Research and Application Progress on Noise Control of Transformers

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Keywords: Transformer, Noise control, Active noise control, Sound insulation materials

Abstract: Noise pollution of transformers becomes serious among rapid developing communities in modern cities. This paper reviews existing applicable measures of transformer noise control from three aspects: noise suppression of transformer itself, transmission path and transformer peripheral structures. It is indicated that the active noise reduction measure is a targeted noise reduction measure, while the system design and algorithm complexity make it not widely applied. It is also shown that designing a lightweight sound insulation material with high performance for the insulation layer of transformer is a more convenient and long-term noise reduction measure.

1. Introduction

The noise generated during the operation of a power transformer can be divided into three types based on the mechanism: 1) aerodynamic noise generated by gas vibration. 2) It is the electromagnetic noise of the vibration of electrical parts caused by magnetic field pulsation and magnetostriction. 3) Mechanical noise caused by solid vibration. The source of transformer noise can be mainly divided into transformer body and cooling system. The noise of the transformer body mainly comes from the vibration of the transformer core and windings in an alternating electromagnetic field. The noise of the cooling system comes from the vibration of the cooling system itself, mainly the air vibration and mechanical vibration generated by the operation of the cooling fan, which generates aerodynamic noise and mechanical noise, and the vibration of the transformer column is transmitted through the structural parts Noise from vibration generated on other systems.

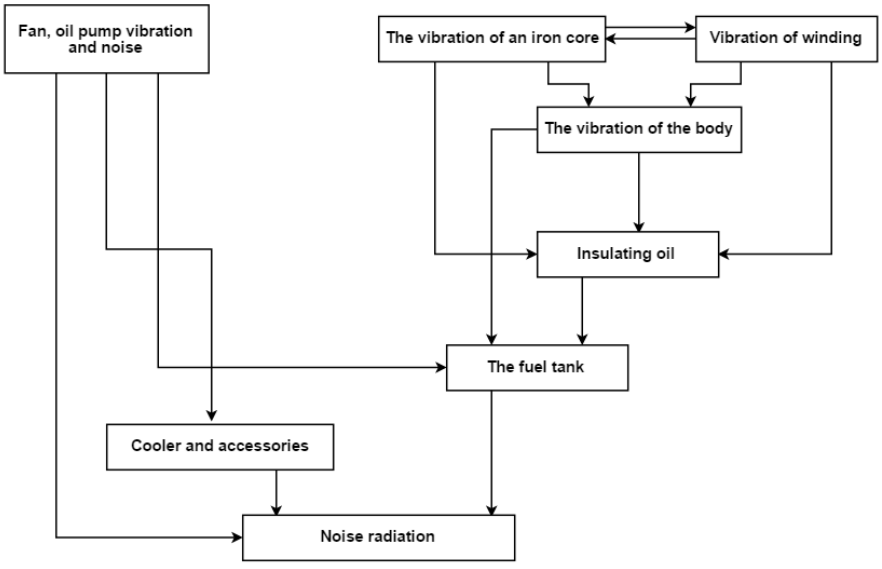

Fig.1 Transmission of Transformer Vibration and Noise

  DOI: 10.25236/iiicec.2019.043

Hu Jingzhu et al. [1] started from the physical mechanism of noise generated by the transformer, established a finite element model of the electromagnetic-structure-sound field of the transformer, obtained the spectrum and spatial characteristics of the sound field of the transformer, and provided a theoretical basis and calculation for the prediction of transformer noise.

Zhu Lihua et al. [2] established the finite element model of electromagnetic-structure-sound field coupling using the principle of energy variation, and further considered the magnetization characteristics and anisotropy of silicon steel sheet.

2. Transformer Body Noise Suppression

The suppression of the transformer body noise mainly includes the work of the material properties and structure of the iron core and the design of the winding structure.

2.1 Material Properties and Structure of Iron Core

Measure 1: Select high-quality iron core silicon steel sheet to improve processing technology. Choosing a high deflection magnetic material has small magnetostriction and good magnetization performance, which can reduce the no-load loss of the transformer. Silicon steel sheets are often severely impacted during production and processing, damaging material properties.

Measure 2: Reducing the working magnetic flux density of the iron core is the most reliable and direct method to reduce the magnetostriction of the iron core silicon steel sheet.

Measure 3: The iron core adopts multi-level joint structure. The more the number of overlapping stages, the more the local magnetic density and the number of times the magnetic flux passes between the core joints decreases, which is beneficial to reducing the core noise.

2.2 Winding Structure Design

Measure 1: Select high-quality iron core silicon steel sheet to improve processing technology. Silicon steel sheet can choose high deflection magnetic material, which not only has small magnetostriction, but also good magnetization performance, which can reduce transformer no-load loss.

Measure 2: Reduce the working magnetic flux density of the iron core. This is the most reliable and direct way to reduce the magnetostriction of iron core silicon steel sheet and reduce the core vibration and noise.

2.3 Passive Noise Reduction

Transformer noise passive control technologies include:

(1) Increase the damping at the junction of the transformer core. Vibration isolation pads are installed between the iron feet and the lower fuel tank to convert the rigid connection into an elastic connection, reducing the transmission of vibration to achieve the effect of reducing noise.

(2) The sound insulation layer or sound absorption layer reduces noise. Materials such as fiberglass or rock wool can be placed between the layers of the transformer tank structure. When the transformer's body noise is transmitted to the sound insulation layer, part of it will be absorbed through the sound insulation layer, and the other part can be reflected back. To achieve the purpose of reducing noise.

(3) The sound absorption structure on the surface of the oil tank is a thin plate resonance sound absorption structure on the periphery of the transformer tank, which absorbs a part of the noise and can suppress the transformer noise from propagating to the air.

2.4 Active Noise Reduction Technology

(1) Research on noise reduction mechanism

Based on the spatial and temporal coherence of the sound field and the principle of linear superposition, by adjusting the amplitude and phase of the secondary sound source, it cancels the interference with the primary sound source in the target area, thereby achieving noise reduction. Studying the acoustic interference characteristics of primary and secondary sound sources is critical

to the design of active noise reduction systems.

(2) Research on Equivalent Model of Transformer Noise

When performing active transformer noise reduction experiments in the laboratory, speakers are usually used to simulate transformer noise. Li Cailian et al. [3] proposed an equivalent sound source model that is more in line with the actual acoustic radiation characteristics of speakers than the point sound source model. The conclusion of this study can provide some guidance for the optimal layout of secondary sound sources.

(3) Design of active noise reduction system

ANC system based on disturbance tracking method. The perturbation tracking method algorithm adjusts the perturbation voltage to the maximum point of the output power by applying the perturbation voltage and determining the direction of the output power change. Wang Jinwei et al. [4] proposed a perturbation tracking method for perturbative tracking of three frequency components of 100 Hz, 200 Hz, and 300 Hz. This method has the best noise reduction effect on 100 Hz frequency noise components, but its tracking ability varies with the frequency of the signal. Increase and decrease. The active noise control system does not consider the optimization of the placement of secondary sound sources. In addition, the three noise frequency components are used as targets to be eliminated, and the noise reduction effect can only be achieved in a certain area. The actual tracking performance of the algorithm is not guaranteed.

Adaptive inverse control transformer noise cancellation system. Wang Guodong et al. [5] designed an active noise reduction system for power transformers using adaptive inverse control theory. The scheme diagram of the power transformer active noise reduction system based on the adaptive inverse control theory is the same as that in Figure 2. It is mainly divided into three parts: adaptive modeling of the secondary channel transfer function, adaptive implementation of the controller, and object disturbance canceller.

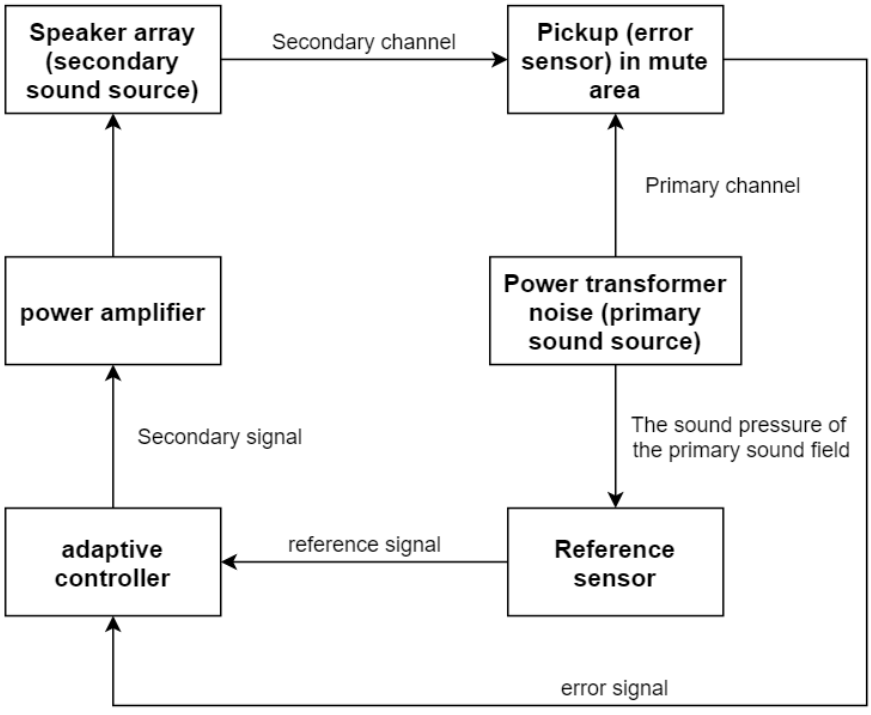

Fig.2 Adaptive Inverse Control Transformer Noise Control Scheme

3. Noise Suppression Using Transformer Peripheral Structure

The cooling system around the transformer is also one of the main sources of noise. Optimizing the cooling system can reduce noise. In addition, a sound insulation structure for suppressing transformer noise can be installed around the transformer.

(1) Optimization of cooling system

The noise of the structural parts on the transformer will be superimposed with the noise of the cooling system, so self-cooled transformers should be used to reduce the noise of the cooling system as much as possible. For large-capacity transformers, the cooling system of low-speed fans should be selected as much as possible.

(2) Box-In structure

The fixed Box-In is a closed hexahedron soundproof room with a sound absorber attached to reduce the internal reverberation of the Box-In. The detachable Box-In improves the installation method. The mobile Box-In is a part of the Box-In steel structure fixed on the converter transformer and can be moved with the equipment, which is convenient for the maintenance and repair of the converter transformer.

(3) Sound insulation cover design

Mao Wanhong et al. [6] designed an acoustic enclosure with a ventilation and cooling system based on the analysis and calculation of transformer noise, heat generation, and summer ventilation for outdoor box-type power distribution transformers. The main purpose is natural ventilation and mechanical ventilation. As a supplement, the main material is a 2mm thick steel plate with a damping layer, and a muffler is provided at the vent to ensure a high sound attenuation at low and medium frequencies.

4. Concluding Remarks

Based on the analysis of transformer noise sources, this paper summarizes and analyzes the current research on transformer noise reduction technology from the three aspects of transformer structure noise suppression, noise suppression in the propagation path and noise suppression of transformer peripheral structures. And application progress. In related technologies, the algorithm structure of the active noise reduction technology is relatively complicated, and the noise reduction effect is good but the pertinence is too strong and has not been widely used; the sound insulation cover needs to be conveniently designed without affecting the maintenance and repair of the transformer. Acoustic performance; Once the design of sound absorption and insulation materials is broken, the combination of sound insulation materials and sound insulation hood designs will be a cost-effective transformer noise reduction measure and is expected to be widely used in transformer noise reduction.

Acknowledgement

This work was funded by the Zhejiang Provincial Electric Power Co., Ltd. 2019 collective enterprise technology project.

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