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On the Dynamic Behavior of a Quadrilateral Mechanism

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Abstract

In the paper some results concerning the dynamic behavior of a quadrilateral mechanism are presented. The structure of the mechanism is modeled using the Inventor software. Also, Inventor software is used for analyzing the dynamics of the mechanism. Some interesting simulation results regarding the variation on a cinematic cycle of the equilibrium moment are presented. Also, the Von Mises stress distributions on the component links have been determined.

Key words: *quadrilateral mechanism, dynamics, Von Mises stress*

Introduction

An optimum design of the mechanisms required a more accurate assessment of the dynamic behavior under different types of loads. Today the design and the analysis of the dynamic behavior of the mechanisms which are parts of different devices and machines can be realized using performance computer programs such as: Inventor, Catia, SolidWorks, Solid Edge etc. Using these computer programs virtual prototypes of the mechanisms are designed and then precisely verified. A rigorous analysis of the running behavior of these mechanisms is obtained.

In this paper a quadrilateral mechanism is designed and dynamically analyzed using Inventor software. Some interesting simulation results regarding the variation on a cinematic cycle of the equilibrium moment are presented. Also, the Von Mises stress distributions on the component links have been determined.

Theoretical Considerations and Simulation Results

In figure 1 the cinematic scheme of a quadrilateral mechanism is presented. The following elements are considered to be known:

- the dimensions of the component links: *OA*=0.11 m; *AB*=0.3 m; *BC*=0.25 m; *OC*=0.4 m. The mass centers: C_1, C_2, C_3 are on the middle of the corresponding links.
- the mass of the component links: $m_1 = 0.476$ kg; $m_2 = 1.222$ kg; $m_3 = 1.026$ kg. The component links are made of steel.

- the moments of inertia of the links: $I_{C_1} = 8.725 \cdot 10^{-4}$ kgm^2; $I_{C_2} = 0.011$ kgm^2; $I_{C_3} = 0.006$ kgm^2.
- the technological moment: $M_{ru} = 150$ Nm.
- the nominal angular speed of the leader link of the mechanism: $\omega_1 = 2\pi$ rad/s.

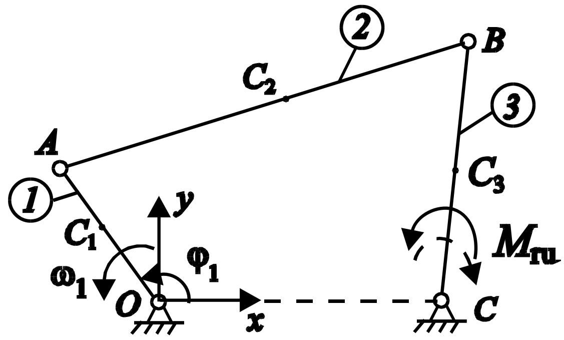

Fig. 1. Quadrilateral mechanism

The component links of the mechanism have been designed using Inventor software. The mechanism is presented in figure 2. The *Dynamic Simulation* module which is part of Inventor has been used for the cinematic and dynamic analysis of the mechanism.

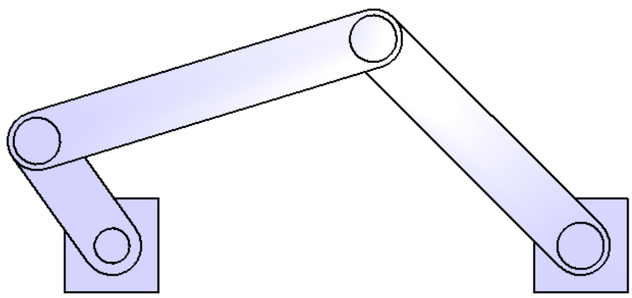

Fig. 2. Quadrilateral mechanism designed with Inventor software

In figure 3 (the curve 1) the variation of the equilibrium moment M_e on a cinematic cycle, obtained with the *Dynamic Simulation* module, is presented.

This result has been verified using a computer program that simulates the quadrilateral mechanism functioning [2]. In this case, the angular and linear speeds and accelerations distributions have been determined by deriving with time the variation functions of the corresponding position parameters [2]. Then, the variation of the equilibrium moment M_e [3] has been obtained using the relation:

$$\overline{M}_e \cdot \overline{\omega}_1 + \sum_{j=1}^{3} \overline{G}_j \cdot \overline{v}_j + \sum_{j=1}^{3} \left(\overline{F}_{ij} \cdot \overline{v}_j + \overline{M}_{ij} \cdot \overline{\omega}_j \right) + \overline{M}_{ru} \cdot \overline{\omega}_3 = 0 \qquad (1)$$

where: $\overline{M}_e$ is the equilibrium moment, $\overline{G}_j, j = \overline{1,3}$, are the weight forces corresponding to the component links, $\overline{F}_{ij}$ and $\overline{M}_{ij}$ are the resultant inertia force and the resultant inertia moment corresponding to the j link, $\overline{v}_j$ is the speed of the mass centre of the j link, $\overline{\omega}_j$ is the angular speed of the j link.

The variation of the equilibrium moment M_e on a cinematic cycle obtained in this case is presented in figure 3 (the curve 2).

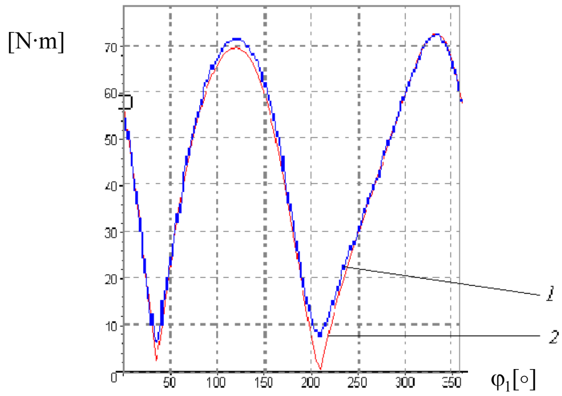

Fig. 3. The variation of the equilibrium moment

The *Dynamic Simulation* and *Stress Analysis* modules of Inventor software have been used to determine the von Mises stress distributions on the component links. By analyzing the stress distributions for different positions of the quadrilateral mechanism, it has been established that the position corresponding to: $\varphi_1 = 180^\circ$ is the most dangerous. In figures 4, 5 and 6 the von Mises stress distributions on the links *1, 2* and *3* respectively, when $\varphi_1 = 180^\circ$, are represented.

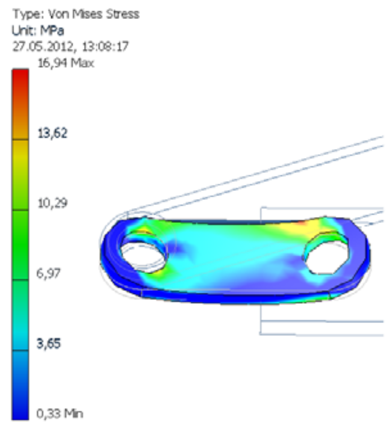

Fig. 4. Von Mises stress distribution on the link *1*

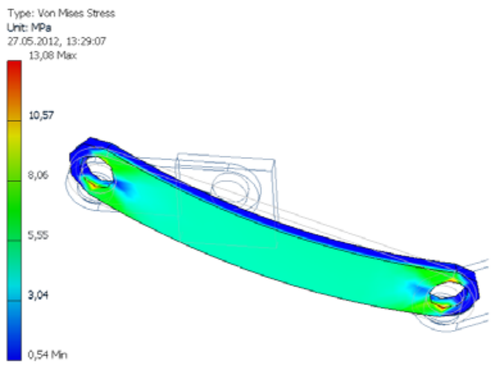

Fig. 5. Von Mises stress distribution on the link *2*

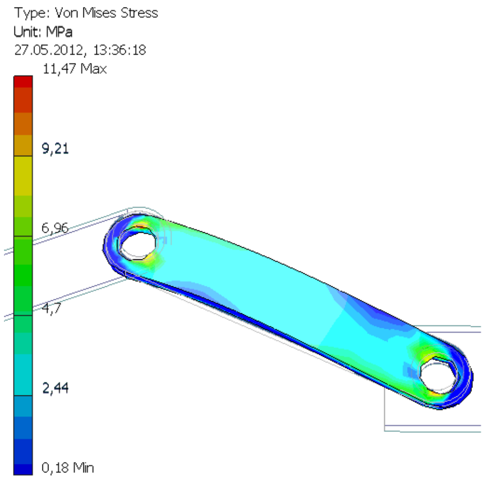

Fig. 6. Von Mises stress distribution on the link *3*

Conclusions

In this paper some results concerning the dynamic behavior of a quadrilateral mechanism are presented. The analysis has been realized using Inventor software. Some results have been verified using a computer program that simulates the mechanism functioning. Von Mises stress distributions on the component links have been analyzed and the stress distributions for the most dangerous position of the mechanism have been represented.

References

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Asupra comportării dinamice a unui mecanism patrulater

Rezumat

In articol sunt prezentate o serie de rezultate privind comportarea dinamică a unui mecanism patrulater. Structura mecanismului este modelată folosind softul Inventor. De asemenea, Inventorul este folosit pentru analiza dinamică a mecanismului. Sunt prezentate câteva rezultate interesante privind variaţia pe un ciclu cinematic a momentului de echilibrare. De asemenea, au fost determinate distribuţiile de tensiuni Von Mises pe elementele componente ale mecanismului.