

Design and stress simulation of crankshaft for slider crank-drive Stirling engine

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Abstract. In this present work, the design and simulation of crankshaft for multi-cylinder Stirling engine is studied based on finite element analysis. The proposed crankshaft design is based on the typical crosshead slider-crank mechanism that is being used with the consideration of design needs for multi-cylinder Stirling engine. The study focused on the piston-crankshaft assembly that is subjected to compression load in Stirling cycle. Based on the simulation results, the maximum von Mises stress for crankshaft model varies from 0.82 MPa at 1 bar charge pressure to 1.65 MPa at 20 bar charge pressure. Minimum factor of safety is founded to be 33 with maximum deformation under maximum charge pressure. For piston-crankshaft assembly load, minimum factor safety of 2 was observed with maximum compression pressure for minimum charge pressure. The results indicate no yielding and structural failure under compression load case, can be satisfied.

Introduction

Crankshaft plays an important role as a main moving engine component. The crankshaft transfers the rotary power produced by the engine which will be an input to many devices such as generators, pumps or compressor. In reciprocating engine type, the crankshaft converts the reciprocating displacement of the piston to a rotary motion [1]. For many years, the slider crank-drive has been used in reciprocating engines because it is extremely reliable, with a wealth operating experience.

Stirling engine designs are usually known as either kinematic or free-piston engine [2]. For kinematic Stirling engine, the power piston is mechanically connected to a rotating output shaft (crankshaft) with a connecting rod. This type of mechanism is typically used in slider crank-drive configurations Stirling engine. The slider crank-drive is being used extensively in double acting Stirling engine because of the reliability and ease of construction, although having the disadvantage of being almost impossible to balance [3]. Moreover, this mechanism is widely used in multi-cylinder versions of the basic Stirling engine.

For the present work, the objective is to design a crankshaft for displacer-piston Stirling engine having a slider crank-drive as a driving mechanism. The study was conducted within designing a twin cylinder gamma-type Stirling engine that could potentially being used as energy conversion devices in parabolic Dish/Stirling technologies for Concentrating Solar Thermal (CST) application.

Crankshaft Design

Taking into consideration the design needs for multi-cylinder configuration, the typical crosshead slider-crank mechanism of own design has been used as the driving mechanism. In order to obtain necessary relation of movement of the displacer against the power piston, both crankshafts are interconnected by means of coupling, stated by the constant phase angle, θ . In addition, a counterweight balance has been used to minimize the vibrations. The counterweight provides for the possibility of balancing the reciprocating and rotating forces, since the masses of the displacer assembly and power piston assembly are quite different. The overall proposed design of the crankshaft is shown in Fig. 1. The design was expected to be as simple as possible for ease of

