Tightening Dynamics of Wound Rolls: The Interplay of Solid Friction and Interfacial Compressibility

Frederic Lechenault*[1]

[1]Laboratoire de physique de l'ENS - ENS Paris – Sorbonne Universite, Centre National de la Recherche Scientifique, Université Paris Cité, Département de Physique de l'ENS-PSL – France

Résumé

The capstan equation predicts that the tension along a flexible band wrapped around a cylinder decreases exponentially with the number of turns due to solid friction, preventing relative slipping. However, we demonstrate in a controlled experiment that a loosely wound roll can in fact be tightened efficiently. The key lies in the interplay between solid friction and interfacial compressibility due to surface roughness: a circular slipping zone nucleates at the fixed core and propagates outwards through a stick-slip sequence, producing successive tightening waves. Each wave slightly reduces the inter-layer spacing while conserving length, so that slack accumulates and the outer part rewinds onto the inner layers. We quantify the front kinematics and the force build-up, and demonstrate that the process is governed by the compression of interfacial roughness, which depends logarithmically on the pressure.

*Intervenant