Maintaining a Temperature Gradient in Stirling Engine Regenerators

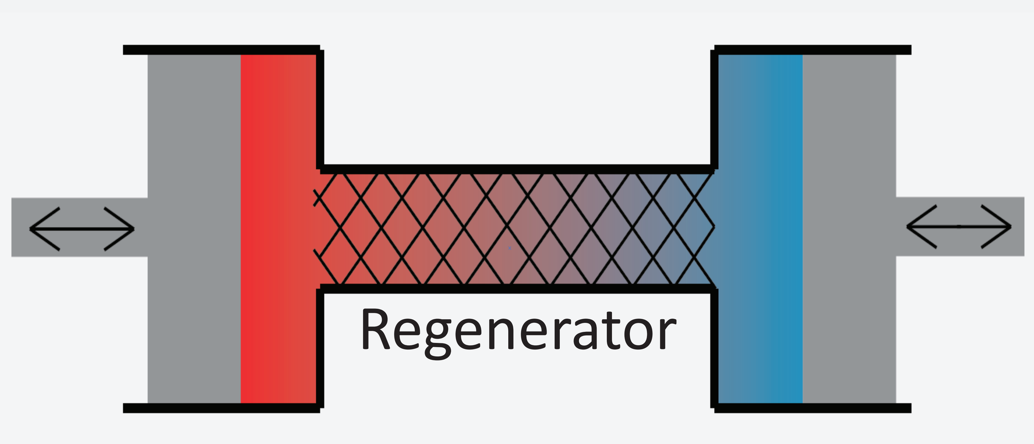
Brayden T. York, Brendan D. MacDonald

UNIVERSITY OF ONTARIO INSTITUTE OF TECHNOLOGY

MacDonald Lab

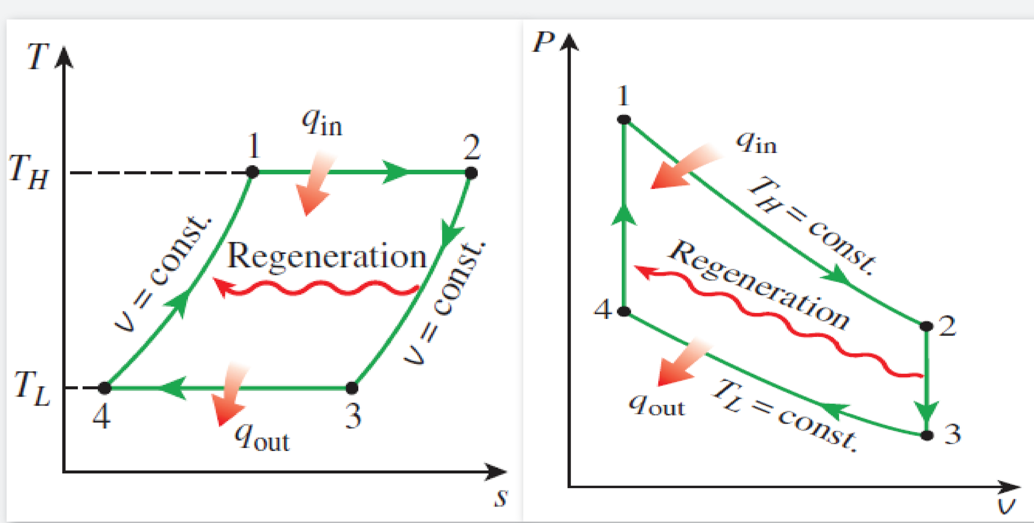
Regenerator Background

A regenerator is a heat exchanger in a close-cycle hot air engine. First patented by Robert Stirling in 1816, the regenerator serves to capture and recycle heat that would normally be rejected between the compression and expansion strokes.



The addition of a *perfect* regenerator to a hot air engine allows the theoretical efficiency to approach that of the Carnot cycle, the highest possible efficiency for a heat engine.

In reality, regenerator efficiency can currently only reach 50%, significantly reducing the engines overall efficiency.



Cengel, Yunus A, and Michael A Boles. Thermodynamics: an Engineering Approach. 8th ed., Mcgraw-Hill, 2015.

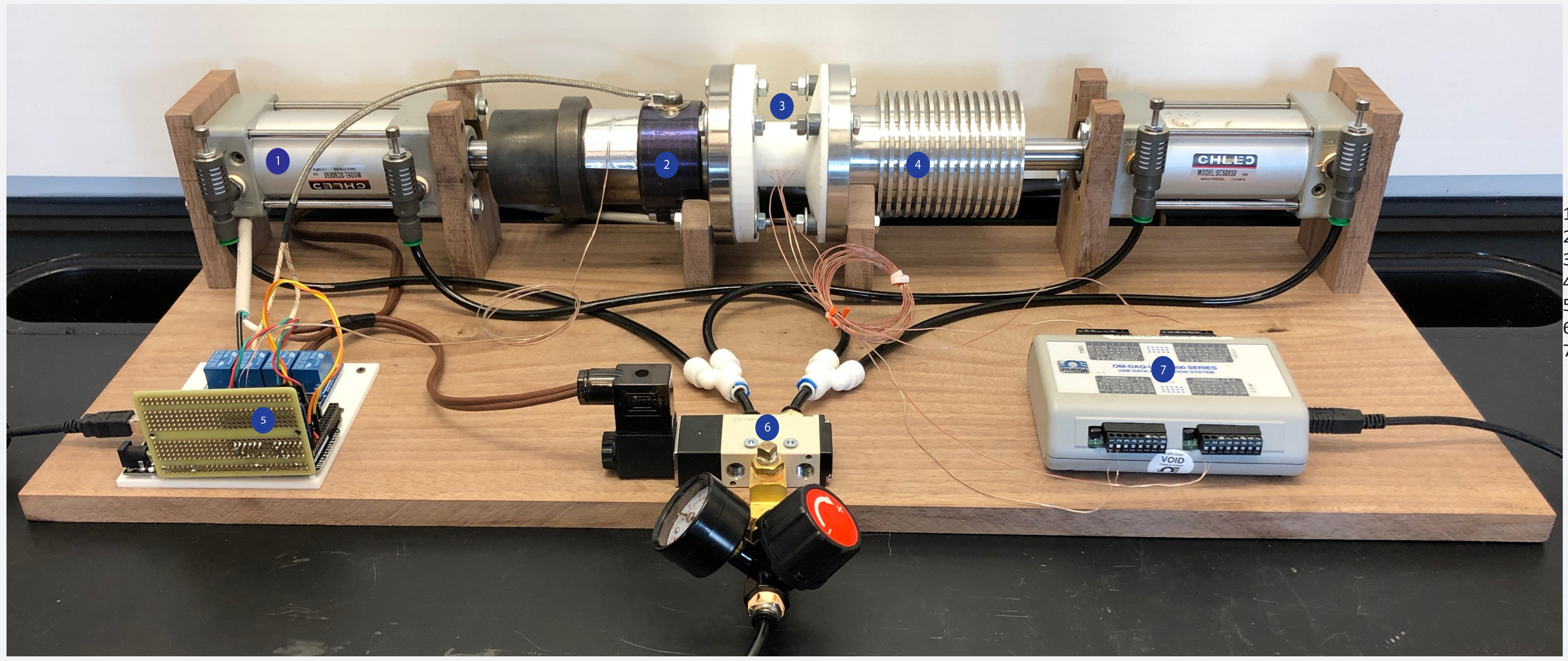
Objective

The goal of this experiment is to successfully maintain a temperature gradient across multiple thermally isolated sub-regenerators. A difference in temperature measured would show that additional energy after the initial regenerator can be captured and recycled.

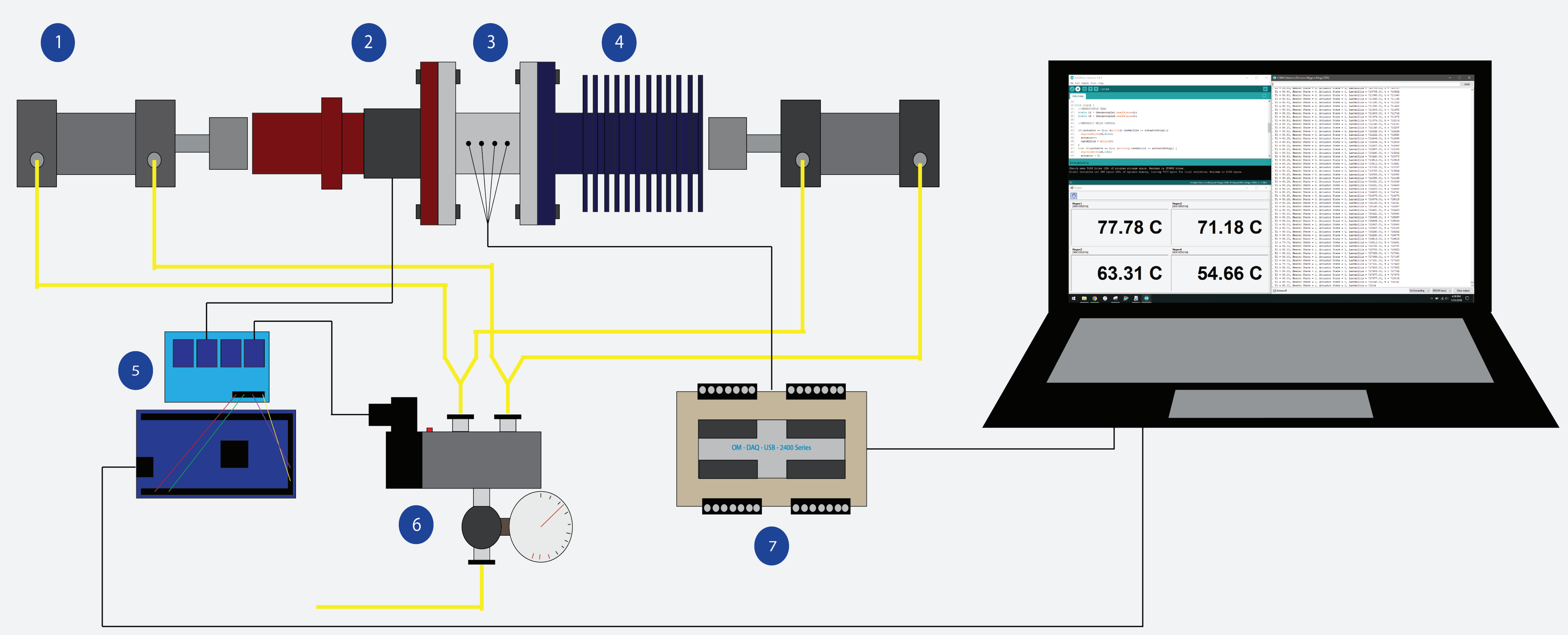
Another goal of the experiment is to measure the transient response in each sub-regenerator to validate existing thermodynamic models.

Experimental Apparatus

Pneumatic pistons were used to pass a constant volume of air from a hot chamber past the regenerator to the cold chamber, and back again cyclically. A USB DAQ read the temperature of each sub-regenerator every 8 ms.

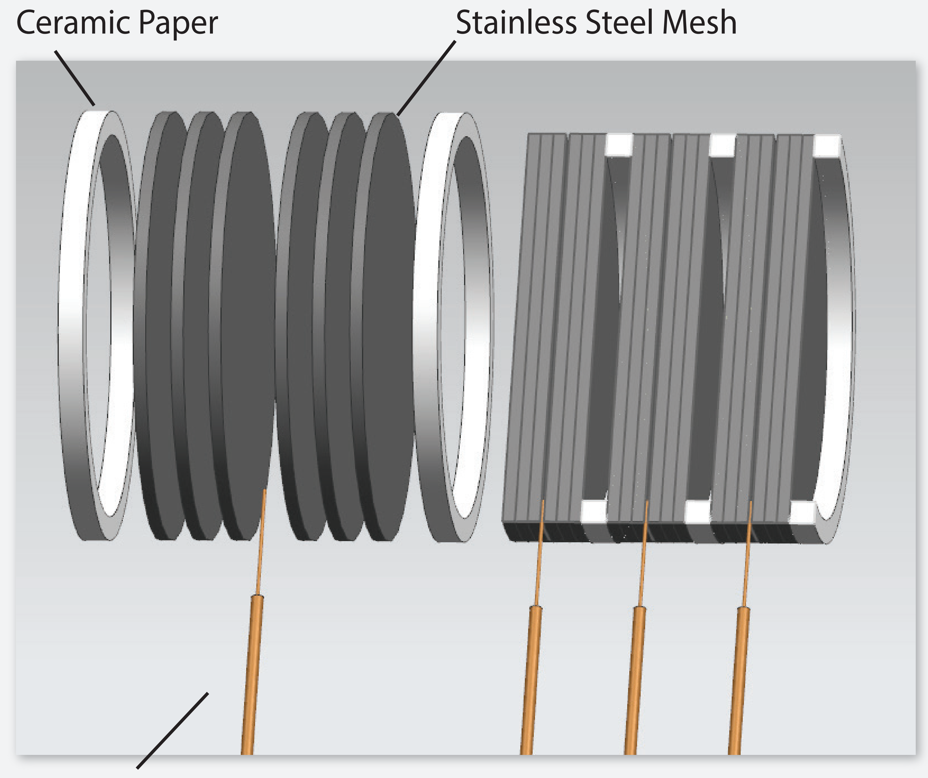


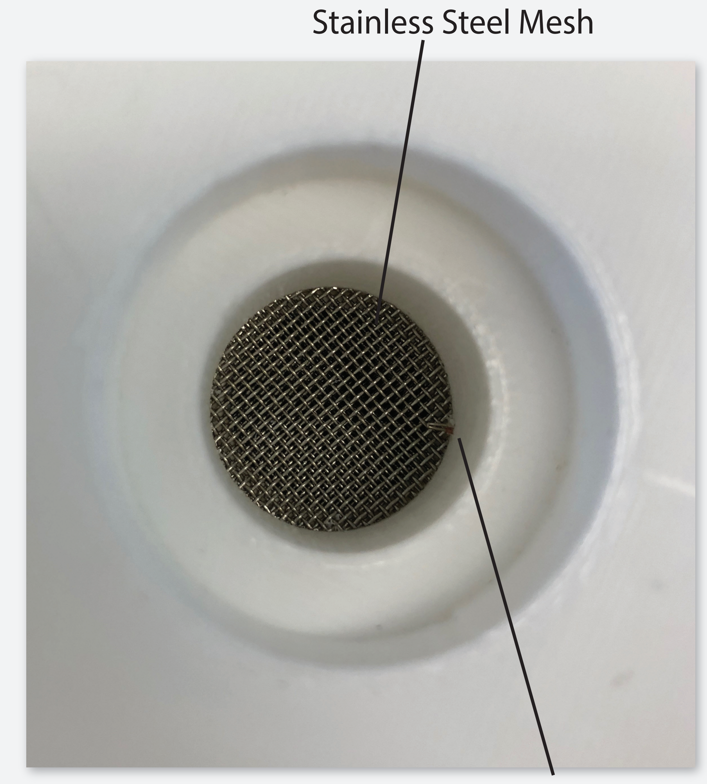
1 - Pneumatic Actuator
2 - Hot Cylinder
3 - Regenerator Housing
4 - Cold Cylinder
5 - Arduino and Relay Control
6 - Solenoid Valve
7 - Omega DAQ



Regenerator

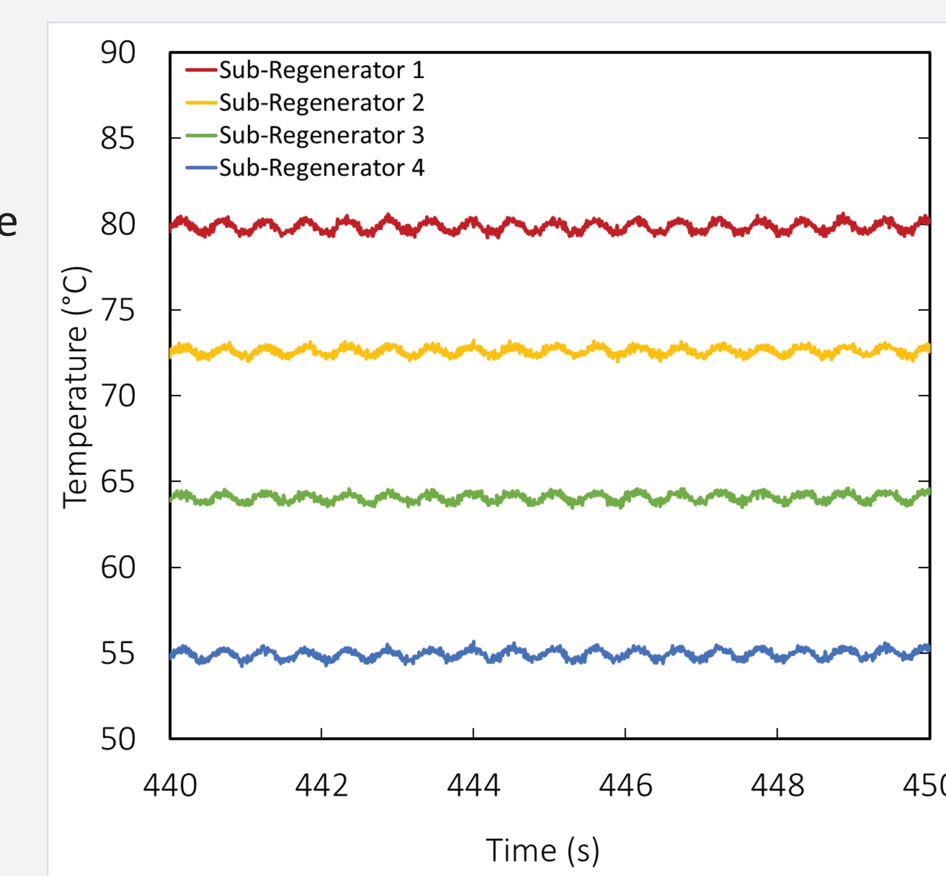
A stacked regenerator was built with thermal isolation to accomplish the temperature gradient.

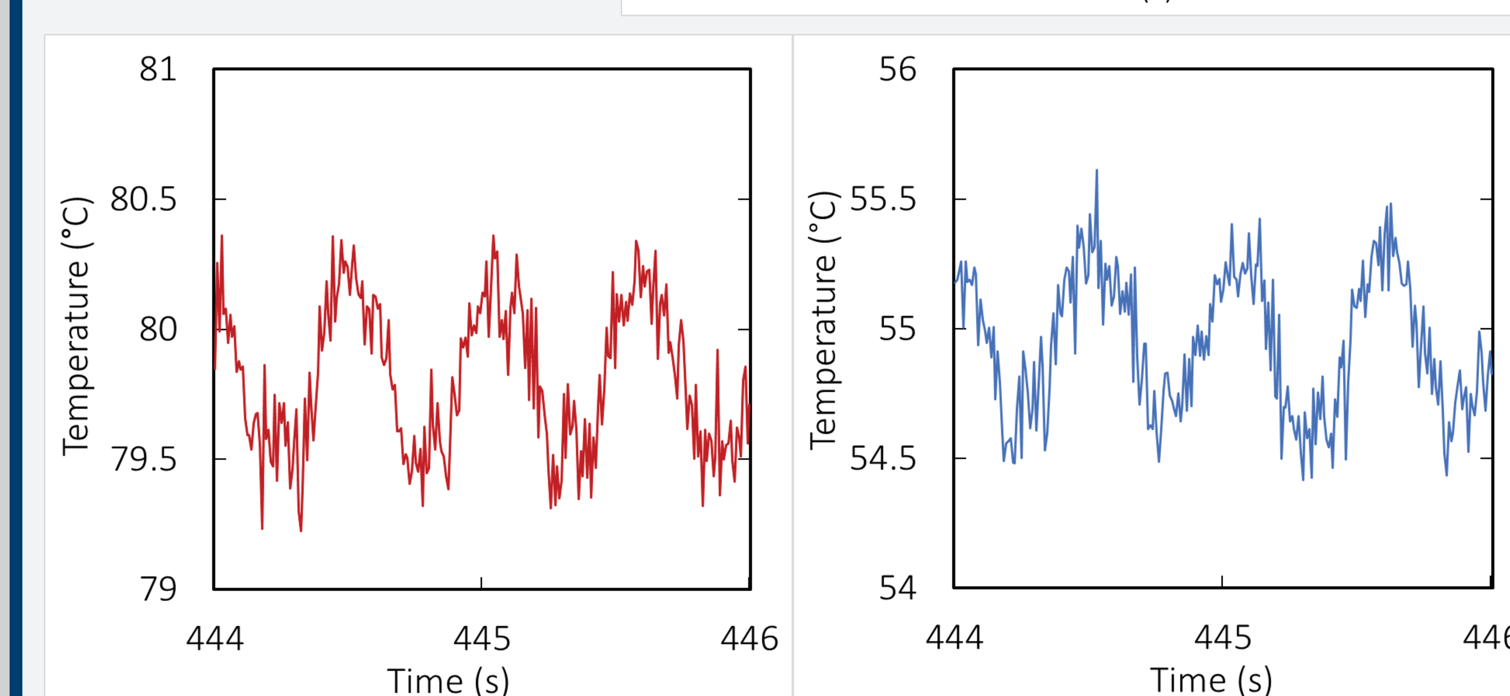




Results

A temperature difference of 25°C was maintained between the first and last sub-regenerators. This accomplished our goal, and reveals a new method for increasing the efficiency of regenerators and Stirling engines.





An equal temperature variation amplitude of 1°C was measured in each sub-regenerator at steady state.