

Leibniz Universität Hannover

Inductive and Ohmic Heating

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Part 1: My ETP Work/Research

My Work/Research



- Worked on two projects: Inductive and Ohmic heating
- Learn how to use a simulation and design software program ANSYS
 - Created 2D & 3D models and coded to create the geometry
 - Used 2D for faster simulation and with rotational symmetry
 - Used 3D when geometry has no rotational symmetry
- Used ANSYS to simulate inductive and ohmic heating to meet specific parameters
- Conducted many simulations
 - Sometimes one simulation takes about 3 hours or more
- More efficient and cost less than testing it in real life
- Supposed to conduct an exprimental setup to validate my 2nd project
 - Unfortunately, the power supply broke



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What is Inductive Heating?

- Conductive coil wraps around the workpiece (object to be heated)
- Coil made by copper
 - Better conductivity and efficiency
- High-frequency alternating current travels through inductor
 - Creates a rapid alternating magnetic field
- Rapid alternating magnetic field penetrates the workpiece
 - Induces electrical current inside conductor called eddy current
- Eddy currents flows through the workpiece
 - Heats the workpiece by Joule Heating
- Common application to cook food modern cooktop
- Other applications for inductive heating:
 - Furnance
 - Welding
 - Sealing







What is Ohmic Heating?

- Also known as Joule Heating
- More efficient thermal processing method
 - Electrical current directly passes though the workpiece to heat it up
- Electrical current passes through conductive material to generate heat
- Some applications for ohmic heating:
 - Cooktop techonology
 - Clothes Iron
 - Incandescent Light Bulb
 - Hair Dryer



<u>**Goal</u>**: Find a connection between power & the workpiece's length and width</u>



Ohmic Heating: Project 1

*Practice 3D modeling; what it looks like in ANSYS



¼ of Workpiece (middle horizontal bar) & Conductors (Cubes)

Workpiece's Magnetic Field Distribution



40.000,0

20.000.0

0,00



Data from changing workpiece's width and length



<u>**Result</u>**: Linear relationship between power & workpiece's length and width Increase workpiece's length and width = smaller temperature at workpiece</u>

500

200

Length (mm)

200mm

300mm



Inductive Heating: Project 2



<u>**Goal</u>**: Reach uniform temperature around 500°C within the points in each 5 holes</u>

5 points (white dots) with same temperature at about 500°C



← Result

Induction Model with 5 holes

¹/₂ Workpiece (horizontal block) and copper coil (5 rectangular blocks)

1.475kHz, 1.5kA, Theating = 120s, Tcooling = 50s, Tmax = 502.8°C, Max Dev. = 2.8°C



4kHz, 1.34kA, Theating = 51s, Tcooling = 5s, Tmax = 499.346°C





ANSYS Release 19.2 Build 19.2 NODAL SOLUTION STEP=1 SUB =6 TIME=1 TEMP RSYS=0 PowerGraphics EFACET=1 AVRES=Mat SMN =165.305 SMX =676.047 165.305 222.054 278.803 335.552 449.051 505.8 562.549 619.298 676.047

5kHz with 4kHz parameters



<u>**Goal</u>**: Experiment with different frequencies using parameters from 4kHz</u>

6kHz with 4kHz parameter

2kHz with 4kHz parameters

<u>**Goal</u>**: Get the max temperature at around 500°C</u>

Build 19.2 NODAL SOLUTION

PowerGraphics

SMN =140.365 SMX =499.487 140.365

180.267 220.17 260.072

379.78 419.682 459.585 499.487

STEP=1 SUB =5

TIME=1 TEMP RSYS=0

EFACET=1

AVRES=Mat



4kHz, **1.34kA**, Tcooling = 5s, Theating = 51s, Tmax = 499.346°C



ANSYS Release 19.2

Build 19.2 NODAL SOLUTION

PowerGraphics EFACET=1 AVRES=Mat

AVRES=MAT SMN =161.596 501.767 161.596 237.189 274.986 312.783 350.58 386.377 426.174

STEP=1 SUB =5 TIME=1

1kHz, **2.05kA**, Tcooling = 5s, Theating = 57s Tmax = 501.767°C





2kHz, **1.645kA**, Tcooling = 5s, Theating = 54s, Tmax = 498.942°C



5kHz, **1.24kA**, Tcooling = 5s, Theating = 52s, Tmax = 500.237°C



6kHz, **1.175kA**, Tcooling = 6s, Theating = 53s, Tmax = 502.788°C



Image: Second second

7kHz, **1.11kA**, Tcooling = 5s, Theating = 53s, Tmax = 503.158°C



1 NNYE Pelese 19.2 Build 19.2 WOML SOLUTION STEP-1 SUB =5 TIME-1 TAMP(AVG) RSYS-0 PowerGraphics EFACE-1 AVRES-Mat SNN =113.251 113.251

8kHz, **1.15kA**, Tcooling = 5s, Theaing = 43s, Tmax = 504.828°C

<u>**Result</u>**: Exponential decrease in the current while decrease in frequency to get Tmax = ~500°C</u>

9kHz, **1.041kA**, Tcooling = 6s, Theating = 52s, Tmax = 501.619°C

10kHz, **998A**, Tcooling = 5s, Theating = 52s, Tmax = 501.015°C



Part 2: My Experience in Germany & Hannover



It was a great experience!





- Food currywurst, schnitzel, spaghetti eis, etc.
- Traditions bachelor/bachelorette party
- Cars a lot of hatchbacks
- Clothing better dressed/more fashionable
- Buildings Architectural design
- Beer culture
- A lot of carnivals and festivals
- Efficient public transportation
- Bike-friendly







