Development and research of non-contact starting devices for electric consumers and motors

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Abstract. This article presents the analysed information about power consumers and electric motor starters in order to ensure the reliable operation of the power supply system, which is relevant today. Disadvantages of contact starters used for small power electric motors in the power supply system and advantages of non-contact starters are given. In addition, it is based on the creation of additional opportunities when using this device, that is, it creates opportunities for protection and automatic control. Contactless starters are recommended for some heavy-duty electric motors. The article describes these cases in details.

1 Introduction

Nowadays, in addition to the increase in the type of electric consumers, there is also an increasing demand for starting devices that can reliably connect them to the network. In order to ensure the reliable operation of the power supply system and to eliminate defects in contact devices, it is advisable to use starters that can eliminate new types of defects.

These starters allow reliable connection and disconnection of small power consumers and electric motors. It is advisable to use single-phase and three-phase consumers in places where there is a risk of fire, as a device for starting electric motors in the oil and gas processing industry, mining industry and residential buildings. These starters eliminate excessive noise and sparking (arcing) that occurs in contact systems.

Below are the advantages, disadvantages and special features of using this starter instead of a contact starter.

2 The current state of the investigated problem

Today, contact starters are used to start electrical devices and motors. In particular, these starting devices are used in the oil and gas industry. Examples of contact starting devices: automatic circuit breakers, magnetic starters, contactors, and electromagnetic relays [1]. In the contact part of these starting devices, during overloading and many times when reconnecting, the contacts are destroyed by the electric arc and are welded to each other. In turn, it can cause a fire hazard. Raw materials processed in the oil and gas industry and mining industry are often considered to be highly flammable products. Their processing technologies and electric drives used in the transportation of rocks cannot be imagined without launching devices. Contact parts of contact starters also have some requirements, but in the process of disconnecting many times, the contacts begin to lose their characteristics slowly [2]. In the experiment, we can see that during the operation of the magnetic starters, due to defects in their contacts, the circuit is not completely disconnected, which causes the electrical device to be under voltage. This can endanger the lives of service personnel. During the operation of contact starters, especially during start-up and cut-off, the moving mechanisms cause a certain amount of noise. As an example, we can consider the operation of elevators installed in high-rise residential buildings. Many contact actuation and control systems installed in control cabinets generate noise during elevator movement. This noise causes inconvenience to the apartments located near the control cabinet. One-speed or two-speed types of elevator electric drives are also very common. Two-speed elevator electric drives allow people in the elevator cabin to move without feeling overloaded and reduce the time it takes to get to their floor [3]. But a two-speed elevator requires more contact starters than a single-speed start when starting electric drives. In this

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case, their working sequence increases and increases the amount of noise. Reducing the amount of these noises is one of the current problems [4, 5].

Contact starters consume significantly more power through their electromagnet during start-up than the power consumption in normal operation. We can also see this in Table 1 below.

The amount of noise in the enterprise increases due to the fact that electrical devices used in automated production enterprises work in different operating modes and are connected and disconnected many times in different situations. Some electrical consumers need to be disconnected from the network many times. It is impossible to perform these actions with contact starters, because they are limited to a certain number of disconnections [6].

For frequent disconnection, connection and disconnection times should be very short.

Table 1. Operation of magnetic starters and power consumption during start-up and start-up time.

Current rating of magnetic starters.	1	2	3	4	5	6
Power consumption of magnetic starter coils after starting W	68	87	200	280	350	530
Power consumption of magnetic starter coils after starting W	8	8,6	20	40	45	60
Start-up time of magnetic starters, ms	17	22	25	20	20	25

In the case of contact starters, they are made in 4 different versions.

1. Without inertia (0.001 s);
2. Fast-acting (0.001 ÷ 0.05 s);
3. Normal (0.05 ÷ 0.15 s);
4. Slow down (0.15 ÷ 9 s). [7,8].

To overcome the above shortcomings, it requires the development of single-phase and three-phase non-contact starting devices. Internet materials and educational literature were analyzed in preparation of these launchers. When analyzing the working principles and circuits of single-phase and three-phase starting devices, some shortcomings were noticed. For example, single-phase starters use only one non-contact starter unit. Such a starting device always requires the detection of phase and neutral conductors and the connection of a contactless starting device to a fixed phase conductor[9,10]. Always complying with this requirement will cause additional inconvenience to users. If the demand is not met, the consumer disconnects the neutral conductor from the network, and the phase pole remains connected to the consumer. In the starter that we offer, a non-contact starter unit is installed on both the phase and neutral conductors. Polarity reversal does not cause any defects. In any connection, the starting device can perform the operation of connecting and disconnecting the phase and neutral poles. [11, 12].

3. Single-phase and three-phase contactless starting device.

Currently, devices based on semiconductor elements (thyristor and triac) and various hybrid modules based on these elements are used to start and stop uncontrolled electric motors operating in alternating current. Their use shows a steady trend of transition from the usual contact switching of the stator circuits of asynchronous electric motors to non-contact starting devices in a number of drives. Non-contact starting devices are mainly made on the basis of semi-conductor elements and used in various circuits [13, 14]. Thyristors and triacs are mainly used to adjust the load current. When thyristors are used, an opposite-parallel circuit is used to connect and disconnect single-phase circuits. Two thyristors are used for each phase [15, 16].

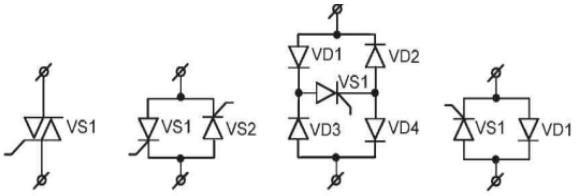

Fig. 1. Non-contact starters are semi-conductor elements of the power circuit

Three-phase starters use six thyristors. When using a circuit breaker, the elements are reduced by half, one for each phase. Basically, thyristor and triac control electrodes are provided by the phase currents to which they are connected. Only the voltage of this supply circuit and the current flowing through the circuit should be adjusted to the required value of the thyristor control electrode. For this purpose, circuits use resistance and semiconductor diodes that correct the type of current [17, 18]. In the scheme we propose, the current of the control circuit is taken from the phase, and only it is controlled by the microcontroller whether it is supplied to the control electrode or not. At startup, the microcontroller provides the required voltage to the optocoupler. In this case, the optocoupler opens and connects the necessary current circuit to the thyristor control electrode. The thyristor opens and disconnects from the consumer network. If the consumer needs to be disconnected from the network, a shutdown signal is given to the microcontroller. Then the microcontroller stops the voltage supplied to the optocoupler. The optocoupler stops working, which in turn cuts off the control circuit. The control circuit to the thyristor is cut

off using an optocoupler, and the current supplied to the thyristor control circuit is stopped. The thyristor also separates the consumer from the network [19, 20].

Three-phase non-contact starters work similarly to single-phase non-contact starters. In this case, it is necessary to install three single-phase starting blocks for each phase. The block includes a thyristor or triac, an optocoupler, a voltage-reducing resistor, and a rectifying diode [21, 22]. The microcontroller device is common for all three phases. In a microcontroller device, the number of input and output ports differs from each other. The microcontroller we offer has 14 digital 6 analog input-output ports, with the help of which we can assemble a starting circuit that allows starting and reversing single-phase and three-phase electric motors, starting and reversing two-speed elevator electric motors [23].

4 Conclusion

In conclusion, we can say that contactless starting devices are required to be installed for electric motors and consumers used in a certain difficult operating mode. They eliminate dangerous situations and excessive noise. In addition, it can be used instead of a contactor in the set of reactive power compensators used in industrial enterprises. For smooth adjustment of reactive power, capacitor banks of different values of reactive power are connected and disconnected from the network in a certain logical sequence. In this case, the amount of reactive power can increase and decrease smoothly. Several contactors are used for this. Connecting and disconnecting them many times increases this risk in environments with high noise and fire sources. Therefore, single-phase and three-phase starters can overcome these shortcomings. It allows for easy automation of modern power system devices. It is also possible to create the possibility of starting by a remote control system with a microcontroller contactless starting device.

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