Microwave-assisted Volumetric heating by 915 MHz Solid State Source for Household Grill Oven

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Aiming at the microwave auxiliary function of the oven, this thesis proposes a microwave oven model that uses a 915MHz solid-state microwave source to feed microwaves. At the same time, the feeding structure of coaxial and microwave antenna is designed to ensure that the microwave generated by the solid-state source can be radiated to the inside of the oven through the microwave antenna. First, an overall model of the microwave oven is established by using HFSS large-scale three-dimensional electromagnetic field simulation software. In the overall model, the establishment of the microwave antenna selects the PIFA antenna structure that can match the impedance through the size parameters. At the same time, in order to select the optimal antenna size scheme, the established The microwave antenna model is simulated and optimized in terms of size parameters, and then the microwave antenna structure with the determined size is processed and tested in kind. During the test, the antenna needs to be placed inside the cavity as shown in Figure 1(a). The optimized simulation results and measured results are shown in Figure 2(a)(b). The test results show that the designed microwave antenna is at a frequency of 915MHz, and the S11 is lower than -12dB. Compared with the simulation results, the test results have a certain deterioration, but the test results basically meet the design requirements. After completing the machining and testing of the antenna, under the condition that the input power is 500W and the load is 5 cups of 100mL water load, the multi-physics simulation platform of the microwave oven is built by using ANSYS Workbench software, and the electromagnetic-thermal multi-physics simulation platform of the water load is completed for the heating time of 60s. Finally, an experimental platform for heating test was built to conduct the actual heating test. The 915MHz solid-state source used in the heating test experiment is shown in Figure 1(b). For the simulation results and the final experimental data analysis, the maximum temperature difference between the loads and the temperature coefficient of variation (COV) are selected to study the heating uniformity of the loads. The final test results and simulation results are shown in Table 1. Through the comparison between the two, it is found that the COV calculated in the test results is slightly larger than the COV calculated by the simulation results, and the difference between the experimental results and the simulation results in terms of the maximum temperature difference is 2.5°C. Compared with the measured results of the load temperature and the simulation results, it is found that the measured results of the two cups of water in Nos. 1 and 5 are worse than the simulation results, and the measured results of the three cups of water in Nos. 2, 3 and 4 are roughly consistent with the simulation results.

Antenna design and simulation results

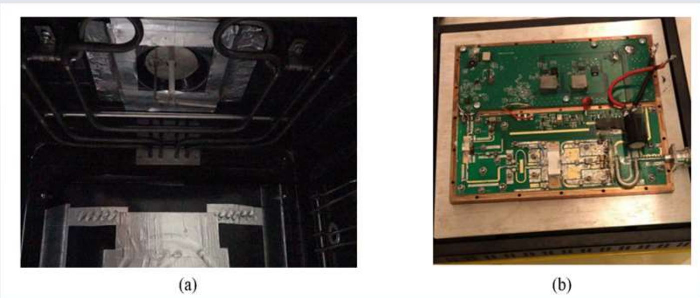

Fig. 1. The mounting position of the antenna inside the cavity and the actual solid-state source at 915MHz. (a) The installation position of the antenna inside the cavity; (b) The physical map of the 915MHz solid-state source.

Figure 1(a) represents Installation position of antenna in actual cavity.and the figure 1(b) represents the physical map of the 915MHz solid-state source.

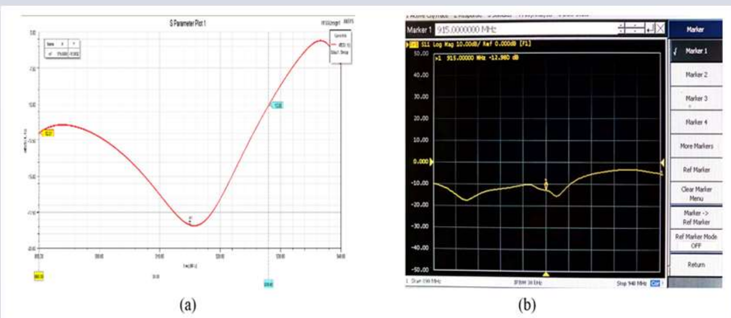

Fig. 2. Simulation results and measured results of the antenna. (a) Simulation results of the antenna; (b) Measured results of the antenna.

Simulation results and actual test results of the antenna shown in Figure 2(a)(b).We can see that the test results have a certain deterioration, but the test results basically meet the design requirements.

Microwave heating simulation test results and actual test results of the antenna

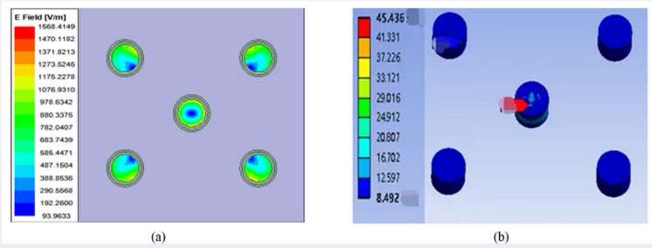

Fig. 3. Electric field distribution results and temperature distribution results on the surface of the water load. (a) The results of the electric field distribution on the surface of the water load; (b) The results of the temperature distribution of the water load.

The final test results and simulation results are shown in Table 1.

TABLE I

SIMULATION RESULTS AND EXPERIMENTAL RESULTS AFTER HEATING WITH WATER LOAD FOR 60S (UNIT: °C)

Simulation results after heating with water load for 60s						
Number	Heating time	Initial temperature	final temperature	Average temperature rise	Maximum temperature difference	COV
water cup 1	60s	8.6	23	15.16	3.7	0.0623
water cup 2		8.6	23.2			
water cup 3		8.6	26.7			
water cup 4		8.6	23.2			
water cup 5		8.6	22.7			
Experimental results after heating with water load for 60s						
Number	Heating time	Initial temperature	final temperature	Average temperature rise	Maximum temperature difference	COV
water cup 1	60s	8.6	14.6	9.78	6.2	0.186
water cup 2		8.6	22.4			
water cup 3		8.6	20.1			
water cup 4		8.6	20.8			
water cup 5		8.6	14			

Conclusion

In conclusion, we designed a PIFA antenna structure suitable for 915MHz microwave frequency, and carried out practical tests to verify the feasibility of the antenna structure. Then, on this basis, the multi physical field simulation and heating test experimental platform of the microwave oven is built. Through the comparison of simulation and experiment, it is found that under the same load conditions, the trend of the measured results and the simulation results is roughly the same, but there are some errors.

References

1. Z. Fan, Y. Yang, K. Huang, H. Zhu. A dual-frequency microwave heating analysis of 915 MHz and 2450 MHz [J]. Vacuum Electronics Technology, 2020(02): 11-14.

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