Discharge Mechanism and Mathematical Physical Model of AC Air Arc Plasma

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Ground faults occur frequently due to the harsh operating environment of the distribution network. The air gap inside the cable and between the cable and the ground is easily broken down and cause AC air arcs.[1]–[3] AC Air arc discharge has caused serious fire accidents around the world, causing serious casualties and economic losses. Due to the strong randomness of AC air arc discharge and the lack of on-site data, the arc model is usually used to obtain data for fault detection.

At present, the commonly used AC air arc models are mainly divided into mathematical models and physical models.[4] For mathematical model, the arc is equivalent to a variable resistor, and the resistance value is expressed through an analytical formula. For arc physical model, the arc is equivalent to plasma, and the internal field quantity and transport coefficient of the arc are solved by the plasma physics method. However, there are still some problems with existing arc models. The electrical characteristics of the arc are significantly different under different working conditions (grounding medium, climate and environmental conditions, etc.), and it is difficult to describe it by a unified analytical form. The calculation process of the physical model is complicated, and it is difficult to be used in the long-term simulation of the power system. Therefore, it is necessary to explain the electrical characteristics of the arc under different working conditions from mechanism.

To address these challenges, we measured the electrical characteristics of the AC air arc, and analyzed the heat transfer process and the post-arc medium recovery process. Based on this, the arc mathematical physical model was established. The mathematical physical AC air arc model can reflect the electrical characteristics of the arc gap under variations in the air pressure, ground resistance, and arc gap length. The research process of the overall work is shown in Figure 1. The overall work includes the measurement of arc electrical characteristics, the research of arc discharge mechanism and the establishment of mathematical physical model. This work is supported by the National Natural Science Foundation of China no. 51477018.

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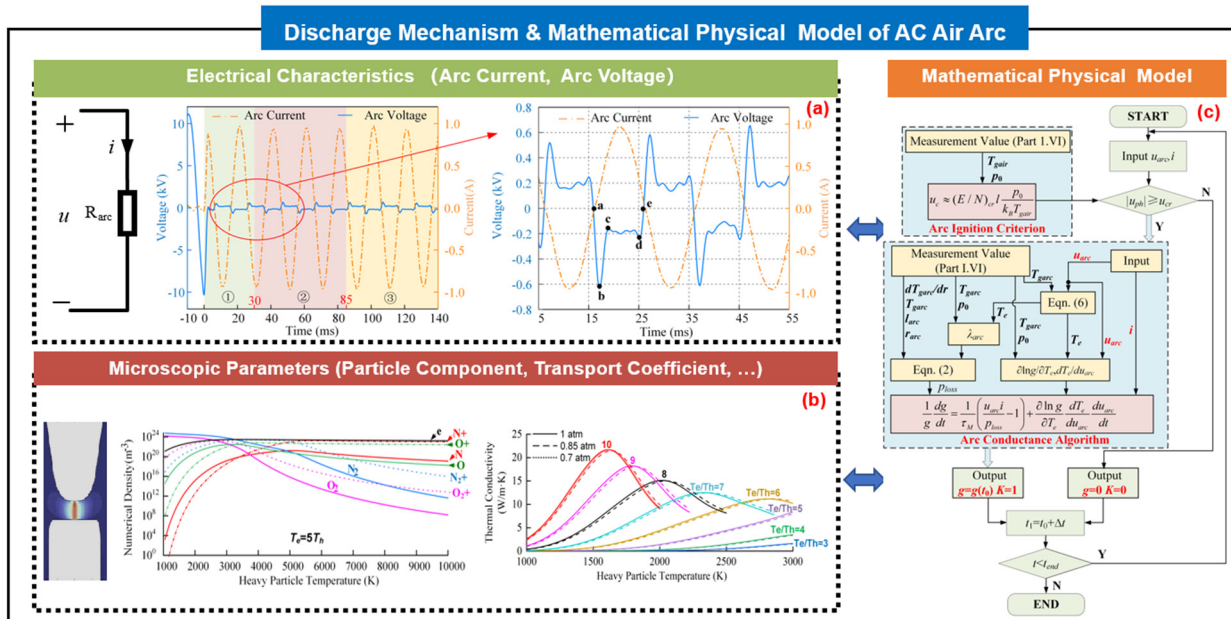
Figure 1. The research process of the overall work. a) Measurement of arc electrical characteristics. b) Research of arc discharge mechanism. c) Establishment of mathematical physical model.