ISSN: 2664-9640

Research on the Current-Carrying Vessel Structure of Current Transfer Fault Current Limiter Using Pressure-control Material

Chao Sun[1,*], Shutian Xue[1], Liyan Zhang[1], and Xuesong Liu[2]

[1] School of Electrical Engineering, Dalian University of Technology, Dalian, China

[2] School of Control Science and Engineering, Dalian University of Technology, Dalian, China

[*]Corresponding author

Abstract

At present, the current limiting or breaking application using the principle of current transfer has received a lot of research in the field of electrical engineering as an economical fault breaking scheme. The principle of current transfer is to use the voltage competition of the parallel branch to transfer the current from the main current branch to the functional branch in parallel with it. It is mainly used in the field of fault current limiting and DC breaking.

Keywords

Miterials; Structure; Voltage.

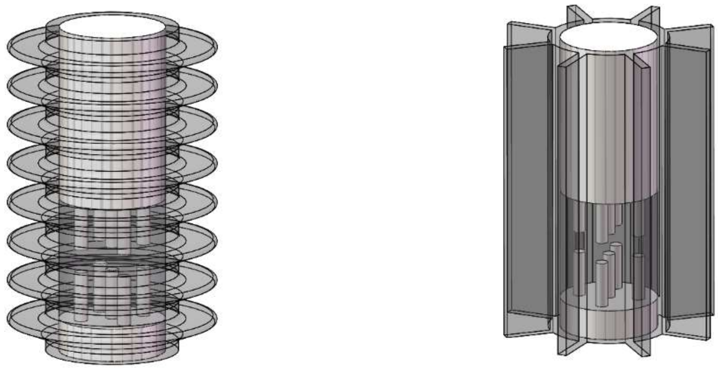
1. Introduction

Pressure-controlled materials are a kind of special materials whose resistance changes due to pressure changes [1]. By controlling the pressure change of the material connected to the circuit, the current transfer speed of the entire fault circuit is affected [2]; the fault current limiter using the pressure control material has two states when working: when the line is in normal operation, there will be greater heat generation due to the passage of current , It will withstand a large voltage when the line is faulty and current-limiting. In this paper, by simulating the structure of the pressure control material container connected to the circuit, the influence of the container structure on the heat dissipation and insulation capacity of the device is studied.

The structure of the outer container of the pressure control material will also have an important impact on its heat dissipation capacity [3]. In the field of electrical engineering, there are many common heat dissipation structures. For example, a larger chip on a circuit board often has a multi-piece heat sink, but its fundamental purpose is actually to optimize the structure to increase the heat dissipation area [4], so as to transfer heat on the material parameters and surface When the coefficient is the same, there can be higher energy dissipation. In this article, the simulation compares the heat dissipation capabilities of the cylindrical, insulator, and longitudinal fin-type structures. At the same time, since the container is under high voltage and high current in actual use, the simulation compares the electric field distribution of the three structures under the same voltage condition.

2. The Influence of Container Structure on Heat Dissipation

The pressure control material container is an insulator-shaped sleeve and a longitudinal fin sleeve as shown in Figure 1. The inner diameter, wall thickness and height are the same as the cylindrical sleeve, which are 32 mm, 4 mm, and 100 mm, respectively, and the number of umbrella skirts is equal to The number of longitudinal heat sinks is 8 each. There are up and down dynamic and static contacts inside, and the height of the pressure control material is 36.5 mm.



(a) Insulator shell cylinder container (b) Vertical fin cylinder container

Figure 1. Several shapes of pressure-controlled material container sleeves

Using steady-state and transient heat dissipation models respectively, when the initial temperature of the container and the environment is room temperature (300 K), the current passing through the pressure-controlled material is set to 210 A, the resistance of the pressure-controlled material is set to 16 mΩ, and the external container is The thermal conductivity of silicon nitride is 80 W/m·K, and the upper and lower contacts are made of aluminum alloy. When the surface heat transfer coefficient is 50 W/m·K when the wind blows, the cylindrical sleeve and the insulator-shaped sleeve And the longitudinal fin sleeve for simulation analysis.

According to the simulation results under three different container structures, the temperature at the center of the pressure-controlled material and the temperature at the outer edge of the container bottom under steady-state conditions were measured, as shown in Table 1. Table 2 shows the temperature values at the above two positions of three different container structures when t=60 s.

From the temperature values in Table 1, when the dynamic balance of temperature is reached, the heat dissipation capacity of the insulator-shaped sleeve is almost the same as that of the longitudinal fin sleeve, and both are better than the cylindrical sleeve. Among them, the temperature rise of the inner material of the insulator-shaped sleeve is about 34.1 K smaller than that of the cylindrical sleeve. From the temperature value in Table 2, in the transient process, the insulator-shaped sleeve and the longitudinal fin sleeve are also better than the cylindrical sleeve. On the one hand, these two structures both increase the surface area of the outside of the sleeve that is connected to the environment, so when other parameters are the same, more heat can be dissipated in the same time and there is a greater heat flux.

Table 1. Temperature at different measuring points of different container structures at steady state

Container structure	Temperature at the center of the pressure-controlled material (K)	Temperature at the outer edge of the bottom of the container (K)
Cylindrical sleeve	402.2	374.5
Insulator type sleeve	368.1	344.4
Longitudinal heat sink sleeve	367.1	344.3

ISSN: 2664-9640

Table 2. Temperature at different measuring points of different container structures at t = 60s

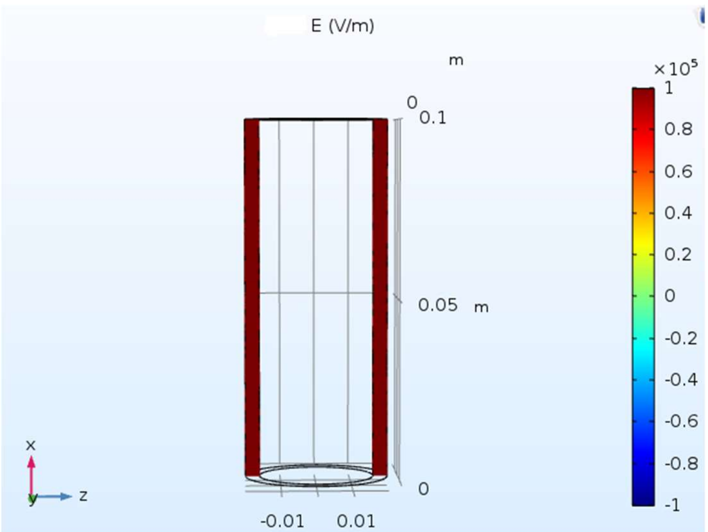
Container structure	Temperature at the center of the pressure-controlled material (K)	Temperature at the outer edge of the bottom of the container (K)
Cylindrical sleeve	344.6	316.9
Insulator type sleeve	335.8	311.2
Longitudinal heat sink sleeve	336.6	312.7

3. Analysis of Insulation Capability of Vessel Structure

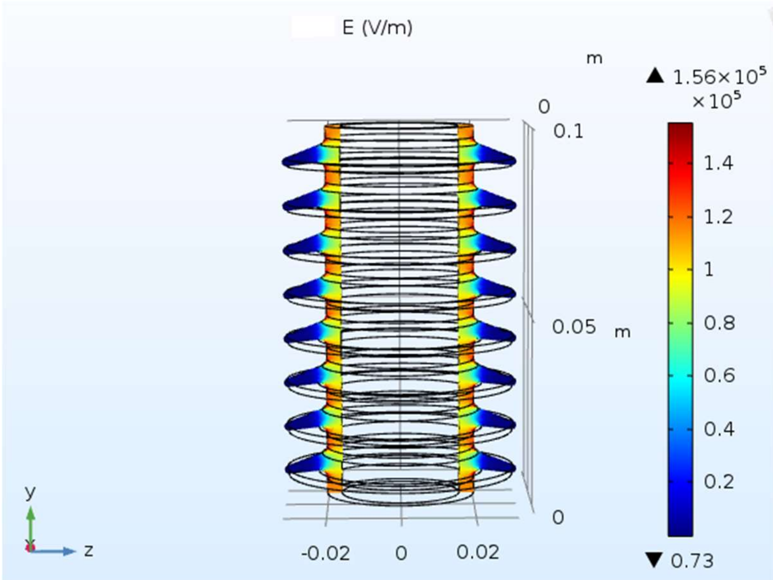
In the use of pressure-controlled material containers, not only the problem of timely heat dissipation to avoid excessive temperature rise, but also the challenge of high voltage and high current. In order for the pressure-controlled material to be used as the main current-limiting transfer circuit, the container should have good insulation properties. Therefore, the container should choose low-conductivity materials to effectively improve its insulating ability. When the material is the same, the structure of the container also has a certain impact on the pressure resistance[5]. Studying the pressure resistance of different structures is of great significance for designing a higher life and safer pressure control material sleeve.

In this section, on the basis of the above container structure, simulation software is used to simulate the electric field of the insulator-shaped container and the longitudinal fin-shaped container with better heat dissipation ability. Using the electrostatic field model, the top end surface of the sleeve is set to an electric potential of 300 V, and the bottom end surface is set as the ground plane. The electric field calculation formula is added to simulate and analyze the electric field distribution of the three sleeve structures.

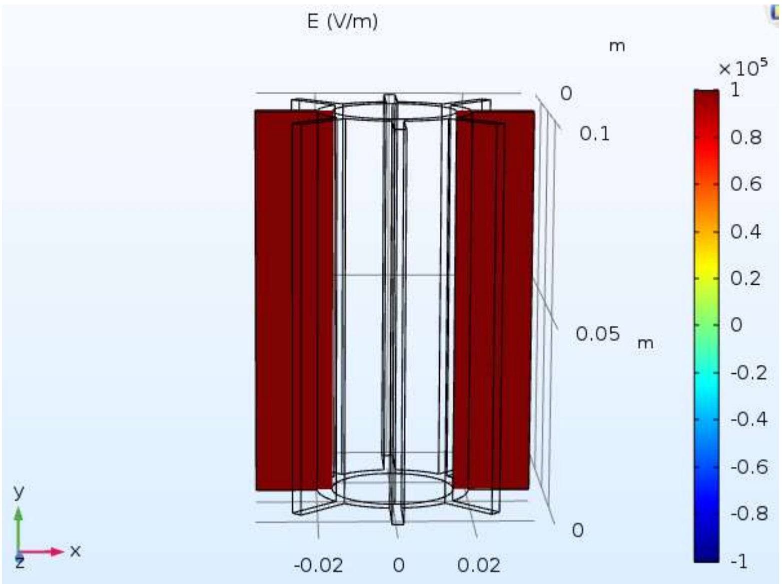
After the sleeve centerline, draw the longitudinal section, Figure 2 shows the electric field intensity distribution of the three sleeve structures.



(a) Electric field distribution of cylindrical sleeve vessel



(b) Electric field distribution of insulator sleeve vessel



(c) Longitudinal fin sleeve container electric field distribution

Figure 2. Electric field intensity distribution of three kinds of sleeve structures

According to the simulation results, it can be found that under a voltage of 10 kV, the cylindrical sleeve and the longitudinal fin sleeve have a uniform electric field distribution, and the electric field strength is 100 kV/m, while the electric field strength inside the insulator-shaped sleeve From 73 kV/m to 156 kV/m, the edge of the umbrella skirt has the lowest electric field, and the maximum field strength is at the connection of the skirt root. From the perspective of material insulation, the root of the shed of the insulator-shaped sleeve will withstand greater electric field strength, and when it is made of the same material, breakdowns such as breakdown are more likely to occur. The longitudinal fin structure and cylindrical sleeve are safer and can withstand greater voltage.

4. Conclusion

Under the 10 kV model, from the perspective of heat dissipation, the umbrella skirt structure and the longitudinal fin structure are better than the cylindrical structure for the pressure-controlled material container, and the longitudinal fin structure bears smaller electric field

ISSN: 2664-9640

strength, so longitudinal fins should be used The structure is used as a pressure control material container to connect to the circuit, which is more conducive to the heat dissipation and safe operation of the line flow state, and is more conducive to the realization of the overall function of the system.

References

[1] Jianjian He,Yicai Sun. Preparation of foristor strips for high temperature pressure sensors [J]. Sensor world, 2009(4): 18-21.

[2] Yuehua Hu. Finite Element Simulations of Piezoresistive Pressure Sensors under the Influence of Elastic Thermal and Electric Fields [D]. Harbin Instiyute of Technoligy.2018.

[3] Bohan Shao. Monitoring System for High Temperature Heat Transfer Liquid Container Based on Numerical Heat Transfer [D]. Harbin Instiyute of Technoligy.2015.

[4] Huazhu Liu,Mingzhu Lin,Zhihao Liu,Hongjun Lin. Analysis and research on material selection and thermal performance of copper-based sintered Printed Circuit Board[J]. Printed Circuit Information, 2018(5): 44-47.

[5] Xinghai Zhang. Study on Overvoltage Analysis and Insulation Fault Detection of Critical Elecric Equipment in Converter Station [D].Southwest Jiaotong University.2012.