Leibniz Universität Hannover

Inductive and Ohmic Heating

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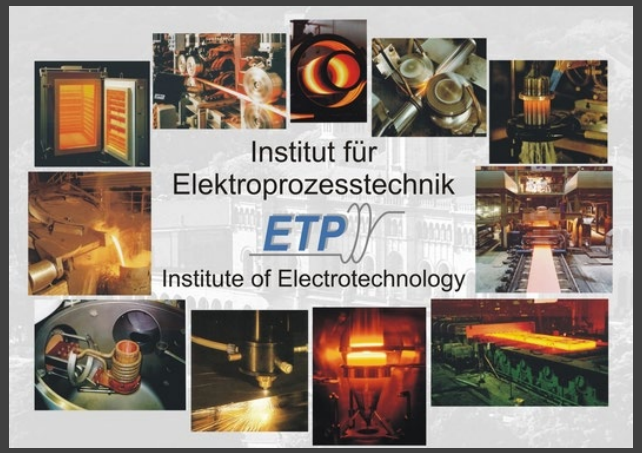
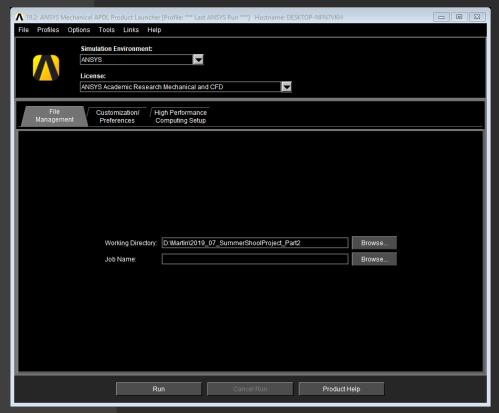
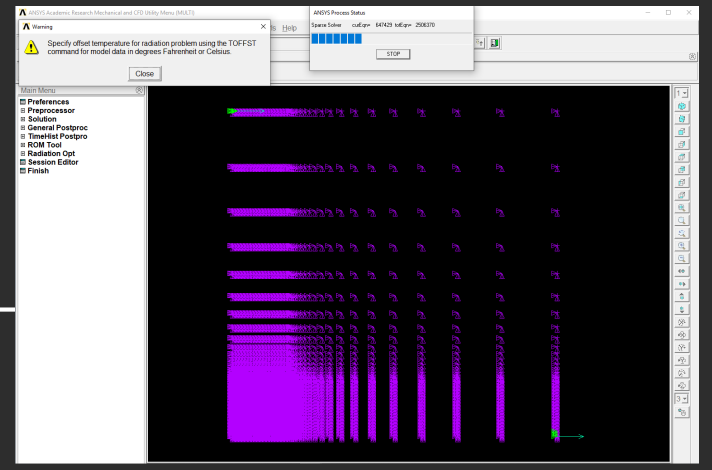


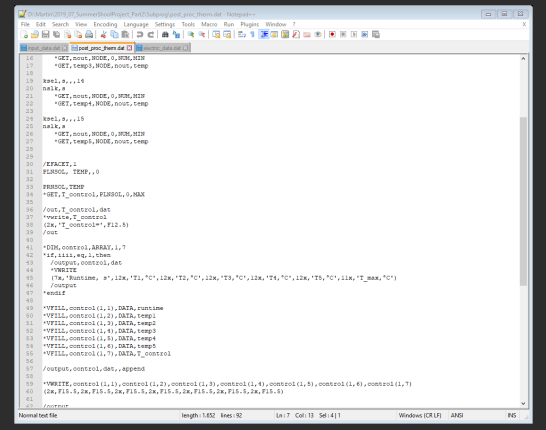
Part 1: My ETP Work/Research

My Work/Research



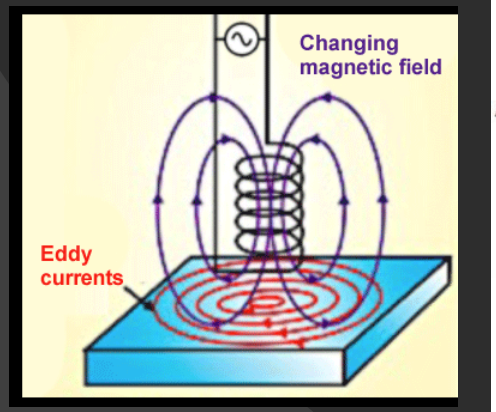


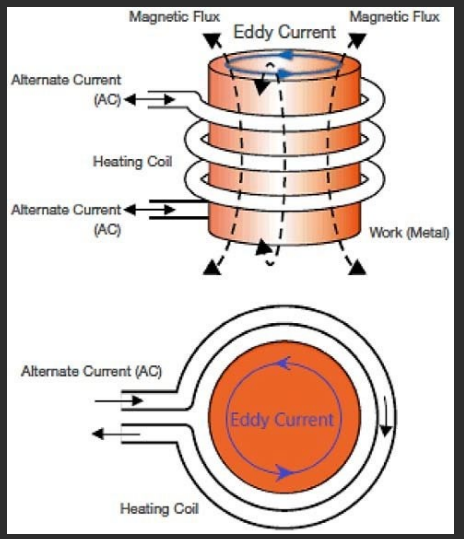
- Worked on two projects: Inductive and Ohmic heating
- Learn how to use a simulation and design software program ANSYS
  - Created 2D & 3D models and coded to create the geometry
  - Used 2D for faster simulation and with rotational symmetry
  - Used 3D when geometry has no rotational symmetry
- Used 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



What is Inductive Heating?

- Conductive coil wraps around the workpiece (object to be heated)
- Coil made by copper
  - Better conductvity 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





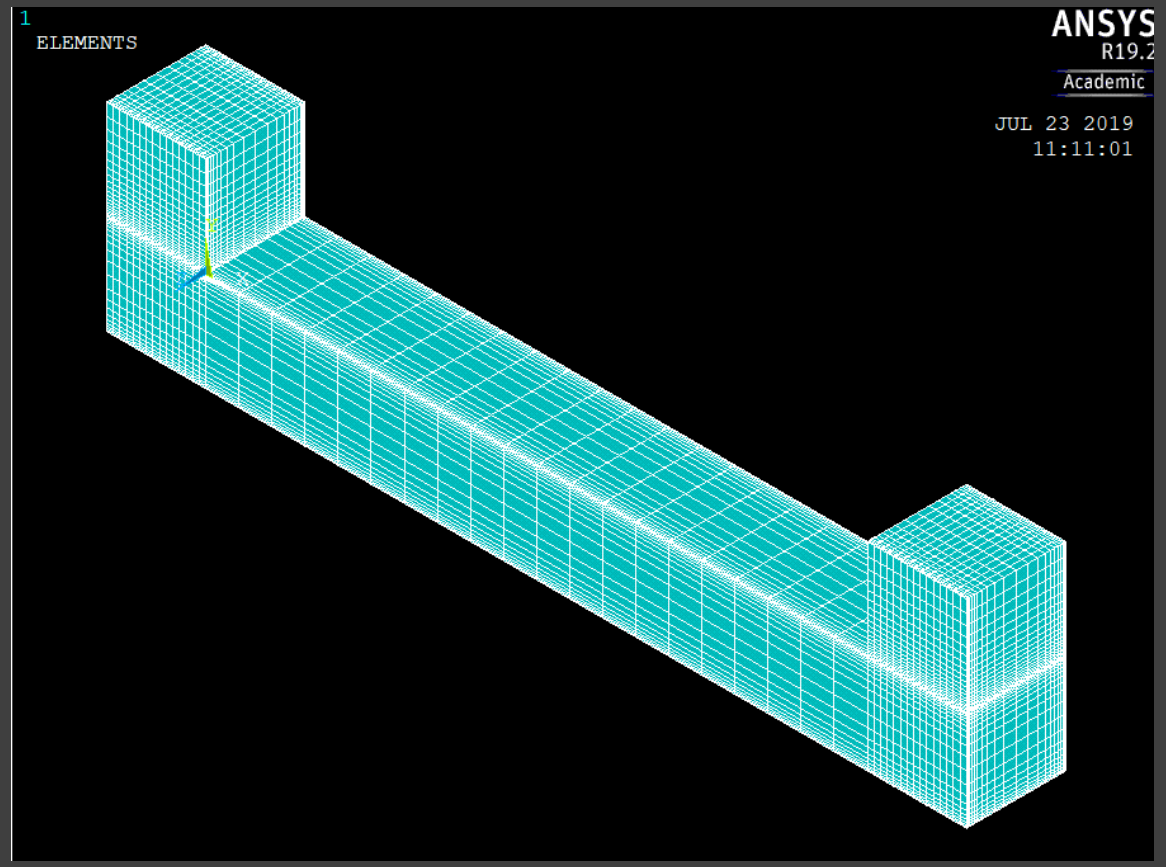
What is Ohmic Heating?

- 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

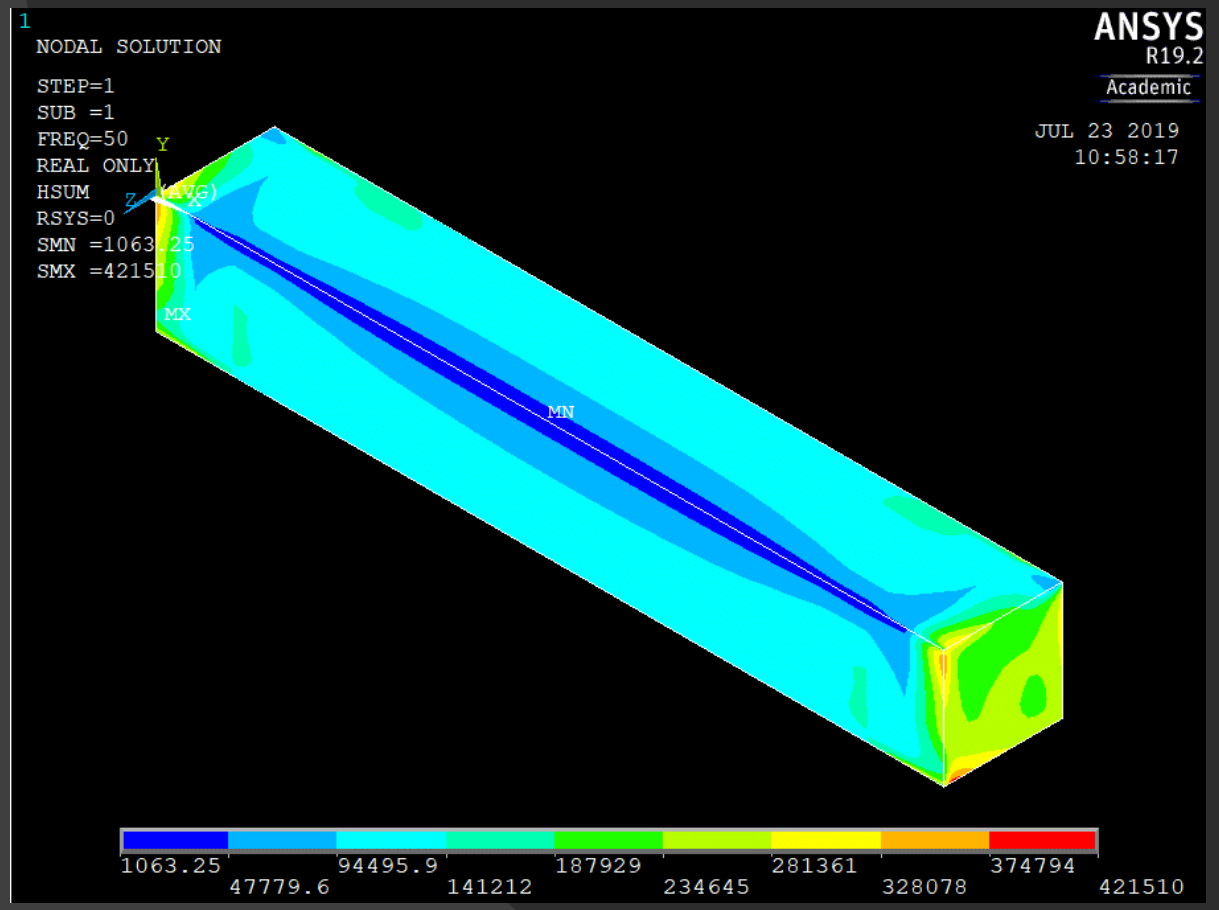
Ohmic Heating: Project 1

Goal: Find a connection between power & the workpiece‘s length and width

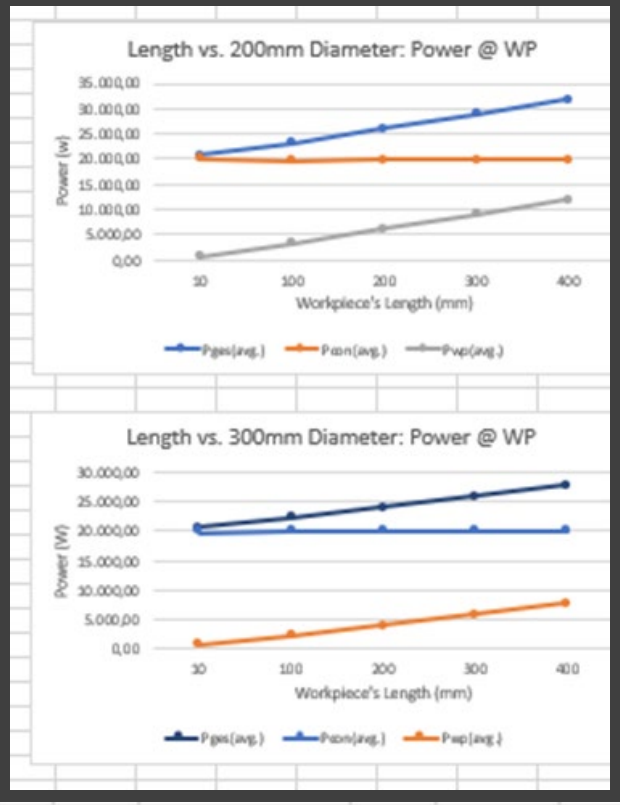
*Practice 3D modeling; what it looks like in ANSYS

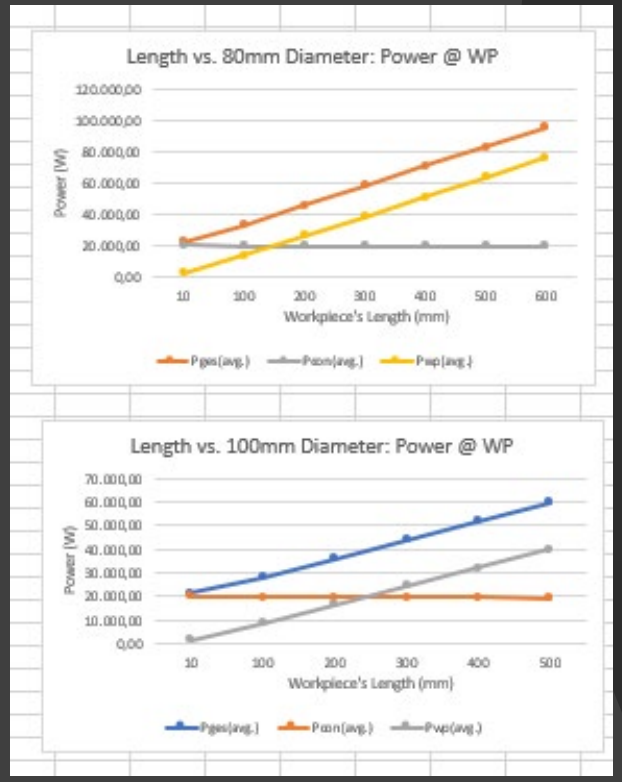


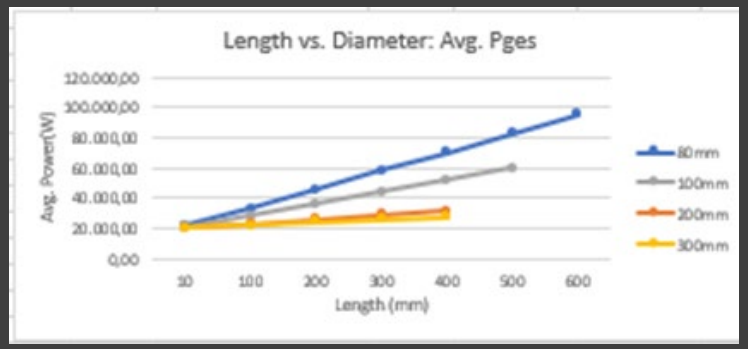
¼ of Workpiece (middle horizontal bar) & Conductors (Cubes)



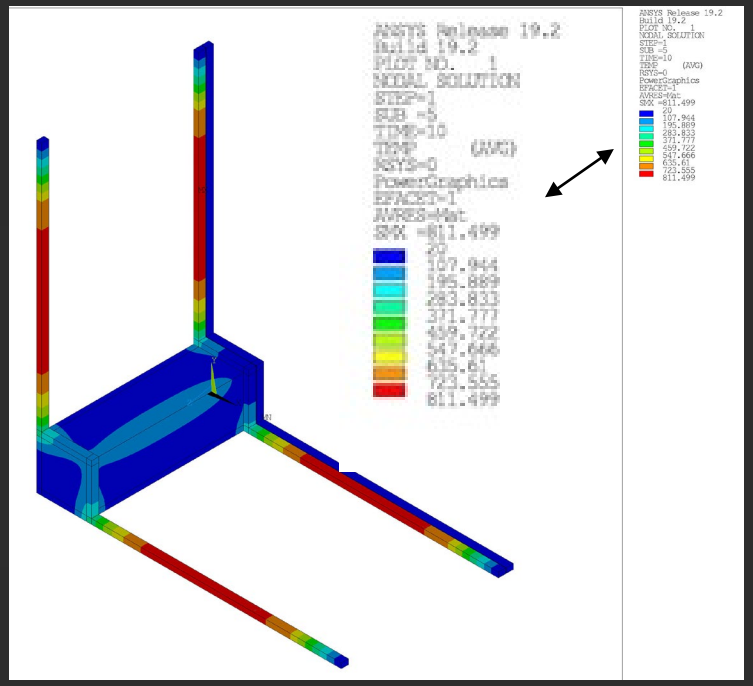
Workpiece‘s Magnetic Field Distribution

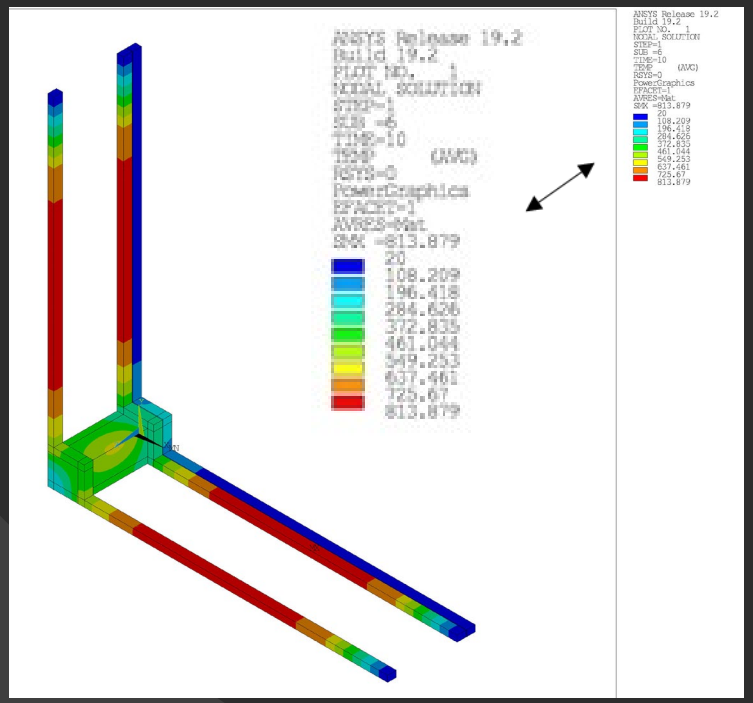






Data from changing workpiece‘s width and length





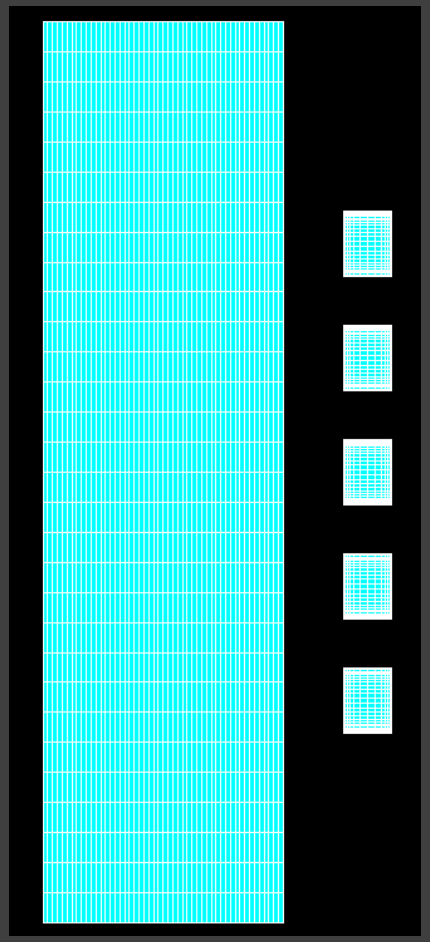
¼ of Workpiece (middle horizontal bar) & Conductors (skinny bars)

Result: Linear relationship between power & workpiece‘s length and width
Increase workpiece‘s length and width = smaller temperature at workpiece

Inductive Heating: Project 2

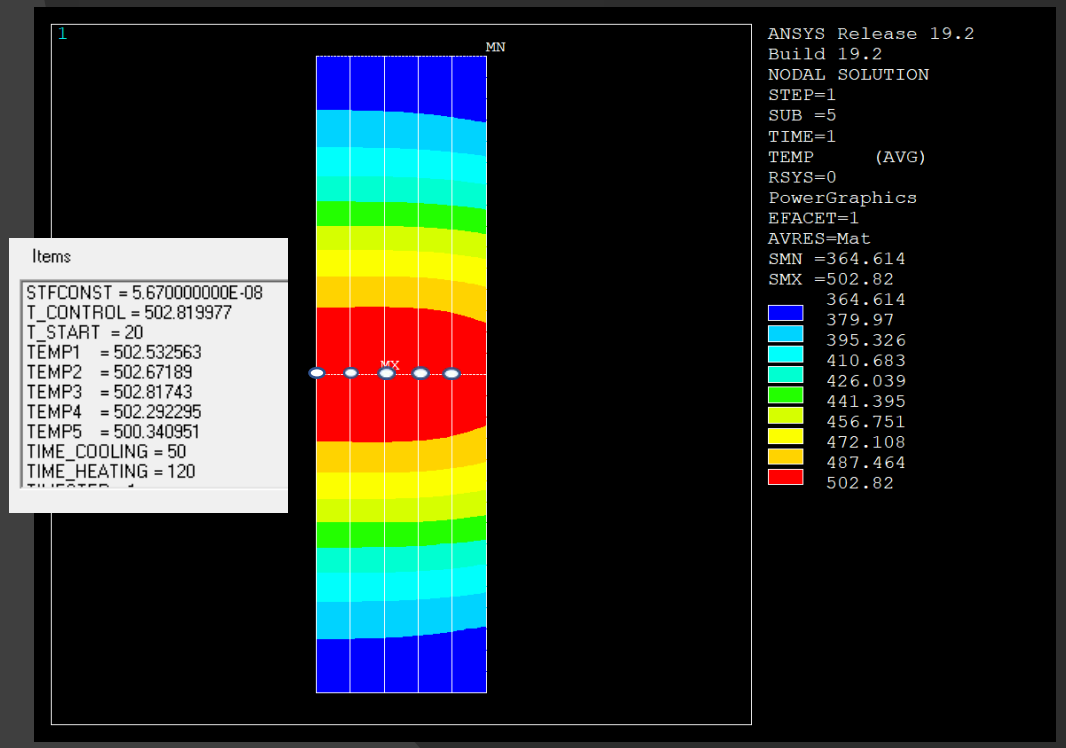
Goal: Reach uniform temperature around 500°C within the points in each 5 holes

Induction Model with 5 holes



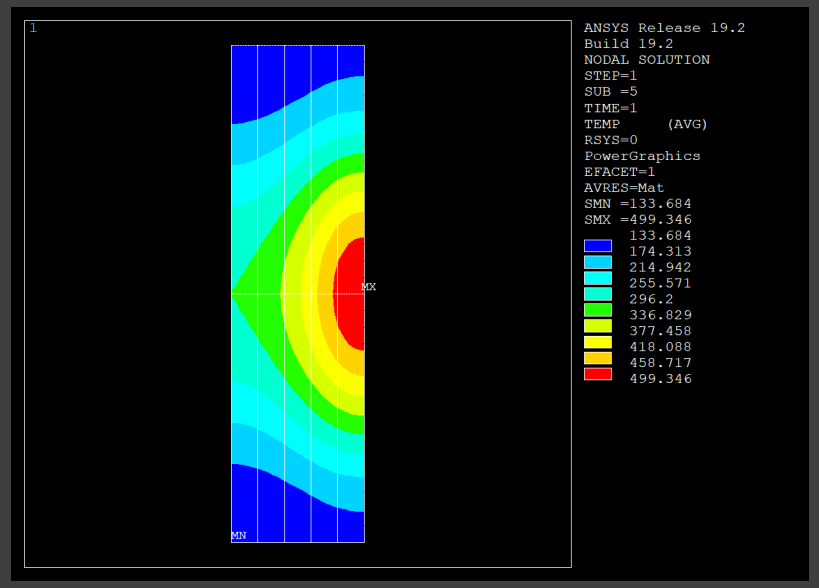
½ Workpiece (horizontal block) and copper coil (5 rectangular blocks)

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

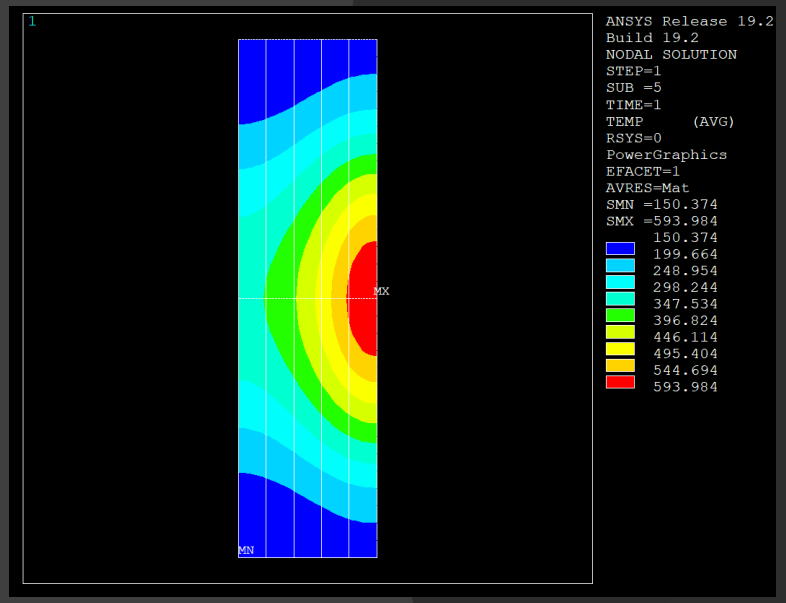


← Result

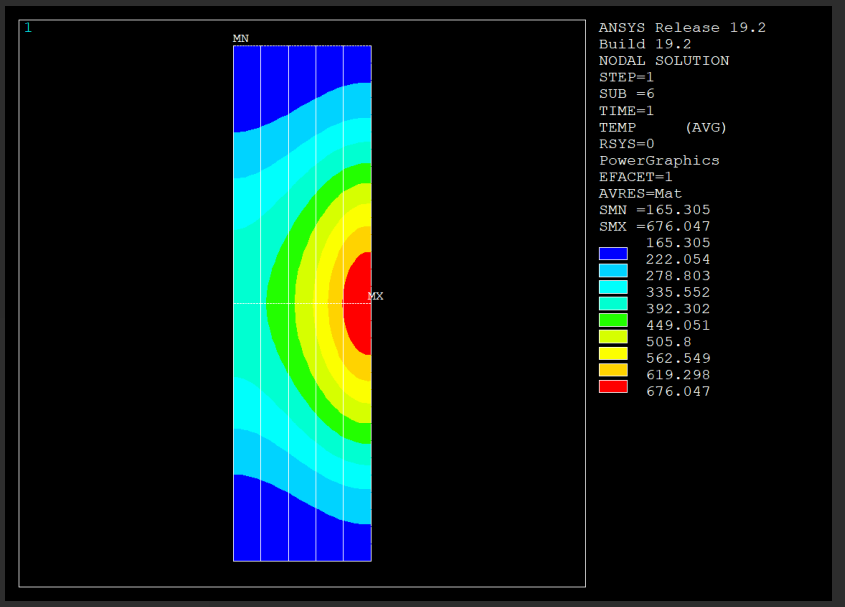
1.475kHz, 1.5kA, Theating = 120s, Tcooling = 50s, Tmax = 502.8°C, Max Dev. = 2.8°C



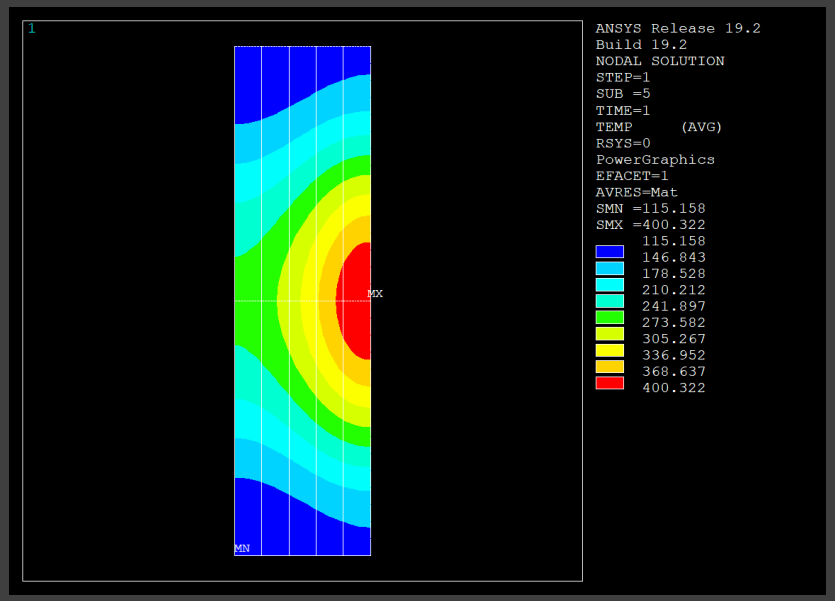
4kHz, 1.34kA, Theating = 51s, Tcooling = 5s,
Tmax = 499.346°C



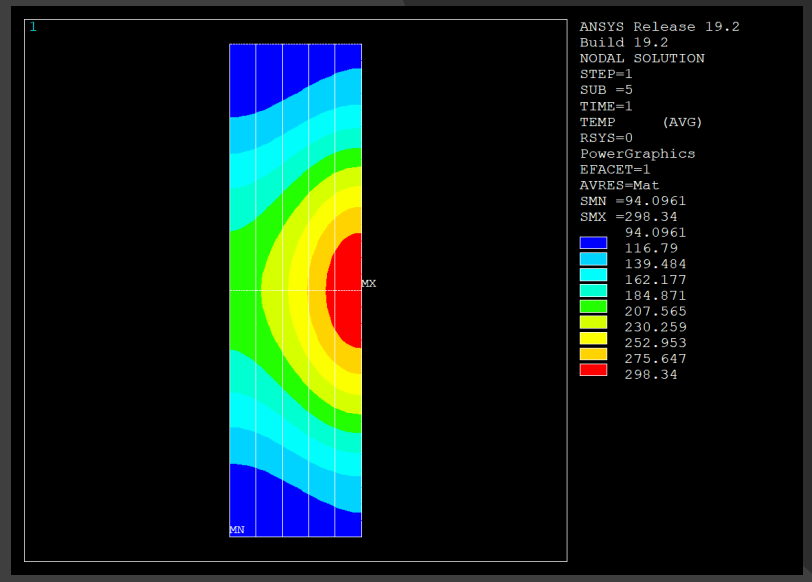
5kHz with 4kHz parameters



6kHz with 4kHz parameter



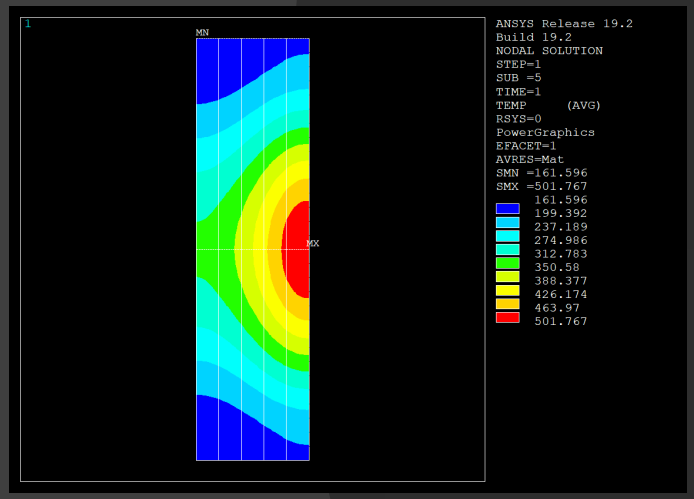
3kHz with 4kHz parameters



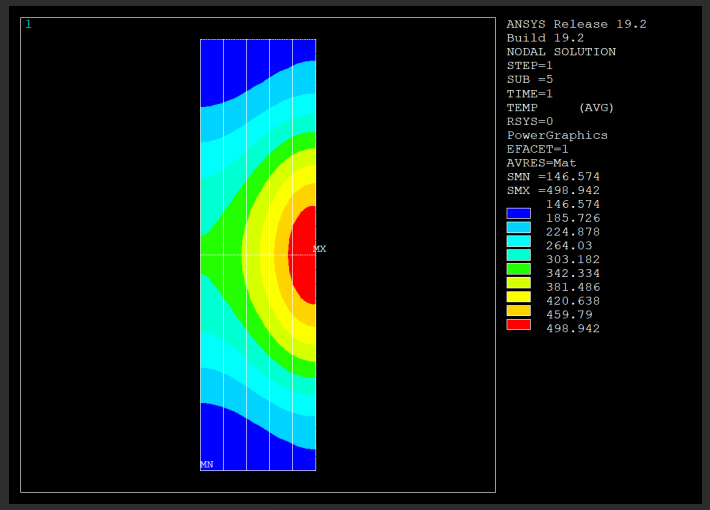
2kHz with 4kHz parameters

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

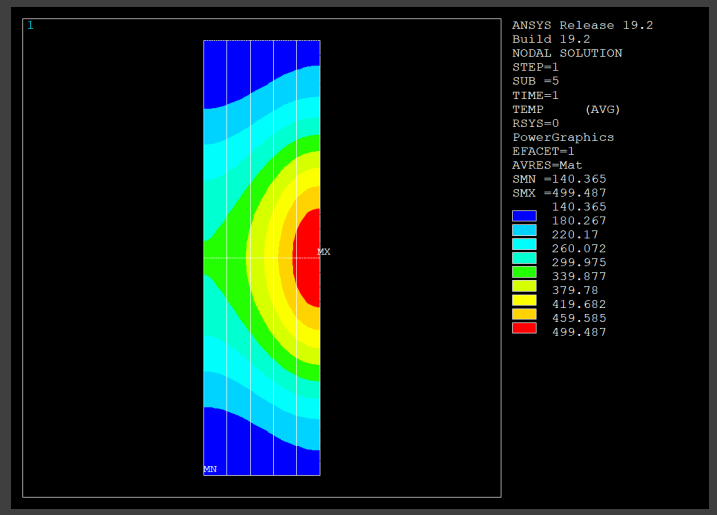
Goal: Get the max temperature at around 500°C



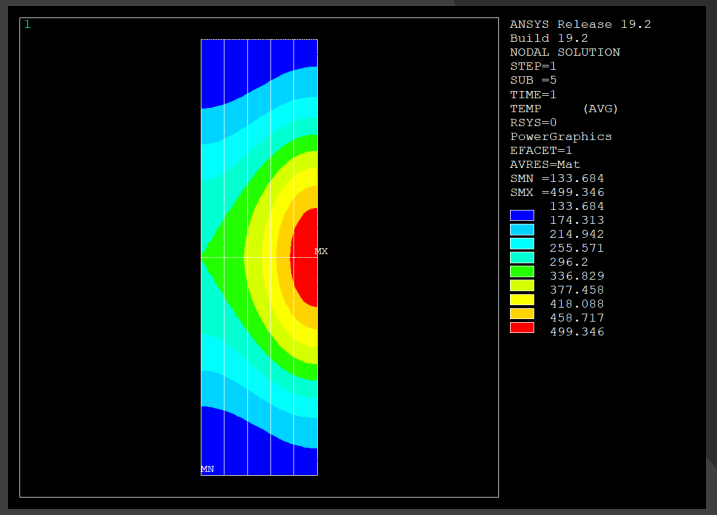
1kHz, **2.05kA**, Tcooling = 5s, Theating = 57s, Tmax = 501.767°C



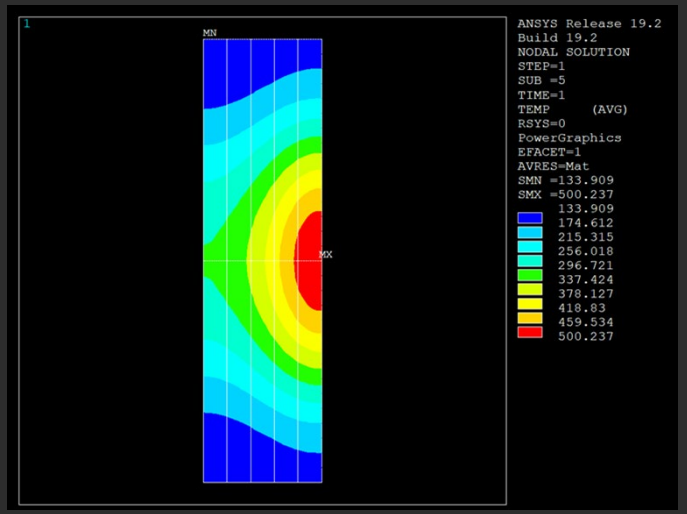
2kHz, **1.645kA**, Tcooling = 5s, Theating = 54s, Tmax = 498.942°C



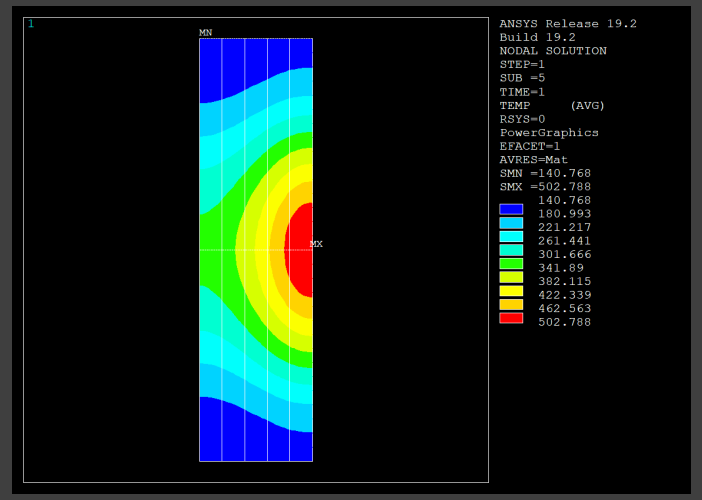
3kHz, **1.45kA**, Tcooling = 5s, Theaing = 53s, Tmax = 499.487°C



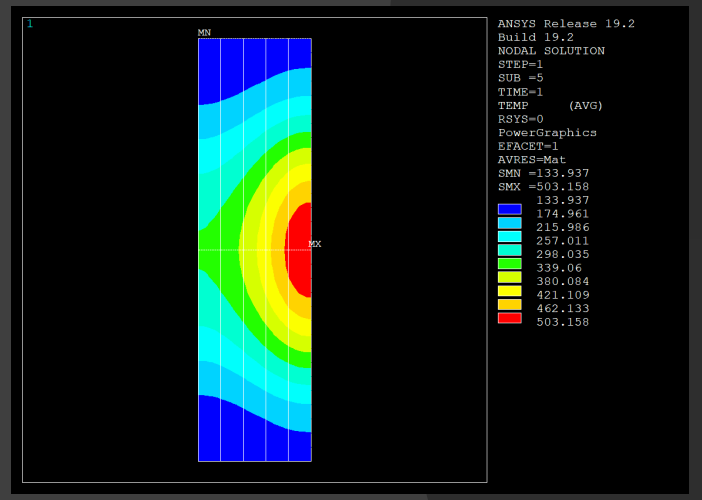
4kHz, **1.34kA**, Tcooling = 5s, Theating = 51s, Tmax = 499.346°C



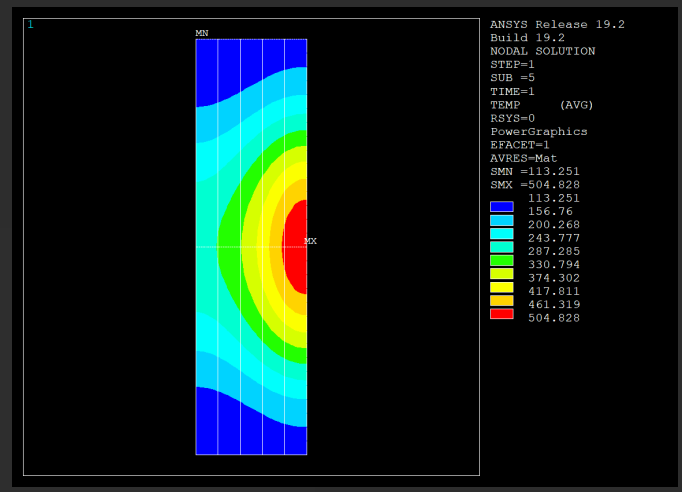
5kHz, **1.24kA**, Tcooling = 5s, Theating = 52s, Tmax = 500.237°C



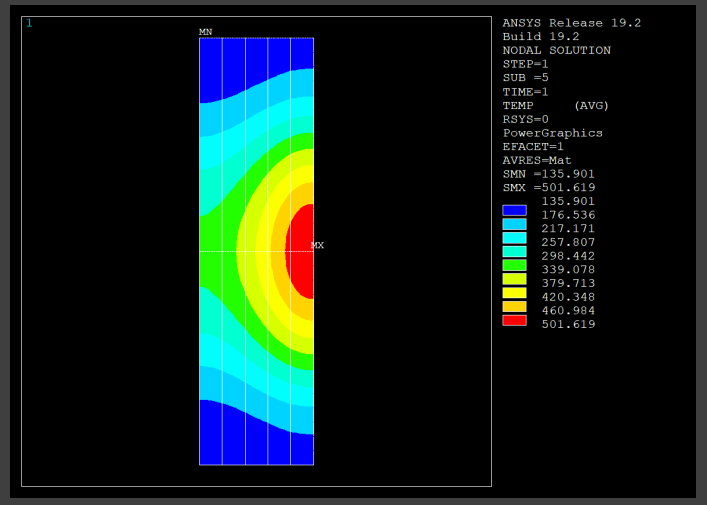
6kHz, **1.175kA**, Tcooling = 6s, Theating = 53s, Tmax = 502.788°C



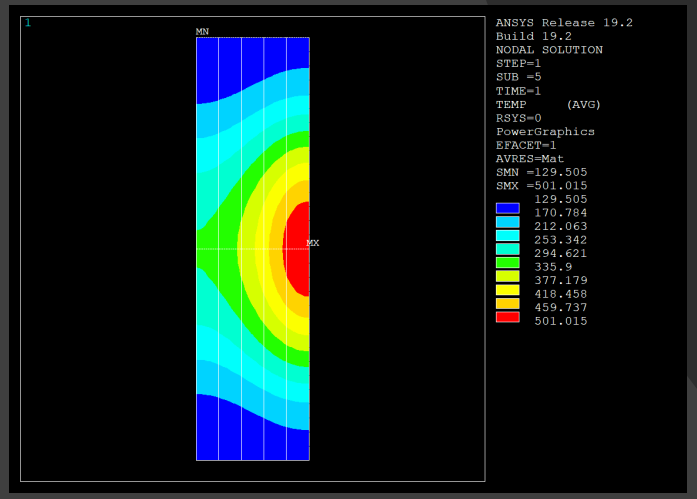
7kHz, **1.11kA**, Tcooling = 5s, Theating = 53s, Tmax = 503.158°C



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



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



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

Result: Exponential decrease in the current while decrease in frequency to get Tmax = ~500°C

Part 2: My Experience in Germany & Hannover

*Technically in Austria…

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