$$E_{dmax} \approx 1{,}35U_{л} \cdot \cos\beta \approx 1{,}27U_{л}, \qquad (1)$$

wherein $U_{л}$ – is the line voltage of the supply main, 1,35 – the coefficient for the three-phase bridge, cosβ = cos 20^0 = 0,94. At the same time the rotor EMF in the wound-rotor induction motors is much less, it means that there is no current in the rotor circuit, and the capacitor 11 is charged up to the rectified diode three-phase bridge 2 EMF magnitude. At $U_{вх} > 0$ the key 5 begins to unlock periodically in the mode of pulse-time modulation. In the "on" condition moments of the key 5 the current through the restrictor 4 grows. At the key 5 break the restrictor 4 gives the condensed energy to the capacitor 11. When the capacitor 11 voltage exceeds the bridge thyristor inverter 3 back EMF the sliding motion energy output into the supply main starts. The smoothing inductor 10 provides the current continuous character, and the presence of the intermediate storage of energy in terms of the capacitor 11 allows refusing of the impedance-matching transformer and performing the slip energy inversion into the high and constant phase factor network irrespective of the asynchronous motor 1 rotation frequency.

Thus, the offered device makes the wound-rotor slip recovery system use efficient at any adjustable speed range of the asynchronous motor 1.

The device contains some supplementary elements; however, the current-limiting reactors are incomparably less both in price and mass-size factors compared to the impedance-matching transformer in the schemes of the known analogs, the cut-off diode 9 doesn't cause significant losses, and the mass-size factors of the restrictor 4 and capacitor 11 at the modulation frequency of 500 Hz already are rather small. The smoothing inductor 10 only is comparable on its parameters to the restrictor 3 in the "classical" wound-rotor slip recovery system, but the advantages of the offered device compensate this disadvantage.

References:

1. Onishchenko G.B. and others (under reduction of Onishchenko G.B.). Automatic electric drive of full-scale plants. – M.: RAAS – 2001. – p. 520.

2. Bystrov A.M., Shepelin V.F. Switching modes of wound-rotor slip recovery system thyristors with two-region rate control. "Electricity", 1971, N7, pp. 31-42.

3. Patent № 2314636 of RF. Wound-rotor slip recovery system. Magazinnik L.T. Published 10.01.2008. Bulletin № 1, priority 17.10.2006.

WELDING CURRENT THYRISTOR SWITCHES FOR CONTACT WELDING

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The duration of spot and seam welding fluctuates from several seconds to centiseconds, and the number of switching the welding transformer on and off can reach several thousands for one working shift. For such switching frequency the power contactors turn out to be unfit on their mechanical strength, and their own action time proves to be more than that necessary for one unit point welding. The requirements of practical non-persistence and high switching frequency were met by ignitron current switches, but they are of considerable gabarits, poor efficiency and need water cooling. So, it is advisable to use a thyristor commutation switch in the primary coil circuit of the welding transformer feeding the load. The use of the transformer load thyristor commutation switch has its own features, and the optimization of such controlling systems for the purpose of their work reliability enhancement is topical.

It is known that the cutting a transformer into mains is attended with magnetizing current inrush, the amount of which reaches a tenfold value from the current rating. For the minimization or virtual elimination of the current rush at the moment of the transformer switching on the thyristor commutation switch controlling system is synchronized with the feeder line, and the on-off trigger included in this system in the known devices [1] provides "remembering" the sign (plus or minus) of the last current half-period. The next switching on the transformer is possible only in the half-period reversed in sign. Thus, through the transformer an even number of current half-periods passes, and magnetic biasing of the transformer is excluded. The controlling system synchronization with mains guarantees also an optimal start switching angle of the thyristor commutation switch.

The analogous thyristor commutation switches controlling systems are used in developments of recent years [2]. Particularly, in the FORWEL firm catalogue, 2004, pp.1-6, there is a resistance (i.e. contact) welding machine control system given, the simplified functional scheme of which is given in Fig.1.

A disadvantage of the abovementioned controlling systems is the memory loss by the on-off trigger at the loss of voltage in mains owing to accidental or operational cutting off and, as a consequence, the magnetizing current inrush possibility, when the device is cut into mains after the interval in feeding.

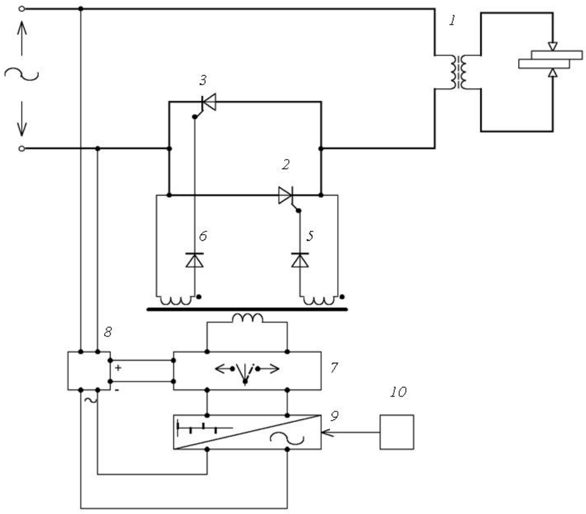

Fig.1. 1 – single-phase power transformer; 2,3 – thyristors; 4 – pulsing transformer; 5,6 – diodes; 7 – on-off trigger; 8 – power box; 9 – pulse-phase controlling system; 10 – automatic control system.

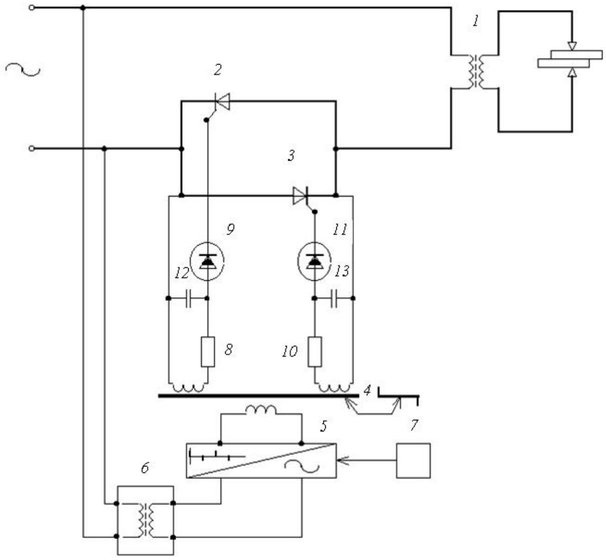

Fig. 2. 1 – welding transformer; 2,3 – thyristors; 4 – pulsing transformer; 5 – pulse-phase controlling system; 6 – power box; 7 – automatic control system; 8,10 –resistors; 9,11 – dynistors; 12,13 –capacitors.

A new thyristor commutation switch controlling system enabling to eliminate this significant disadvantage is offered [3].

The system represented in Fig. 2 functions as follows.

When cutting the device into the supply main through the power block 6 the voltage (with the corresponding transformer ratio) converted into the sequence of heteropolar pulses (the diagram of the pulsing transformer magnetic reversal – the change of its voltage U in the function wt and induction B in the function of ampere-winding iW of the pulsing transformer wind are represented in Fig. 3) is given to the system of pulse-phase control 5. The necessary start angle of these impulses' lagging is provided by the automatic control system 7, as in all known devices of analogous destination. The very first pulse, depending on its polarity, switches one of the thyristors on, for example, thyristor 2. Simultaneously with that the pulsing transformer 4 is transferred by this pulse into the saturation mode, for example, into the point 1 in Fig.3. After the impulse loss the transformer core remains magnetized in the point 2, i.e. remains unsaturated due to the rectangularity of the hysteresis loop. This state will be retained by the pulsing transformer by the opposite polarity pulse arrival, which will transmagnetize the transformer core into the point 3 and at the same time will switch the thyristor 3 on, and the transformer core will remain magnetized in the point 4. At the voltage loss in the supply main the pulsing transformer core will retain the final pulse magnetic moment density as long as desired, so, at the voltage recovery the pulse with the polarity opposite to the last pulse before the mains cutting off only can be first to pass on the thyristors. In other words, if the thyristor 2 (Fig. 2) was switched on the last, then after the voltage recovery the thyristor 3 only can be the first to switch on in any random time interval. Thus, an even number of current half-periods will always pass through the transformer 1 (Fig. 2) as well, i.e. it will be transmagnetized on the symmetrical hysteresis loop, whatever the cutting-off intervals could be.

Therefore, even a short-run magnetizing of the power (in the considered example welding) transformer is excluded and the magnetizing current inrushes after time gaps in power supply of the device are excluded as well.

As the hysteresis loop rectangularity of the known ferromagnetic cores is not ideal, the passage from the saturation point to the remanent magnetization point (Fig. 3) is attended by a little induction drop ΔB and, therefore, a short duration interference pulse in the pulsing transformer winds, which is able to switch on "falsely" one of the thyristors of the commutation switch. Not to miss the interference pulse on the thyristor control input, there are the abovementioned interference-suppressing networks: at the occurrence of such a "false" pulse, it is shunted by the capacitors 12 and 13. Due to the little induction drop ΔB (Fig. 3) the "false" pulse voltage integral is negligible and the voltage value (amplitude) of these pulses is little and insufficient to changeover the dynistors 9 and 11 into the conducting state. It excludes the "false" switching the commutation switch thyristors on. At the same time the "working" pulses have a large enough width required by the load. The devices providing the necessary width of the working pulses are widely known, come with the system of pulse-phase control and are not given in Fig. 2 for the sake of simplicity.

Finally, it should be noted that the offered controlling system not only excludes magnetizing current inrushes after intermittent electrical power, but renders possible to somehow simplify the scheme by eliminating the on-off “memory” trigger from it.

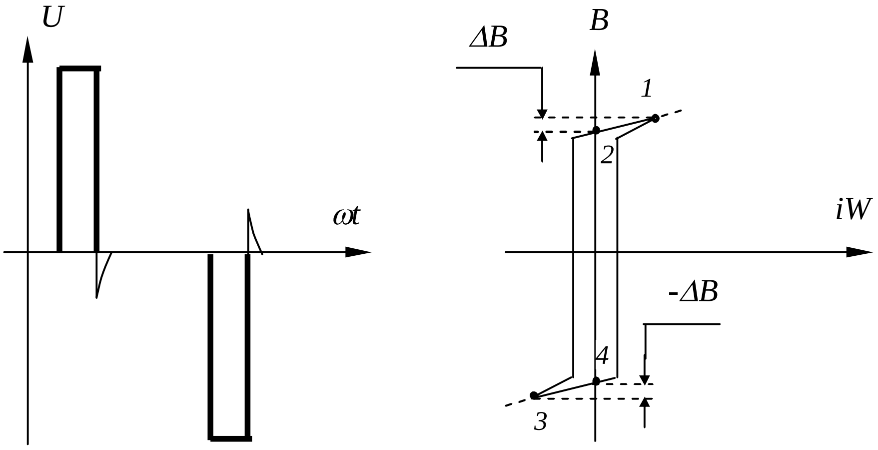

Fig. 3. Diagrams of pulsing transformer transmagnetizing

References:

1. Glebov L.V. and others. Computation and construction of contact welding machines. Energoizdat, Leningrad, 1981, p.424, Fig. 8-4, 8-5.

2. FORWEL firm catalogue (2004), p. 1, section 6 - Resistance Welding Control. Fig. 1.

3. Thyristor commutation switch of transformer load. Patent of RF № 2281604. Published БИ № 22 from 10.08.2006, priority 26.04.2005, author Magazinnik L.T.