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OBJECTIVE

To design, manufacture, and validate a system to separate metallic uranium from glass and zirconium oxide waste.

BACKGROUND

The EBR-II and certain modern advanced nuclear reactor designs produce low level mixed quartz and metallic uranium waste through the production of their fuel. High assay low enriched uranium (HALEU) is extremely expensive and is subject to stringent tracking requirements, necessitating a system to efficiently separate residual uranium for recycle from the quartz waste.

VALUE PROPOSITION

Magnetic separation is widely used in industry to separate metallic materials from non-metallics. Using powerful permanent magnets, the weak paramagnetism of uranium could be utilized to separate it from diamagnetic glass and zirconium oxide. This would create a way to efficiently process waste from past and future reactor designs.

KEY REQUIREMENTS

- 95% Uranium Recovery by Weight
- 15 Minute Maximum Cycle Time
- Dry Process

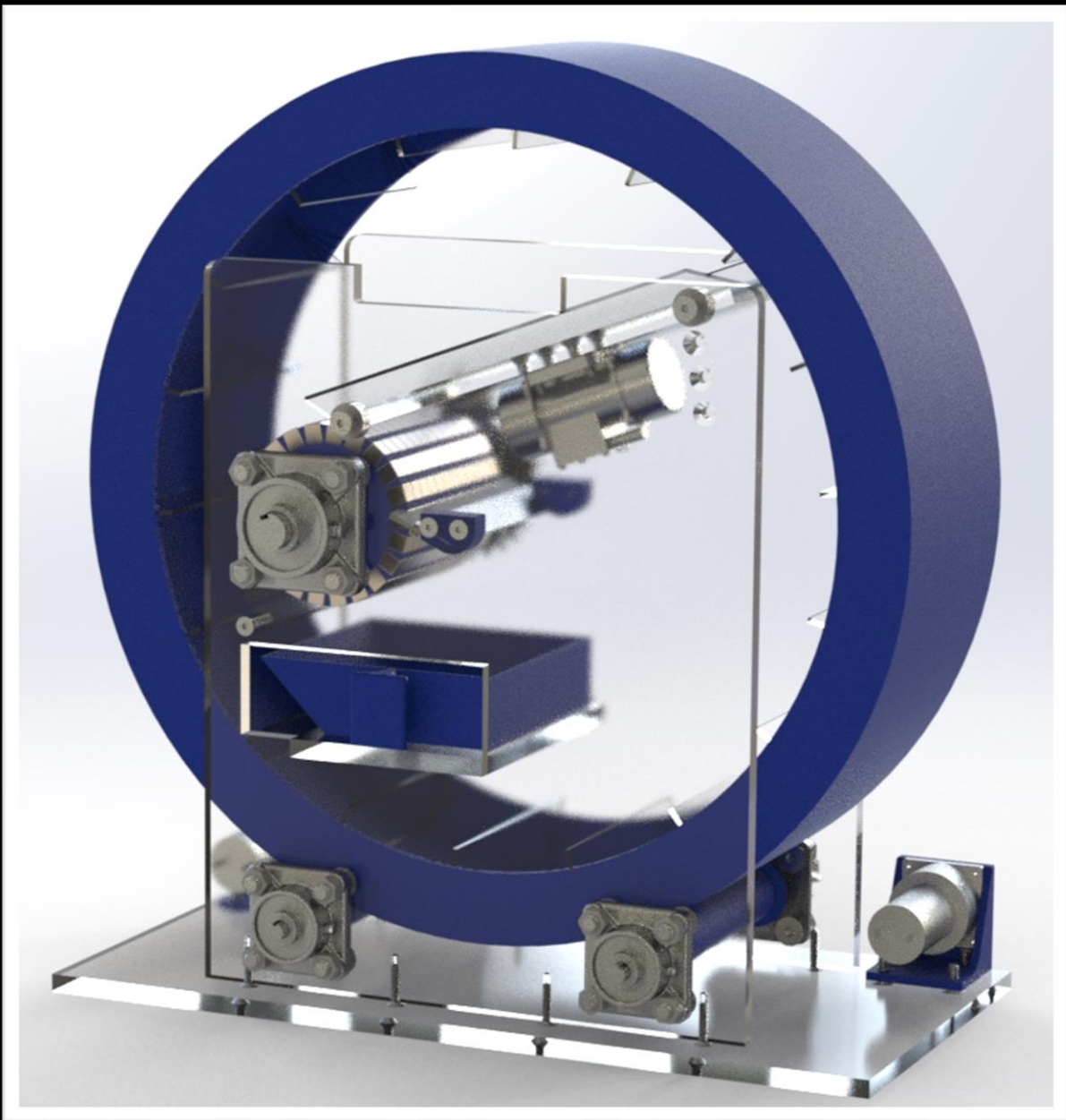
THE FINAL PRODUCT

- Magnet roller constructed with ½ inch N52 neodymium magnets used to separate mixed material stream
- Structure constructed with polycarbonate for easy viewing and high durability
- Ring, magnet roller frame, mounting brackets, diverter, and ring rollers 3D printed using PLA
- Powered with individually controllable DC motors linked with chains and sprockets

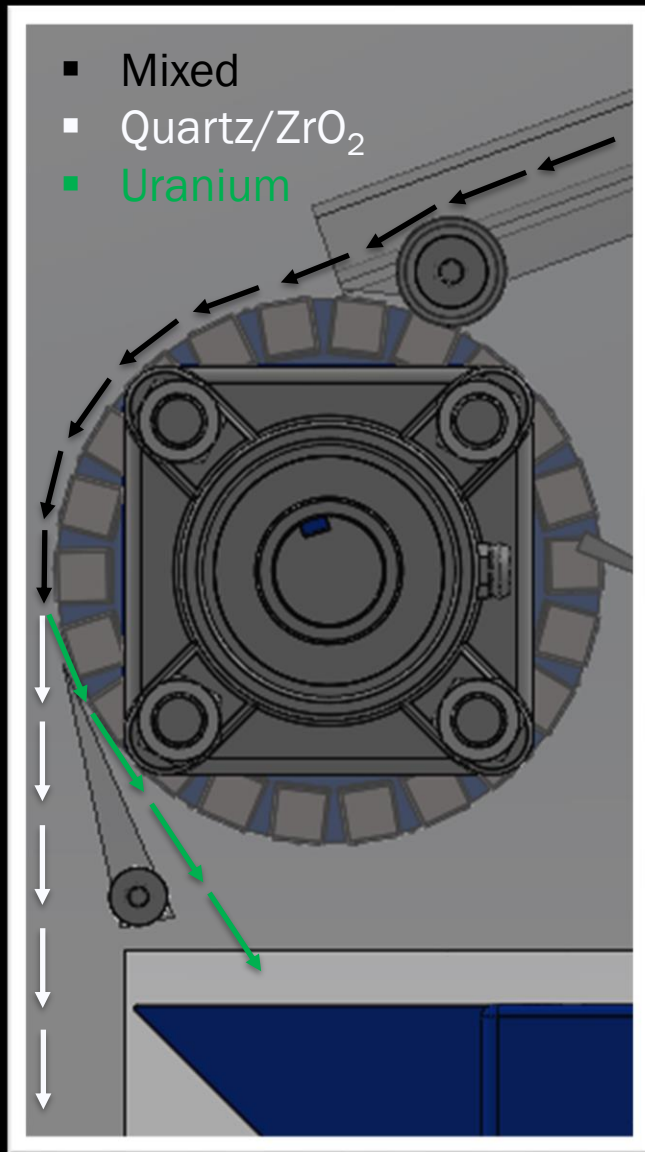
ACKNOWLEDGEMENTS

Client : Randall Fielding | Instructor : Michael Maughan | Grad Mentors : Ryan Sundburg, Dillon Morehouse | Shop Manager : Brian Petty

CONCEPT DEVELOPMENT

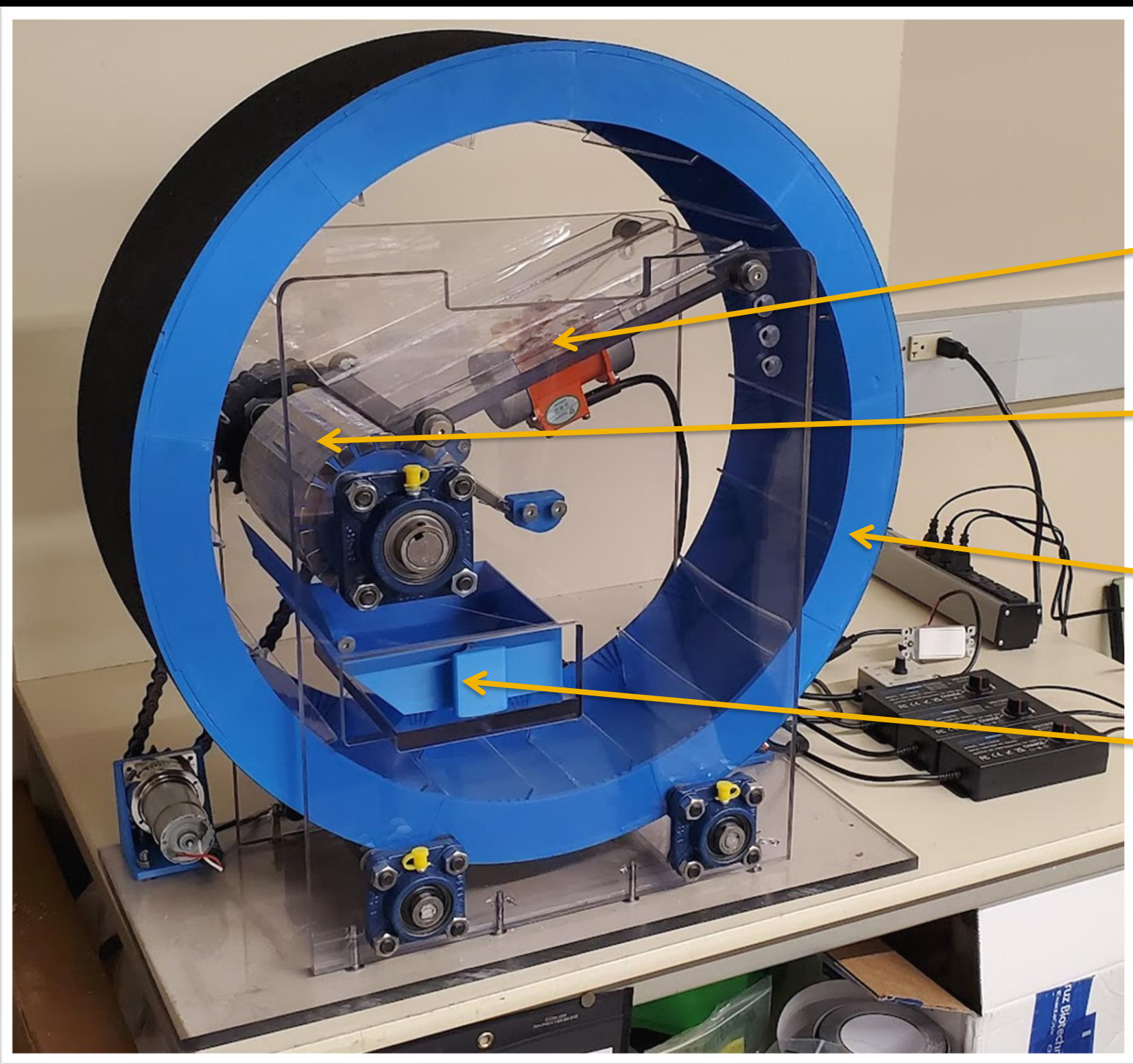


Final SolidWorks Design



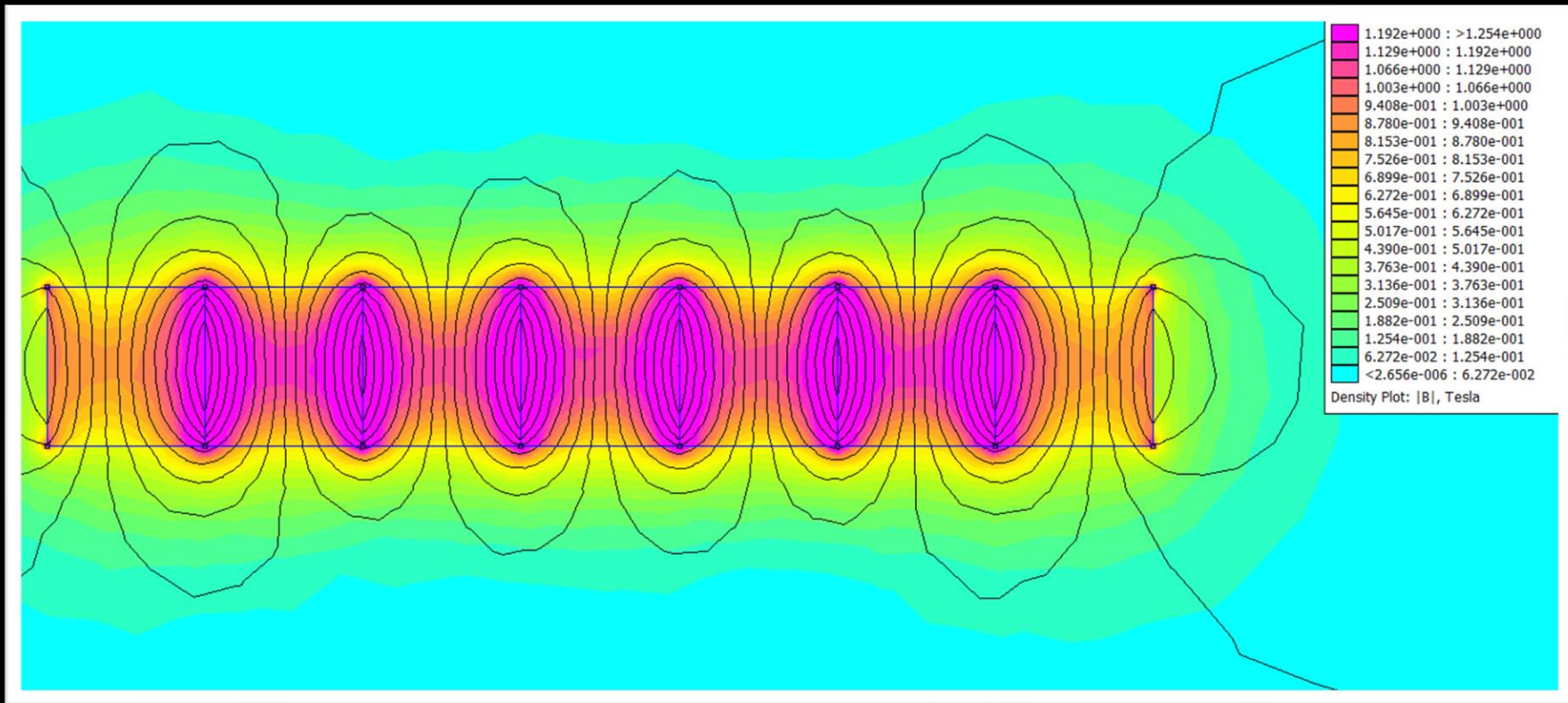
Material Path Over Roller

- Design revolves around magnetic roller constructed from 264 ½ inch cube magnets
- Vibration platform feeds material evenly over roller
- Mixed material stream is separated slightly as it goes over the roller
- Diverter plate directs uranium to collection box and other materials to the recycling ring
- Recycling ring carries mixed material back up to beginning of cycle, allowing for continuous operation and recycling until required recovery is reached

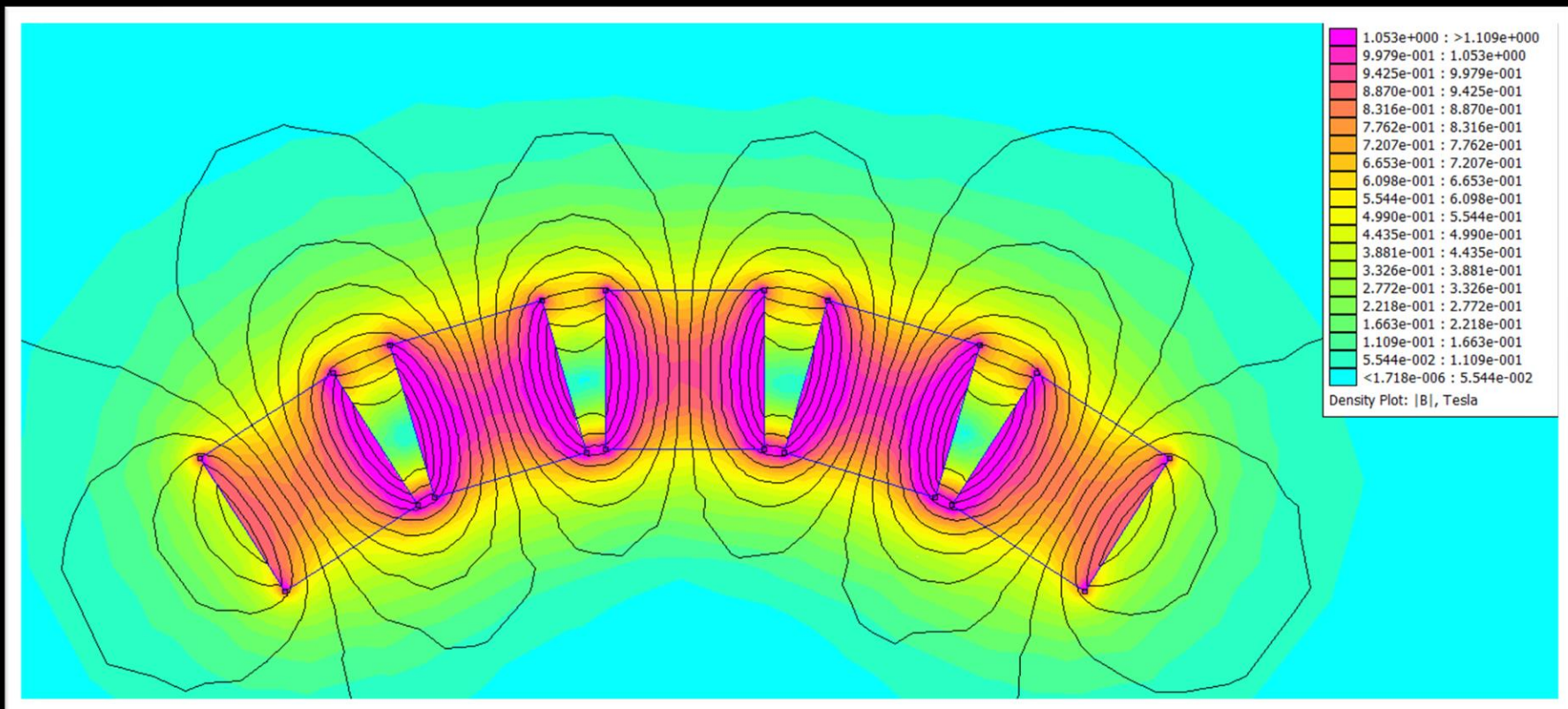


- Vibration Platform
- Magnetic Roller
- Recycling Ring
- Collection Box

VALIDATION AND RESULTS



North-South Alternating Magnet Array



Radial Alternating Magnet Array



Surrogate Material Mixture

Fraction (Mesh)	Uranium Recovery (%)	Cycle Time (Minutes)
-18/+35	96.25%	12.5

Final Testing Results

FUTURE WORK

- Reduce loss of material through open spaces in current design
- Inclusion of industrial plate magnet roller
- Implementation of cascading conveyor design
- Smart controls for speed, material recovery, and cycle completion
- Manufacture of more robust design with stronger materials for long term use in industry

- Finite Element Method Magnetics (FEMM) used for magnetic field modelling
- ~2 Tesla max field strength at magnet array edges
- Titanium granules used as uranium material surrogate due to its chemical stability and similar magnetic properties

Material	Mass Magnetic Susceptibility (m³/kg)	Density (kg/m³)
Uranium	2.16×10⁻⁸	19,050
Titanium	4.01×10⁻⁸	4,507

Material Comparison



The Dust Busters

