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# "DESIGN, FABRICATION AND TESTING OF STIRLING ENGINE"

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**Abstract:** *A Stirling engine uses a single-phase working fluid which maintains an internal pressure close to the design pressure, and thus for a properly designed system the risk of explosion is low. In comparison, a steam engine uses a two-phase gas/liquid working fluid, so a faulty release valve can cause an explosion. The engine mechanisms are in some ways simpler than other reciprocating engine types. No valves are needed, and the burner system can be relatively simple. They start easily and run more efficiently in cold weather, in contrast to the internal combustion which starts quickly in warm weather, but not in cold weather. Stirling engines can run directly on any available heat source, not just ones produced by combustion, so they can run on heat from solar, geothermal, biological, nuclear sources or waste heat from industrial processes.*

***Keywords*** *– Stirling Engine, External Combustion Engine, Design, Fabrication, Efficiency Testing*

## I. INTRODUCTION

The Stirling engine is a heat engine of the external combustion piston engine type. It was invented and developed by Dr.Robert Stirling in 1816.

A well-designed Stirling engine can achieve 30% to 50% of the ideal efficiency in the conversion of heat into mechanical work, limited only by friction and material properties. The engines can theoretically run on any heat source of sufficient temperature, including solar energy, chemical and nuclear fuels. While the Stirling engine is more expensive than an internal combustion engine of the same power rating, its many unique advantages make it preferred for a variety of applications. Compared to internal combustion engines, Stirling engines can be made very energy efficient, quiet, reliable, long-lasting and low-maintenance [1]. In recent years, these advantages have become increasingly significant given the general rise in energy costs and the environmental concerns of climate change. This growing interest in Stirling technology has led to the ongoing development of Stirling devices for many applications, including renewable power generation and Astronautics [3].

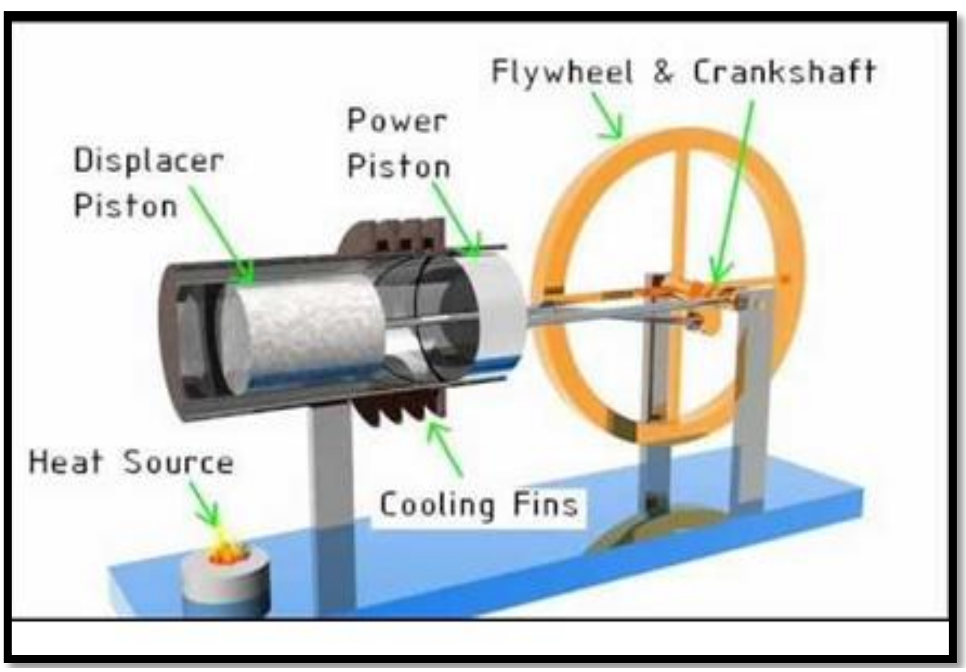



Figure No. 1: Schematic diagram of stirling engine

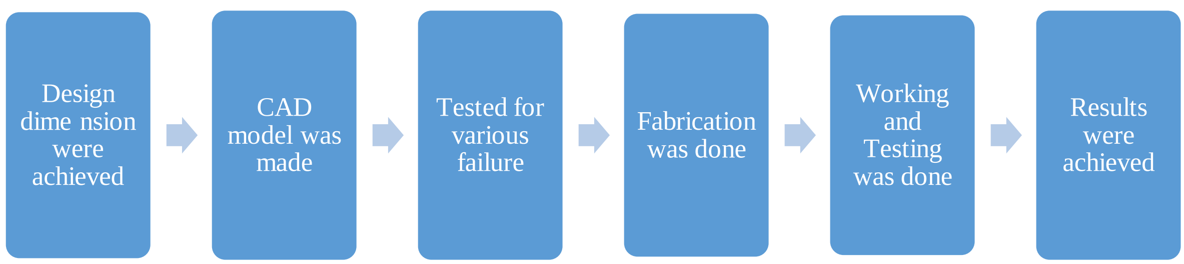
## II. OBJECTIVE

The goal of design is achieving high efficiency at low cost. In the space of energy applications, the low Price of energy requires technologies to satisfy tight constraints on cost and produce enough energy to be Competitive. Previous analytic and empirical results from the design and development of low-power engine Prototypes in this space informed many of the design goals and decisions of this prototype

1) To fabricate a prototype of Stirling engine and assess its performance.
2) To develop a low cost prototype model and Design of a Stirling engine that could be easily fabricated for small scale
3) To explain the concept of sterling engine and study the difficulty in manufacturing and calculation
4) To check for feasibility of sterling engine in various applications like solar power generation, sterling engine water pump and geothermal energy

## III. METHODOLOGY

The methodology is as follows :




## IV. FABRICATION

Various materials used in fabrication work are mild steel, stainless steel, cast iron and brass for making parts such as compression piston and cylinder, expansion piston and cylinder, angles, clits, gussets, fillets flats & the round bars. These sections are cut to required size precisely and marked for drilled holes & then fastened together with the help of rivets & bolts, Nuts & Screws.

**4.1. Following are the operations carried out on the component to be manufactured:**

1) Electric Arc Welding: For heavy duty parts.
2) Gas Welding: For light duty parts.
3) Gas Brazing: For Brass parts.
4) Soft Tin soldering: For light duty parts in MS & Brass.

**4.2. Following are the component used:**

Table No.1: List of components used

| Sr. No | Name Of Parts | Qty. Nos. | Material |
|---|---|---|---|
| 1. | Frame | 1 | MS |
| 2. | Blow Lamp | 1 | Brass |
| 3. | Crank Shaft | 1 | MS |
| 4. | Crank Pin-Expansion Piston | 1 | CI |
| 5. | Crank Pin-Compression Piston | 1 | CI. |
| 6. | Fan Blade | 1 | AL |
| 7. | Engine Base Plate | 1 | MS |
| 8. | Bush-Expansion Piston Rod | 1 | MS |
| 9. | Compression Piston | 1 | CI |
| 10. | Compression Cylinder | 1 | MS |
| 11. | Expansion Cylinder | 1 | MS |
| 12. | Expansion Piston | 1 | MS |
| 13. | Compression Piston Connecting Rod | 1 | MS |
| 14. | Expansion Piston Connecting Rod | 1 | MS |
| 15. | Piston Pin | 1 | MS |
| 16. | Hardware-Nuts, Bolts Etc. | 1 Lot | MS |
| 17. | Bracket | 1 | CI |

## V. WORKING PROCESS

The Stirling engine is a heat engine. It works on the principle that heat is allowed to flow from the hot side to the cold side and in this process some heat is converted to work. Theoretically, a heat engine can operate because of the heat flow between two sources of heat one of which is just a little bit colder than the other.

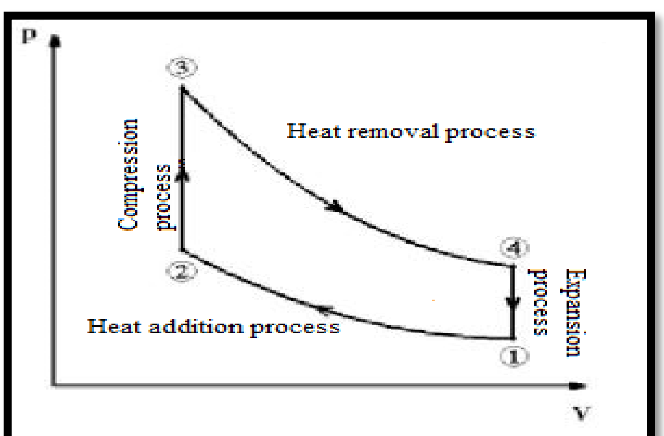



Figure No. 2: Stirling engine cycle

**4.1. Processes of Ideal Stirling Cycle:**

The ideal Stirling cycle comprises of two isothermal processes and two constant volume processes. The rejection of heat and absorption of heat takes place at constant temperature.

1) Heat addition process 1-2:The gas is heated gradually to temperature Th. The Displacer piston moves upwards thereby compressing the gas on the cold side.
2) Compression process 2-3: The heated gas pushes the power piston to the farthest limit of the cylinder. This is called as power stroke.
3) Heat removal process 3-4:The displacer piston now moves downward due to inertia, shunting the gas to the cold end of the cylinder. In this position the heat is extracted from the gas using water cooling jacket.
4) Expansion process 4-1:During this process the flywheel will provide motion to the piston and further it will compress the gas.

## VI. RESULTS & DISCUSSIONS

The efficiency of Stirling engine is given by-

$$n = \frac{T_2 - T_1}{T_2 + \frac{C_v(T_2 - T_1)}{n*R*\ln(V_2/V_1)}}$$

Volume of cylinder = $\pi/4 * d^2 *$ stroke length

Volume of expansion cylinder = $93.27\ cm^3$
= $9.37 * 10^{-5}\ m^3$

Volume of expansion piston = $45.8\ cm^3$
= $4.58 * 10^{-5}\ m^3$

Temperature of hot end = 473 k

Temperature of cold end = 273 k

The following results were achieved:

1) High Temperature difference was achieved due to use of MS, SS & Brass.
2) The power output achieved due to heat difference could be seen due to use of fan blades as flywheel.
3) For 100 Degree Celsius, fan speed = 250-275 rpm
4) For 150 Degree Celsius, fan speed = 300-350 rpm
5) For 200 Degree Celsius, fan speed =350- 365 rpm
6) Efficient, Economical & Compact design is achieved
7) The efficiency of Stirling engine was increased from 18% to 21.11% due to introduction of water cooling jackets.

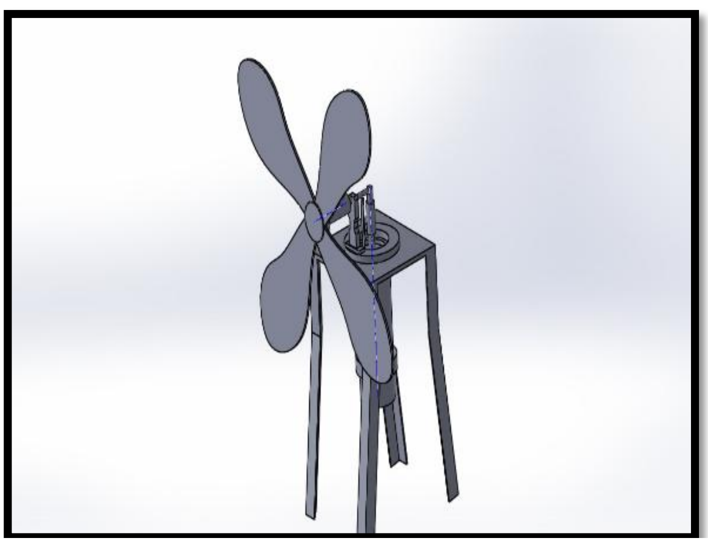


Figure No. 3: Actual model of Stirling Engine

## VII. CONCLUSION

The Stirling cycle engine has numerous natural benefits over other engines, including the ability to operate from any heat source, enabling alternative energy options. A few technical challenges have prevented widespread success of the Stirling engine including manufacturing cost, limited power density, and efficiency values not reaching the theoretical potential. Prime sources of these limitations includes adiabatic operation in the working chambers necessitating expensive external heat exchangers that add dead space, non-ideal piston displacement profiles, and challenges sealing low molecular weight gases at high pressure.

## VIII. ACKNOWLEDGEMENT

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