ние разных газовых сред дугогашения постоянного тока, где сам процесс удается обеспечить с большим быстродействием и без негативного воздействия на окружающую среду. Для этого сделан лабораторный стенд трехполюсного выключателя, одна из камер которого изменена так, чтобы ее можно было заполнять разным газом. На стенде исследованы переходные процессы дугогашения в оксигидрогенной смеси с разным объемным соотношением водорода и кислорода.

Полученные данные сравнены с результатами аналогичных испытаний гашения дуги в вакуумной камере. Оказалось, что в среде оксигидрогена время гашения дуги меньше, чем в вакууме. Вместе с тем, однако, зафиксированные показатели перенапряжения больше, а время восстановления диэлектрической прочности оксигидрогенной смеси в четыре раза длиннее, чем вакуума, что требует дополнительной проверки и продолжения экспериментов.

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INVESTIGATION OF ARC-STILLING PROCESSES IN OXYHYDROGEN ENVIRONMENT

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ABSTRACT

This article presents the results of research of arc-stilling processes in oxyhydrogen environment under laboratory conditions. The transient states in admixture with a different volume ratio of hydrogen and oxygen were studied; obtained data were compared with the results of similar tests in a vacuum chamber. To perform research, program laboratory bench was used, which was designed and created by a team of teachers and students of Todor Kableshkov University of Transport.

ENGLISH SUMMARY

Background.

One of the main problems in the field of energy and electric vehicles is the development of rectifiers with high speed. Among the parameters that affect the performance exists arc suppression environment, where there are poles of the rectifier. In modern devices, separate hermetic arc-interruption chamber is used, and in recent years mainly two types of rectifiers are being developed- electrogas and vacuum [1,3,5].

In electrogas rectifiers [5,6] arc control devices operate in the environment of «electrotechnical gas», sulfur hexafluoride. Their disadvantage is the decomposition products of sulfur hexafluoride – inert gases which do not appear in the atmosphere. Although they are not themselves toxic, they are easily hydrolysed by reacting with moisture to form hydrofluoric acid and sulfur dioxide. Therefore, to absorb them, the gas-insulated circuit breakers are equipped with filters capable to neutralize both gaseous decomposition products, and moisture.

Vacuum circuit breakers use another kind of environment in the arc- interruption chamber – vacuum [2,4,5]. Their advantages are: full explosion and fire safety, the ability to implement any turn-off mode, high switching resource, and high mechanical and electrodynamic resistance in commutation in normal and emergency modes, no negative impact on the environment. The disadvantages are: high prime cost, loss of turn-off function due to an accident in the vacuum arc-interruption chamber, a strong dependence on the quality of the contact communication, inapplicability at high voltages, and the occurrence of overvoltage [5].

Objective.

The aim of the author is to show results obtained in the research with the use of laboratory bench.

Methods.

The question arose whether it is possible to create DC and AC circuit breaker with high speed of arc suppression in comparison to existing technical solutions and without any negative impact on the environment. The team of Todor Kableshkov University of Transport created a laboratory bench for the study of transient state by arcing DC and AC voltage. Arc suppression in oxyhydrogen mixture was studied and interesting results were obtained, which are introduced in this article.

Results.

Description of a modified circuit breaker

The basis of the laboratory bench was a three-pole vacuum circuit breaker (10 kV/300A). By replacing one of the arc-interruption chambers with an airproof one, made of electric insulating material (Pic. 1), which withstands the absolute pressure of 20 Pa to 1000 kPa, modified phase of a circuit breaker was obtained (Pic. 2).

Each chamber is furnished with two pole contacts of a material with high electrical conductivity. One of them is stationary, fixed to the body of a corresponding chamber and is electrically connected to the upper

current terminal, and another contact is movable, attached to the rod of insulating material for contact motion transmission and is electrically connected to the lower current terminal of the chamber.

Magnetic valves are mounted in a modified chamber of the circuit breaker by tappings and gas lines.

The device has a gas generator (electrolytic cell) for generating and delivering oxyhydrogen mixture. It has identical sections, each of them consists of a body, electrodes, electrolyte, fluid input, gas outlet, pressure and level sensors.

Before activation of the circuit breaker a modified chamber is filled with oxyhydrogen mixture with a pressure of about 100 kPa. Oxyhydrogen mixture is produced by a gas generator, connecting a gas pipeline with a tank. After activation of the circuit breaker, chamber is filled with a fluid of water and water vapours with a pressure between 20 and 200 Pa, which is a consequence of the process of arc suppression. Chamber is connected with a releasing high-speed solenoid valve and pipeline to the vessel with a liquid to remove a fluid, created after activation of the circuit breaker.

Magnetic valves – releasing and forcing valves provide necessary quantity and pressure of gas in the chamber and emptying the chamber after the phase transformation of oxyhydrogen mixture.

The circuit breaker is equipped with an electric control unit, which includes an electrically connected programmable microprocessor, passive and active electronic components, connecting and disconnecting coil.

Characteristics of arc suppression

Turn- off time, that is, time from tripping command until contact breaking, is an important parameter for circuit breakers. It reflects the proper time of the circuit breaker (from tripping command until contact breaking) and time for arc suppression at the poles.

The energy required to produce oxyhydrogen is about 10,000 J per liter at a pressure of 100 kPa and it is determined by the first Faraday's law of electrolytic processes [7]. The minimum energy required for the combustion of oxyhydrogen mixture is only 0,019 mJ and it is provided by pole breaking, when current flows in the external circuit of the circuit breaker.

In the course of research changes were detected, in particular, changes in breaking current, voltage and chamber pressure as a function of time. For the first time the transient process of arc suppression in the chamber with 33% hydrogen and 67% oxygen was studied. It is graphically shown in Pic. 3. During the process through the surveying glass of the chamber, hydrogen burning was observed for about 2 sec., which arose as a result of an electric arc. Pressure increased prior to turn- off moment due to thermal expansion of gas during burning. The duration of the transition process in this case is 25 ms. Dielectric strength recovery time is 660 microseconds. Remote hydrogen energy in the chamber is 135 J [7].

The duration of transition process in a chamber with 50% hydrogen and 50% oxygen (Pic. 4) is 18 ms. Pressure in the chamber at the turn-off moment is 760 kPa, and then it reduces to 140 Pa within 2.28 ms. Dielectric strength recovery time is about 40 microseconds. Remote hydrogen energy in the chamber is 205 J [7].

Transient process in the oxyhydrogen mixture with a volume ratio of hydrogen and oxygen of 2:1, and with duration of 15 ms is illustrated in Pic. 5.

Chamber pressure is 960 kPa. Dielectric strength recovery time is less than 40 microseconds, due to the lower strength of polarization.

Conclusion.

The task, to be solved by the efforts of the team from Todor Kableshkov Transport University, was the study of different gas atmospheres of DC arc suppression, where the process can be provided with greater speed and without any negative impact on the environment. The laboratory bench with a three-pole circuit breaker was created, one of the chambers is modified so that it could be filled with various gas. On the laboratory bench, transient processes of arc suppression in oxyhydrogen mixture were studied with different volume ratio of hydrogen and oxygen.

The obtained data were compared with the results of similar tests to arc suppression in the vacuum chamber. It turned out that in the oxyhydrogen environment arc suppression time is less than in a vacuum environment. Meanwhile, however, the recorded overvoltage indicators are higher, and the dielectric strength recovery time for oxyhydrogen mixture is four times longer than that of vacuum, which requires additional checking and continuation of experiments.

Keywords: electric transport, arc-stilling processes, high speed rectifiers, vacuum, gas environment

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