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Research on Internal Temperature Field and Hydrogen Diffusion Characteristics of Inverted Oil-Immersed Current Transformer

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I. INTRODUCTION

In In the field of transformer fault research, many scholars have conducted in-depth research on the formation and causes of internal insulation oil temperature rise fault and internal pressure fault. For example, by analyzing the head insulation of an oil-immersed current transformer, it is concluded that because the head insulation adopts a manual wrapping method, it has high requirements on the wrapping process and is prone to insulation defects. The internal oil volume of the transformer is small, and serious leakage or repeated oil extraction can easily cause structural defects such as low oil level or internal negative pressure. By investigating the current research results of transformer failures, the author found that there is little discussion about the internal temperature field variation characteristics and the hydrogen diffusion characteristics in the oil in the inverted oil-immersed current transformer under different working conditions. The research on the temperature field distribution characteristics and hydrogen concentration variation characteristics of current transformers has certain guiding significance for the fault diagnosis of equipment.

By using the ANSYS fluent simulation platform, the internal temperature field variation and hydrogen diffusion characteristics of the inverted oil-immersed current transformer were simulated. In addition, an online monitoring system for the concentration of hydrogen in the oil has been built to realize the monitoring and early warning of hydrogen failures.

II. ESTABLISHMENT OF SIMULATION MODEL

SolidWorks modeling software and Fluent simulation software were selected for the establishment of a three-dimensional inverted oil-immersed current transformer model and multi-physics simulation analysis. In this model, the y-axis is defined by the opposite direction of gravity acceleration, the x-z plane is the horizontal plane, the origin of the coordinate system is the center point of the bottom of the model, and the y-axis coincides with the central axis of the model.

The heat of the inverted oil-immersed current transformer during normal operation mainly comes from the internal resistance loss and dielectric loss. And the resistance loss is mainly caused by the heating of the primary conductor and the secondary winding. he overall dielectric loss of inverted oil-immersed current transformer can be obtained by high voltage test. According to the equation of active power of dielectric loss $P = U^2 \omega C tan\delta$, the dielectric loss is proportional to voltage, power frequency, dielectric capacitance C and dielectric loss factor $tan\delta$.

When the transformer fails, a concentration gradient of hydrogen will be generated in the oil, and the hydrogen will diffuse under the action of the concentration difference. Diffusion coefficient of hydrogen in non-polar liquid solvent as followed.

$$D_{AB} = 2.751 \times 10^{-3} \frac{T R_B}{\mu R_A^{2/3}}$$

In the equation, D_{AB} is the diffusion coefficient of hydrogen dissolved in oil ($10^{-9} m^2/s$); T is the temperature (K); R_A and R_B are A and B are the radius of rotation of the solute and solvent ($10^{-10} m$); is the viscosity of solvent ($m\text{Pa} \cdot s$).

III. TEMPERATURE FIELD DISTRIBUTION AND HYDROGEN DIFFUSION CHARACTERISTICS

The 2000A current is applied to the primary terminal to study the internal temperature field distribution of the transformer. The Fig. 1-3 are temperature distribution cloud diagrams when the ambient temperature is 10, 30, and 50℃.

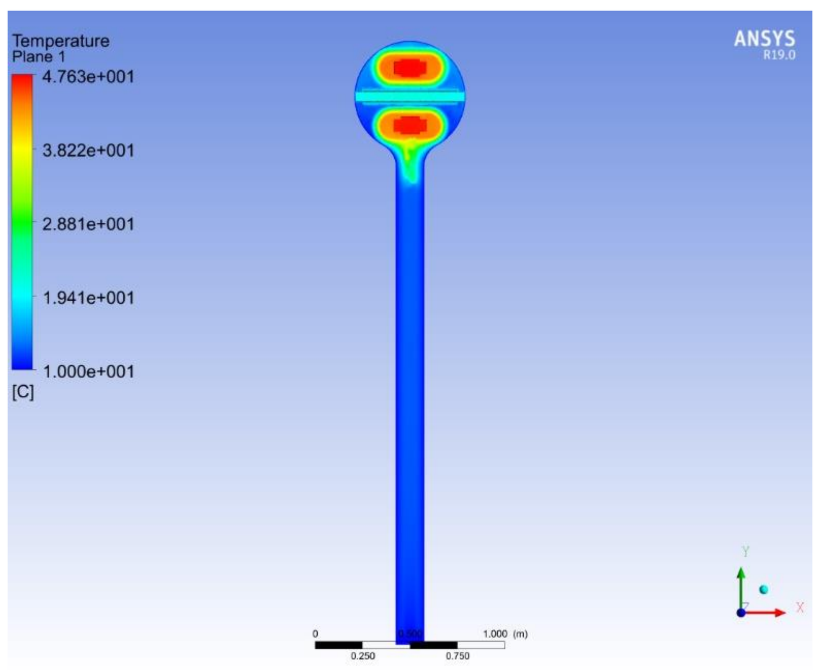

Fig. 1 10℃ temperature field distribution

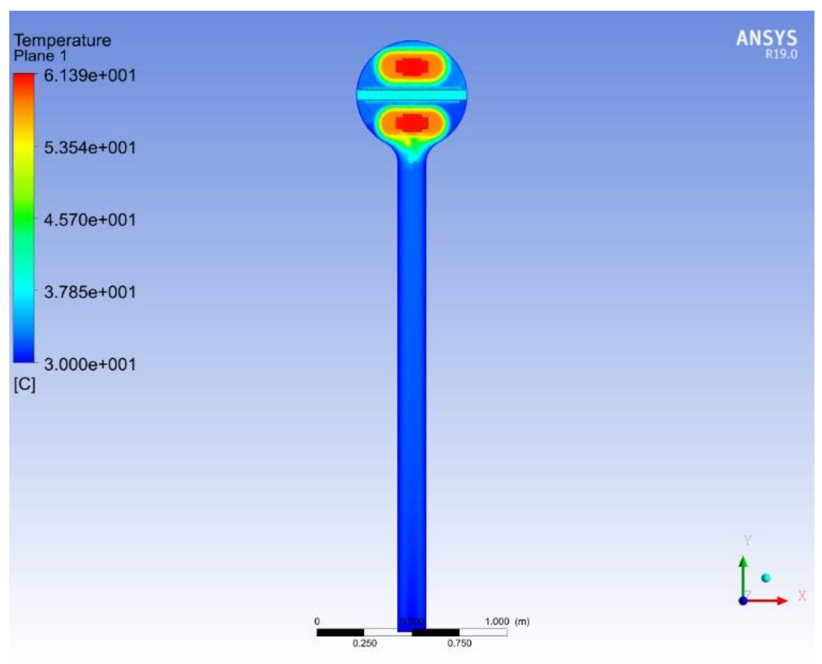

Fig. 2 30℃ temperature field distribution

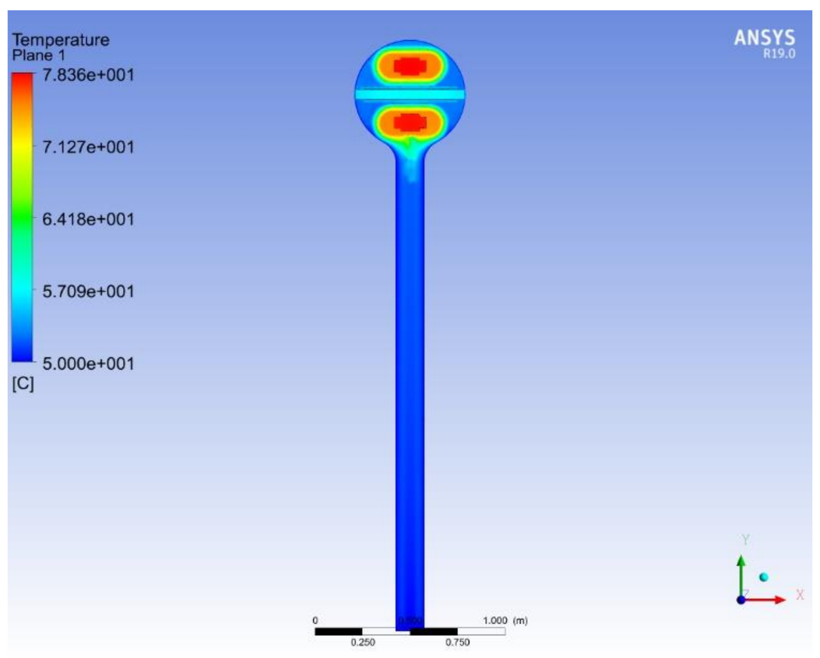

Fig. 3 50℃ temperature field distribution

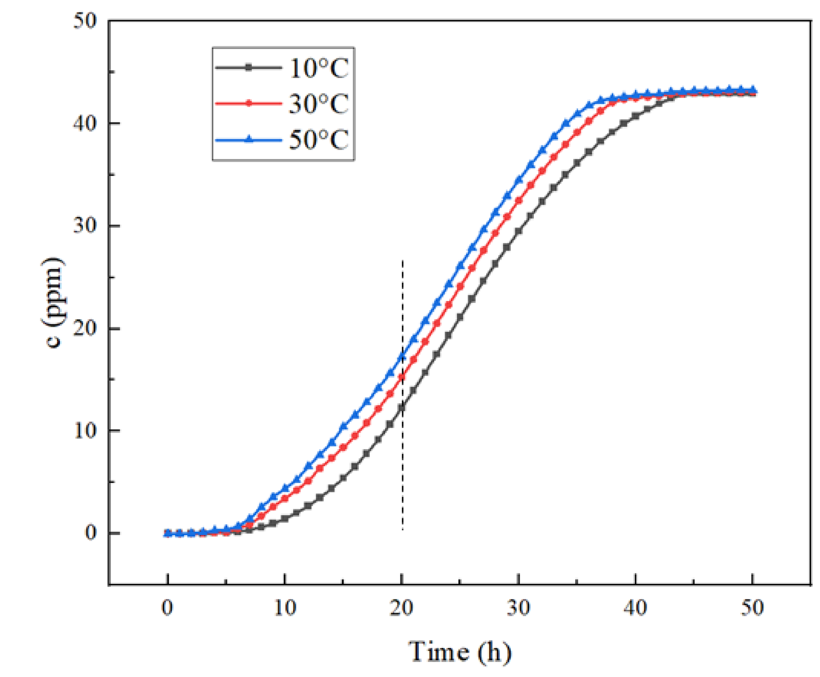

Fig. 4 Hydrogen concentration curve

The hydrogen concentration at take oil port at different ambient temperatures as shown in Fig. 4.

IV. HYDROGEN DIFFUSION EXPERIMENT

The current transformer experiment platform consists of 110kV inverted oil-immersed current transformer, power frequency high voltage generator, pressure sensor, temperature sensor, hydrogen concentration monitoring device and so on.

Under the condition of the ambient temperature of 30℃, the experiment and simulation comparison of the temperature variation of the head oil conservator and the variation of the hydrogen concentration of the bottom oil intake port are shown in the Fig. 5 and Fig. 6.

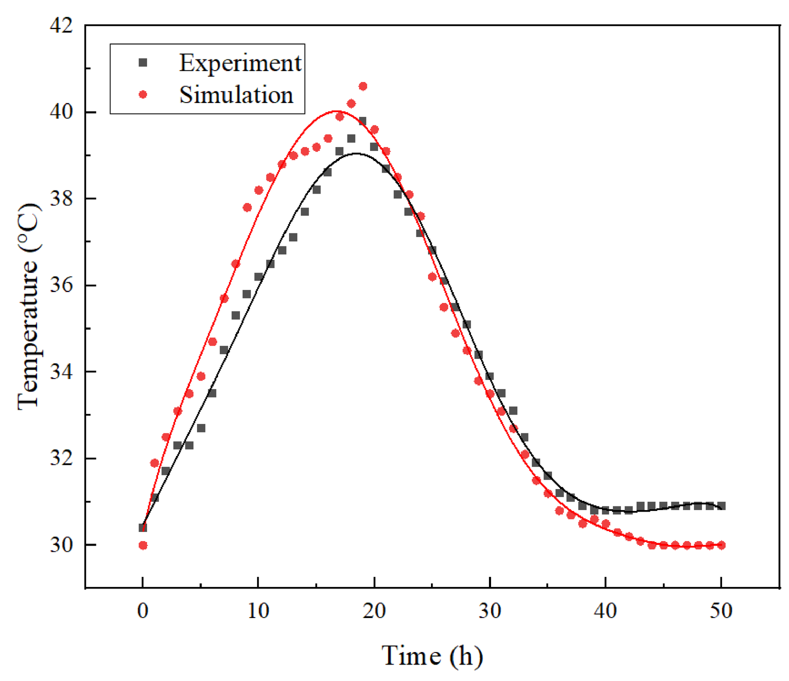

Fig. 5 Comparison of the temperature variation.

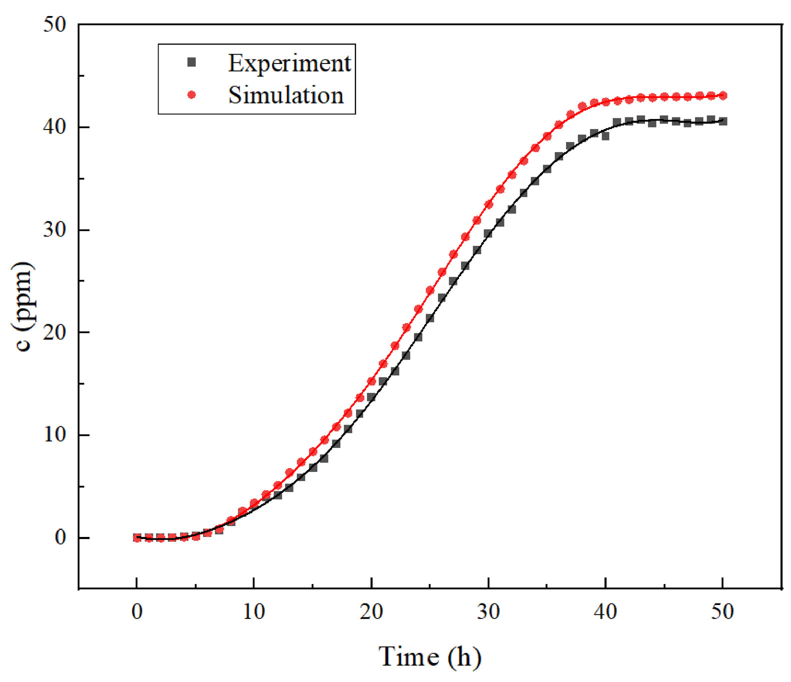

Fig. 6 Comparison of the hydrogen concentration variation.

V. CONCLUSION

The hydrogen diffusion simulation model of an inverted oil-immersed current transformer is established, and the relationship of the hydrogen concentration at the oil outlet with time is obtained, which provides a new method for studying the hydrogen diffusion characteristics of the current transformer.

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