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ENERGY SUPPLY OF THE ELECTRIC TRACTION PROCESS OF THE URBAN ELECTRIC TRANSPORT

Abstract

The article describes the features of the energy supply of the electric traction process in the urban electric transport system. The main indicators of a stable and reliable energy supply are defined and also the stochastic nature of some of them is identified. A mathematical model that identifies the process of energy supply of electric traction of the urban electric transport is proposed. The results have a scientific-theoretical and practical significance and can be used to improve the existing methods of calculating the energy supply of electric traction at a direct current.

Keywords: the power engineering supply, the traction power supply system at a direct current, the urban electrical transport, the mathematical model of energy supply of urban passenger traffic.

The full and reliable power engineering supply of the transportation process, risk reduction and avoidance the development of crisis situations in the power supply of electric transport are one of the priorities of the energy strategy of the transport industry. The guarantied energy supply of passenger traffic is one of the main tasks of the economy electrification and power supply that have to be decided at the design stage of the traction power supply system [1, 16].

The power engineering supply of the electric traction process on the urban electric transport (UET) carried out by the traction power supply system (TPSS) – the specific electric power system which has features in the formation of electrical loads and voltages, the selection of parameters of elements and of various kind of interactions. The operation of electric traction networks differs from the operation of other power supply systems by essential features: train traffic characterized by constant mode change – start, steady movement, slow down, variable track profile. This leads to the permanent fluctuations in the TPSS of currents and voltages. Uneven number of trains in the sections and mode variations in the primary system are added to this. Simultaneous accounting of all these factors is extremely complicated especially if we take into consideration its random nature [2, 103; 3, 312; 4, 70; 5, 53].

Movement conditions of the electric rolling stock (ERS) and energy consumptions on the UET and on the direct current electric railways differ essentially among themselves, however, from the point of view of building a traction power supply system these kind of transport have common features. Therefore, the main directions in the development of reliable and stable energy supply are common to urban and rail transport.

The traction power supply system and parameters its operation requirements are regulated [6, 14; 7, 16; 8, 29].

The analysis of the traction power supply system rules and requirements allow to define the main indicators (criteria), characterizing stable and reliable energy supplies of the ERS of UET, namely enough power (including reserve of the site bandwidth) and stability of the traction power supply system parameters. The enough amount of power, which needed for realization of

transportation process for specified conditions of operation (a passenger traffic, a track profile, an amount of the ERS) connected with the concept of energy supply. Herewith, it is obviously, that the power store is envisaged for motion dimensions increase, and, consequently, is characterized by the bandwidth limit.

The criteria indicators of full and reliable energy supply in assessing bandwidth are the elements of the load capacity of the TPSS: power equipment capacity of traction substations, heating wires of contact network, voltage on the current receiver of the electric rolling stock, protection conditions from short circuit current, elements load capacity of reverse traction network [1, 56; 3, 415; 4, 87].

Stability of parameters of the traction power supply system also is being one of the criteria of stable and reliable energy supply of ERS of the UET, is characterized by the voltage modes of the TPSS. The voltage levels at the current receiver of ERS constantly changing, which connected with current fluctuations and the number of trains, are being in the substation area. Power sources as a primary network and traction substations also have voltage fluctuations on the clamps because of permanent changing of operation modes of consumers. According to GOST 13109-97 for networks of constant current the electricity quality indicators are deviations and fluctuations at the current receive of consumers [6 and etc.]. Normalized voltages at substation tires and current receives of ERS are installed GOST 6962-75 «The electrified transport with the power from the contact network. The voltage range» [7, 26]. If such criterion of energy supply of ERS as the power reserve defines potential opportunities of electrical traction process on the each construction level, without affecting on the its realization, that voltage level participates in the formation of each level and significantly affects on the many process.

The processes complication affecting to the formation of voltage level and also many factors defining its realization are identified the need of using of probability theory principals. The modern condition of calculating theory of traction networks bases on the simulation modeling principles, in which stochastic mathematical schemes are used [3, 271; 4, 72; 5, 52; 9, 168].

The voltage value of contact network U_{CN}, characterized stable and reliable energy supply of the electric traction process, might be accepted as a random process, dependent from the time t, the voltage of traction substation tires U_{TS}, the position coordinate of ERS in section s, the amount of n and distribution ERS, characterized by values of mathematical expectation $M[n]$ and dispersion $D[n]$, are being on the contact network area [3, 326: 5, 51; 10, 201]. The mathematical model of contact network voltage U_{CN}, with considering GOST 6962-75 [7, 20], might be represented by the next expression:

$$U_{CN}(U_{TS}, t, s, M[n], D[n]) = \begin{cases} U_{CN\,nom} = 600\ B \\ U_{CN} \in [400; 700] \end{cases},$$

Based on the foregoing can determine simplified mathematical model of energy supply of the electric traction process:

$$\begin{cases} U_{CN} = f(U_{TS}, t, s, M[n], D[n]) \\ P_{TS} > K_2 \sum_1^n P_{ERS} \end{cases},$$

where P_{TS} – the traction substation power; P_{ERS} - the power of the ERS; K_2 – the energy needs factor, for $K_2 \leq 1$; $M[n]$, $D[n]$ – the mathematical expectation and the amount dispersion n ERS, are being in the substation zone; U_{TS} – the traction substation tires voltages.

The proposed mathematical model, identified energy supply process of the electric traction of the urban electric transport, might be used by employees of expert and analytical groups of the electrification and power supply property for energy supply calculating of electric traction of the urban electric transport.

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