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Mathematical modelling of transitional emergency processes in traction power networks of railway transport

Abstract. *The results of mathematical modelling of emergency modes of short circuit in railway traction power networks have been given*

Анотація. *Викладені результати математичного моделювання аварійного режиму короткого замикання в тягових мережах залізниці*

Keywords: *modelling, modes, emergency, power supply, traction, railways*

Ключові слова: *моделювання, режими, аварійні, електропостачання, тягові, залізниці*

The systems of electric power supply of the electrified railways of both direct and alternating currents are complex non-linear parameter dynamic systems. Their traction electric networks are exposed to frequent transient emergency modes. Model researches of these modes are complex and insecure not only because of specific operation of railways but also because of high voltage (from 3 to 27.5 kV) and large values of currents (up to 10 кА) at which these systems are exploited. In this connection the researches of electromagnetic and electroenergy processes in the indicated systems should be carried out with the help of modelling, but, in our opinion, it must be mathematical one not computational one.

The most dangerous emergency modes from the power and technical point of view, are short circuits of traction network. In practice, they arise as a result of: precipice of wires; arc-over of insulators of contact network; locking of sectional insulator or air space, which separates the section of the system which is under voltage, from an earthed one; by current collector; casual connections of metallic constructions with the wires of contact network; erroneous switchings-on in the sectionalization scheme; damages of electric train etc. Short circuits lead to different breaches of normal work of electric supply system. At short circuits, currents arising up near-by traction substation, reach enormous values, 20-40 times exceeding the normal load current. Such emergency modes with large values of overcurrents, even at their very short duration, as a result of dynamic influence, can lead to destruction of commutation appliances and devices, to the thermal damages of current leading parts. At the same time the most sensible to thermal influence are contact wires at which mechanical properties change because of thermal influence. If the current of short circuit takes a long course, and is accompanied by arc burning, thermal influence can result in burn-out of contact wires.

At short circuits, arising up in the distance from traction substation, currents, on the contrary, can be so insignificant that in some cases they are smaller than normal load currents. If such «small» currents of short circuit at their lengthy course can also be dangerous. Sometimes they can result in destruction of network because of burn-out of contact wire or rope in the place of short circuit, they can cause annealing of contact wires, lowering their durability and other undesirable phenomena.

The models of short circuit have been calculated for one of operating power areas of the Pridneprovskaia railway. The modes of nearby (in relation to supplying electric power substation), middle and distant short circuits have been tested. It has also been stated that the maximal value of emergency current (after working of protection) is 7.5 кА in the first mode 3.8 кА e in the second one and ~3 кА E in the third mode. In addition, during a short circuit there is a sharp (linear the speed from 2720 to 263 kV/s) diminishing of voltage on the output lines of supplying substation, depending on the place of short circuit.

Another «negative» sign of the testable mode is a transition of electric trains during a short circuit from the traction mode into a generator one that is recuperative. In this case electric train supplies the place of short circuit and leads to more «complex» processes in the system of electric traction; causes worsening of conditions of disconnecting of emergency mode of protection system and considerable thermal influence on the wires of contact network.

The above-mentioned signs and also other results of modelling are necessary for the development of multi parameter microprocessor highly sensitive, selective protection of the devices of traction protection, the parameters of which are easily adjusted to the conditions of the specific feeder with its typical mode of operation) protection systems of feeders 3.3 kV of direct-current. The basis of such systems can be microprocessor technologies and modern level of theoretical knowledges which are based on the results of mathematical modelling and accumulated experience of exploitation of the systems of traction power supply by direct current. Therefore, the primary tasks to achieve these aims arc: the development of mathematical model of the system of traction power supply which includes the modelling of probabilistic train timetable; formation of numeral instantaneous charts; modelling of operating and emergency transients of fraction network of direct-current. Statistical processing and analysis of calculations results of these models will allow to get mathematical dependences of current change and voltage of feeders in time, by which it is possible to choose the work parameters of the protection systems for every specific area and situation on a traction network.

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