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Power Generation by Stirling Engine

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Abstract - Attempts are being undertaken around the world to boost the usage of renewable energy sources while also improving the efficiency of our current fossil fuel energy sources. The goal of this project is to recover waste heat from power plants or to use solar energy to power a Stirling engine. Stirling technology is used in both the renewable energy and waste heat recovery industries. Investigating the use of Stirling engines in the aforementioned domains is important for developing more efficient external combustion units and maximizing the use of renewable energy sources. The goal of this project was to design, develop, and test an electrically powered Stirling engine. A gamma type layout based on a one-cylinder air compressor was chosen after testing several designs.

Gamma engines, like Beta engines, have a displacer and a power piston, but in different cylinders. The heat exchangers associated with the displacer cylinder and the compression and expansion work space associated with the piston are thus conveniently separated.

Keywords - Gamma type / Stirling engine / external combustion engine / Spirit Lamp/ Dynamo.

I. INTRODUCTION

The Stirling Engine is an old technology that has recently been resurrected due to its potential as a green energy source. It's a heat engine, which means it converts heat or thermal energy into mechanical energy, which is subsequently utilized to generate electricity. Heat from an external source is necessary in the Stirling Engine to expand the working fluid inside the piston, allowing work to be generated.

The Stirling Engine is a heat engine; however, it is very different from other heat engines, particularly the Carnot Engine. The Carnot Engine, which consists of two isothermal and two adiabatic processes, is the ideal heat engine. The Carnot cycle determines the maximum amount of heat from an engine that may be used to perform work, assuming the process is reversible and no entropy change happens. The Carnot Engine is an idealization of the most efficient engine, based on the notion that engines cannot be totally reversible, and hence the Carnot efficiency indicates the highest efficiency that any heat engine can reach. The Stirling Engine, on the other hand, is made up of two isothermal and two isometric processes, as opposed to the Carnot Engine's two isothermal and two adiabatic processes. Because of the changes between these two cycles, the overall work, heat transfer, and efficiency attained throughout the cycle are calculated differently.

Stirling engines are not like the ordinary internal combustion engines seen in most modern automobiles. Stirling engines do not require the use of fossil fuels; therefore, they can be operated without generating hazardous waste. They can generate electricity using solar energy or waste energy from other sources. The Stirling engine is a relatively environmentally friendly power source because of its feature.

II. LITERATURE SURVEY

(2009)-Papyrus et al. – investigated that in design and development of Stirling engine. It is done for Stirling engines of different capacities. A second order cyclic analysis approach is used to examine the Stirling engine. This comprises calculating theoretical power output and heat intake under predetermined circumstances. It also involves the computation of power output and heat input losses. The engine is optimized using a univariate method that takes into account the influence of the hollow displacer and overlapping volume. Finally, we are able to calculate engine efficiency. The engine in question is a single cylinder, beta configuration, rhombic drive engine that runs on Hydrogen as the working fluid at 30 bar mean pressure, 1440 rpm, and a gas temperature range of 750 k to 350 k. According to the current state of the project, the engine's predicted thermal efficiency will be around 38%. The project will provide 1.5 kW of electrical output at 24 Hz, which may be changed to 50 Hz using electronics. This can be utilized in remote regions for illumination, fans, charging storage batteries, and driving modest capacity pumps for irrigation. A group of three to four families with enough cattle to generate bio-gas for gas-based or hybrid systems can use it successfully.

(2014)-Javier Arco Sola et al. – observed that in application of bio-mass Stirling engine for electrification. This report examines and simulates a feasible system configuration for the implementation of a Stirling engine for rural electricity in Bolivia. The review's goal is to see if a hybrid system that combines a biomass-fuelled Stirling engine with photovoltaic technology can meet a basic electricity demand. Following a brief explanation and research on the subject, the Stirling engine appears to be a potential instrument for electrifying rural areas where biomass use is widespread, as well as the ability to employ solar energy via photovoltaic technology as an additional energy input to the system.

(2019)-Pratik Sirsath et al. – reviewed on Stirling engine performance. It's all been put to the test with a Stirling engine that runs on solar energy and is intended for tiny temperature differences. They created a Stirling engine without a regenerator and investigated the impact on the engine's thermal efficiency. A computer program was used to simulate the effect of variations in regenerator efficiency on the engine's theoretical efficiency. It has been discovered that the higher the regenerator efficiency, the higher the Stirling engine's thermal efficiency.

(2021)-Youssef Mejdoub et al. – investigated that in Stirling engine efficiency on the basis of temperature difference. Youssef Mejdoub's goal in this article is to improve the engine's efficiency by utilizing temperature differences. Youssef Mejdoub investigates the efficiency of the Stirling engine in this article, as well as the use of a parabolic mirror to focus sunlight onto the engine and an isothermal and adiabatic analysis of the engine. Youssef Mejdoub works on the performance of Stirling engines. It led to the temperature of the cold and hot sources being adjusted to get the best temperature differential.

III. MATERIAL AND METHODS

A. Power Piston

A piston head and connecting rod slide in an airtight cylinder to form this. Power is transmitted from the working gas to the flywheel by the power piston. In addition, before the heating cycle, the power piston compresses the working fluid on its return stroke. The piston itself was also machined from steel to allow for smooth operation in the steel cylinder, and also to have a comparable thermal expansion coefficient in the event that this side of the engine became hot shown in Fig. a

B. Displacer Piston

The displacer is a special-purpose piston that transports working gas between the hot and cold heat exchangers. The displacer may or may not be sealed to the cylinder, depending on the engine design. It is a loose fit within the cylinder that allows the working gas to travel around it as it moves to occupy the part of the cylinder beyond shown in Fig. b.

C. Connecting Rod

The displacer and power pistons are connected to the driving shaft by connecting rods. Two 1/4" diameter steel shafts were pin-jointed to 1/8" thick flat bars to make the original connecting rods. The pin joint is essential for the engine to rotate because it allows the top and bottom rods to move independently of one another. The pistons move the top halves (steel shafts) of the rods vertically up and down, while the driving shaft moves the lower halves (steel bars) in a circular pattern. To keep the engine's overall weight down, 1/4" diameter shafts and 1/8" bars were used. The two rods are of various lengths to accommodate the pistons' differing throws. While the power piston connecting rod is hung in the air, the displacer piston connecting rod must likewise go through the bottom of the displacer case shown in Fig. c.

D. Drive Shaft

The Stirling engine's driving shaft is an essential component. It connects the engine's components and sends the engine's generated power to the output device. The shaft is bent 90 degrees to force the displacer and power pistons to be out of phase by 90 degrees. The phase difference means that if one piston is at top dead centre (totally up), the other is halfway up, and vice versa. The preliminary driving shaft was made from 1/4" steel threaded shafts attached to 1/8" thick steel bars. This design was chosen to reduce the weight of the driving shaft while also simplifying fabrication shown in Fig. d.

E. Flywheel

The flywheel is connected to the power piston's output power and is used to store energy and create momentum for the engine to run smoothly. For maximum energy storage, it is built of heavy materials such as steel. Energy absorption needs an increase in speed, whereas energy restoration necessitates a decrease in speed. Although the speed variations are minor, the flywheel must be correctly matched to ensure that they do not exceed legal limits. The flywheel's kinetic energy is given by and shown in Fig. e.

$$IK_S\omega^2 = ½\,E_f$$

where I = mass of the flywheel's moment of inertia = mass * (radius of gyration) ^{2} = m k^2

Ks = coefficient of speed

ω = average angular speed

Area under torque vs. rotation angle figure with E_f = energy fluctuation

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F. Spirit Lamp

A spirit lamp or alcohol burner is a piece of laboratory equipment that produces an open flame. Brass, glass, stainless steel, or aluminium can all be used.

For safety reasons and in laboratories where natural gas is not available, alcohol burners are preferred over Bunsen burners in some applications. Their flame is confined to around 5 centimetre’s (two inches) in height and operates at a lower temperature than the Bunsen burner's gas flame. While they don't produce as hot of a flame as other types of burners, they're hot enough for various chemistries, normal microbiology laboratory procedures, and flame sterilization of other laboratory equipment and shown in Fig. f.

G. Dynamo

A dynamo is an electrical generator that uses a commutator to generate direct current. Dynamos were the first electrical generators capable of supplying power to industry, and they served as the foundation for many subsequent electric-power conversion devices, such as the electric motor, alternating-current alternator, and rotary converter and shown in Fig. g.

Fig. a. Power Piston

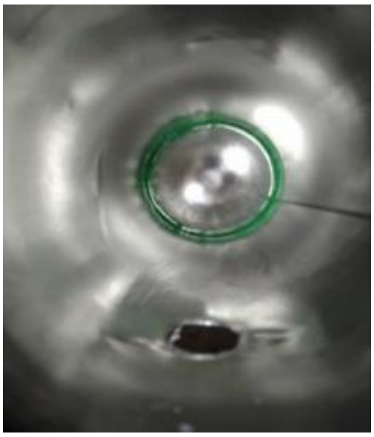

Fig. *b*. Displacer Piston

Fig. *c* Connecting Rod

Fig. d Drive Shaft

Fig. e Flywheel

Fig. f. Spirit Lamp

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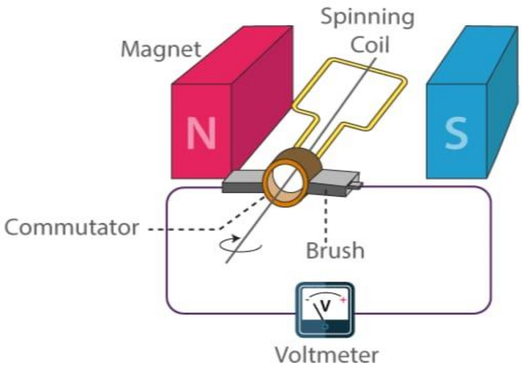

Fig. g. Dynamo

IV. WORKING

The Stirling cycle is the most efficient and has a higher work ratio than the Carnot cycle. The Stirling engine produces the best output, despite the fact that its efficiency may not be realistic in real construction and testing.

As shown in Fig.6, the idealized Stirling cycle consists of four thermodynamic processes working on the fluid network.

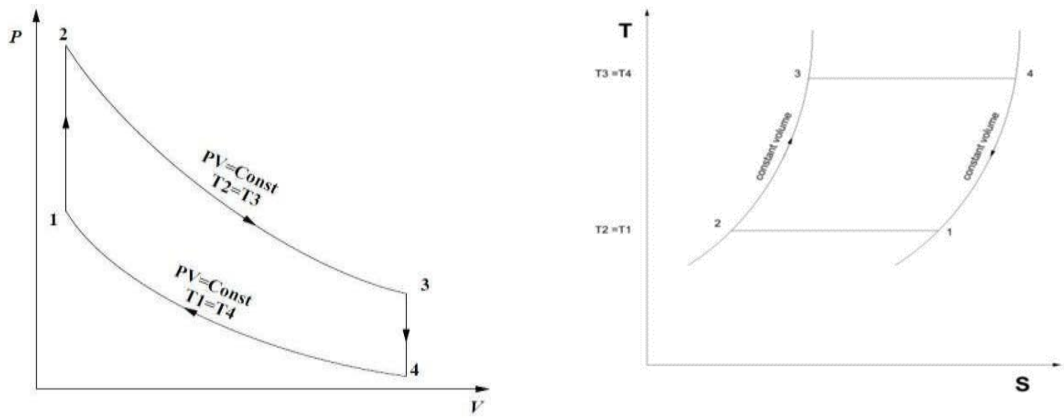

Fig. 6. The Stirling cycle on a P-V & T-S diagram

i. 1-2: Constant volume heat addition: The gas goes through the regenerator, recovering a portion of the heat transmitted and heating up as it travels to the expansion space.

ii. 2-3: Isothermal expansion: The gas undergoes isothermal expansion while absorbing heat from the heat source, and the expansion chamber and accompanying heat exchanger are kept at a constant high temperature.

iii. 3-4: Constant volume heat removal: The gas is cooled in a regenerator, which transfers heat to the regenerator for use in the following cycle.

iv. 4-1: Isothermal compression: The compression chamber and accompanying heat exchanger are kept at a constant low temperature such that the gas is compressed isothermally and heat is rejected to the cold sink.

In the process 2-3, when the gas expands isothermally (T2 = T3), heat is theoretically delivered to the working fluid. In the process 4-1, when the gas is compressed isothermally (T1=T4), heat is also rejected to an external heat sink. The constant volume processes 1-2 and 3-4 connect the two isothermals, with temperature variations of similar magnitude (T2 - T1).

Rotating shaft is connected to the wheel/ coil assembly. At rotating shaft attraction is mounted. Thus, attraction launch gyration around bobby coil of the line and attraction, pushes the electrons in the line and creates an electrical current.

V. CONCLUSION

Stirling engines are classified as "free energy" when they enable us to access previously inaccessible natural energy sources. For a given temperature difference between the heat source and the heat sink, Stirling cycle engines are particularly efficient. Steam engines (the Rankine cycle) are also included in this category. However, depending on your preferences for hardware and upkeep, one or the other will be favoured. Steamers have fewer parts and produce more power. Water can be replaced with other fluids, such as a variety of refrigerants. Stirling avoids fluid containment difficulties by using air as the operating fluid. They also require minimal maintenance. Stirling engines are extremely adaptable. Engines come in a variety of shapes and sizes. They can be very compact and run with only a minor temperature difference, and they are extremely silent, making them suitable for use in submarines or as a CHP plant.

The Stirling engine, as shown in this document, is an intriguing device with a wide range of applications and rapid development. Its advantages are extremely useful to the environment because it is possible to generate electricity with high efficiency using the sun's power (theoretically like the Carnot Cycle). It is a significant economic benefit because it is possible to use the cheapest gasoline instead of the more expensive one. This engine is also more comfortable for individuals because it is quieter than an internal combustion engine.

Depending on the type of fuel used in the procedure. Because the Stirling Engine is an external combustion mechanism, CO_2 emissions are not reduced when fuel is consumed. It has been demonstrated that performance has improved, however the fundamental problem remains in terms of the surroundings. Find a heat source to make it function; in the case of biomass fuels in conjunction with a Stirling engine, the focus is on transporting heat from the fuel combustion to the working gas, and the solar use is similar. Because, as businesses increasingly turn to alternative power sources, it's feasible that the Stirling engine may carve out a space for itself in the market, either as part of a hybrid power plant or through further development and optimization. There are no high-tech materials required. Solar cells compete with this. Stirling engines, when combined, create a massive shift in human history. We believe this region has a lot of potential because contemporary industries should be supported by renewable energy systems. It's not a dead end, but rather a fresh start.

REFERENCES

1. Hargreaves, C. M., The Philips Stirling Engine, Elsevier Science Publishers, Amsterdam 1991.

2. Schmidt, G. “Theorie der Lehrmanschen Calorischen Maschine,” Z. Ver. Dtsch. Ing., 15(1), pp. 1–12, 1871.

3. Finkelstein, T., “Generalized” Thermodynamic Analysis of Stirling Engines,” SAE paper 118 B. See also (10), Appendix VIII, 1960.

4. Reader, G.T., and Hooper, C., Stirling Engines, E. & F.N. Spon, London, Appendix A. 1983. 5. Walker, G., Stirling Engines, Clarendon, Oxford, 1980.

6. Organ, A.J., The Regenerator and the Stirling Engine, Mechanical Engineering Publications Limited, London, 1997.

7. Urieli, I., and Berchowitz, D. M., Stirling Cycle Analysis, Adam Hilger Ltd., Bristol, 1984. 8. Walker, G., and Senft, J. R., Free Piston Stirling Engines, Springer-Verlag, Berlin, 1985

9. Rizzo JG. The Stirling engine manual. Somerset: Camden miniature steam services, 1997. 10. Shah Alam. A proposed Model for Utilizing Exhaust Heat to run Automobile Air conditioner. International Conference on "Sustainable Energy and Environment (SEE 2006)".

10. Senft JR. Ringbom Stirling engines. New York: Oxford University Press, 1993.

11. Walpita SH. Development of the solar receiver for a small Stirling engine. In: Special study project report no. ET-83-1. Bangkok: Asian Institute of Technology; 1983.

12. Trayser DA, Eibling JA. A 50-Watts portable generator employing a solar-Powered Stirling engine. Sol Energy 1967; 11:153–9.

13. Gupta RK, Deshpande AM, Brave KM. Development of 1 kW solar powered reciprocating engine for rural applications. In: International Solar Energy Congress, New Delhi. 1978. p. 2016–20.

14. Spencer LC. A comprehensive review of small solar-powered heat engines: Part I.I. Research since 1950 - "Conventional" engines up to 100 kW. Sol Energy 1989; 43:197–210.

15. Pearce JM, Al Zahawi BA, Auckland DW, Starr F. Electricity generation in the home: evaluation of single-house domestic combined heat and power. IEE Proc-A 1996; 143:345–50.

16. Markman MA, Shmatok YI, Krasovkii VG. Experimental investigation of a low-power Stirling engine. Geliotekhnika 1983; 19:19–24.

17. Orunov B, Trukhov VS, Tursunbaev IA. Calculation of the parameters of a symmetrical rhombic drive for a single-cylinder Stirling engine. Geliotekhnika 1983; 19:29–33.

18. Abdalla S, Yacoub SH. Feasibility prediction of potable water production using waste heat from refuse incinerator hooked up at Stirling cycling machine. Desalination 1987; 64:491–500.

19. R. Tugrul Ogulata. Utilization of waste-heat recovery in textile drying. Applied Energy 2004; 79:41-49.

20. Shung-Wen Kang, Meng-Yuan Kuo, Jian-You Chen, Wen-An Lu. Fabrication and Test of Gamma-Type Stirling Engine. PEA-AIT International Conference on Energy and Sustainable Development: Issues and Strategies (ESD 2010).

21. Can Cinar, Halit Karabulut. Manufacturing and testing of a gamma type Stirling engine. Renewable Energy 2005; 30:57-66.

22. Kongtragool B, Wongwises S. Investigation on power output of the gamma-configuration low temperature differential Stirling engines. Renewable Energy 2005;30: 465–76.