VHF Radiowave Oven for Thawing Large Tuna

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***Abstract*— In this paper, VHF radio wave oven for thawing large size tuna was proposed. The 108 MHz frequency is used with advantage of having a relatively large penetration depth compared with 2.45 GHz band. Proposed VHF radio wave oven is effectively utilizing the cutoff effect which confine electromagnetic wave in water. It is demonstrated that a cutoff parallel plate waveguide allows electromagnetic waves to propagate only within the water and current is limited only in the frozen tuna.**

Keywords—IRS, Liquid Crystal, Scattering, Sidelobe level

I. Introduction

Miyagi Prefecture in Japan is known as the prefecture with the highest tuna catch in Japan. Tuna caught by deep-sea fishing boats are immediately flash-frozen to about -60 degree in the freezer on the fishing boat as shown in Figure 1 with typical dimensions, and are kept in the freezer after arriving at the fishing port. This thawing process currently takes a considerable amount of time, and advances in thawing technology are desired.

Foods including tuna can be preserved for several years at temperatures below -18°C, preventing the growth of bacteria and mold. However, if tuna cooled to approximately -60°C on fishing vessels could be rapidly thawed to a consumer-safe temperature of approximately -20°C, this would shorten the time it takes to deliver the tuna to consumers, potentially increasing the number of catch and resulting in significant economic benefits. However, while meat thawing technology is well-established in Japan, our research has revealed no technology for thawing large tuna.

Currently, studies are being conducted on how to utilize the frequencies from 95 MHz to 108 MHz, which have become available with the digitalization of terrestrial television broadcasting, with possible uses being considered: expanding FM broadcast frequencies, disaster prevention, new services, and experimental and demonstration purposes.

In this research, we aim to develop a radio wave oven for thawing tuna using 108 MHz in the VHF band as a technology to promote the effective use of radio waves in the V-low band, taking into account the goal of effective use of radio waves. In addition to the VHF band's long penetration depth, the electromagnetic wave confinement effect of new technology makes it possible to realize a radio wave oven that can effectively thaw large tuna.

II. Geometory

Parallel plate waveguide (PPW) with spacing d, height H and length L, have a cutoff where the cutoff frequency is provided by fc=c/(2d), where c is speed of light. When the operating frequency is less than the cutoff frequency fc, radiation of waves are blocked. More precisely, cutoff exists

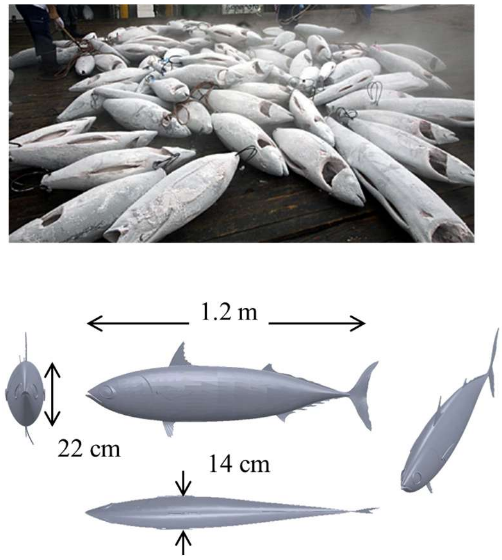

Figure 1. Frozen tuna and dimensions.

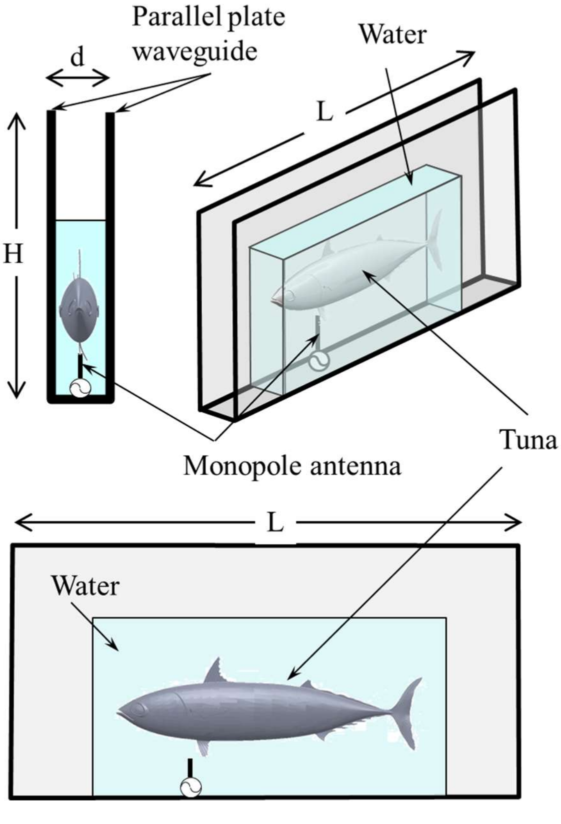

Figure 2. U-shaped microwave oven consisting of parallel plates.

2026 IEEE International Workshop on Antenna Technology (iWAT) | 979-8-3315-7303-4/26/$31.00 ©2026 IEEE | DOI: 10.1109/IWAT66946.2026.11501887

only for polarized waves whose electric field direction is parallel to the parallel plates. As shown in Figure 2, consider a U-shaped microwave oven consisting of parallel plates with spacing d and with a bottom conductor plate. A monopole antenna attached to the bottom conductor plate has its antenna axis parallel to the parallel plates and excites electromagnetic waves with an operating frequency of 108 MHz.

For example, if the distance between the parallel plates d is 2 m, the cutoff frequency is 75 MHz, and 108 MHz electromagnetic waves can radiate outside the parallel plates. On the other hand, if d is set to 20 cm corresponding the thickness of a tuna, the cutoff frequency is 750 MHz, creating a cutoff space that blocks electromagnetic waves below 750 MHz including the operating frequency of 108 MHz. Furthermore, when water is partially filled in this cutoff space, the wavelength becomes shorter within the water, which equivalently widens d, removes the cutoff, and allows electromagnetic waves to propagate within the water and the transmitted power can be confined inside the water.

III. FDTD SIMULATIONS

A FDTD analysis model of a radio wave oven for thawing large size tuna and the electric field intensity distribution (|E|) and the current distribution (|J|) on the cross section of the tuna are shown in Figures 3, respectively [2-9]. A monopole antenna with length of 15 cm was used for excitation. Relative permittivity and conductivity of water are set as 84.6 and 0.0023, respectively [1], those values are of the case of room temperature of 20 degree. Relative permittivity and conductivity of frozen tuna are set as 5 and 0.1, respectively, those values are selected as the estimated values in the case of temperature -20 degree. It is observed that the electric field is confined within the water, and that the electric field penetrates into the tuna. It has also been observed that strong currents are excited only in the area of the tuna because the conductivity of the tuna is significantly greater than that of water.

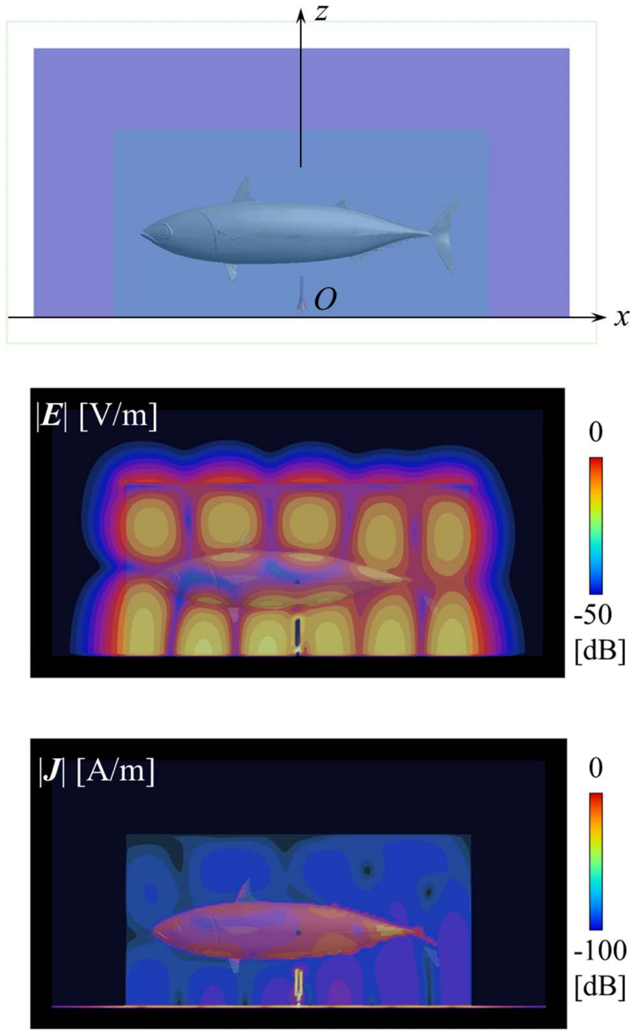

Figure 3. Simulated electric field intensity distribution (|E|) and current distribution (|J|) on cross section of tuna.

IV. CONCLUSION

In this paper, VHF radio wave oven for thawing large size tuna was proposed. It is demonstrated that a cutoff parallel plate waveguide allows electromagnetic waves to propagate only within the water and the transmitted power is mainly consumped only by the loss of frozen tuna. The 108 MHz frequency used in this research has the advantage of having a relatively large penetration depth, and by effectively utilizing the cutoff effect confine electromagnetic wave in water and it is possible to create a radio wave oven that can effectively heat the thaw tuna. Measurement of the complex permittivity of tuna and the experimental results will be conducted as the upcoming works.

ACKNOWLEDGMENT

This research was partly supported by the Ministry of Internal Affairs and Communications, FORWARD with #JPMI250230001.

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