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СУЩНОСТЬ ОБЪЯСНЕНИЮ ВОЗНИКНОВЕНИЯ КРАТКО ТОРМОЖЕННОЕ РЕЖИМОВ ТЕПЛОВОЗОВ С ЭЛЕКТРИЧЕСКОЙ ПЕРЕДАЧЕЙ ПОСТОЯННОГО ТОКА.

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THE ESSENCE OF EXPLAINING THE EMERGENCE OF BRIEFLY BRAKING MODES OF DIESEL LOCOMOTIVES WITH DIRECT CURRENT ELECTRIC TRANSMISSION.

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Аннотация. *Для эффективного использования локомотивов и продления срока их службы важно изучить работу электрооборудования локомотивов. В частности, важное значение имеет тяговый генератор тепловозного типа 2ТЭ10М и обратное протекание тока в цепи тока тяговых электродвигателей. Эти токи были обнаружены при изучении причин оплавления контактов контакторов. В этом случае при работе тяговых двигателей в режиме затухания магнитного поля после выключения привода тягового генератора, резисторов тягового генератора тягового двигателя протекает обратный ток с шунтов тяговый двигатель. В данной статье подробно описаны особенности проявления обратных токов в токовых цепях тяговых генераторов и тяговых электродвигателей с научно-практической базой и научными рукописями ученых.*

Annotation. *In order to use locomotives efficiently and prolong their service life, it is important to study the operation of locomotives' electrical equipment. In particular, the traction generator of the locomotive type 2TE10M and the reverse current flow in the current circuit of traction electric motors are important. These currents were detected during the study of the causes of contact melting of VSh contactors. In this case, when the traction motors are operating in the mode of attenuation of the magnetic field, after switching off the drive of the traction generator, the resistors of the traction generator of the traction motor, the reverse current flows from the shunts of the traction motor. This article describes in detail the features of the manifestation of reverse currents in the current circuits of traction generators and traction electric motors with the practical-scientific basis and scientific manuscripts of scientists.*

Ключевые слова: *тепловоз, ЭДС, возбуждения, контактор, обратной ток, магнитной поток, цепи нагрузки, поездных контакторов.*
Key words: *diesel locomotive, EDS, excitation, contactor, reverse current, magnetic flux, load circuits, train contactors.*

In 1980, for the first time, when investigating the causes of melting of contacts of contactors of the VSh type PKG-565, on a 2TE10M diesel locomotive, reverse currents were detected in the power circuit after switching off the excitation of the traction generator when the traction motor was operating in the field attenuation mode. The reverse current flowed through the circuit: traction generator traction motor resistors, shunt winding excitation traction motors. The direction of the current in the excitation winding of the traction motor remained unchanged [1,3,5,7,9,11,13]. After switching off the excitation of the traction generator, there were no reverse currents in the power circuit when the traction motors were operating in the full field mode. In the works of the scientist V.N. Zhidkov, the physical essence of the occurrence of reverse current surges was described and experimentally confirmed on the stand by the example of a circuit consisting of a generator and an electric motor. Such a circuit makes it possible to exclude the influence of other traction motors connected in parallel on the transient process [2,4,6,8,10,12,14].

When the train contactor and the KV excitation contactor are switched on, the voltage of the traction generator is balanced by a voltage drop in the load circuit and the back EMF of the engine:

$$U_Г = E_∂ + IR \tag{1}$$

where IR- voltage drop in the load circuit;
$E_∂$ - back EMF of the engine.

After disconnecting the KV contactor, the current of the traction generator $ǐ_г(t)$ - sharply decreases to zero. The change in the magnetic flux of the poles lags behind the change in current. In general, the expression of the magnetic flux in a function of time can be written as:

$$\Phi_п = \Phi_н - \frac{\partial \Phi}{\partial t} t \tag{2.}$$

where $\Phi_п$- the value of the magnetic flux in the transient process;
$\Phi_н$- the value of the magnetic flux before the transient process;

In this case, the voltage $U_Г(t)$ of the traction generator in the transient process:

$$U_Г(t) = f(\Phi_{НГ} - \frac{\partial \Phi_Г}{\partial t} t) \tag{3}$$

A decrease in the voltage of the $U_Г$ (t)- traction generator at a constant speed of the traction motor and the train contactor switched on will cause a change in the motor current. The motor current tends to zero. Therefore, by analogy with (3), the expression for the back EMF $E_∂(t)$ traction motor can be written:

$$\ell_∂(t) = \varphi(\Phi_{н∂} - \frac{\partial \Phi_∂}{\partial t} t) \tag{4}$$

Considering that the voltage drop in the load circuit is IR - small compared to the back EMF traction motor, it is possible to accept

$$U_Г(t) = e_д(t)$$

or $$f(Ф_{нг}) - f(\frac{\partial Ф_Г}{dt}t) = \varphi(Ф_{нд} - \frac{\partial Ф_д}{dt}t) \qquad (5)$$

parts $f(Ф_{нг})$ and $\varphi(Ф_{нд})$ defines the transition mode,

parts $f(\frac{dФ_Г}{dt}t)$ and $\varphi(\frac{dФ_д}{dt}t)$ the nature of the transient process, i.e. the transient process is determined by the rate of change of magnetic fluxes. Thus, during the transient process, the voltage of the traction generator:

а) when $\frac{dФ_Г}{dt} = \frac{dФ_д}{dt}$ equal to the counter EMF traction motor.

The transition time is determined by the time of the magnetic flux decay of the poles of the traction generator from a steady value to zero:

б) when $\frac{dФ_Г}{dt} > \frac{dФ_д}{dt}$ the back EMF of the traction electric motor will exceed the voltage of the traction generator, which will lead to the occurrence of reverse current. The duration of the transition process is determined by the time the magnetic flux of the traction motor decreases to zero:

в) when $\frac{dФ_Г}{dt} < \frac{dФ_д}{dt}$ the duration of the transition process will be determined by the demagnetization time of the poles of the traction generator. The current in the traction motor - traction generator circuit will not change its direction. On a diesel locomotive, the transient process caused by the removal of the excitation of the traction generator when the train contactors P1 + P6 are switched on is accompanied by a change in the direction of the current of the motor $i_д(t)$ armature and shunt resistors $i_к(t)$.

The current of the excitation winding of the traction motor $i_{ов}(t)$ does not change in direction until the field attenuation contactor is switched off. Therefore, the contactor current at the time of switching is determined by the sum of the reverse armature current and the forward current of the excitation winding. In experimental trips, the values of the reverse current I_k =-855A were recorded.

This current was switched by the GS contacts. The value of the switched current in this case exceeds the permissible value of the switching current $I_k(t)$ of the contactors of the VSh type PKG-565.

The transient process in electrical transmission caused by the removal of the generator excitation when the train contactors are switched off without holding time can be accompanied by the appearance of reverse currents only in the resistors of the excitation winding of the traction motor. A change in the current in the traction generator - traction motor circuit causes EMF and self-induction current of the excitation winding of the traction motor.

With the existing speed of KV, P1 + P6 and VSh, the armature current of the traction motor decreases to zero by the time the contactor is switched off. Therefore, the VSh contactor commutes only the self-induction current of the excitation winding.

In some cases, the traction current of the electric motor after switching the contactor of the VSh passed from the region of negative to the region of positive values. In the works of V.I. Yushko, V.N. Zhidkov, this was explained as an oscillatory process caused by the arc burning on the contactors of the high school.Gorenje. Later, scientists V.I. Yushko, V.N. Zhidkov explained only the transition to the region of negative values. The transition back to the region of positive values is explained by the switching of train contactors P1+P6 [3,13-15].

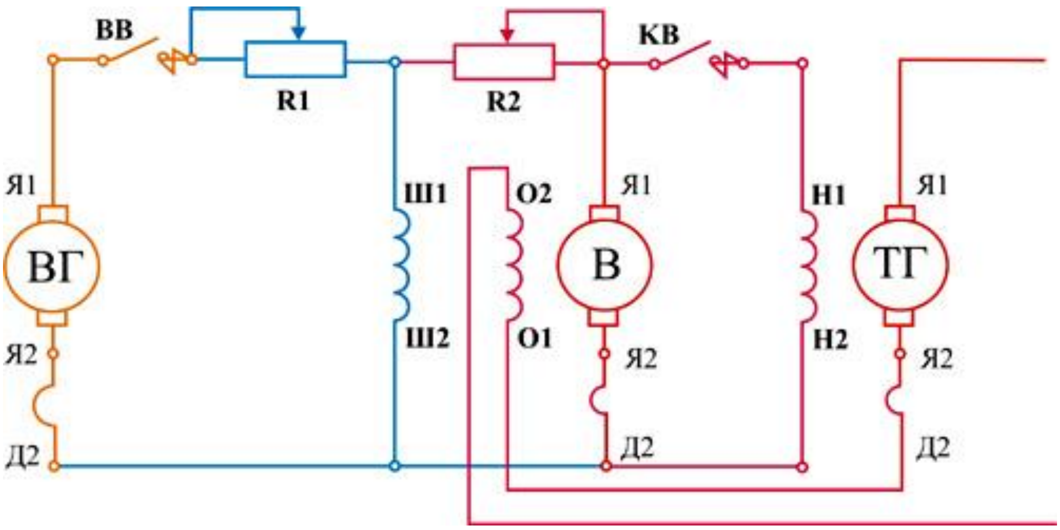

Fig. 1. Circuit diagram of the traction generator of the locomotive TEM2

On diesel locomotives TEM2 train contactors P1÷P2 are switched off with a time delay as well as on diesel locomotives of type TE10. Therefore, in order to detect reverse currents, oscillography of the current $i_r(t)$ and voltage $U_r(t)$ of the traction generator was carried out when its excitation was switched off in various ways in the modes of the traction motor to full field and attenuation of the field. When the KV excitation contactor was switched off by switching the controller to the zero position and the "Machine Control" toggle switch, if the TKPD-45-10 excitation attenuation contactors were installed, a reverse current surge occurred in the armatures and resistors shunting the excitation winding of the traction motor (Fig. 1). The reverse current was observed only when the KV contactor was switched off by the "Control" toggle switch cars". When the traction motor was operating in the full reverse current field mode, no reverse current was observed. Similar results were obtained on the TEM-2 diesel locomotive (TKPD-45-10 contactors are not installed on them).

The transient process in electric DC transmission of diesel locomotives of type TE10, when the traction motor is operating in OP1 and OP2 mode, caused by the removal of the excitation of the traction generator when the train contactors are

switched on, is accompanied by reverse current surges in the anchors of the traction motor and resistors shunting the excitation winding of the traction motor;
- the contactor of the VSh traction motor commutes the sum of the reverse armature current and the self-induction current of the excitation winding of the traction motor;
- the absence of reverse current in the transient process caused by the removal of the excitation of the traction generator when the traction motor is operating in full field mode indicates that in this case the voltage attenuation coefficient of the traction motor is greater than that of the traction generator;

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