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.

$$E_{\text{max}} \approx 1.35U_a \cdot \cos \beta \approx 1.27U_a,$$  \hspace{1cm} (1)

wherein \(U_a\) – is the line voltage of the supply main, \(1.35\) – the coefficient for the three-phase bridge, \(\cos \beta = \cos 20^0 = 0.94\). 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 \(U_{\text{in}} > 0\) 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:
A new thyristor commutation switch control-
ling system enabling to eliminate this significant dis-
advantage 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 corre-
sponding transformer ratio) converted into the se-
quence of heteropolar pulses (the diagram of the pul-
sing transformer magnetic reversal – the change of its
voltage $U$ in the function $t$ and induction $B$ in the
function of ampere-winding $iW$ of the pulsing trans-
former 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 re-
 mains magnetized in the point 2, i.e. remains unsatu-
rated 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 trans-
 magnetize 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) trans-
former is excluded and the magnetizing current in-
rushes 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 magnetiza-
tion point (Fig. 3) is attended by a little induction drop
$\Delta B$ 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 com-
mutation switch. Not to miss the interference pulse on
the thyristor control input, there are the abovemention-
ed interference-suppressing networks: at the oc-
currence of such a “false” pulse, it is shunted by the
capacitors 12 and 13. Due to the little induction drop
$\Delta B$ (Fig. 3) the “false” pulse voltage integral is negli-
gible and the voltage value (amplitude) of these
pulses is little and insufficient to changeover the
dynistors 9 and 11 into the conducting state. It ex-
cludes 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.