An Overview of Mars Hopper Research at the University of Idaho

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INEST
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University of Idaho
A LEGACY OF LEADING

Acknowledgements

- Steve Howe, CSNR
- Idaho Space Grant Consortium

Students

Graduate Students:

Jennifer Hasenoerhl

Matthew Hanson

Garrett Hanson

Drew Flerchinger

Senior Design Teams:

(2010)

Kacey Bowen

Tamara Crowther

Travis Hunter

Jacob Wood

(2011)

Nathan Bartel

Lee Fuller

Trever Pope

Justin Mendonca

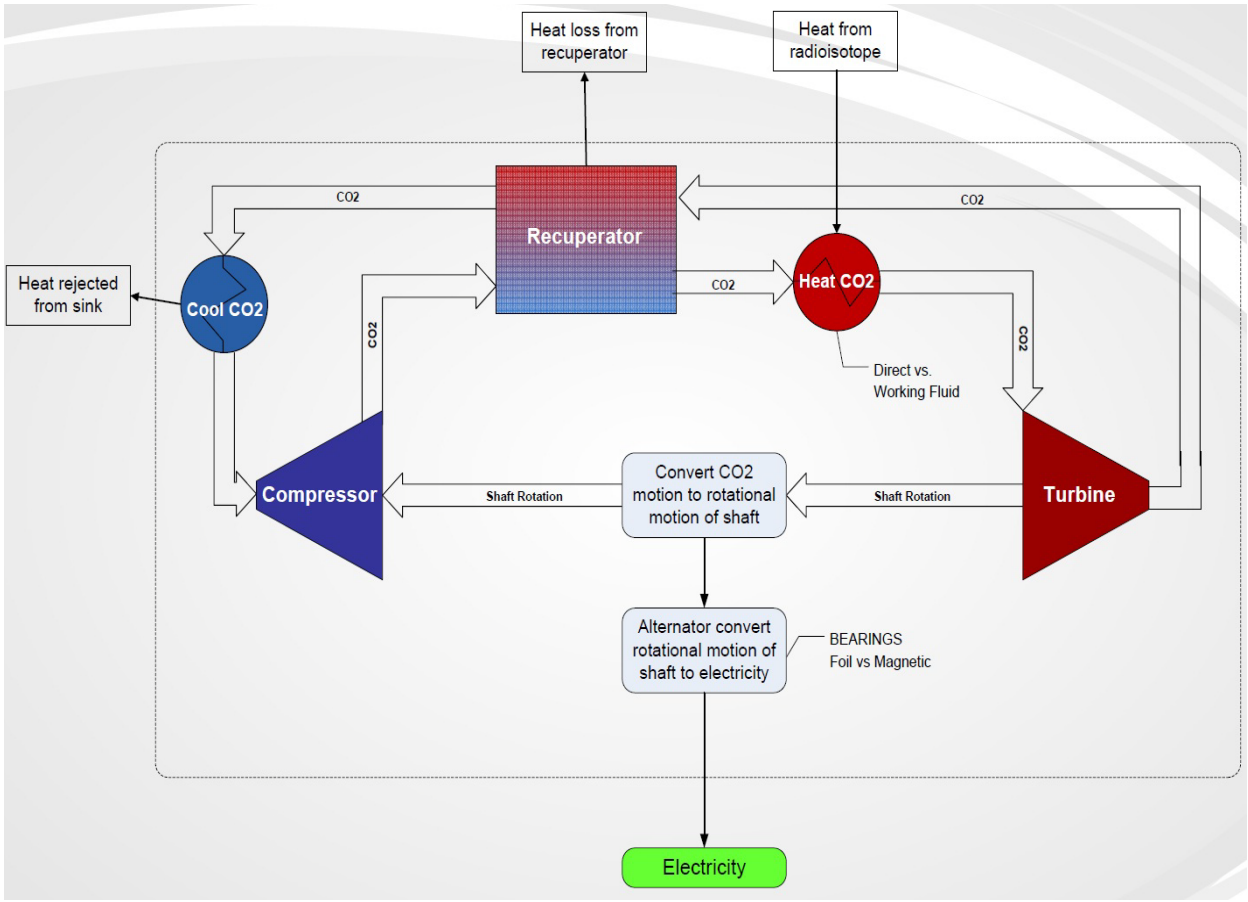
Erik Sterbentz

Senior Design Projects

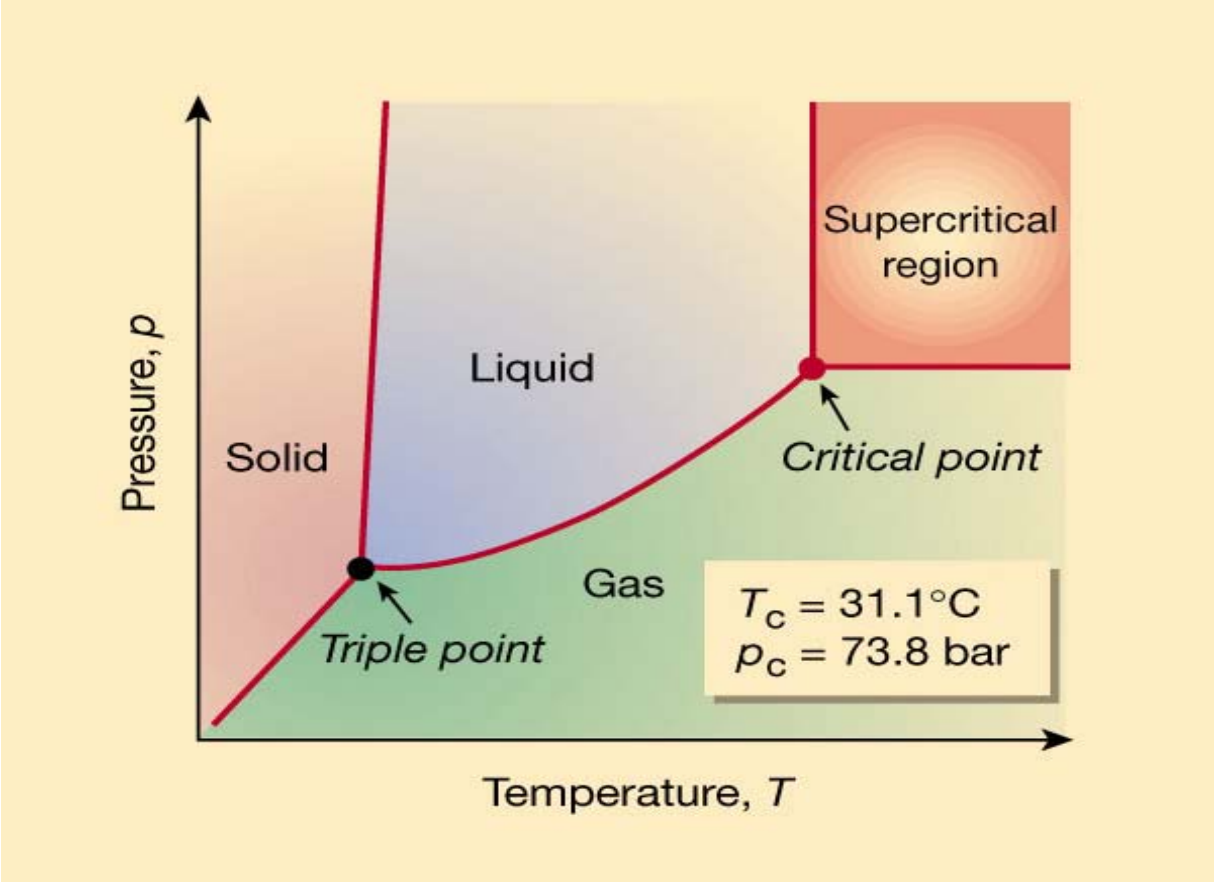
CSNR funded two senior design projects, both related to the power conversion system for the Mars Hopper.

The first senior design group evaluated different systems including thermoelectric, thermoacoustic, supercritical Brayton and open and closed Brayton cycle systems.

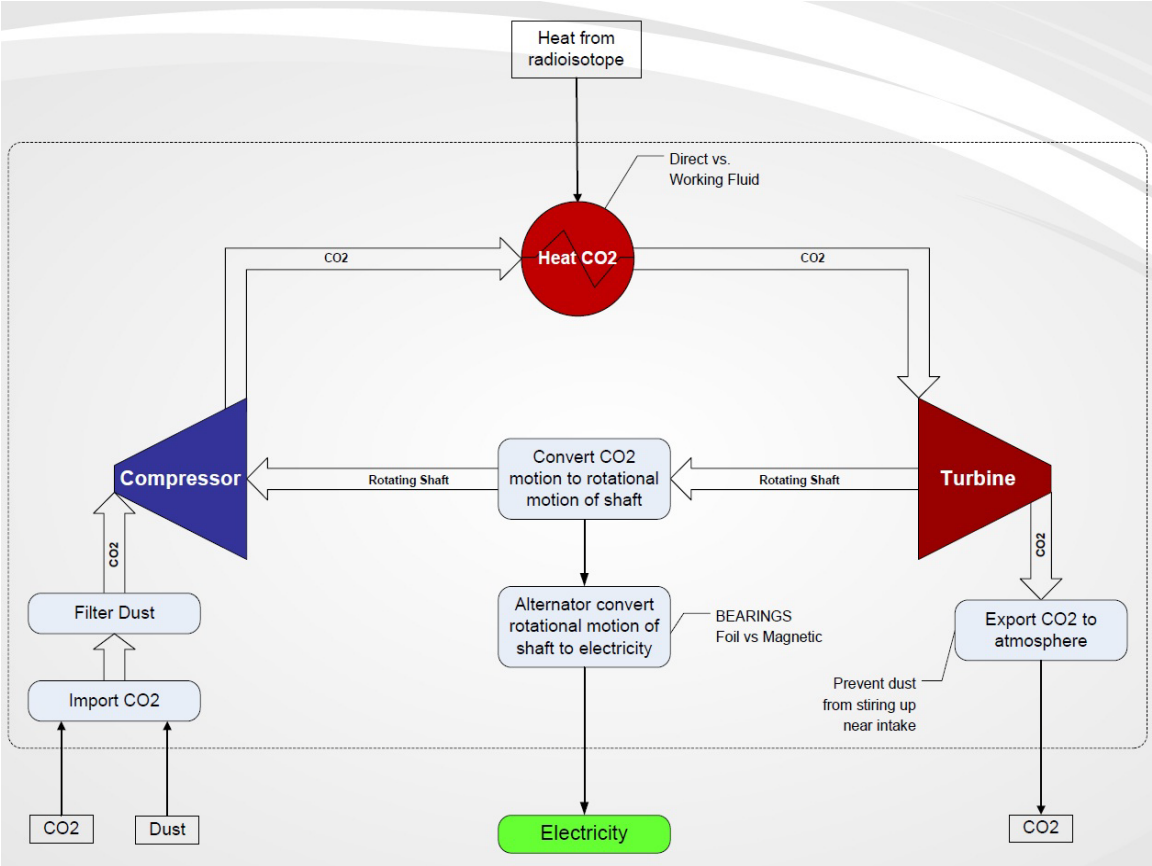
Closed Brayton Cycle



CO_2 Phase Diagram



Open Brayton Cycle



Power Cycle

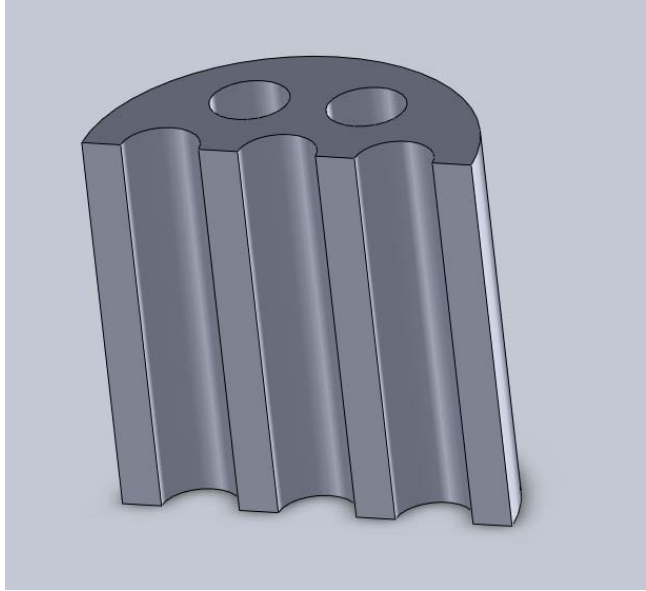
The first senior design group eventually settled on a valved system so that the cycle could perform in both open and closed modes, and preliminary testing was performed.

The second senior design team is working on modifying and improving the first team's design.

Graduate Student Work

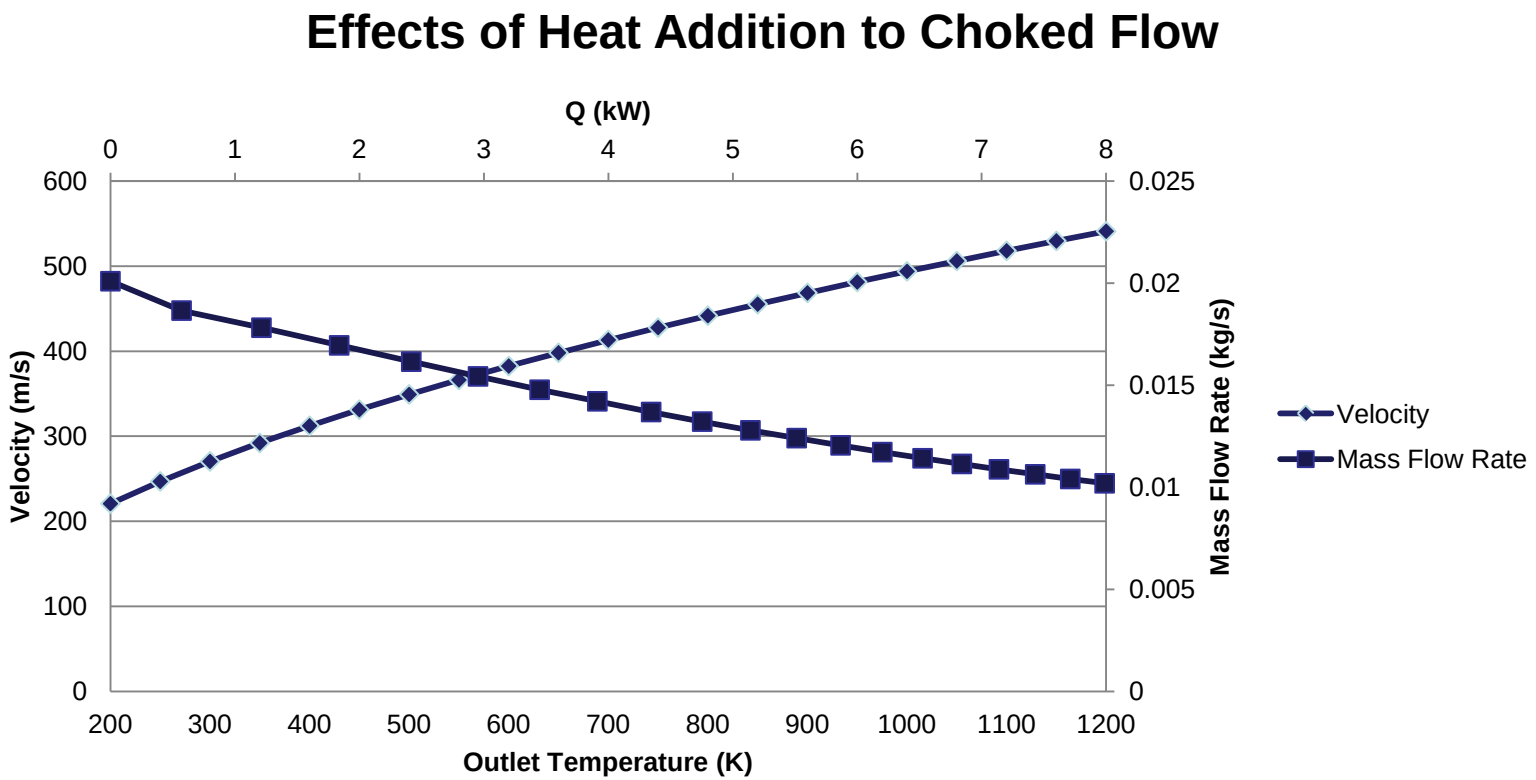
One of the graduate students is studying the compressible flow and heat transfer through the core.

Beryllium Core



Constant Area Flow Channels

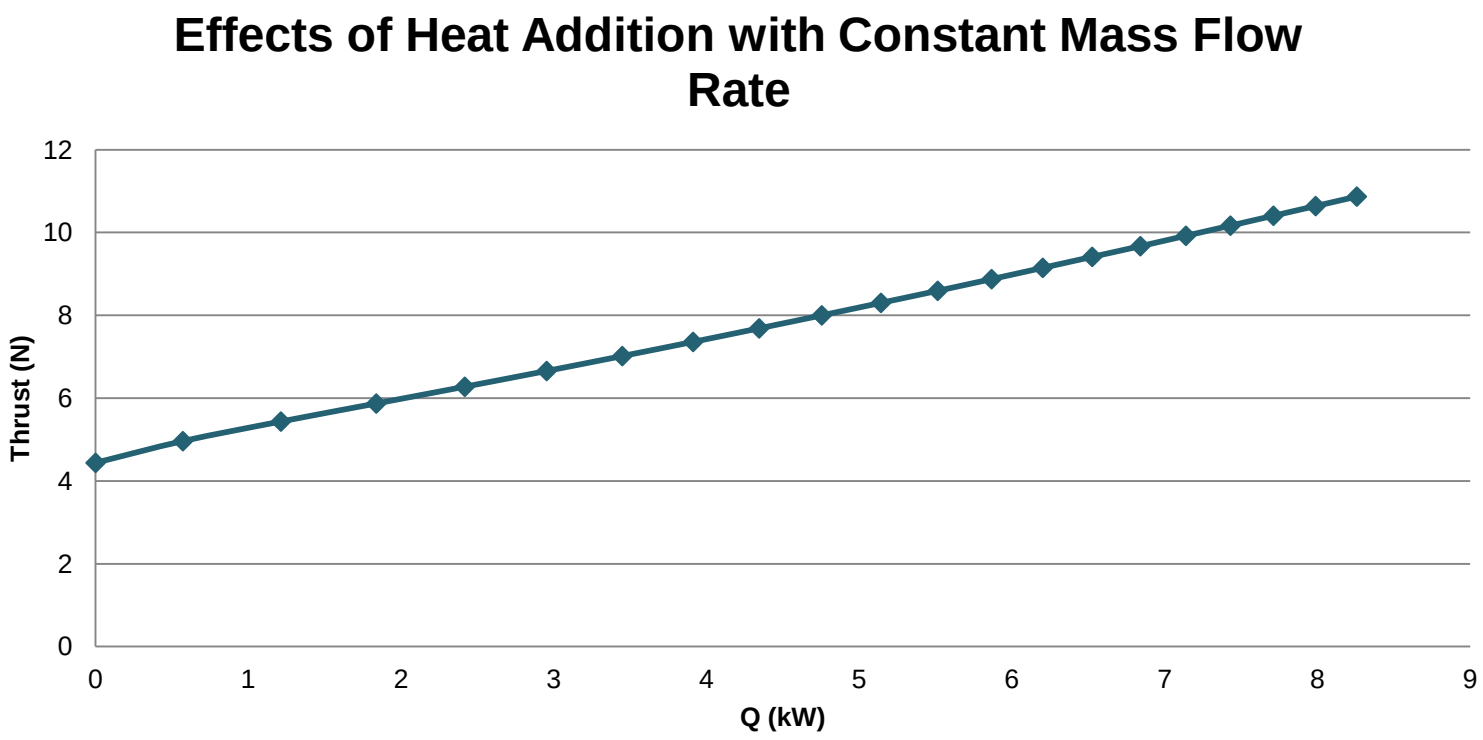
Graduate Student Work



Graduate Student Work

Increasing Diameter Flow Channels

Graduate Student Work

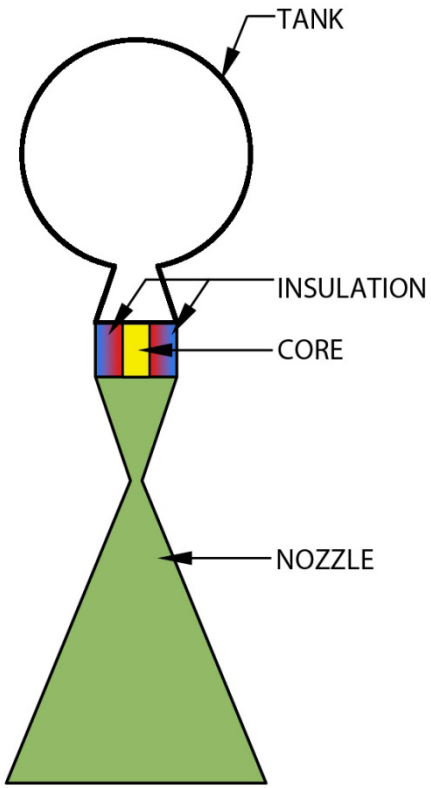


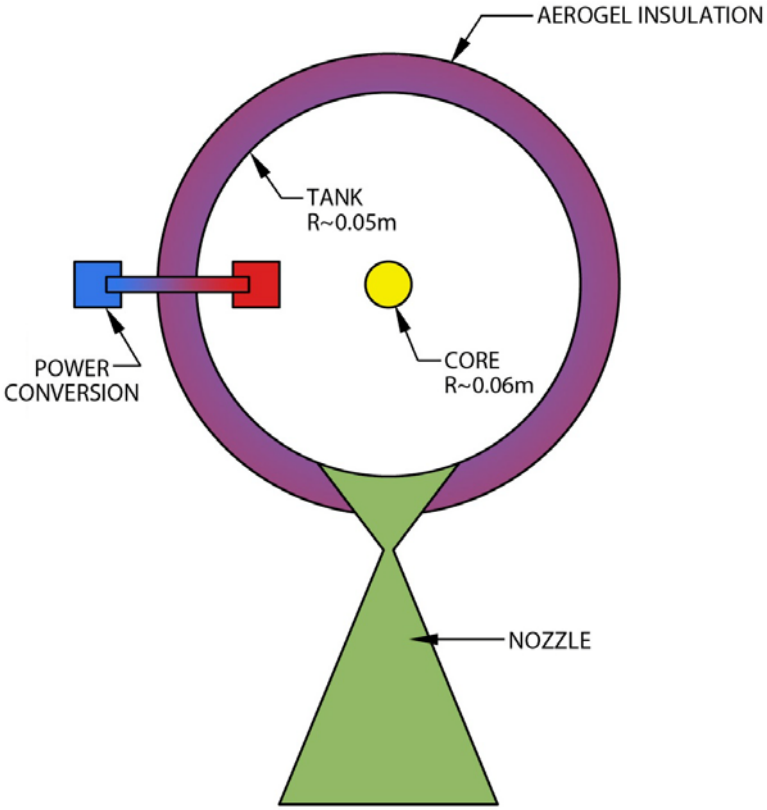
Graduate Student Work

In addition to the external heater concept, we investigated an immersed heater concept.

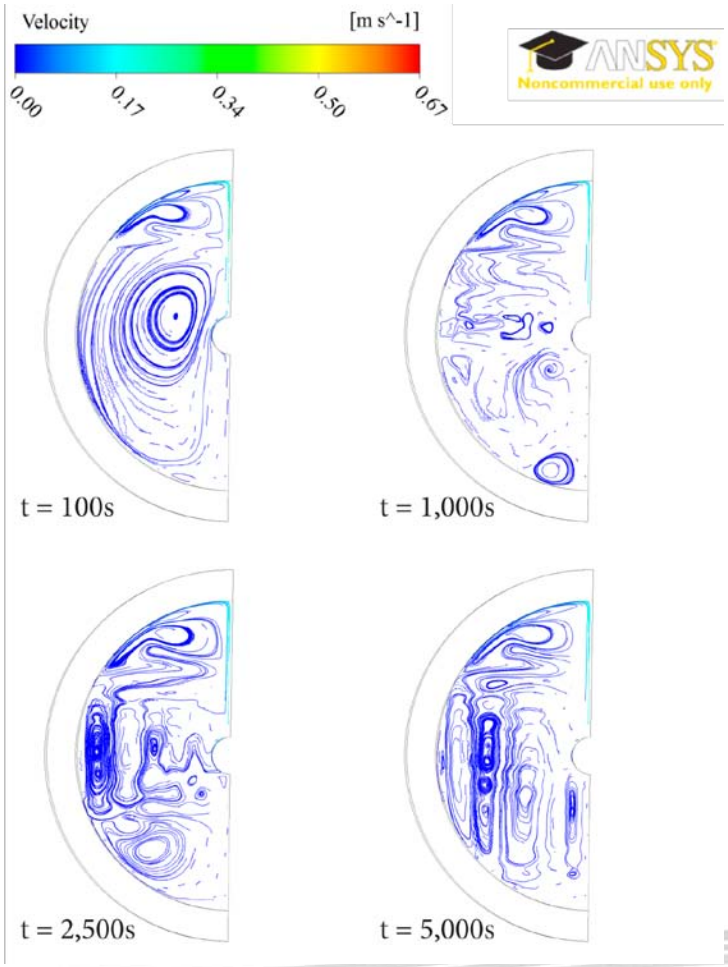
For the immersed heater, the CO_2 in the tank could be kept at a single gaseous phase, avoiding the problem of two phase flow through the external heater and the associated thermodynamic transition problems. However, if the gas remains in a single gaseous phase, the pressure in the tank would be much higher, meaning a heavier pressure tank.

Graduate Student Work

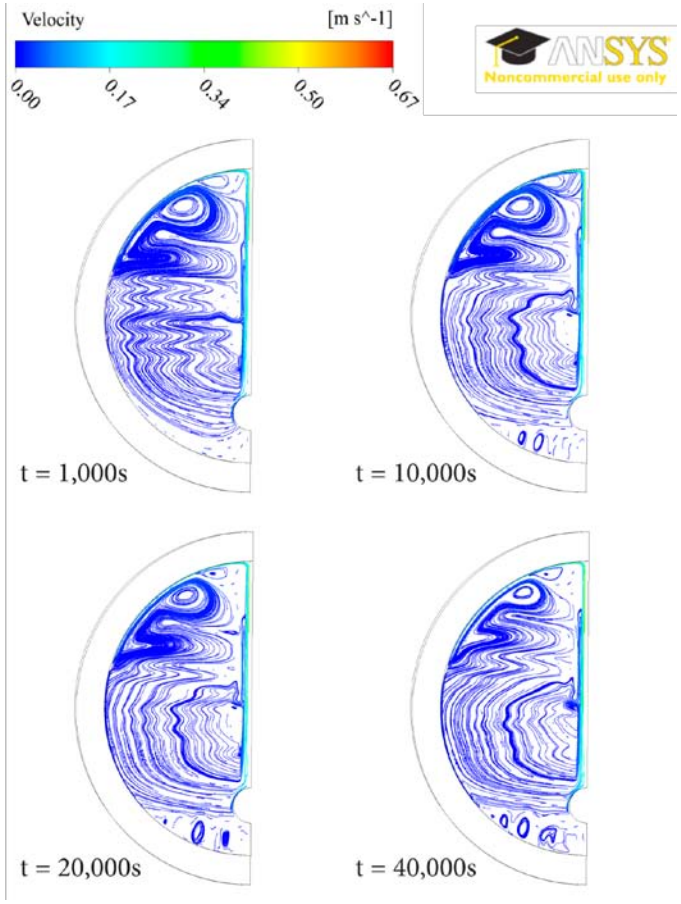




Graduate Student Work



Graduate Student Work



Graduate Student Work

An exergy analysis was performed on the two configurations. Exergy is a measure of the available work that a system contains. As opposed to the First Law of Thermodynamics which gives the energy efficiency of a system, the exergy determines the amount of entropy generated by the system, so it gives a second law efficiency measure.

Graduate Student Work

Accounting for exergy:

$$\psi_{flow} = \left(h_i - h_0\right) - T_0\left(s_i - s_0\right)$$

Ability to do work is lost to entropy generation:

$$W_{lost} = T_0 S_{gen}$$

Graduate Student Work

External Heater

Process	Lost work [kJ/kg$_{CO2}$]
0—1	9.93
1—2	601.1
2—3	1457
3—4	244.3
Total	2312

Immersed Heater

Process	Lost work [kJ/kg$_{CO2}$]
0—1	9.93
1—2	480.9
2—3	706.6
Total	1197.4