Simulation on Far Field Eddy Current Detection on Condenser Tube Groups in Fossil Power Plants (II)

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Abstract. Condenser tube tubes are widely applied in condenser in thermal power plants. Leakage often occurs in condenser tube groups due to the quality of condenser media or high serving stress. Condenser tube leakage not only brings economic losses to power stations, but even influences the safety operation of the power generation units. This paper simulates and experimentally studies the influence of wall thickness and frequency on the far field current. Experiment on ferromagnetic tube with defects detecting by eddy current has also been carried out. The result verifies the simulation conclusions. Far field current examination technique could judge and recognize the defects in ferromagnetic tube. It is a useful and effective method in defect emanation in fossil power plant

Numerical Simulation of Far Field Eddy Current

Influence of Wall Thickness on Far Field Eddy Zone under Fixed Tube Inner Diameter

This part is to study the influence of tube wall thickness on far field eddy current zone with the tube with same size. When the inner thickness keep the same, to study if the eddy current will formed when increasing the wall thickness.

Different far field eddy current simulation models have been established. The inner diameter of the tube has been set as 12mm. Wall thickness is 1mm, 3mm, 5mm and 7mm. The curve of log (Bz) varies with distance under different wall thickness has been obtained by simulation, refers to figure 1.

When wall thickness is 1mm, the far field zone position is closer to the exciting coil compared with the position when the wall thickness is 3mm. This means that the position of the far field zone moved forward with the increasing of wall thickness. When wall thickness is 5mm and 7mm, curves of log (Bz) varying with distance meet together. No turning point from sharp to smooth could be found in the curve. This means that the magnetic line could no longer penetrate the tube wall to form far field when the wall thickness exceeds 5mm [1].

According to the above simulation result, when the inner diameter of the tube is 12mm and wall thickness changes from 1mm to 3mm, the position of far field zone will be closer to the to the exciting coil with the increasing of wall thickness. When the wall thickness of the tube reaches 5mm, no far field exists and no eddy current will form.
Influence of Tube Inner Diameter on Far Field Eddy Zone under Wall Thickness

In theory the distance between far field zone and the center of exciting coil is 2-3 times of the tube inner diameter. This part is to verify the relationship of 2-3 times is in accordance with theory result or not.

Different far field eddy current simulation models have been established. The Finite Element Method simulation parameters have been set as followings: wall thickness of the tube has been set as 12mm, tube inner diameter is 5mm, 10mm, 15mm and 20mm. The curve of log (Bz) varies with distance under different inner tube diameter has been obtained by simulation, refers to figure 2. It can be seen that with the increasing of tube inner diameter, the position of the far field zone is far to the exciting coil.

According to the above simulation result, when the wall thickness of the tube is fixed, the distance of far field zone is 4-5 times of the inner diameter tube, which is larger than the theoretical 2-3 times.

Figure 1. Changes of log (Bz) with distance under different tube wall thickness.

Influence of Tube Inner Diameter on Far Field Eddy Zone with Different Frequency

This part is to study the influence of different frequency on the position of far field eddy current.

Different far field eddy current simulation models have been established. The simulation parameters have been set as followings: far field eddy current frequency is 50Hz, 70Hz, 90Hz, 110Hz and 130Hz. The inner diameter of the tube is 12mm. Under different frequency, the relationship of log (Bz) and distance has been simulated. Here Bz is the amplitude of magnetic field in the tube axle, refers to figure 3. It can be seen that with the increasing of far field eddy current frequency, the distance between far field zone and the exciting coil is increasing.

Decreasing eddy current frequency could increase the eddy current skin depth and decrease the eddy current energy to penetrate from the tube wall into the air. The indirect coupling energy will return to the examining coil, which may reduce the distance between far field zone and exciting coil [2].

Experimental Verification

Experimental Parameters

According to the above analysis, the verification frequency has been set as 50Hz. The distance between the examining coil and exciting coil is 60mm. Figure 4 indicates the experimental structure for verification based on ferromagnetic tube.
Figure 2. Changes of log (Bz) with distance under different tube inner diameter.

Figure 3. Changes of log (Bz) with distance at different frequency.

Experimental Sample
A ferromagnetic tube has been chosen for verification. The diameter is 12mm, wall thickness is 2mm, length is 665mm. The artificial defects includes the following: 1) through-hole with 1mm diameter; 2) half through-hole with 1mm diameter and 1mm depth; 3) half through-hole with 3mm diameter and 1mm depth; 4) half through-hole with 5mm diameter and 1mm depth; 5) 4 half through-hole with 5mm diameter and 1mm depth. The artificial defect is prepared according to NB/T47013.
Experimental Results

Figure 6 indicates the verification results. The examination frequency is 50Hz. All the artificial defects have been detected. The reflection signals, including through-hole with 1mm diameter, half through-hole with 1mm diameter and 1mm depth, half through-hole with 3mm diameter and 1mm depth, half through-hole with 5mm diameter and 1mm depth, 4 half through-hole with 5mm diameter and 1mm depth are clearly indicated. This means that the far field probe could find all the defects. The far field theoretical research results have been experimentally verified.
Conclusions

1 When the inner diameter of the tube is fixed, the position of far field moves backwards with the increasing of wall thickness. When wall thickness reaches certain value, the magnetic line could not penetrate into tube wall for forming far field, no far field will exist.

2 When the wall thickness of the tube is fixed, the position of far field moves backwards with the increasing of tube diameter.

3 When exciting frequency is fixed from 50~150Hz, the position of far field moves forwards with the increasing of frequency.

4 The theoretical calculation of the far field has verified by experiment. Four types of defects have been prepared on ferromagnetic tubes with 12mm inner diameter and 2mm wall thickness. When the distance of exciting coil and receiving coil is 60mm, all the defects could be detected by self-prepared far field eddy current probe.

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