3D (SLS) Printer for Magnets

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Executive Summary

Currently a technology gap exists in manufacturing strong magnets on the nanometer scale that have flexible characteristics. Our project will effectively solve this problem by integrating a magnetization head with a selective laser sintering (SLS) process. The magnetization head is designed to concentrate a high magnetic field strength of 1 T at the point between the tips. In addition, a rotation mount supporting the magnetization head will allow for pole pattering capabilities. Simultaneously, the diode laser will sinter the ferromagnetic polymer layer by layer in the SLS process.

Key Features

- Magnetization Head
  - This includes the steel core, hyperco50 tips, and copper coils.
- Rotation Mount
  - This connects the magnetization head and diode laser.
  - Rotation allows for magnetic pole pattering.
- Z-Printer Gantry
  - Linear rods for motion of printing head in the x-y and z directions.
  - Roller for spreading ferromagnetic powder.
- Diode Laser
  - 10 W, 450nm, 30mm focal length.
- Control Board
  - Controls up to 8 stepper drivers with 9 stepper outputs total.
  - In coordination with Raspberry Pi.
  - Klipper Software for stepper motor actuation.

Engineering Analysis

Utilized COMSOL Multiphysics to simulate the magnetization head and determine the location of the maximum magnetic flux density as well as the flux losses present.

- Simulation Specifications
  - 10 A, 1000 Turns of Coil, 20 mm Coil Length, 1 mm Air Gap Length
- Material Properties
  - Magnetic Core: 1008 Low Carbon Steel
  - Magnetic Tips: 1008 Low Carbon Steel (Hyperco50 to be used once the relative permeability is known)
- Results
  - Maximum magnetic flux density of 1.3 T at 1mm below surface of tips.
  - Large magnetic flux density leaks at bends along tip distance.

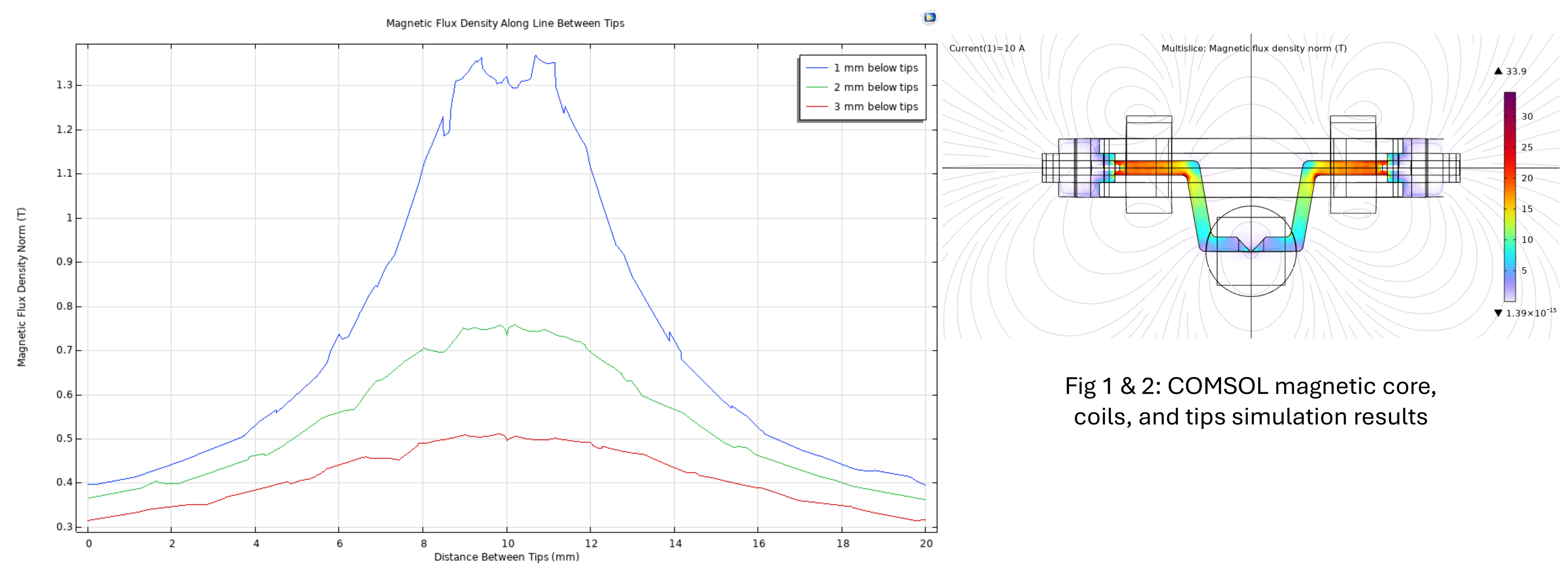

Fig 1 & 2: COMSOL magnetic core, coils, and tips simulation results

Future Improvements

- Fine tuned z-axis motion by stepper motors.
- Alter Z-Printer bed to have smaller build volume.
- Allow for easy adjustment of tip height from bed.

Team Contributions

MAE151A
- Simulations, CAD modeling, magnetic circuit calculations, 3D printing, electrical circuits, motor testing, and developing stakeholder needs and expectations.

MAE151B
- CAD modeling, Z-Corp printer deconstruction and integration, new controller-motor testing,

Impact and Considerations

Impact
- Due to being sponsored by the US Army Research Lab, applications such as magnetic drone charging.
- On a broader scale, this project enables the fabrication of intricate magnetic structures with greater precision and flexibility.
- Conventional magnet production involves significant material wastage due to subtractive machining methods. SLS reduces material loss, making the process more eco-friendly and cost-effective.

Consideration
- Magnetic properties of the printed magnets need to be tested and compared to traditionally manufactured magnets.

Overview

Full CAD Design

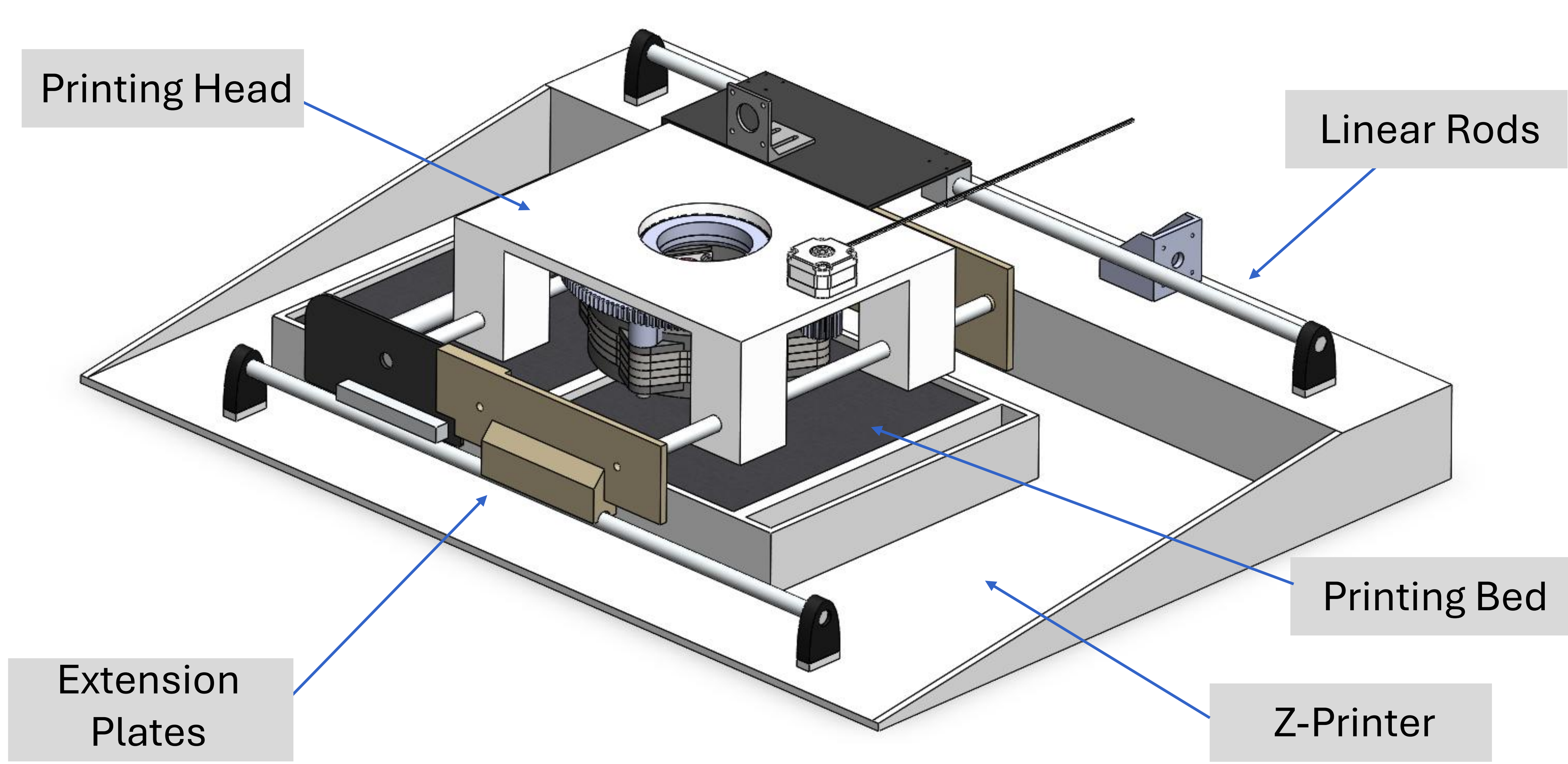

Fig 3: Complete model of rotational gantry and magnetic core within a model of the Z- Corp printer

Rotation Gantry CAD

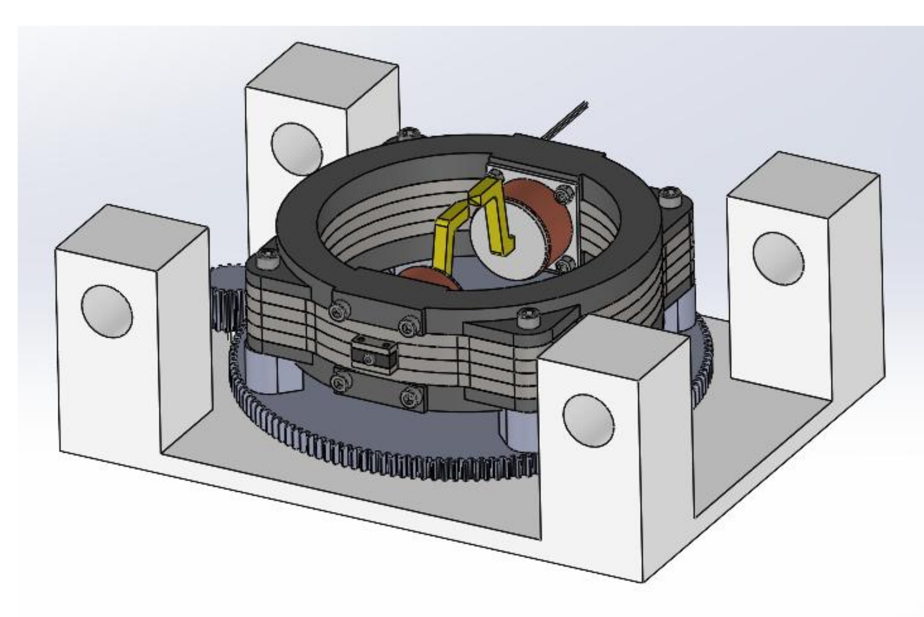

Fig 4: Inverted image of rotation mount and magnetization head connection model

Magnetization Head CAD

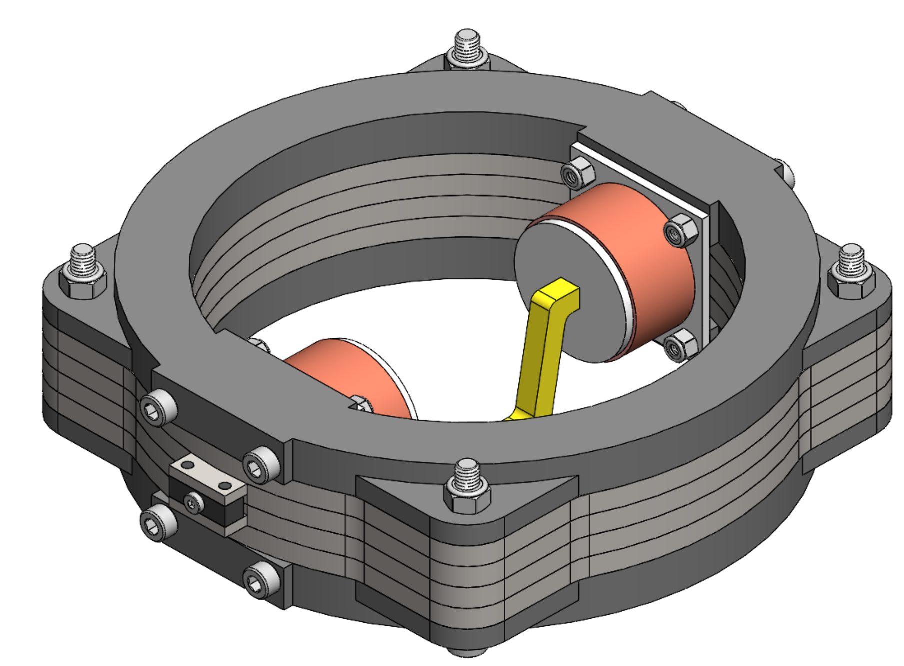

Fig 5: Magnetic circuit model (core, coils, and tips)

Acknowledgements

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