Surface du Verre et Interfaces
CNRS/Saint-Gobain

Saint-Gobain Research Paris

IUSTI
CNRS/Aix-Marseille Université

Funded Ph.D project: Mechanics of aggregated and entangled fibers

Industrial context:

One of the challenges of reducing greenhouse gas emissions is related to energy savings. Saint-Gobain, actively committed in this effort for its processes, also contributes to energy savings through its thermal insulation solutions for housing. One of the products at the heart of this strategy is the insulation using glass wool, which can be applied as a mat or as fiber flakes blown below the roofs, known as blowing wool. These fibers are blown into attics or between walls. Ensuring a quality of final insulation requires controlling the evolution of this fibrous material during the pneumatic projection as well as during the filling stage. One key point is understanding the mechanics of this material: the fiber aggregates should not be compacted but should be loosened, and the product density should be homogeneous.

Subject:

The peculiarity of fibrous materials used for thermal insulation is that they are made up of an entanglement of fibers with a very high aspect ratio. In such a medium, like in a plate of spaghetti, the fibers are bent and in contact with many neighboring fibers. At each contact, a frictional force prevents the fiber from sliding and straightening. This mechanism is the basis for their mechanical strength, even without any binding agent between the fibers, unlike conventional granular media which do not exhibit any cohesion.

This medium, which exhibits heterogeneities of local densities, is highly compressible and can become decompacted when the cohesive forces are exceeded. Predicting the behavior and evolution of this material constitutes the heart of the Ph.D.

Figure 1: Break-up of an aggregate made of model entangled fibers.

Objectives:

The PhD project will focus on measuring the mechanical response of homogeneous volumes or "flakes" (aggregates) of model fibers (Fig. 1). From a homogeneous material, how do heterogeneities develop? What is the tearing resistance? Under what conditions do the fibers form aggregates? How do fiber clusters disintegrate?

Through various mechanical stresses (vibration, air flow, rotating drum, shear (friction) ...), we will construct a mechanical model of entangled fibers. The reorganization of surface fibers will be particularly studied, notably through image analyses (microscopy or X-ray tomography), based on the mechanical properties of the fiber and the solid wall (elasticity, coefficient of friction, aspect ratio, roughness). The results will be compared to tests that will be carried out with blowing fiberglass flakes.

Profile:

We are looking for a female or male master's student in physics or engineering who is motivated by experiments and interested in the physics of soft matter.

Laboratory:

The PhD supervision involves Saint-Gobain Research Paris (SGR Paris), the Glass Surface and Interfaces Laboratory (SVI, CNRS/SG), and the University Institute of Thermal and Industrial Systems (IUSTI, Aix-Marseille Univ./CNRS). Saint-Gobain Research Paris, one of the group's main R&D centers, develops knowledge on blowing wool and its manufacturing processes and hosts SVI, whose one activity is dedicated to granular materials. IUSTI hosts an expert group in divided matter and the mechanics of soft objects. This work will be carried out with regular interactions with the teams at SGR Paris. The results will help to better predict the state of fiber flakes and provide precise recommendations on industrial processes.

Supervisors:

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