 account for about a third of road traffic victims. Road traffic crashes are the second leading cause of death among young people aged 5-29 and the third leading cause of death for people aged 30-44. The need for hospitalization of victims in subsequent road accidents is 7 times more likely and 6 times more likely to become disabled, including children. In Russia, the mortality rate of persons from road accidents is 14.0 per 100 victims of road traffic accidents, which is 5-7 times more than in developed countries The distribution of the number of road traffic victims by category of road traffic accident participants in the Russian Federation, for the same period of the accounting year is presented in Table 1.

| Participants in an accident | 2019 November | 2018 November | 2017 November |
|----------------------------|---------------|---------------|---------------|
|                            | total accident died, people | injured, people | died, people | injured, people | died, people | injured, people |
| People in cars              | 10230         | 1005          | 1359          | 10865         | 1067         | 14491          | 10482         | 1095          | 13945         |
| People in trucks            | 880           | 138           | 1074          | 999           | 143          | 1247           | 961           | 181           | 1188          |
| Pedestrians                 | 4811          | 526           | 4509          | 5169          | 602          | 4808           | 5968          | 721           | 5532          |
| Motorcyclists               | 85            | 13            | 83            | 53            | 10           | 49             | 69            | 19            | 69            |

Statistics show that about a thousand people die in road accidents in Russia every year due to technical malfunctions of vehicles. Consequently, the design safety of vehicles does not fully take into account the factors that can affect the severity of the consequences after an accident.

Vehicle safety as one of the sources of road accidents affects road safety in general. The continuously modernized design of the vehicle makes it possible to practically promptly implement measures to improve safety. An important role in this process is played by the constructive safety of the car and the methods of its testing, the perfection of these methods. Ensuring passive vehicle safety is part of one common problem - road safety.\[3\]

Passive vehicle safety is the property of a vehicle to reduce the severity of the consequences of an accident. Passive safety is manifested in a period when the driver, despite the safety measures taken, cannot change the nature of the car's movement and prevent a road traffic accident (the culmination phase of an accident). Distinguish between internal passive safety, which reduces injuries to passengers, the driver and ensures the safety of goods transported by the car, and external safety, which reduces the possibility of causing damage to other road users.
2. Materials and methods
Passive safety includes a number of factors that can contradict each other in various emergency situations. However, passive safety should provide a number of tasks in the event of an accident:
1. Ensure the possibility of saving human life inside the cabin;
2. Provide the ability to reduce the severity of injury (both a person inside the passenger compartment and outside the car, for example, a pedestrian);
3. Provide unhindered, emergency evacuation of people from the vehicle interior.
Passive safety is the main quality indicator of the system for ensuring the constructive safety of vehicles. Therefore, reducing the likelihood of injury to a person in the process of a road traffic accident is fundamental in the functioning of the passive safety system and its subsystems. In this case, the main indicators are the anthropological data of a person, and the ability of individual parts of the human body to withstand overload.[4]
The main ways to increase the passive safety of passenger cars are considered in the context of the main requirements for individual elements of the structure of passenger cars, to ensure the protection of drivers and passengers in an accident:

![Diagram of Group of requirements for passive safety of vehicles]

**Figure 3.** The main group of requirements for passive safety of vehicles

Light vehicle passive safety (PS) studies are a regulated procedure for the automotive industry. The main object under study is the many variations of various factors that affect the behavior of the car at the time of an accident.

Most reliably, the safety of a vehicle can be estimated by the consequences of an accident, which are expressed in the severity of a person's injury in an accident. The assessment of the severity of injury is based on data on the human tolerance of overloads at the time of an accident within a given time interval without receiving serious injuries.

The severity of injury to a person in an accident is determined by the maximum or average value of the following factors: overloads acting on a person, duration of exposure, rate of increase, direction of action and place of application of efforts.

The result of passive safety assessment is an accurate assessment of the severity of injury to a person in an accident and the risk of an accident.[5]

Determination of the hazard indicator of an accident makes it possible to determine the endurance limit of the human body to the impact of shock loads and how much a particular element of the car's structure is dangerous to humans, as a result of which the evaluation criteria of the vehicle design will be changed and the severity of the consequences of an accident will be minimized.

Based on research carried out by the Cornell Aeronautics Laboratory in accordance with the American Traffic Accident Severity Program, an analysis of injuries sustained by vehicle occupants by source was carried out, shown in Figure 4.
3. Analysis of Simulation Results and Experimental Data.

The analysis showed that the main cause of serious and fatal injuries was impacts on the front guard and steering column - 20.23%. In second place are impacts on the instrument panel, which accounted for 19.17% of serious injuries and deaths. In addition, windshield is the cause of 18.7% of injuries (skull trauma, concussion, etc.).

During an accident, the driver most often hits the dashboard or other structural element of the vehicle with his head (13%), and the front passenger - with his feet (11.3%). The use of seat belts reduced serious injuries to 7% and minor injuries to 34%. With the use of more effective restraints with an inertial device, as a result of road traffic accidents, only 5% of the victims were seriously injured and 29% light.

At the same time, the main causes of death in an accident of the driver and passengers of passenger cars are: ejection from the seat, impacts on the steering column, on the door, on the windshield and on the instrument panel.[5-6]

Also, studies have found that the vast majority of fatal accidents, namely 120 dead out of 136 people, were in the front seat during the accident. Therefore, the main focus should be on ensuring the safety of the driver and front passenger.[6]

The study of the statistical data of Italian, American and German researchers made it possible to identify the structural elements of the car interior, which most often injure a person. The distribution by groups of injury hazard in road accidents is shown in Figure 5.
4. Conclusion
The existing and prospective criteria governing passive safety indicators cover a small number of all types of road accidents. The applied assessment principles are not quantitative, but qualitative, which implies compliance or non-compliance with established standards. There are practically no methods for a generalized quantitative assessment of the passive safety of a car. Therefore, expanding the scope of application of safety criteria to the widest possible range of types of road accidents and taking into account the anthropological parameters of a person is the most significant potential way to reduce the number and severity of injuries in road accidents.[7-9]

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