Stirling Engine

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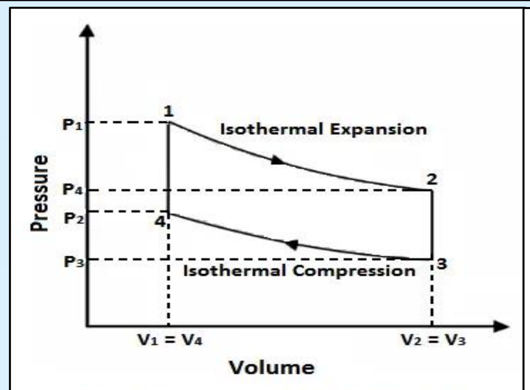
Aim of the Project

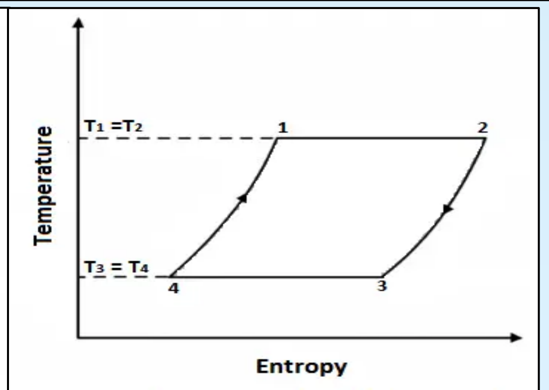
The Aim of the project is to design, build and test a Stirling engine.

Background

The Stirling engine is an external combustion engine, which is based on a closed cycle, where the working fluid is alternatively compressed in a cold cylinder volume and expanded in a hot cylinder volume. A Stirling engine works on the basis of thermodynamics creating a temperature difference between the hot and cold cylinders in order to facilitate heat energy transfer. The Stirling-cycle is a set of thermodynamic processes, two of which are isochoric (fixed volume) and two isothermal (fixed temperature) processes which can be seen on plotted P_v diagrams and T-s diagrams. Process 1-2: Isothermal Compression and Heat Rejection, Process 2-3: Isochoric Heat Addition, Process 3-4: Isothermal Expansion and Heat Addition, Process 4-1: Isochoric Heat Rejection



P-v Diagram of a Stirling Cycle



T-s Diagram of a Stirling Cycle

Research

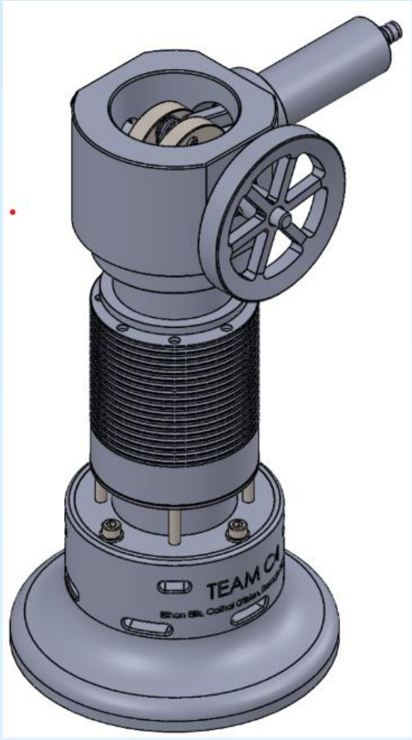
There are 11 main components used in a Stirling engine. Displacer, Displacer Rod, Displacer Yoke, Gearwheels, Piston Bush, Gaskets, Flywheel, Crankshaft, Piston, Piston Rod, Connecting Rod. Taking a further look at Stirling engines in modern day, they have returned to focus among many researchers for their possible uses in various cases. In military uses the Stirling engine has been place in submarines due to its quiet and vibration free operation. Stirling engine has uses in heat pumps for industrial and residential use as well as in automotive propulsion and electricity generation

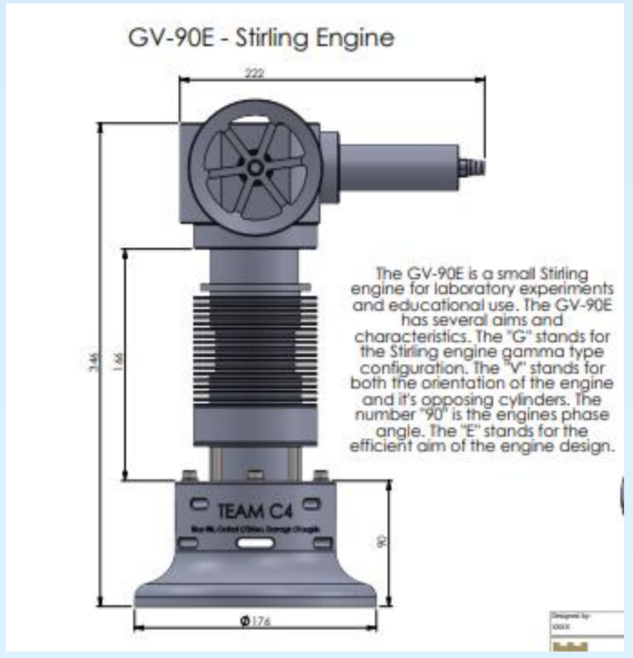
Design Process

The development of a Stirling engine involves a systematic and iterative design process. This process explores, assesses, and refines various concepts to select the optimal solution that meets the project's objectives and requirements. The focus is on the systematic design process, design calculations, and the progressive development of the selected solution. This project adopts a systematic design methodology, blending the Scrum framework with the V-model, to enhance project management and development outcomes for an optimized Stirling engine design. Stirling engines are classified into three main configurations: Alpha, Beta, and Gamma. Each configuration has unique operational characteristics and design features that make it suitable for different applications. The Alpha Stirling engine is built for high power output, with two separate cylinders - one hot and one cold - each with its own power piston, In the Beta Stirling engine, a single cylinder houses both the power piston and the displacer piston, The Gamma Stirling engine separates the power and displacer pistons into different cylinders connected by a passage. Selecting the right configuration is vital for achieving the desired balance between uniqueness, efficiency and simplicity in a Stirling engine.

Final Design

For our Final design we landed on the gamma type Stirling engine. We chose it due to greater mechanical simplicity and easier maintenance, , with separate cylinders for the power piston and displacer, allows for efficient heat management, reducing mechanical wear and dead volume, improves thermal efficiency under moderate-to-low temperature. The final design has a v-type geometry. The V-type layout can provide better mechanical balance, reducing vibrations compared to other Stirling engine types. This makes it ideal for precision applications, such as cooling systems and power generation in sensitive environments, The V-shape facilitates better heat dissipation, as the hot and cold cylinders are positioned at an optimal angle. The design we went with was chosen due to it looking different and unique while providing us with a nice challenge during the machining of the engine



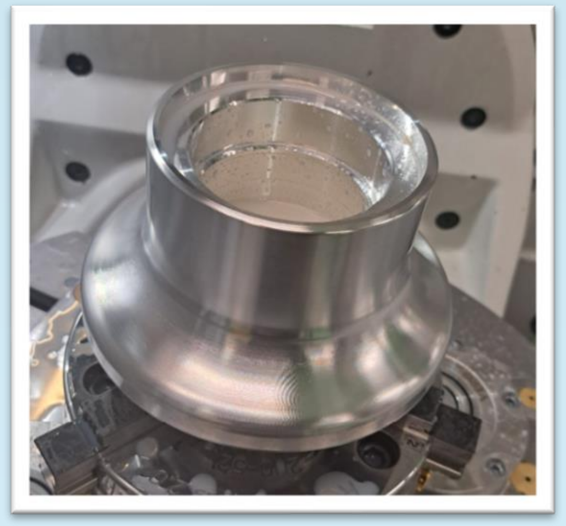


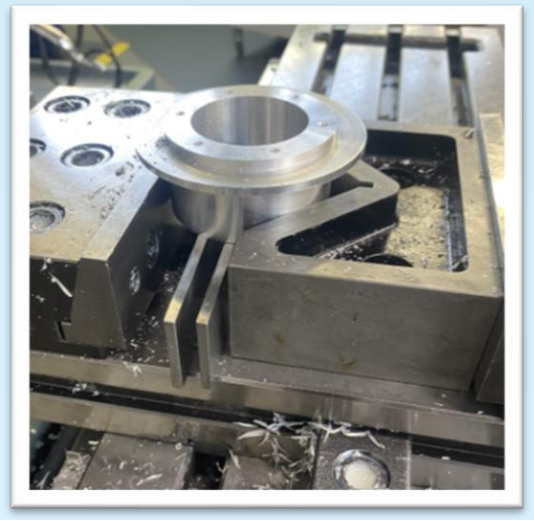
Materials

The material we chose for the machining were aluminum, brass, silver steel, PTFE and bms. All chosen for a variety of reasons, aluminum due to its light weight and easy machineability, bms due to its weight for both cam and flywheels, PTFE for the thermal break due to its heat absorption and easy machineability and brass so its doesn't bind to the inside of the power piston cylinder.

Manufacture and Assembly

Three parts were made by cnc and the conrods were 3D printed. The rest of the machining was done by .Lathe and mill. SolidWorks d Cam were the main software's used. Process planning CAM, Spigot, No holes in displacer cylinder, brass instead aluminium power piston





Conclusion

During this project we encountered problems from start to finish from design where we had to reimagine are sterling engine to machining from changing design and material in the workshop. Time was also a huge factor in this project as the setbacks and changes shortened the time slot, we had for completion od the project. If we were to take on a project like this again then we would make the necessary changes to up efficiency when it came to research, design and machining