

EXPERIMENTAL INVESTIGATION TO CHANGE THE TYPE OF EXCITATION OF THE GENERATOR (INDEPENDENT WITH SERIES) IN THE CASE OF THE ELECTRIC BRAKING SYSTEM

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Abstract: The braking is one of the most important duty cycles of a rail vehicle , irrespective of the type of the vehicle, i.e. a classical or a high speed one, due to the traffic safety that it must ensure and to the great diversity of factors that may influence its function.

The electrical braking (with rheostat or regenerative) is characteristic for the rail stock motor vehicles and is based on the principle of reversibility in the electrical equipment.

The authors present in the paper a solution obtained as a result of experiments on the electrical braking system for vehicles with frequent starts and stops. The experiments consisted in the replacement of the electrical braking system produced by an independent excitation generator with one produced by a series excitation generator.

Keywords: *Electrical braking system, Independent excitation generator, Series excitation generator.*

I. Introduction

The braking system is the main system that intervenes between two energy states of a moving vehicle, modifying the parameters of the initial energy state (the kinetic energy E_c and the speed V), [1-4], [11,12], [14].

If the total resistance to the forward movement of the train is considered as a continuous involuntary brake , the diagram in

Fig.1 shows a classification of the braking systems according to the following criteria : the physical phenomenon which determines the braking force (criterion 1) and the manner in which the braking is controlled and performed (criterion 2), [2], [11,12].

In all the braking systems given in the diagram the braking force is dependent on the adherence of the wheel to the rail, except for the electromagnetic track brake (the mechanic braking system), the eddy current brake and the aerodynamic brake.

The major requirements for the braking systems used by the rolling stock are as follows, [5-9], [12-14]:

- Simplicity of design (small overall dimensions , volume and weight);
- Rapid and nevertheless smooth braking movement within the allowed range of deceleration;
- A braking way as limited as possible;
- Reduced driving forces via the use of compact and light equipment;

The elimination of self-braking phenomena.

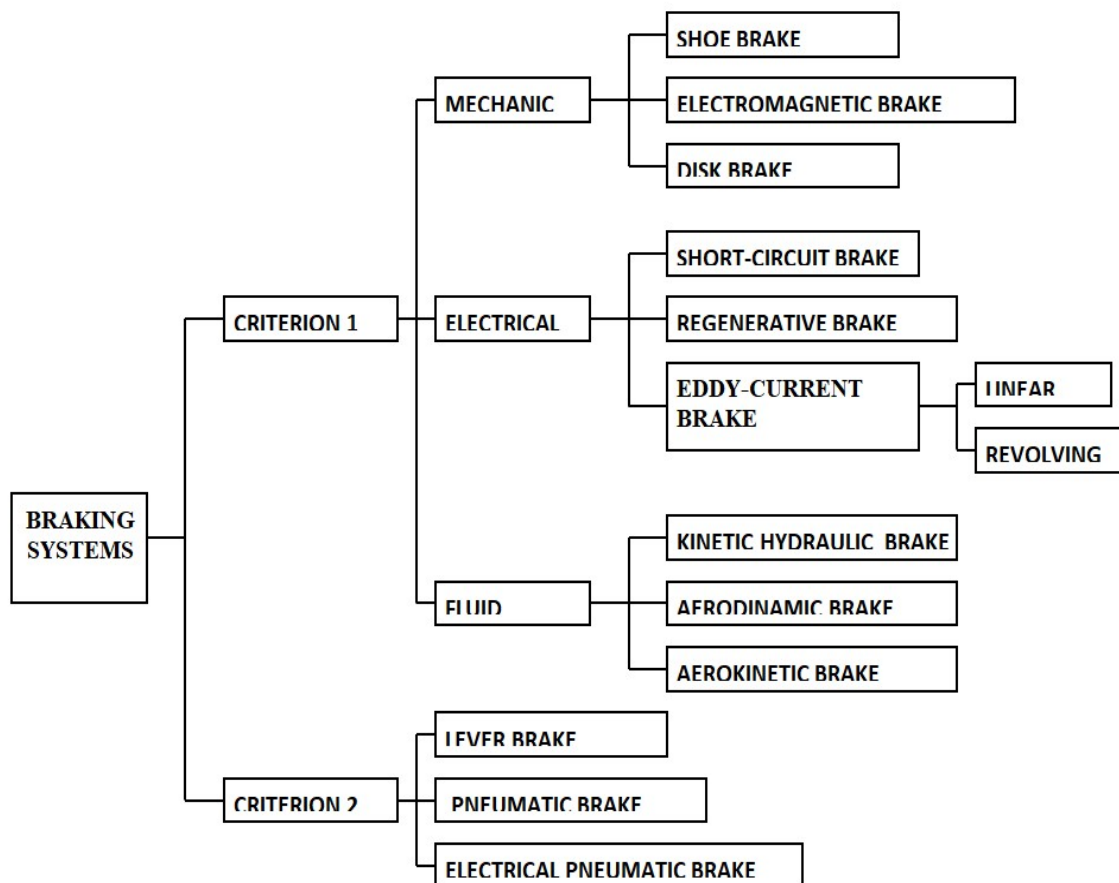


Fig. 1. Classification of braking systems

II. Materials and methods

A *The use of the electric braking*

The electric braking is based on a characteristic feature of the electrical motor to turn into a generator when driven. The mechanical energy received by the generator from the train is changed into electric energy, which can be dissipated on electrical resistances (electric braking with rheostat) or into the contact line and used by other engines in driven cycle (regenerative braking).

The electric braking with rheostat is used at engines and trains powered by direct current as well as by monophased alternating current with rectifiers.

The regenerative braking is used for d.c. vehicles and for monophased a.c. vehicles fitted with thyristor converters. The regenerative braking can be applied, as a rule, to engines that haul heavy trains on big platforms, but it is also suitable for electrical trains with frequent starts and stops. The vehicles equipped with regenerative brakes have also electric braking with rheostat and the transfer from one type of braking to the other is performed automatically.

B. Requirements for the electric braking

The electric braking has to meet the following important requirements:

- The braking has to be electrically and mechanically stable;
- It has to ensure the braking force necessary for a safe descent of steep slopes without an excessive service stress of the electrical equipment;
- The braking force and the vehicle speed have to be easily adjusted within large limits;
- It must have a high efficiency, a term which applies to the regenerative braking.

For the d.c. electrical motors used in electric hauling, the connection in of the excitation can be performed in two ways, namely in *series* and *independently*. During the hauling duty-cycle the switching in is performed usually in series, whereas during the braking cycle the connection can be either in series or independently. For the existing vehicles in which the excitation during the braking cycle is connected independently, the energy consumption is quite significant. The electric energy required is taken over from a low voltage source, usually from a storage battery shunted to the generator unit for auxiliary operations.

The consumption of energy increases mostly in the case of urban electric trains where the starting and braking are very frequent.

The service braking for these vehicles ensures, on the conductor's control, the braking of the train in the speed interval from the maximum speed to 10 km/h by means of an electrical brake. If, due to certain reasons, this brake doesn't work, the electrical pneumatic brake is switched in.

Within the speed interval 10 km/h ÷ 0 km/h, as the electric braking effect is low (even in the case of a regular operation), the electrical pneumatic or pneumatic brake is automatically switched in.

If, after the stopping, the start and brake lever is set in position '0' and the "dead-man" button is released, the spring brake is activated as stationary brake.

The braking is performed gradually, on several positions with different decelerations. The positions of the brake lever ensures decelerations from 0.1 m/s^2 up to 1.15 m/s^2 . The gradual movement is obtained by modifying the excitation circuit of the electrical motors in the case of the electric braking, or by modifying the pressure in the brake cylinders, in the case of the electrical pneumatic or pneumatic brake.

C. The proposed solution

The use of the solution with the excitation connected in series requires additional preparation and equipment so that the starting of the braking process should be performed unconditionally. It is well known that there are cases when the braking process would not start.

This is the reason why for the vehicles with frequent starts and stops there is a need for separate sources of pre-excitation. These sources differ significantly from the other sources by the fact that they are connected only for a short period of time (approx. 3-5 seconds).

The electrical diagram in the electrical braking with rheostat and *independent excitation* is presented in Fig.2 where the following notations have been made, [1], [3-6], [14]:

m1, m2, m3, m4 – hauling motors;

1u5, 1u6 – reversing switch;

1u8 – brake controller;

1r31, 1r32, 1r33, 1r34 – shunts measuring the current in the electrical machines;

44u1, 44u2 – braking rheostats (the same are used for startings);

11c6, 11c8 – braking contactors;

11c13 – contactor for the serial connection of the electrical machines excitations;

11c12 – contactor supplying the electrical machines excitations from an external source;

1r6, 1r4 – additional braking resistances;

11c14, 11c16, 11c18, 11c20, 11c34 – contactors for the adjustment of the excitation current;

31p8 – inverter diode for the power supply of the independent excitations of the electrical machines;

For the carrying out of the braking circuit, diagram contactors 11c6, 11c8 are coupled, as well as other contactors belonging to brake controller - 1u8.

The supply of the circuit is achieved through the coupling of contactor 11c12. The electric energy discharged by the electrical machines turned into heat and evacuated into the outside atmosphere via coolant fans.

In the electrodynamic braking cycle the adjustment of the excitation current is performed by means of four contactors, i.e. 11c14, 11c16, 11c18, 11c20, as well as an additional braking resistance 1r6.

The supply source is the generator unit of the auxiliary operations in the buffer with a storage battery at a voltage of d.c. 110 V. The higher is the voltage the lower is the current. This is the reason why this solution of the independent excitation cannot be applied in the case of hauling vehicles where the value of the control voltage is d.c. 24V. The excitation windings of the four electrical machines are connected in line and an adjusting resistance for the excitation current - 1r6- is also connected into the respective circuit

Conclusions

The solution presented brings considerable advantages as the energy consumption is very low, limited to a few seconds while the pre- excitation source is connected. This source can be static, fitted with a simple automatic control. The reliability of the framework increases very much, the safety of operation also increases and the maintenance and exploitation conditions are modified.

The diagram of the electric braking simplified, thus is becoming suitable for automation and for the use of the microprocessor. The time allotted for general overhauls and troubleshooting diminishes considerably and the proposed solution can be adopted during the annual general overhauls.

This system can be applied to all types of hauling vehicles, but is particularly appropriate for those in which the number of starts and stops is very high.

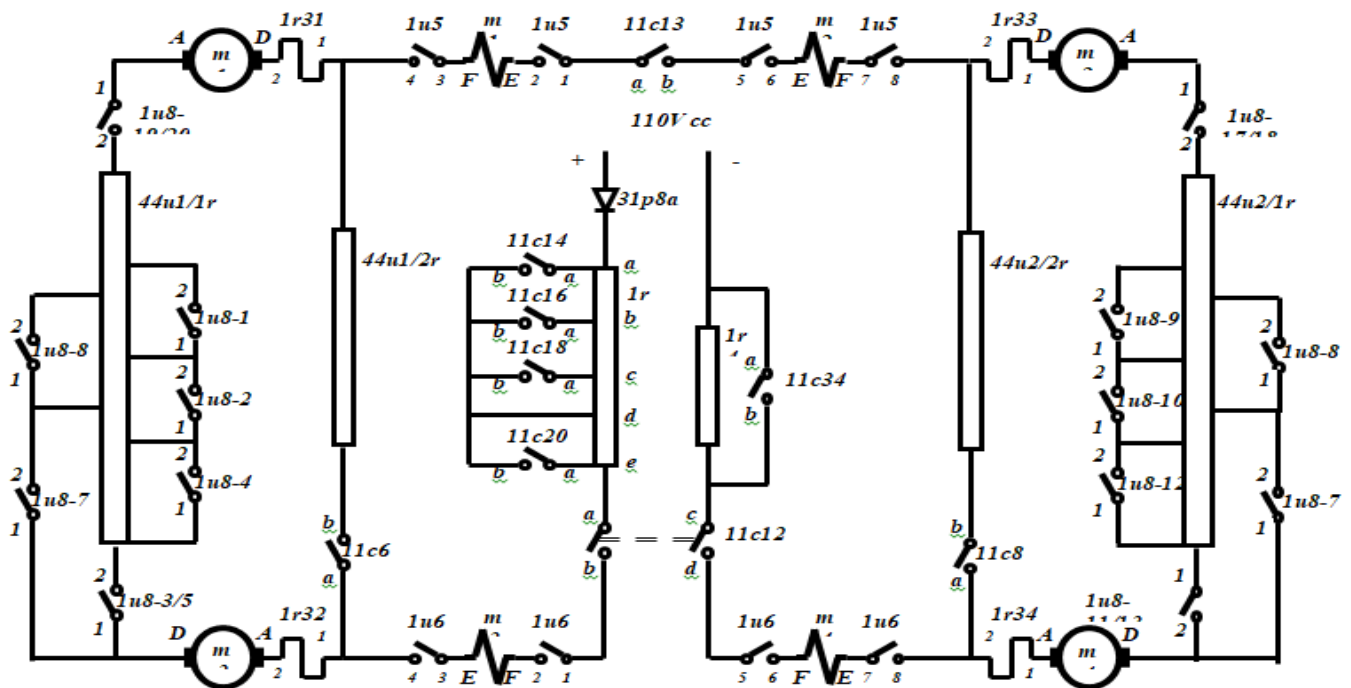


Fig. 2. The power plant in the electric braking cycle

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