FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

ČKET

FLUXTROL®

Investigating the Benefit of Soft Magnetic Composite Inserts on Energy Efficiency in Cold Wall Billet Casters Using Computer Simulation

Tareq Eddir, Fluxtrol Inc. (tieddir@fluxtrol.com)
Robert Goldstein, Fluxtrol Inc.
Robert Haun, Anspanner LLC

03/09/2021

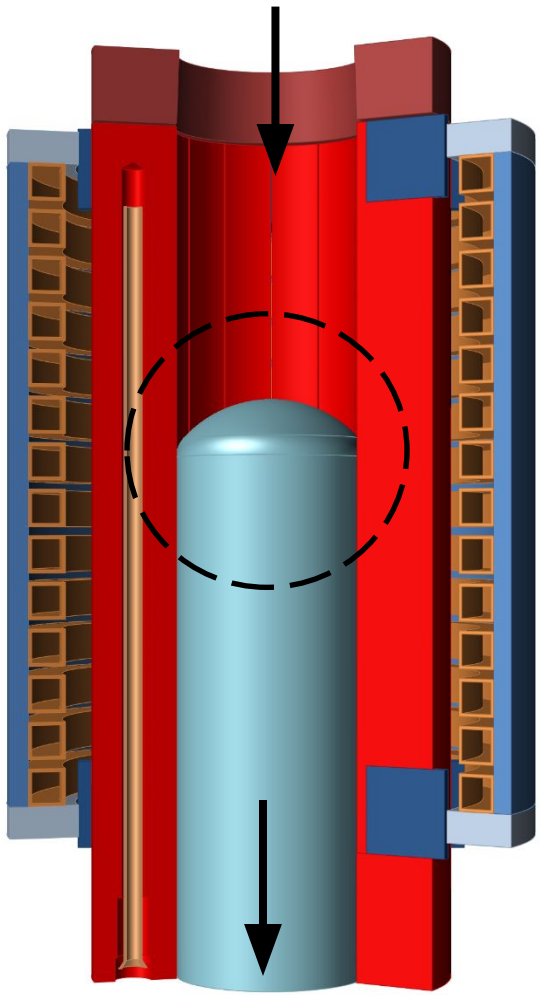
Outline

- Cold Wall Induction Billet Caters background
- Geometry Description
- Simulation Description
- Electrical Parameter Results
- Current Density Results
- Conclusions

Background

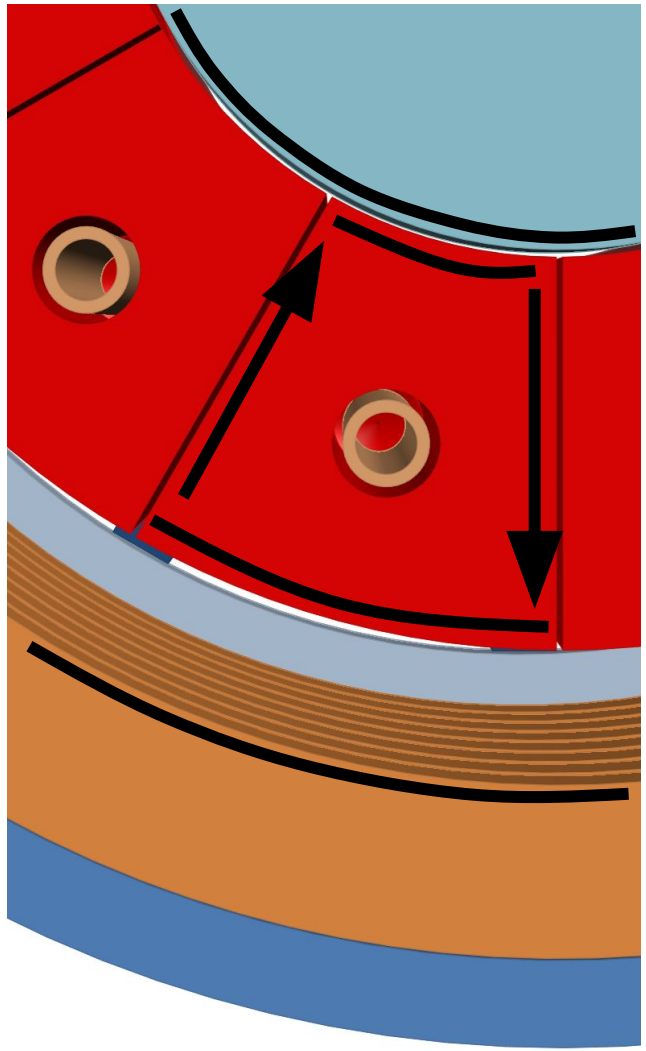
- Titanium powder production has increased substantially for additive manufacturing and the aerospace industry
- Powder is manufactured via techniques such as EIGA, which results in a relatively non-uniform powder size
- Additive manufacturing of titanium parts requires uniform powder sizes, resulting in low yields of acceptable powder sizes
- Rejected powder is recycled through cold wall billet casters
  - The cold wall design results in low electrical efficiency
- Soft magnetic composites have shown to increase efficiency of cold crucibles and may help reduce power demand in billet casters as well

Geometry Description



Powder Titanium is deposited from the top onto a billet being slowly pulled. The molten top of the billet (dashed circle) is heated through an induction heating coil.

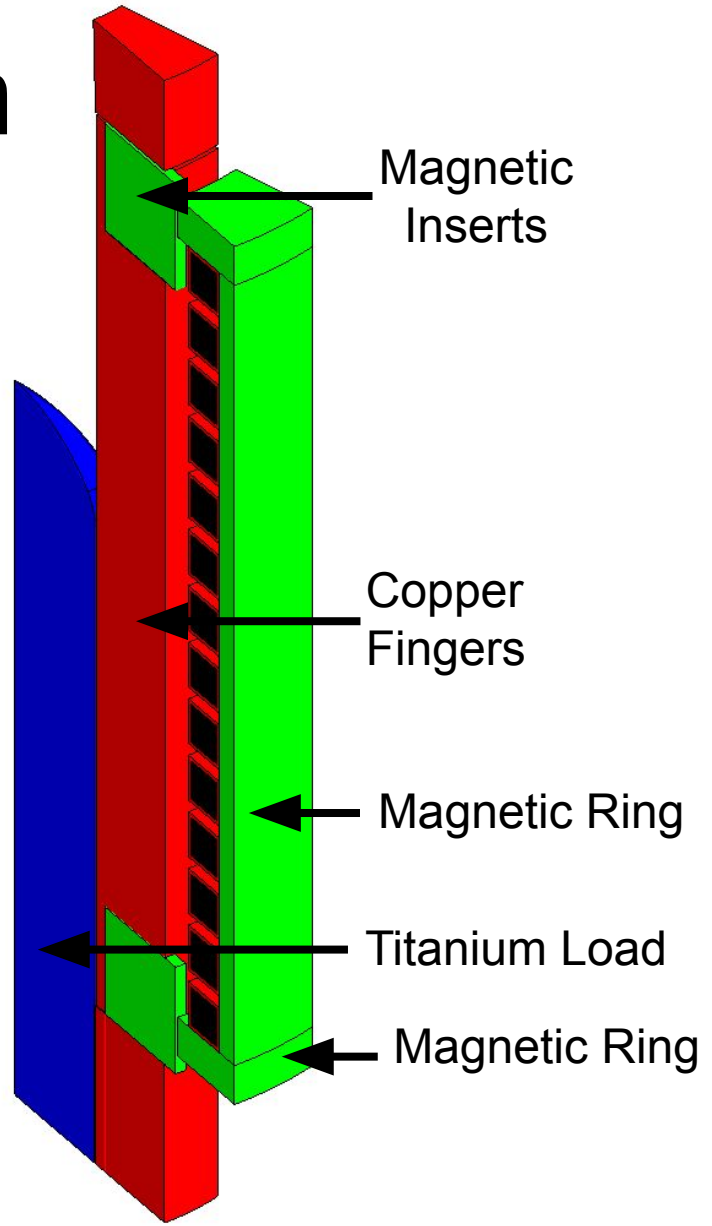
The black arrows indicate current direction in the coil, caster fingers, and load. The fingers are individually water-cooled to extract heat from the Joule losses and heat from transferred from the load.



Simulation Description

Flux 3D FEM software was used for the simulation.

- 3D geometry was used
- Electromagnetic physics was used
  - 1000A_{RMS} at 5 kHz was used for all simulations
- Load resistivity of 1.7μΩm was used
- Fluxtrol 100 soft magnetic composite was used for the magnetic inserts, rings, and shunts
- 1/24th of the geometry was modelled using symmetry planes



Electrical Results

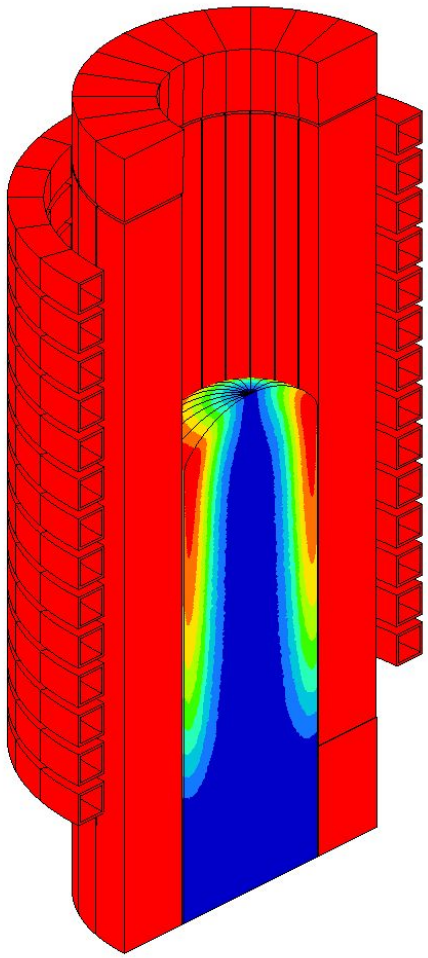
Case	U	P_{Load}	P_{Coil}	P_{Mold}	P_{SMC}	η
Bare	7.9	368	280	612	0	29.2%
Inserts	9.1	634	268	647	4	40.8%
Rings and Inserts	9.8	714	279	733	7.7	41.2%
Rings and Shunts	9.4	435	316	771	29	28.0%
Rings, Shunts, and Inserts	11.1	824	328	872	47	39.8%

$$\eta = P_{Load} / P_{total}$$

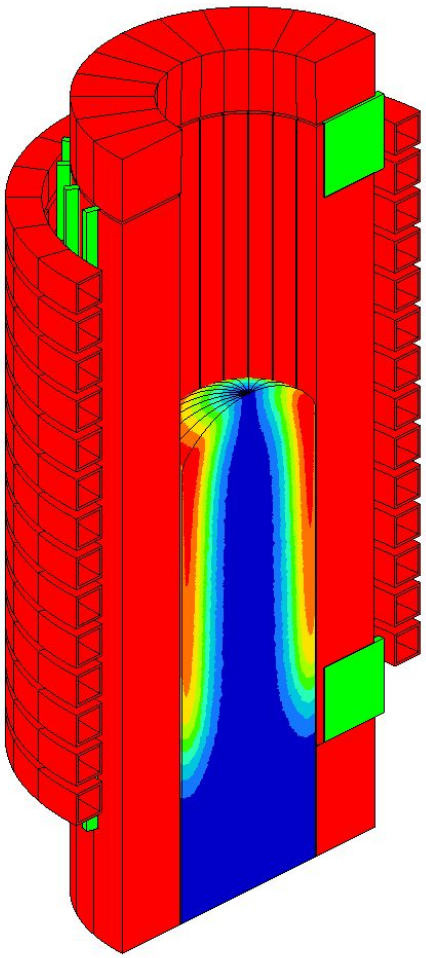
$$P_{Total} = P_{Load} + P_{Coil} + P_{Mold} + P_{SMC}$$

Where:
η is efficiency
U is potential in V
and P is power in W
SMC is Soft Magnetic Composite (Rings, Inserts, and Shunts)

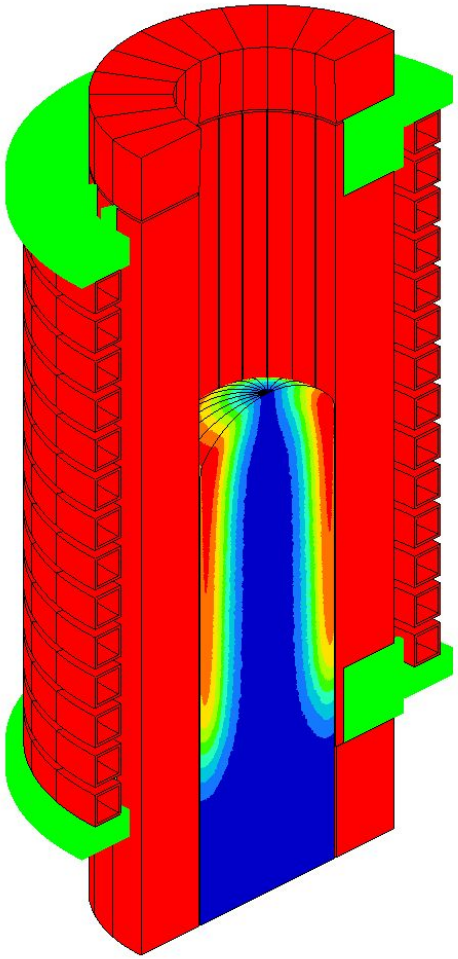
Load Current Density Contour



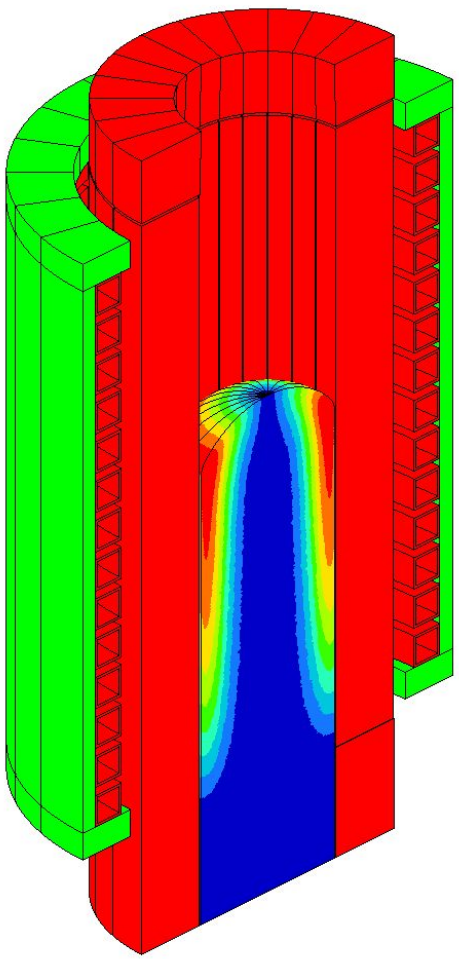
Bare Coil



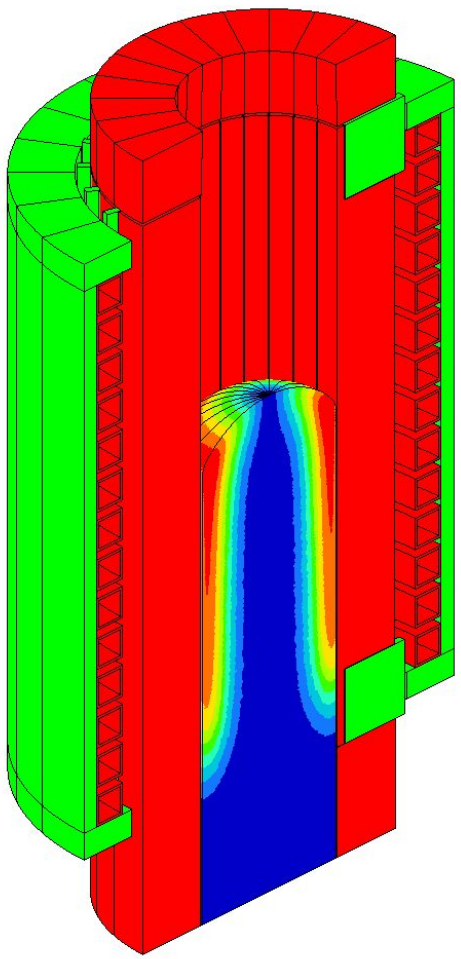
Inserts



Rings and Inserts

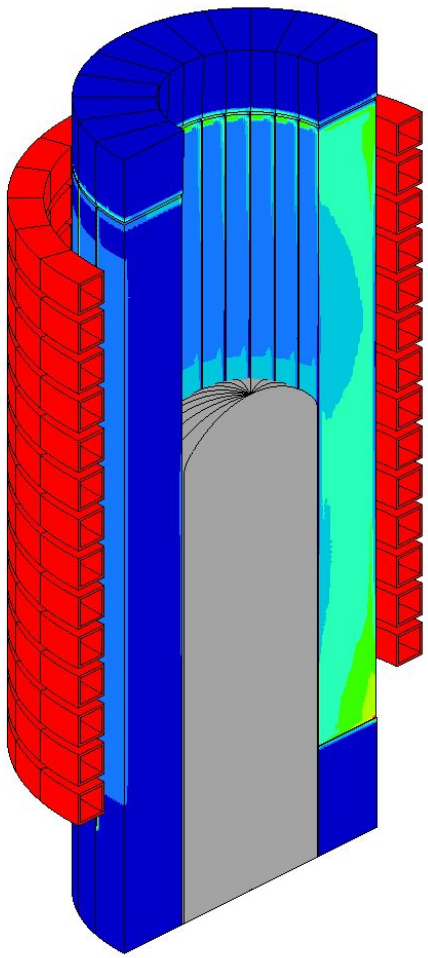


Rings and Shunts

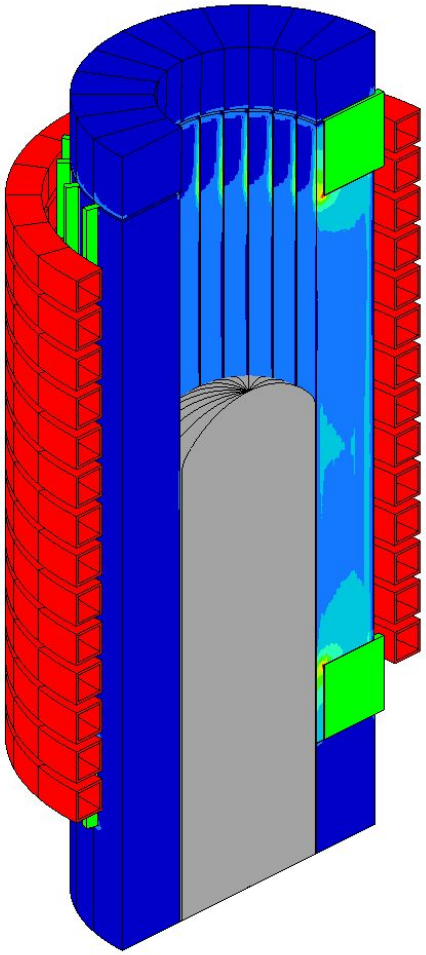


Rings, Shunts, and Inserts

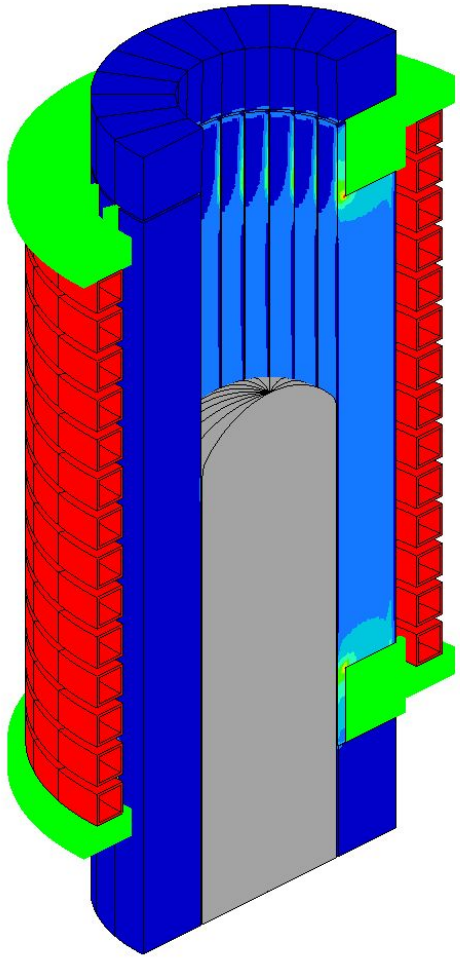
Mold Current Density Contour



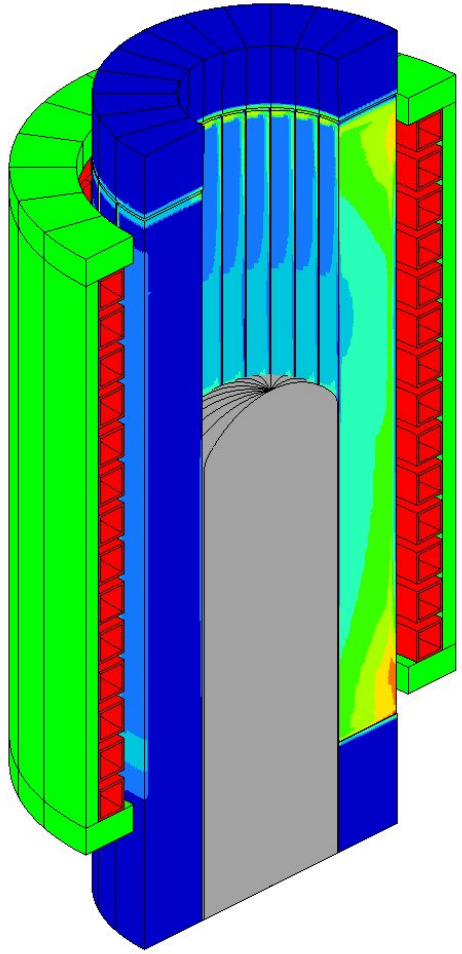
Bare Coil



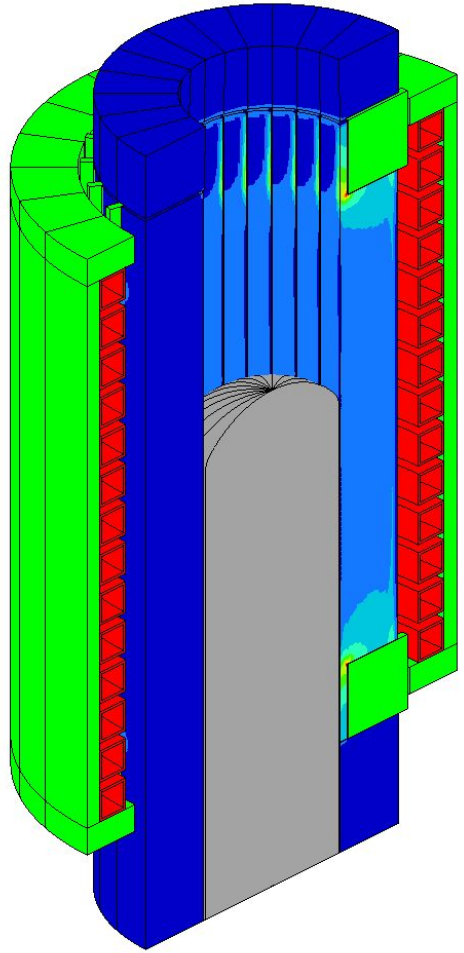
Inserts



Rings and Inserts

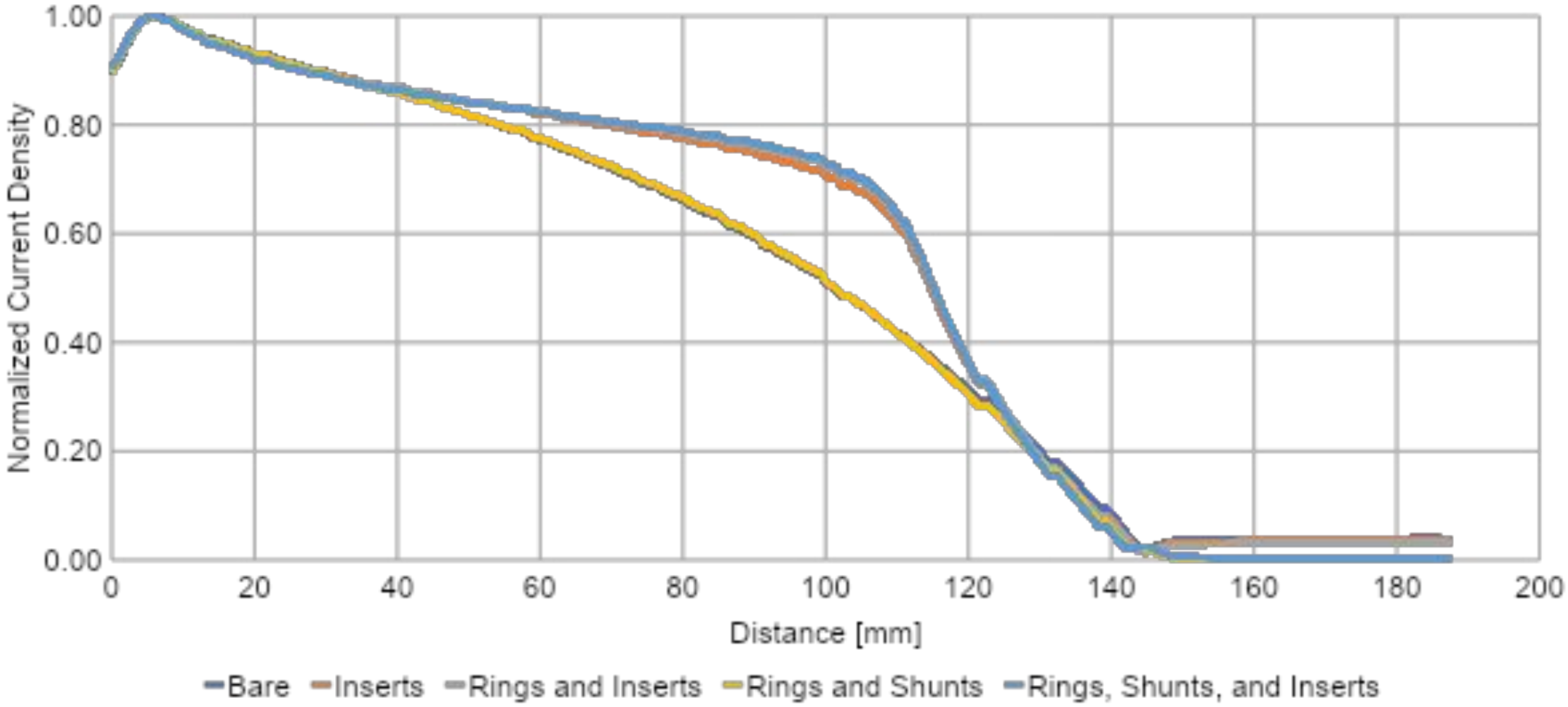


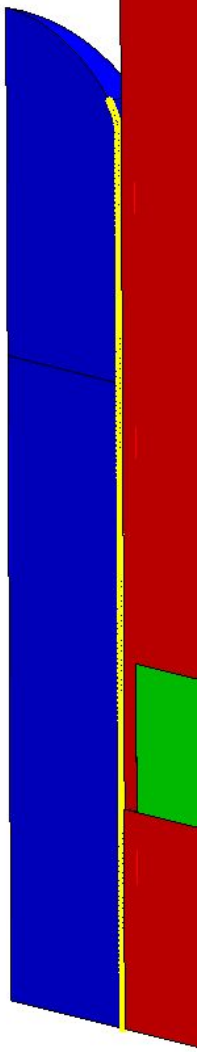
Rings and Shunts



Rings, Shunts, and Inserts

Normalized Current Density Graphs





Conclusions

- 3D Simulations were made to predict the electrical parameters of different cases
- The results show using soft magnetic composites for cold wall billet casters increases the electrical efficiency
  - Adding rings and shuts on the coil showed no benefit on the efficiency
    - When considering chamber heating and size, rings and shunts can be beneficial
  - Addition of inserts to the billet caster increases efficiency by ~10%
- An existing mold design was considered, further improvements may be achieved with an optimized design