Rapid Magnetothermal Annealing

Overview
Superconducting materials have significant engineering applications such as maglev trains, magnetic resonance imaging (MRI) and magnetic fusion devices. With zero resistance, the material can carry huge power with an extremely low cost. Dean Schwartz’s lab is interested in superconducting, magnetic and multiferroic materials and the systems they enable. The research team wants to construct a Rapid Magnetothermal Annealing (RMA) system and use the superconducting magnet that is capable of generating 8.5T magnetic field to create these superconducting materials.

Objectives
Our goal is to develop a Rapid Magnetothermal Annealing system that can produce heating rates of >10 °C/sec up to temperatures of at least 600 °C in an ambient environment to create new magnetic and superconducting materials.

Approach
• Our project team went through a process of concept generation and selection and the use of an AHP matrix to best meet the criteria laid out by our sponsor along with the allotted budget.
• Our team researched existing patents to examine prior designs which influenced many of our design choices
• Sponsor meetings occurred on a bi-weekly basis to update the sponsor on our progress and design choices, which allowed us to validate our design concepts for the best outcome of the project.
• SolidWorks were used to 3D model our mechanical fixture, and LabVIEW was used to design the control system.
• Many design reviews and iterations were conducted before fabricating the mechanical fixture. This fabrication was done in the Penn State Learning Factory using their machinery.
• Once both the fixture and control system was fully designed and fabricated, two experimental testing was conducted to examine the heating and control capabilities of our design.
• We supplied power to one halogen lamp to heat a metallic sample and used the LabView control system to analyze peak temperatures, heating ramp rate, and temperature fluctuations.

Outcomes
• Our design has allowed the sponsor to conduct experiments quickly in a safe and structurally sound environment.
• The control system we have designed is easily programmable and user-friendly.
• The mechanical fixture provided to the sponsor has minimized thermal heat losses from the sample and insulated the magnet from any heat exposure.
• The RMA system we have created allows the sponsor to heat samples at a rate of 40°C/sec up to temperatures of at least 500°C.