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DETERMINATION OF THE QUANTITY OF SIMULTANEOUSLY SELF-STARTING PUMPING PLANTS

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ABSTRACT
The article deals with the calculation technique for determining the number of self-starting pumping units depending on the network voltage setting and the main design dependencies of the self-starting process of electric motors fed from a three-phase three-winding transformer, and a replacement circuit for one phase of the circuit is made up. Technical solutions for the modernization of pumping units are proposed, which allow the application of the self-starting mode at reclamation pumping stations.

Timely irrigation is one of the main factors affecting the yield of crops, in particular cotton. Therefore, the uninterrupted operation of pumping plants during the irrigation season to ensure the specified schedule of water supply to pumping stations is of great importance for the economy of the republic. When the pump systems of the pumping stations are scheduled to be disconnected, the drive on the pressure pipeline is pre-closed [1]. In this case, the frequency of rotation of the pumping plant is reduced to zero. In addition, water remains on the pressure pipeline (collector). Currently, in both emergency and successful automatic restart (APV) of the electricity network, there is a complete sudden disconnection of the pumping systems of pumping stations. Due to the loss of the pump drive, the power supply is reduced to zero, the installation will rotate in the previous direction. The flow of water through the pump initially brakes the pump, the rotation frequency reaches zero, after changing the direction of rotation goes into turbine mode and accelerates to the established conveyor, as the pipeline is empty it slows down and stops. As a result, there is no water left in the collector burn and failure of the pumps, weaken the fasteners, fails the pumping system as a whole [2].

To start the pumping system after expiration, it is necessary to remove the pump plugs, to pull out the inflated plugs, to plug new plugs and to collect the plugs. It is necessary to close the rear drive tightly to create a vacuum before starting the pump. Therefore, in such cases it is necessary to fill the collector with water in order to create a vacuum in the pump before starting. After each repayment, an emergency situation is created at the pumping station. The launch of pumping systems requires skilled personnel and scarce materials (salmon fillings,

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turbine oil). It takes a long time (2-3 days) to carry out the start-up and adjustment work and bring the pumping system to normal operation, which leads to a breakdown of the irrigation water supply. Therefore, the problem of self-starting pumping systems is relevant [3]. The number of pumping units installed at the meliorative pumping stations varies widely (2-16 units). Pump power engines are powered by the pump station's descending substation. In these substations, two- and three-wheel-drive transformers are used.

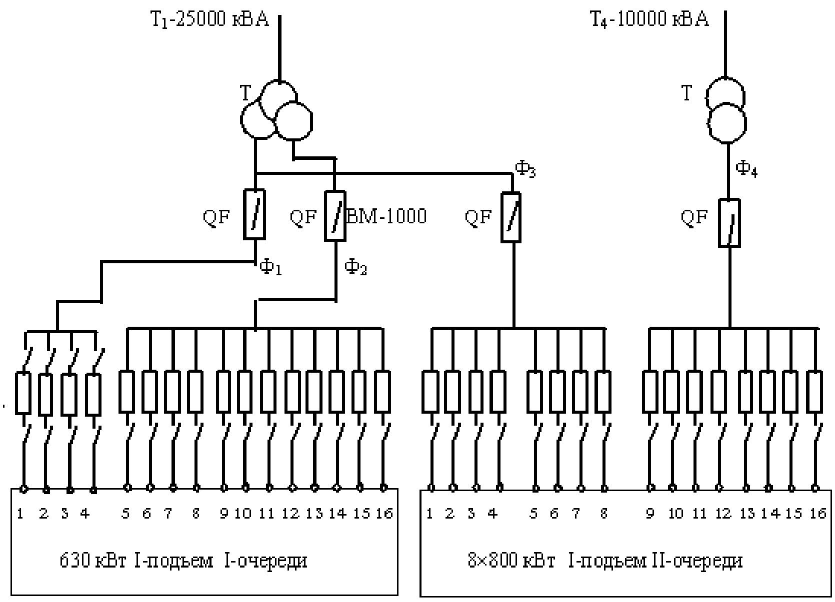

Figure 1. Amu-Zang-I, I and II row pumping station electric circuit

The number of simultaneously self-starting engines of the pumping station shall be determined on the basis of the permissible value of the decrease in the voltage of the network at the time of self-launch. Knowing the voltage of the grid and the resistance of the power source, the value that restores voltage on the engines is determined. If the torque of the engine at this voltage is greater than the moment of the resistance of the pumps, then the self-start of this engine is possible. The methodology for calculating the number of self-launching pump units depending on the network voltage is given. Fig. 1 shows the scheme of the electricity supply of the typical pumping stations of the first lift. The main calculated dependencies of the self-start process of electric motors powered by a 3-phase three-wheel-drive transformer are presented.

Peripheral nominal linear voltage: UNL.

Phase primary voltage:

$$U_{1н\phi} = \frac{U_{1нл}}{\sqrt{3}}; \qquad U_{2н\phi} = U_{2нл}. \tag{1}$$

Transformer transformation coefficient:

$$К_{m_{12}} = К_{m_{13}} = \frac{U_{1_{нф}}}{U_{2_{нф}}} = \frac{U_{1_{нф}}}{U_{3_{нф}}};$$ (2)

We determine the nominal currents of the three-wheel-mounted transformer:

$$I_{1_{нф}} = I_{1_{нл}} = \frac{S_{нI} \cdot 10^3}{\sqrt{3} \cdot U_{1_{нл}}};$$ (3)

$$I_{2_{нл}} = I_{3_{нл}} = \frac{S_{нII} \cdot 10^3}{\sqrt{3} \cdot U_{2_{нл}}} = \frac{S_{нII} \cdot 10^3}{\sqrt{3} \cdot U_{3нл}};$$ (4)

$$I_{2_{нф}} = I_{3_{нф}} = \frac{I_{2нл}}{\sqrt{3}} = \frac{I_{3нл}}{\sqrt{3}}.$$ (5)

By the values of the short circuit voltage we find the full short circuite resistance, relating to one phase, when the power transformer is three-wheel-drive:

$$Z_{к_{23}} = \frac{U_{к_{23}}}{100} \cdot \frac{U_{1_{нф}}}{I_{1_{нф}}};$$ (6)

$$Z_{к_{12}} = \frac{U_{к_{12}}}{100} \cdot \frac{U_{1_{нф}}}{I_{1_{нф}}};$$ (7)

$$Z_{к_{13}} = \frac{U_{к_{13}}}{100} \cdot \frac{U_{1_{нф}}}{I_{1_{нф}}}.$$ (8)

We give these resistance to secondary and tertiary wave:

$$Z'_{к_{23}} = Z_{к_{23}} \cdot \frac{1}{K_m^2};$$ (9)

$$Z'_{к_{12}} = Z_{к_{12}} \cdot \frac{1}{K_m^2};$$ (10)

$$Z'_{к_{13}} = Z_{к_{13}} \cdot \frac{1}{K_m^2}.$$ (11)

Ignore the active components of short-circuit resistors. Then the inductive short-circuit resistance resulting from secondary and tertiary winding:

$$X'_{к_{23}}; \quad X'_{к_{12}}; \quad X'_{к_{13}}.$$ (12)

The inductive resistance of the primary winding to the secondary and tertiary windings:

$$X'_{\delta_1} = \frac{X'_{к_{12}} + X'_{к_{13}} + X'_{к_{23}}}{2};$$ (13)

Inductive dispersion resistance of secondary and tertiary windings:

$$X'_{\delta_2} = \frac{X'_{\kappa_{12}} + X'_{\kappa_{23}} + X'_{\kappa_{13}}}{2}; \quad (14)$$

$$X'_{\delta_3} = \frac{X'_{\kappa_{13}} + X'_{\kappa_{23}} + X'_{\kappa_{12}}}{2}. \quad (15)$$

Convert the secondary and tertiary wrappings of the transformer connected to a triangle into equivalent stars:

$$X'_{\delta_{1э}} = \frac{X'_{\delta_1}}{3}; \quad (16)$$

$$X'_{\delta_{2э}} = \frac{X'_{\delta_2}}{3}; \quad (17)$$

$$X'_{\delta_{3э}} = \frac{X'_{\delta_3}}{3}. \quad (18)$$

Let's assume that the grid that feeds the transformer has infinite power. To calculate the self-start of electric motors powered by the transformer, make a replacement scheme (Figure 2) for one phase of the circuit. We ignore the resistance of the transmission line. The calculation formulas for the replacement scheme and the calculation of the self-starting of electric engines from the 3-wheel-drive transformer are given below: On the basis of the expressions obtained, the calculation is made at the parametrically specified values of the engine slide S=1; 0.5; 0,06; the current values in individual feeds F1; F2; F3; as well as the voltage at the end of these feeds, i.e. on the clamps of individual groups of electric motors powered by these feeders and the tension in the windings of the transformer (excluding losses in the connector cables), when the number of powered at S = 1 and self-starting at S=0,5; 0.06 electric engines varies from one to four. On the basis of the calculated dependencies obtained, the number of self-starting electric motors of the active pumping stations "Amu-Zang -I" is determined.

$$Z_{\phi_I} = \left(\frac{R_{1_I}}{n_1} + \frac{R'_{2_{II}}}{n_1 S}\right) + j\frac{X_{\kappa_I}}{n_1}; \quad (19)$$

$$Z_{\phi_{II}} = \left(\frac{R_{1_{II}}}{n_2} + \frac{R'_{2_{II}}}{n_2 S}\right) + j\frac{X_{\kappa_{II}}}{n_2}; \quad (20)$$

$$Z_{\phi_{III}} = \left(\frac{R_{1_{III}}}{n_3} + \frac{R'_{2_{III}}}{n_3 S}\right) + j\frac{X_{\kappa_{III}}}{n_3} + jX_{\delta_{3э}}; \quad (21)$$

$$Z_{\phi_I} - \Phi_{II} = jX_{\delta_{2э}} + \frac{Z_{\phi_I} \cdot Z_{\phi_{II}}}{Z_{\phi_I} + Z_{\phi_{II}}}; \quad (22)$$

$$Z_э = jX'_{\delta_{2э}} + \frac{Z_{\phi_{III}} . Z_{\phi_I} - \Phi_{II}}{Z_{\phi_{III}} + Z_{\phi_I} - Z_{\phi_{II}}}; \quad (23)$$

$$I_э = \frac{U_{2\phi}}{Z_э}; \quad (24)$$

$$U_{AB} = U_{2\phi} - I_э \cdot X'_{\delta_{1э}} \cdot \varepsilon^{j90^o}; \quad (25)$$

$$I_{\phi_{III}} = \frac{U_{AB}}{Z_{\Phi_{III}}}; \qquad I_{\phi_I} - I_{\Phi_{II}} = I_э - I_{\phi_{III}}; \quad (26)$$

$$U_{qIII_л} = \sqrt{3} I_{\phi_{III}} \left(\frac{R_{III}}{n_3} + \frac{R'_{2III}}{n_3 S} + j \frac{X_{кIII}}{n_3} \right); \quad (27)$$

$$U_{qI_л} = U_{qII_л} = \sqrt{3} \left(U_{AB} - U_{\phi_I} - I_{\Phi_{II}} \cdot X_{\delta_{2э}} \cdot \varepsilon^{j90^o} \right); \quad (28)$$

$$I_{\phi_I} = \frac{U_{qII_л}}{\sqrt{3} Z_{\phi I}}; \qquad I_{\phi_{II}} = \frac{U_{qII_л}}{\sqrt{3} Z_{\phi II}}. \quad (29)$$

Transformer parameters TDTN-25000/110/6/6.

Scheme and group of Y/*Δ*/ *Δ* /-II-II foldings.
Short circuit voltage:

VN - NN at 2500 kWA 10.7%,
VN - NN at 12500 kWA 16.5%,
VN - NN at 12,500 kWA 9.87%,
VN - NN at 12.500 kWA 9.48%.

3-phase asynchronous engine type DAZO 15-59-10Y1:

$U_{ДЛ}$=6 кВ, η=93%, $P_{2Н}$=630 кВт, $M_{п_{кр}} = \frac{M_п}{M_н} = 1{,}3,$

n=595 об/мин, $I_{п_{кр}} = \frac{I_п}{I_н} = 6{,}6,$ $I_Н$=80 А, $M_{мах_{кр}} = \frac{M_к}{M_н} = 3{,}26;$

Cos$\varphi_Н$ =0,81. Pneumatic type: 24НДС, $Д_{РК}$=875 мм.

The results of the scores are presented in consolidated table 1 and on Figure 3.

Calculation of self-starting electric motors from transformer TDTH-25000/110/6/6.

Table 1

S	n	$U_{qлI} = U_{qлII}$	$U_{qлIII}$	$I_{\Phi I}$	$I_{\phi II}$	$I_{\Phi III}$	$\Delta U_{qлI} = \Delta U_{qлII}$	$\Delta U_{qлII}$

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	шт	В	В	А	А	А	%	%
1,0	1	5680	5832	540	675	560	5,3	2,8
	2	5393,64	5660,6	1046	1277	1098	10,1	5,8
	3	5130	5495	5495	1500	1840	16,10	8,4
	4	4894,7	5344,6	1899	2314	2073	18,4	10,9
0,5	1	690	5838	535	668	553	5,1	2,7
	2	3406,1	5668,45	1035	1266	1085	9,9	5,5
	3	5150	5520	1488	1828	1599	14,1	8
	4	4914,09	5377,1	1881	2301	2058	18,01	10,4
0,06	1	5880	6940	343	430	342	1,5	1,0
	2	5755,94	5869,35	664	843	677	4,05	2,2
	3	5633	5810	973	1235	1006	6,1	3,2
	4	5516,86	5743,12	1273	1616	1325	8,05	4,3

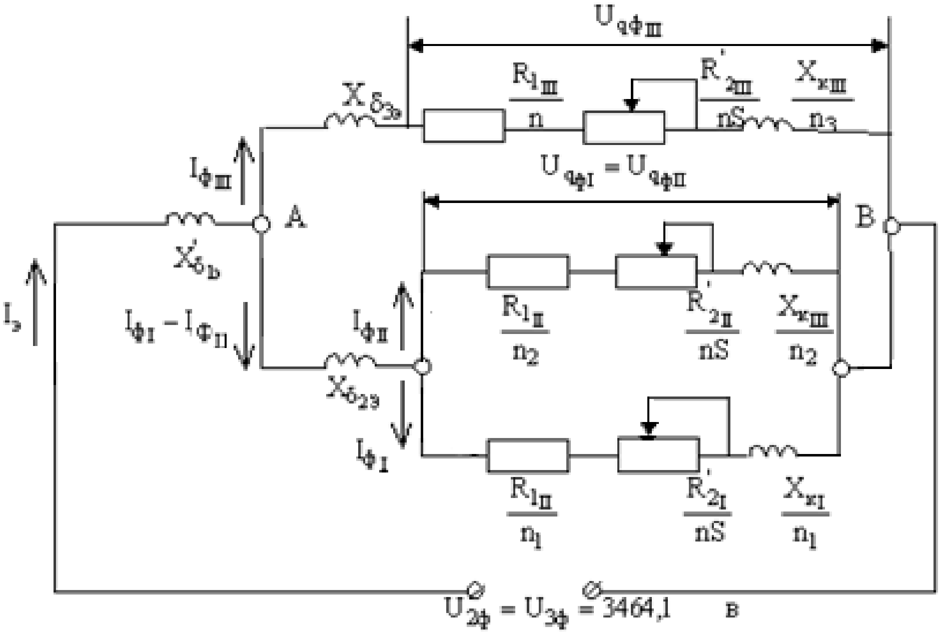

Figure 2. One-phase circuit replacement scheme powered by a three-stroke transformer

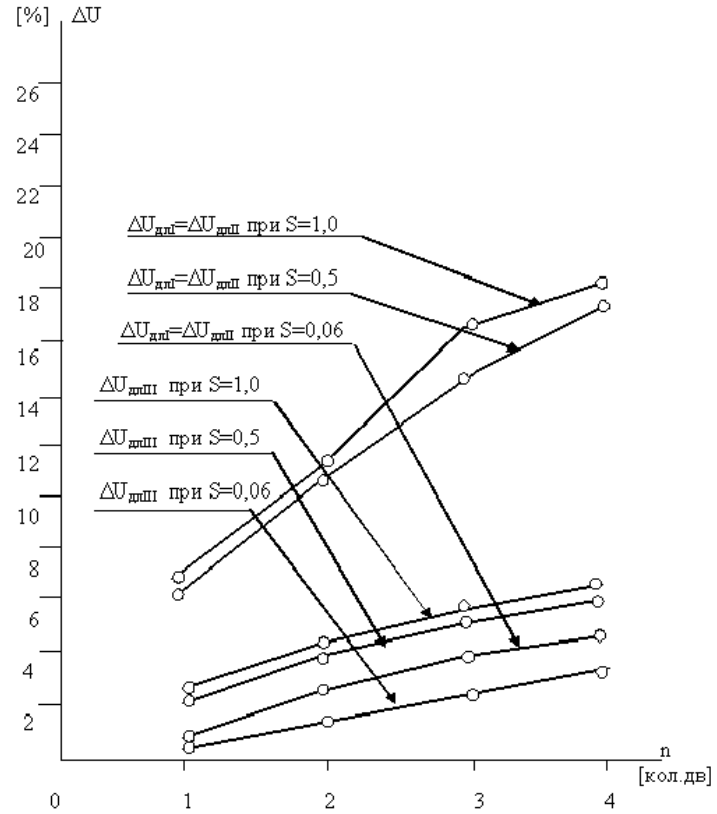

Figure 3. Number of self-launching pump units

As a result of a study of the work of the pumps of the pumping station of the first elevation of first row, it was established that it was possible to self-start asynchronous engines. The number of self-starting asynchronous engines in the existing circuitry of the pumping station depends on the time of the network. The maximum number of self-launching engines of pumping stations is obtained at 8 at a time of 0.8 s and 4 at an time of 2.5-3 s. The network voltage in these modes is within permissible limits.

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