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Basic dynamical analysis and comparison of balancing systems of non-conventional piston machine FIK

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Abstract

The paper is divided into two main sections. First part deals with description of FIK non-conventional mechanism, main parts and its functionality. Second part deals with measuring system, which is designed to measure dynamic parameters of non-conventional piston mechanism. The concept of measuring system is applied to a special type of piston machine with wobble mechanism, which is used in this instance of Stirling engine type. Analysis compares the three basic states, without balancing mass and with first and second type of balancing mass. Balancing system is determined from the calculation of the dynamic model. Design of balancing system and placement of sensor for acceleration measurement corresponds to the constructional possibilities of prototype model FIK.

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Keywords: Stirling engine; FIK mechanism; Balancing system

1. Introduction

There are several types of mechanisms, which are suitable for use in a Stirling heat engine. Main advantage of crank mechanism is relative design simplicity. Amount of experiences with mathematical modeling and dynamic calculations of crank mechanism allows its optimization on the operating conditions [1]. Stirling engines with non-conventional mechanisms have several advantages in practical applications, but the design of calculation model is often difficult. FIK mechanism (Fig. 1) is a swinging system. Center (center of gravity) of the swinging plate

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creating circular motion during the rotation of the shaft [3]. Bevel gear is used against parallel rotation of swing plate with shaft [1]. Reciprocating movement of the pistons is transformed to the rotational movement of shaft through ball joint segments [2]. This schematic and virtual representation was designed for application in type of a Stirling engine, specifically for alpha configuration [3].

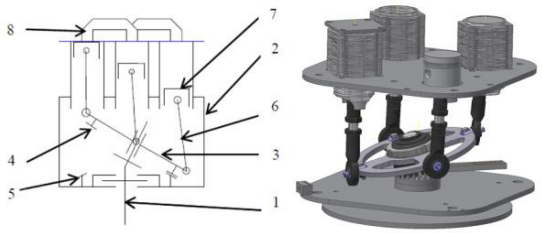

Fig. 1. Mechanism FIK: 1- shaft, 2- crankcase, 3- swinging plate, 4- bevel wheel (part of swinging plate), 5 bevel wheel (part of crankcase), 6- ball joint segment, 7- piston, 8- head cylinder and regenerator pipe

1.1. Basic dimensions for calculation of kinematic a dynamic parameters

Basic dimensions of schematic model are the most important parameters for creating a kinematic model which is described by mathematical equations. Fig. 2 (left) shows some of basic dimensions. Main dimensions, its individual shortcuts and their values are:

- Dv- Distance between opposite cylinders (distance of cylinder axis), Dv= 0.275m,
- D- Bore, D= 0.075m,
- Z- Stroke, Z= 0.069m,
- R- Radius of base rolling cone, R= 0.294m,
- Rko- Distance between angle cranked axis of shaft and center of lower ball joint center, Rko= 0.1346m,
- φ- Angle between main axis and axis of crank shaft part, φ= 15°.

1.2. Dynamic model

On the fig. 2 is a schematic view of engine (left part) and dynamic model with the specified points of the reduced mass. Masses of these specified points are:

- mP- The reduced mass of the piston and connecting rods- 0.6691 kg,
- mAv- The reduced mass of the connecting rods 0.572 kg,
- msw. a cs- The reduced mass of the swinging plate and cranked shaft part-5.73kg.

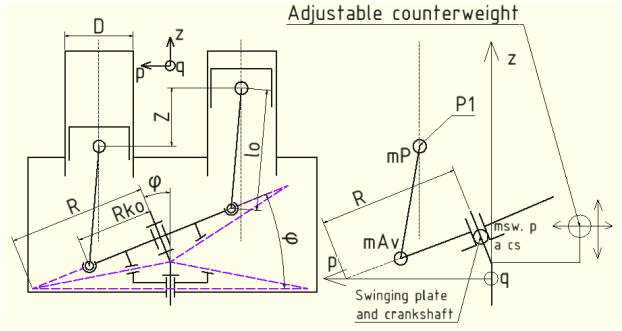

Fig. 2. Dynamic and modified schematic model