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Design of Stirling Engine and Solar Collectors to Run an Automobile Alternator

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Abstract: Stirling cycle engine, a hot gas engine or an external combustion engine, offers potential advantages over conventional engines in fuel choices, noise and emissions. Multi-fuel such as agricultural by-product, biomass, biodiesel, solar energy and etc. can be employed as the heat source for a Stirling engine. This paper presents about automobile alternator powered by a viebachstirling engine (VSE) - utilizes solar energy as the heat source.The solar dishes are mounted as parabolic solar collector providing heating temperature for hot section of VSEA up to 700°C (1300°F). Then the solar trough collectors with glass material, collect heat source and reflects to heating tube for hot section of VSEA up to 700°C (1300°F).The alternator delivers flow to the load incorporates an accumulator under 12V, at rpm range of 1200. Solar energy is free and available energy to be converted to useful power. Using proper heat source higher output efficiency can be produced.

Key words: External Combustion engine · Automotive Power · Misalignment · Solar Collector · Stirling Cycle · Alternator.

INTRODUCTION

Fossil fuels are the crucial energy that provide power and meet requirements. The limitation of fossil fuels leads to fuel price crisis. Emission and heat release from energy consumptions cause world's pollutions and global warming which are continuing affect and become serious problems. It is very important and necessary to search renewable and alternative energy for sustainable power production and efficient engine.. Solar energy is free and available energy to be converted to useful power. Stirling engine, first patented by Robert Stirling in 1816, is one of mechanical device that heated by solar energy and work perfectly providing high thermal efficiency compared that with other solar energy converters such as solar cell or photovoltaic cell.

Many applications were investigated and integrated with the Stirling engine such as water pump, generator, linear alternator, hydraulic pump and etc. Beale W.T. [1] purposed the design concepts of a 250 watt viebachStirling engine for use as a solar automotive alternator. However, the engines were inefficient for automobile alternator. Loss in power occurred because the reduced rpm range. Although the model 100 was modified and had excellent performance, producing about 70 watts of electric power from an alternator of about 70 percent efficiency but when it used to pump water, producing about 50 watts(5 liter-meter/sec). A sprag clutch drive was utilized in order to achieve high frequency short stroke engine. West C.D.[2] designed and focused on liquid piston using fluidyne technology on Stirling engine to pump water in form of pulsating pressure.

NASA Glenn Research Center presented dynamic model of a linear alternator coupled with Stirling engine producing electricity [3-5]. Moreover, NASA Glenn Research Center also performed research on Stirling engine with automotive output know as a 1kW (1.33 hp) Stirling engine or RE-1000. RE-1000 was designed and built by Sunpower Inc. of Athens, Ohio for research and testing at NASA Lewis Research Center.. The engine heater power consisted of two Sorensen electric power supplies connected in parallel and each delivering current 1000 amperes directly to the engine. The design of a suitable electrical output mechanism of this engine was performed by a design team from Foster-Millller, Inc. and Sunpower, Inc [6-8].

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Stirling Energy Systems (SES), Inc. has been successful on a niche market of the solar power Stirling engine plants or calling the SES SunCatcher system. The SES SunCatcher is a highly concentrating solar thermal technology that converts sunlight with maximum temperature of 720°C into electricity at a rate of 31.25 percent, significantly more efficient than its closest competitor by far. Each SunCatcher dish is 38 feet tall, 40 feet wide and generates 25,000 watts of power, which means they occupy much less space compared to any solar voltaic panels power to power [9].

Automotive power is widely used in many factories, industries, machines and pumps. However, few of research works have been conducted with mechanical output of a solar dish viebachStirling. This research presented the design of a solar dish viebachStirling engine-alternator that combines a solar dish and trough collectors, a viebachStirling engine and a as showed in Fig.1. A solar dish collector is a parabolic dish that concentrates the sun light into a beam and focus on hot section of the Stirling engine. The solar dish collector was adjusted and controlled in both polar and inclination axis. A viebachStirling engine (VSE) is a Stirling engine that operates without initial lubricant oil.

The output power from the solar dish Stirling engine is extracted in form of automotive power and store in an accumulator.

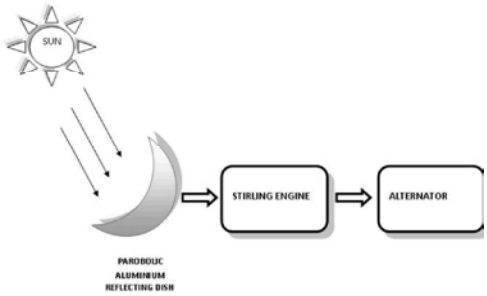
This research presented a numerical simulation of a solar dish viebachStirling engine-alternator and some preliminary testes of the VSEA prototype. Performance and dynamic characteristics of this VSEA have been simulated to determine its operating characteristics over a wide range of conditions. Numerical simulation programs have been written using Matlab code and ANSYS code in order to do a parametric study and examine how the viebachStirling Engine-alternator works using either a 12V vehicle at rpm range of 1200. The analysis assumes constant cold and hot temperatures. The proof of concept used an electric heater to be used to provide heat for VSEA [10].

Objective: Based on the above literature reviews, material selection should be highly concentrate,

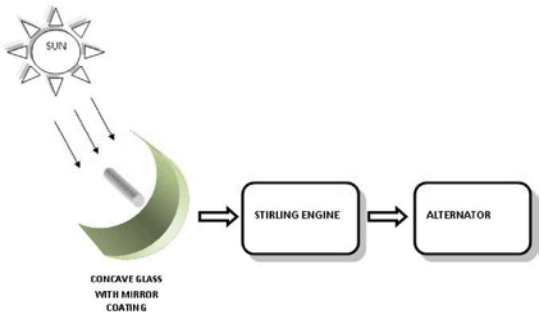
- To fabricate the prototype of the experiment.
- Output power of VSE given input to automobile alternator (12V).
- To fabricate using aluminum material as heat source.
- To fabricate using concave glass material as heat source.

MATERIALS AND METHODS

Design of the Stirling Engine with Solar Dish Collector: The parabolic solar collector is an aluminum dish with chromium coated as solar collecting material with suitable dimensions. The length of material is 1050mm and height of the aluminum material is 300 mm. The focal point is made at the height of 310 mm. A 2 inch diameter is made at bottom of the aluminum material to insert glass tube inside the parabolic solar collector and the output power is given to automotive alternator (12V).



Design of the Stirling Engine with Solar Dish Collector: The parabolic solar trough collector is an glass material with mirror coated as solar collecting material with suitable dimensions. The length of glass material is 1200 mm and height of the glass material is about 300 mm. The focal point is made at the height of 310 mm. A 1400 mm absorber tube is placed parallel above the glass material, the absorber tube collect the heat source from glass material and thermal process takes place and heat energy converted to electrical energy and the output power is given to automotive alternator (12V).



The design of the VSE couples with automotive alternator (VSEA) either a 7V or 12V at a rpm range of 1200. The VSE consists of two moving pistons which are a light weight piston called displacer and a working piston. The Displacer and the working piston movements are controlled by flow of the working gas between hot and

cold spaces or gas expansion and compression zones, respectively. As the working gas expands at the hot space, the displacer moves and compresses the working gas at the cold space pushing the working piston to give power stroke from VSE. After the working piston gives the power stroke, the displacer and the working piston are returned to restart the new cycle motion by gas spring and bounce chamber, respectively.

Stirlingengine
ST05G(200-500W)with alternator ST 05 GA (200W ele)

Technical Data:

Height	:	About 600mm
Land	:	About 350*300mm
Fly wheel dia	:	280mm
Working piston dia	:	85mm
Stoke	:	75mm
Working medium	:	Air (or) nitrogen
Operating pressure	:	up to 10 bar
Machinery efficiency (without burner)	:	22%

Required Temperature:

Engine runs at 200°C,for 500W max. 650°C

Heating	:	Any(prototype with propane)
Cooling	:	Water cooling
Ideal speed	:	About 800 rev/min
Torque	:	8 Nm
Performance planned	:	200-500 watt

Fabrication of Composite Materials:

The materials used in our fabrication process are

- Parabolic Aluminum dish collector.
- Parabolic trough collector with mirror coated.
- Absorber glass tube.
- Linear actuator.
- ViebachStirling engine.
- Automotive alternator.

Fabrication Procedure:

The steps followed during fabrication are

- Fabricate the parabolic aluminum material, with cromium coated with suitable dimensions.
- Fabricate the parobolic trough collector with mirror coated with suitable dimension.
- Specification of the viebachstirling engine with aluminum dish material.
- Specification of the viebachstirling engine with parabolic trough collector with glass materials.
- Apply cromium coating on the aluminum dish material.
- Selection of the viebachstirling engine.
- Selection of the automotive alternater.
- Selection of the linear actuator for the selected solar collectors.

The Various Types of Materials in the Fabrication Process:

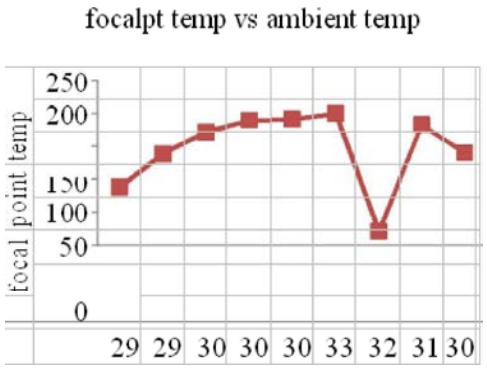
- Parabolic aluminum dish collectors.
- Parabolic trough collector with mirror coated.
- Absorber glass tube.
- Linear actuator.
- Viebachstirling engine

RESULTS AND DISCUSSIONS

Result on 8th April, 2010: The simulation was done with air as the working gas at 3.5 MPa (500 psi) working gas pressure and with an engine displacement of 24.8 cm3 (1.5 in3) running at 4000 cycles per minute can produce 2 kW. The experiment was conducted with air as the working gas at a pressure of 0.62 MPa (90 psi).

Table 1: Variation of Temperature at Focus Point with Time on the First Day

Time	Ambient Temperature (°C)	Focal point temperature(°C)
9am	29	89
10am	29	139
11am	30	172
12am	30	190
1am	30	192
2am	33	200
3am	32	22
4am	31	183
5am	30	140



CONCLUSIONS

Current research and development efforts on solar-powered viebachStirling engines show considerable promise for future applications. The Stirling engine efficiency may be low, but reliability is high and costs are low. Simplicity and reliability are key to a cost effective Stirling solar generator.

Air as the working gas at 3.5 Mpa (500 psi) working gas pressure and with an engine displacement of 24.8 cm3 (1.5 in3) running at 4000 cycles per minute can produce 15, (15 hp). The engine power is increased with the increasing of working gas pressure, heater temperature, engine speed and stroke. The scope of this work in the future is Fabrication can be done by using different parabolic solar collectors. Solar energy is free and available energy to be converted to useful power. Using proper heat source higher output efficiency can be produced.

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