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The investigation of effects on the engine performance characteristics of different channel geometries in the displacer cylinder for a beta-type Stirling engine with the slider-crank drive mechanism

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Abstract

This study was focused to develop a power generation system that could use renewable energy resources more efficiently. In accordance with this purpose, the design, manufacturing, and testing of a Stirling engine with a β-type slider-crank drive mechanism were carried out. Helium, nitrogen, and air were utilized as working fluids, and experimental studies were performed at various charge pressures. Moreover, the effects of three different channel geometries in the displacer cylinder on the performance were researched. The maximum power was obtained as 160.5 W in a 120-slot channel displacer cylinder in the helium working fluid at a charge pressure of 4 bar and 400 rpm engine speed. The highest torque was found to be 7.92 Nm in a 66-slot channel displacer cylinder in the helium working fluid at the aforementioned charge pressure and 100 rpm engine speed. The lowest engine power output among the maximum engine powers was obtained to be 48.3 W when air was used as a working fluid at a pressure of 4 bar and an engine speed of 200 rpm, using a smooth displacer cylinder. Use of channels in the displacer cylinder and the increased number of channels had positive effects on engine performance. It was determined that the maximum engine power output obtained in the experimental studies was 46.0% and 49.86% higher in the 66-slot channel, and 120-slot channel cylinders, respectively, compared to the smooth displacer cylinder. It has been observed that when the number of channels on the displacer cylinder was increased by approximately 81.8%, an increase of approximately 2.62% was obtained in the engine power output. This situation revealed that optimization of the number of channels is important.

Keywords

Stirling engines, engine design, engine performance, slider crank drive mechanism, kinematic analysis, thermodynamic analysis

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Introduction

Nowadays, a significant part of energy needs is met by fossil fuels.[1–3] As a result of the use of fossil-based fuel types, harmful chemicals such as carbon dioxide, sulfur and nitrogen oxides are released into the atmosphere and the environment we live in.[4] This causes us to face significant problems such as global warming and climate change that will reach global dimensions. Debates about the future of the engines are ongoing with the guess that fossil-based fuels will be consumed in the next 50 years.[5,6] Therefore, extensive studies and researches have been carried out on the development of machines that can use clean, sustainable, and renewable energy sources that can replace fossil fuels and do not depend on fuel type.[7–9]

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