Simplified Model and Simulation Analysis of Ferrite Hollow Bead Coating Based on Computer Aided Design Method

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Abstract: When ferrite hollow beads were made into coating materials, because ferrite hollow beads had hollow internal structure and conductive and magnetic ball wall, ferrite hollow beads have typical resonant ball characteristics in structure. The absorbing coating composed of numerous ferrite hollow beads could be considered as a resonant absorber. With the rapid development of information technology, especially computer technology, the introduction of computer simulation technology can often save experimental costs and reduce the blindness of experiments. Therefore, in order to comply with this development trend, this chapter will establish the absorber model of ferrite hollow bead coating based on HFSS (high frequency simulator structure) electromagnetic simulation software, and qualitatively analyze the relationship between the thickness of ferrite hollow bead coating and the resonant frequency of absorber and the distribution state of electromagnetic field inside the coating through the of computer simulation software.

1. Introduction
With the rapid development of information technology, especially computer technology, the introduction of computer simulation technology could save experimental costs and reduce the blindness of experiments, which had become a method to explore research ideas and enrich research means and had been the development trend of scientific research in the future. The simplified model of ferrite hollow bead coating was constructed based on computer aided design method in this paper for deeper research on absorbing wave mechanism of ferrite hollow bead coating and a more intuitive understanding of the relationship between the thickness of ferrite hollow bead coating and the coating performance. According to the structural characteristics of ferrite hollow beads, the ferrite hollow bead coating was simplified into a resonant cavity model. The qualitative relationship between the coating thickness and the resonant frequency of the absorber and the distribution state of the electromagnetic field in the coating was analyzed based on this simplified model, which would provide reference and help for the future application of ferrite hollow bead coating.

2. Model Construction

2.1 Design of simplified model construction
When the electromagnetic wave was incident on the surface of ferrite hollow bead coating, it could be seen that the particle chain composed of beads interacts with the electromagnetic wave, and the particle size of hollow beads was much smaller than the wavelength of electromagnetic wave. Therefore, the absorber composed of hollow beads could be simplified into a cylindrical resonator, so
the simulation research could be carried out according to the design mode of cylindrical resonator. The relationship between resonant frequency and thickness of microwave absorbing coating was studied. Figure 1 shows the simplified structure of Ferrite Hollow Bead absorber, where D was the particle size of hollow bead and H is the thickness of coating. The thickness of coated absorber could be adjusted by HFSS software.

2.2 Parameter setting of the simplified model
Based on the above research ideas, the ferrite hollow bead coated absorber was simulated and analyzed. In order to make the simulation study representative, this simulation study takes the ferrite hollow beads with good microwave absorbing effect and BaFe12O19 as the main phase as the simulation object. According to the design experience of the coating and considering the characteristics of the analyzed absorber model, first set the thickness of the coating h as 10mm and the section radius r as 10mm. From the data obtained from the test, The ferrite hollow beads with BaFe12O19 as the main phase had the lowest reflectivity at 15.2GHz. At this time, the electromagnetic parameters of the hollow beads were $\varepsilon' = 0.75$, $\varepsilon'' = 1.10$, $\mu' = 0.76$, $\mu'' = 0.02$. Therefore, set the properties of the material according to this.

2.3 Description of Simulation environment
According to the basic method and mode of cylindrical resonator design environment, the design environment was described and set as follows:
1. Solution type: mode solution
2. Model Manipulation: cylinder resonant structure
3. Boundary condition: finite conductor boundary.
4. Solution setting: the minimum frequency was 3GHz
5. Post processing: resonance frequency, quality factor Q and field strength distribution diagram.
6. Optimetrics: parameter scan analysis.

3. Results and analysis
In the results node under the project tree, select [solution data] from the pop-up menu to open the solution result display window. Click the eigenmode Data tab to view the resonant frequency and quality factor Q under mode 1 and mode 2. You can see the resonant frequency from the figure. By changing the coating thickness through parameter scanning analysis, the change trend of resonant frequency can be obtained after changing the coating thickness H. Figure 2 showed the simulation analysis results.
As can be seen from Figure 3, the resonant frequency in mode 1 (i.e. TM010 mode) was 11.603 ghz and the quality factor Q was 1888. In mode 2 (i.e. tm111 mode), the resonant frequency is 17.45 ghz and the quality factor was 7026. The difference of simulation results between the two modes was mainly due to the difference of electromagnetic wave propagation mode. According to the usual thickness range of coated microwave absorbing materials, the two cases of thickness h = 6mm and H was 16mm were studied respectively. Figure 3 shows the simulation results when h was 6mm and figure 4 shows the simulation results when h was 16mm.
Through the comparison of figures 2, 3 and 4, it could be seen that when the electromagnetic wave was incident from the side, the change of coating resonance frequency has little relationship with H, but when the electromagnetic wave was incident vertically, when $h$ increased from 6mm to 10mm and then to 16mm, the resonance frequency would change from 18.53GHz to 17.45GHz, and then reduce to 12.92 GHz. It could be seen that when the thickness of the coating increases, the resonant frequency decreases.

Figure 5 showed the distribution of electric field and magnetic filed inside the coating when electromagnetic wave was incident from the side. Due to the change of coating thickness, the distribution law of electromagnetic field in the coating was also different. Especially when the electromagnetic wave is incident vertically, with the increase of $H$, the distribution of the electromagnetic field gradually changes from a chaotic state to a central symmetrical state about the interior of the coating. Therefore, by means of simulation, we can have a more intuitive understanding of the thickness of the coating and the key factors affecting the absorbing effect in this application. The specific design of ferrite hollow bead coating in microwave absorption need to be further studied and discussed.

4. Conclusion
The ferrite hollow bead coating was studied by computer simulation. Firstly, according to the structural characteristics of Ferrite Hollow Beads, the ferrite hollow bead coating was simplified into a
cylindrical resonator model, and then based on this simplified model, the relationship between the thickness of the coating and the resonant frequency of the absorber was analyzed qualitatively. When the electromagnetic wave was incident from the side, the change of coating resonant frequency had little relationship with the thickness. However, when the electromagnetic wave was incident vertically, the coating thickness increases from 6mm to 10mm and then to 16mm, the resonant frequency will change from 18.5GHz to 17.45GHz, and then decrease to 12.92GHz. It can be seen that when the thickness of the coating increases, the resonant frequency decreases. Through the further analysis of the electromagnetic field distribution in the coating, in a certain range, with the increase of thickness, the electromagnetic field distribution gradually changed from a chaotic state to a centrosymmetric state in the coating.

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