THE PRESENCE OF VELOCITY DISCONTINUITIES IN NANOINDENTATION TESTS

Severin Traian Lucian [1], Ciornei Florina Carmen [1], Baesu Marius[1], Alaci Stelian [1] , Românu Ionuţ Cristian [1]

[1] *Faculty of Mechanical Engineering, Mechatronics and Management, "Stefan cel Mare" University of Suceava,[1]alaci@fim.usv.ro*

Abstract: *Analysing the data obtained from a nanoidentation, it becomes apparent that, contrary to the predictions of theoretical models existent in the scientific literature, according to which during the whole test, the penetration speed of the punch must have a continuous variation, the time variation plot of depth penetration presents an angular point, when reaching the maximum depth. The penetration speed of the punch was determined confirming the presence of the velocity jumps. The speed of the punch was interpolated with parabolic arcs accurately determining the value of velocity jump. For a case of bearing steel, the value of the jump is about six times the total variation from the unloading phase.*

Keywords: *contact, nanoindentation, hysteresis loop*, *velocity jump*

1. Introduction

Multibody system dynamics is a new subject that deals with the behaviour of a dynamic system as a whole. In the scientific literature there are many references dedicated to this subject, as example [1]- [3]

As a principle, the method involves writing dynamic equations representative for the motion of each element of the system, after which, these equations are grouped into a global differential matrix equation.

Lankarani [4] presents the dynamic equations for characterizing the motion of a dynamical system in the form of

$$\begin{aligned} \boldsymbol{h} &= \boldsymbol{M}\dot{\boldsymbol{q}} - \Phi_q^T \sigma \\ \dot{\boldsymbol{h}} &= \boldsymbol{g} - \dot{\Phi}_q^T \sigma \end{aligned} \tag{1}$$

In the relation 1, h is the vector of the generalized momenta, M is the system's mass matrix, in which the mass and the inertia proprieties of the system's components are placed, g is the vector of applied forces and moments and σ is a vector which contains all of m Lagrange's multipliers associated with the momenta of constraints. The links which exist between the generalized coordinates q are contained in the Φ matrix, the matrix constraints:

$$\Phi(\boldsymbol{q}) = 0 \tag{2}$$

By differentiating twice with respect to time, Eq. 2, generalized accelerations are obtained:

$$\ddot{\Phi} = \Phi_q \ddot{\boldsymbol{q}} + \left(\Phi_q \dot{\boldsymbol{q}}\right)_q \dot{\boldsymbol{q}} = \boldsymbol{0} \tag{3}$$

The matrix $\Phi_{\boldsymbol{q}} = \partial \Phi / \partial \boldsymbol{q}$ represents the Jacobian matrix.

In a dynamic systems modelling, determining the constraints matrix is an essential condition for obtaining correct results.

A particular type of constraints is represented by the sudden constraints, characterized by quickly variations of cinematic parameters of the system. The sudden variation of cinematic parameters leads to developing forces of considerable