A STUDY ON THE POWER CONVERTER PERFORMANCE COMPARISON & OPTIMAL DESIGN INDUCTION HEATING COIL FOR IH JAR

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Introduction

- The principle of the induction heating is based on the Faraday's law of electromagnetic induction.
- The IH technology is used for induction furnace, melting, and heat treatment of metal as industrial applications while microwave oven, IH rice cooker, IH cooker as kitchen applications. Especially, IH products for home cookware are highly interested. Among them, IH electric rice cookers are being developed mainly in Southeast Asia including Japan, Korea, and China.
- In this paper, modeling an electric circuit of a working coil and an inner pot and modeling integrated equivalent circuit for electric field analysis. Through the modeling results, heating coil structure suitable for IH electric rice cooker to optimize heat conversion efficiency was optimized and designed. As a result of the experiment, it was confirmed that the conversion efficiency of about 1% was improved.

Equivalent modelling of heating coil and pot

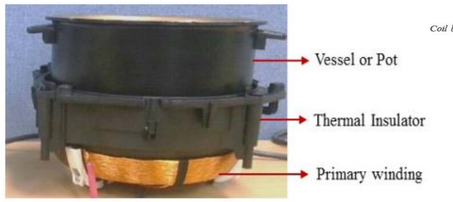


Fig.1 . Induction heating cooker model

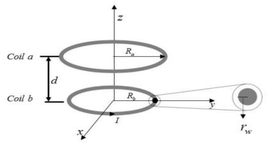


Fig. 2. Circular loop of wires

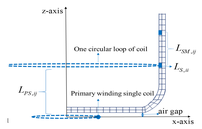


Fig. 3. Cut view of induction heating cooker

Simplified equivalent circuit

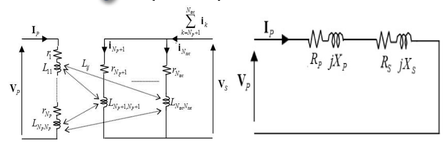


Fig. 4. **Simplified equivalent circuit**

$$Z_{EQ} = \mathrm{Re}\left(-Z_{PS}^{T}Z_{S}^{-1}Z_{PS} + Z_{PP}\right) + j\mathrm{Im}\left(-Z_{PS}^{T}Z_{S}^{-1}Z_{PS} + Z_{PP}\right) = R_{EQ} + X_{EQ}$$

$$Z_{EQ} = \mathrm{Re}\left(-Z_{PS}^{T}Z_{S}^{-1}Z_{PS}\right) + R_p + j\mathrm{Im}\left(-Z_{PS}^{T}Z_{S}^{-1}Z_{PS}\right) + jX_P = R_S + R_p + X_S + X_{EQ}$$

Comparison analysis results

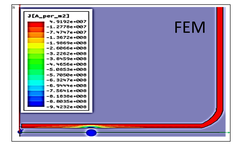


Fig. 5. **Current density**

Optimization heating coil

Choice of available coil positons

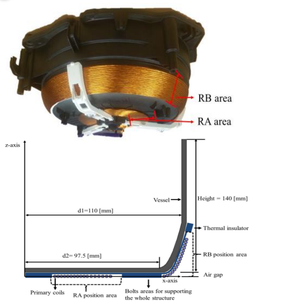
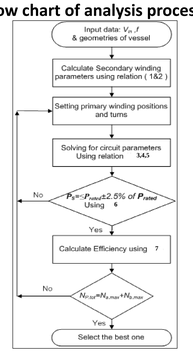


Fig. 6. Dimension of induction heating coil

Table 1. Parameter of analysis practical model

Input supply voltage V_{in}		177 V_{rms}
Input supply frequency f		20 kHz
Primary winding	Material	Copper
	Diameter Litz wire	2.2 mm
	Number of strands	23
	N_a	17 turn
	N_b	16 turn
Secondary Pot	Material	Aluminum
	Thickness of Pot	3.5 mm

Flow chart of analysis process



Analysis results

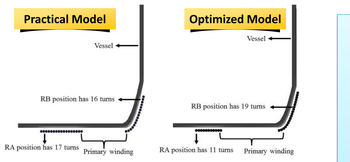


Fig. 7. FEM models of induction heating cooker

Fig. 8. Flux density and flux lines analysis

Thermal analysis

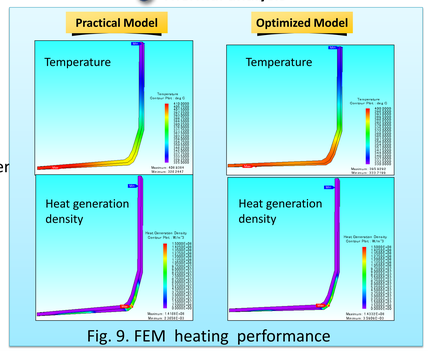


Fig. 9. FEM heating performance

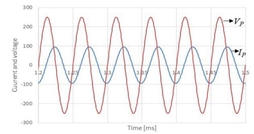


Fig. 10. Input voltage and current of primary winding

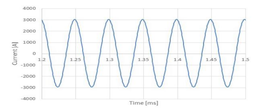


Fig. 11. Secondary winding current

Table.2 Analysis results of practical model

Parameters	Analytical Results	FEM Results
I_p	69.3 A	68.9 A
I_s	2103 A	2083 A
P_s	1300 W	1321 W
Efficiency	66.1 %	66.3 %

Table3. Analysis results of optimized model

Parameters	Analytical Results	FEM Results
I_p	68.6 A	67.4 A
I_s	2084 A	2067 A
P_s	1329 W	1341 W
Efficiency	67.0 %	67.5 %

The result of experiment

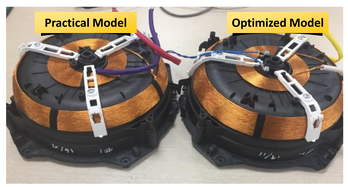
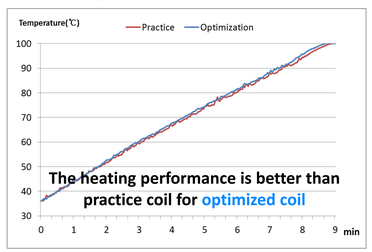


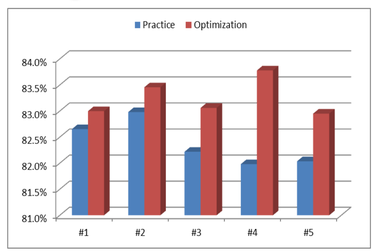
Fig. 12. Heating coil comparison

Fig. 13. Test environment

Heating performance



Thermal conversion efficiency



Practice coil: 82.0~83.0%, Average: 82.4%

Optimized coil: 82.9~83.8%, Average: 83.2%

The average thermal conversion efficiency 0.8% higher for optimized coil.

Conclusion

- In this research, based on the design results presented through the IH Jar heating coil's new analysis method and its optimum design, the practical effectiveness of a heating coil was verified.
- Design through equivalent circuits shows results similar to those of FE analysis, and allows fast analysis. A heating coil test sample was created through the heating coil design optimized using equivalent circuits.
- This was applied to an induction heating electric rice cooker and tested, obtaining a 0.8% efficiency improvement.

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