COMPARISON BETWEEN SOLAR STIRLING ENGINE AND OTHER SOLAR DEVICES

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Abstract- Today worldwide concerns about the best way of utilization of the natural energy and developing technique to reduce pollution. Stirling engine is one of the best example of heat engine which convert heat energy into mechanical work. Stirling engine is based on Stirling cycle. Stirling engine is also operated by heat from sunrays. The solar Stirling have better efficiency than that of other solar device like photovoltaic cell, solar panel etc. the aim of this paper is to focus on the comparison between solar dish stirling engine and solar panel and photovoltaic cell in order to generate electricity. Solar dish Stirling is efficient to convert 1/3rd of sunlight into electricity. Ripasso energy, a solar technology company designed a new Stirling dish modules that set a new record of 31-32% efficiency. In this paper I review the new upcoming plans related to solar Stirling engine that bring ours generation into new world. I also try to explore the future use of Stirling engine and how it is better, effective and efficient than other solar devices. Many companies work in this field to make solar Stirling engine as a less expensive product for customers. In the coming world solar dish Stirling engine replace the photovoltaic cells and other solar devices.

Keywords- heat energy, photovoltaic cell, pollution, Stirling cycle, Stirling engine.

I. INTRODUCTION

Today we are moving toward the use of natural resource for the energy generation. Stirling engine is one of the effective and efficient device to convert solar energy into mechanical work. It is the best device as compare to other solar device in power generation. A Stirling cycle machine operates on a closed regenerative thermodynamic cycle using a Working gas, and subjects the gas to expansion and compression processes at different temperatures. Since Stirling engines are externally heated, environmentally very clean engine having high theoretical cycle efficiency, they can be powered using awide variety of fuels and heat sources such as, combustible materials, solar radiation,geothermal hot water, radioisotope energy [4]. Based on the fuel use for heating the Stirling engine it is available in different form and size. In solar modules, Stirling-Dish, the solar radiation is converted to electricity in three stages. In the first stage, radiation is converted to heat by focusing the solar radiation onto a light absorbing heat pipe by means of a parabolic reflector. In the second stage, the heat is converted to mechanical power by a Stirling engine. In the final stage, the mechanical power is converted to electricity by an alternator [5].The dish modules convert sunlight in most climates, however they have proven to be most effective in hot and dry climates, where the system converts one third of the solar energy into electricity.

Now I will review seven most developed system [2]:-

1. Advanco's Vanguard system by ADVANCO in southern California (1982-1985).
2. Schlaich-Bergermann and partner 50kw system (1968).
3. Mcdonnell-Dogulas stirling engine system.
4. SB and Partner 10kw system.
5. Cummins power generation 7 and 25kw system.
6. CPG 7kw system.
7. Science application international coperation 25kw system.

II. STIRLING ENGINE SET A NEW WORLD RECORD

Stirling energy system along with Sandia National Laboratories they announced a new world record for a "solar-to-grid system conversion efficiency " of 31.25 percent over the previous record of 29.4 percent [9].Ripasso Energy, a solar technology company based in Sweden, has designed a Solar stirling dish modules that set a new efficiency world record of 32% [7].The dish modules convert sunlight in most climates, however they have proven to be most effective in hot and dry climates, where the system converts one third of the solar energy into electricity.Stirling engines are significantly more efficient at converting sunlight into energy than most photovoltaic panels or concentrating solar power plants, whether parabolic trough or tower designs. The test units have reached 31 percent efficiency, compared to 16 percent for parabolic troughs and about 14-18 percent for PV panels in use today.

Recent plan of solar Stirling engine for energy production

World's largest solar installation to use Stirling engine technology20-year purchase agreement

between Southern California Edison and Stirling Energy Systems, Inc. will result in 20,000+ dish array, covering 4,500 acres, and capable of generating 500 MW -- more electricity than all other present U.S. solar projects combined.The agreement includes an option to expand the project to 850 MW.Initially, Stirling would build a one-MW test facility using 40 of the company's 37-foot-diameter dish assemblies. (Each dish generates 25 kilowatts.) This phase is slated to be completed in the first quarter of 2007. One of the 40-unit arrays capable of a 1 MW output, will be dubbed a "solar power group" and will be the basis of modular calculations for future installations. Subsequently, the 20,000-dish array is to be constructed near Victorville, California, during a four-year period, starting in early 2008. If Edison opts for the additional 350 MW installation, that will take two more years, and will bring the total number of panels to 34,000.Although Stirling dish technology has been successfully tested for 20 years, the SCE-Stirling project represents its first major application in the commercial electricity-generation field. Experimental models of the Stirling dish technology have undergone more than 26,000 hours of successful solar operation. A six-dish model Stirling power project is currently operating at the Sandia National Laboratories in Albuquerque, New Mexico.However, this isn't the first commercial application of Stirling engine technology. For instance, Swedish submarines use Stirling engines for propulsion.Infinia is one of a growing number of companies focusing on the clean energy sector. The initial solar Stirling engine design from Infinia calls for 3-kilowatt systems, which roughly suits the power needs of a residential home. Roughly 15 feet high, the dishes--which move to maximize light input during the day--are meant to compete against photovoltaic systems mounted on the ground, rather than panels on a homeowner's roof. Potentially, thousands of the generators can be placed together if enough land is available, according to the company [10].

III. NEW RESEARCH IN SOLAR STIRLING ENGINE FOR MASS PRODUCTION

SES faced a manufacturing challenge in preparing its Sun Catchers for mass production though. In order to do this, SES turned to the experts in rapid production of engines and related parts: the automotive industry. In partnership with automotive companies such as Tower Automotive and Linamar Corporation, SES managed to reduce the parts in the PCU by 60 percent (to about 650) and slash the weight of the entire system by roughly 2,250 kilograms. Andraka highlights one example of the upgrade: in the original engines, he points out, gas passed over the outside of the engine, with pieces of tubes and fittings at either end, requiring a total of approximately 20 parts. "On the new engine, the gas passage is a part of the block with no external parts. It's much more reliable, much cheaper to assemble, with fewer parts and fewer places to leak," Andraka says. The new systems have been running on test sites for more than 100,000 hours [8].

IV. COMPARISON BETWEEN SOLAR STIRLING ENGINE AND OTHER SOLAR DEVICES

1) Advantages over photovoltaic cells

The US residential house uses 120 VAC electricity but solar cells produce direct current (DC) voltage. This means you have to have an inverter to transform the electricity to a usable form for the house. Thesterling engine can produce electricity at 120 VAC directly and also at 60 HZ which means the output can be fed directly into the power grid.Multi-junction photovoltaic cells (III–V), which can Achieve relatively higher energy converting efficiency than commonly used silicon cells, are Usually made with poisonous materials like gallium arsenide (GaAs) or cadmium telluride (CdTe), can cause harm to the environment if leaked [1]. On the other hand solar Stirling engine is ecofriendly.

2) Advantage over towerconcentrating solar power (CSP) technology

Solar Stirling engine has advantage over CSP technology which also captures the sun's heat. Most CSP systems require significant amounts of water, which has proven to be a challenge in desert regions of the U.S. where solar power is most attractive, while Stirling engines require none other than small amounts for cleaning the mirrors [8]. In addition, if one engine goes down, it has minimal impact on overall production.Tower CSP technology, which doesn't generate electricity until the entire system is complete.The solar parabolic trough system doesn't produce fluid temperature as high as solar dish-stirling engine system.

3) Advantage over Solar Thermoelectricity [1]

According to the University of the Pacific, a single thermoelectric module capable of producing 14 watts of electrical power costs approximately $100. Their typical efficiencies are around 5–8%, which is very low as compare to solar Stirling engine. Although its size is smaller than Stirling engine. Material used in concentrator thermoelectric generator (CTEG) like Bismuth telluride which is toxic and expensive.

4) Advantage over heliostat solar tower system

The heliostat solar tower system produces a fluid temperature greater than that of the single axis tracking, parabolic trough and linear Fresnel system, but less than that of the two axis tracking, parabolic dish - Stirling engine system. Thus it cannot achieve an efficiency for conversion of electricity from thermal energy as high as that of the parabolic dish - Stirling engine system [3].

5) Advantage over solar Fresnel solar system

A linear solar Fresnel solar plant doesn't produce a fluid temperature as high as the parabolic trough or parabolic dish solar concentrators, so its thermal efficiency for conversion of solar power to electricity is lower [3].

	Operating temperature(c°)	cost	Plant peak efficiency	production	size
Photovoltaic-cell	~100	medium	14-15%	commercially	smaller
Solar -thermoelectricity	143-150	medium	5-8%	commercially	smaller
solar parabolic trough	350-550	high	14-20%	commercially	larger
heliostat, solar Tower system	250-550	high	23%	Not commercially	larger
linear solar Fresnel system	390	high	18%	commercially	larger
Solar Dish - Stirling Engine	550-750	Not defined	31-32%	Demonstrating model	medium

Comparison of different solar power technologies [6]

REFERENCE

[1]. Yinghao Chu, Research Associate, Global Energy Network Institute (GENI), August2011 charlie0586@address.com

[2]. Thomas R. Mancini, Ph.D., distinguished Member of the Technical Staff, sandia National Laboratories, Albuquerque, NM 87185 USA.

[3]. Dr. Harlan Bengtson, PhD in Chemical Engineering.

[4]. Ö.E. Ataer and H. Karabulut, 'Thermodynamic Analysis of the V-Type Stirling-Cycle Refrigerator', International Journal of Refrigeration, Vol. 28, N°2, pp. 183 – 189, 2005.

[5]. M. Abbas, N. Said and B. Boumeddane
Revue des Energies Renouvelables Vol. 11 N°4 (2008) 503 – 514

[6]. The International Renewable Energy Agency (IRENA), RENEWABLE ENERGY TECHNOLOGIES: COSTANALYSIS SERIES, Concentrating Solar Power, Volume 1: Power Sector Issue 2/5, June 2012

[7]. Mila Luleva, researcher and scientist, January 18, 2013.

[8]. Cynthia Graber, Dec 30, 2009, advertisement in scientific American.

[9]. Tim McGee, Energy / Renewable Energy February 14, 2008

[10]. Martin LaMonica, Staff Writer, CNET News, October 25, 2006.

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