train, safety, control, emergencies, terroristic act,
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ALGORITHM OF TRAIN CONTROL IN EXTREME CONDITIONS

Summary. The report describes thesystem for increasing safety of train passengers in the case of emergencies. The system functions according to specially developed algorithm of actions in the case of detecting one or more events: derailment, activation explosive device and (or) spreading toxic substances in the train carriage salon. Using this system on rolling track of railways will allow decreasing negative social and economic consequences of emergencies.

АЛГОРИТМ УПРАВЛЕНИЯ ПОЕЗДОМ В ЭКСТРЕМАЛЬНЫХ УСЛОВИЯХ

Аннотация. В статье приводится описание системы для повышения безопасности пассажиров поезда в случае чрезвычайных ситуаций. Система функционирует в соответствии со специально разработанным алгоритмом действий в случае регистрации одного или нескольких событий: сход колес с рельсов, приведение в действие взрывного устройства и (или) распространение отравляющих веществ в салоне вагона поезда. Использование системы на подвижном составе железных дорог позволит снизить негативные социальные и экономические последствия чрезвычайных ситуаций.

The basis of safety of railway transport is a condition of accident-free functioning of system “wheel – railway track”. Violation of this condition connected with wheels coming off the rail as a rule leads to serious social and economic consequences.

Analysis of accidents at railway transportshowed that derailment occurred under the influence of the following factors:

- discrepancy of characteristics of rolling stock and railway track to existing technical requirements;
- driver mistakes while operating rolling stock;
- dispatching services mistakes concerning the conditions of train movement;
- natural emergencies (earthquakes, hurricanes, etc.);
- terroristic acts;
- random items on the railway track, etc.

The experience of railways exploitation showed that mentioned factors mainly had sudden nature and as a rule their removal or reduction of potential consequences might be achieved only by controlling the rolling stock. But in many extreme situations the driver has just fractions of a second to find the solution and this makes finding right solutions almost impossible. In these cases it is advisable to use the elements of automated control of rolling stock [1].

Although the full automation of process of train control could not be made nowadays (mainly as a result of significant influence of random factors) but implementation of partial automation of control process which is realized in the case of emergencies is quiet reasonable [2 - 4]. The signal for using algorithms of automated control may be exceeding the value of the control parameters of the system rolling stock which are responsible for safety of train movement.

Taking into account the foregoing the authors propose the system of rolling stock control which is automatically turned into action in the cases of emergencies.

The aims of creating such system are following:

- decreasing negative economic and social consequences in the case of committing terroristic acts in the train which are related to activation of the explosive devices or spreading toxic substances in the carriage salons;
- preventing accidents on the railways by reducing the time for making the right decisions on train control in extreme conditions;
- automatic braking of rolling stock in the case of derailment.

The system consists of three sensors: sensor 1 for detecting the explosion, gas analyzer 2 and sensor 3 for detecting derailment (fig. 1).

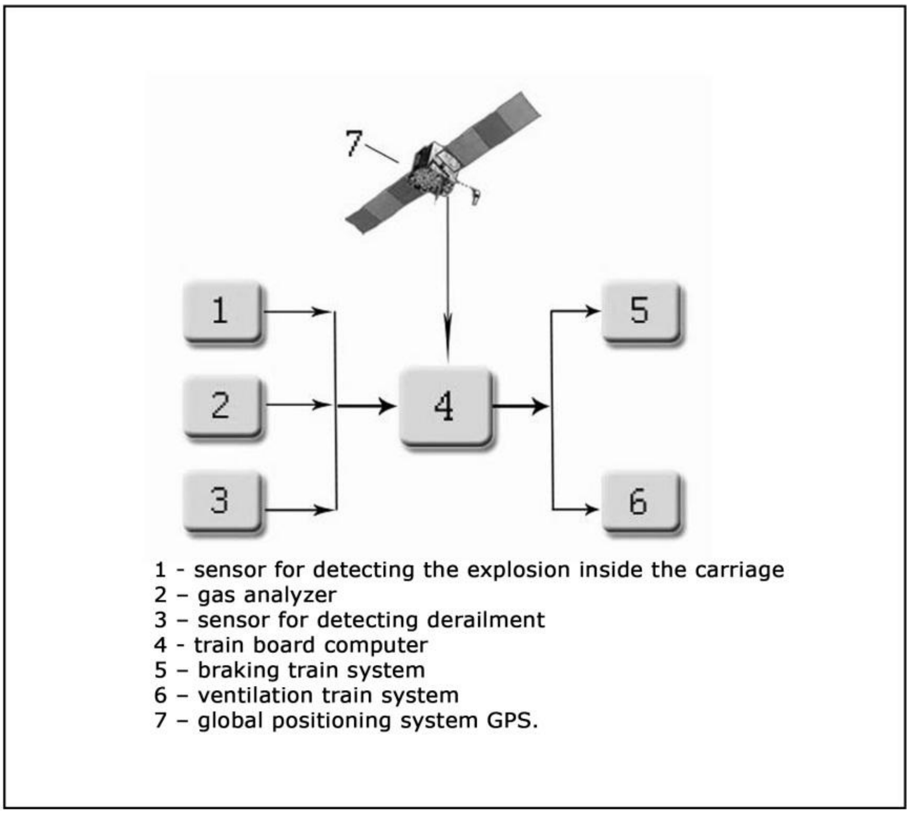

Fig. 1. Automatic system of rolling stock control in extreme conditions
Рис. 1. Автоматическая система управления подвижным составом в экстремальных условиях

The sensor 1 for detecting explosion operates on the principle of change of air pressure that occurs during the activation of explosive device. The sensors 1 are placed in the salons, tambours of train and also in the places that are close to the technical devices which provide the safety of train passengers.

Gas analyzers 2 are able to detect toxic substances in the air and give appropriate signal to central computer of the train. The sensors 1 for detecting explosion as well as gas analyzers 2 are known in the technic and do not require special modernization except for their parametric adaptation to the system.

The sensors 3 for detecting derailment are also known in the technic [5], moreover they have permanent use on rolling stock of railways of special purpose. Fire prevention system may be also adapted to the structure of the designated system. Now it operates autonomously on trains.

Sensors 1, 2 and 3 have connection with train board computer 4 which processes the signals from them and according to special algorithm outputs the signals for turning into action braking 5 or ventilation 6 train systems.

Besides this train board computer 4 has connection with global positioning system GPS. GPS system helps to determine the train locationwith the required accuracy according to its movement route.

The operating principle of the suggested system is switching to automatic control in the case of emergencies when manual control is impossible because of the lack of time for making decisions. As it was shown above the system contains three sensors, their signals may initiate switching to the automatic mode of control according to special algorithms in accordance with variants of sensors operations.

Gas analyzer 2 is not connected functionally with sensors 1 and 3. Sensors 1 and 3 are functionally connectedwith each other. According to this if sensors 1, 2 and 3 are actuated the following variants are possible:

1. the sensor 1 for detecting explosion is actuated;
2. the sensor 3 for detecting derailment is actuated;
3. the sensor 1 for detecting explosion and the sensor 3 for detecting derailment are actuated simultaneously;
4. the gas analyzer 2 is actuated.

According to mentioned combinations of actuating sensors the train control turns to automatic mode by special algorithms, specifically:

№ 1. The sensor for detecting explosion is actuated.

If board computer has a signal from sensor 1 about detecting explosion in the carriage salon the possibility of braking in a given locality along the route is analyzed. The analysis is carried out via the global positioning system GPS and the route plan stored in board computer. If the train is in places that are not suitable for passengers evacuation (tunnels, steep slopes, bridges, etc.), the train keeps moving with the purpose of passing these places and only then the braking is carried out.

№2. The sensor 3 for detecting derailment is actuated

The urgent train braking is carried out regardless of place position on the route.

№3.The sensor 1 for detecting explosion and the sensor 3 for detecting derailment are actuated simultaneously.

The urgent train braking is carried out regardless of place position on the route.

№4. The gas analyzer 2 is actuated

If gas analyzer 2 is actuated in one carriage the ventilation system switches on at full capacity. If gas analyzers 2 are actuated in more than one carriage the ventilation system switches on at full capacity and the place position on the route is defined via the global positioning system GPS. If the train is in places that are not suitable for passengers evacuation (tunnels, steep slopes, bridges, etc), the train keeps moving with the purpose of passing these places and only then the braking is carried out.

The most difficult over implementation are algorithms of automated control №2 and №3 that are switched on in the case of derailment. The difficulty of implementing these algorithms is caused due to the fact that in the case of derailment it is necessary to avoid longitudinal stresses of compression in the connections between carriages. These stresses may contribute to further descent of other wheelsets from the rails.

Mentioned necessitymay be satisfied in the train that has modular system of braking when the brakes of separate carriages or groups of carriages are turned into action. Consider the braking process of train which consists of three brake modules.

The main principle of train braking during derailment is in the fact that module (carriage or a group of carriages) in which the derailment happened is not subject to braking and other modules are braked so that to prevent forces of compression in connections between carriages.

That is why if wheels derail in the module 3 (variant A) the modules 1 and 2 are braked. If the wheels derail in the module 2 (variant B) the module 1 is braked and if the wheels derail in the module 1 (variant C) the modules 1, 2 and 3 are braked (fig. 2).

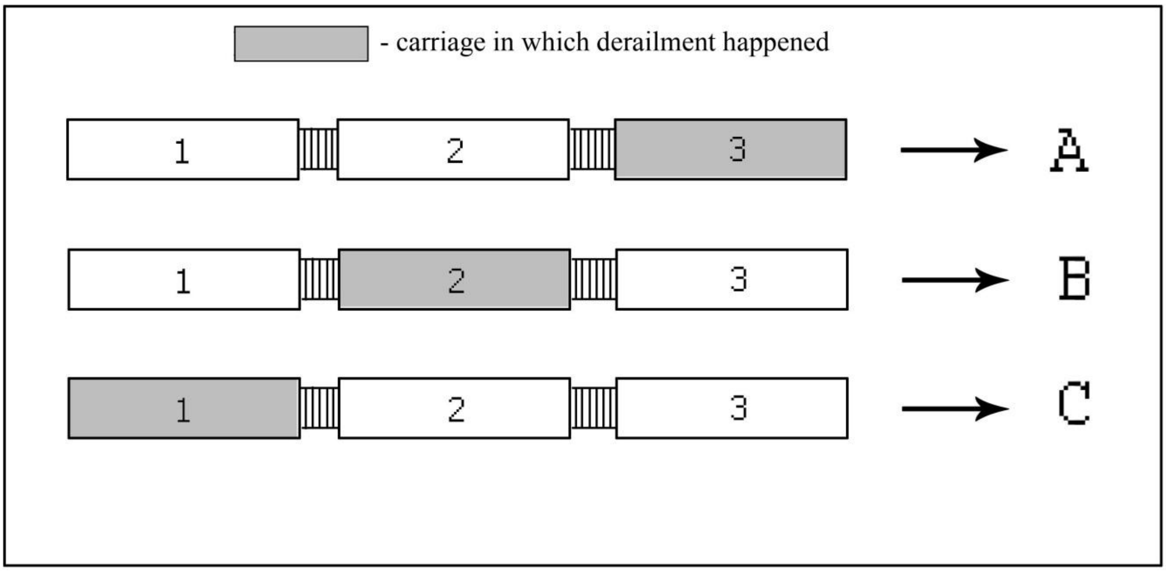

Fig. 2. Variants (A, B, C) of derailment for modular scheme of braking system
Рис. 2. Варианты (А, В, С) схода колес с рельсов при модульной схеме тормозной системы

Listed variants are related to braking schemes in the case of derailment in one train module. Certainly in the process of developing transport event connected with wheels coming off the rails more difficult variants of derailment (derailment in two or more modules) may happen. In these cases the adequate braking schemes are used which do not conflict with above mentioned principle of train braking.

Together with these algorithms of automatic train control in extreme situations the auxiliary ones may be implemented. They are aimed at timely informing in automatic mode dispatching and special services about the action, switching-on warning signals, opening doors for passengers evacuation, etc.

CONCLUSIONS

1. The system for train control in the conditions of terroristic act and emergencies will allow:
- to reduce negative social and economic consequences in the case of terroristic acts in train connected with turning into action explosive devices or spreading toxic substances in the carriage salons;
- to prevent emergencies at the railway due to the reducing time for making right decision on train control in extreme operating conditions;
- to make monitoring of the interaction of wheels with rails and ensure automatic braking of rolling stock in the case of derailment.

2. The main principle of train braking during derailment is in the fact that module (carriage or a group of carriages) in which the derailment happened is not subject to braking and other modules are braked so that to prevent forces of compression in connections between carriages.

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