NUMERICAL SIMULATIONS FOR THE CASE OF RIGID ROTATING KINEMATIC COUPLING WITH BIG CLEARANCE

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Abstract: *In this paper an algorithm based on [1] [2] are numerical simulations, achieving generalized coordinates of motion, positions, speeds of a rigid rotating kinematic coupling with big clearance in joint, case without friction*

Keywords: algorithms, energy, angular velocities.

1.Numerical application

Based on algorithms developed in [1] and [2] will be solved for a revolute motion rectangular table with $m = 15\,kg$ (fig. 1) and dimentions $b = 0.4\,m; h = 0.6\,m$ with big clearance joint $r = 2\,mm; 2L = 10\,mm$, wherea the moment $M = -80\,N \cdot m$, moments of inertia are $J_x = \frac{mh^2}{12} = 0.45\,kg \cdot m^2$; $J_z = \frac{mb^2}{3} = 0.8\,kg \cdot m^2$; $J_y = J_x + J_z$

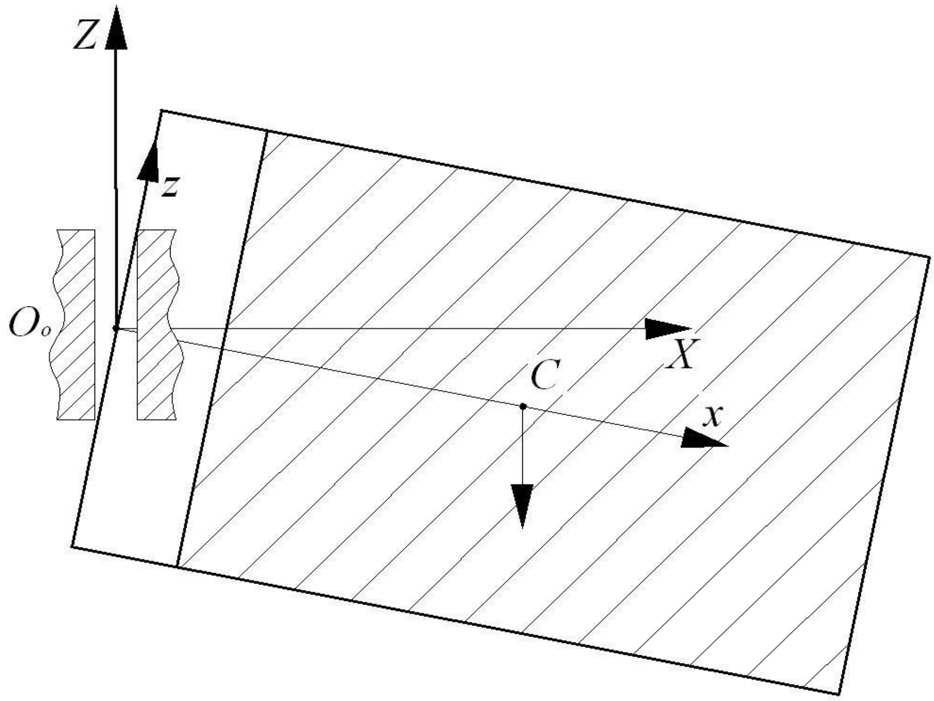


Fig.1

Potential energy given weight mg is

$$V = mg \cdot Z_C \cdot \frac{b}{2} \cos\theta \cdot \sin\varphi \tag{1}$$

and so the components are generalized forces,

$$Q'_\theta = -\frac{\partial V}{\partial \theta} = -mg \cdot \frac{b}{2} \cos\theta \cdot \sin\varphi ; Q'_\varphi = -\frac{\partial V}{\partial \varphi} = -mg \cdot \frac{b}{2} \sin\theta \cdot \cos\varphi \tag{2}$$

The moments are:

$$\begin{bmatrix} M_x \\ M_y \\ M_z \end{bmatrix} = [R]^T \begin{bmatrix} 0 \\ 0 \\ M \end{bmatrix} = M \cdot \begin{bmatrix} \sin\theta\sin\varphi \\ \sin\theta\cos\varphi \\ 0 \end{bmatrix} \quad (3)$$

components of generalized forces given the moment M is

$$Q_\psi^{''} = M_x \frac{\partial\omega_x}{\partial\dot\psi} + M_y \frac{\partial\omega_y}{\partial\dot\psi} + M_z \frac{\partial\omega_z}{\partial\dot\psi}$$
$$Q_\theta^{''} = M_x \frac{\partial\omega_x}{\partial\dot\theta} + M_y \frac{\partial\omega_y}{\partial\dot\theta} + M_z \frac{\partial\omega_z}{\partial\dot\theta} \quad (4)$$
$$Q_\varphi^{''} = M_x \frac{\partial\omega_x}{\partial\dot\varphi} + M_y \frac{\partial\omega_y}{\partial\dot\varphi} + M_z \frac{\partial\omega_z}{\partial\dot\varphi}$$

Into account expressions

$$\omega_x = \dot\psi\sin\theta\sin\varphi + \dot\theta\cos\varphi;\ \omega_y = \dot\psi\sin\theta\cos\varphi - \dot\theta\sin\varphi;\ \omega_z = \dot\psi\cos\theta + \dot\varphi \quad (5)$$

can writer:

$$Q_\psi^{''} = M\ ;\ Q_\theta^{''} = 0\ ;\ Q_\varphi^{''} = M\cos\theta \quad (6)$$

and obtain expressions for generalized forces total

$$Q_\psi = Q_\psi^{'} + Q_\psi^{''} = M$$
$$Q_\theta = Q_\theta^{'} + Q_\theta^{''} = -mg\frac{b}{2}\cos\theta\sin\varphi \quad (7)$$
$$Q_\varphi = Q_\varphi^{'} + Q_\varphi^{''} = -mg\frac{b}{2}\sin\theta\cos\varphi + M\cos\theta$$

a). If the point O is fixed

If the point O is fixed then $\theta = ct. = arctg\frac{r}{L}$ and obtain the equations of motion

$$\begin{bmatrix} J_x\sin^2\theta\sin^2\varphi + J_y\sin^2\theta\cos^2\varphi + J_z\cos^2\theta & J_z\cos\theta \\ J_z\cos\theta & J_z \end{bmatrix} \cdot \begin{bmatrix} \ddot\psi \\ \ddot\theta \end{bmatrix} +$$
$$+(J_x - J_y)\cdot \begin{bmatrix} \dot\psi\dot\varphi \\ -\frac{1}{2}\dot\psi^2 \end{bmatrix} \cdot \sin^2\theta\sin 2\varphi = \begin{bmatrix} M \\ M\cos\theta - \frac{m\cdot b\cdot g}{2}\sin\theta\cos\varphi \end{bmatrix} \quad (8)$$

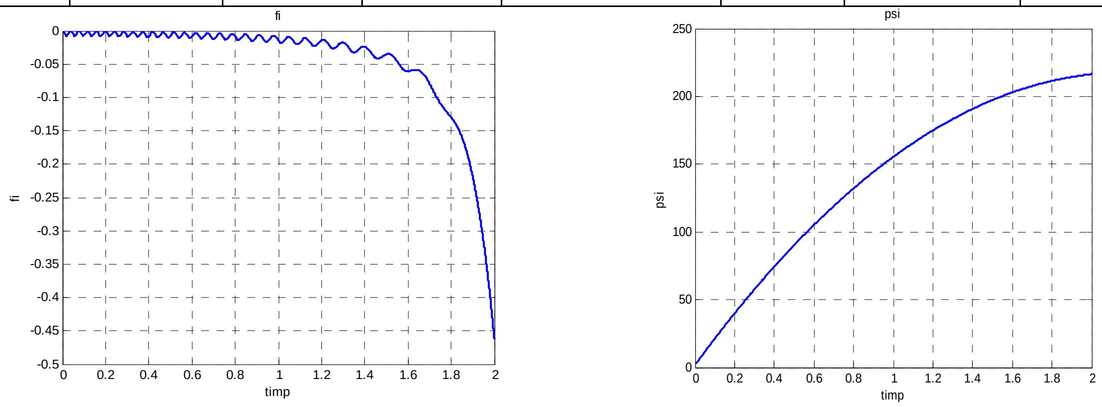
The initial conditions

$$t=0;\psi=\frac{\pi}{2};\varphi=0;\dot\psi=200 rad/s;\dot\varphi=0 \quad (9)$$

and using the calculation of annexes are obtained table 1 and diagrams of variation of parameters φ, ψ from fig. 2 a), b) and angular velocities $\dot\varphi, \dot\psi$ from fig. 3 a), b) so.

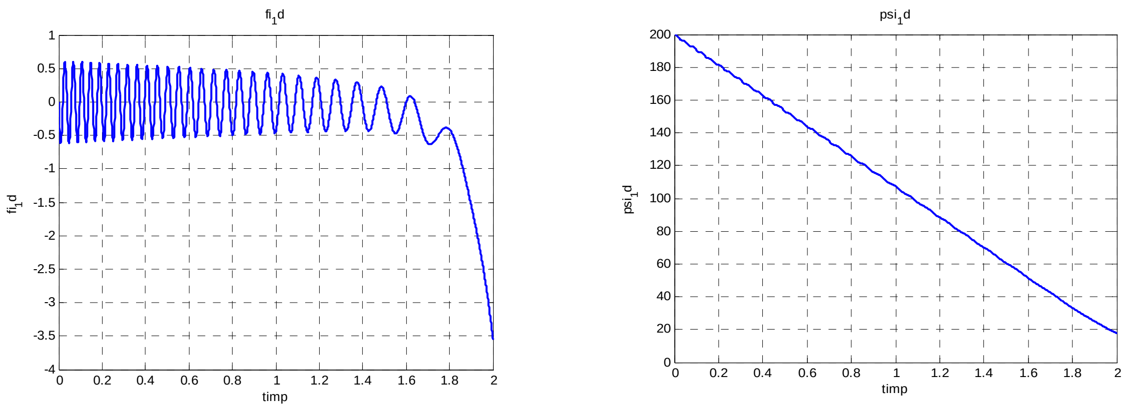
Tab.1.

t	$\ddot{\psi}$	$\ddot{\varphi}$	ψ	φ	$\dot{\psi}$	$\dot{\varphi}$	z_c
0	-5.14	-101.74	1.5708	0	200	0	0
0.001	-6.3449	-100.34	1.7708	-5.0752e-005	199.99	-0.10127	-3.7698e-006
0.002	-9.921	-96.187	1.9708	-0.00020161	199.99	-0.19977	-1.4975e-005
0.003	-15.761	-89.403	2.1708	-0.00044839	199.97	-0.2928	-3.3305e-005
0.004	-23.701	-80.179	2.3707	-0.00078442	199.95	-0.37778	-5.8265e-005
0.005	-33.516	-68.773	2.5707	-0.0012005	199.93	-0.4524	-8.9174e-005
0.006	-44.93	-55.506	2.7706	-0.0016853	199.89	-0.5147	-0.00012518
0.007	-57.628	-40.746	2.9704	-0.0022254	199.84	-0.56301	-0.0001653
0.008	-71.257	-24.903	3.1702	-0.0028061	199.77	-0.59593	-0.00020843
0.009	-85.448	-8.4085	3.37	-0.0034116	199.69	-0.61256	-0.00025341
0.01	-99.814	8.2868	3.5696	-0.0040257	199.6	-0.61256	-0.00029902
0.011	-113.97	24.731	3.7692	-0.0046317	199.49	-0.59604	-0.00034403
0.012	-127.53	40.476	3.9686	-0.0052131	199.37	-0.56344	-0.00038722
0.013	-140.11	55.08	4.1679	-0.0057538	199.24	-0.51558	-0.00042738
0.014	-151.38	68.151	4.3671	-0.0062392	199.09	-0.45378	-0.00046343
0.015	-161.04	79.348	4.5661	-0.0066566	198.94	-0.37977	-0.00049444
0.016	-168.85	88.387	4.765	-0.0069954	198.77	-0.29569	-0.0005196
0.017	-174.61	95.032	4.9636	-0.0072467	198.6	-0.20376	-0.00053826
0.018	-178.13	99.081	5.1621	-0.0074027	198.42	-0.10652	-0.00054985
0.019	-179.32	100.42	5.3605	-0.0074591	198.24	-0.0065789	-0.00055404
0.02	-178.16	99.028	5.5586	-0.0074146	198.06	0.093383	-0.00055074



a) b)

Fig. 2



a) b)

Fig. 3

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