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Design and Development of Hot Air Engine

Sourabh Hole[1], Tanmay Gangawane[1], Yash Jagtap[1], Ritikesh Bagul[1], C. S. Choudhari[2]

Students, Department of Mechanical Engineering[1]

Associate Professor, Department of Mechanical Engineering[2]

A.I.S.S.M.S College of Engineering, Pune, Maharashtra, India

Abstract: *The demand for electrical energy has been extremely high in recent years. In today's world, more emphasis is being placed on producing electricity using clean renewable energy sources. For instance, by utilizing solar energy. This project discusses the design and development of a hot-air engine to generate electricity using solar energy. A hot air engine is designed and developed primarily on the principles of the Stirling engine. This engine will be tested with hot air as a fluid. This hot air will be forced through the cylinders. We are going to use solar energy as a heating source to heat the air. The development of such a hot air engine for domestic use is regarded as a primary design criterion. The Hot Air engine makes best of use of solar sources in an environmentally friendly way. It has no emissions and live longer as compared to Photovoltaic cells. The Stirling engine can operate at Low Temperature difference, which makes it prominent. In order to study the efficiency of a conversion from thermal energy to work. The main purpose of the Engine is to promote the use of Stirling engines in 'Green and Clean energy' applications. For future solar energy generation research Hot Air engines are of prime importance as it has high theoretical efficiencies.*

Keywords: Hot air engine, Power piston, heated gas, etc

I. INTRODUCTION

The increase in pollution levels and depletion of natural resources has created a need to find out alternative clean sources of energy generation. One of the means of Effective energy conservation is the hot air engine. The hot air engine is a technology of the past. But being compatible with a clean use, it is nowadays more and more considered as a possible clean energy technology for the future.

The hot air engine shares with the steam engine a unique feature the external heating. This is what`s make it clean energy compatible. Knowing that the theoretical efficiency of the hot air engine is well over the one of the steam engines, the former is a candidate of choice for clean energy. For more than a century the attention of mechanicians has been directed to means for making air and gases available in driving machinery. The inventions resulting from these efforts have led in different directions, or to different sets of specific means. Some have attempted to make available the expansion of air, previously mechanically condensed and stored in reservoirs. It was not understood, apparently, that the valuable effect would only be equal to the force employed in condensing the air, minus some friction, leakage, and other incidentals. Yet another form of air engine has consisted of two chambers filled with air or gas, and connecting by pipes with the respective ends of a cylinder in which a piston reciprocates as the bodies of air in the said cylinders are alternately expanded and contracted. Basically, the concept of hot air engine is derived from the concept of Stirling engine. The engine works with a closed cycle and we can use various gases as working fluid mainly air and also helium or hydrogen. But as the name suggests we are going to use hot air as a working fluid. To power the engine, many energy sources can be used such as combustible materials, solar radiation, geothermal hot water, radioisotope energy, etc. This engine can generate energy. electricity by using renewable sources, thus helping to conserve the environment.

II. BASIC CONCEPTS OF HOT AIR ENGINE

A hot air engine is a heat engine that uses the expansion and contraction of air under the action of temperature changes to convert heat into mechanical energy. These engines can be based on a number of thermodynamic cycles including open-cycle devices such as those of Sir George Cayley and John Ericsson and closed-cycle engines by Robert Stirling. The hot air engine is distinct from the internal combustion engine and steam engine. In a typical process, air is continuously heated and cooled in the cylinder and expansion and contraction is used to move a piston and generate useful mechanical work. An ideal hot air engine thermodynamic cycle may include 3 or more processes. Hot air engines operate on the Stirling cycle.

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CYCLE	COMPRESSION1-2	HEAT ADDITION2-3	EXPANSION 3-4	HEAT REJECTION4-1	NOTES
STIRLING	ISOTHERMAL	ISOCHORIC	ISOTHERMAL	ISOCHORIC	HOT AIRENGINE

Stirling cycle

The Stirling engine fixed mass of gas called the "working fluid" such as gases like air, hydrogen or helium. The working principle is the thermal expansion and contraction of this fluid due to a temperature differential. So the ideal Stirling cycle consists of four thermodynamic process acting on the working fluid: Each one of which can be separately analyzed

- Process 1-2 (Isothermal compression): Helium as working fluid is compressedat constant temperature. Heat [Q (1-2)] = area 1-2-b-a on T-s diagram Work is done on the working fluid. W (1-2) = area 1-2-b-a on P-v diagram.
- Process 2-3 (Isochoric heat addition): Heat is added at constant volume to the hot cylinder. Heat [Q (2-3)] = area 2-3-c-b on T-s diagram Work done [W (2- 3)] is zero.
- Process 3-4 (Isothermal expansion): Working fluid is expanded at constant temperature. Heat [Q (3-4)] = area 3-4-d-c on T-s diagram Hot air expands Workis done by the working fluid W (3-4) = area 3-4-a-b on P-v diagram.
- Process 4-1 (Isochoric heat rejection): Heat id rejected at constant volume to thecold cylinder. Heat [Q (4-1)] = area 1-4-d-a on T-s diagram.
- The efficiency of Stirling cycle is same as that of Carnot cycle efficiency when bothare working with the same temperature limits.

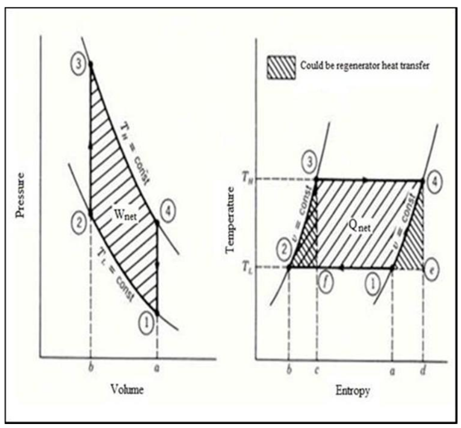


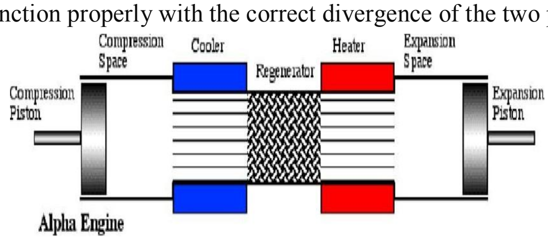
Fig 1 Stirling Cycle

III. ENGINE TYPES

There are three common Stirling engine configurations, namely the Alpha Stirling engine, the Beta Stirling engine and the Gamma Stirling engine.

Alpha Stirling engine

The Alpha engine has two pistons in separate cylinders connected in series by a heater, regenerative and intercooler. The Alpha engine was conceptually the simplest Stirling engine configuration, but had the disadvantage that the hot and cold pistons had to have seals to contain the working gas. There are several mechanical mechanisms that allow this type of engine to function properly with the correct divergence of the two pistons.



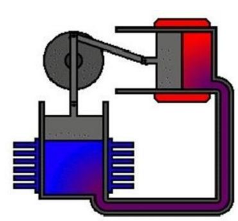


Fig.2 and 3 Schematic diagram of Alpha Engine and V-type Engine

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With the purpose of the project in mind, where efficiency is a key factor, we decided to develop an Alpha configuration that was better than the other two.

Beta Stirling Engine

The beta configuration is a classic Stirling engine configuration and has been very popular from its inception to the present. Sterling's original engine from the 1816 patent drawing shows a beta deployment. Unlike the alpha engine, the beta engine has a single working piston and displacer, the ideal purpose of which is to "replace" a certain amount of working gas and inflate with an in-line arrangement of cooler, regenerator, and heating. It is to transport between space and compressed space. In a real engine, the linkages that drive the pistons and displacers move them, compressing the gas primarily when it is in cold compression space and expanding it when it is in hot expansion space.

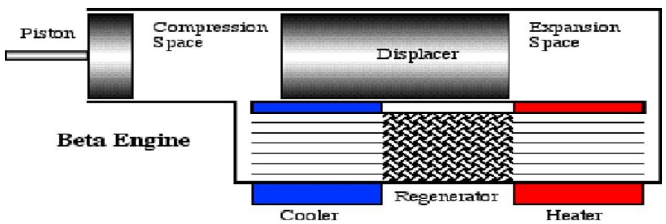


Fig 4

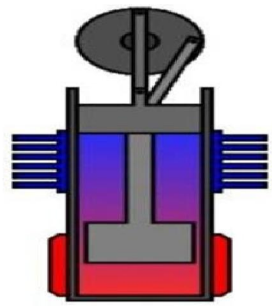
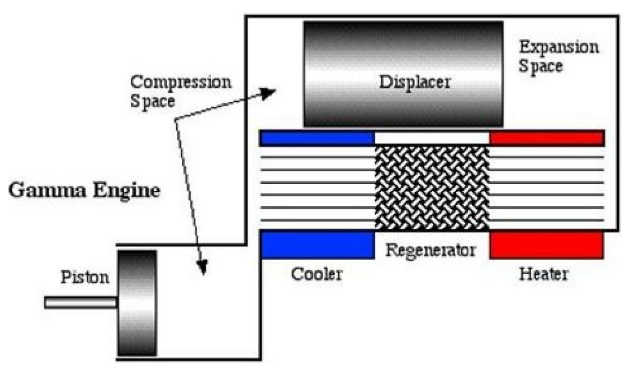


Fig 5

Fig. 4 and 5 Schematic diagram of Beta Type Engine

Gamma Type Stirling Engine

- Gamma type engines have a displacer and power piston, similar to Beta machines, however in different cylinders.
- This allows a convenient complete separation between the heat exchangers associated with the displacer cylinder and the compression and expansion work space associated with the piston.
- Thus, they tend to have somewhat larger dead volumes than either the Alpha or Beta engines.
- This avoids the complications of the displacer piston linkage passing through the power piston



III. METHODOLOGY

1. Selection of material for various parts of Hot Air engine depending upon its application.
2. Design of individual parts.
3. Manufacturing of Hot Air engine.
4. Assemble all the parts of Hot Air engine and check.
5. Take a trial on the engine and check the flow of working fluid.
6. Observed the working of the engine.

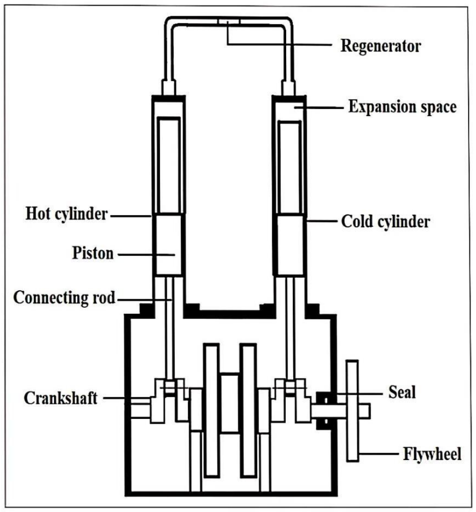


Fig 7 schematic diagram of Hot

Fig 8 Manufactured model of Hot Air Engine

Fig 7 and 8 Hot Air Engine

Hot Air Engine Working

In this hot air engine, a parabolic Scheffler dish is used as a parabolic reflector and reflects 70% of the solar radiation to the receiver, but because it uses an aluminum plate, it is of heat. Only 30% is absorbed. Foil. Arrange the three bowls so that the sunlight from each bowl is focused on a separate receiver. The receivers are arranged in series so that all the radiation heats the thermal fluid. The hot liquid temperature rises to 300 ° C.

The thermal fluid is stored in a storage tank. Now the hot Thermic fluid mixture` is pump out to the hot cylinder where the fluid is guided by a passage created in the jacket. In the cylinder we are using air as a working fluid. The air absorbs the heat of Thermic fluid and gets expands to the cold cylinder. In cold cylinder we are using water cooling method for cooling purpose. When the heated air is passed in the cold cylinder the piston will reach to BDC. The hot air in the cold cylinder is now cooled by the surrounding water, leading to a new compression of the piston from the BDC to the TDC. Changes in gas temperature cause corresponding changes in gas pressure, and movement of the piston alternately compresses and expands the gas. In this process, thermal energy is converted to mechanical power in a hot air engine by the continuous compression and expansion of the piston.

The flywheel is mounted on a crankshaft that stores mechanical force. In addition, this mechanical force is converted into electricity by the generator. In this process the gas always passes through the regenerator absorbing heat hot gas and adding it when cooled air in it goes back to hot cylinder. Regenerator may be insulated.

1. Hot Cylinder

Fig 9 Hot Cylinder

The hot cylinder consists of two cylinders, an inner cylinder and an outer cylinder. A hot fluid circulates between the two cylinders and transfers heat to the Air present in the inner cylinder. External heat is transferred to the inner cylinder by the thermal fluid. In a hot air engine, the regenerator is an internal heat exchanger and a temporary regenerator, located between the hot and cold spaces, where the working fluid first flows in one direction and then in the other direction. Extracts heat from the fluid in one direction. As simple as metal mesh or foam, it benefits from high surface area, high heat capacity, low conductivity and low flow friction. The main effect of regeneration in a hot air engine is to increase thermal efficiency by "recycling" the internal heat that would otherwise irreversibly flow through the engine. As a secondary effect, the increased thermal efficiency results in higher output from certain hot-end and cold-end heat exchanger sets. To realize this regeneration principle, we used a regenerator placed on top of the inner hot cylinder to allow the inner cylinder and regenerator to be mounted together inside the outer hot cylinder. Its function is to maintain the heat in the system that would otherwise be exchanged for the environment. For this purpose, we used baffles and wire mesh to resist the flow of liquid. This helps maintain the heat of the regenerator. The top of the regenerator has a cone that acts as a guide path for liquid to enter the tube connecting the cold cylinder.

2. Cold Cylinder

Fig 10. Cold Cylinder

In a small low power engine, this may simply consist of the walls of the cooling chamber, but if higher power is required, transfer enough heat to increase the temperature difference. In order to achieve a good temperature difference, the cylinder on the low temperature side also needs to be cooled violently. Therefore, it is designed to cool the air inside the inner cold cylinder by circulating cold water between the inner cold cylinder gap and the outer cold cylinder.

3. Piston

Fig 11. Piston

The hot air engine is exposed to the pressure of the expanding gas in the inner cylinder. This force then acts on the crankshaft through the connecting rod. The connecting rod is attached to the piston via a pivot gudgeon pin. The pin is fixed to the piston, but it moves freely in the connecting rod. All pins should typically be prevented by a circlip against lateral displacement and by the ends of the pins biting into the cylinder wall. Gas seals are achieved by using piston rings. These are a series of thin iron rings loosely mounted in the groove of the piston just below the crown. The ring is split at one point on the rim, so you can push the cylinder with a light spring pressure. Two types of rings are used. The upper ring has a sturdy surface and provides a gas seal. The lower ring has a narrow edge that acts as an oil scraper. It has many unique detailed design features related to piston rings

4. Connecting rod

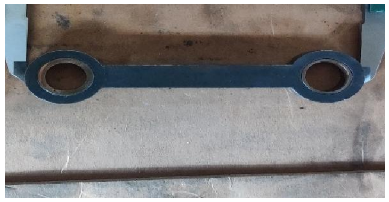


Fig 12 Connecting rod

Connecting rods can also convert rotary motion into reciprocating motion, which is the intended use. Earlier mechanisms like chains could only give pulling action. The rigidity of the connecting rod allows it to transmit either compression or tension. This allows the rod to rotate the crank in half the rotation of both. With a hot air engine, all you have to do is push the connecting rod. Today, connecting rods are best known for use in internal combustion piston engines. These are of a distinctly different design from earlier forms of connecting rod used in steam engines and steam locomotives. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft.

5. Crankshaft

Fig 13. Crankshaft

A crankshaft is a mechanical part able to perform a conversion between reciprocating converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in a reciprocating compressor. The crankshaft has a linear axis about which it rotates, typically with several bearing journals riding on replaceable bearings (the main bearings) held in the engine block.

6. Crankcase

Fig 14. Crankcase

The crankcase is the housing for the crankshaft of a reciprocating engine. The housing forms the largest cavity in the engine and is placed under the cylinder. Cylinders are typically integrated into one or more cylinder blocks in a multi-cylinder engine. Crankcases were often separate parts, but more commonly they are an integral part of the cylinder bank and form the engine block. Nevertheless, the area around the crankshaft is usually called the crankcase. The crankcase not only protects the crankshaft and connecting rod from foreign matter, but also performs other functions depending on the type of engine. This includes storing engine oil and providing a rigid structure that connects the engine to the transmission.

IV. CONCLUSION

The developed hot air engine can be an alternative to generate electricity using renewable energy sources on a local or national scale. In-house production of the engine and all major components such as pistons, crankshafts, hot and cold cylinders helped develop the methodology used to develop hot air engines for power generation with reduced environmental impact. Developed engine would be the better option of electricity generation, especially at domestic and local level. Use of waste heat is also possible for electricity generation avoiding environmental pollution. Performance and ease in manufacturing are the major benefits with the development of hot air engine. This work would be highly innovative way of electricity generation in view of sustainable development.

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