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Development of fast-speed vacuump breaker drive with voltage of 6-10kV

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Abstract

In this article questions of creation of fast-speed vacuum breaker drive are considered. Relevance of works in this sphere is conditioned by the issues, connected with fast picking up of rotating motors at oil pumping stations. This drive, being a part of vacuum breaker, may be used in networks of 6-10 kV class. We have suggested new principle of realization of drive in assembly of vacuum breaker, which has less make-time and costs less in comparison with analogues. Electromagnetic calculations have been performed for drive model, which showed actuation time of 15.2 ms.

Key words: electric networks, fast-speed drive, model, vacuum breaker.

Introduction.

Oil pumping stations are designed for continuous pumping of oil products in mail oil pump lines. Main equipment of electric supply systems of OPS is represented by electric motors of 6-10 kV. Reliability of work of electric motors mainly determines reliability of work of the whole OPS.

Electric supply systems of OPS are built according to the following scheme: two feeding transformers, distribution gear with two sections of bus bars and bas section breaker with automatic transfer equipment (ATE), installed between sections. Factory installed ATE equipment has the character, which often leads to shutdown of electric motors in emergency situations at the input. This has a negative impact on reliability og electric motors and commutation equipment of distribution gear (DG) of OPS.

Creation of high voltage breaker with fast-speed drive will allow quickly picking up running out electric motor onto reserve network without significant current rush (for this it is necessary to perform switching on more slowly than within 30 ms, Figure 1 [presentation of PROMIR company, "High-speed automatic switch" complex]). This gives an offset in resources of drive and commutation equipment. This decision also may be applied at gas pumping stations and for similar consumers, where fast switching to reserve is important.

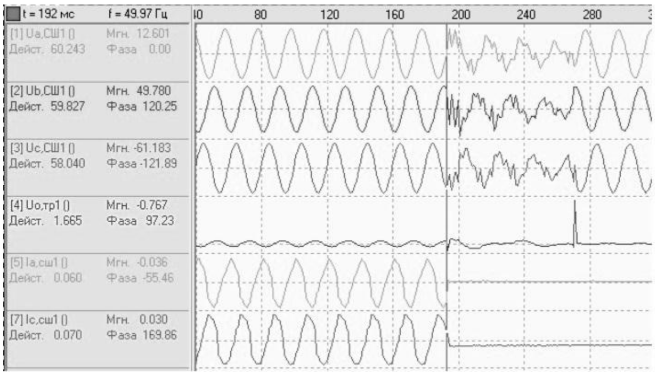

Figure 1. Oscillogram of currencies and voltages at disconnection from the main input.

Currently significant market segment of medium voltage switches is occupied with vacuum breakers. Make-time of such switchers is usually not higher than 30-50 ms.

Nominal voltage, kV	6, 10
Nominal current, A	630-3150
Closing time, s, maximum - ВБЭ-10-20/630-1600 - ВБЭ-10-31,5(40)/2000-3150 - ВБ-10-20(31,5)/630-1600У2 - ВБПП-10-20/1250 У2 - ВБЭМ-10-20/1000 Evolis 7P1-1250 VD4/P 12.16.25 BB/TEL-10-12.5(20)/1000	 0,100 0,100 0,050-0,070 0,050-0,060 0,150 0,065 0,050-0,070 0,090

Closing time values of the breakers

According to construction of drive such switchers may be classified as switchers: with spring-motor mechanism and mechanical latch; with electromagnetic drive and mechanical latch; with polarized bistable drive with latch based on high-coercivity permanent magnet.

Development of the drive.

Main elements of construction of the latter ones are represented by magnet system on non-magnet base, high-coercivity permanent magnets and forced coils that work in short-time duty. Magnetic coils are located under voltage for tens of milliseconds, without having time to be warmed up, that's why their sizes may be small. In limiting conditions of drive's moving part the system doesn't consume energy from electric circuit, and forced mode allows reaching fast response time of configuration change, while sizes of electrical magnet are mainly defined by saturation induction of magnetic core, but not by the coil.

The main parameter of switcher is fast response time, i.e., time from injecting signal for turning on/off before closing/opening time of main contacts of vacuum breaker. This is defined by the mass of moving part of drive plus friction in moving part and electromagnetic forces of coils and permanent magnets. Moving part is fixed in two bilateral positions with maximal magnetic force, provided by magnetic flow of permanent magnet. This allows fixing contacts' position of the breaker in open or closed positions with required contraction force. Such mechanism is called magnetic latch. In startup moment latch's fixation force should be overcome and then all movable mass should be accelerated. This is performed at the account of current build-up of necessary direction in coils. Time for current change in coils represents significant period of switching time.

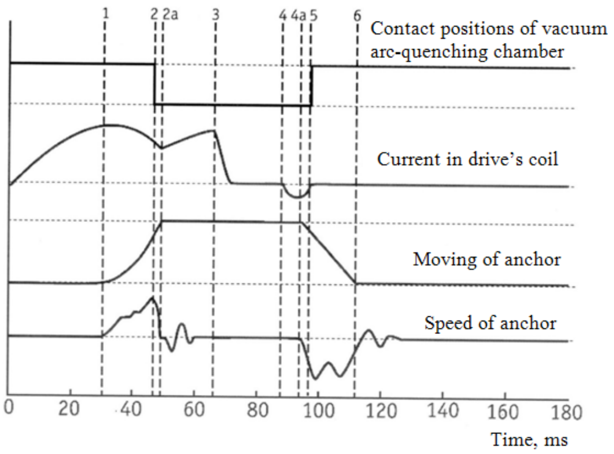

Figure 2. Standard oscillogram of turning on/off of vacuum breaker.

As it follows from the abovementioned, for obtaining maximal fast response it is necessary to lighten moving parts of the whole mechanism to the extent possible, as well as to minimize the time of current build-up in the coils while keeping the force of magnetic flow. This is made possible when reserved energy is used in powerful permanent magnets not only for creation of magnetic latch, but also for obtainment of driving force. It is required that coils work not for creation of main magnetic flow, but for its redistribution. Magnetization in magnetic circuit is created at the account of permanent magnets. Thanks to magnet flow of permanent magnets, iron of magnetic circuit is in condition of low magnetic penetration, drastically curtailing current rise time and current fall time in the coils. By varying geometrics of magnetic circuit's elements, we obtain needed values of powers and movement times of moving marts of the mechanism.

In the model presented we have also performed comparative calculations of various materials of magnetic core and its geometric parameters. Models with various parameters of coils (spooling diameter, wire diameter, number of turnings, current in coils) of have been built. We have also considered various geometric forms of anchor, clearances between anchor and magnetic circuit for enhancement of construction's work. Modeling of drive is not limited by performance of statistical calculations of magnetic circuits. The most informative are dynamic calculations of construction's models, which are based upon electromagnetic field equations inhomogeneous, non-linear medium, equations of nonlinear electric circuit and equations of motion. We have performed calculations of transition processes that appear when voltage is applied to pilot coils, time of transition process as a part of common time of make-time, the moment of voltage disconnection and speed and time at each point of anchor's movement. Using Elcut program, the processes of fast speed drive were modeled, which showed possibility of reaching 15 ms as a value for closing time.

Conclusion. Fast-speed drive that is being developed would allow switching to reserve network in a short time, which would allow avoiding running out of electric motor, and, thus increase service life time. The authors have developed principal construction, have investigated materials that fit best for this task, have analyzed models of transition processes in magnetic and electric circuits, which prove the possibility of task's implementation. Modeling of drive in Elcut program has shown that action time equals 15 ms, which is quite sufficient.

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