SIMULATIONS OF NONCONVETIONAL DESINGNES WITH REGARD TO COMPRESSION ABILITY FOR USE IN STIRLING ENGINE

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Abstract: *This paper deals with comparing three types of non-conventional mechanisms of Stirling engines [1]. It is a wobble yoke mechanism, a special type of wobble yoke mechanism and mechanism with ring. The mechanism with a ring was designed as another possible mechanism for structural design of wobble plate in projekt Nonconventional engine FIK –Stirling [2]. The aim is to compare the relative movement of two consecutive pistons in the Stirling engine system and thus evaluate the course compression that arises in one interconnected system of this engine. The paper deals with the dynamic simulation of these mechanisms. The dynamic simulations were made in Autodesk Inventor sofware.*

Keywords: *WOBBLE YOKE, MECHANISM, SIMULATION, DESIGN*

1. Introduction

There is no need to use only the standard types of mechanisms, such as the Stirling engine in design of heat engines. Non-conventional mechanisms of heat engines replace in some areas of energetics and transport the classic crank mechanisms [3] [4]. Indisputable advantage of crank mechanism is its relative design simplicity. Amount of experiences with mathematical modeling and dynamic calculations of crank mechanism allows its optimization on the operating conditions [5]. Engines with non-conventional mechanisms may have several advantages when used in practice, but the design calculation model is often more difficult. Mechanisms of transforming linear reciprocating motion to rotary motion can be investigated in several aspects. These aspects are the suitability of the mechanism for given type of heat engine, advantage in terms of designsize and location of individual components, etc.

In the power engineering industry, these unconventional mechanisms displace or completely replace the traditional conventional mechanisms.

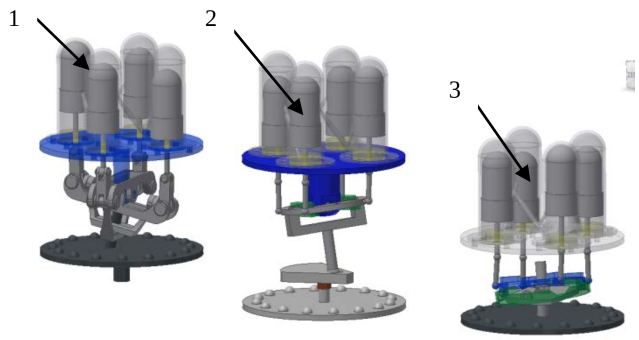

Fig.1 *Virtual models of the nonconventional designs: 1-Whispergen- wobble yoke, 2-wobble yoke, 3- mechanism with ring*

2. Description of the compared mechanisms

Models have been proposed for the design of Stirling engine with a double-acting piston. In the design of each compared types of mechanisms were specified the initial conditions. The models have the same strokes, the same length of connecting rods or ball joint segments (used in a mechanism with ring, and a wobble yoke), because the task was to compare the relative motion of the pistons one interconnected part and to show course of the these strokes per time unit. The initial conditions were determined with a view to achieving comparable graphically results.

Wobble yoke system:

The mechanism (details Fig.2,Fig.3) is designed so that the wobble plate 4 is allowed to circulate through the universal joint 7. The cross is attached to the fixed part 3 and the wobbleboard 4. Transformation of energy is further mediated through a ball joint 5 which is eccentrically attached to the output shaft.

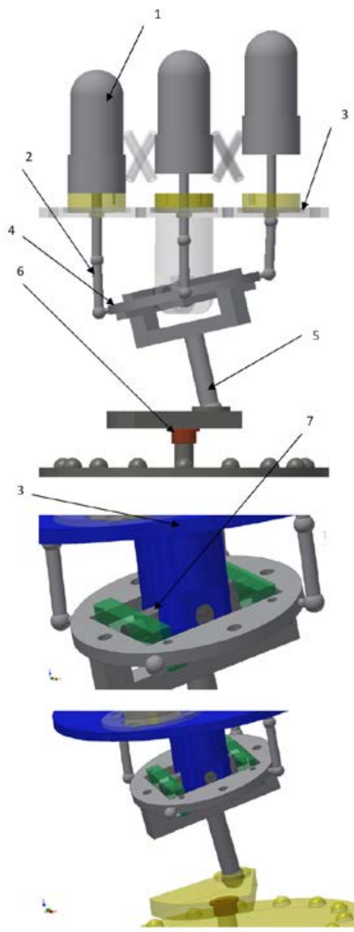

Fig.2 *Model of wobble yoke: (general view- up, details of wobble board mechanism- down): 1- piston, 2- ball joint segment,3- handle cylinders (fixed part), 4-wobble board, 5- shaft with ball joint, 6-bearing flywheel (fixed part), 7-cross joint*

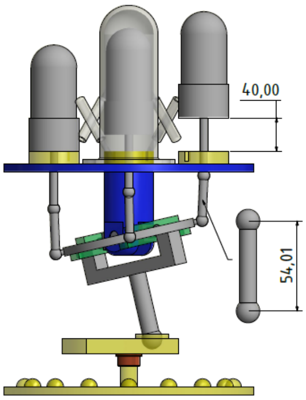

Fig.3 *Model of wobble yoke mechanism- stroke and length of ball joint segment*

Whispergen system:

This system (Fig.4,Fig.5) is designed so that each pair of opposite piston 1 is attached to its own joint mechanism (this is a universal joints 5), thus the whole mechanism is a double universal joint. Joint pins are attached to the fixed part 2 and the swinging arm 6. Transformation of the rocking motion to rotary motion is provided by swing arms (Fig. 4 position 6)fixed to the connecting segment (Fig. 4 position 7 and 8). Reciprocating motion of the pistons is transmitted through the connecting rods 3 and universal joints on the eccentric shaft which is fixed component part of the output shaft 4.

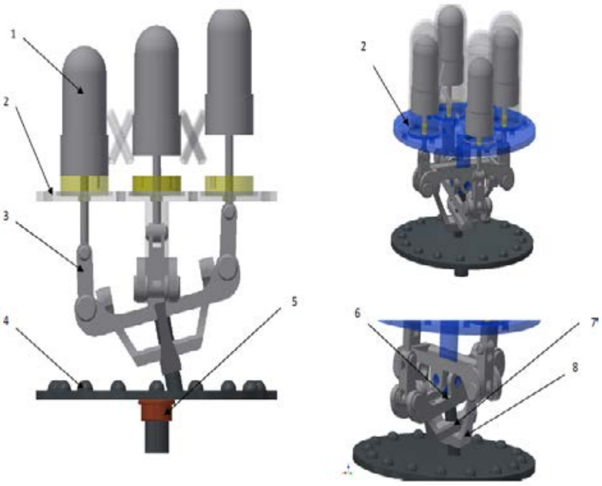

Fig.4 *Model of whispergen wobble yoke mechanism: (general view-right side, details of wobble board mechanism-left side): 1- piston, 2- handle cylinders (fixed part),3- rod, 4- shaft with flywheel, 5- bearing flywheel (fixed part), 6- swing arm,7- upper connecting segment, 8- lower connecting segment*

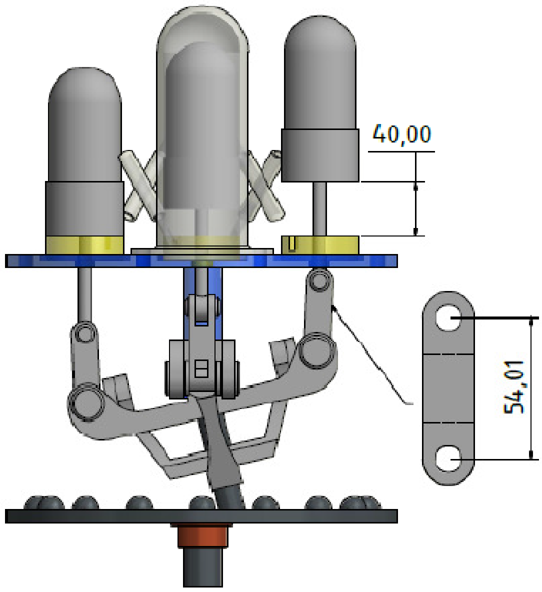

Fig.5*Virtual model of wobble yoke-whispergen mechanism- stroke and length of rod*

Mechanism with ring:

This mechanism was designed as another possibility in case the mechanism of floating plate. In that case serves against concurrent rotational movement of a wobble board 3 along with crankshaft ring 4 (shown in green), the axis of the pins must intersect point (intersection of the axes) crankshaft. Ring pins are fixed to the fixed plate 6 and on the wobbling plate 2, thereby allowing the board to perform a rocking motion, which is transformed into rotary motion by means of a cranked shaft 5.

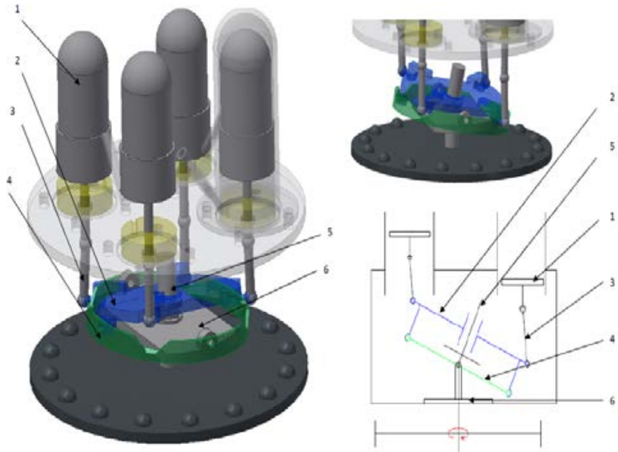

Fig. 6 *Design of mechanism with ring (general view right side, details of mechanism and scheme- left side): 1-piston, 2-wobble plate, 3- ball joint segment, 4- ring, 5- shaft, 6-fixed plate*

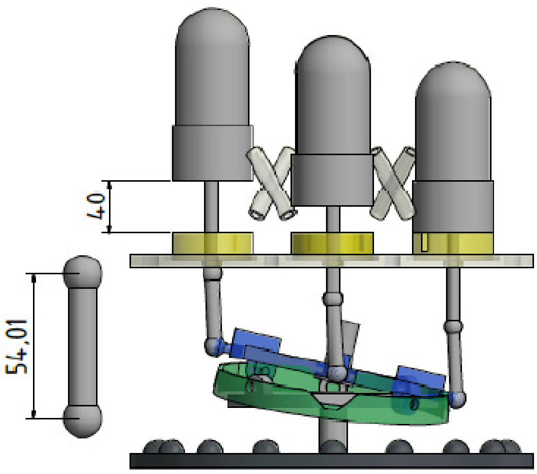

Fig.7 Virtual model of mechanism with ring- stroke and length of ball joint segment

Virtual models used in the simulations were simplified, but these models are sufficient to evaluate the desired issue. Dimensional images with parameters such as the length of piston stroke and connecting rod, ball joint etc. were generated using the CAD software.

3 Results

The simulations were made in Autodesk Inventor. Simulations were set for one revolution. It means that the graphs show the course for one working cycle of one pair of pistons. The relative movement of the pistonswas compared.

Setting of dynamic simulationparameters:

- angular velocity of the shaft 10 deg.sec^{-1}

- simulation time- 36 sec

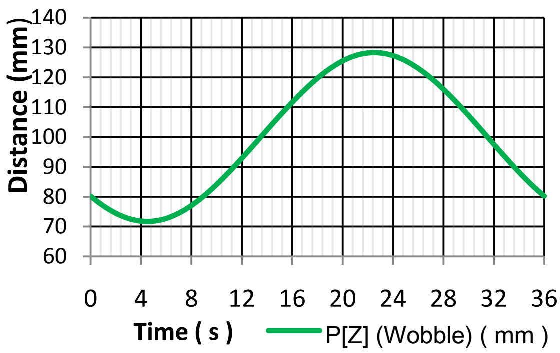

Fig.8 Course of the relative movement - Wobble yoke system

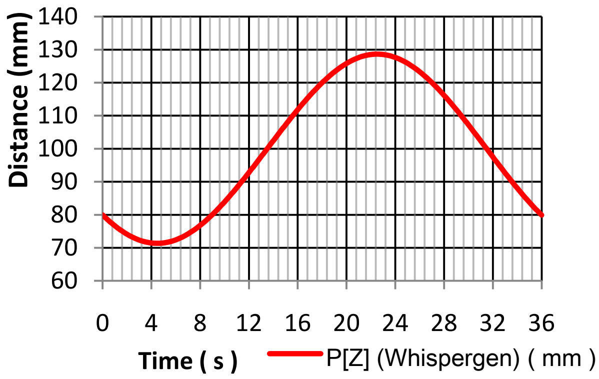

Fig.9 Course of the relative movement- Whispergen system

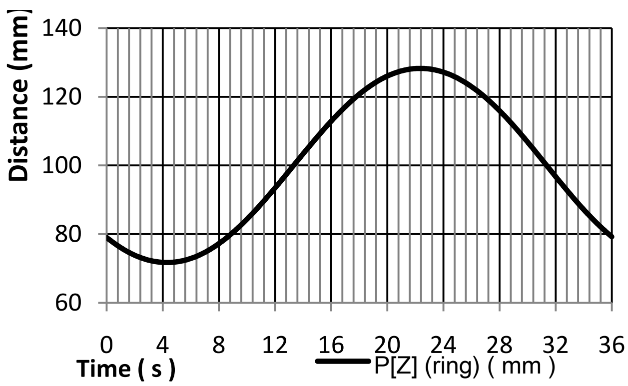

Fig. 10 Representation during the relative movement - Mechanism with ring

4 Conclusion

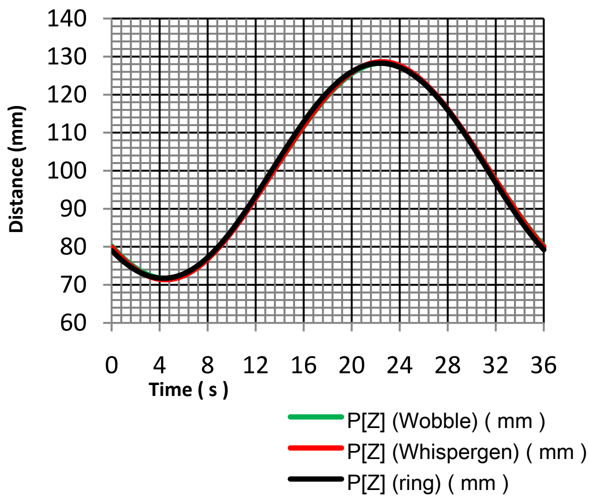

Fig.11 The comparison of relative movement courses

The resulting graphs were imported from Autodesk Inventor to Microsoft Excel. Fig. 11 shows the course of all three types of engines. It can be seen only small deviations in courses of compression, transfer and expansion stroke. Models of wobble yoke and whispergen-wobble yoke have the same course. The mechanism with ring slightly deviates from them. From this comparison it can be said that the model with ring, which has been constructed so far only in virtual form, is suitable as an unconventional mechanism for Stirling engine design. Since the deviations of the piston movement courses are negligible, we can conclude that all three types of monitored models are in terms of heat transfer, respectively thermodynamics equivalent.

5 Literature

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