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Influence of Shielding processes on Field Strength of Reverberation Chamber

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Abstract

In order to study the influence of shielding technology of reverberation chamber (RC) on the field strength, the equivalent reflection coefficient of RC is obtained from PDP (Power delay profile). By comparing the RC of four different shielding processes with the same cavity size, the same net input power can obtain higher field strength in the RC with galvanized steel plate welding (GSPW). The experimental results show that the net input power of the RC with GSPW is lower than that of the RC with copper plate welding (CPS) when the field strength reaches 100V/m, and the typical value is 2dB.

1 Introduction

The RC has been widely used in Electro Magnetic Compatibility (EMC) testing [1]. Compared with the anechoic chamber, the biggest advantage of RC is that higher field strength can be obtained with lower feed power [2]. The field strength of the RC is formed by the superposition of electromagnetic waves reflected by the metal cavity wall. With the propagation of electromagnetic wave in the RC, the energy of electromagnetic wave is also dissipated according to a certain law, and a large part of the energy is absorbed by the cavity wall and dissipated into heat energy [3, 4]. The energy left over after dissipation determines the field strength, the more energy left, the stronger the field. The energy dissipated by the cavity wall is directly related to the cavity material and shielding technology. In this study, the energy reflection coefficient of electromagnetic wave in RC is obtained from PDP, and then the influence of different materials and shielding technology on the field strength of RC is analyzed, provides reference for the comprehensive cost consideration of building RC.

2 Equivalent Reflection Coefficient

1) In RC, the average propagation time of the electromagnetic wave reflection path can be expressed as [5]:

$$t_{\text{ave}} = \frac{8V}{cS} \tag{1}$$

where c is the speed of light, V is the volume of the cavity in RC, and S is the surface area of the cavity.

2) PDP of wireless channel in RC could be explained by multi-attenuated-reflections as shown in Figure 1. Statistically, power of electromagnetic signal will attenuate with certain factors after each reflection. Then PDP before and after each t_{ave} should be expressed as follows [6]:

$$PDP(t + t_{\text{ave}}) \approx R \times PDP(t) \tag{2}$$

where R is the attenuation factor of each reflect. Submitting

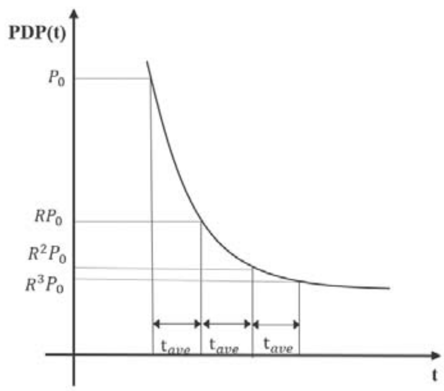

Figure 1. PDP explained by attenuated reflection.

(1), (2) to $PDP \approx \exp(-t/\tau)$, attenuation factor of each reflect can be expressed as:

$$R \approx \exp(-t_{\text{ave}}/\tau) \tag{3}$$

where τ is the attenuation time of the RC, and its expression is [7]:

$$\tau \approx \frac{3V}{2S\omega\mu_r\delta} \tag{4}$$

where $\delta \approx \frac{2}{(\omega\mu\sigma)^{\frac{1}{2}}}$, V is the volume of the RC, S is the internal surface area of the RC, ω is the angular frequency, μ_r, μ, σ are the relative permeability, permeability and conductivity respectively. Equation (3) can be written as:

$$R \approx \exp(-\frac{32}{3c}\mu_r \times \sqrt{\frac{\omega}{\mu\sigma}}) \tag{5}$$

3) The equivalent reflection coefficient is defined as the weighted average of all reflective surfaces, similar to what

is done in acoustic and electromagnetic cavities [8]and [9], and its expression is:

$$R_{\text{eff}} = \frac{\sum R_n S_n}{\sum S_n} \tag{6}$$

Where S_n is the area of material n.

3 Simulation

The shielding technology of RC is divided into three types according to the metal materials used: galvanized steel plate, copper plate and aluminum plate. According to the electric continuous scheme of metal materials, there are two main types: welding type and splicing type. Because the copper plate and aluminum plate generally only use the splicing process, so there are four main types of shielding process: galvanized steel plate welding (GSPW), galvanized steel plate splicing (GSPS), copper plate splicing (CPS) and aluminum plate splicing (APS). For the welding method, it can be regarded as the reflection caused by the same material, and the splicing method can be regarded as the electromagnetic wave at the splicing place is absorbed by the conductive lining material in the gap. The reflection coefficient in Equation (5) considers that all reflective surfaces are the same, and for reverberation chambers with different shielding processes. For the RC with four different processes of GSPW, GSPS, CPS and APS, Assuming that the reverberation chambers are of the same size and the gap between the metal plates accounts for 0.1% of the total area of the whole cavity.

The permeability and conductivity of common metal materials are shown in the following Table 1.

Table 1. μ_r and σ_r of some metallic materials

Material	Relative permeability μ_r	Relative conductivity σ_r
Sliver	1	1.064
Copper	1	1
Gold	1	0.70
Aluminum	1	0.61
Zinc	1	0.305
Iron	200	0.17

The equivalent reflection coefficient with four different materials and shielding processes is calculated, as shown in Figure 2. Although copper and aluminum can obtain higher reflectivity than galvanized steel on the metal surface, the splicing process used when using copper and aluminum and other materials will produce reflection loss of the order of 10^{-3}, and the corresponding loss of galvanized steel welding is still on the order of 10^{-5}. Therefore, from the overall effect, the influence of the gap between the metal plates is two orders of magnitude higher than the influence of the

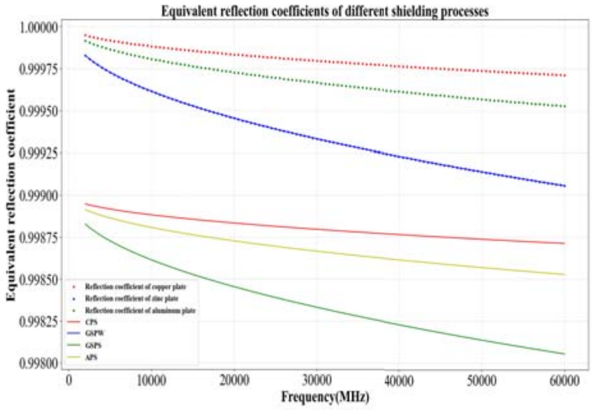

Figure 2. Equivalent reflection coefficients of RC with different shielding processes.

metal surface. Welding is the focus of process and metal materials don't play the most important roles here. So RC construction with GSPW would be an appropriate choice.

4 Measurement

In order to verify the above conclusions, we did field tests on the RC with two different shielding processes: GSPW (inner cavity size: 6.43m × 5.09m × 5.57m) and CPS (inner cavity size: 10.60m × 6.80m × 4.60m). Considering the loss caused by the difference size of RC, the attenuation compensation of galvanized steel RC is carried out according to that of copper spliced RC, and the power curve required for the normalized 100V/m field strength is shown in Figure 3:

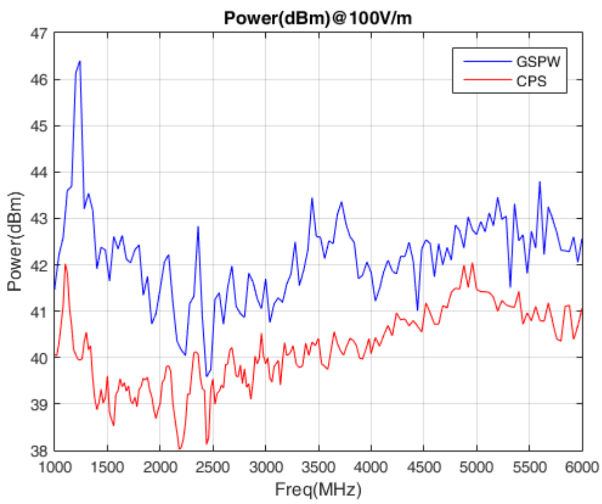

Figure 3. Comparison of net input power between GSPW and CPS RC at 100V/m field strength.

After removing the influence factors such as cable and size, the net input power required to reach 100V/m field intensity (red curve is RC using GSPW, blue curve is RC using CPS), the measured performance of the RC using GSPW is better than that using CPS, and the typical net power saving is 2dB.

5 Conclusion

GSPW is appropriate for the construction of RC for EMC, which can bring less electromagnetic wave reflection loss and save the net input power. The main reason is that the influence of the gap between the metal plates is two orders of magnitude higher than that of the metal surface.

Acknowledgements

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