Evaluation of Magnetic Fields Generated by Induction Hob Under Assumed Actual Usage Conditions

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Abstract

Assuming the actual usage, the magnetic fields generated by a household induction hob were measured and these measurements were confirmed to be in conformance with the ICNIRP magnetic field reference level. The measurement method was in accordance with IEC 62233. The spatial distribution around an induction hob user was roughly determined by scanning three measurement planes at different distances from the hob and parallel or perpendicular to the hob's front. Moreover, measurements were taken with different metallic material types and sizes of cooking pots as well as under the conditions of various position gaps between the centers of the pot bottom and the coil used for magnetic field generation in the hob. As a result, it was confirmed that all measurement results in this study were lower than the magnetic field strength reference levels for general public exposure provided in the ICNIRP 2010 guidelines.

Introduction

Induction hob has become increasingly popular in regular households due to their convenience and high level of fire safety. Several researches have published the reports on the magnetic fields generated by induction hob.

In our study, the conformance with the magnetic field reference levels for general public exposure provided in the ICNIRP 2010 guidelines was verified regarding magnetic fields measured under the actual usage conditions by changing standing positions of a hob user, pot materials and sizes, and gaps between the centers of the pot bottom and the coil.

Methods

Measurement Target / Instrument

Measurements were conducted for a common induction hob model made by Japanese manufacturer. The measuring instrument used was the ELT-400 from Narda S.T.S.

This instrument performs a time-domain evaluation of the exposure level of the measured low-frequency magnetic field (10 Hz - 400 kHz), so it implements the measurement that complies with IEC 62233.

Sensor (Narda S.T.S ELT-400)

- 3-D coil magnetometer
- Mode ; ICNIRP 2010 Gen.Pub
- Probe ; 100cm^2
- Detect ; RMS
- Range ; LOW
- Frequency range ; 10Hz - 400kHz

Measurement / Evaluation Methods

1. Spatial distribution around the user

- Measurement of the spatial distribution of magnetic fields around the induction hob user was conducted by scanning with 100 mm intervals on the three measurement planes as shown in Fig2.
- Measurement was conducted using an iron pot with a diameter of 180 mm at a maximum output of 3 kW. The maximum output was confirmed by checking the electric current flowing through power cord.

2. Material and size of pot

- Measurements were conducted for iron and aluminum pots of five different diameters under the condition of maximum output of 3 kW for the iron pot and 2.5 kW for the aluminum pot.
- According to IEC 62233, the maximum value of measurements obtained along vertical axis from 500 mm below to 1,000 mm above the countertop at distance of 300 mm from the front of the hob was determined.

3. Position gap between the centers of pot bottom and coil

- Measurements were conducted by changing the gap between the centers of pot bottom and coil in the range of 0-90 mm to back direction of hob, using an iron pot of 180 mm in diameter.
- The power output and measurement positions were the same as described in 2.

Evaluation Methods

The evaluation of measurements obtained was performed by calculating their ratio (%) to the corresponding reference levels of ICNIRP guideline using Formula 1.

Figure 1 Measurement set-up.

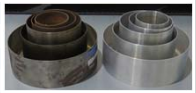
Induction hob

- 3 cooking zones (all-metal compatibility)
- Type ; Built-in
- Volt ; 200V (single-phase)
- Maximum output ; 3.0kW (iron pot)
  2.5kW (aluminum pot)
- Frequency (measured value) ;
  23.1kHz (iron pot) , 79.0kHz (aluminum pot)

Pot

- Material ; Iron / Aluminum
- Size ;

Diameters (mm)				
110	145	180	210	300
Height (mm)				
140	140	140	120	100



$$\text{Ratio of measurement value to magnetic field reference level (\%)} = \sum_{j=10Hz}^{400kHz} \frac{Hj}{Hrj} \times 100 \quad \text{(Formula 1)}$$

Hj : Magnetic field strength at frequency j , Hrj : ICNIRP magnetic field strength reference level at frequency j

Results

1. Spatial distribution around the user (Fig2)

- The maximum values were found on the coil center axis in each measurement plane.
- The maximum value was larger and its position was vertically higher in the measurement plane 1 than in the measurement plane 2.
- Horizontal decrease rate of the values according to the distance from the maximum point is larger than vertical one in the measurement plane 3.
- The calculated ratio of the maximum value found in the measurement plane 1 was 19.0 %, which means the maximum value in the spatial distribution is well below ICNIRP magnetic field strength reference levels.

2. Differences due to the material and size of pot (Fig3)

- Measurement results with iron and aluminum pots showed values similar to each other. However, the electric current flowing through the power cord at maximum output was 120 % larger for the iron pot than for the aluminum one.
- With regard to the influence of pot diameter, as increasing the diameter, magnetic field was decreased. But above 180 mm in diameter, the decline of magnetic fields was getting slight.
- The calculated ratio of the maximum value was 3.7 %, which means, regardless of the material and size, all of the measurements were well below ICNIRP magnetic field strength reference levels for general public exposure.

3. Differences due to the gap between the centers of pot bottom and coil (Fig4)

- The value increased linearly from 0 mm (no gap) up to 60 mm. With gaps larger than this, the Induction hob's automated control function decreased the output and the value declined.
- It was confirmed that at its highest the ratio was 5.3 %, which demonstrates that even the highest field strength is much lower than the magnetic field strength reference levels for general public exposure provided in the ICNIRP 2010 guidelines.

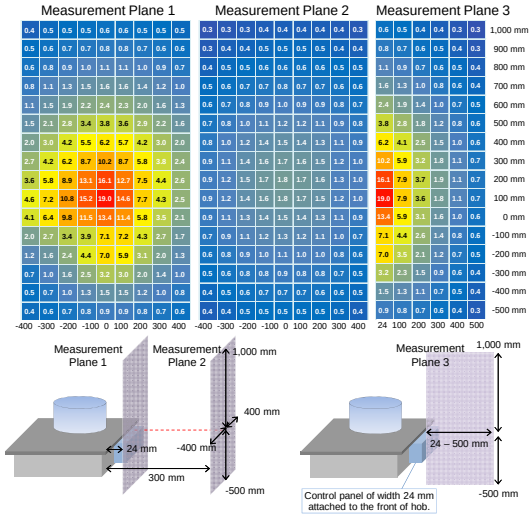


Figure 2 Spatial distribution of magnetic fields generated by Induction hob.

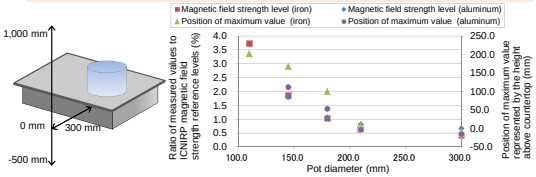


Figure 3 Changes in the ratios of measurement values and the positions of maximum values by the diameter of pot.

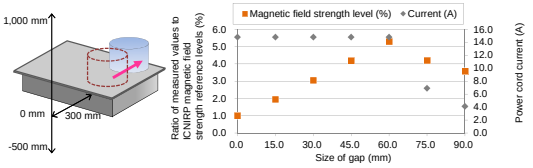


Figure 4 Changes in the ratios of measurement values and the power cord currents by the gap between the centers of pot bottom and coil.

Conclusion

Assuming the actual usage, the magnetic fields generated by a common induction hob were measured. The spatial distribution of magnetic field intensity around the user, differences due to the material and size of pot as well as the gap between the centers of pot bottom and coil were shown. Measurements were evaluated by calculating their ratios to the corresponding reference levels of ICNIRP guideline resulting in confirmation of compliance with the ICNIRP guideline.