Polyolefin Plastics
Still a challenge for Chemical Engineers?

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DOW

Polyolefin Plastics

- What does it take to make it
- Applications
- Processing
- Chemistry
- Feedstock
- History
- Future

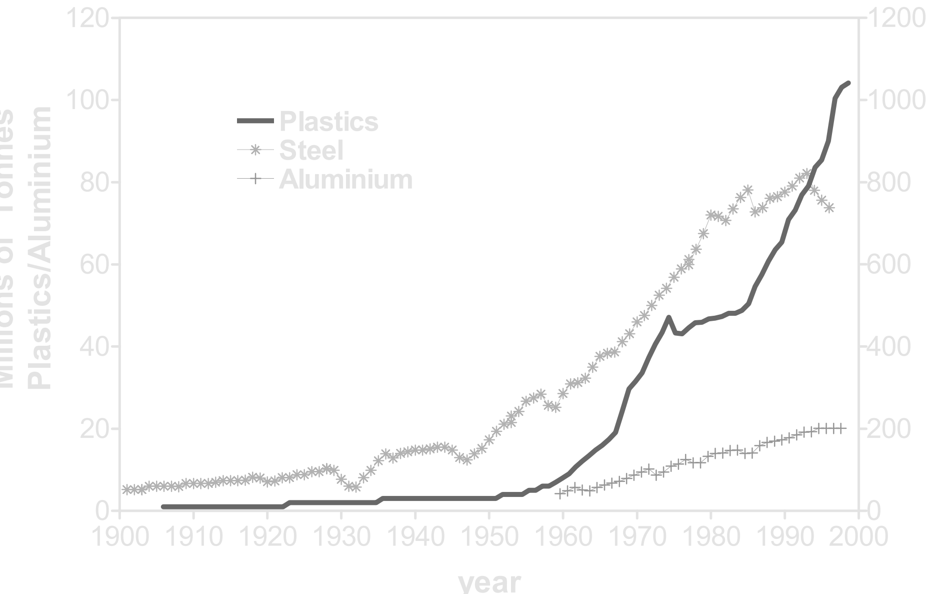
What does it take to make Plastics?

- Plastics
  - An ensemble of polymers and other organic and/or inorganic components
- Polymers
  - An ensemble of macromolecules of equal chemical composition but of different molecular mass
- Macromolecules
  - An ensemble of large molecules of same chemical composition and molecular mass

What does it take to make Plastics?

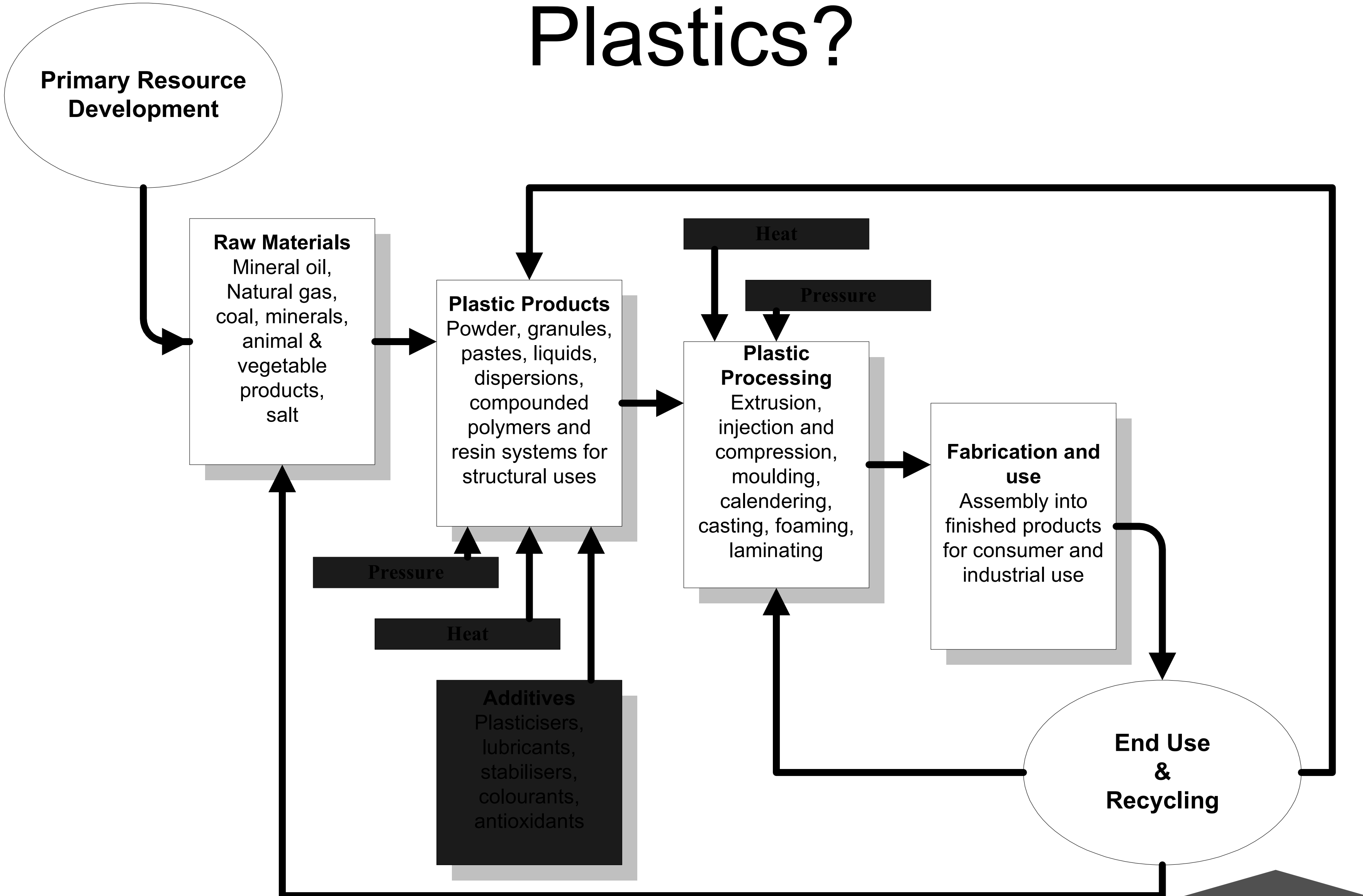
What does it take to make Plastics?

The Plastics Industry

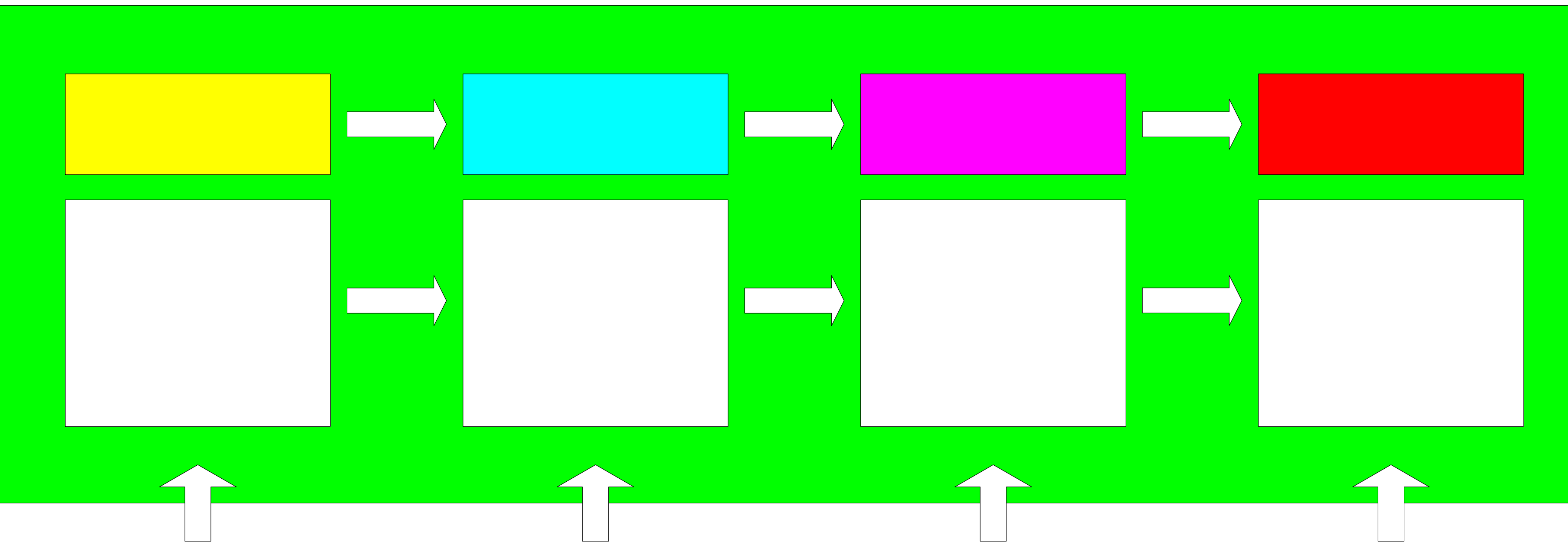


- Western Europe
  - 1.1 mm employed
  - 135 billion Euro
  - 45 Global Companies
  - 30,000 SME
- World
  - > 120 mm T
  - 5% average growth

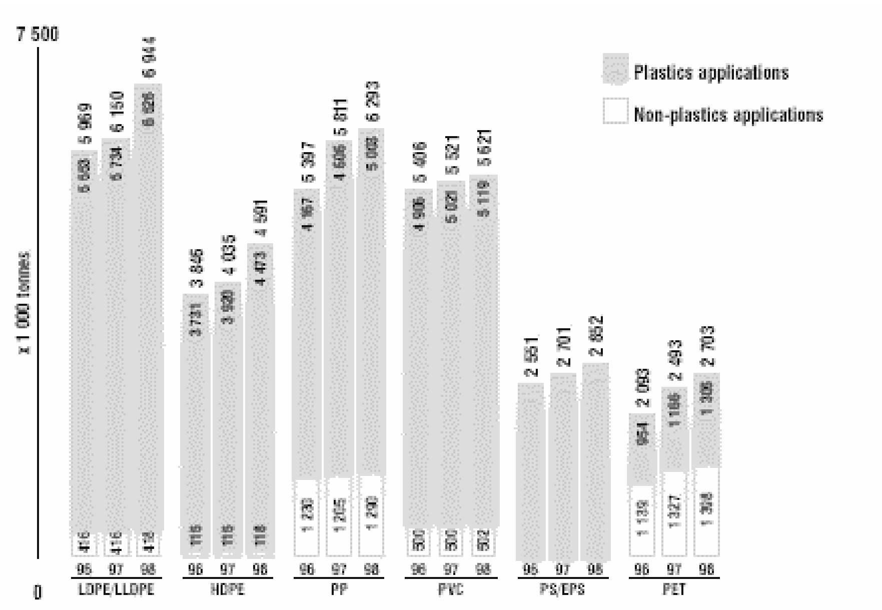
What does it take to make Plastics?

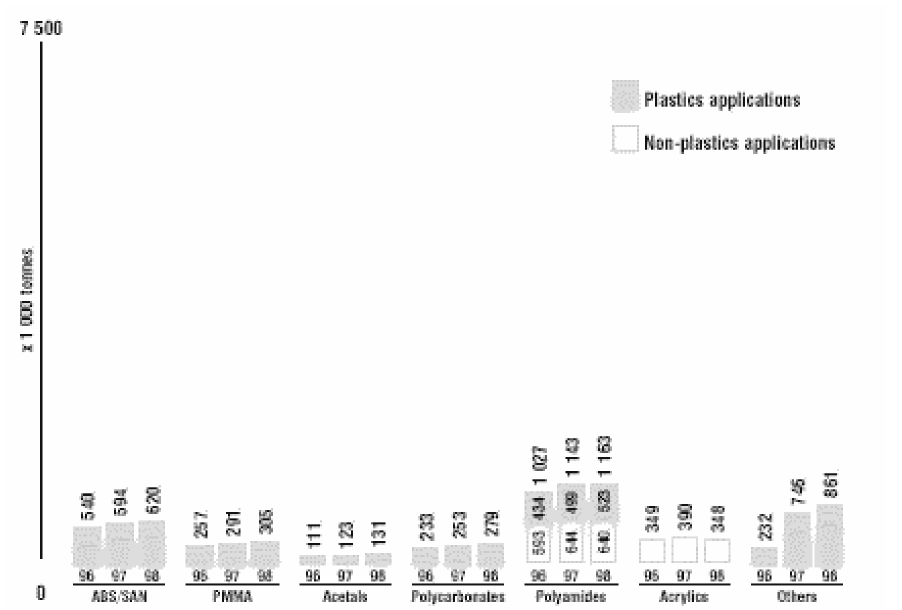


What does it take to make Plastics?



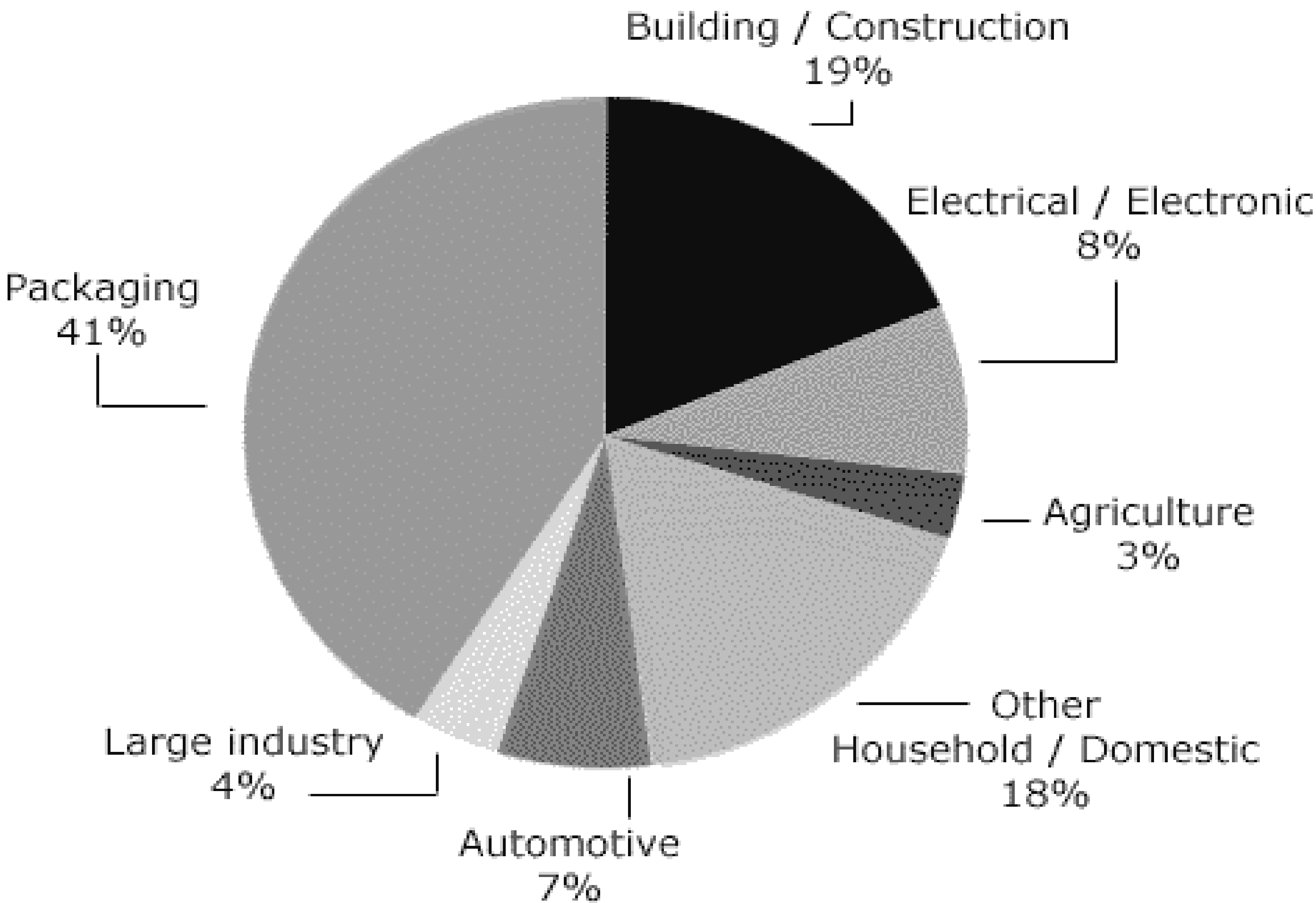
Plastics Applications & Use by Sectors in Europe





- Thermoplastics
  - Commodity plastics
  - Engineering plastics
- Thermosets

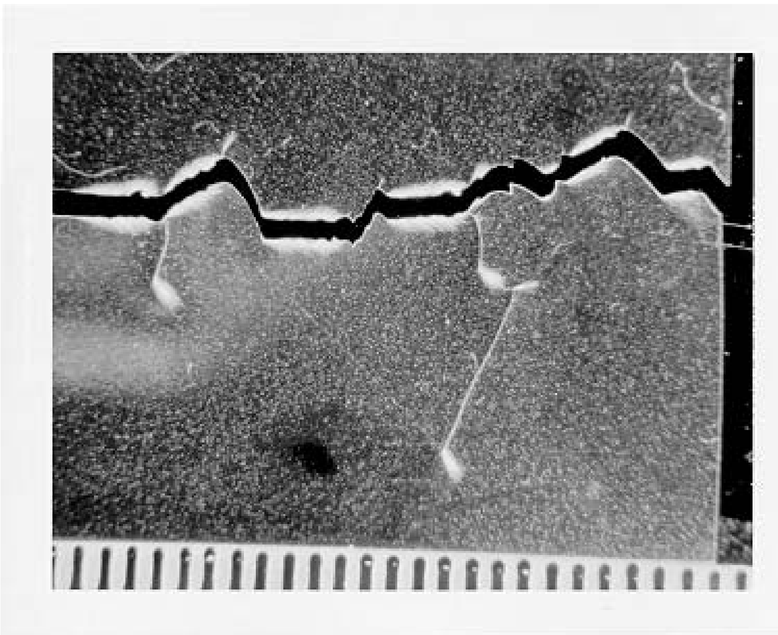
Plastics Applications & Use by Sectors in Europe



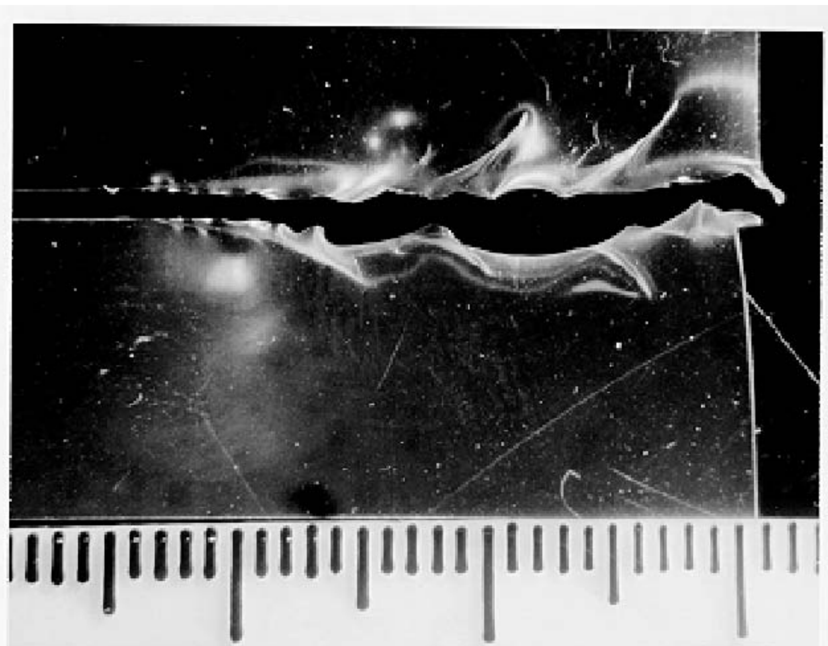
Application Performance

- Low Cost
- Light Weight
- Though
- Easy processing
- Sustainable – recyclable
- ….

Applications: Brittle and Ductile failure

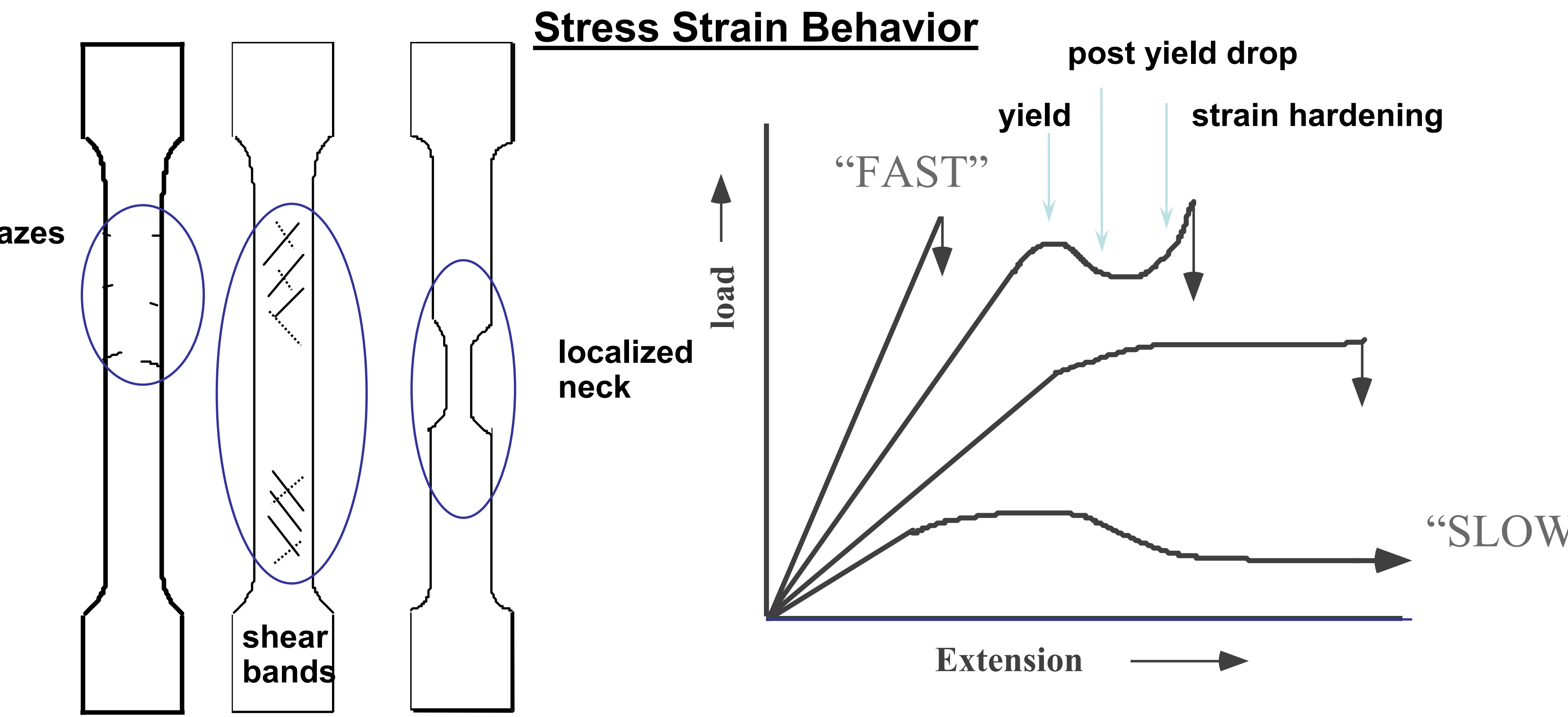


Brittle tear



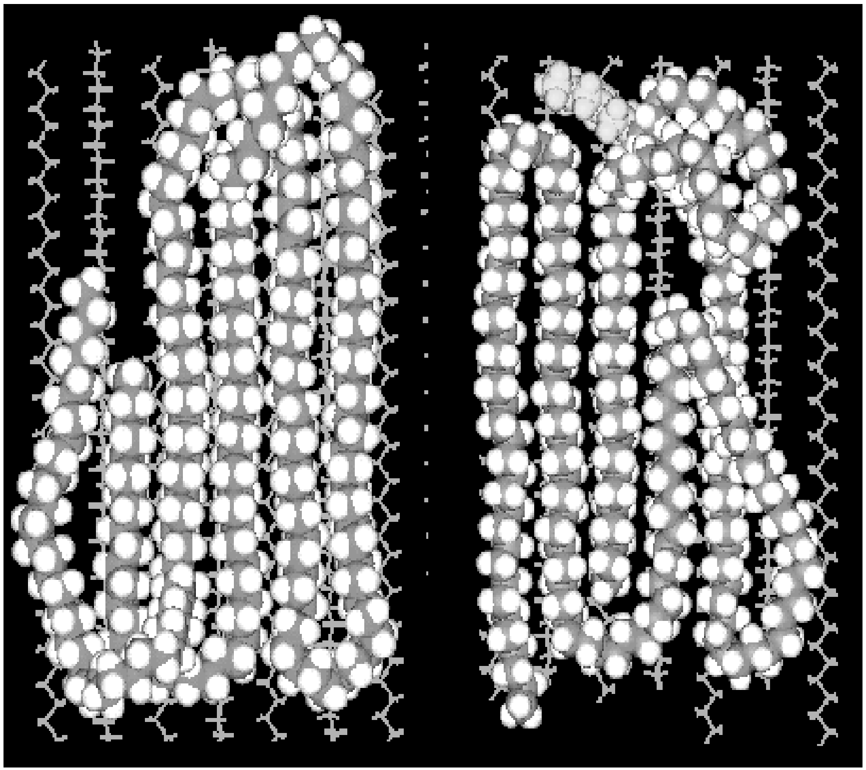
Ductile tear

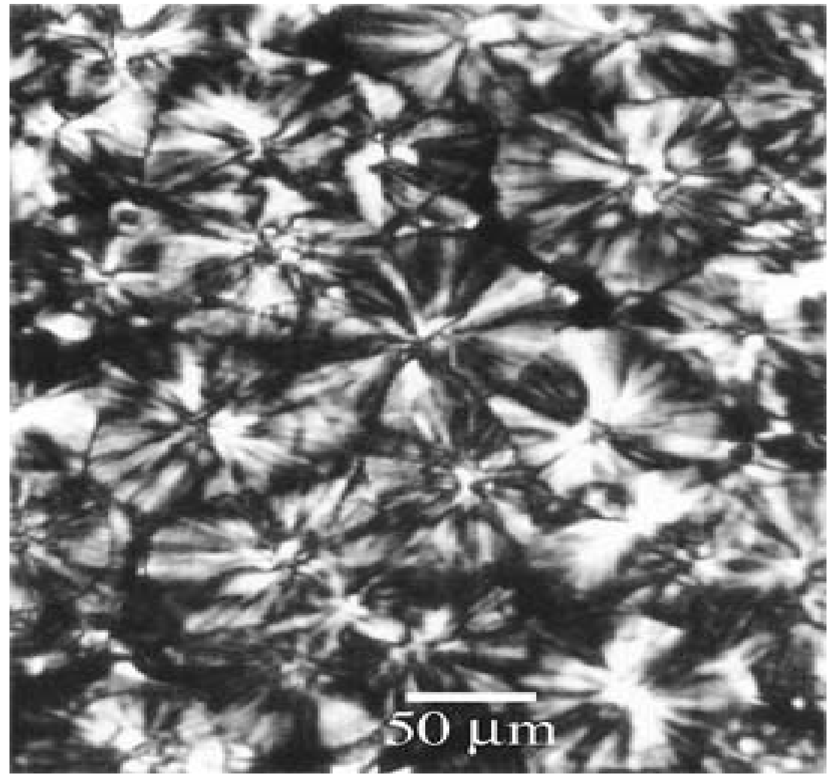
Applications: Tensile Testing



Consider temperature also

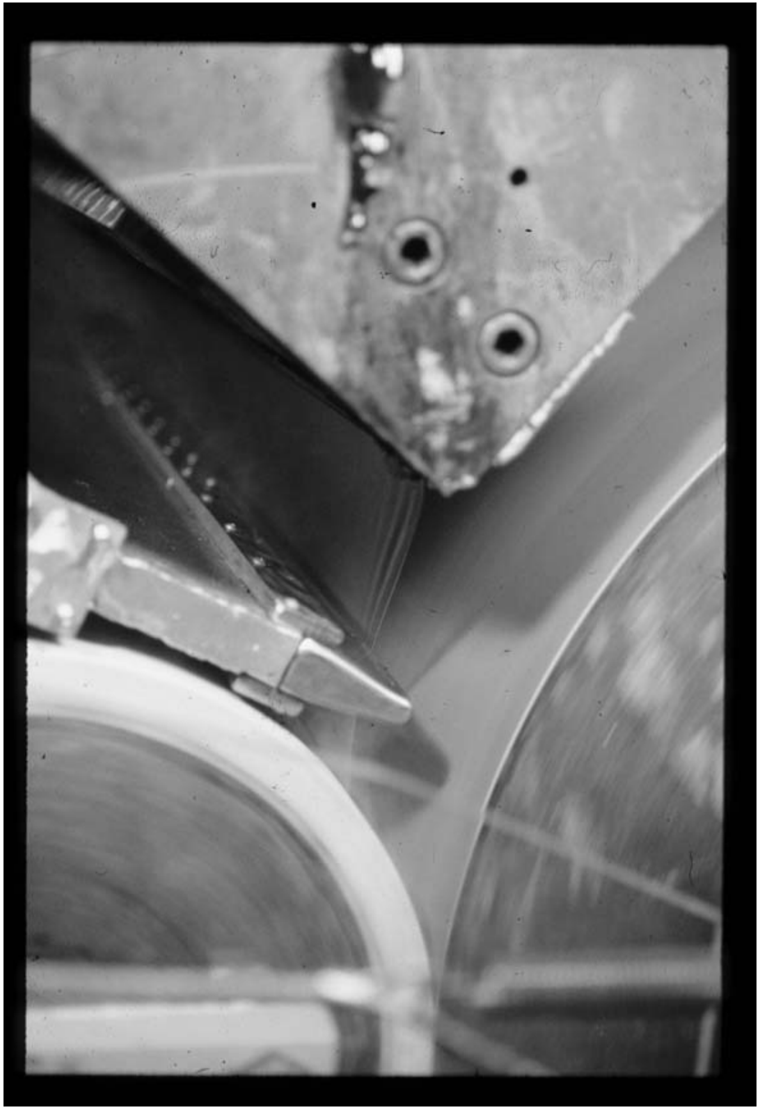
Applications: Crystallisation

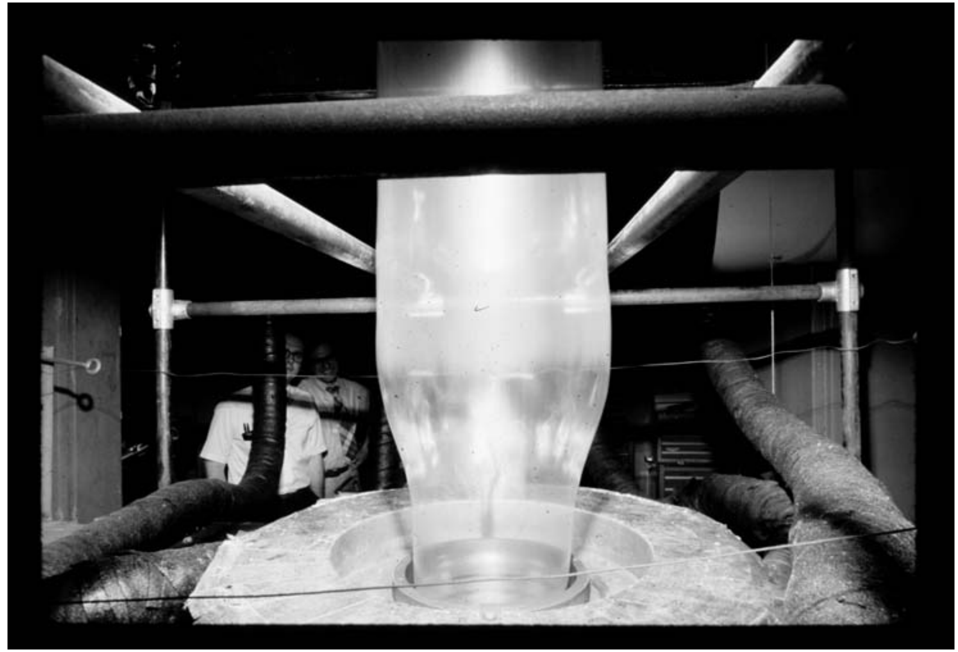




Extrusion Blown Film Application

Processing

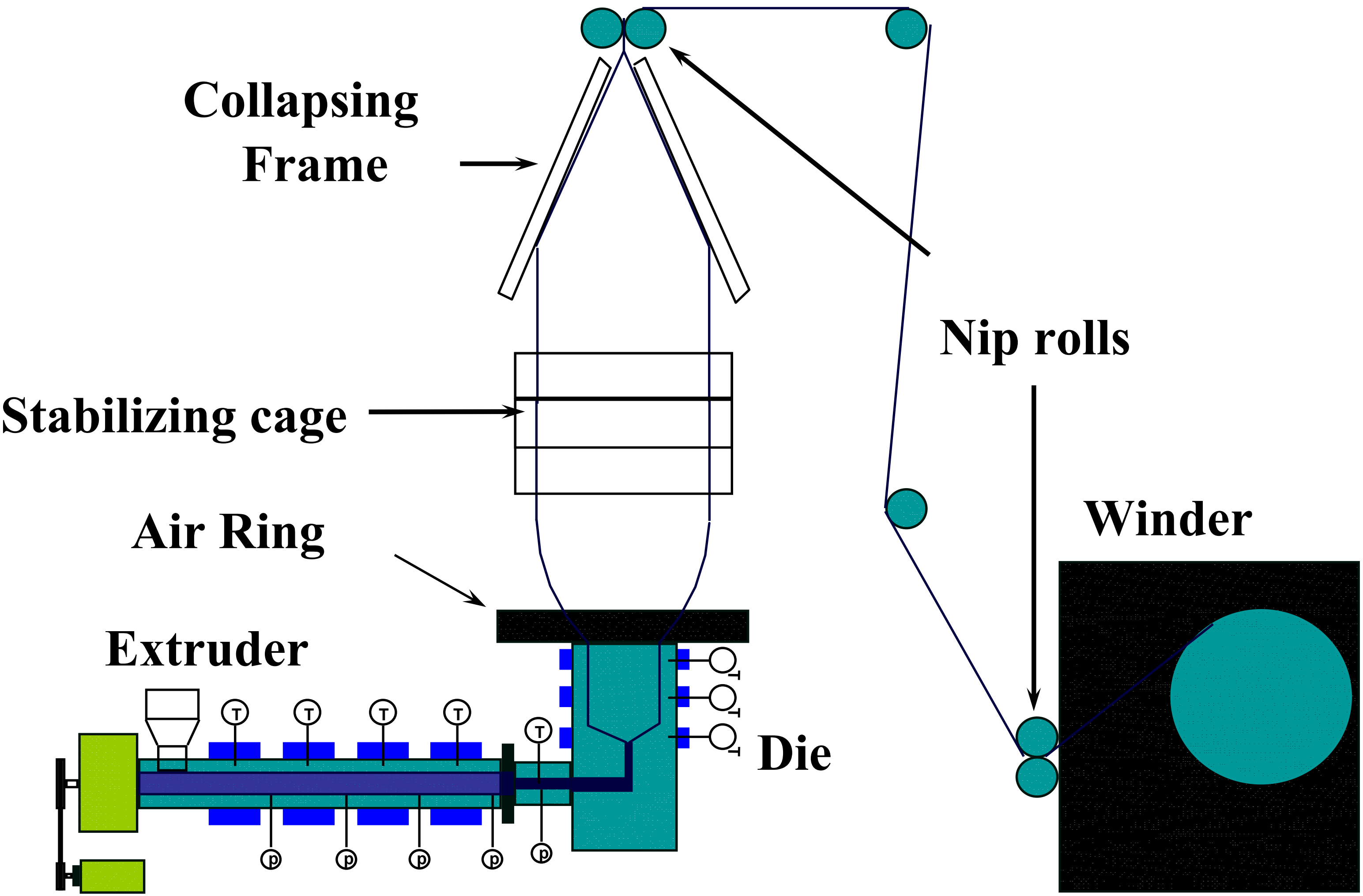




Processing of Film:
Extrusion Casting process
Extrusion Blowing process

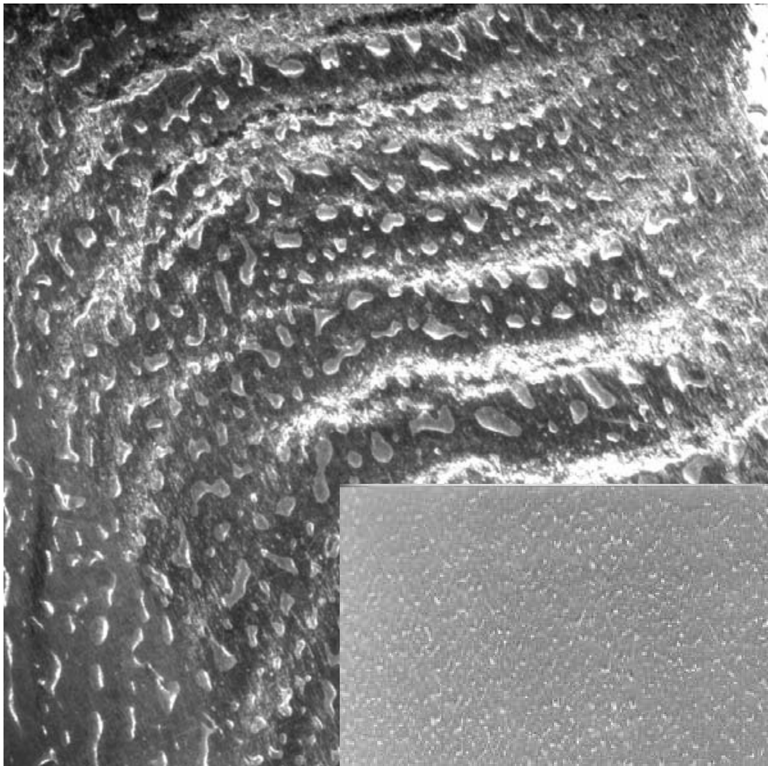
→ Output driven

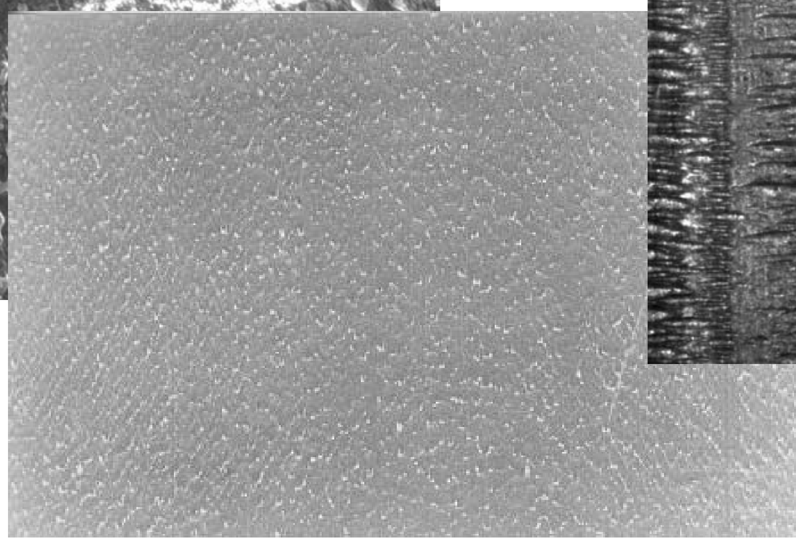
Extrusion Blown Film Process

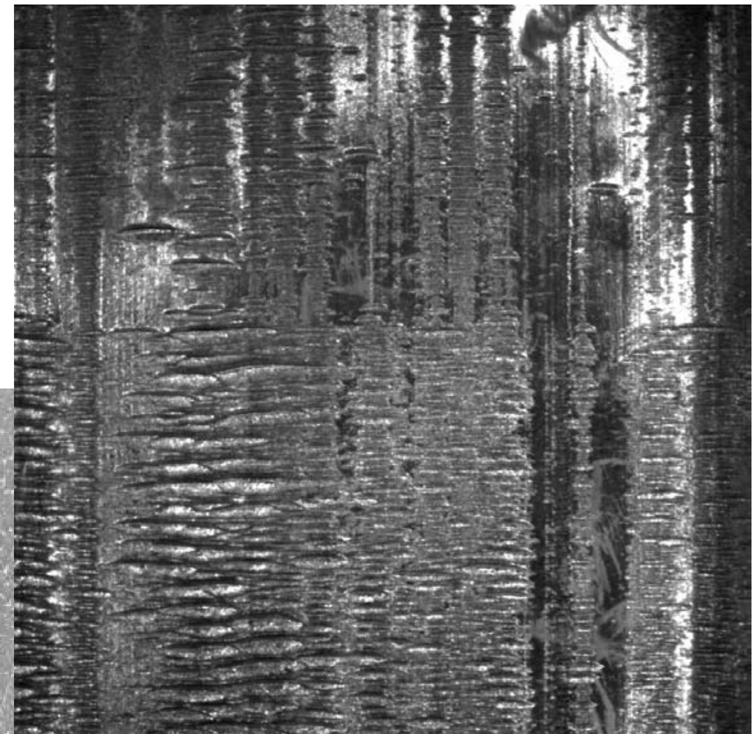


Processing Challenges

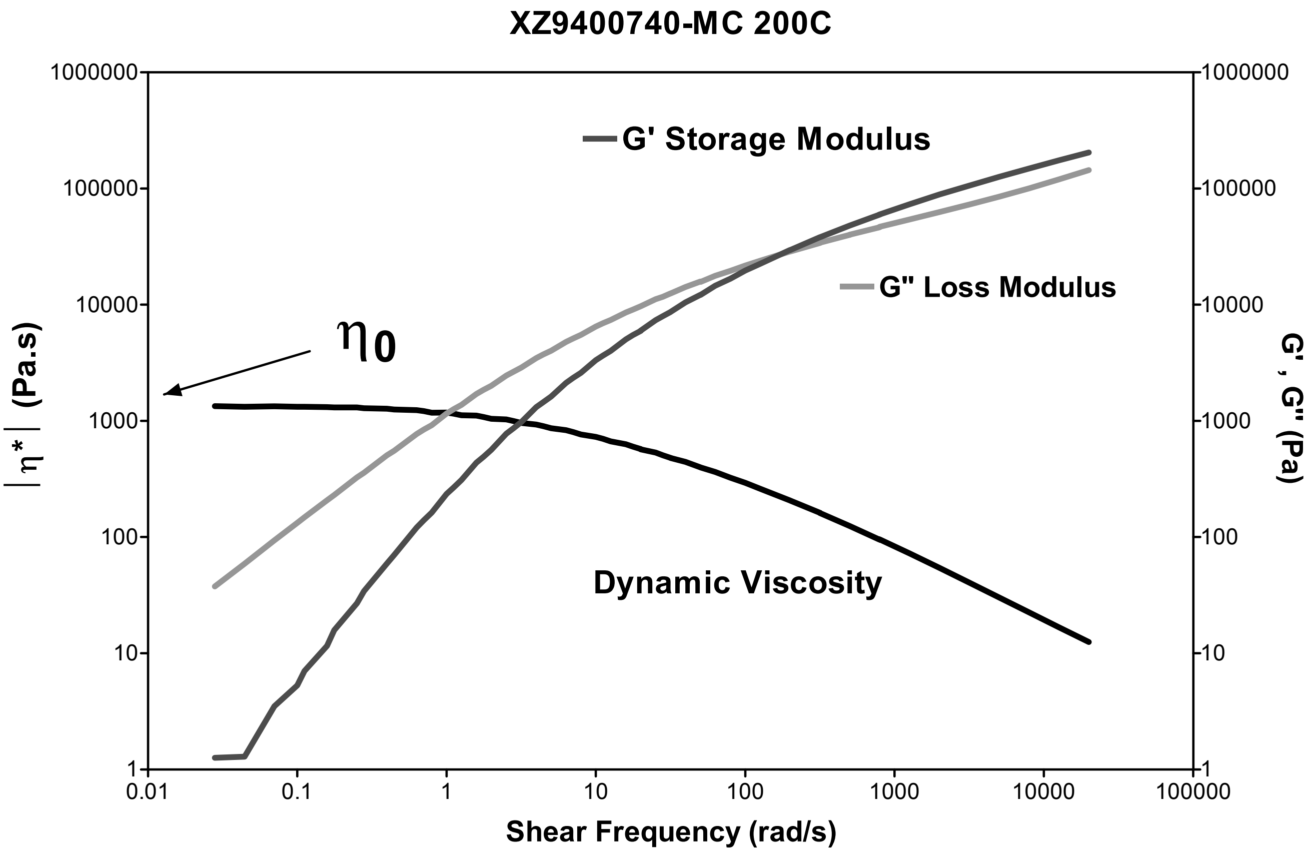
Film distortions come in many shapes





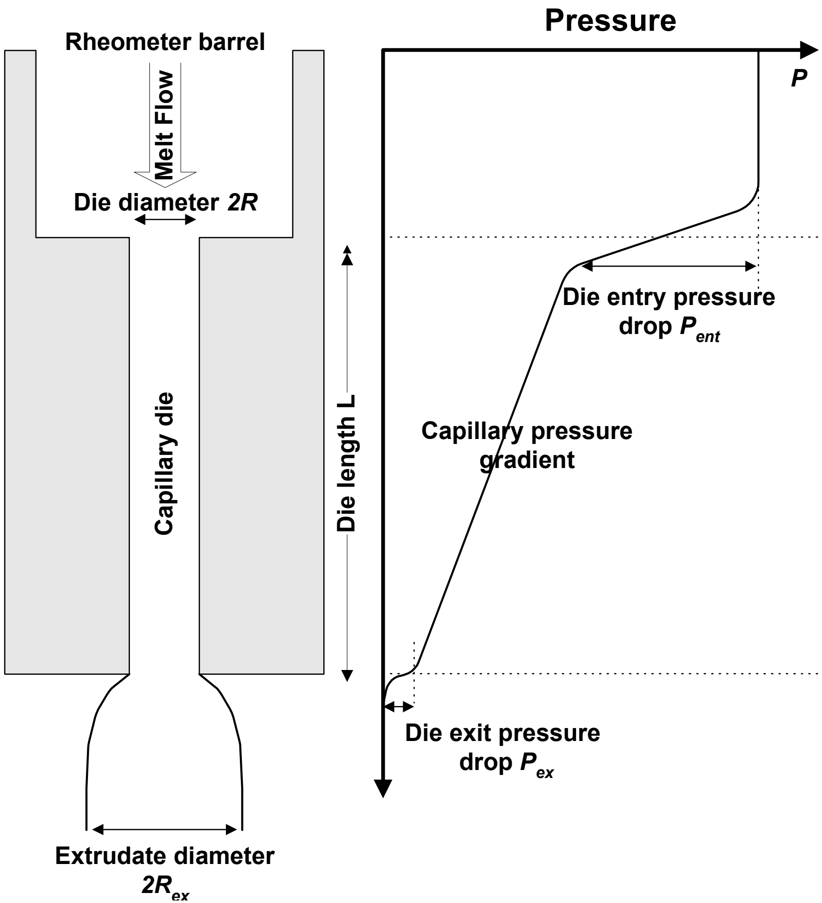


Melt Flow Instabilities



η_0 key metric of the flow curve

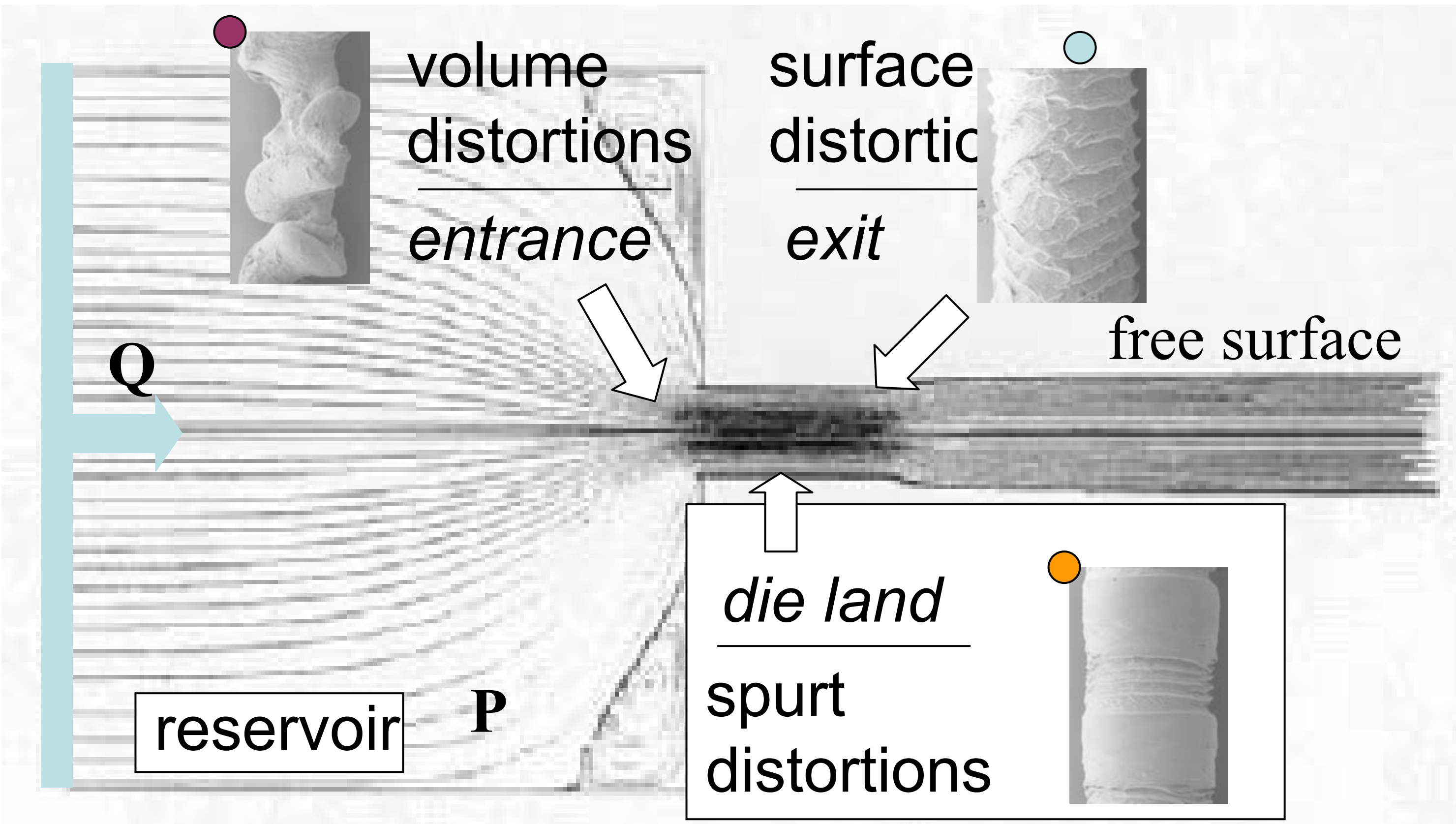
Capillary Rheometer



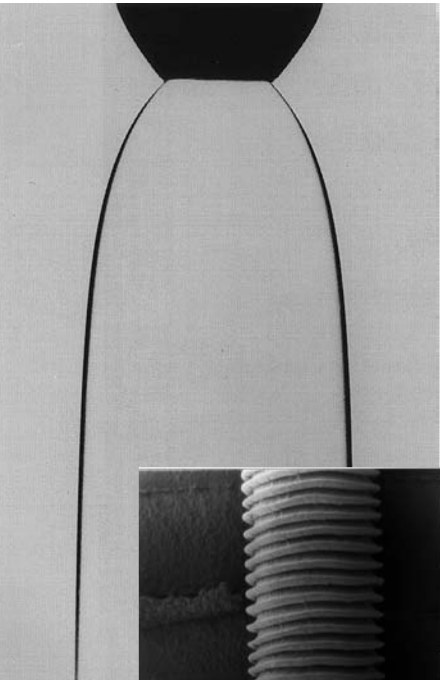
Shear Viscosity Only !

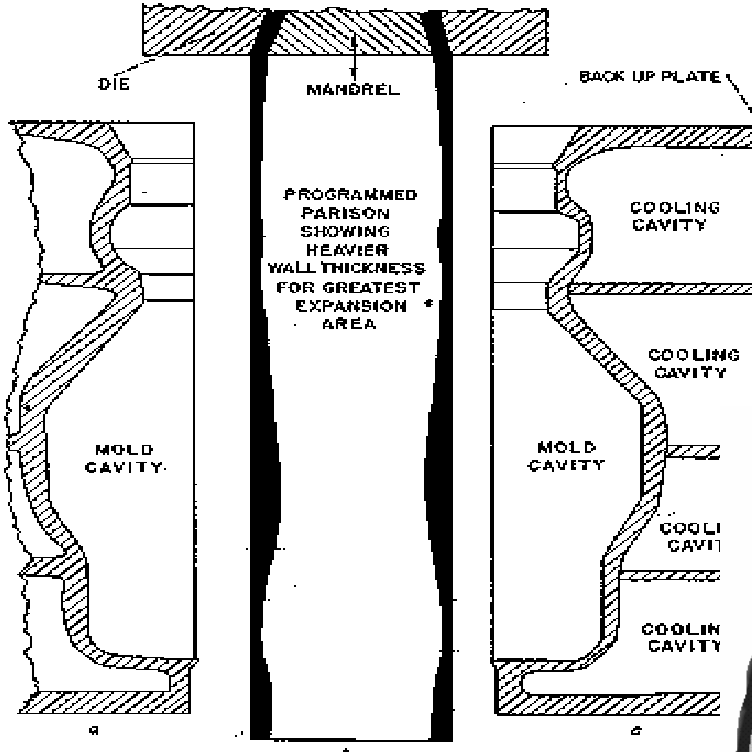
Melt Flow Instabilities

- Examples: LLDPE, HDPE, PP, PS
  - all distortion types

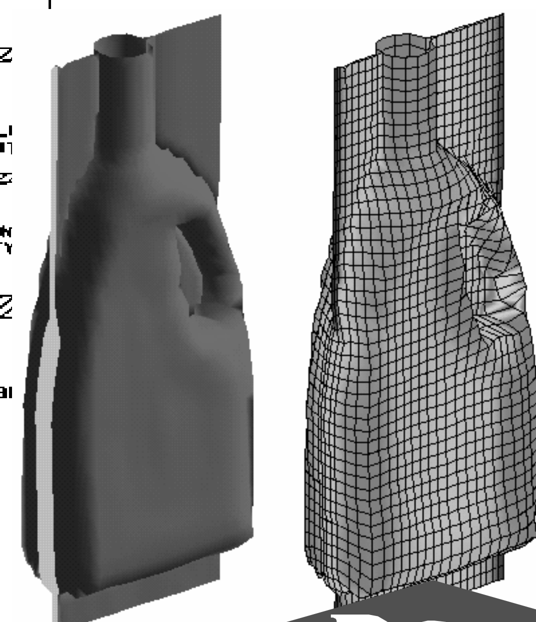


Extrusion Blow Molding of Bottles

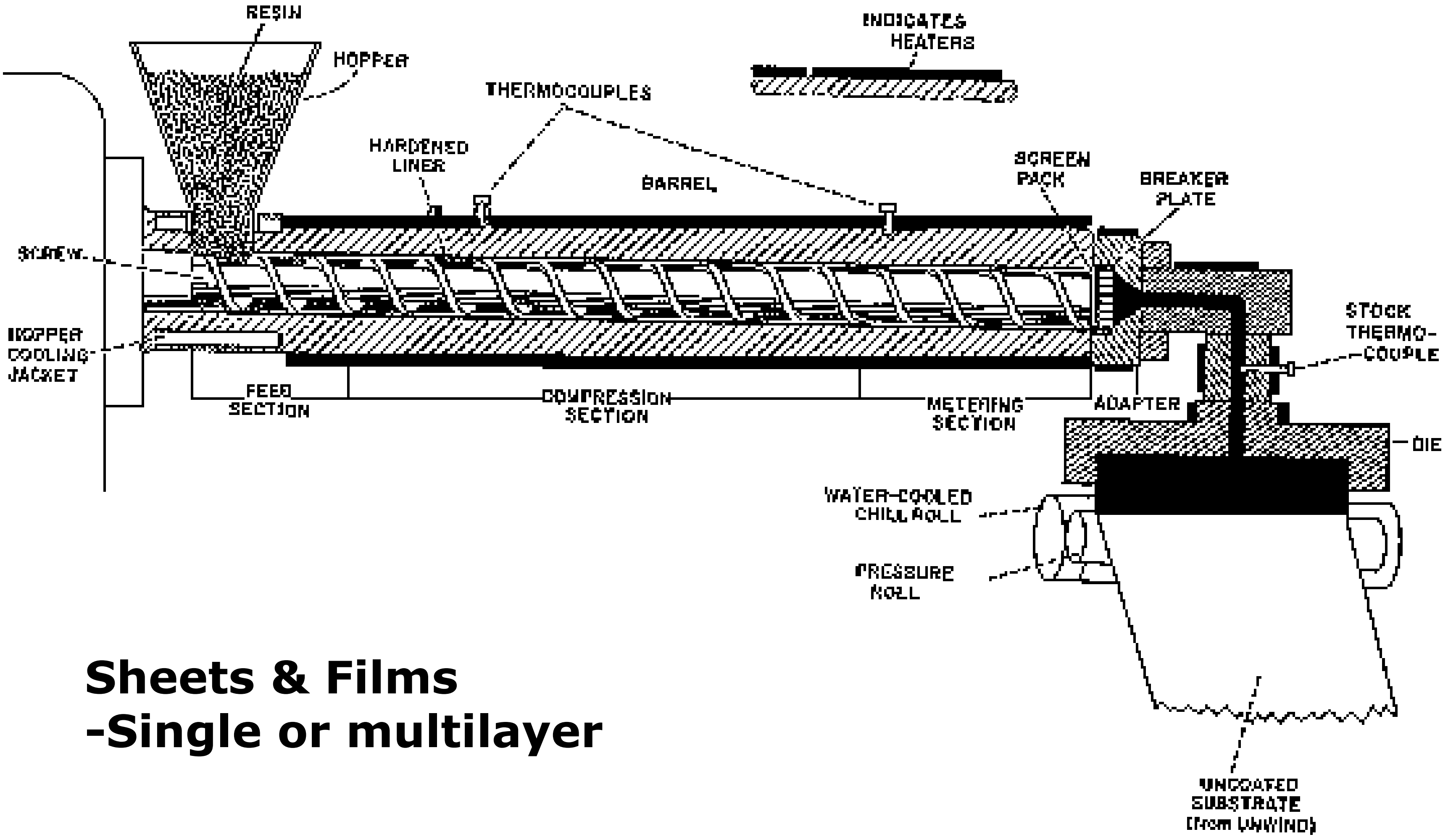




A programmed parison designed to fit a par ticular mold configuration.

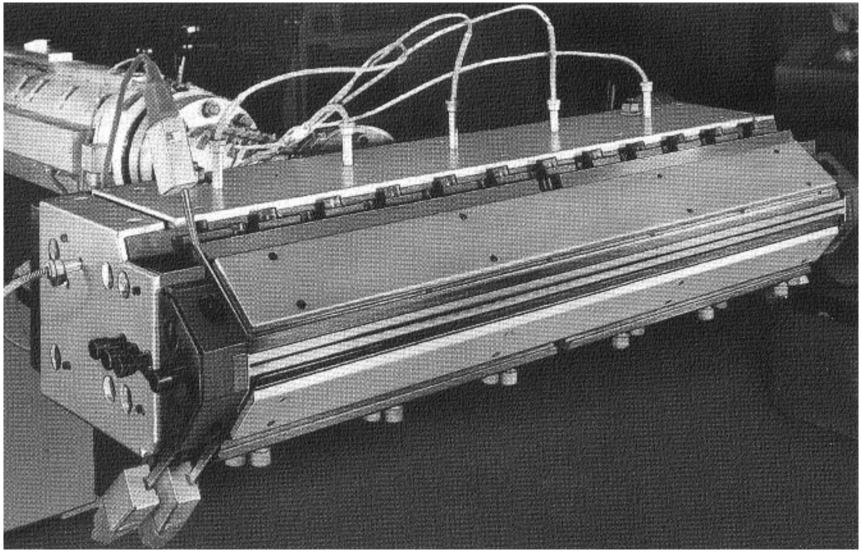


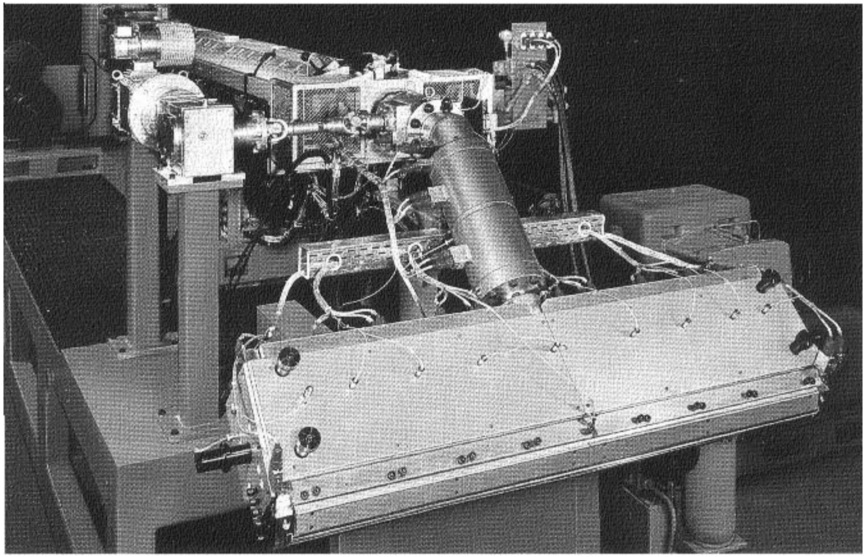
Cast Extrusion



Sheets & Films
-Single or multilayer

Cast Sheet Extrusion





Cast Extrusion

Kinematic hypotheses:

Elongation

$$\dot{\boldsymbol{\varepsilon}} = \begin{bmatrix} \frac{du}{dx} & 0 & 0 \\ 0 & f(x) & 0 \\ 0 & 0 & g(x) \end{bmatrix}$$

Membrane approximation ($\sigma.\mathbf{e_z}\sim 0$)

$$u(x); v(x,y) = y.f(x); w(x,z) = z.g(x)$$

ass conservation: $$\frac{\partial(eL)}{\partial t} + \frac{\partial(eLu)}{\partial x} = 0$$

orce Equilibrium: $$div(\mathbf{e}.\sigma) = \mathbf{0}$$

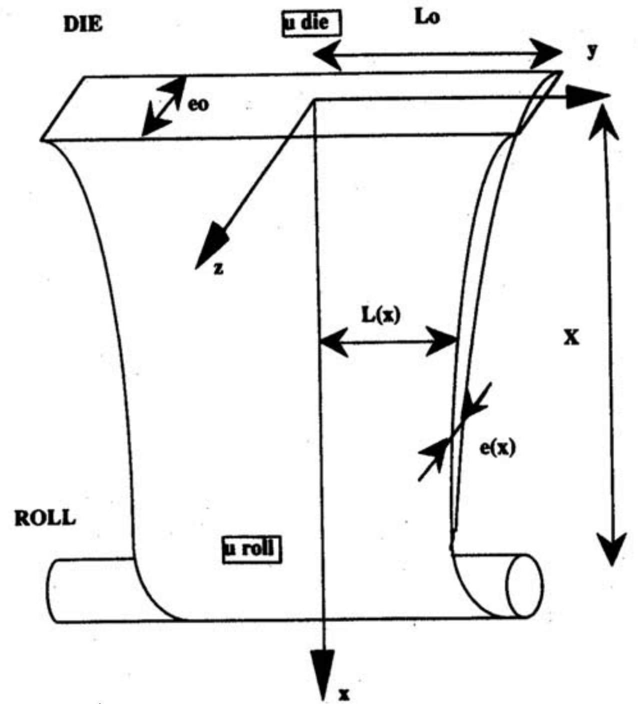
(inertia, gravity, surface tension << drawing force)

onstitutive equations:

$$\begin{cases} \boldsymbol{\sigma} = \boldsymbol{\sigma}' - p\mathbf{I} \\ H(\boldsymbol{\sigma}')\boldsymbol{\sigma}' + \lambda \frac{\delta \boldsymbol{\sigma}'}{\delta t} = 2\eta\dot{\boldsymbol{\varepsilon}} \qquad H(\boldsymbol{\sigma}) = \exp\left[\frac{\varepsilon\lambda}{\eta} tr(\boldsymbol{\sigma})\right].\mathbf{I} \\ \frac{\delta \boldsymbol{\sigma}'}{\delta t} = \frac{\partial \boldsymbol{\sigma}}{\partial t} + (\mathbf{u}.\nabla).\boldsymbol{\sigma}' - \nabla.\mathbf{u}.\boldsymbol{\sigma}' - \boldsymbol{\sigma}'^{t}\,\nabla.\mathbf{u} \end{cases}$$

oundary conditions: $$\boldsymbol{\sigma}.\mathbf{n} = 0 \text{ , } \mathbf{U}.\mathbf{n} = 0$$

(Edge of the film is a free surface)



imensionless numbers:

$$Dr = \frac{u_{roll}}{u_0} \text{ , } A = \frac{X}{L_0} \text{ , } De = \frac{\lambda u_0}{X} \text{ , } \frac{1}{E} = \frac{FX}{\eta e_0 L_0 u_0}$$

D.Silagy, Y.Demay, J.F. Agassant, Pol. Eng. Sci., 1996, vol.36, No.21

Cast Film Stability Map