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Development of light weight stirling engine to generate power using heat energy

#1Mr. Rashinkar Akshay R., #2Mr. Shinde Aniket A., #3Mr. Thorat Amol B., #4Mr. Udamale Akshay R., #5Prof. B.D. Patil

3amolthorat1304@gmail.com
#12345Department of Mechanical Engineering

Sinhgad Institute of Technology & Science, Narhe (Pune)

ABSTRACT

In recent year's usage of energy is very high. Researches are being done to find alternative sources for energy. There are many ways by which modifying existing techniques will help to reduce the usage. The project proposes the way to build and utilize the low cost Stirling engine for the green energy applications. The research on Stirling engine is being increased, many inventions reveals the suitability of engine for low power applications that includes an alternative for motors in industries. As it knows that Stirling engine has closer theoretical Carnot cycle efficiency. This theoretical efficiency of engine provides an alternative for various industrial low duty applications. Finally this project will outline theoretical background of Stirling cycle; various design parameters, innovative use of fabrication works and industrial implementation ways. The design process involves the design of cylinders, its mass flow rate, amount of heat addition, heat rejection, efficiency and many more. These sub design parameters helps in finding out power outcome of the engine. The fabricated work involves usage of available materials in and around effectively. As a result final assembly of the engine meets the objective.

Keywords: Stirling engine, low temperature, solar and conventional heat source, design, manufacturing, material selection, further scope, industrial applications, cost.

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I. INTRODUCTION

The main purpose of the project served to promote the use of Stirling engines in „green energy‟ applications. To make an engine this can generate mechanical energy from a heat of flame. To build a simple external combustion engine design, this operates relatively low pressure, which emits relatively low gases, indirectly having very high efficiency.

Scope:

The output of the engine is less than what is been expected it can be further increased by following ways. To increase the efficiency fins are provided over the cylinder so the heat transfer rate will be high when compared to normal cylinders by operating at various temperatures we can obtain various efficiencies. Also Stirling engine can utilize the power of the sun to provide the necessary energy to the system with the help of micro controllers. The main purpose of the project served to promote the use of Stirling engines in „green energy‟ applications. Due to the high theoretical efficiencies of Stirling engines they are a prime candidate for future solar energy generation research.[4] Solar powered Stirling engines are now commercially available up to 25 kW of generating capacity.

II. LITERATURE SURVEY

Fabrizio Alberti, Luigi Crema, Design of a new medium-temperature Stirling engine for distributed cogeneration applications.

This paper presents and discusses the design and first prototype realization for a brand new generation of Stirling engines. This unit is realized within the DiGeSPo Project, in which it is coupled with a smallsize parabolic trough concentration solar field. The engine is conceived for working with low-temperature heat sources (200-300°C), in order to match the typical temperatures for the solar field itself.

The thermodynamic design of the cycle has used different tools in order to find the optimal parameters for main components of the engine, including pistons, the regenerator and heat exchanger. The starting point is Schmidt analysis and the Beale number, from which qualitative parameters can be extracted. From the beginning the Beale number make clear that an high density power, which means reducing the swept volume, can be achieved by increasing the charge pressure or the working frequency. Increasing the working frequency has the disadvantages of increasing mechanical losses from friction, and leaves with the option of increasing instead the pressure. Other engine realized for medium temperature application show that the design of a low speed engine is the way to follow, in order to achieve good efficiency and reduce mechanical losses. A low speed engine can also operate more quietly and with less noise.

The design procedure followed for the realization of a low-temperature Stirling engine is presented. Thermodynamic and heat transfer calculations are conducted in order to achieve and optimize the requirements fixed within the Digespo Project. Results obtained during this phase (pressure, forces) will be used to design the mechanical components, and to realize a full-scale demonstrative prototype. [1]

Hojjat Damirchi, Gholamhassan Najafi, Siamak Alizadehnia , Barat Ghobadian, Talal Yusaf and Rizalman Mamat, Design, Fabrication and Evaluation of Gamma-Type Stirling Engine to Produce Electricity from Biomass for the micro-CHP system.

With consideration of the biomass energy potential, a gamma type Stirling engine with 220cc swept volume and 580cc total volume was designed, optimized and manufactured. The engine was tested with helium. Working characteristics of the engine were obtained within the range of heat source temperature 370- 410˚C and charge pressure 10 bar for biomass resources and heat source temperature 540- 560 ˚C and range of charge pressure 1-12 bar with 1 bar increments at each stage for gases. By using of thermodynamic and heat transfer design methods, the key parameters of the designed Stirling engine like required surfaces for heat transfer were calculated (hot side 307 and the cold side 243 squares of centimeters).

Stirling engines have been investigated as the new technology for micro combined heat and power applications. As external combustion engines permitting close control of the combustion process, their characteristics of low emissions, high efficiency, reliability, extended service intervals, low noise and vibration levels are all well suited to the demands of micro-CHP with stirling engines systems. The performance of Stirling engines as external combustion engines meets the demands of the efficient use of energy and environmental security and therefore they are the topic of present attention in technical investigate and engineering requests. Among external combustion engines, Stirling engines has been investigated due to numerous benefits such as the ability to operate from any heat source, quiet operation with low noise and vibration releasing low pollutant emissions, requiring less maintenance and high efficiency. Stirling engine can operate with heat as energy input and can produce electricity. These engines could be applied to the MCHP systems (Micro Combined Heat and Power) driven by solar, biogas, mid-high temperature waste gases.

The test results confirmed the fact that Stirling engines driven by temperature of biomass gases are able to achieve a valuable output power. Maximum brake power output was obtained with helium at 550˚C heat source temperature and 10 bar charge pressure at 700 rpm as 96.7 W. Electrical energy produced from biomass sources.[2]

Dinesh.K, Gowtham Raj.R, Naresh.M, Rakesh.N, Sriram.R, Design And Fabrication Of Low Cost Stirling Engine For Low Duty Industrial Applications.

In recent year‟s usage of energy is very high. Researches are being done to find alternative sources for energy. There are many ways by which modifying existing techniques will help to reduce the usage.

Even though output of engine is not sufficient to run a entire vehicle but it can be used as secondary engine in automobiles, and for all industrial light duty operations. Hence the objective of designing and manufacturing of engine was successful and can be implemented as a replacement to low power motors. It‟s been proved that running cost of the engine is also very less this will help to minimize the usage of fuel and reduce air pollution.[3]

Implementation of stirling engine for industrial problems :

Stirling engines can run directly on any available heat source, not just one produced by combustion, so they can run on heat from solar, geothermal, biological, nuclear sources or waste heat from industrial processes.

1. Electricity production: By coupling the dynamo with Stirling engine, above mentioned heat source engine is made to run and electricity is produced.
2. Alternate for motors: In industries, instead of using motors the pumps, compressors and low power machines are directly run with the help of Stirling engine by utilizing waste heat.
3. Dual power output to increase engine performance: Waste heat is easily harvested (compared to waste heat from an internal combustion engine) making Stirling engines useful for dual-output heat and power systems.
4. Fuel saver: Like Petrol-Battery hybrid cars, Petrol Stirling or diesel-Stirling hybrid vehicles can be used.
5. Increase in engine efficiency: Stirling engine are used in automobiles to operate Air conditioning and various pumps. So we can increase the main engine efficiency.
6. Alternate for Air conditioner: engine is extremely flexible which can be used as CHP(combined heat and Power) in winters and as coolers in summer.

Rutansh Patel, Bhargav Pandya, Solar Powered Stirling Engine- A New Hope, Volume-3.

The planet is progressively marching towards a serious energy crisis owing to an escalating desire of energy becoming greater than its supply. We have always accepted that the energy we make use of each day is not unrestricted, still we take it for granted. In the energy deficient world it is strongly felt that the use of solar energy as possible source is not being fully utilised. So in an attempt to deploy its use a novel concept of "Solar Powered Stirling Engine"is introduced in this paper. The StirlingEngine used here runs using solar heat radiation concentrate by „Solar Concentrator". A Stirling engine is basically a heat engine that operates by cyclic compression and expansion of air or other gas, the working fluid, at different temperature levels such that there is net conversion of heat energy to mechanical work. In general Stirling engines have comparatively high thermodynamic efficiencies. Because they need only heat, Stirling engines also permits high fuel flexibility and allow for better control for emission. The purpose of this study is to provide an alternate energy source to operate Stirling engine.

III. METHODOLOGY

Organization of dissertation

A Stirling engine uses a single-phase working fluid. Run directly on any available heat source. They start easily & run more efficiently in cold weather. No exhaust gas produced. Waste heat is easily harvested.

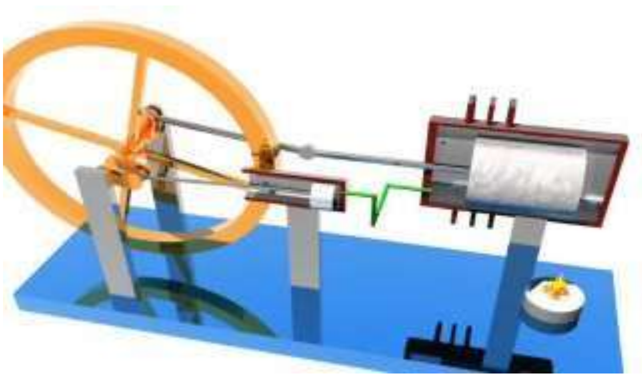

Figure 1. Actual Stirling engine

The Stirling Cycle

The key principle of a Stirling engine is that a fixed amount of a gas is sealed inside the engine. The Stirling cycle involves a series of events that change the pressure of the gas inside the engine, causing it to do work. There are several properties of gasses that are critical to the operation of Stirling engines:

If you have a fixed amount of gas in a fixed volume of space and you raise the temperature of that gas, the pressure will increase.

If you have a fixed amount of gas and you compress it (decrease the volume of its space), the temperature of that gas will increase.

Heat is added to the gas inside the heated cylinder (left), causing pressure to build. This forces the piston to move down. This is the part of the Stirling cycle that does the work.

The left piston moves up while the right piston moves down. This pushes the hot gas into the cooled cylinder, which quickly cools the gas to the temperature of the cooling source, lowering its pressure. This makes it easier to compress the gas in the next part of the cycle.

The piston in the cooled cylinder (right) starts to compress the gas. Heat generated by this compression is removed by the cooling source.

The right piston moves up while the left piston moves down. This forces the gas into the heated cylinder, where it quickly heats up, building pressure, at which point the cycle repeats.

The Stirling engine only makes power during the first part of the cycle. There are two main ways to increase the power output of a Stirling cycle:

Increase power output in stage one - In part one of the cycle, the pressure of the heated gas pushing against the piston performs work. Increasing the pressure during this part of the cycle will increase the power output of the engine. One way of increasing the pressure is by increasing the temperature of the gas. When we take a look at a two-piston Stirling engine later in this article, we'll see how a device called a regenerator can improve the power output of the engine by temporarily storing heat.

Decrease power usage in stage three - In part three of the cycle, the pistons perform work on the gas, using some of the power produced in part one.

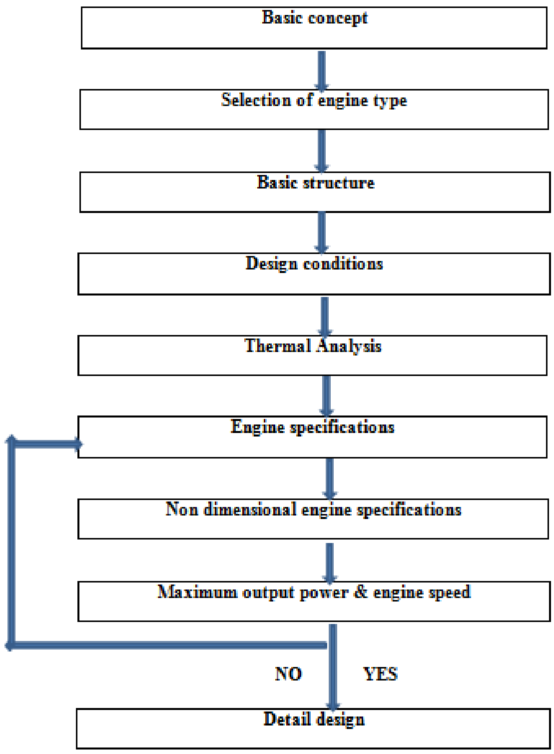

Fig 2. Flow methodology

IV. CONCLUSION

Even though output of engine is not sufficient to run a entire vehicle but it can be used as secondary engine in automobiles, and for all industrial light duty operations. Hence the objective of designing and manufacturing of engine was successful and can be implemented as a replacement to low power motors. It‟s been proved that running cost of the engine is also very less this will help to minimize the usage of fuel and reduce air pollution.

As said earlier that it is an attempt to operate Stirling engine with help of solar power. The Engine has run smoothly and without any noise pollution. The aim of this study is to find a feasible solution which may lead to a preliminary conceptual design of a workable solar-powered Stirling engine, which has been achieved.

The test results confirmed the fact that Stirling engines driven by temperature of biomass gases are able to achieve a valuable output power. Maximum brake power output was obtained with helium at 550˚C heat source temperature and 10 bar charge pressure at 700 rpm as 96.7 W. Electrical energy produced from biomass sources. Most power be obtained from the sawdust (46 watt) and pruning of trees for wood for low power (21 watts), respectively. Minimum ignition time of the Sawdust (4 min) and the most time flammable wood from pruned trees (10 min) was measured. At maximum power, the internal thermal efficiency of the stirling engine was measured as 16%. Results of the present work encouraged initiating design of a single cylinder, gamma type Stirling engine of 1 kWe capacity for rural electrification.

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