INERTIA DRIVEN REDUCED DOE MECHANISM FOR AEOLIAN PUMPS

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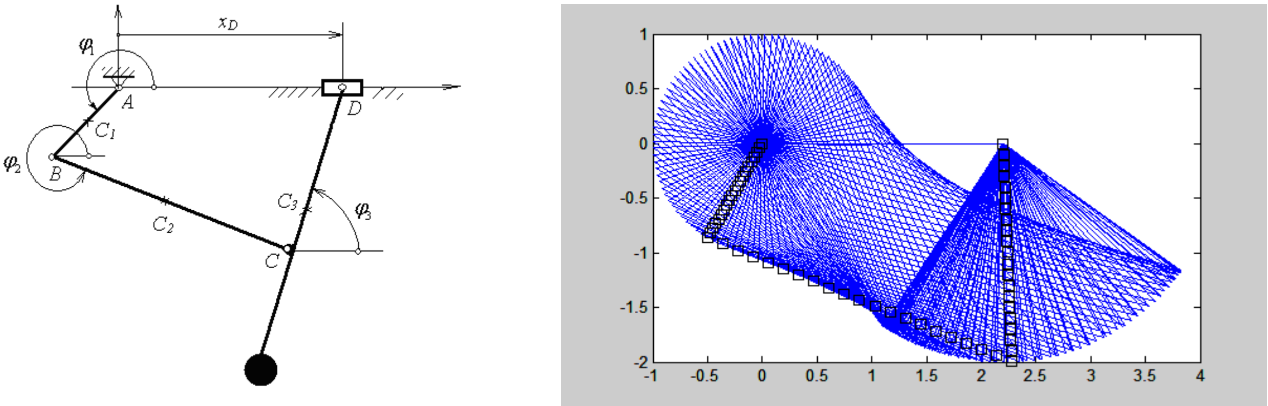
Abstract The herein paper aims to present the layout of a two degree of freedom mechanism that can be used for a wind driven pump. It will be shown that, despite of the reduced number of freedom degrees, this mechanism can perform a quasi-periodic motion. A kinematical approach will aid the motion analysis with respect to the reference coordinate system. The associated equations of motion will be analyzed, both qualitative and quantitative, to prove the quasi-periodicity of motion. The mechanism depicted herein is characterized as having a motion strongly influenced by the inertia of its elements.

INTRODUCTION

Technical literature is abundant with many referential that can be use to prove that a mechanism like the one approached herein can be used in the architecture of the wind driven pump, the control of the motion being achieved by the inertia of its elements[1]. The main focus is to achieve a periodical and controlled motion of the piston D as a result of the crank AB rotation. If the rotation of the later is quasi uniform it is presumed to get it in the form of quasi periodic movement. In the herein paper were established a set of values for the mass and lengths of the mechanism elements with the purpose to achieve a stable motion of the piston.

DYNAMIC ANALYSIS

The configuration of the investigated mechanism has two degree of freedom. We choose this number for the degree of freedom and assigned to the rotation angle of the crank AB, φ_1, and the horizontal displacement of the piston, x_D, respectively.



a) b)

Figure 1 Mechanism and its associated motion: a) kinematic representation, b) working space

Imposing the kinematical condition for the whole mechanism and writing the motion equations using the Lagrange equation or other methods (see [3],[4]) one can finally obtain the nonlinear equations of motion under the form [2]:

$$\begin{bmatrix} \{A_1\}^T[m]\{A_1\} & \{A_1\}^T[m]\{A_2\} \\ \{A_2\}^T[m]\{A_1\} & \{A_2\}^T[m]\{A_2\} \end{bmatrix} \begin{Bmatrix} l_1\varepsilon_1 \\ \ddot{x}_D \end{Bmatrix} + \begin{bmatrix} \{A_1\}^T[m]\{B_3\} \\ \{A_2\}^T[m]\{B_3\} \end{bmatrix} \begin{Bmatrix} (l_1\omega_1)^2 \\ (l_1\omega_1\dot{x}_D) \\ (\dot{x}_D)^2 \end{Bmatrix} = \begin{bmatrix} \{A_1\}^T\{Q\} \\ \{A_2\}^T\{Q\} \end{bmatrix}$$

From an engineering point of view the ideal situation is to have a rotation of the crank that determines a quasi-periodic motion of the piston D. In this case the device (e.g.aeolian pump) can accomplish its job. Due to the reduced number of DOE (i.e. degree of freedom) the overall motion becomes unstable. In Fig. 2 is being presented the plots associated with the unstable motion obtained by setting arbitrary values for the mechanism elements' mass and length.

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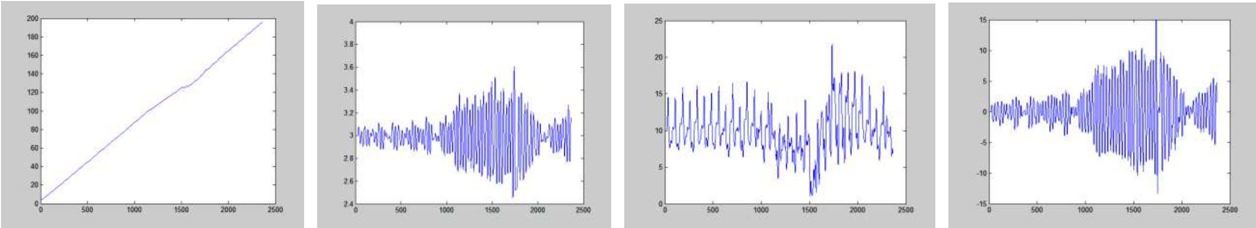


Angle φ_1 Piston displacement x_D Angular speed $\dot{\varphi}$ Piston velocity $\dot{x}_D$

Figure 2 Kinematic parameters and their variation due to the chaotic motion

DETERMINATION OF THE MASSES AND DIMENSIONS OF THE MECHANISM

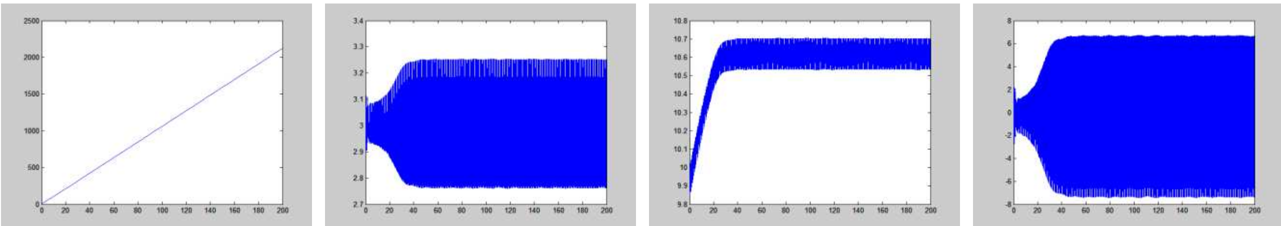
In order to obtain a stable motion we impose an average value to the angular speed over a rotation of the crank and a period p of the piston oscillation:

$$\varphi_1 = \omega t; \quad \omega_1 = \omega; \quad \varepsilon_1 = 0; \quad \dot{x}_D = A\sin pt .$$

If we make an average of the motion equations over a rotation of the crank AB, with the imposed condition we can obtain a set of values of masses and lengths of the mechanism that can allow the appearance of a stable motion (some of the masses and lengths must be choose from engineering reason).

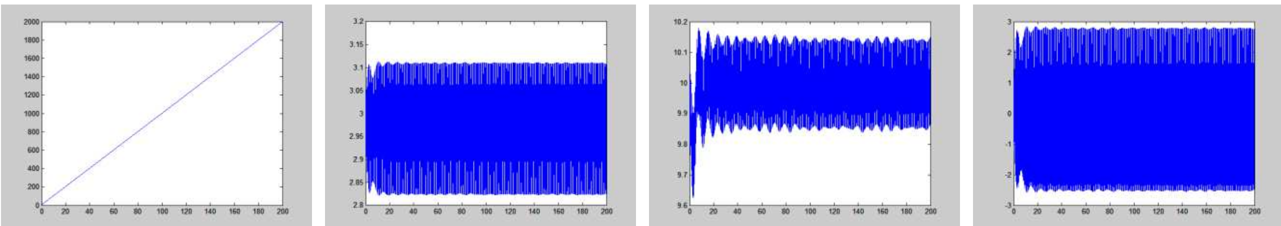
RESULTS AND CONCLUSIONS

In Figure 3 and Figure 4 a representation of the mechanism motion parameters have been made using values retrieved analytically considering two different imposed initial conditions (e.g. different values for the initial angular velocity, piston displacement and velocity of piston). The plotting reveals the assumptions made previously, namely the fact that the motion is quasi-stable and the proposed mechanism can accomplish the role of usefulness within a wind driven device.



Angle φ_1 Piston displacement x_D Angular speed $\dot{\varphi}$ Piston velocity $\dot{x}_D$

Figure 3 Case A of initial conditions



Angle φ_1 Piston displacement x_D Angular speed $\dot{\varphi}$ Piston velocity $\dot{x}_D$

Figure 4 Case B of initial conditions

Aknowledgment.

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