The blistering of viscoelastic filaments

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When a polymer solution experiences capillary thinning, the finite time singularity of the pinch off process is suppressed and an almost uniformly cylindrical thread is formed. The reason for this effect is the high resistance of polymers against elongational flow that leads to the so called elongational viscosity. Capillary thinning is one of the few experiments that allow the determination of this material parameter. Still, there exists no satisfying constitutive theory that describes e.g. shear and elongational flow consistently. We present measurements on a variety of different flow types that shall help to identify the relevant scaling laws. In the last stages of thinning, when polymers have become fully stretched, the filament becomes prone to several instabilities, e.g. a "breathing" instability, originating from the edge of the filament, and a sinusoidal instability in the interior, which ultimately gives rise to a Rayleigh Plateau instability followed by a blistering pattern of beads on the filament. High speed video observation with sub-difractional spatial resolution and micro-PIV measurements indicate the existence of irregular flow fields. For sufficiently high polymer concentrations, the filament eventually separates out into a solid phase of entangled polymers, connected by fluid beads. A solid polymer fiber of about 100 nanometer thickness remains, which is essentially permanent.