Investigations into Solar Powered Stirling Engines for Electricity Generation

P. Khoza, P. Naidoo and S.H.Connell
Department of Mechanical Engineering Science
University of Johannesburg
Auckland Park, Johannesburg, RSA
201203250@uj.student.ac.za; naidoop@uj.ac.za, shconnell@uj.ac.za

Abstract

The Stirling engine was an industrial one invention to address the problem of constant explosions of steam engine boilers due to excessive pressures. The Stirling engine converts heat energy to torque. The salient safety feature is based on temperature difference rather than pressure difference of the steam engine. The efficiency of the Stirling engine vests with its geometric and thermodynamic properties such that under ideal conditions, the thermodynamic efficiency equals that of a Carnot cycle. The Stirling engine operates on a closed thermodynamic cycle. The thermodynamics of the system pertains to the working fluids and heat transfers whilst, the geometric design incorporates the configuration, crank mechanism, sizing and layout. The efficiency of the Stirling engine decreases with an increase in cylinder size, thus multiple smaller cylinders systemically connected to a single crank shaft are more efficient than a bigger single cylinder engine. This paper reviews the design of a Stirling engine to be powered by a laboratory concentrated solar energy heat source. The idea emanated from Nasa's 10kW KRUSTY nuclear powered electrical generator that was designed for the Mars expedition.

Keywords
Stirling Engine, Concentrated Solar Energy, , Heat Transfer, Thermodynamics, KRUSTY

Biographies

Penwell Khoza is a Mechanical Engineering Science graduate of the University of Johannesburg. His masters study is based on understanding and defining the boundary conditions for the application of stirling engines for various heat sources. For his dissertation, the emphasis is on experimental investigations using a laboratory concentrated solar dish as heat source for electrical power generation. The typical loads are in the magnitude of 1 to 3 kW; representing ideal capacities for domestic residential customers, remote off grid customers, small commerce, telecommunications repeater stations and agricultural irrigation.

Pathmanathan Naidoo is Professor of Research in the Faculty of Engineering and the Built Environment, University of Johannesburg. He is a Fellow of the South African Academy of Engineers, a Fellow of the South African Institute of Electrical Engineers, a senior member of IEEE and a member of IET and Cigre. He is a registered professional engineer and a specialist consultant in electrical energy and power systems. His current research interests are in Sustainable Development as driven by the Green Economy and Industrial Revolution 4.0. Dr. Naidoo's four decade industrial career was with the Electricity Supply Commission of South Africa; from Engineer in Training to Non-Executive Director.

Simon Connell is Professor of Physics at the University of Johannesburg within the Faculty of Engineering and the Built Environment in the Department of Mechanical Engineering Science. Research interests in Particle Physics, Nuclear Physics, Nuclear Energy, Materials Science, Quantum Physics, High Performance Computing and Applied (innovation) Physics. Rating by the SA Research Funding Agency (NRF) acknowledges "considerable international recognition". He is a past president of the South African Institute of Physics. He is the founding member of the South African participation in High Energy Physics at the ATLAS Experiment at CERN.