ANALYSIS OF APPROACHES TO BUILDING A MODERN HIGH-SPEED TRAIN CONTROL SYSTEMS AC

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Railway transport is one of the basic sectors of the modern economy. Stable and effective functioning of rail transport it is necessary to ensure the defence, national security and integrity of the state, improve the quality of life of the population.

Currently the railway partially satisfies the needs of production and population in the transportation. Condition of the production and technical base of Railways and technological level of traffic on many parameters it does not meet the growing needs of the company and European quality standards of provision of transport services. This is an obstacle for the further socio-economic development of the state.

The problems arise in the activities and development of railway transport due to several negative factors, in particular the progressive aging of assets. The average depreciation of fixed assets of railway transport is 56 %, including rolling stock - 68 %. Needs substantial upgrading of the infrastructure of Railways.

The strategic goal of the state policy of Ukraine in the development of railway transport is the creation of a competitive rolling stock, as well as modern domestic capacity to manufacture and repair, i.e. reducing the dependence of Ukraine from import of railway transport and spare parts.

The total operational length of non-electrified routes on the Railways of Ukraine is 12234 km, which is a percentage of the total length of main roads is 55.9 %. At the same time, the percentage of diesel traction in operational work is 20 %. In connection with the rise in fuel prices is important is carrying out modernization and updating of the Park of diesel trains. Priority direction of modernization is the development and introduction in manufacture of modern domestic diesel trains with optimal energy costs.

Diesel train is a type of rolling stock that receives power from the diesel engine. It is used in suburban traffic on not electrified and partially electrified railway lines.

Diesel trains develop calculated on a wide variety of operating conditions in various countries and regions. Currently, the prevailing view is that they are more attractive to passengers from the point of view of speed and comfort, more economical and easy to use than the trains on locomotive traction. In this aspect the main advantages of diesel trains are:

- negligible influence on the train the path through reduced axial loads;

- possibility of modular execution of bodies in General and accommodation of all equipment, including the equipment of interiors;
- lower life-cycle costs;
- high energy efficiency;
- possibility of motion in both directions (Shuttle);
- large values of acceleration;
- high reliability and availability;
- the possibility of increasing passenger capacity through the placement of major components and assemblies, including elements traction transfer, under the car body.

Diesel trains classified by type traction transfer (electrical, hydraulic or mechanical), and depending on structural speed.

On diesel trains common series is used, as a rule, a hydraulic or electric traction transfer. The transmission of power from the diesel engine to the wheel pair must have high reliability and durability, minimum size, weight and cost, high coefficient of performance (COP) in all modes of operation, minimal maintenance costs and repairs. For modern electric transmission characterized by increasing capacity while maintaining almost the same size, and a reduction of the mass of transmission elements. On diesel trains apply electric power transmission into a permanent shift-DC and AC currents.

The dispersion in the world practice has power transmission DC. This is because the efficiency of electric DC transfer in continuous mode at speeds up to 160 km/h is 87 %. But when speed diesel train over 160 km/h transmission DC inferior AC transfer efficiency and energy indicators.

The transmission AC-DC is used for freight diesel trains great power. In the conditions of modernization of the rolling stock of the world and increasing speed diesel trains over 160 km/h is increasingly used traction AC power transmission. Besides diesel trains pulling transmission of alternating current for the same mass, and with other modes of transmission are developing a large tractive force, which allows using fewer motorized of car axles for the same mass of rolling stock.

One of the components of the complex of tasks on creation of modern management tools is to develop control laws, including the definition of the optimal proportions between the frequency and the amplitude of the voltage. Under the laws, which are developed, largely dependent on the quantity and quality controlled information regarding the parameters of the engine. At the present stage of development of the theory of optimal control noted the desire to ensure an acceptable quality of static characteristics of the engine by controlling the voltage amplitude as a function of frequency and load torque. The most widespread system, implementing the proportional method of management under the law Kostenko. This method, while providing acceptable in some cases the practical application of mechanical characteristics and modes of operation, however, is not optimal. It is not directed at the achievement of limiting parameters of quality of functioning of the transmission from the point of view of minimization of power losses, energy consumption, heat. To optimize the above indicators at change of the load torque is advisable not to stabilize, and in a certain way to change the magnetic state of the engine.

Development of structures traction AC power is based on the following converters:

- two-sectional frequency converters with intermediate DC;
- direct frequency converters.

The most common are the system with two-sectional frequency converters, which are based on Autonomous inverter voltage or Autonomous inverter voltage.

Power part of two-sectional frequency converters with intermediate DC rectifier consists of a filter and inverter. In two-sectional frequency converters is twofold conversion of electrical energy. First energy source AC power is converted to DC current power, and then in the energy of alternating current with a given frequency. The characteristic feature of converters of this type is the presence of the drive energy in the intermediate DC. They initially had limited use, mainly for low-speed drives, which use direct frequency converters with natural switching valves. If direct frequency converters run on a fully managed keys AC, by which, at any moment of time you can make direct two-way communication of the engine and of the supply network and to provide for the regulation of frequency and voltage (current) in the required ranges, this Converter will have obvious advantages over two-sectional frequency converters, because that will most fully meet the requirements of the automatic control system. This direct frequency Converter exceeds of two-sectional frequency converters for energy performance through a single energy conversion, dynamic performance, because it does not in the power circle cumulative reactive elements. In his power circle no such unreliable elements, as capacitors (voltage inverter they are part of the smoothing filter). Patterns drives on the basis of direct converters can be built based on the same principles as with independent voltage source inverters are simpler in implementation, taking into account sustainability and dynamics of systems with the current inverter. This direct frequency Converter combines the advantages of two-unit Converter on the basis of both types of inverters, except their flaws.

The most common type of two-sectional frequency converters today is the frequency Converter with uncontrolled rectifier and voltage inverter.

Converters with intermediate DC have the following advantages:

- ability to obtain at the output of two-sectional frequency inverters for a wide range of frequencies that do not depend on the frequency of the mains;
- the use of relatively simple power schemes and management systems of two-sectional frequency converters for objects with low requirements in terms of the range of regulatory performance;

- the possibility of increasing the complexity of the power part and control system of two-sectional frequency converters in accordance with the level of growth of requirements for traction power;

- possibility implementation in relatively few elemental structure of two-sectional frequency converters of various laws governing the eligible systems, wide range of use;

- an easy transformation of two-sectional frequency converters for use in systems with Autonomous power sources or local DC networks.

The disadvantages of two-sectional frequency converters:

- two energy conversion that leads to additional losses;

- the presence of the DC link current filter, resulting in reduced reliability and deterioration mass-dimensional parameters.

In these converters have not been fully resolved the issue of energy recovery in the network, the issue of quality power and electromagnetic compatibility in.

For these systems are most fully investigated the properties established in many works. The problems of dynamics was investigated by many authors, however, several problems still to be tackled. One of the main issues typical for systems with on-off control method is the presence of self-oscillations in the system of traction alternating current transmission and the need for compensation of cross-connections. However, due to the complexity of electromechanical processes occurring at traction power transmission difficult to find a universal method, which allows tuning and selection of parameters of regulators.

A device for adjustment does not always produce a satisfactory result in a wide frequency range and loads. Spread the methods based on the introduction of an additional signal to the channel frequency equal to the difference signal of frequency and feedback electrolysing power or voltage. The specified method provides a satisfactory job in single-band management. When a two-band management, due to the limited growth voltage, electromotive force remains unchanged, and the signal frequency is increasing, which makes this method is not suitable for such a regime.

A method was developed, allowing compensating the electromotive force of rotation in all ranges control. It is based on the synthesis in control channel voltage inverter dual current regulator, in which separate integral part. This allows you to perform full payment of the electromotive force of rotation for any mode of the system. However the transfer functions are dependent on the changes to the parameter power circuits drives.

Configuring warning systems of self-oscillations is usually performed at the Converter to the motor. However, the design should define the necessary parameters of the controllers, which provide for the specified system configuration. Therefore, it is necessary to use the methods of synthesis of parameters of regulators, increase stability, allowing considering peculiarities of the system and changing the settings in the functioning of many works.

The improvement of the management system includes the optimal coordination of modes of operation of all elements, taking account of system modes, action elastic masses. Optimal coordination of these processes may microprocessor control system, which completely controls electromechanical parameters.

There are several types of modulation control the power switches voltage inverter:

- pulse-width control;
- sinusoidal;
- sine pulse-width modulation with advanced modulation of the third harmonic;
- the simplex method.

In practice the most frequently used sinusoidal modulation, which at the relative ease of implementation allows receiving the necessary form of the output voltage.

The use of modulation method for generating output voltage substantially changed properties Converter:

- output voltage form close to a sinusoidal; the result is smooth rotation at low frequencies, which allowed to expand the range of regulation;
- increased performance, power because the filter is actually excluded from control channel output voltage Converter;
- increased power factor converters as energy consumer.

In the medium voltage system voltage source inverters are used powerful power semiconductor devices (mainly IGBT and IGCT). Power switches IGBT provide at voltages from 3.3 kV (production «Infinion» and «EUPEC») up to 10 kV (manufactured by «ABB»). This allows instead of several connected in series of keys to use one of the modern power switch that increases the system reliability, simplify the scheme. The switching frequency is set by the manufacturers of these keys is in the range 250-1500 Hz.

Characteristic features of high-voltage systems with voltage source inverters high power (compared with low-voltage systems of this type) are as follows:

- low frequency modulation of power switches voltage inverter (in practice amounts to 300 Hz);
- not-sinus form stator currents of the engine;
- high requirements to the safe operation of the system and its operational reliability.

Consider the basic principles, which found application in automatic control traction power transmission AC. A significant portion of these systems is based on the scalar control principle (peak) at which the NAO is set only the necessary balance between the amplitude and frequency of the first harmonic components of the stator voltage or current. To advantages such SAK refers technical simplicity and, to the disadvantages - the quality of electromechanical transient processes depends on the instant velocity and torque of the engine. Despite this, almost all leading producers (Siemens", "ABB", "Schneider Electric", "Omron", "Danfoss") continue to release systems with such SAK. To exclude self-oscillatory regimes of the air force no work at steady regimes for certain frequency bands.

A significant number of automatic control systems built with the use of vector control. In this case, is regulated not only the relations between the amplitude and frequency of the first harmonic components of the stator voltage or current, but also the phase shift of the main harmonic components of the first harmonics stator voltage or current relatively phase polices caner engine.

A significant advantage of the automatic control systems with vector principle is the possibility of the formation of the normalized quality Electromechanical transient processes, ensure the stable operation of such systems in a dynamic and well-established regimes at all speeds and loads. However, such systems have substantial drawbacks:

- the complexity of technical implementation, due to the presence of complex computing devices (coordinate converters, vector analyzers, blocks identification of magnetic, the compensation unit of internal cross-links);
- complexity with group managing multiple engines;
- presence of the delay in the formation of electromagnetic moment;
- a significant number of internal cross-links. To address these deficiencies were proposed management methods, which are called Direct Torque Control (DTC (direct torque control and polices caner). Methods DTC are distinguished by the absence of a coordinate transformation and regulation of current circuits, high performance. However, significant disadvantage is the presence of pulsations in the electromagnetic moment and pools cape, which reduces the accuracy of regulation, increases the power consumption of the motor.

Along with the creation of scalar and vector management systems are developed quazer system that the quality of the transient process are approaching vector systems, and for the technical implementation of such scalar. They can be implemented with the installation of the sensor on the motor shaft and without sensor shaft. In high-voltage systems of scalar and quazer system became more common than vector, through the demand vector systems to high-frequency switching power switches voltage inverter, complexity perform qualitative identification of magnetic engine, installation necessary more sensors and providing them with galvanic isolation.