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ACTIVE SAFETY IN THE SYSTEM OF MOTOR-TRANSPORT SAFETY

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Abstract. *The article considers the impact of active safety on motor-transport safety and on road traffic safety with the purpose of RTA preclusion. The matter of active safety in the system of motor-transport safety is furnished, the main trends in improving traffic safety are determined. While considering the problems of motor transport safety and the problems of improving traffic safety, the need for development of systems that would neutralize any excess control action or even carry out a correction of insufficient control actions of a driver in the «Driver–Vehicle–Road Traffic» system is proven.*

Key words: *motor-transport, active safety, road traffic safety, road traffic accidents, driver, vehicle.*

АКТИВНА БЕЗПЕКА В СИСТЕМІ БЕЗПЕКИ АВТОМОБІЛЬНОГО ТРАНСПОРТУ

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Анотація. *Розглядається сутність активної безпеки автомобіля в системі безпеки автомобільного транспорту, визначено основні напрями роботи щодо поліпшення безпеки руху. Обґрунтовано необхідність розробки систем, які дозволять або нейтралізувати надлишковий керуючий вплив, або здійснити корекцію недостатніх керуючих дій водія.*

Ключові слова: *автомобільний транспорт, активна безпека, безпека дорожнього руху, дорожньо-транспортні пригоди.*

АКТИВНАЯ БЕЗОПАСНОСТЬ В СИСТЕМЕ БЕЗОПАСНОСТИ АВТОМОБИЛЬНОГО ТРАНСПОРТА

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Аннотация. *Рассматривается сущность активной безопасности автомобиля в системе безопасности автомобильного транспорта, определены основные направления работы по улучшению безопасности движения. Обоснована необходимость разработки систем, которые позволят либо нейтрализовать избыточное управляющее воздействие, либо осуществить коррекцию недостаточных управляющих действий водителя.*

Ключевые слова: *автомобильный транспорт, активная безопасность, безопасность дорожного движения, дорожно-транспортные происшествия.*

Introduction

Motor-transport is a branch of transport sector that is to satisfy the needs of general public and social production in passenger and cargo transportations by means of motor-vehicles. The global statistics evidences that the number of victims of various accidents in motor-transport goes beyond the total number of victims of accidents in rail, air, and maritime transport. In this regard, in many countries development of a safety system in motor-transport is a part of national policy, which includes implementation of regulatory and legal acts, and of complex national programs. Increase of number of automobiles with apparent aging tendency and inflow of old cars from abroad, have some effect both on road traffic safekeeping and on motor-transport safety in Ukraine. At the same time the level of constructive safety of motor-vehicle, which describes the capability to preclude road traffic accidents (RTA), to reduce the severity of their aftermath, not to harm people and the environment, retards in many characteristics in comparison to automobiles of foreign manufacture. It applies, particularly, to active safety of the motor-vehicle. Active safety is to fit the highest requirements.

Analysis of publications

Regulatory bases and scientific literature consider the category of motor transport safety in various aspects; moreover, its concept varies [1–3, 5, 9, 11–14]. The issues of studying motor transport safety on the basis of major principles of providing work-capacity of motor vehicles and their reliability are raised in works by Anilovich V. Ya., Bazhinov A. V., Varfolomeev V. M., Velichkin I. M., Getsovich E. M., Govorushchenko M. Ya., Dyumin I. E., Elizavetin M. A., Kuznetsov E. S., Kukhtov V. G., Lebedev A. T., Nichke V. V., Podrigalo M. A., Polyanskiy A. S., Turenko A. M. and by other authors. They highlighted that the state of motor transport safety touches upon native interests of everyone who is involved into activities of the motor transport complex.

It should also be mentioned that in spite of numerous common proceedings, assessments and opinions, the acting requirements for active safety of motor-transport always get stricter, some of new procedures come into force, and the methods get reviewed and improved.

Purpose and problem statement

To consider the impact of active safety both on motor-transport safety and on road traffic safety in order to prevent RTA.

Active safety in the system of motor-transport safety

A lot of references [4–7, 10, 12, 13] tell that motor transport safety and overall road traffic safety (RTS) are dependent on numerous factors. For convenience of studying all these factors are classified into four interacting parts: «Man – Automobile – Road – Environment» and they are considered as the elements of the unified MARE complex. Among the three elements of the «Driver – Automobile – Road» system, a motor-vehicle poses the greatest potential risks.

It should be mentioned, that there exist some specific methods of direct impact of motor transport on road traffic safety management. One of the groups of such methods is the methods of motor transport active safety and their impact on automobile safety.

Active safety is a capability of the automobile to reduce the risks of RTA occurrence or to preclude it [6]. The essence of automobile active safety derives from absence of sudden failures in constructive systems of the automobile, especially of those related to maneuver capacity, and in driver's ability to operate the mechanical subsystem «Automobile – Road» with confidence [10]. Active safety depends on configuration characteristics of a motor-vehicle (overall dimensions and weight), on its acceleration capacity, steadiness, manoeuvrability, informativity, etc. It must be admitted, that appropriateness of traction and deceleration dynamics of a motor-vehicle to road conditions, transport situations, as well as to psychical and physiological peculiarities of a driver [10, 12] is an important function of active safety. Consider this statement in more detail.

It is well-known, that possibility of RTA preclusion is often correlated with intense braking, that's why, braking characteristics of the automobile must ensure its effective deceleration in any kind of road situations. That means that deceleration capacity is an aptitude of a car for emergency stop in case of sudden appearance of an obstacle on the traffic route. To fulfill this condition the power developed by the brake mechanism must not exceed the power of traction to the road, which depends on wheel weight load and on road surface condition. Deceleration capacity has an effect on breaking distance value, which must be the smallest. Furthermore, the braking system must allow the driver to adjust softly the intensity of braking needed.

Traction dynamics substantially affects the confidence of the driver in such traffic situations as overtaking, detour, road intersections passing and road crossing, in other words, when maneuvering in plane. In the cases when braking is no more possible, traction dynamics has primary importance for getting out of critical situations. The more dynamic the car is, the faster it can accelerate and move at higher speed in a variety of driving conditions. Improvement of traction capacity_is possible due to increase in power density of the engine and to improvement in its acceleration, which is achieved by reducing weight of the motor-vehicle, by improving its air shape, and by improving construction of the engine, transmission and steering gear. The automobile with relatively higher traction dynamics, in real driving conditions, possesses large power reserve, which may be consumed to overcome road resistance and to accelerate the vehicle.

Thus, automobile is a responsible member of the MARE complex system, and it has great importance for guarantying the active safety. The main characteristics of automobile construction, which affect active safety are: automobile configuration; steadiness (ability to withstand the drift and turn-over in various traffic conditions during high-speed movement); manoeuvrability (exploitation characteristics of the automobile, which enable driving with minimal consumption of mechanical and physical energy when performing maneuvers in plane to keep or set a vector of movement); manoeuvrability (characteristics of the automobile, which are described by the value of the smallest turn radius and overall dimensions); stabilization (ability of the elements of the «Driver – Automobile – Road» system to resist unstable automobile movement, or ability of the system to maintain the optimal position of native automobile axles while moving); deceleration capacity; acceleration capacity; informativity; comforts; good tyres; alarm system; lightning.

The analysis of works by foreign authors, which has been carried out by Ryabchinskiy A. I., Rusakov V. Z., Karpov V. V. [12] allows us to mark some modern trends and tendencies in field of active safety improvement. It should be mentioned that capability of motor-vehicles to reduce (or to preclude) probability of RTA occurrence, i.e. – active safety of the MARC complex, is a matter of priority importance when analyzing RTS nowadays. At the same time foreign and domestic studies in field of efficiency improvement of a system for keeping active safety are currently on the rise, and a complex approach which is being actively developed in countries with advanced automobile industry, sets new vectors for its further development.

According to experts' estimates automobile active safety, for the time being, is just a limiting factor, but it's not the main one in road traffic safekeeping. Such prioritization is a consequence of primary and sole driver's responsibility for safety of the driving process. It is obvious that, still for a long time, scientists and automotive engineers will have only one challenge: to do their best to provide the driver with the maximum opportunities in their problem of safe driving.

We believe that, in spite of rapid development of information and computer technology, the technology that could run the vehicle driving functions with much more reliability than the man does, is a challenge because of a moral conflict over perspective of transferring the responsibility for our lives and for lives of surrounding people to some artificial intelligence. For instance, in aviation industry, the step considered has already been made and it is quite successful, but this is due to the fact that this industry is served by highly professional and very few in number staff. When talking of RTS it must be taken into account that almost every one is involved into this process as a road traffic party.

Since driving refers to directionally-oriented sensorimotor human activity, it is possible to divide it into three levels of behaviour: behaviour based on knowledge; behaviour that is determined by certain rules; and behaviour based on existing skills [4, 6, 7, 9, 12].

On the first level, the driver has to analyze different behavioral alternatives, choosing of them the one he finds appropriate. Mental processing of available experimental or theoretical knowledge takes the most time, and after that, the chosen variant is transferred to actions through motor reactions. The second level is distinguished by the fact that a driver has already some set of rules of conduct in a given traffic situation, since similar situation-associative conditions have already taken place quite often earlier. Human behavior at the third level is characterized by reflex and response reactions to certain stimuli actions. It is obvious that the third level is the most effective form of human behaviour in limited time circumstances.
It is perfectly clear that the main trends of work on improving traffic safety are: minimization of the situations which evoke the first behavioral level, optimization of the second level of driving task, and providing maximum efficiency and

reliability of stabilizing influence of a driver at the third level. The solution to the first task among the mentioned ones lies in range of improvement of drivers' professional skills, as well as in development of various navigation systems that would help to choose the best traffic route.

Optimization of control level of the driving task has great importance for the overall traffic safety too. At this level man is endowed with an extremely important ability to predict the development of traffic situation, i.e., to choose the required parameters of movement in advance, in order to compensate for the time of retardation, which is usually inherent in the system described. The main directions of efforts are seen in development of driver information-support systems, warning systems against various hazards, and also recommendations on appropriate actions in a given situation. At stabilization level the driver as a subject of operating and the vehicle as an object, form a well-known dynamic system. The main purpose of this system is to avoid any failure in interaction between a driver and a vehicle. At the same time, the quality of vehicle response to control action must be maintained at the required level, regardless of the intensity and the speed of driver's actions so that automatism of driver reactions to corresponding situations would stay within their physical limits. Now we approach to the problem of development of the systems that would allow to provide the highest level of indices of vehicle movement (in particular, the indices of steadiness and manoeuvrability of the vehicle), that would improve substantially its active safety and, as a result, the overall level of motor transport safety.

Consider one more approach to studying the problem of motor transport safety and road traffic safety. It is obvious that one of the most objective parameters for assessment of RTS is a relative index of quantity of road traffic accidents during some period of time [12, 14]. When considering a macroscopic approach to causal analysis of RTA occurrence, which bears on the statement that there exist some critical points on the road network, where, according to statistics, the risk of occurrence of a road traffic accident is the highest, then, the problem of reducing their number lies in sphere of rational traffic management.

From the point of microscopical approach there exist a lot of conflict situations even under normal undisturbed transport movement. The approach is based on analysis of the processes, which take place in certain unified system «Driver – Vehicle – Movement Environment».

Emergence of a conflict situation may be caused both by disturbance from inside of the vehicle (for example, inadequate dangerous control actions that are made inadvertently by a driver, or breakdowns in some systems of the motor-vehicle), and by disturbance from outside a vehicle (suddenly changing characteristics of a road or unexpected behavior of the other road traffic parties). At this point there happens a very negative process of change of driver's conduct from the third level to the first one. It is possible to preclude appearance of this kind of situations only through introduction of fully automated solution for operation task by excluding the man from this process. This is unattainable at the present stage due to the reasons mentioned above.

Considering the problems of motor transport safety and problems of improving the traffic safety from the point of this approach, there reasonably comes the conclusion that there is a strong need for development of some systems, which would neutralize any excess control action, or even carry out a correction of insufficient control actions of a driver. Thus, Automatic Block System (ABS) was the first in the history of development of these systems [10, 12, 14]. It limited the braking force set by driver's control actions so that to perform the maximum traction under which braking would be the most effective. In a similar manner, Automatic Slip Control system (ASC) limits an excessive input signal from a driver in the moment of pushing the accelerator pedal.

In the system of active kinematics of rear suspension the mode of rear wheels control (ARK) is realized in such a way that it controls maintaining of lateral stability while a vehicle moves, even under extreme input control actions. It is achieved by redistribution of lateral forces acting on the front and rear axles.

The system of Dynamic Stability Control (DSC) is a complex solution for all exploitation modes and almost for all kinds of extreme maneuvers. It is worth to be mentioned that functioning of these systems doesn't come into direct conflict with the control role of the man as a subject of control which has been discussed above, since this systems actually lead to optimal parameters of control action, and this is just the thing the driver endevours to achieve.

To see examples of practical solution let's consider the systems that optimize the parameters of manoeuvrability and stability of a vehicle as very important indices of vehicle active safety. One of vehicle manoeuvrability and stability indices while turning maneuvers is a control of turning and lateral displacement of a vehicle in relation to the plane of a road, which is carried out by vehicle drivers only through using control actions to the front wheels. Such type of control with a single level of freedom is often not enough to control lateral displacement, and for essential orientation of the longitudinal axis of a vehicle on the road under conditions of a constantly changing traffic route. With that a driver actually has no ability to control a negative phenomenon of a body roll.

There are two main ways to help a driver with additional input control actions: to supplement (compensate) a driver's input control action to control the trajectory of the movement of a vehicle; to prevent or suppress any undesirable uncontrolled movement of a vehicle, caused by a driver's action, or by some external forces.

Availability of adequate driving force is an important element in using active control technology. These forces, affecting the movement of a vehicle, can be received in various ways. So far most studies are based on the use and control of external forces affecting the tyres, and internal forces that arise in the suspension system of a vehicle. The forces acting within the contact of the tyre and the road can be used in various ways: firstly, through lateral forces by introducing additional degree of freedom of control action to the wheels, and secondly, through the difference between the longitudinal forces at the left and the right side wheels of a vehicle.

As a rule, modern developments are based on the schemes that unite these concepts. However, not only integration of these methods is possible and rational, as it was proven, but also coordination of functioning of such modern systems as Active Front Steering (AFS) system and Active Roll Moment Control (ARMC) system with additional use of a Slipping Controller (SMC). These systems reflect a variety of means to help a driver both under normal driving conditions and in critical situations.

AFS system integrated with SMC may affect input control action from a driver by adding the adjusting controlling angle to keep angular steering speed of a vehicle under control during the whole driving process. The idea of using ARMC system lies in availability of a controller capable to set differential changes in distribution of a roll moment which regulates distribution of vertical load on the tyres of the front and rear axles. This system can use, firstly, an active suspension for adaptive changing of roll stability of both axes in order to achieve desired lateral movement, and secondly, to control forces of active suspension to proportionally change the roll angle using additional springing actions, thirdly, to reduce the roll angle, realizing a closed control of lateral acceleration, or using simple PID-controllers.

Collateral use of the given systems in a united strategy of centralized control allows to gain huge benefits, especially during driving in critical situations. Accuracy of AFS system is achieved due to use of SMC method, which, in its turn, is based on conformity of actual movement parameters of a vehicle to the etalon model of its conduct and its functioning is highly infallible.

Conclusions

To conclude the analysis of safety of the MARE complex, lets highlight the following: nowadays, active safety of vehicles is paid much attention when analyzing the safety of the MARE complex; three-level models allow to carry out a complex analysis of the problems of active safety of vehicles and of improving the RTS, due to that the logics of their structure keeps all the elements of the MARE complex in interaction; the approach considered is one more method for analysis of RTS. This leads us to necessity of creating some driver-assistance systems, which would neutralize (complement) external input control actions depending on a particular traffic situation to reduce the risk of RTA occurrence.

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