DSTA 2021 dys-ta.com
16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Influence of a cracked rod in the dynamic of a planar slider-crank mechanism

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Abstract: A simplified model of a slider-crank mechanism with a cracked rod is obtained through Lagrange's theory and used to demonstrate non-linearities on the dynamic response of all components caused by the presence of an open and non propagate crack. The open crack is modelled as a massless rigidity spring. To further evaluate the influence of crack presence, the influence of crack depth and position, torque and pressures force, the dynamic response of the damaged mechanism is validated and compared to the health system. Results show, for all cases, a significant difference in the kinematic and dynamic response of both healthy and damaged systems.

Keywords: Multibody Dynamics, Damage assessment, Dynamic response.

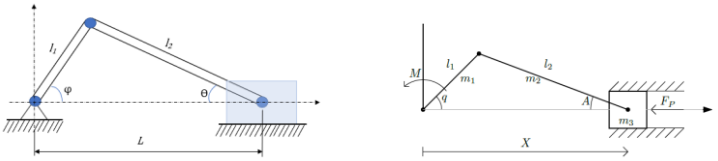
1. Introduction

Many researchers have investigated the dynamic response of multibody system and their dynamic characteristics through an analytical model, numerical, and experimentally. The slider-crank mechanism is present in many machineries in use in industry. Common defaults diagnosis in these mechanism are clearance[1], bearing ovallisation[2], and crack[3,4]. In general, those defaults can cause excessive wear, noise, impact dynamic load, and serious effect on the dynamic performances and stability.

This paper analyse of undamaged and damaged slider-crank mechanism and the impact of a crack in the dynamics response. It is also verified the effect of external forces in the mechanism dynamic. The results show that the crack influences the mechanical system dynamic performance and vibration characteristic by comparing the results between the slider-crank mechanism with crack and without crack, and external forces enhance it.

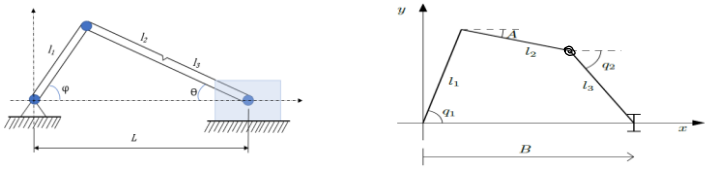
2. Numerical model and Discussion

The planar slider-crank mechanism ideal model has only one degree of freedom (dof) due to the constraints presented in the ideal joints. Therefore, the crack is modelled with a torsional spring located in a joint between two rods for the damaged mechanism. In this case, two or more degrees of freedom will be inserted between the components. Figure 1(a-b) shows the undamaged slider-crank mechanism one-dof composed of two rigid components l_1 and l_2, with q_1 being the angular displacement of the crank. Figure 2 (a-b) shows the damaged slider-crank mechanism two-dof composed of three rigid components l_1, l_2 and l_3, with q_1 and q_2 as the angular displacements of the crank and the slider, respectively.



(a) (b)

Fig. 1. Undamaged slider-crank mechanism(a) and its diagram representation (b).



(a) (b)

Fig. 2. Damaged slider-crank mechanism(a) and its diagram representation (b).

The governing equation for the one-dof slide-crank based on Lagrange approach and considering the pressure is expressed as

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}}\right) - \frac{\partial L}{\partial q} = Q^{nc} \tag{1}$$

where $T = \frac{1}{2} f(q)\dot{q}^2$, and

$$f(q) = I_{KO} + m_2(K_{X_2}{}^2 + K_{Y_2}{}^2) + I_2 K_A{}^2 + m_3 K_X{}^2.$$
$$\frac{df(q)}{dq} = 2[m_2 K_{X_2} L_{X_2} + m_2 K_{Y_2} L_{Y_2} + I_2 K_A L_A + m_3 K_X L_X]. \tag{2}$$

And the equation of motion for the cracked slider-crank with two-dof is given as

$$([K_c]^T[M][K_c])\begin{Bmatrix}\ddot{q}_1\\ \ddot{q}_2\end{Bmatrix} + \left(\begin{bmatrix}\dot{q}_1 & -\dot{q}_2\\ 0 & 2\dot{q}_1\end{bmatrix}[N_1] + \begin{bmatrix}2\dot{q}_2 & 0\\ -\dot{q}_1 & \dot{q}_2\end{bmatrix}[N_2]\right)\begin{Bmatrix}\dot{q}_1\\ \dot{q}_2\end{Bmatrix} + \frac{\partial V}{\partial \begin{Bmatrix}q_1\\ q_2\end{Bmatrix}} = \begin{Bmatrix}Q_1\\ Q_2\end{Bmatrix} \tag{3}$$

3. Final Remarks

This paper analyses the dynamic response of an undamaged and damaged planar slide-crank mechanism and the impact on the system. Aside from the enhance of the crack effect under externa forces

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