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TRANSIENTS OF SERIES AND PARALLEL CONNECTED THYRISTORS OF A HIGH-VOLTAGE ELECTRIC DRIVE «TVS-AM»

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Abstract
This article shows the functions of efficient use of small-power thyristors in the operation of large-power asynchronous motors. There are no large voltage-driven thyristors for starting large-capacity asynchronous motors with the help of thyristors. This article shows solutions for the use of small capacity thyristors with serial and parallel connections . Opening the contacts of the thyristors connected to the serial and parallel must take place simultaneously. When the thyristors are connected in series and parallel, the transitory processes observed in them are indicated. Depending on the type of load, the transient processes in the thyristors are different. According to him, if the load is inductive, the current decreases and the voltage increases, if the load is capacitive, the current increases and the voltage decreases, and if the load is active, the current and the voltage values remain unchanged.
Keywords:thyristor, microprocessor, memory, low power of electric motors,medium powerful electric motors, large power, asynchronous short-circuit rotor motor, cooling system, active loading, inductive loading, capacitance loading, current, voltage, start-up time, startup device, startup current, dynamic torque, static torque, series thyristors,parallel thyristors,working modes, volt-Ampere characteristics.

1. Introduction

Transients of direct start-up of AD are accompanied by large surges of currents of stator and rotor windings. This is facilitated by a combination of electromagnetic and mechanical transients in an asynchronous electric drive. In some cases, due to the lack of need to study the effect of high currents of the motor windings on the processes occurring in an Electromechanical energy Converter, in such engines as small and medium-power AD, the influence of electromagnetic transients is not taken into account, since the starting process in them lasts several seconds. However, their research in the field of asynchronous machines is devoted to small and medium-power electric drives. Start-up of AD with high-capacity TVS is not considered, since powerful converters are not produced by the industry. In addition, direct start-up of asynchronous motors is accompanied by stator winding currents 4-7 times higher than the rated currents, which causes frequent failure of the TVS elements. When starting small and medium-power asynchronous motors, a thyristor voltage Converter (TVS-AM) is used. There is a problem of application for large powerful electric motors, devices with a thyristor voltage Converter. Large powerful asynchronous electric motors in mining enterprises and thermal power plants are started directly by connecting to the network. Currently, there are types of thyristors for current up to 800 A, and for voltage up to 2.8 kV [7-p28]. There are no powerful thyristors for starting large-capacity electric motors. Due to the lack of thyristors designed for high voltages and high currents, this article discusses the transients of series-connected low-voltage thyristors and parallel-connected low-current thyristors for starting.

According to the second Kirchhoff law, the instantaneous value of the phase voltage U_F of the stator winding in the AD start mode can be written as the sum of the voltage drops in each series-connected thyristor

$$U_F = U_1 + U_2 + \dots U_N \quad (1)$$

There $U_1 + U_2 + \dots U_N$- voltage drops in 1, 2,... N-thyristor.

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2. The degradation of the marineandcoastalecosystems

The use of serial connection of thyristors will be effective if the problem of uniform distribution of reverse and forward voltages in static and dynamic modes is successfully solved. If the values of reverse currents and leakage currents, the values of direct voltage in the conducting state, p-n junction capacitances, the delay time of switching on and off of individual devices are scattered, the condition of thyristor connection efficiency is not met. Therefore, when connecting in series, measures must be taken to ensure uniform voltage division[2.35 p].

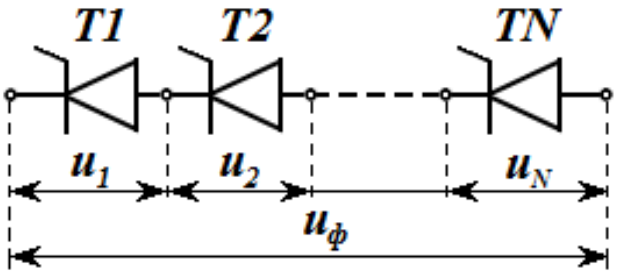

FIGURE1. Serial connection of thyristors

In the literature on electronics [1-p50], it is noted that to equalize the voltage, it is necessary to select thyristors of the same class with similar values of reverse currents and leakage currents. If it is not possible to select thyristors of the same class in practice, then you need to install special control schemes for thyristors. For a particular choice of path for equalizing the voltage of series-connected thyristors high voltage ESRD first, we consider transients include one thyristor, then the transitional processes enable groups of two or more series-connected thyristor. After that, we will make a final conclusion on the choice of the stress equalization method.

Switching on the thyristor begins with the supply of a current pulse to its control electrode. Since the control current of the IU no longer affects its operation after one valve is unlocked, short-term pulses (several hundred microseconds) are used to control the thyristor. For clear switching on, the control current pulse must have sufficient steepness S = 1-5 A/mks. Time diagrams of electromagnetic processes when the thyristor is switched on are shown in Fig. 1.

After analyzing the inclusion of a single thyristor, we consider the transients of inclusion of a group of two (Fig.2.) sequentially connected thyristors.

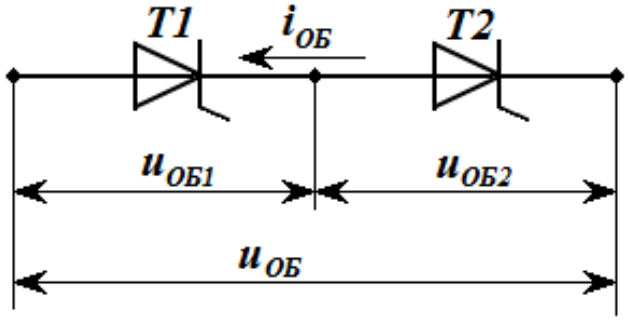

FIGURE 2. reverse voltage Distribution
when the thyristor is switched on sequentially

Still, we will assume that the thyristor activation begins with a short-term control pulse. After it is fed, the thyristors must be unlocked and pass the mode, with a duration of time . This will continue if control pulses are applied to all series-connected thyristors simultaneously, for a time duration equal to 0 (zero) microseconds [1,13 185 pp].

Otherwise, if one thyristor receives a control pulse at least 1 MS late, the electrical circuit will be opened, no current will flow through them in the forward direction, and the process of initial injection of electrons from the emitter region of the thyristors will not begin.

Thus, in contrast to the operation of a single thyristor, for the operation of a sequentially connected thyristor group, one of the main requirements follows, which is formulated by the following expression. In a series-connected group of thyristors, the control signal to all thyristors in the group must be received simultaneously (with zero delay), and the duration of the thyristor control pulse must be longer than the delay time.

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Due to the technological variation of the volt-ampere characteristics (VAC) when connected in series, individual thyristors are overloaded with voltage. When thyristors T1 and T2 are connected in series (Fig. 2), which have a spread of reverse branches of the VAC (Fig. 3), when the reverse voltage is applied, the total reverse current flows through the thyristor circuit[6,8] .

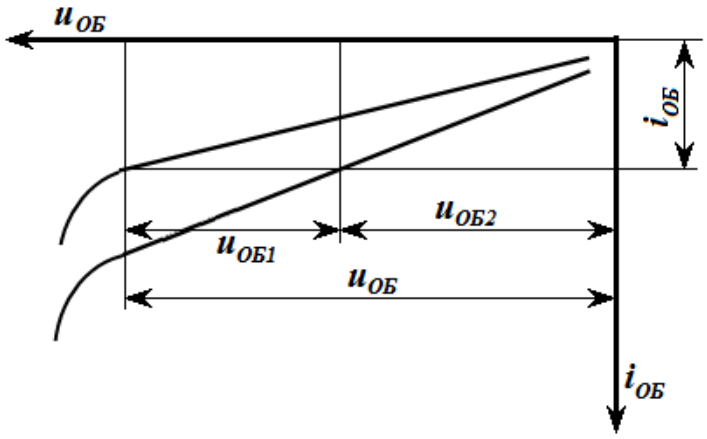

FIGURE 3. Graphs of uneven distribution
reverse voltage

The T1 thyristor with a flatter reverse characteristic has a large share of the total reverse voltage, equal to . The increase in dispersion characteristics degrade the performance of the thyristors of the group join.

The operating conditions are even worse in dynamic modes of direct voltage application, because of the spread of the recovery time of the locking ability, the full voltage of the entire circuit can be applied to the thyristor with less time, and the thyristor can spontaneously turn on.

To ensure reliable operation of thyristors when they are connected in groups, measures should usually be applied to evenly distribute the current when connected in series.

Active-capacitive dividers (RC-chains) or capacitive dividers (C), combined dividers with thyristors (RCD-chains) are used as leveling devices in dynamic modes (Fig. 4).

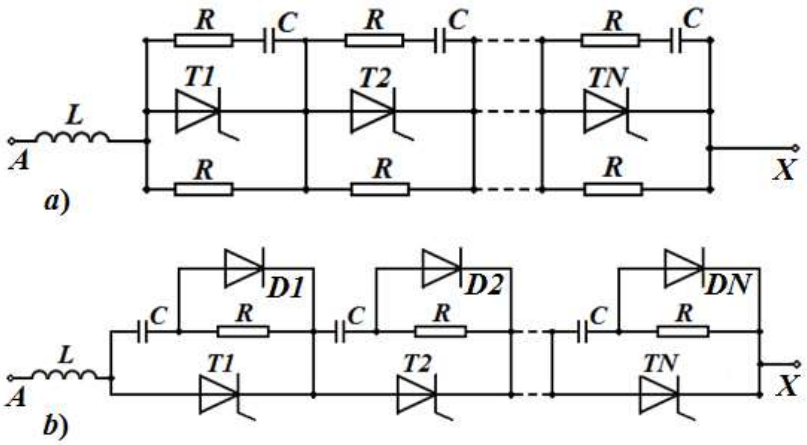

FIGURE4. Scheme of series connected thyristors,
with voltage equalization in dynamic mode

The use of active dividers R is accompanied by a loss of energy, the value of which increases with a decrease in the resistance of the resistors. Therefore, they strive to install resistors with the maximum possible resistance, at which the

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voltage spread does not exceed the permissible limits. In a serial circuit, the highest voltage is perceived by the device with the highest internal resistance. Its reverse current or leakage current is the smallest[1,10].

3. Methodology

When the thyristors are switched on in series with the capacitors,a low-resistance (approximately several tens of Ohms) resistor is switched on (Fig. 4, a). The resistor is used to limit the discharge current of the capacitor through the switched-on thyristor. For thyristors, an RCD circuit is used, which provides uniform division of the reverse voltage as an RC circuit, and the direct voltage as a capacitive divider (Fig. 4, b). This circuit, in addition to the divisor functions, reduces the speed of direct voltage application [12,6 210 p]. If to start the AD with a high-power short-circuited rotor, use a TVS with two or more thyristors connected in parallel (Fig. 5), then a large starting current AM[4,11].

$$I_{Star} = (5 \div 8)I_N$$

will be distributed between these thyristors. In this case, each thyristor will be loaded with a part of the inrush current, which is significantly less than the permissible for this type of thyristor

$$I = \frac{I_П}{N}, \quad (2)$$

where is the N number of parallel thyristors.

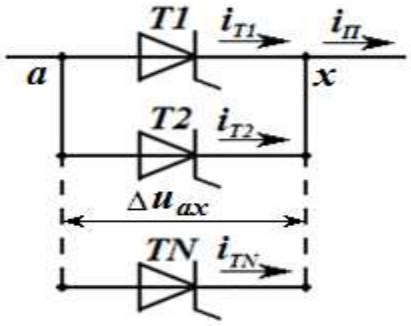
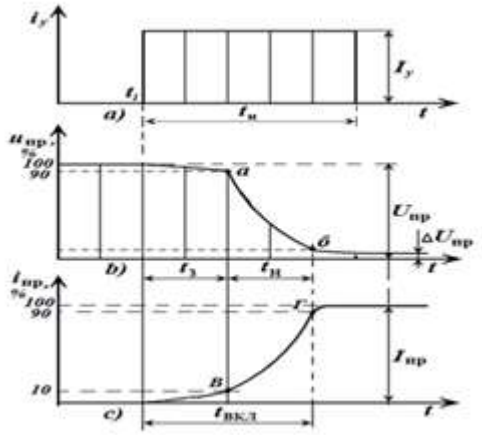


FIGURE 5. Parallel connection of thyristors (a) and their VAC (b)

We will analyze the dynamic process of switching on a group of parallel connected thyristors TPN at direct start of high-voltage AD of high power.

If at a time t_1 (Fig.6) a control signal is applied to the control electrode of the thyristor T1 (Fig.5), then during the time it is switched on and the full starting current AD begins to flow through the thyristor T1[5,9].



The scientific and practical significance of the research results is as follows:

- in the introduction of microprocessor control, the development of mathematical models of transient starting modes of the electric fan drive and pump of the boiler plant, on the basis of which recommendations were developed to improve the conditions for starting asynchronous motors;

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- in the development of a method for smooth start-up of a high-voltage asynchronous motor of high power using a thyristor voltage Converter consisting of series and parallel connected thyristor groups that allow increasing the voltage and power of the TVS;
- in the development of methods and means for simultaneous unlocking of thyristors in thyristor groups of TVS, allowing reliable operation of the electric drive;
- development of a mathematical model for the microprocessor control system of a high-voltage device TVS -AM of high power for conducting a computational experiment;
- in the development of an experimental installation-a physical model of the microprocessor control system for launching the TVS -AM.

In contrast to the recommendations of the course "Fundamentals of electronics" about the minimum duration of the control pulse, for a group of thyristors of the "TVS-AM" system, the duration of the thyristor control pulses should be longer than the delay time for these thyristors. It is necessary to exclude the start HELL with UCC or, take him out of this circuit [3,14].

4. Finding

Based on the performed theoretical and experimental studies, an actual scientific and technical task was solved for the research and development of the system "thyristor voltage Converter - asynchronous motor" with the use of microprocessor control based on a high-voltage asynchronous electric drive of high power, providing a smooth start with adjustable current limitation, characterized by improved performance indicators.

The main scientific and practical results of the dissertation work are summarized as follows:

1. Based on the analysis of technological processes, the use of electric drives of the discharge pump and suction fan of TPP boilers, dynamic modes AND other technological devices, the necessity of introducing modern methods of smooth start-up of high-voltage asynchronous motors of high power with improved TPN with combined groups of sequentially and parallel connected thyristors is proved.

2.It is Proved that a necessary condition for the operation of a group of thyristors as part of a TPN that feeds a high-voltage high-power AD with its multiple (from the nominal) starting current is to ensure simultaneous unlocking of all thyristors of the corresponding group without exception.

3. In contrast to the recommendations for unlocking single thyristors on the sufficiency of the minimum duration of the control pulse for a group of thyristors of the "TPN-AD" system, it is proved that the duration of the thyristor control pulses should be at least the switching time for this thyristor.

4. It is revealed that with increasing duration time of thyristors and reliable switching of the FLC, it is necessary to ensure the regime of the blood pressure with an active-inductive load, what not to-to allow the inclusion of capacitive reactive power compensator in the circuit between ESRD and HELL.

5. Conclusion

The method of controlled microprocessor start-up of a high-voltage asynchronous short-circuited motor with a high-power TPN, consisting of a combination of connected tiri-stor groups, is Proposed. A refined mathematical model of microprocessor control of the transient process of starting the system "Thyristor voltage Converter-asynchronous motor" of the boiler feed pump and the fan for carbon dioxide intake of thermal power plants was Obtained. A computational experiment was Conducted on a mathematical model of the TPN-AD microprocessor control system, which showed the adequacy of the proposed solutions. A simulation model of TPN-AD was Developed and experimental studies were conducted on the model, which confirmed the theoretical assumptions of the research work.

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