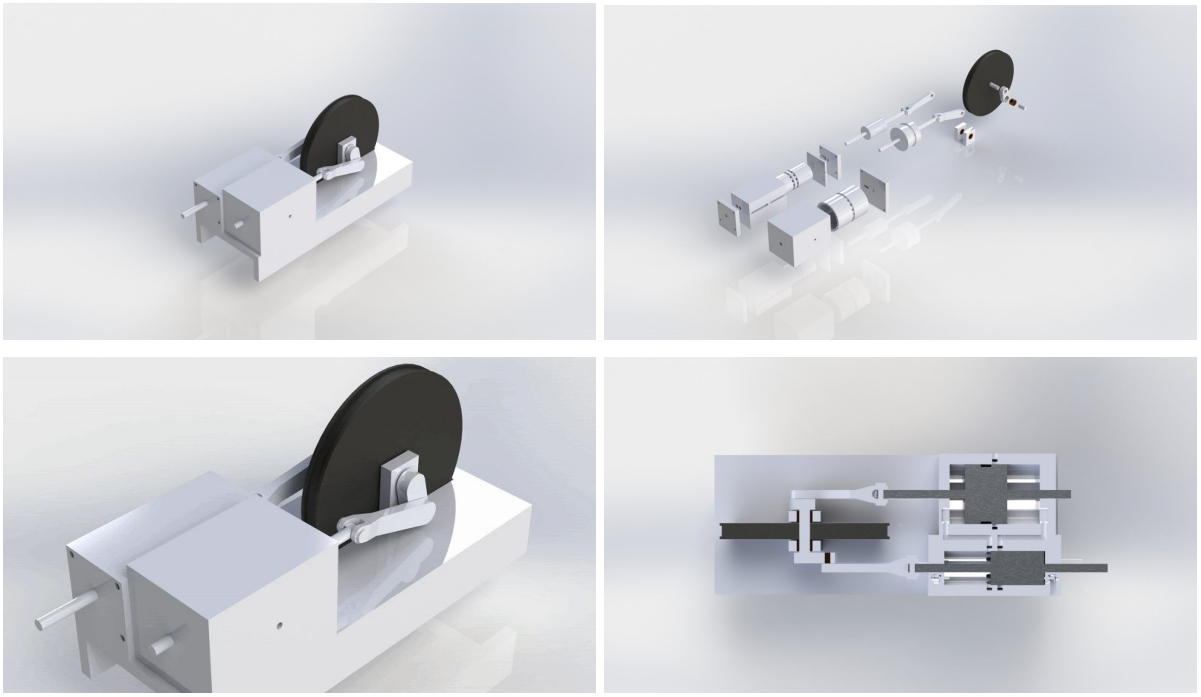
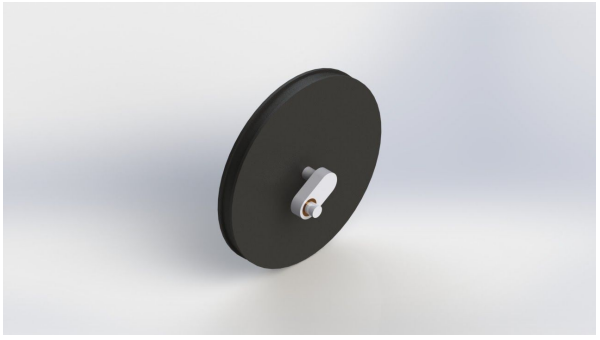
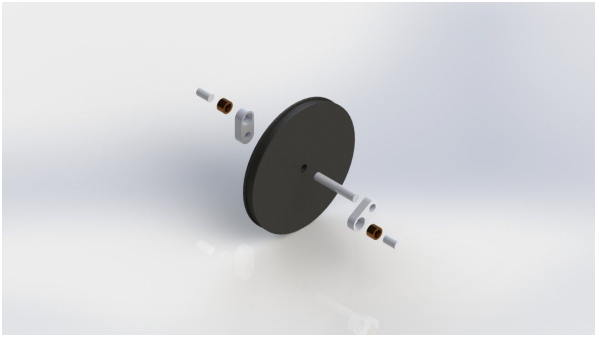
Greensteam Design Report

Double-acting Compound - Phase I
Tae Rugh
Fall 2020
Initial design CAD, renders, and motivation

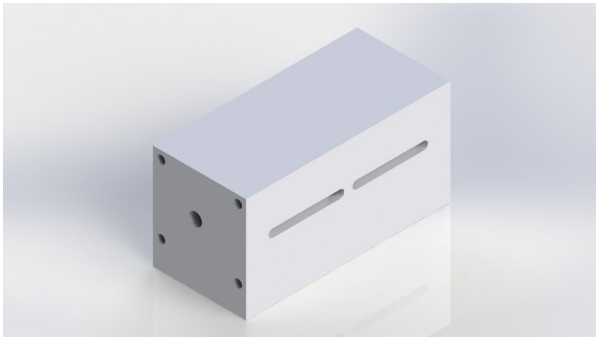
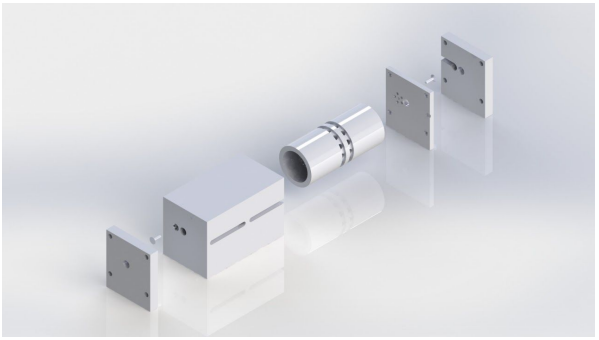


This is a 2 stage double-acting inline compound engine. This engine replaces the traditional cross-slide by extending the piston rod through the back end of the cylinder, thereby supporting the piston on either end. This increases the amount of required seals by two, but reduces moving mass and engine complexity. Steam enters the high pressure cylinder on both ends through bash valves. After high pressure expansion, steam exits through uniflow ports into a manifold which goes to the low pressure cylinder. Here, the semi-expanded steam expands again before finally exiting through uniflow exhaust ports into the atmosphere. The timing between high and low pressure pistons is slightly offset such that for the first ~5-10% of low pressure power stroke, the low pressure piston acts as a pump to improve the exhaust performance of the high pressure cylinder. For this portion, the low pressure piston is actually doing negative work, but the hope is that this produces more efficiency gains in the exhaust process to offset these losses. This claim is not too far-fetched considering, for example, internal combustion engines also incorporate an exhaust stroke in which the piston acts as a pump to remove the exhaust gas. Of course, this mechanism will need to be validated with further calculations.

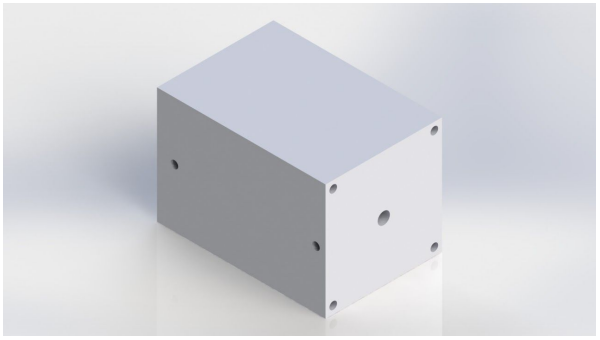
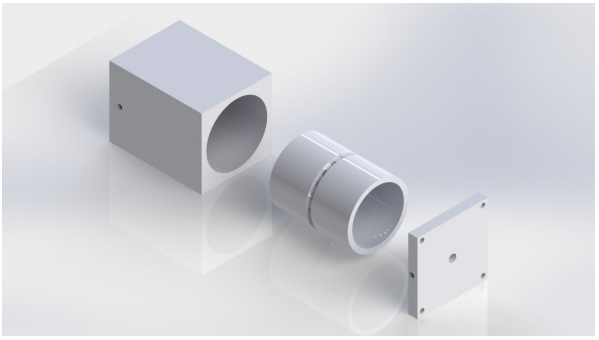
Part Breakdown

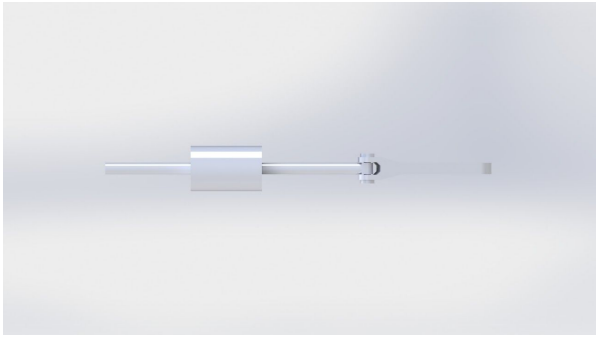
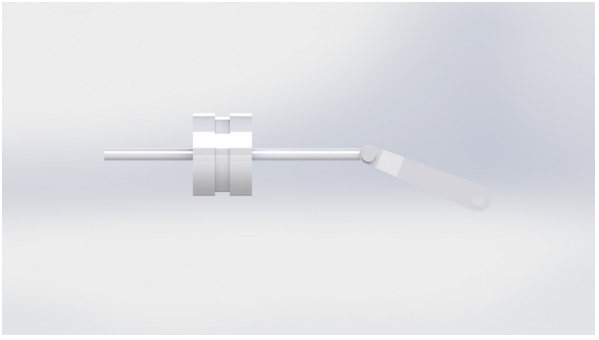
The crankshaft has overhung cranks on either end, much like bicycle pedals, in order to avoid the manufacturing complexities that accompany traditional (non-overhung) cranks. The cranks are offset from each other (currently at 120^{o}) such that the low pressure piston is slightly ahead of the high pressure piston, which induces the vacuum pump function of the low pressure piston. In the center of the crankshaft is a large flywheel which also acts as a pulley connecting to an external driveshaft (this is necessary since both ends of the crankshaft are overhung).

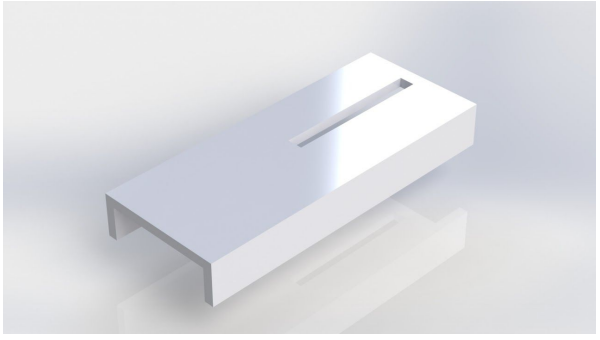
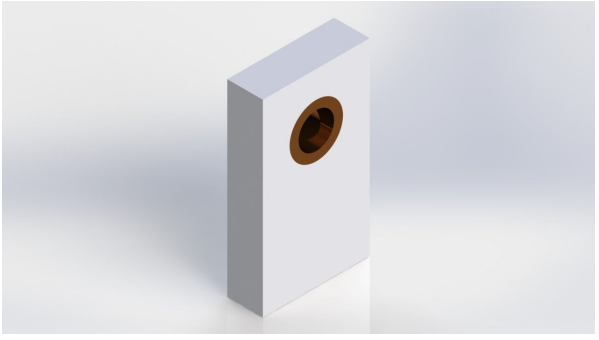
The high pressure cylinder is where the first stage of expansion occurs. A steam reservoir is supplied to the bash valves which regulate inlet timing. Due to the geometry constraints of a mechanical bash valve, the valve must be open before dead center for the same amount of time that it is open after dead center. Exhaust occurs through two separate uniflow ports (one for each side of the piston) which connect to corresponding inlets on the low pressure cylinder.

The low pressure cylinder receives partially expanded steam from the high pressure cylinder. Timing is dependent on the timing of the high pressure cylinder, so no valves are required. Steam expands for its second stage before exiting through the uniflow exhaust.

The high pressure piston (left) and low pressure piston (right) have rigid rods extruding out both ends and are connected to a conrod which links to the cranks. The piston rods extend out of both ends of the cylinders in order to align the piston without requiring a cross-slide.

The base (left) is where all of the components are mounted and holds them in the correct orientation. The two support bearings (right) mount to the base and hold the crankshaft in place.

Files:

- Master CAD
- Renders