SIMPLIFIED METHOD TO PREDICT TRANSLATIONAL JOINT WEAR IN RIGID MULTIBODY SYSTEMS

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EXTENDED ABSTRACT

1 Introduction

This work analyzes the effect of wear in the contact between the slide and linear guides of a translational joint due to the presence of clearances caused by manufacturing tolerances and the life cycle of the product. The objective is to establish an agile but precise method to be able to determine the variations of lateral forces and wear that appear within a mechanical press during its useful life. The aim is to define a design criteria and to stablish the maintenance guidelines.

In the design of dynamic machines, joints are a key mechanical element that define their correct operation. For the analysis of the life behavior of mechanisms, usually multibody systems with ideal joints are used. This way, the forces and dynamics of the different bodies of the mechanism are determined. However, real joints present great simulation challenges due to the presence of factors that have a great influence on the dynamics of the analyzed system [1]. In the last decades there has been a significant increase in studies of joints with clearances [2] in order to better understand the evolution of the clearance over time due to wear, and thus be able to predict the behavioral change of the machines during their lifetime [3]. In some other applications, the aim was to obtain reliable mechanical models, to improve the control of precision robotic systems. On the other hand, few works have been carried out on translational joints with clearances [2, 4] and mostly they have been focused on laying the groundwork to better understand the loads and changes in dynamic behavior that appears as the clearance increases.

2 Developed model.

Following the developments already indicated [2, 4], a model has been developed that allows predicting the force amplification due to clearances. This model considers a circle at each corner of the slider which limit the dimensions of the slider as shown in figure 1. Using a contact condition between each of the circles (c_{sd}, c_{si}, c_{id}, c_{ii}) and the lines that define the guide system, a translational joint with clearance has been developed allowing the free movement of the slider in the plane.

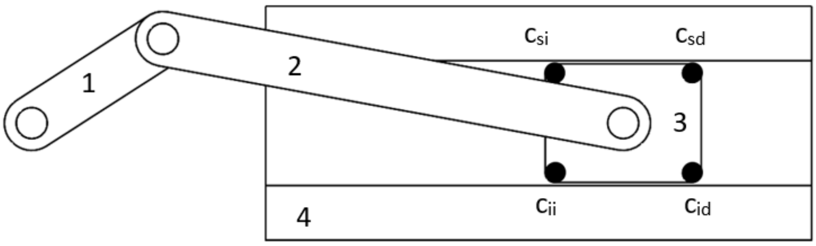

Figure 1: Image of the developed crank slider model

To model the clearance, the nonlinear contact model developed in Simulink [5] has been used in which a "Stick-slip continuous" friction model is considered. The model has been implemented in SimScape (Matlab 2021) considering the bodies as rigid solids. The slider-crank mechanism is composed of 3 ideal revolution joints and a linear joint in which clearance and friction are taken into account.

This MBD model makes it possible to determine the forces that appear on the edges of the slide at any instant. And depending on whether the forces appear in only one vertex or in both vertices of the same lateral, it is established if the wear occurs in the radius or in the corresponding face (Figure 2), allowing to determine the wear of the slider. The wear of the guide has been disregarded.

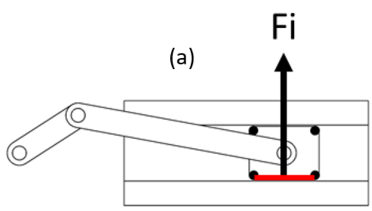

Figure 2: Differentiation of the normal forces that produce wear on the surface (a) and in the corners (b)

To consider the evolution of the clearance, the analysis of the wear of the translational joint has been proposed based on the Archard's formula and taking as a reference the developments carried out in [7].

As wear between one cycle and the next is extremely small and does not involve relevant changes, it is not worthy, due to its computational cost, to determine the wear that occurs in each cycle and continuously update the geometry and asses the behavior of the system. Instead, periodic calculations are done. First, for a given clearance and edge geometry, normal forces are computed, and then, the number of cycles required to reach a predetermined wear limit (in both slider round corners and guide lines). When this limit is attained, the geometry of the slider is updated and the new normal forces are determined, and so on and so forth.

3 Results and conclusions

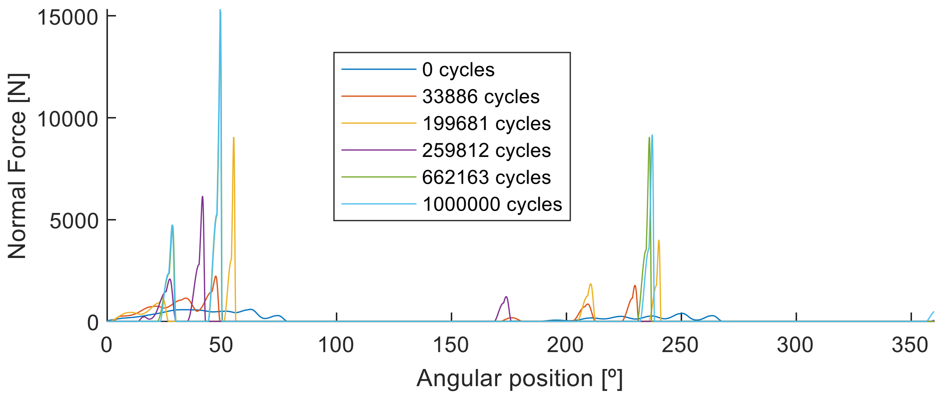

Figure 3: Variation of normal forces as the cycles progress

As can be seen in figure 3, the forces that appear in the model with small clearances are small and show a continuous behavior. As the clearance increases due to wear, the forces show higher peaks, more punctual and chaotic. In this case, force peaks exceeding 25 times the maximum values detected in the initial cycle are observed in the last cycle. These normal forces that appear in the guide are unwanted and have impact on the lifetime of the guide and other adjoining elements. Through the use of the developed model, the intention is to be able to analyze in greater detail the dynamic behavior in mechanical presses, and to improve the structural design of its components, taking into account the force amplifications due to wear during their lifetime.

Acknowledgements

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