DEVELOPMENT PROBLEMS OF DC DISCONNECTORS WITH A DRIVE BASED ON AN EXPLOSIVE WIRE

Yurchenko Vladislav

Undergraduate of St. Petersburg State University of Aerospace Instrumentation, Russia, St. Petersburg

Petrov Eduard

Undergraduate of St. Petersburg State University of Aerospace Instrumentation, Russia, St. Petersburg

Abstract. This article is devoted to the consideration of various types of direct current breakers, as well as the development of a layout of a direct current breaker with minimum overall dimensions. The basis for creating explosive wire.

Keywords: Circuit breakers, direct current, explosive substance, exploding wire.

Introduction

There are certain areas of life where direct current firmly holds its leading position. This primarily relates to electric drives. DC motors allow forming a wide variety of electrical characteristics that are not available when using alternating current.

Another advantage of using direct current is DC high voltage power lines, which can be more economical when transmitting large amounts of electricity over long distances. The use of direct current for underwater power lines avoids the loss of reactive power due to the large cable capacity that inevitably occurs when using alternating current.

Switching to direct current consumption requires a significant upgrade of equipment and changes in technical standards and conditions for energy use. Therefore, the correct selection and development of new switching equipment for DC circuits is necessary [1].

Types of circuit breakers and operating principles

Air magnetic switches use an arcing chamber as an interrupt device. The current shutdown occurs due to the elongation of the arc and its contact with ceramic plates, providing cooling of its combustion products [2]. This switch is shown in fig. 1.

The air explosive switch extinguishes the arc through the hole of the explosion valve during separation of the arc contact. Compressed air passing through the arc contacts leads to an increase in dielectric characteristics in the arc gap, as well as to fast cooling [1]. The design of such a switch for high voltage networks is shown in Fig. 2.

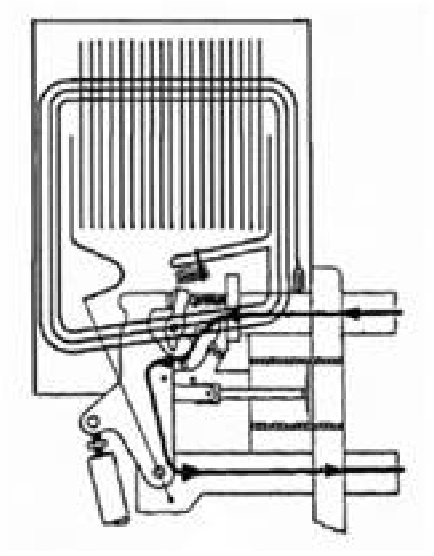

Figure. 1. Air magnetic switch

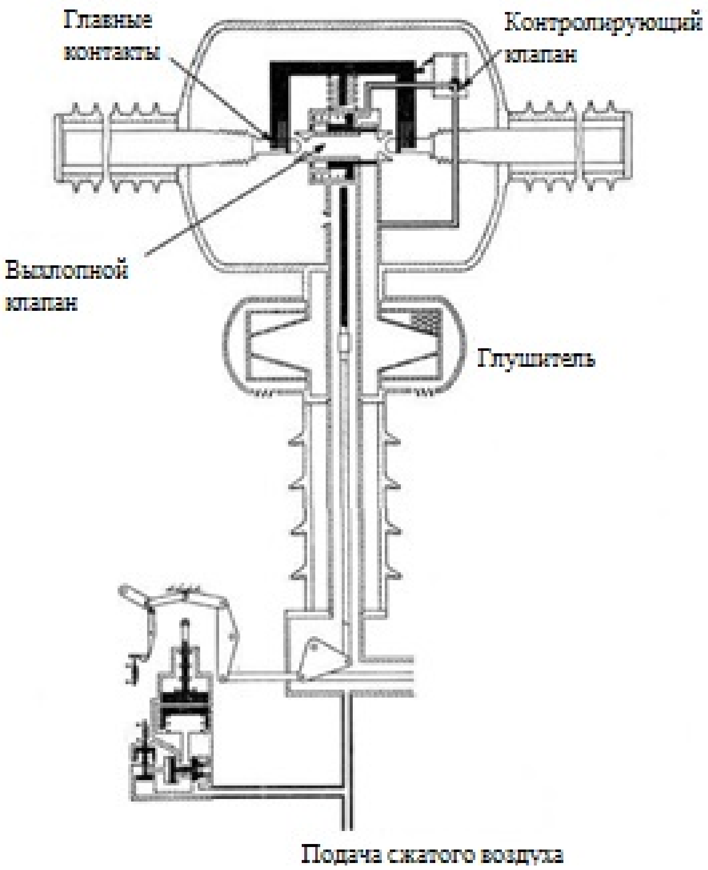

Figure. 2. Air explosive switch

The performance of an air explosive switch is mainly influence by operating pressure, nozzle diameter and interrupt current, while a magnetic switch is more dependent on voltage and opening capabilities. The disadvantages of such switches are the large size and cost compared to other switches.

It is also necessary to give an example of a system of DC switches based on semiconductor elements. CSCs have a natural ability to withstand short circuits, since DC inductors can help limit currents in faulty operating conditions. VSCs are more vulnerable to line damage, so cables are more attractive for VSC —HVdc applications. Malfunctions on the DC side of VSC HVdc systems can also be resolved with DC circuit breakers (CB). [3]

Pyrobreaker design and operation principles

The disconnector consists of two functional units: the switching part and the separator connected in series. Both parts of the circuit breaker operate independently of each other and use the energy released during the detonation of a small explosive charge to operate [4].

The switching part consists of a thin — walled copper cylinder with annular grooves, inside of which there is an explosive charge. The internal volume of the cylinder is filled with water. After detonation of the charge, the cylinder breaks along the annular grooves — voltage concentrators. The quenching of the electric arc occurs due to cooling with water leaving the internal volume of the cylinder after its destruction.

Basically, heat is generated in the current-carrying cylinder of the switching part, the cooling of which is carried out in the near-surface boiling mode and substantially depends on the water pressure inside the cylinder.

The switching section is able to interrupt the current, diverting it to the discharge resistors, and then withstand the high voltage that appears at the terminals of the circuit breaker for 0.1 s.

The protective circuit breaker, the design of which is shown in Fig. 3, consists of a switching section and a separator.

The switching section of the circuit breaker contains a thin destructible current-carrying element connected at both ends to current leads. An explosive charge is located along the axis of the cylinder. Round grooves are provided on the cylinder, which serve as stress concentrators and ensure the formation of multiple gaps after the charge is triggered.

DC circuit problems

In DC circuits, the relative direction of current is of particular importance, therefore, it is necessary to connect the load with strict polarity. Errors inevitably lead to severe emergency processes. With reverse polarity, serious damage can also occur in many electronic circuits.

In addition, one of the problems associated with the use of apparatus AC and DC is the electric arc. It occurs between open contacts due to ionization of the air space between them.

In DC circuits, in general, the parameters of the arc depend on the characteristics of the circuit, the current value, as well as the parameters of the medium itself: temperature, pressure, air composition, etc. There is a set of conditions under which an electric arc can stably burn for a long time when the contacts in the DC circuit are opened. Thus, to extinguish it, it is necessary to change the process parameters so that there is no point of stable combustion.

Model of DC disconnector

The basis for the development of the model of a DC breaker is a protective breaker with an explosive-based drive.

The main difference between this circuit breaker model from Pirobreaker is that the exploding wire is the drive in the circuit breaker. It is also necessary to note the modernization of the design, which for the better affects the dimensions of this unit. It is substantially smaller than Pirobreaker.

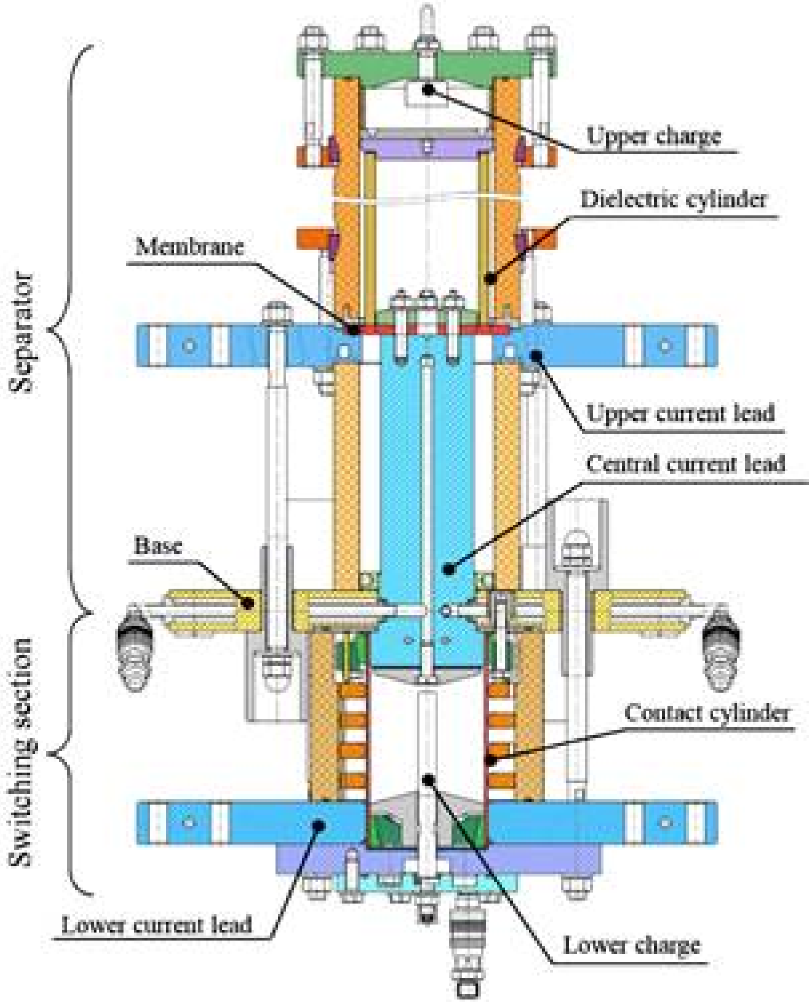

Figure. 3. Safety Switch Pirobreaker

The switching section of the circuit breaker with the drive based on the exploding conductor contains a thin destructible current-carrying element connected at both ends to current leads. The conductor is located along the axis of the cylinder. A circular groove is provided on the cylinder, which serves as a voltage concentrator and provides a gap after breaking the conductor. Two dielectric rings are installed around the contact cylinder and are arranged in such a way as to ensure proper destruction of the cylinder. In fig. Figure 4 shows a sketch of a future layout of a DC breaker.

In continuous operation, demineralized water flows through the internal cavity of the contact cylinder, ensuring its cooling. During the current switching process, this water acts as a medium for the propagation of the shock wave created by the explosion of the conductor. When the conductor ruptures, a plasma channel arises, which, expanding, pushes water toward a thin conductive destructible element. The characteristics of the electric explosion plasma averaged over the cross section are easily determined if the spatiotemporal development of the discharge channel is known. The principles of generation of a shock wave during the explosion of a conductor in water are described in detail in [5]. Upon reaching the contact cylinder, the shock wave leads to the destruction of the cylinder along the circular groove. An electric arc appears in the formed gaps, which is extinguished by the flow of water.

Conclusions

The proposed model allows us to study the electrical and mechanical parameters of the DC-current process in Pirobreaker-type apparatuses, as well as circuit breakers with an explosive-based drive. Studying the process of propagation of a shock wave in a liquid, the effect of a conductor explosion on the switching process, and the possibility of using it as a “drive” allows us to evaluate the prospects of developing new devices for switching constant currents.

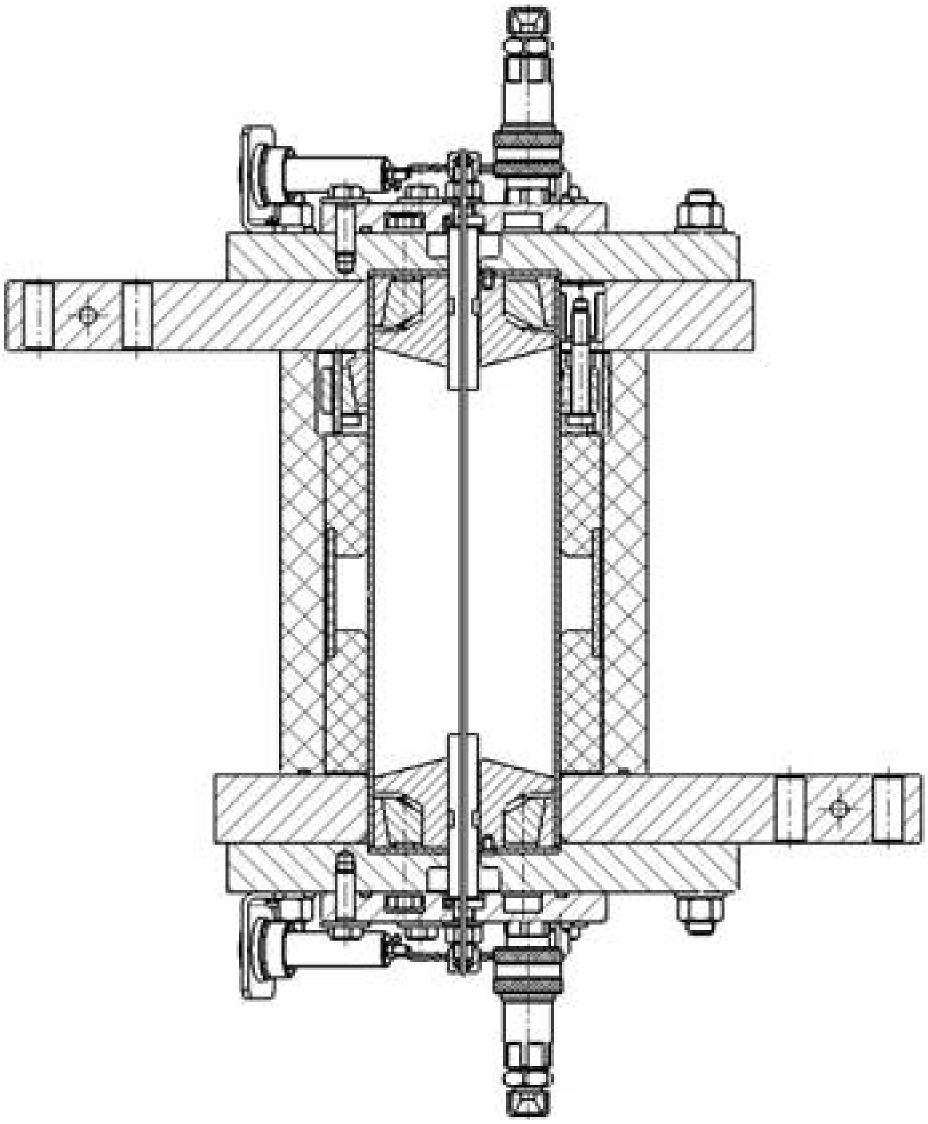

Figure 4. Design of DC circuit breaker

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