Sheet tearing

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Student number: 2

Context: Do you remember the last time you tear a plastic sheet in a hurry? The result turned out to be an undulanting tear, or even worse, a twisted tear, instead of the expected straight tear. Do you remember the last time you try to peel off an adhesive tape? Sooner or later a scrap appeared, leading to a small disaster.

Scientific studies emerged from these common facts. A research team of the PMMH laboratory (ESCPI Paristech) is specialized in this field, using rigorous experimental protocols to characterize the shape of these tears and confront them to models. They have already modelled several types of tears :

- « undulating » (Fig. 1 (a)). An objet moving through the sheet plane creates a periodic tear.
- « converging » (Fig. 1 (b)). Two tears define a scrap with a specific geometry.
- « fractal » (Fig. 1 (c)). This type appears when the edges are highly elongated during tearing.

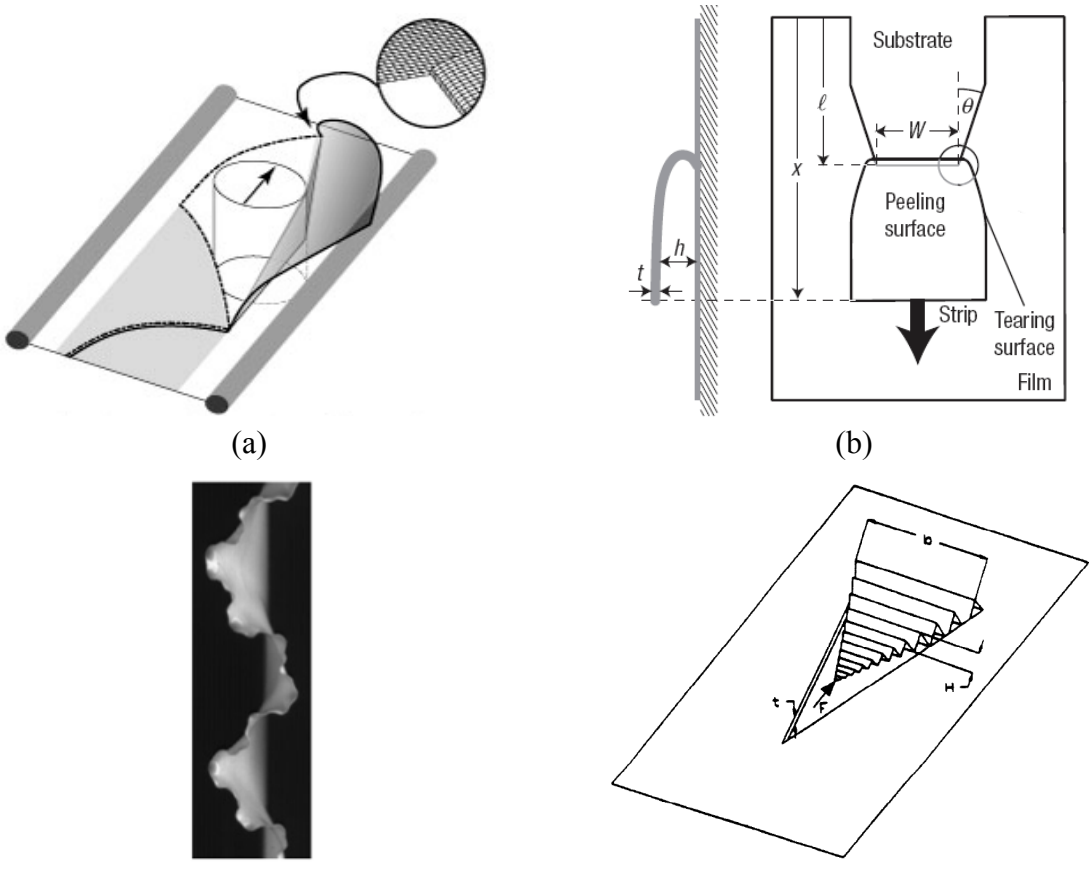

Fig. 1 : tear examples: (a) undulating, (b) converging, (c) fractal, (d) concertina.

Even though these phenomena are partially understood, numerous questions are still unanswered. Lots of these questions are related to the role of plasticity. For example,

undulating tears appear only on sheets with very little plastic strain. Why? What is the threshold of ductility leading to non-undulating tears? On the contrary, concertina tears (Fig. 1 (d)) do not appear on purely elastic sheets. Why, and for what threshold of ductility? Where does the plasticity concentrate?

Goal : Since plasticity mechanisms are irreversible, a share of the mechanical energy is changed into heat. A temperature field measurement performed during tearing may thus help us to locate where the energy is mainly expended, and consequently better understand why tears are undulating- or concertina-type.
Because of the expected range of temperature variation, a rigorous experimental protocol will be necessary. Students must like experimental approaches, but also not be reluctant to material models and numerical data processing.

Schedule : First, some simple cases will be studied so that students get accustomed to theoretical (material behaviour models, heat equation) and technical tools (IR thermography). Second, a specific measuring protocol will be designed, enabling repeatability, thermal field measurement, and minimizing thermal/optical disturbances. A numerical implementation of the heat source equation is also in the scope of this work to calculate the heat sources.

Technical means : Tensile testing machine, IR camera, matlab

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