UNIVERSITY SCHOOL OF AUTOMATION AND ROBOTICS

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY NEW DELHI

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Project Report: Kinematics and Dynamics Analysis of Robotic Grippers

Kinematics & Dynamics of Machines Lab

(ARA 202)

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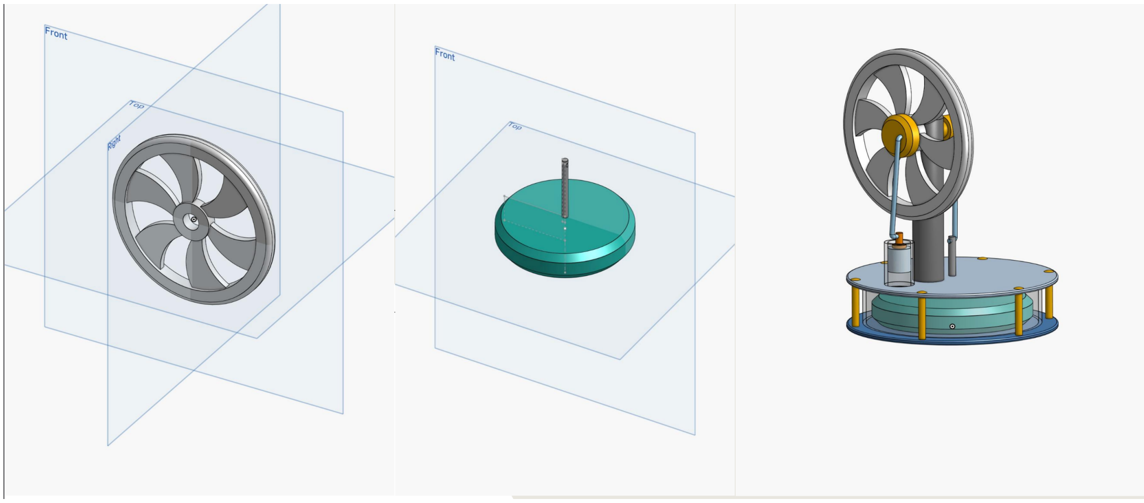

1. Introduction

The Stirling engine is a type of closed-cycle regenerative heat engine that operates through cyclic compression and expansion of air or other gases. It converts heat energy into mechanical energy and operates efficiently using various heat sources such as solar, geothermal, or waste heat.

2. Objective

• To design and simulate a basic Stirling engine.
• To understand the thermodynamic cycle of the engine.
• To analyze the mechanical components and their motion.
• To demonstrate energy conversion from thermal to mechanical form.

3. Description of the Mechanism

3.1 Components
• Flywheel: Converts reciprocating motion into rotary motion and maintains momentum.
• Displacer Cylinder: Moves the working gas between hot and cold regions.
• Power Piston: Extracts mechanical energy from pressure differences.
• Connecting Rods and Crankshaft: Transmit motion between pistons and flywheel.
• Base Platform: Simulates thermal zones (hot and cold plates).

3.2 Materials Suggested
• Flywheel: Aluminum or Steel
• Pistons and Cylinders: Brass or Stainless Steel
• Connecting Rods: Steel or Aluminum
• Base: Acrylic or Aluminum

3.3 Type of Mechanism
• Thermodynamic-based mechanism utilizing a closed regenerative cycle.
• Mechanically linked pistons and flywheel to ensure continuous motion.

4. Working Principle

The engine operates using the Stirling cycle, comprising:

- Isothermal Expansion
- Isochoric (Regenerative) Heat Transfer
- Isothermal Compression
- Isochoric Heat Addition

5. Efficiency Analysis

5.1 Ideal Efficiency

The ideal thermal efficiency of a Stirling engine matches that of a Carnot engine:

$\eta = 1 - TC / TH$

Where:

- TH: Hot reservoir temperature (K)
- TC: Cold reservoir temperature (K)

5.2 Work Done per Cycle

For a monatomic ideal gas:

$W = nR(TH - TC) \ln(Vmax / Vmin)$

6. Performance Factors

- Greater the temperature gradient ($\Delta T = TH - TC$), higher the performance.
- Methods to improve output:
  - Increase TH using a flame or solar concentrator.
  - Improve heat dissipation at TC using fans or heat sinks.

7. Advantages

- Operates quietly
- Any fuel source can be used
- No explosive risk (unlike steam engines)
- Requires minimal lubrication
- Used in air-independent systems (e.g., submarines)

8. Applications

- Submarine propulsion systems
- Solar thermal energy systems
- Cryogenic cooling (as reverse Stirling engine)
- Backup generators for remote/off-grid areas
- Low-noise scientific/military equipment

9. Software Used

- ONSHAPE (for CAD design and simulation)

10. Conclusion

This project explored the working principles, mechanical structure, and thermodynamic performance of the Stirling engine. With its eco-friendly and low-maintenance design, it holds significant potential in both renewable energy systems and specialized engineering applications.