

Design of Alpha Stirling Engine in Conjunction with Solar Concentrator

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Abstract – This paper provides a design approach and thermodynamic analysis of a solar stirling model. Out of the three configurations viz. Alpha, Beta and Gamma an Alpha configuration was chosen because of its ease of fabrication. Parabolic solar concentrator is used to provide heat to the engine. The main objective was to determine how much work can be extracted from a 49cc Stirling Engine. Further the effect of regenerator effectiveness on Stirling cycle efficiency. Variation of expansion volume, compression volume and total volume is also calculated with respect to crank angle variation.

Key Words: Solar Stirling model, Alpha Configuration, Stirling Engine, Parabolic Solar Concentrator, regenerator effectiveness, crank angle, expansion volume, compression volume.

1. INTRODUCTION

Stirling engine is a mechanical device working theoretically on the Stirling cycle, in which compressible fluids, such as air, hydrogen, helium, nitrogen or even vapors, are used as working fluids. The Stirling engine offers possibility for having high efficiency engine with less exhaust emissions in comparison with the internal combustion engine. The earlier Stirling engines were huge and inefficient. However, over a period of time, a number of new Stirling engine models have been developed to improve the deficiencies.

The modern Stirling engine is more efficient than the early engines and can use any high temperature heat source. The Stirling engine is an external combustion engine. Therefore, most sources of heat can power it, including combustion of any combustible material, field waste, rice husk or the like, biomass methane and solar energy. In principle, the Stirling engine is simple in design and construction, and can be operated easily.

Direct solar-powered Stirling engines may be of great interest to countries where solar energy is available in unlimited quantity. To use direct solar energy, a solar concentrator and absorber must be integrated with the engine system.

1.1 Configuration of Stirling Engine

There are mainly three configurations of stirling engine namely, Alpha, Beta and Gamma.

- In the alpha-configuration a displacer is not used. Two pistons, called the hot and cold pistons, are used on either side of the heater, regenerator, and cooler. These pistons move uniformly in the same direction to provide constant-volume heating or cooling processes of the working fluid. When all the working fluid has been transferred into one cylinder, one piston will be fixed and the other piston moves to expand or compress the working fluid. The expansion work is done by the hot piston while the compression work is done by the cold piston.
- In the beta-configuration, a displacer and a power piston are incorporated in the same cylinder. The displacer moves working fluid between the hot space and the cold space of the cylinder through the heater, regenerator, and cooler. The power piston, located at the cold space of the cylinder, compresses the working fluid when the working fluid is in the cold space and expands the working fluid when the working fluid is moved into the hot space.
- The gamma-configuration uses separated cylinders for the displacer and the power pistons, with the power cylinder connected to the displacer cylinder. The displacer moves working fluid between the hot space and the cold space of the displacer cylinder through the heater, regenerator, and cooler. In this configuration, the power piston both compresses and expands the working fluid. The gamma-configuration with double-acting piston arrangement has theoretically the highest possible mechanical efficiency. This configuration also shows good self-pressurization.

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