Research on Shielding Effectiveness of UHVDC Hall Structure

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Abstract —In ultra high voltage direct current (UHVD) converter station， working converter valve can produce electromagnetic interference to the equipments in the convertor station and communication system in the near-by area， generally we must take electromagnetic shielding measures strictly to reduce the electromagnetic radiation. As supporting and shielding structure for converter valve tower, UHVDC hall has large scale and the distribution of inner electromagnetic field is heterogeneous， therefore the shielding analysis for traditional structure is no more applicable.In this paper aperture coupling in large scale space is applied to study shielding effectiveness. With complex shielding structure， a convertor station hall model is created and further we compute the field value of each shielding structure. Shielding effectiveness of UHVDC hall is obtained according to the calculation data. The simulation results are closer to reality, and it makes more significance for the design of the UHVDC project.

I. INTRODUCTION

When converter valve makes DC into AC or AC into DC, the valve tower will switch rapidly and produce electromagnetic interference[1,2].The electromagnetic interference value will superpose when the electromagnetic wave transmit in metal circuit, therefore the amplitude value increase and result in electromagnetic interference escaping. Converter transformer， smoothing reactor and other equipments have large volume and complex structures， partial structure must pass through the hall wall and connect with valve tower. Adding blocking material in UHVDC hall wall bushing can reduce electromagnetic interference escaping[3]. Furthermore the gate structure and hall lap structure also affect the shielding effectiveness of the UHVDC hall. This article mainly studied UHVDC hall modeling, especially the gate structure, wall bushing structure and hall lap structure. The shielding effectiveness of UHVDC hall is obtained according to the simulation results.

II. ANALYSIS ON SHIELDING EFFECTIVENESS AND APERTURE COUPLING THEORY

A. Shielding effectiveness

The shielding effectiveness (SE) is known as the measure of the protection against the propagation of electromagnetic fields from one region to another by using conductive or magnetic materials[4]. SE is defined as

$$SE_{dB} = 10\log\left(\frac{P_1}{P_T}\right) = 20\log\left(\frac{E_1}{E_T}\right) = 20\log\left(\frac{H_1}{H_T}\right)$$

Where P_I (E_1 / H_1) and P_T (E_T / H_T) are the power (electric/magnetic field) of incident and transmitted electromagnetic waves respectively.

B. Aperture coupling theory in large scale space

Solving the aperture problem by equivalence principle[5]

$$J_s = n\times(H^a - H^b)$$

$$M_s = (E^a - E^b)\times n$$

Where, (J_S， M_S) represent the equivalent current and equivalent magnetic current. We can solve the problem when there is an aperture on conducting plane by the equivalence principle as illustrated.

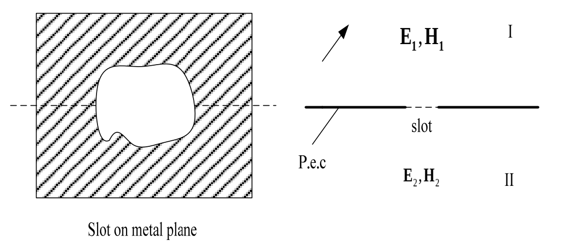

Fig. 1. Aperture problem by equivalence principle

In zone 1, paste the perfect conductor plane S on the aperture, and introduce equivalent sources on S.

$$J_1 = n\times H_1$$

$$M_1 = E_1\times n$$

The field of zone 2 is counteracted under the simultaneous action of equivalent source and origin source. The digestion vector field of the conductor surface is zero, so the equivalent magnetic current M_1 exist only in the aperture region. From the principle of Mirror Image we know that primary current is offset by the equivalent magnetic current and the tangency mirror current of the conductor surface, and the equivalent current is zero. The primary magnetic current is increased by the mirror magnetic current, so the equivalent magnetic current on the aperture becomes twice of the original current. As follows

$$J_2 = (-n)\times H_2$$

$$M_2 = E_2\times(-n)$$

For the multi-aperture problem, the equivalent magnetic current is expressed as follows

$$M_i^{jk} = \sum_{i=1}^{N_{jk}} V_i^{jk} M_i^{jk},\ j = 1,2...;k = 1,2...$$

Substituted into the operator equations, and the solution of the moment can be obtained. Symmetric inner product is defined as follows

$$< F,G >= \int_{A_{ij}} (FG)dx$$

Multiply both sides of the formula with weight function, then calculate their inner product, and the generalized network equations is obtained as follows

$$\{[Y^a]+[Y^b]+[Y^c]\}V = I$$

So, the transmission field of the inner aperture can be calculated based on the voltage vector which is obtained from the above formula.

III. MODELING AND NUMERICAL ANALYSIS

A. Valve tower far field radiation

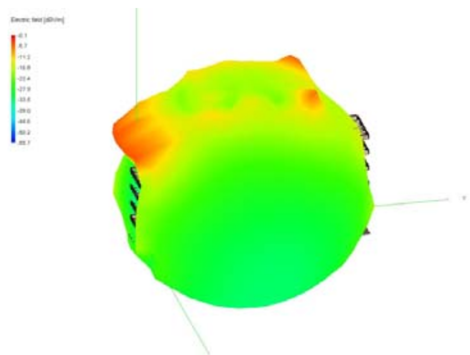

Fig. 2. valve tower E-field radiation

According to the real valve station condition， we put testing voltage on the valve tower. The converter valve model and far field radiation is as above.

B. Numerical Analysis

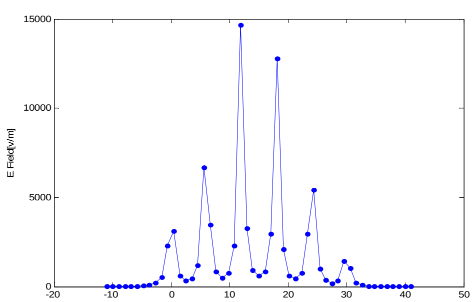

Fig.3. 1MHz: no blocking material wall bushing field value

Because the frequency of inner electromagnetic wave mainly concentrate in low frequency range[6]，we compute at 1MHz and 3MHz.The shielding effectiveness of UHVDC hall structure is as fellows(shielding effectiveness of gate and lap structures are not given here).

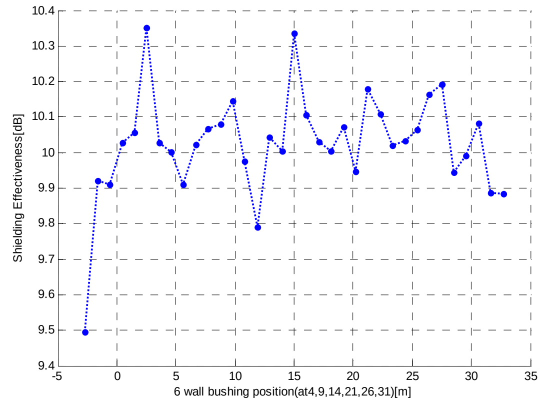

Fig. 4. 1MHz: Shielding effectiveness of wall bushing

IV. CONCLUSION

When the valve tower is switching or on operation state, it produces electromagnetic interference. These electromagnetic wave can transmit outward from UHVDC hall, especially gate， wall bushing and hall lap. Shielding effectiveness is related to electromagnetic wave frequency and different shielding structures. When frequency increases, the shielding effectiveness of gate structure and hall lap structure reduce. However， it also meet the shielding requirement 40dB.The shielding effectiveness of wall bushing will increase when the frequency increases also. But the shielding effectiveness is only about 10dB. We can improve the situation by adding absorbing materials.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

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