CFA/VISHNO 2016

Dynamique de vibration verticale d'un patin rugueux glissant sur une surface rugueuse

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We study experimentally the dynamics of impacts between two rough surfaces sliding at high velocity. We measure simultaneously the vertical acceleration of a slider under gravity and the electric voltage across the sliding interface. The results show that the slider is always in contact with the platform at small velocities, but presents jumping dynamics at high velocities. We study the time statistics of these dynamics as a function of the sliding speed, normal load and roughness. These results will be compared with a simple bouncing-ball-like numerical model.

1 Introduction

The friction between two rough surfaces is characterized by a succession of shocks between surface micro-asperities. This phenomenon has been studied at low sliding velocities and it results in a dynamic vibro-impact regime causing the roughness noise. The noise level depends on the surface topography, the sliding velocity and the vibrational modes. Previous studies have better characterized these macroscopic relationships [1, 2]. However, their microscopic origin in terms of individual micro-impacts remains poorly understood [3]. The principal aim of the study is to provide a time-resolved statistical description of this dynamic. The measurements will be compared to simulations of a numerical model [4, 5, 6].

2 Experiment study

2.1 Experimental set up

Consider two solids, S1 and S2, having the same topographical properties (tab.1). S1 is submitted to its own weight and is moving on S2 at constant velocity V (fig.1).
To guarantee a good temporal resolution of the micro-impacts, two twin accelerometers are placed on top of the slider, one at the front, one at the rear, symmetrically. The vertical acceleration is obtained through the half-sum $\ddot{z}$of both signals, whereas the rotational acceleration can be accessed through their difference. We apply a voltage V_p between the two solids to measure the electric contact voltage. A force sensor measures the driving force applied by a pusher.

	S1	S2
Dimensions (mm^3)	25x25x20	300x100x20
Material	stainless steel	stainless steel
Ra Roughness(µm)	30	30

Table 1: Solid properties

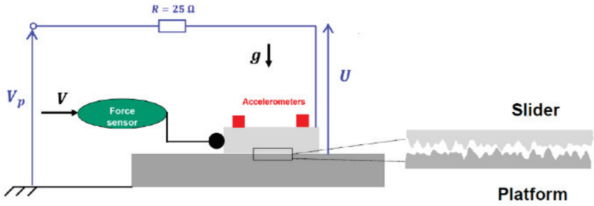

Figure 1: Sketch of the experimental setup to study the sliding of dry and rough surfaces driven at constant velocity V.

When there is no contact between the two solids, i.e during jumps, the slider is in free flight, its acceleration is equal to the gravitational acceleration $\boldsymbol{g}$ and the electric voltage is equal to the supply voltage. Conversely, when an impact occurs, the acceleration is less than $\boldsymbol{g}$ and the electric contact voltage is very low (fig.2).

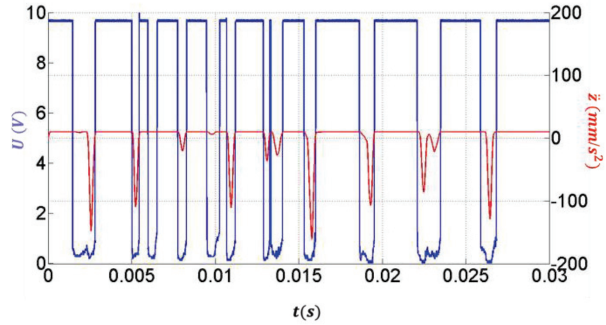

Figure 2: Temporal dynamic

2.2 Results

We investigate the time statistics of the jumping dynamics. As an example, in figure 3 we show the mean flight duration as a function of the driving velocity. There is a transition at V~10mm/s from a continuous contact to a jumping regime. Above the transition, the mean flight duration is proportional to the driving velocity.

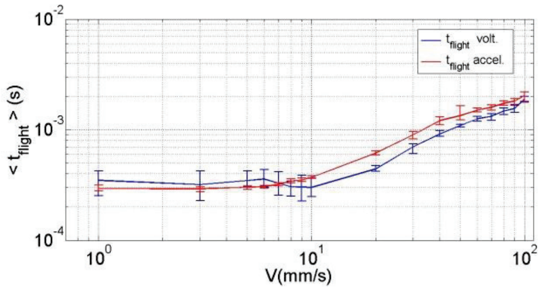

Figure 3: Mean flight duration as a function of the driving velocity.

3 Numerical model

In order to simulate the experimental results for the regime of high velocities, the sliding of the slideris modelled by an adapted Bouncing Ball model [5] under stochastic excitation [6]. The model is described in figure 4.

A ball of masse m is bouncing in the vertical direction on a moving platform of mass M under the action of the gravity $\boldsymbol{g}$.

It is assumed that the platform is infinitely massive compared to the ball and thus the platform is not affected by the impacts of the ball. Its motion is described by a stochastic process.

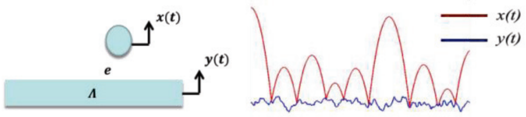

Figure 4: Bouncing Ball model

The dynamics are governed by two dimensionless parameters: the coefficient of restitution e and the reduced acceleration Λ. This model predicts a transition to jumping for Λ~1 (V~40mm/s). It also predicts that the flight duration is proportional to the velocity. Both results are in good agreement with our experiments.

References

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