7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Rubber friction under curvilinear sliding motions

Vincenzo Fazio, Vito Acito, Christian Frétigny and Antoine Chateauminois

Soft Matter Science and Engineering Laboratory (SIMM), CNRS UMR 7615, ESPCI Paris, PSL University, Sorbonne Université, F-75005 Paris, France

Abstract We investigate the friction of a rigid glass lens on a silicone rubber substrate when the sliding trajectory is curvilinear. Circular and sinusoidal paths are especially considered. In such situations, we show that the friction force is not always colinear to the imposed trajectory. From in situ measurements of the surface displacement field of the silicone substrate, this behavior is found to result from the sliding heterogeneities associated with the loss of contact symmetry. Stick-slip motions induced by the trajectory are also evidenced.

Keywords : rubber, friction, unsteady-state, curvilinear paths

1. Introduction

One of the common assumptions of friction models is that the friction force is always colinear to the trajectory. However, some studies by Zmitrowicz [1] and Tapia *et al* [2] showed that friction on anisotropic surfaces can result in friction force components normal to the trajectory. Here, we show that the loss of contact symmetry resulting from the curvature of the sliding paths can also result in a friction force which is not aligned with respect to the trajectory.

2. Results and discussion

A glass lens (radius 12.9 mm) slides against a poly(dimethyl siloxane) (PDMS) substrate under imposed normal load (between 1 and 3 N) and velocity (between 0.01 and 0.4 $mm\ s^{-1}$). We focus here on the case of sinus wave motions with amplitude A and wavelength Λ. Depending on A and Λ, some stick-slip motions induced by the trajectory can be induced when the motion is reversed. The corresponding phase diagram is shown in Fig.1 together with a theoretical prediction of the boundary between the two regimes.

In the continuous sliding regime, it appears that the friction force only progressively realigns with respect to the sliding trajectory when the motion is reversed (Fig. 2). From in situ observation of the sliding velocity field within the contact, we show that the orientation of the friction force during this transient regime is dictated by the non-symmetrical distribution of the local sliding velocity within the interface, as a result of the contact deformation.

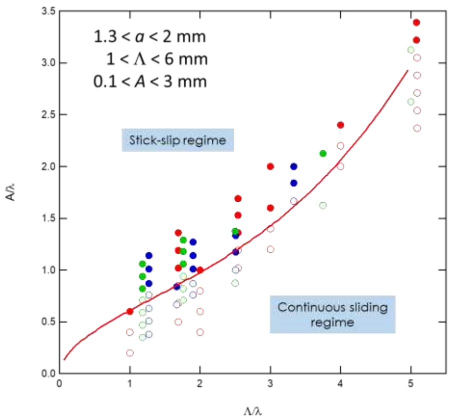

Figure 1: Phase diagram giving the boundary between the continuous sliding (CS) and stick-slip (SS) regimes as a function of the normalized amplitude A/λ and wavelength Λ/λ, where λ is a characteristic elastic length (sinus wave motion, v=0.4 mm s^{-1}). Closed symbols: SS, open symbols: CS. Colors correspond to various contact radii between 1.3 and 2 mm. The solid line corresponds to the theoretical prediction.

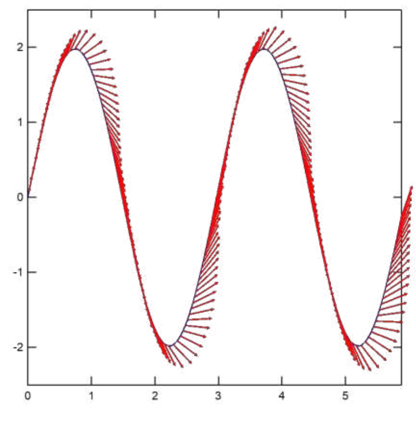

Figure 2: Vector plot (red) of the macroscopic friction force along a sinusoidal trajectory (blue) (Λ=3 mm, A=2 mm, v=*0.4 mm* s^{-1}).

References

1. Zmitrowicz, A. (1999) *Int J Sol Str* **36**, 2825-2848
2. F. Tapia, D. Le Tourneau and J.-C. Géminard (2016) *EPJ Techniques and Instrumentation* **3**:1