Physics sheds light on the role of humidity in ironing

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Ironing increases the humidity of a piece of cloth by injecting water vapor in the form of steam. But how does the vapor affect the fabric? Until now, it was thought that its only effect was to soften the fibers. French researchers at the Laboratoire de Physique de la Matière Condensée et Nanostructures de Lyon have now shown that water vapor plays another key role by acting on the contacts between the fibers, whether or not the material they are made of absorbs humidity. This work has just been published online in the journal *Soft Matter*.

What is the role of water vapor in a material such as fabric (a collection of interwoven micrometer scale fibers)? To find out, the researchers made reproducible folds in the material by passing a sheet or a piece of cloth through a slit of controlled width. This enabled them to discover the parameters that can be used to predict the angle of the fold that is formed. In particular, the width of the slit, the thickness of the sheet, and the elastic stress (in other words, the maximum force with which the material can be deformed without being damaged) all play a role in the formation of the fold. The greater this stress is, the smaller the fold.

The researchers showed that, once the crease was formed, it unfolded over time, whether it was in a solid material or in a fabric. The unfolding process is very slow, in agreement with the laws that govern the ageing of materials, which is characterized by a very gradual increase in the stress over time.

In addition, by carrying out experiments in a controlled humidity

chamber, the scientists have shown that the unfolding process is considerably faster when the atmosphere is more humid. However, this effect only occurs in woven material: a crease in an isolated fiber of the same fabric unfolds at a speed that is independent of the level of humidity.

This work highlights the role of capillary bridges between fibers in this process. Moreover, the results obtained, especially the connection between the unfolding rate and level of humidity, are quantitatively very similar to the effects of humidity on the 'ageing' of piles of sand over time. This implies that the underlying mechanism is similar. According to the mechanism proposed, the rate at which a crease unfolds is governed by the rate at which the capillary bridges reorganize themselves. Humidity therefore plays a crucial role in contacts between fibers, thus speeding up the process of ironing.

More information: The anatomy of a crease, from folding to ironing. Adrien Benusiglio, et al. *Soft Matter*. Online 10 February 2012 (paper version forthcoming)

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