Contact mechanics of isotactic polypropylene: effect of pre-stretch on the frictional response

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Introduction / objective

In applications where relative moving parts are in contact, the dissipation of energy due to friction, i.e. heat production, reduces the lifetime of a product. Extrusion or injection moulding, induce an anisotropic microstructure and lead to direction dependent mechanical properties. The goal of this research is to relate orientation of semi-crystalline isotactic polypropylene to its frictional resistance.

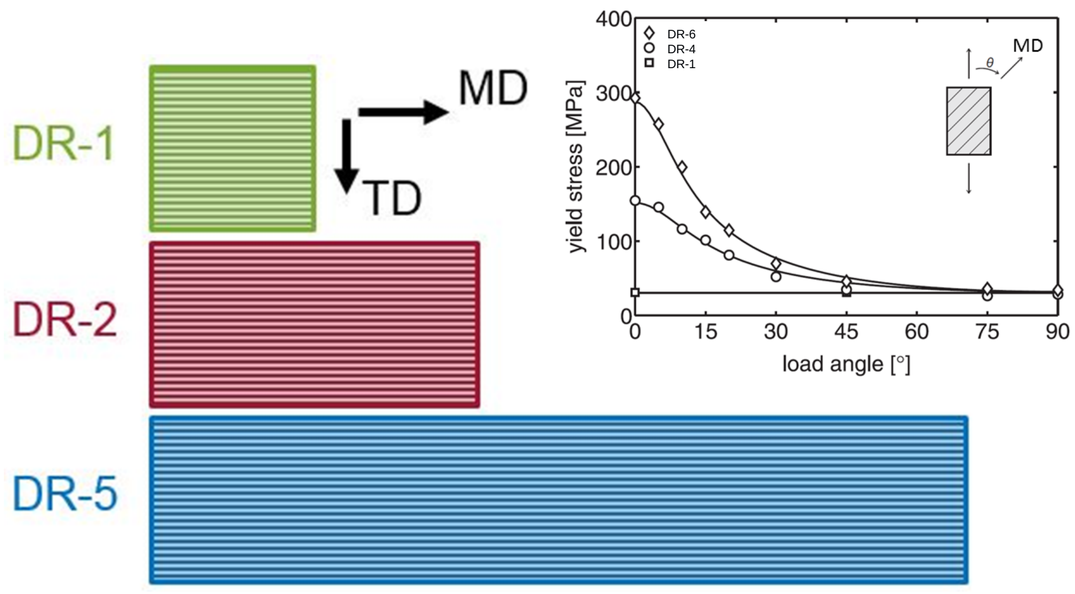

Figure 1: Schematic representation of the pre-stretched systems. Yield stress data adopted from Van Erp [1].

The yield/maximum stress of polypropylene increases with increasing draw ratio (DR) as was shown by Van Erp [1]. A schematic representation of the pre-stretched systems considered is shown in Figure 1.

Results

The yield stress in the machine direction (MD) is higher than in the transverse direction (TD), therefore the accumulation of plastic strain in front of the indenter tip is lower upon sliding in MD, see Figure 2.

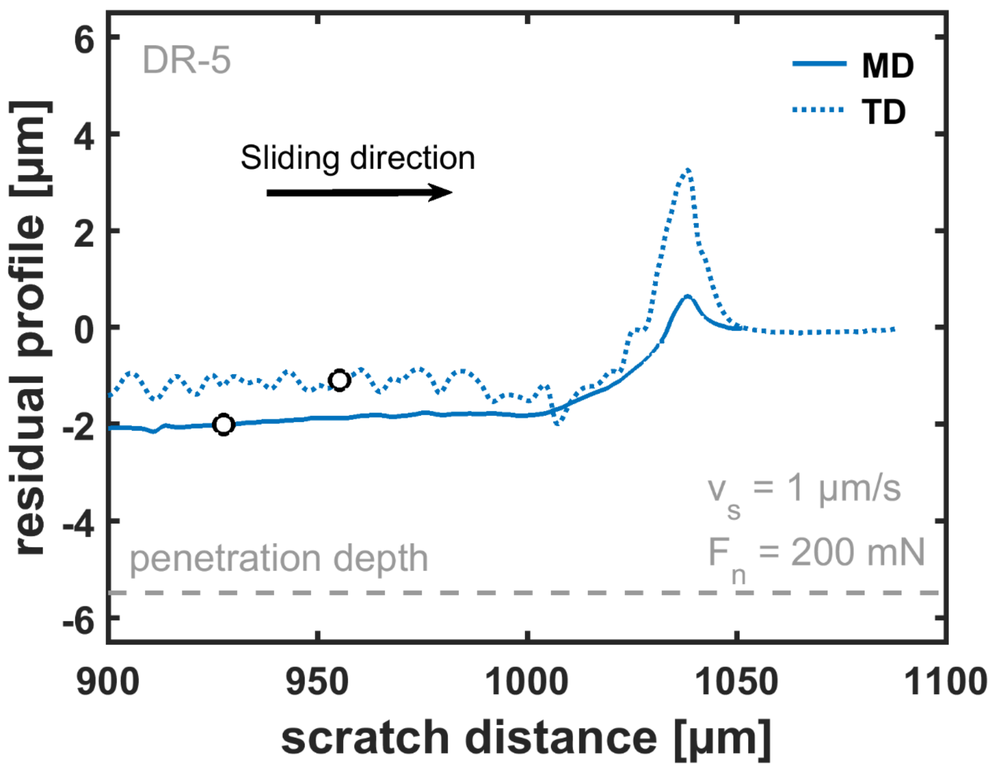

Figure 2: Residual scratch profile after sliding in MD and TD.

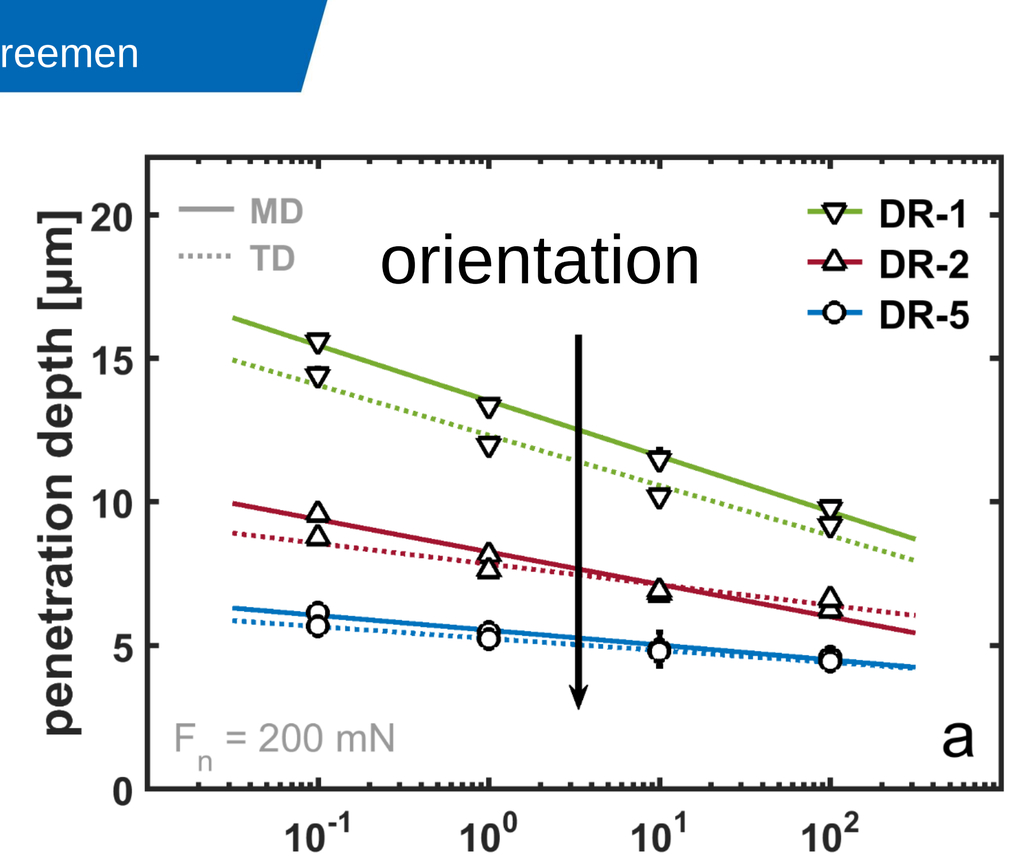

Figure 3: Steady-state surface penetration (a) and frictional resistance (b) for oriented polypropylene as function of the applied sliding velocity.

The penetration depth into the polymer surface, see Figure 3a, is decreased by orienting the system. The lateral force is found to strongly depend on the sliding direction, see Figure 3b, which is explained by the bow-wave size as shown in Figure 2.

Conclusions

Solid-state drawing of isotactic polypropylene significantly improves the scratch resistance; the penetration depth and consequently the frictional resistance are reduced in both principal sliding directions, although a larger beneficial effect is seen in machine direction.

References

[1] T. B. Van Erp, et al. *J. Polym. Sci., Part B: Polym. Phys.* **2009**, 47(20), 2026–2035