Overview of Reverberation Chamber

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Abstract. This paper introduces the basic concept and basic structure of the Reverberation Chamber, as well as its development process. Present situation of the theoretical research and application research on Reverberation Chamber are also introduced. It is emphasized that the Reverberation Chamber has inherent advantages in building a closed controlled, three-dimensional and multi-dimensional electromagnetic environment, and the Reverberation Chamber has broad prospects for development.

Key words: Reverberation Chamber, Theoretical Research, Application Research.

THE BASIC CONCEPT OF REVERBERATION CHAMBER

Reverberation Chamber

The Reverberation Chamber is a multimode shielding cavity with electrically large and high Q value [1]. The transmitting antenna of the Reverberation Chamber injected the electromagnetic wave into the Reverberation Chamber in the form of a beam. Agitating and the strong reflecting of the cavity would form a random field with high field strength and uniform statistics in the Reverberation Chamber. The Reverberation Chamber technology has broken the traditional method to improve the field uniformity by sacrificing the electromagnetic wave reflection and opened up a new way for the uniform field simulation technology.

Structure of Reverberation Chamber

A typical Reverberation Chamber is made up of main parts and auxiliary devices, as is shown in Figure 1 [2].

Apparently, the main part is constituted of shielded cavity, mixing equipment, transceiver antenna and test equipment (EUT). Composing of six good conductor metal walls, the shielding cavity which high conductivity makes the energy loss very little after the reflection of the cavity wall, ensures the high energy utilization of the Reverberation Chamber. The material of the mechanical stirrer is the same as that of the cavity wall. The location in the Reverberation Chamber is generally perpendicular to each other, so that the independent stirring position can be increased as much as possible. The role of transceiver antenna is to provide signal source and to acquisite data. The working frequency, bandwidth and polarization state of antenna are generally considered when selecting and sending antennas. In addition to low frequency limitation, the Reverberation Chamber has a wide range of frequency bands, so there are many kinds of antennas for transceiver antennas selection such as logarithmic periodic antennas, horn antennas and so on. The IEC standard stipulates that the distances between EUT and cavity wall and the distance between EUT and agitator are 1/4 working wavelengths at least, so in the course of the experiment the test equipment is generally taken up with a certain height of non-conductive material, as shown in Figure 1.

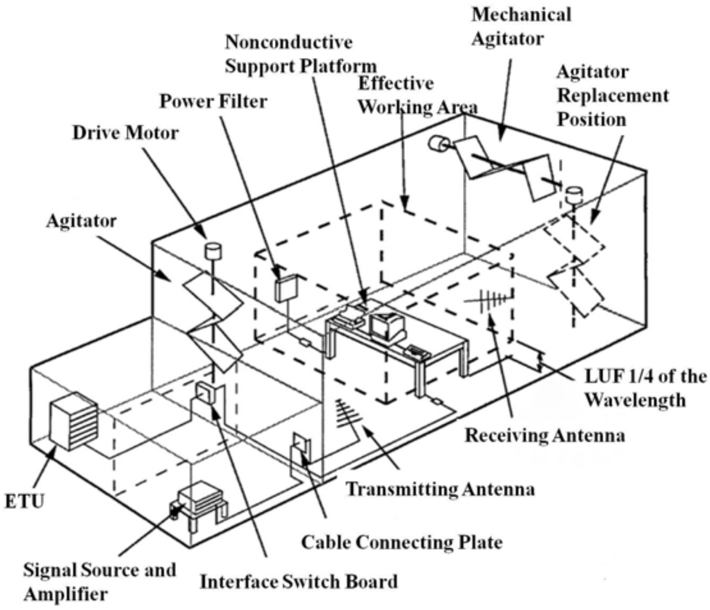

FIG. 1. Typical Reverberation Chamber structure

The auxiliary equipment mainly includes drive motor, signal generator, power amplifier and receiving device. The driving motor controls the agitator to rotate according to the established speed and mode. Signal generator and power amplifier are mainly used to provide a specific type of excitation source for Reverberation Chamber. Because the signal generated by the signal generator is generally weak, the power amplifier is needed to be amplified and then injected into the Reverberation Chamber to achieve effective and continuous signal injection.

There is a special point to be explained that IEC-61000-4-21 has made a clear [3] for the effective working area of the Reverberation Chamber, which is that the distribution of the field is uniform in the area of 1/4 working wavelengths at least beween the cavity wall and the agitator,as is shown in the dotted line area in Figure 1. During the experiment, the test equipment and receiving antenna should be placed in the effective working area, and the transmitting antenna should be placed outside the effective area.

THE DEVELOPMENT PROCESS OF REVERBERATION CHAMBER

The Reverberation Chamber has been introduced into the electromagnetic field since 1968. After more than 10 years of active exploration, the Reverberation Chamber technology has obtained a certain research result [4-6]. However, in view of the problem that the traditional testing methods are not difficult to solve at that time, the research on Reverberation Chamber has not been very demanded intensely, which leads to the research process of the Reverberation Chamber be slowly at one time.With the increasing demand for radiation immunity (EMI) in heavy industry, we hope to carry out high field and high frequency radiation experiments on large size EUT. For open field and half wave Chamber, because of its low energy utilization, it needs higher power amplifier to meet the requirements, but this will greatly improve the cost of testing [2]. Thanks to this opportunity, Reverberation Chamber has come back to people's vision and has been developing rapidly. In 1986, the Mike L. Crawford team in the United States carried out a large number of experimental studies around Reverberation Chambers and launched a large number of useful results through the report (NIST-TN1092), which laid the experimental foundation for the next step of the Reverberation Chamber [7]. Thanks to the active exploration of many experts and scholars in the theory and experiment of Reverberation Chamber, Reverberation Chamber has become the key technology of EMC testing since 1990s

PRESENT SITUATION OF THE THEORETICAL RESEARCH ON REVERBERATION CHAMBER

Foreign aspects. As early as the 90s of last century, the David C.C of the United States systematically studied the relationship between the intrinsic modulus of electromagnetic field and the different experimental conditions in Reverberation Chamber, and first proposed the effect of the mode number on the homogeneity of the inner cavity [8]. In 1991, Kostas Joseph G and Boverie Bill derived the PDF of the electromagnetic field in the Reverberation Chamber and established the statistical distribution model [9]. Subsequently, T.H. LEHMAN applied the complex cavity theory to the Reverberation Chamber and analyzed the statistical model in the cavity more deeply [10]. Then, David A.Hill derives the statistical characteristics of the electromagnetic field in Reverberation Chamber and the response of the antenna receiving, and gives the measurement methods of the main parameters of the Reverberation Chamber such as the quality factor Q, the time constant and the shielding effectiveness, and further perfects the basic theory research system of the Reverberation Chamber [11]. With the gradual improvement of basic theory, people began to focus on the optimization of Reverberation Chamber, the design of new Reverberation Chamber, and the theoretical study of its parameters. In structural optimization, the British National Institute of Physics (NPL) analyzed the relationship between the shape of the agitator and the lowest usable frequency (LUF), stirring efficiency and electromagnetic field of the Reverberation Chamber, and designed a reconfigurable agitator in 2000. L. R. Arnaut studied the effect of agitator on the performance of Reverberation Chamber, providing a theoretical support for further structural optimization [12]. In 2012, D.Fedeli designed a stirrup horse stirrer, which can increase the number of independent stir positions and field uniformity[13]. In the development field of the new Reverberation Chamber, David A.Hill realizes real-time statistical homogeneous fieldby injecting narrowband signal [14]. D. J. Edwards of University of Oxford first proposed the use of the location of the excitation source to change the field uniformity of Reverberation Chamber [15]. In 2005, G. Cerri et al. studied the operability of source location agitation, and further verified the feasibility of source stirring technology to achieve statistical uniform field [16]. In 2014, L. R. Arnaut was designed to switch in source Reverberation Chamber by switch [17]. In the study of the parameters of the Reverberation Chamber, C. Lemoine and others studied the relationship between the mixing efficiency of the Reverberation Chamber and the mixing mode [18]. F. Moglie et al. studied the relationship between the internal setting of the Reverberation Chamber and the independent mixing position [19]. A. Gifuni and others studied the probability density function function of the quality factor in the Reverberation Chamber of different mixing types [20].

At home, the Reverberation Chamber was introduced into China in twenty-first century and has achieved a lot through these years' development. Dr. Ding Jianjin of Beijing Jiaotong University, using the eigenfunction method, derives the analytical expression of the three-dimensional electromagnetic field in the Reverberation Chamber, classifies the state of the Reverberation Chamber according to the number of modes and defines the physical meaning of different states [21]. Tan Wuduan analyzed the chaotic characteristics of the Reverberation Chamber and analyzed the statistical characteristics of the electromagnetic field inside the cavity by chaos theory. The result is consistent with the theory [22]. Zhou Xiang used FDTD (Finite Difference Time Domain) to analyze the influence factors of the performance of the Reverberation Chamber [23]. And Zhu Sai designed a swinging Z agitator and a double N rotary agitator and had been put into use [24]. Yue Chongyi used array antenna instead of the traditional single antenna to realize the mixing in the Reverberation Chamber [25], which Liu Yifei and others have verified the feasibility of frequency mixing technology in building uniform electromagnetic field [26]. To sum up, great progress has been made in the introduction of the concept of Reverberation Chamber, the analysis of the principle and the verification of the existing methods, but there is still a certain gap with the world's advanced level.

PRESENT SITUATION OF THE APPLICATION RESEARCH ON REVERBERATION CHAMBER

The traditional Reverberation Chamber was the electromagnetic compatibility testing device [27, 28]. In recent years, the application of Reverberation Chamber has expanded from single EMC test to biological, communication and other new fields. In the field of biology, Yijian Gong [29] and others rely on the National Toxicology Program (NTP) which is in charge of the National Institute for Environmental Health Sciences to evaluate the life dose of rodents exposed to the Reverberation Chamber. J. Chakarothai[30] et al. used Reverberation chamber as a whole exposure system of small animals for dose detection. Reverberation Chamber technology promotes the development of life dose testing effectively. In the field of communication, the Reverberation Chamber can be used in the OTA

(Over-The-Air) test [31-37] for wireless devices, including the measurement of the antenna radiation efficiency (SF) [31], the diversity gain [32] and the channel capacity of the MIMO system, as well as the total radiation work rate [37] and the omnidirectional sensitivity test for the mobile devices and the base stations. The Reverberation Chamber can also be used as a wireless channel simulator. C. Lemoine and C. L. Holloway are used in the Reverberation Chamber for fading channel simulators, and the Rice fading channel [38] is successfully simulated. This also provides a powerful support for the simulation of the clutter environment. At present, the application field of Reverberation Chamber is further expanding. In recent years, a large number of scholars have begun to test by using Reverberation Chamber to test ACS (absorption and interception area) of complex subject matter [39]. L. Kone uses Reverberation Chamber to test the backscatter power of RFID electronic tags [40].

CONCLUSION

As mentioned above, the basic concept and structure of the Reverberation Chamber, as well as its development process are introduced in this paper. What's more, present situation of the theoretical research and application research on Reverberation Chamber are also introduced. It is emphasized that the Reverberation Chamber has inherent advantages in building a closed, controlled, three-dimensional and multi-dimensional electromagnetic environment, and the Reverberation Chamber has broad prospects for development.

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