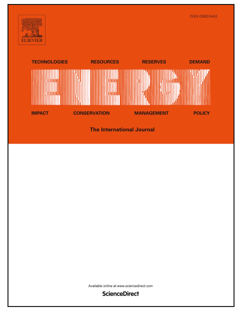
Accepted Manuscript



Design and construction of a two-phase fluid piston engine based on the structure of fluidyne

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PII: S0360-5442(17)30401-2

DOI: 10.1016/j.energy.2017.03.035

Reference: EGY 10502

To appear in: *Energy*

Received Date: 22 March 2016

Revised Date: 16 February 2017

Accepted Date: 8 March 2017

Design and construction of a two-phase fluid piston engine based on the structure of fluidyne

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Abstract

Engines that extract energy from low-grade heat sources, e.g., from other processes, have received considerable attention recently. The use of Fluidyne, which is a liquid piston Stirling engine, is quite popular. Herein, we explore the use of liquid-to-vapor phase change in a Fluidyne. This provides two considerable differentiators; (1) exploitation of very low temperature difference $\Delta T \approx 30$ K, and (2) relatively low temperature $\Delta T \approx 330$K heat sources, for producing mechanical work, and thus electrical energy. The influence of three operating parameters, i.e., input heat flux, working fluid, and filling ratio, on the performance of the engine was characterized. Their optimum values, which yield the best efficiency of the engine, were determined. Increasing the input heat flux led to enhanced energy production. The highest performance was achieved when Acetone was used as the working fluid, attributed to Acetone's lower evaporation temperature, viscosity, and enthalpy of evaporation. A filling ratio of 18% resulted in the highest performance. The efficiency of the engine was compared to Carnot efficiency.

Key words: fluidyne; Stirling engine; slug-plug flow; power generation; phase change.

1. Introduction

Demand for clean energy sources, which do not use fossil fuel combustion, continues to rise. This is largely because of fast depleting fossil fuel reserves, and the environmental impact of fossil fuel combustion. This has motivated research towards utilizing waste heat from various sources in recent years. A large subsection of such studies preface around the utilization of low grade waste heat, i.e., heat at low temperatures, for doing useful work, or to generate energy [1,2]. This is because many of today's industrial processes yield low-grade heat, which is largely wasted. Usage of Organic Rankine Cycle (ORC), thermoelectric systems, Stirling motor, etc., show promising prospects in this area.

The process of the ORC is similar to ordinary Rankine Cycle with a difference of using organic fluids with low boiling temperatures in ORC. This feature enables using the low-quality waste heat as the heat source in the Organic Rankine Cycle. Additionally, they offer higher reliability and fewer maintenance costs [3]. However, the efficiency of ORC is less than expected in real conditions, e.g., about 10% in the evaporator temperature of 160°C.

The Stirling engine, which was devised by Robert Stirling in 1816, was the first machine to extract mechanical energy from a heat source. It found numerous applications, e.g., solar energy, marine, and space mobile vehicles. As the mechanical components in the Stirling Engine were