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LOW-VOLTAGE BREAKER ARCS SIMULATION AND DIMENSIONS

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ABSTRACT:
As one of the most important electrical components, the low-voltage circuit breaker (LVCB) has been widely used for protection in all types of low-voltage distribution systems. In particular, the low-voltage dc circuit breaker has been arousing great research interest in recent years. In this type of circuit breaker, an air arc is formed in the interrupting process which is a 3D transient arc in a complex chamber geometry with splitter plates. Controlling the arc evolution and the extinction are the most significant problems. This paper reviews published research works referring to LVCB arcs. Based on the working principle, the arcing process is divided into arc commutation, arc motion and arc splitting; we focus our attention on the modelling and measurement of these phases. In addition, previous approaches in papers of the critical physical phenomenon treatment are discussed, such as radiation, metal erosion, wall ablation and turbulence in the air arc. Recommendations for air arc modelling and measurement are presented for further investigation.

Keywords: HPLC, PDA, stability indication method, drug.

1. INTRODUCTION:

Electrical power systems typically consist of a power generation system, a high-voltage transmission system and a low-voltage distribution system. In the entire power system, the low-voltage distribution system is the most familiar to end users—this is normally below 1000 V for an ac system and below 1500 V for a dc system. In particular, the low-voltage circuit breaker (LVCB) is a key component of many application fields in a low-voltage distribution system. For example, it is utilized to protect, control and regulate the power systems in many commercial and industrial applications, schools and residential communities [1–5]. It should be noted that a new research area has formed around LVCBs in recent years along with the development of dc power systems that utilize low-voltage dc circuit breaker (LVDCCB) development. The LVDCCB is primarily used in electric propulsion for subways, vessels, solar power and grids, renewable energy sources, and so forth.

There are a number of manufacturing companies for LVCBs worldwide, such as ABB, Schneider, Siemens and GE. The low-voltage device production scale and market are very large. This significant industrial demand is one of the reasons why many people focus on LVCB research. Previous presentations on the phenomena occurring in LVCBs can be found in the literature of McBride [10] and Freton et al [11]. The purpose of LVCB utilization is to switch operating or fault currents in low-voltage system electric circuits. Opening the contacts in a circuit breaker leads to the formation of an electric arc. The arc medium in most LVCBs is air. Only if used for aerospace applications or other special cases, an LVCB is typically designed to be enclosed, and the arc medium can be air, N2, H2 or other inert gas. The primary types of LVCB include the air circuit breaker (ACB), the molded case circuit breaker (MCCB) and the miniature circuit breaker (MCB). The guiding principle of the LVCB is increasing the arc voltage and then cooling the arc column to achieve arc extinction at zero current in an ac system; a typical waveform is shown in figure 1. For an LVDCCB, the arc voltage must be raised

2. RELATED STUDY:

Higher than the dc power source to resist the power source during the current interruption, thus making the current fall to zero. The arc voltage can be increased by elongating the arc length, cooling the arc column and increasing the voltage electrode drop, which are often combined in an actual product; a typical waveform is shown in figure 1(b). Therefore, the arc current in an LVDCCB is not a direct current, and the arc is actually not a dc arc. However, the supply voltage is nearly constant, which makes breaking the circuit more difficult. The schematic diagram and configuration of the LVCB configuration is shown in figure 2. The circuit breaker is typically composed of an arc chute with splitter plates, electrical contacts (including moving and fixed contacts), a mechanism and other control units. It is important that the arc should not have a long stagnation time and be extinguished as rapidly as possible. Therefore, the behaviour of the arc plasma is fundamental in determining the performance of the quenching chamber; the arc is the key factor and the most difficult problem in LVCB development. The air arc in an LVCB is a 3D transient arc process with a very complex geometry.

In general, there is some distance between the arc runner and the moving contact, but their electric potential is the same because they are usually connected by a flexible connection. Once the LVCB is tripped, the opening operation is driven by a mechanism. The arc initially ignites between the two contacts. The arc length continuously increases along with the contact separation. However, the arc column will not maintain a steady state because of the magnetic blow force induced by the current path and the arc itself; the arc column will become elongated and bent. When the new arc root is formed on the arc runner, the arc will commutate to the arc runner; thus, the arc must jump from the contact to the arc runner before entering the arc chamber. This process is called arc commutation. For some low-voltage circuit breakers, there is no independent arc runner; the arc root will only move on the moving contact. Because the arc commutation is much faster than the contact opening process, the arc will typically jump to the arc runner before the total contact opening operation has finished. Therefore, one must either optimize the arc runner configuration or add ferromagnetic material or a magnetic coil to produce or enhance the magnetic Lorentz force to push the arc towards the splitter plates. Because of the effect of the high pressure gas blow produced by the high temperature arc and the configuration of the chamber vent, the arc will be pushed along the flow channel to the splitter plates. During the arc motion process, the arc voltage will continuously increase. This is why the magnetic field and chamber pressure design is very important for the accelerated arc movement in an LVCB.

3. PROPOSED METHODOLOGY:

Under the two aforementioned effects, the arc moves to the splitter plates. The attraction effect produced by ferromagnetic splitter plates also aids the moving process; this is why splitter plates are always made of iron material. Due to the blocking effect of the relatively cold splitter plate, the arc column gradually bends and stretches. As the new arc roots emerge on the splitter plates, the arc will be cut into several short arcs and produce many electrode voltage drops that immediately increase the arc voltage, as shown in figure. Furthermore, when the current is high and the arc remains within the splitter plates for a sufficiently long time, the surfaces of the plates can reach the melting point of the metal. This inevitably leads to the partial vaporization of the metal plates. Figure shows a group of splitter plates in a low-voltage circuit breaker that are strongly eroded by a high-temperature arc plasma after several openings (see the regions marked A and B). The splitter plates occupy the largest fraction of the volume of the quenching chamber; this means that the effect of the metal vapour from these plates is more significant than that of the electrodes. Thus, investigations into the influence of metal vapours from erosion of the splitter plates during the arc-splitting process are very important for the design of switching devices. Ideally, the arc should remain in the splitter plate region to maintain a high-voltage status but not create a serious erosion effect on the electrical endurance and the dielectric recovery of the arc medium. Moreover, the arc voltage will rapidly increase in this phase, and because the high-temperature gas is still in the arc chamber between the contacts or arc runners, the opportunity of a re-strike phenomenon or back commutation is more likely; this can create the possibility of a breaking failure. According to the principle and configuration of an LVCB, we can see that the arc behaviour plays a significant role in the breaking of an LVCB. The aim of the new LVCB technology is to reduce the volume, shorten the breaking time and improve the breaking capacity. The most important factor is a better understanding of the arc behaviour, which strongly depends on the arc model and measuring approach development. There are numerous difficulties. Modelling and measuring a 3D transient arc is a great challenge in the complex geometry present in an LVCB, the calculation scale would be very large. In addition, the arc root and formation mechanism for the moving arc is very complex; the interactions between the metal surfaces and the arc must be obtained to determine the boundary layer treatments of the electrodes or the splitter plates. Moreover, the gas in the arc chamber will be a mixture due to the metal erosion and wall ablation effects. Therefore, the thermal dynamic, transport and radiation parameters will be more difficult to calculate. The diffusion between the different composition and material surface boundary conditions are also extremely complex. In addition, the authors believe that the spectrographic test has potential in determining the material composition of the arc during the short circuit event, which could be useful for understanding the role of the polycarbonate or ceramic material on the gas flow and the simulation model. However, more accurate information of the compositional concentration and temperature is very difficult to obtain for the non-axisymmetrical transient 3D arc in LVCB cases. For this reason, spectroscopic measurements are seldom presented in previous works.

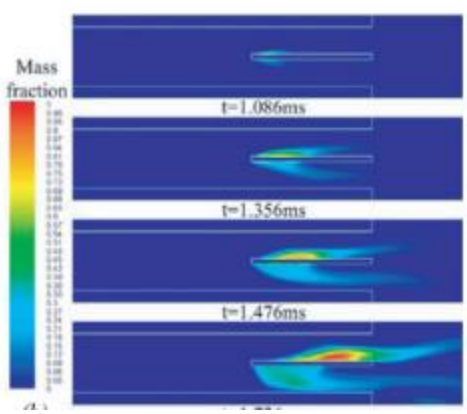

Fig.3.1. Proposed results.

5. CONCLUSION:

Current research covers almost all aspects of the arc phenomena occurring in low-voltage circuits, including arc commutation, arc motion, arc erosion, arc radiation and arc splitting. Many influential factors have been discovered based on simulations and experimental data. Despite the devoted past efforts put forth by many researchers, there remain several problems without resolution, and further research work is required in the future. Previous work shows that some macro-parameters such as arc voltage, pressure and temperature can be well observed using appropriate sensors. In particular, arc motion can be recorded by high-speed cameras, fibre arrays or magnetic sensor arrays, whereas spectrum analysis is limited and seldom used for low-voltage switching arc measurement due to its transient and three-dimensional characteristics. However, the microscopic information of vapour mixtures, arc extinctions and dielectric recovery is more important for large-capacity LVCB development, especially for dc circuit breakers. These phenomena are more complicated because the microscopic particles play a key role in the interaction of the physical processes. Unfortunately, the rule of microscopic particle variation is difficult to detect, resulting in scarce detailed knowledge on arc root behaviour and arc extinction.

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