SINGULAR CASES OF PARALLEL ROBOT

Lubomír Houfek, Lukáš Březina*

The singular cases of mechanisms have been defined as those positions of a mechanism where it loses its unambiguousness. Those positions are characterized with abrupt changes of kinematic magnitudes, which then manifest as complications during the mechanism control.

Key words: *singularity, parallel robots*

1. Introduction

The singular cases have been defined as those positions in the working place, where the system loses the univocal solution. Their occurrence in the working site results in violent changes of speeds, abrupt changes of acceleration and, therefore, in correlated problems as for the system kinematics and dynamics. These problems then reflect in a problematic control of such a mechanism. Therefore great effort has been put in designing the mechanism in a way preventing it from singular cases arising in its working environment or, at least, in minimizing their occurrence.

In the paper we have tried to apply the solution of singularities with the help of the Jacobi's matrix to a simple 3D model with shifting linkages and 6 degrees of freedom.

2. Mathematic model

Let's have a mechanism with n-degrees of freedom and let's describe it as $\boldsymbol{\varphi} = [\varphi_1, \varphi_2, \ldots, \varphi_n]^{\mathrm{T}}$ vector of turning and as $\mathbf{x} = [x_1, x_2, \ldots, x_n]^{\mathrm{T}}$ vector of shifts including both the position and the working member orientation, too. These coordinates may be bound with equations of geometric linkage into the following form

$$\mathbf{f}(\mathbf{x}, \boldsymbol{\varphi}) = \mathbf{0} \; . \tag{1}$$

The speeds of the working mechanism member may then be got from the equation (1) with the help of derivative. In general it applies that:

$$\mathbf{C}(\mathbf{x}, \boldsymbol{\varphi})\, \dot{\mathbf{x}} + \mathbf{D}(\mathbf{x}, \boldsymbol{\varphi})\, \dot{\boldsymbol{\varphi}} = \mathbf{0} \tag{2}$$

and for the acceleration:

$$\dot{\mathbf{C}}(\mathbf{x}, \boldsymbol{\varphi})\, \dot{\mathbf{x}} + \mathbf{C}(\mathbf{x}, \boldsymbol{\varphi})\, \ddot{\mathbf{x}} + \dot{\mathbf{D}}(\mathbf{x}, \boldsymbol{\varphi})\, \dot{\boldsymbol{\varphi}} + \mathbf{D}(\mathbf{x}, \boldsymbol{\varphi})\, \ddot{\boldsymbol{\varphi}} = \mathbf{0} \; , \tag{3}$$

where $\mathbf{C}(\mathbf{x}, \boldsymbol{\varphi})$ and $\mathbf{D}(\mathbf{x}, \boldsymbol{\varphi})$ are the Jacobi's matrices. Equations (1) to (3) represent the kinematic model of the system. From the equation (2) it is possible to distinguish three

* Ing. L. Houfek, PhD., L. Březina, Institute of Mechanics of Solids, Mechatronic and Biomechanics, Faculty of Mechanical Engineering, Brno University of Technology, Technická 2896/2, 616 69 Brno