The influence of material, shape, thickness, and frequency on the power absorption in metal objects

Dries van Wageningen
Philips Research
March 20, 2014
Introduction

• Metal objects can heat up when exposed to a modulated magnetic field
  – Mainly caused by eddy currents

• Power absorption depends on
  ▪ Magnetic field strength – B-field (T)
  ▪ Frequency of B-field
  ▪ Size of the object
  ▪ Shape of the object
  ▪ Material
Objects in magnetic field

Setup

• Coil of 20 windings
• Current 4A
• Frequency 115kHz
• B field at object position: 3 .. 4mT
Influence of material and thickness

Simulation

- El Material Conductivity
- Cu Copper $\sigma = 58$ MS/m
- Al Aluminum $\sigma = 35$ MS/m
- Ti Titanium $\sigma = 1.8$ MS/m
- Fe Iron $\sigma = 10$ MS/m

Maximum Power absorption depends on thickness and material

Iron is special due to its ferro-magnetic behavior
Influence of shape

Disk → Ring

- Maximum absorbed power equal to disk
- Maximum power absorption shifts towards thicker material
Influence of frequency

100kHz → 1 MHz

- Power absorption increases at higher frequency
Influence of frequency

100kHz → 1 MHz – normalized scale

- Maximum power absorption shifts to thinner at higher frequency
Influence of material and thickness

Setup

- Coil of 20 windings
- Current 0.4A
- Frequency 6.7MHz

Maximum Power absorption depends on thickness and material.
Conclusions

• At low frequencies around 100kHz most power absorption can be expected at a thickness of
  – Fe  > 1mm
  – Al  10um .. 1 mm
  – Cu  5um .. 0.5 mm

• At high frequencies around 6.7MHz most power absorption can be expected at a thickness of
  – Fe  10um ..1 mm
  – Al  50nm .. 5um
  – Cu  20nm ..2um

Metallized layers !!