Building a Rotary Stirling Engine

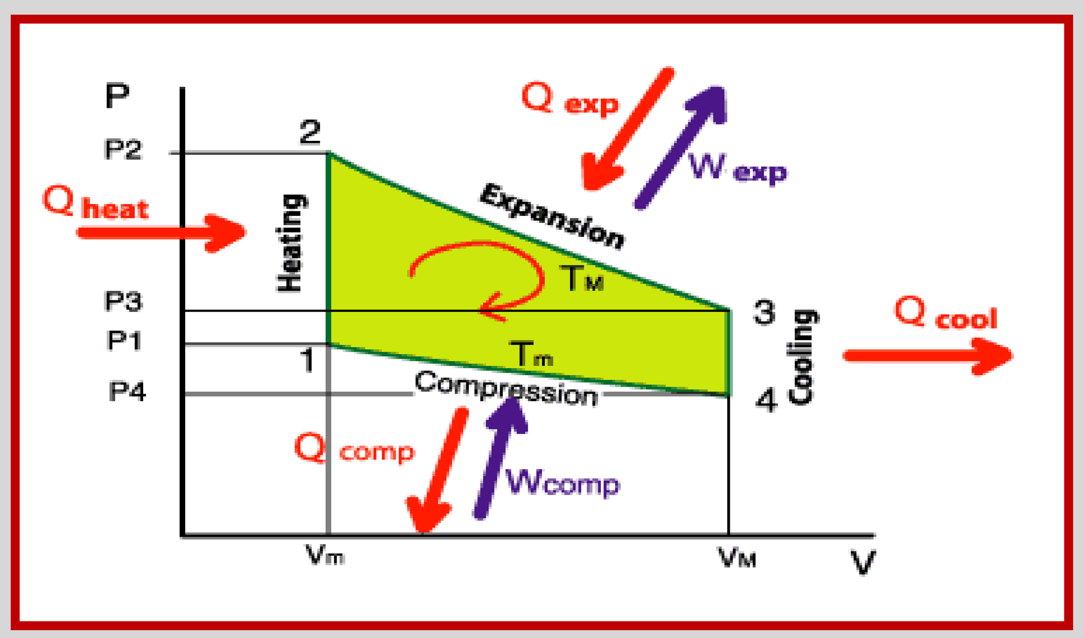
Alex Berlanga, Miguel Berlanga, Scott Sherod, Jagvir Singh, Jan Kmetko Ph.D
SRJC

Abstract

In this project, we are designing and putting together a rotary gamma-type Stirling Engine. The rotary Stirling Engine is an uncommon design compared to the more common "linear" Stirling engines because of its rotational motion of the displacer. The advantages to using a rotary Stirling Engine is that no fly-wheel is necessary on the outside of the engine to carry angular momentum because the displacer carries the angular momentum instead. Stirling Engines are comprised of sealed air that is heated/cooled to provide the compression/expansion needed to power a cyclical engine. A Stirling Engine allows the user to obtain safe usable work with no exhaust, explosions, or pollution. The main building challenges of this rotary Stirling Engine were the cylindrical shape of the air chamber, the balanced-displacer, and the custom parts that needed to be made via 3d print and machining to assure an airtight seal. The introduction of more Stirling Engines into everyday life could see a huge cut of carbon emissions in transportation and in electrical energy production.

Introduction

The Stirling engine operates in a closed system where air is sealed and is instead powered through external heating and displacement of air inside. In simple terms, Stirling engines use the expansion of heated air to move a piston. In order to do this, one end of the engine is heated, and when air is brought to the hot side, the air expands and is hauled by a displacer to a piston where the piston is pushed up. The air which has been brought to the cool side by the displacer is then cooled and pushed back down by the momentum of a flywheel to be heated once again. This is the design of a gamma type Stirling engine where the air displacer and the piston are attached separate from the main housing. In this design, the flywheel is forgone as the displacer acts rotationally giving itself its own rotational momentum.



(1) A pressure vs. volume diagram of an ideal Stirling engine's cycle

Materials and Methods Cont.

Method:
1. Type of engine (Gamma, Beta,or Alpha)
2. Rough sketch
3. Work Distribution(Crank Shaft, Piston, Stand, Body)
4. Parts list (See Materials*)
5. Model (Using Inventor)
6. Purchase parts and assemble.
7. Test troubleshoot
8. Rework in case of failure

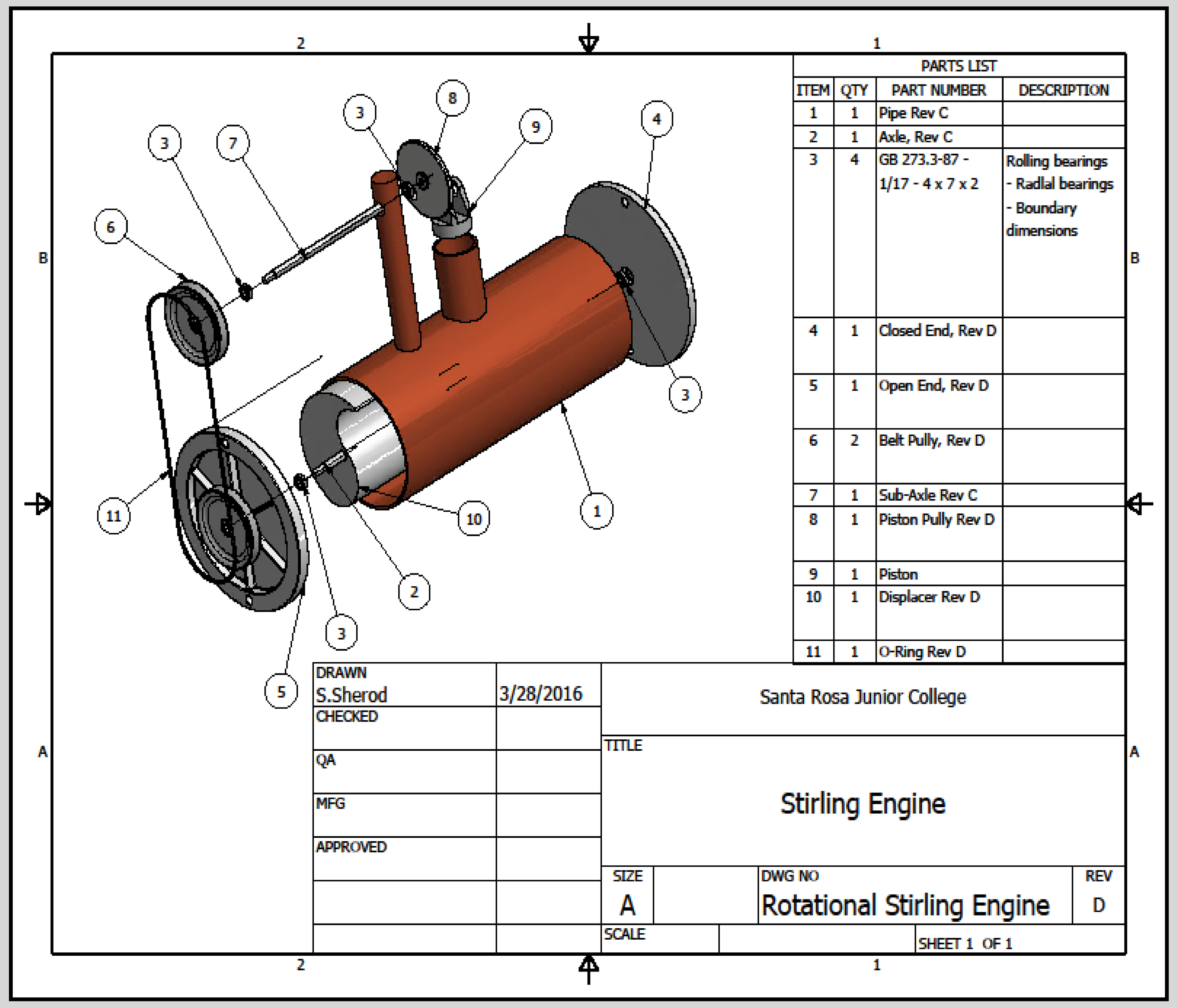
- **Design Challenges:**
- insulating the hold and cold wells
- Pure Copper Sheeting is necessary for making stand
- Air-tight piston
- right materials to use
- Cutting pipe lengthwise and sealing
- cycle timing (crankshaft)
- displacer
  - lightweight
  - center of mass
  - insulated
  - dimensions

Tools:
- Drill
- Sander
- Dremel
- Metal-Sheet Cutters
- Mapp Gas Torch
- Mill
- 3D Printer
- Autodesk Inventor 2016

Materials:
- Copper Pipes (2.5 inch diameter), (1 inch diameter)
- Pure Copper Sheet Metal (Housing)
- Bearings
- 2-Part Epoxy
- Heim Joints
- High Temperature Gasket
- Hose Clamps
- 3D-Printed Plastic (PLA) Displacer, Pulleys, End Caps
- Displacer and Power Piston Axle
- O-Rings
- High Temperature Grease
- All Threaded screw and Bolts

Results

The final product of this Stirling engine was a result of careful design and planning. The axles were finely machined to press fit into the chamber bearings. The piston was custom built from epoxy to be low friction with minimal air leakage. The displacer was custom printed to fit smoothly into the chamber while still taking up enough room to haul air efficiently. In addition, to minimize air leakage, high temperature gaskets were used to seal the hot and cold sides of the chamber and the end caps. To maintain correct engine timing, a belt and pulley system was implemented.



Discussion & Conclusion

We tried two other stirling designs prior to the building of this rotary stirling engine. These designs showed us that air containment and attention to design was an extremely important constraint.

After consulting with Jan Kmetko, and researching other stirling engines, we focused on a new design for a rotary stirling engine. One of the largest obstacles in creating the engine was the need for custom parts and precise machining. This surmounted to many delays in construction which limited our ability to modify the engine further.

Prior Stirling Engine Attempt

Rotary Stirling Engine Design

Future Direction

- Four Stage Cycle Rotary Stirling Engine
- Parabolic Mirror Implementation for Solar Heating
- Attached Alternator to generate electricity
- Improved components with higher heat tolerances
- Implementation of regenerator to improve efficiency

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