# Polymer Processing

# Topics

1. Introduction
   - what is polymer processing?
   - role of chemical engineers in polymer processing industry
   - why rheology?
2. Introduction to extrusion
   - why statistical process control in polymer processing?
3. Introduction to injection molding
   - why design of experiments in polymer processing?
4. Fundamentals of polymers
   - material properties
   - mechanical properties
5. Rheology
   - flow field
   - rheological properties
6. Constitutive equations

- Mid Exam

7. Statistical process control
   - process capabilities
   - 6 sigma process control
8. Design of experiments
   - method of orthogonal arrays
   - Taguchi method
9. Extrusion process
   - mixing
   - single screw extrusion
   - twin screw extrusion
10. Injection molding process
   - CAE (Computer Aided Engineering)
   - typical problems in injection molding
   - new technologies
11. Others
   - other processes
   - role of chemical engineers in polymer processing industry

- Final Exam

평가:

- Mid Exam (20%), Final Exam (35%), HW (25%), Quiz & Reading (20%)

# Questions !

- What is polymer?

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- What is polymer processing?

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- What is polymer processing?
- What is polymer industry?

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- What is polymer processing?
- What is polymer industry?
- What is industry?

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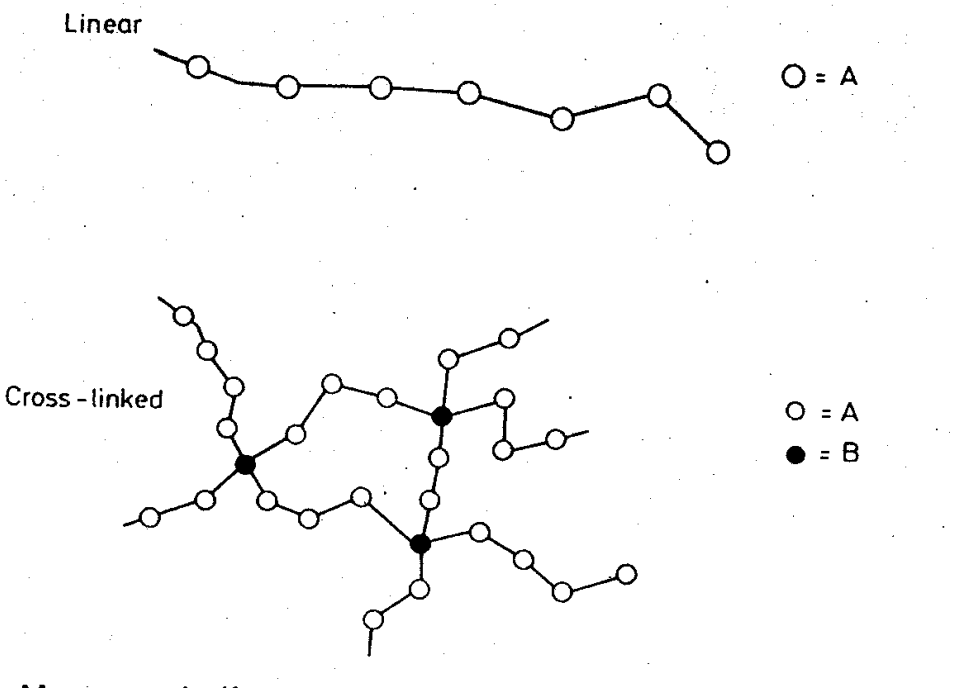
- What is polymer?
- What is polymer processing?
- What is polymer industry?
- What is industry?
- What is the role of chemical engineers in polymer industry?

# Questions !

- What is polymer?

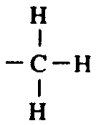
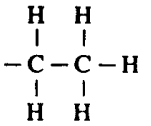
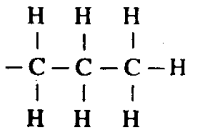
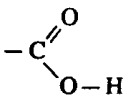
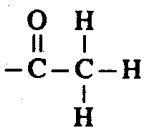
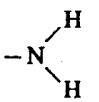
# Polymer

- A long molecule consisting of many small units(monomers) joined end to end



# Radical groups

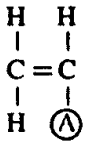
**Table 1.7.** Polymer radical group structure (23).

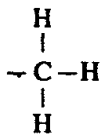
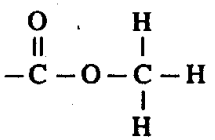
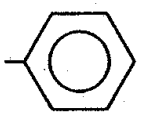
| Radical group name | Formula | Structure |
|---|---|---|
| Methyl | $-CH_3$ |  |
| Ethyl | $-CH_2CH_3$ |  |
| Propyl | $-CH_2CH_2CH_3$ |  |
| Hydroxyl | $-OH$ |  |
| Carboxyl | $-COOH$ |  |
| Acetyl | $-COCH_3$ |  |
| Aldehyde | $-CHO$ |  |
| Amino | $-NH_2$ |  |

Polymer Processing

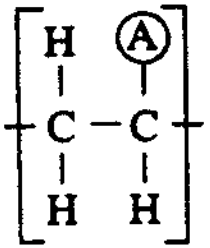
# Vinyl structure

**Table 1.8.** Monomers based on the ethylenic or vinyl structure.

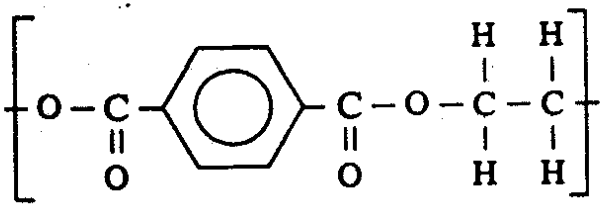
| The basic unit: |  |
|---|---|

| When A is: | Monomer is: |
|---|---|
| —H | Ethylene |
| —Cl | Vinyl chloride |
| —F | Vinyl fluoride |
|  | Propylene |
|  | Methyl acrylate |
|  | Styrene |

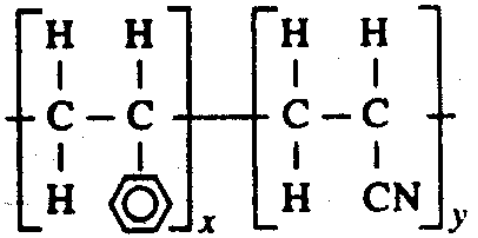
# More...




PE, PP, PVC, PS, PVA ...




Polyethylene terephthalate (PET)




Styrene–acrylonitrile (SAN)

PMMA, PA, PU, PC, SBR, EVOH, ABS ...

# Polyethylene

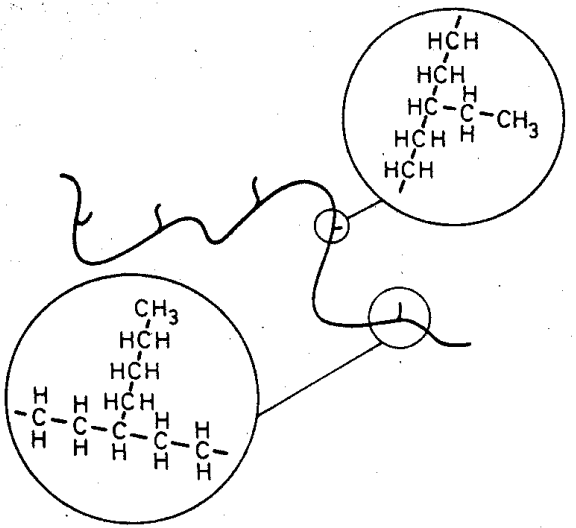


Fig. 1.1. Side branched polyethylene.

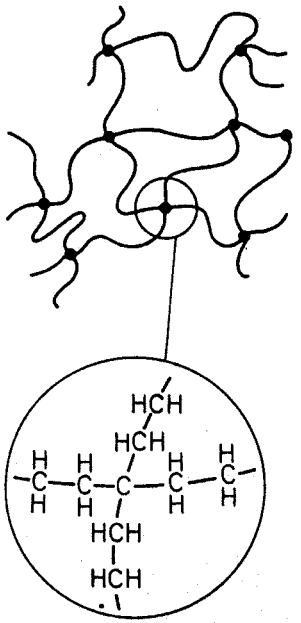
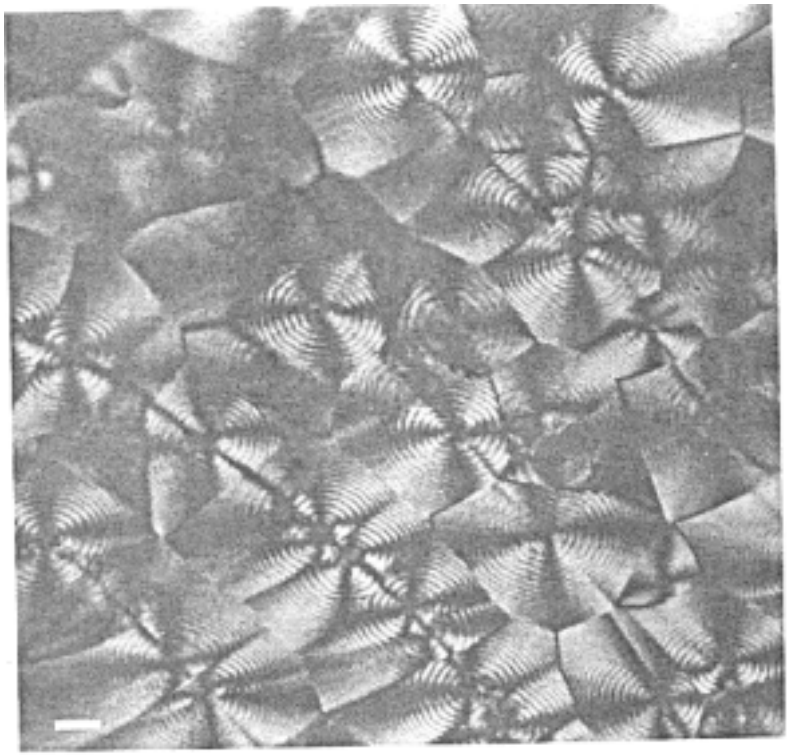


Fig. 1.2. Illustration of the molecular structure of cross-linked polyethylene in the liquid state. The spaces between the sketched net are filled with other parts of the network.

# Polyethylene



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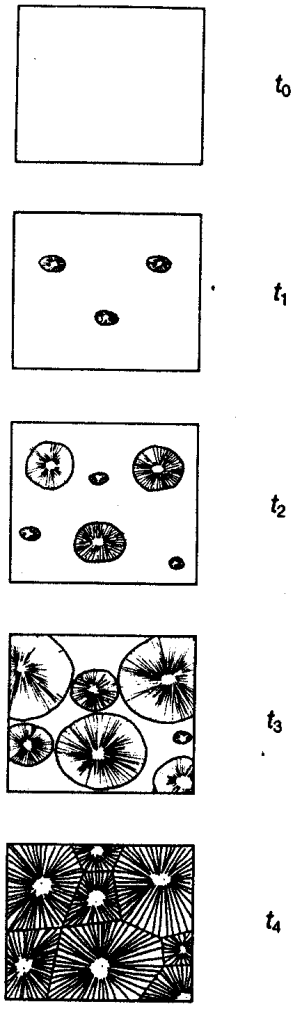
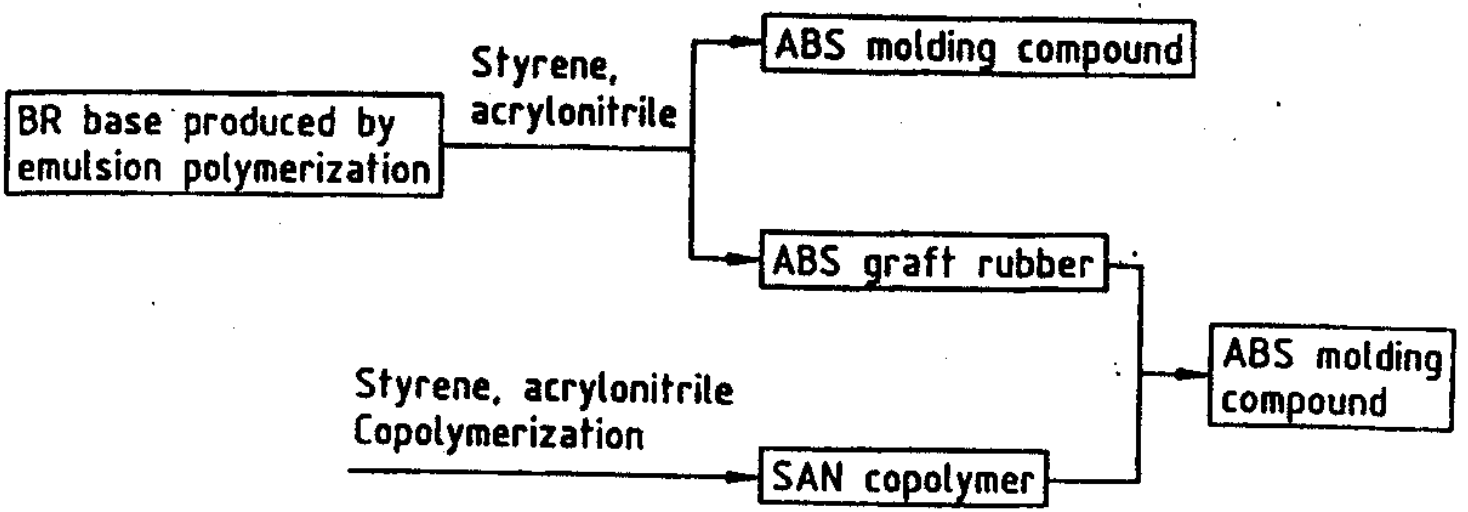
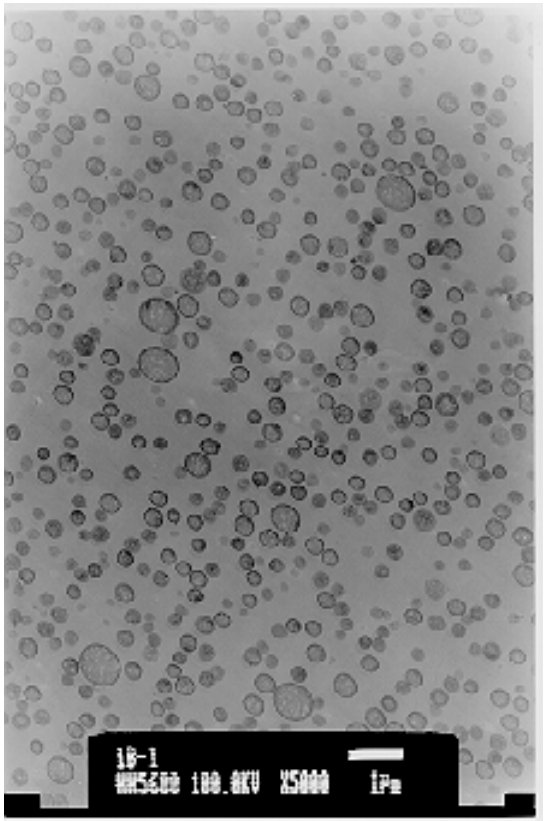
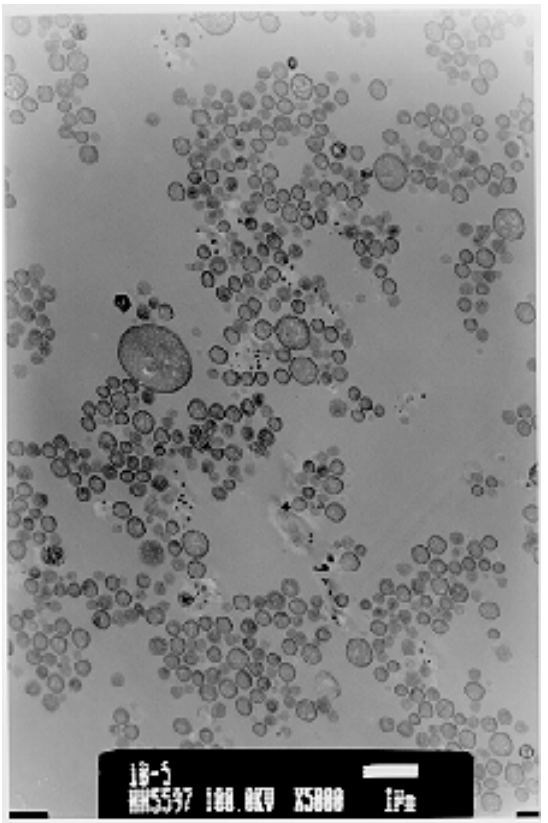


# ABS
## (Acrylonitrile - Butadiene - Styrene)



# ABS



# Components

- G - ABS
- San
- Anti - oxydent
- Lubricant
- colorant
- Others
  - Light stabilizer, acid scavenger, filler, frame retardant, coupling agent...

# What is good resin?

- Design
  - Overall performance
  - Processing, material(chemistry,morphology)
- Production
  - Uniformity, apprearance
- marketing

# Questions !

- What is polymer processing?

# Polymer processing

- Extrusion
  - Compounding, sheet, pipe …
- Injection molding
- Blow molding
- Thermoforming
- Film blowing
- Fiber spinning
- etc

# Extrusion

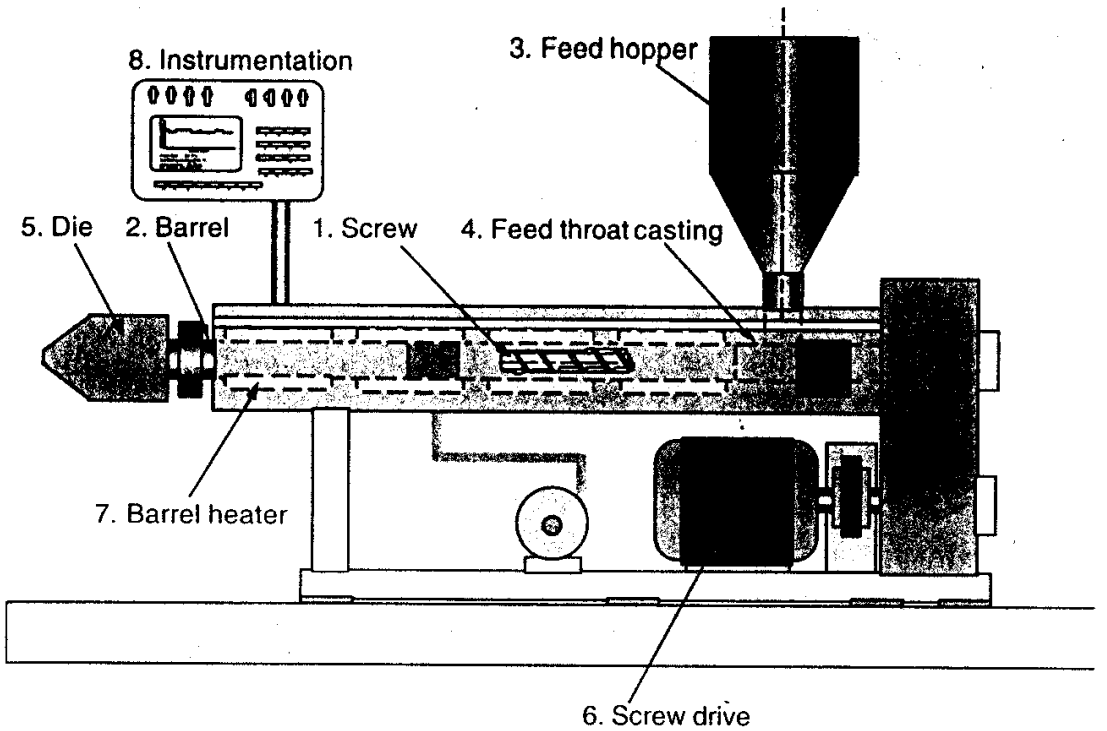



Figure 2.1 The main components of a single screw extruder

# Pipe extrusion

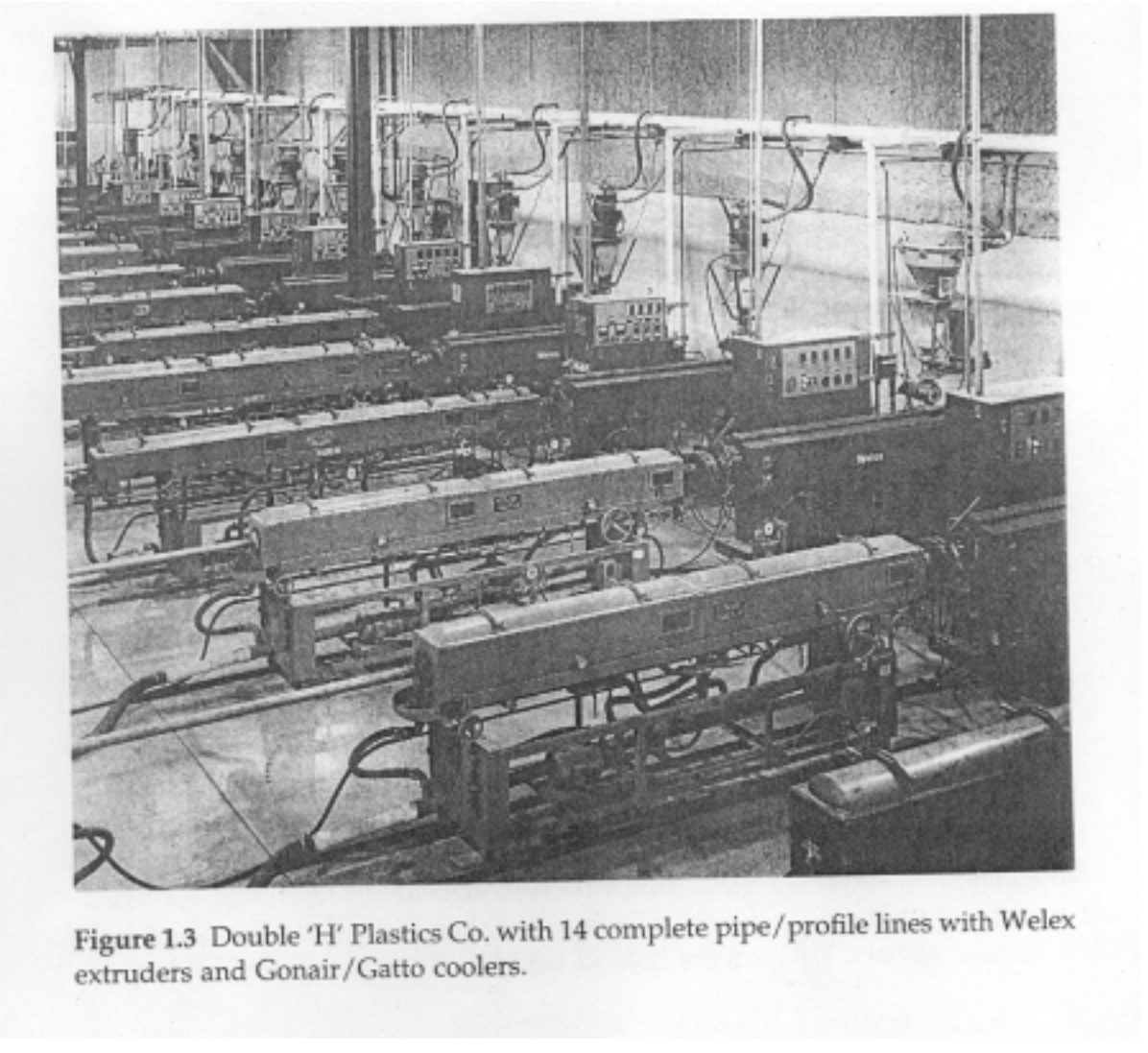


**Figure 1.3** Double 'H' Plastics Co. with 14 complete pipe/profile lines with Welex extruders and Gonair/Gatto coolers.

# Sheet extrusion

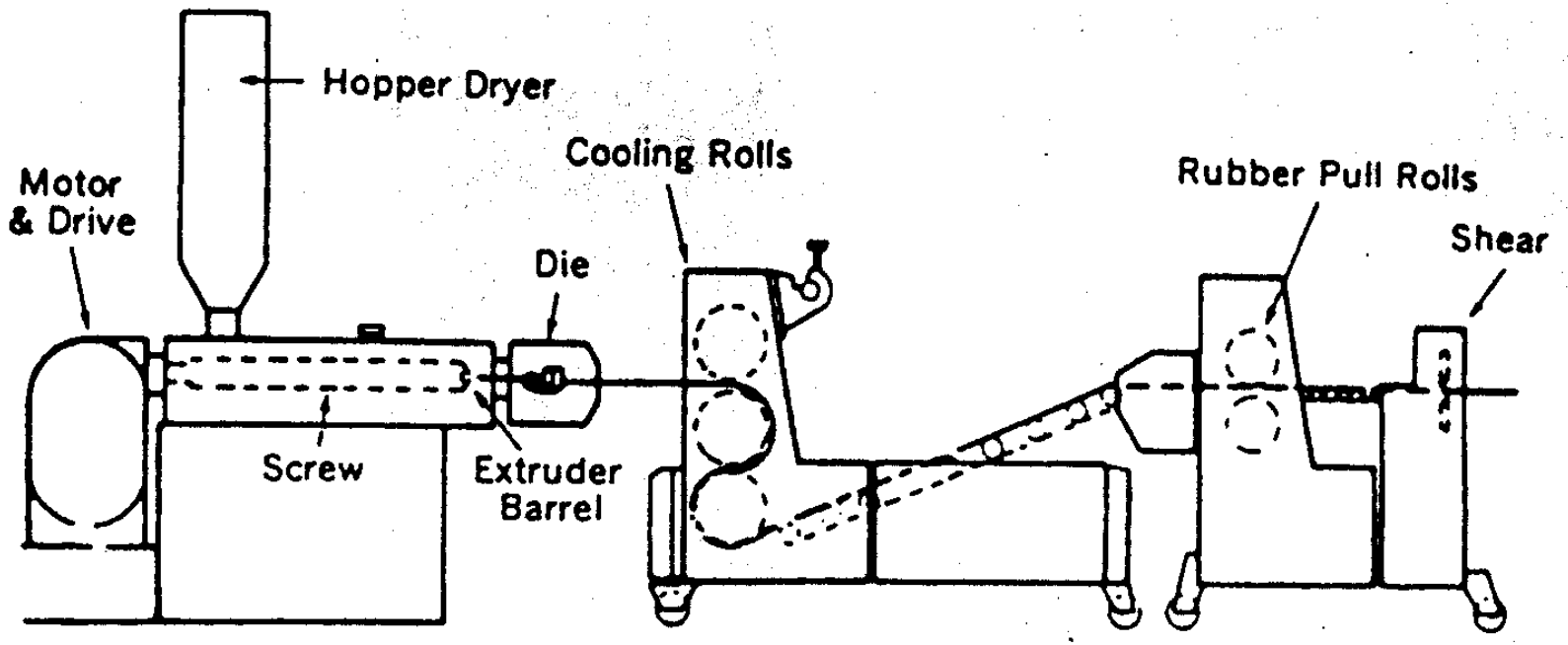



**Figure 9.1** Sheet line using a stand of three cooling rolls.

# Injection molding

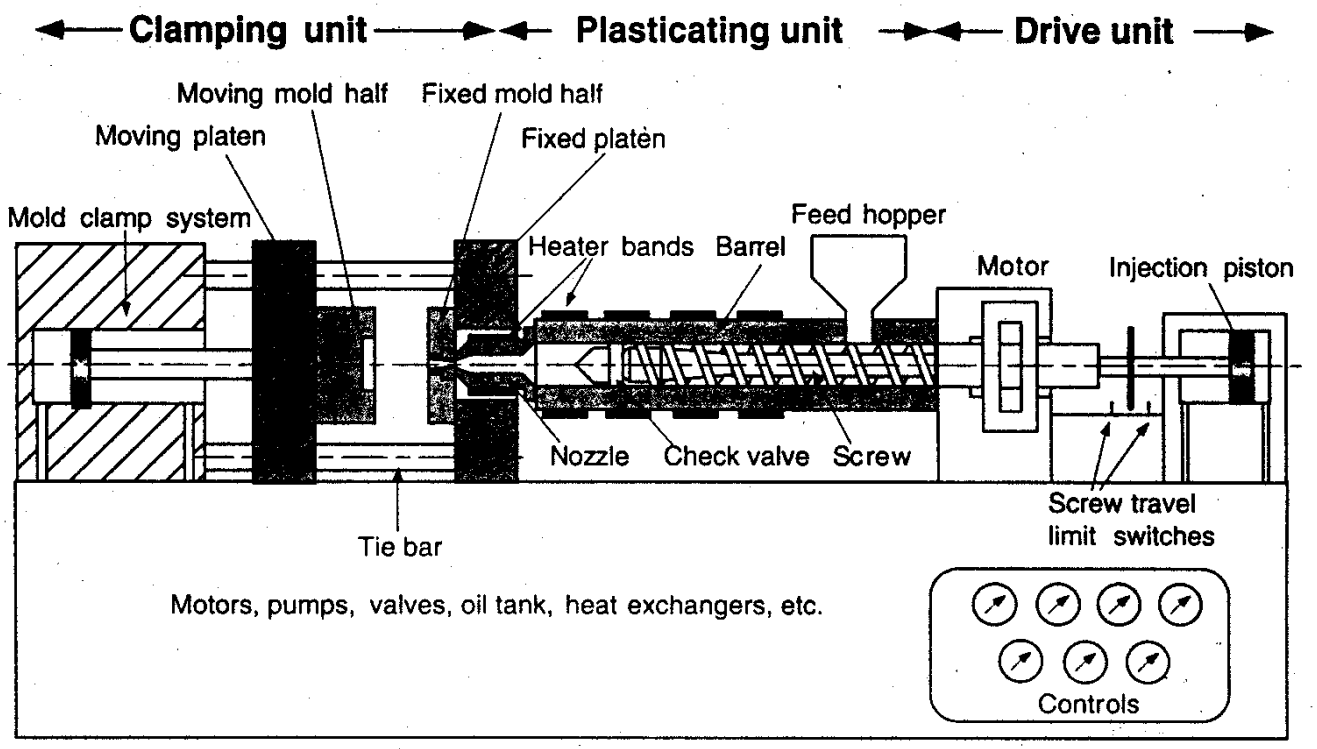



Figure 1.1 Schematic of a typical injection-molding machine

# Blow molding

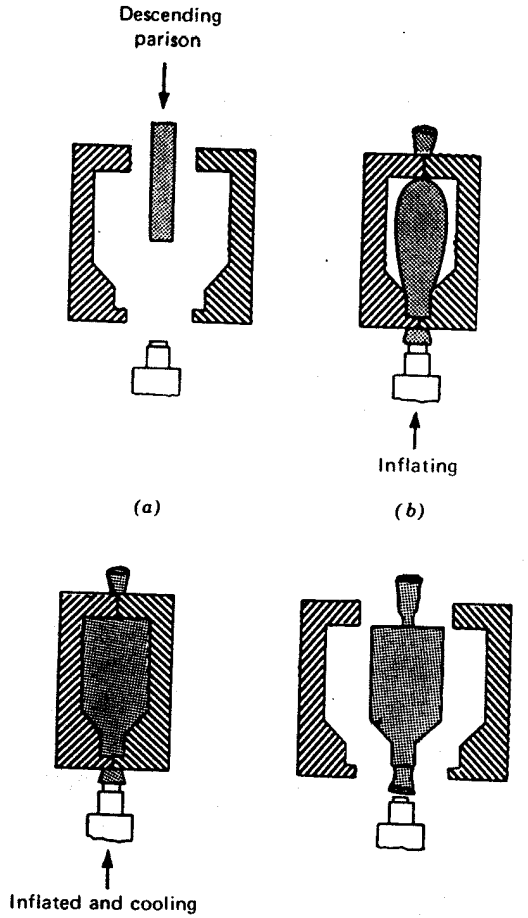
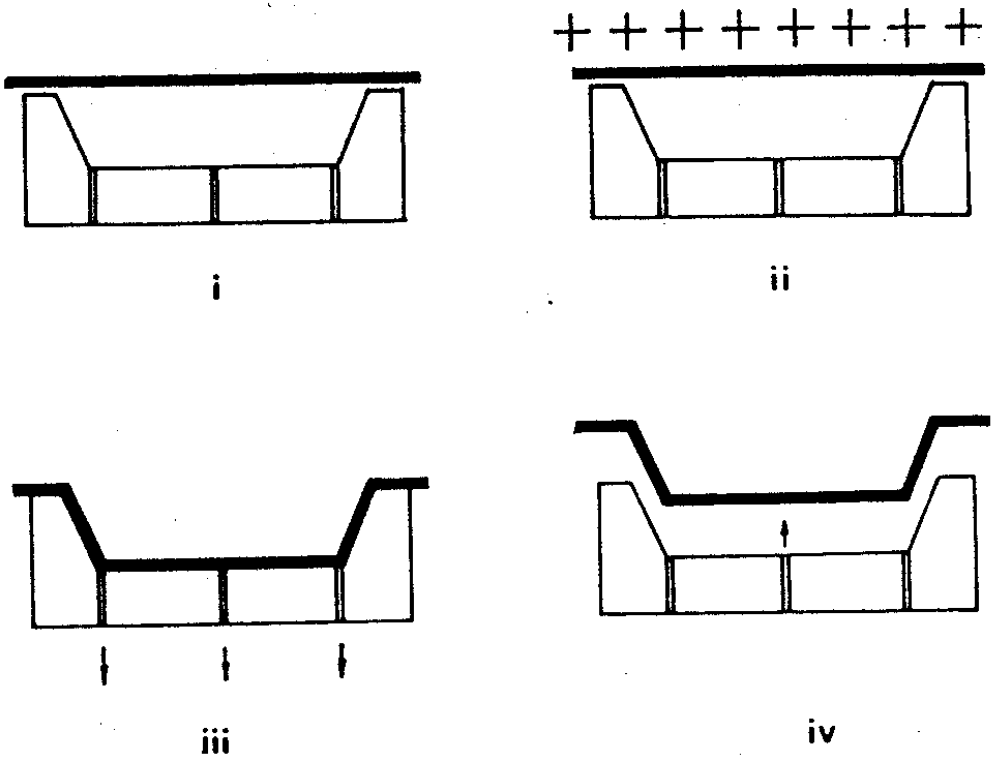


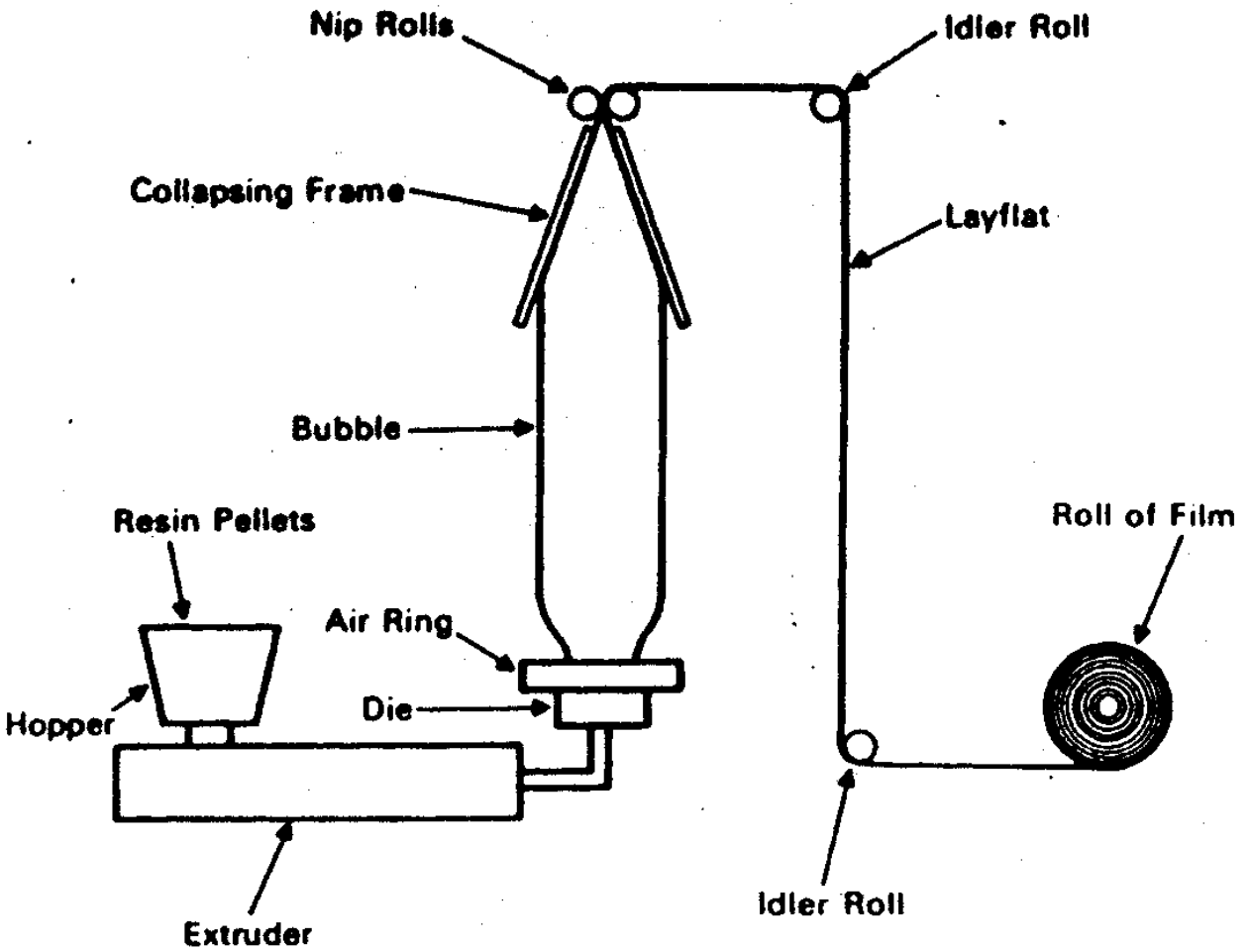

**Fig. 1.17.** Schematic view of the blow molding process. (Reprinted with permission from W. A. Holmes Walker, *Polymer Conversion*, Halsted Press, London, 1975.)

# Thermoforming

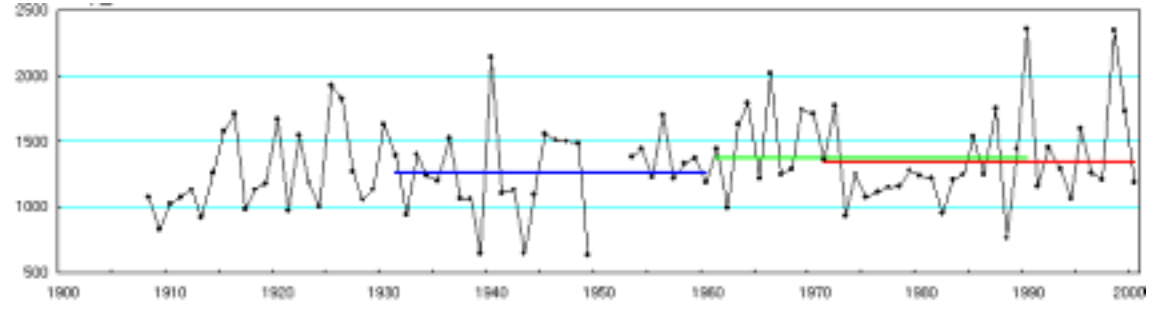



(a)

# Film blowing



# Statistics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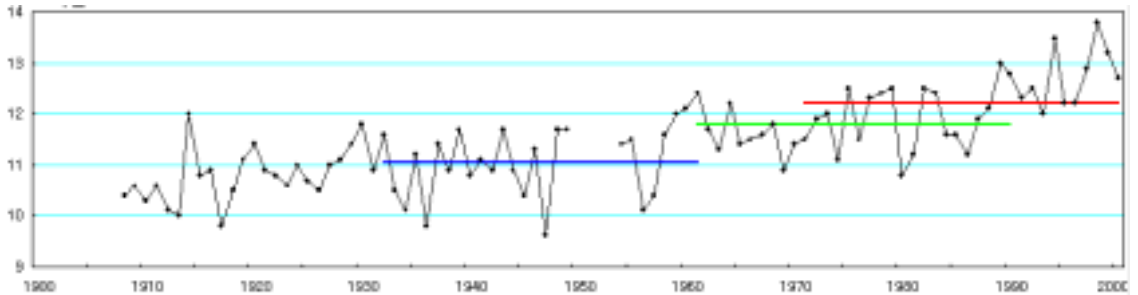
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# Questions !

- What is polymer industry?

# Polymer industry

LG화학

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LG 화학 주요 사이트

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Acrylic Acid & Acrylates, IPA, NPG, Alcohol, NaOH

Polymerwide

ABS, PS, SAN, PMMA, PVC, 가소재, PE...

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OB Club 바로가기

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# Polymer industry

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English / Korean

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# Polymer industry

# Polymer industry

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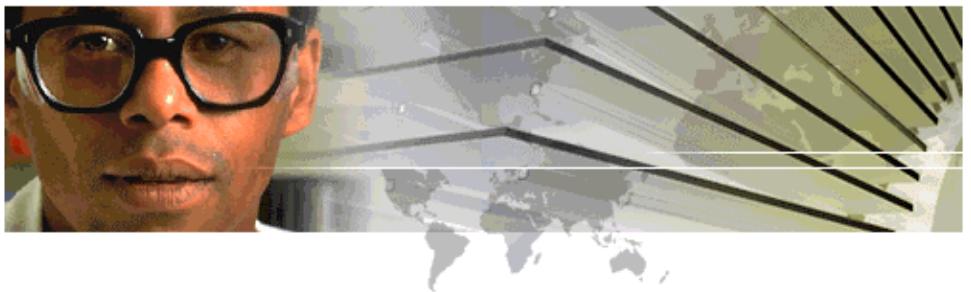

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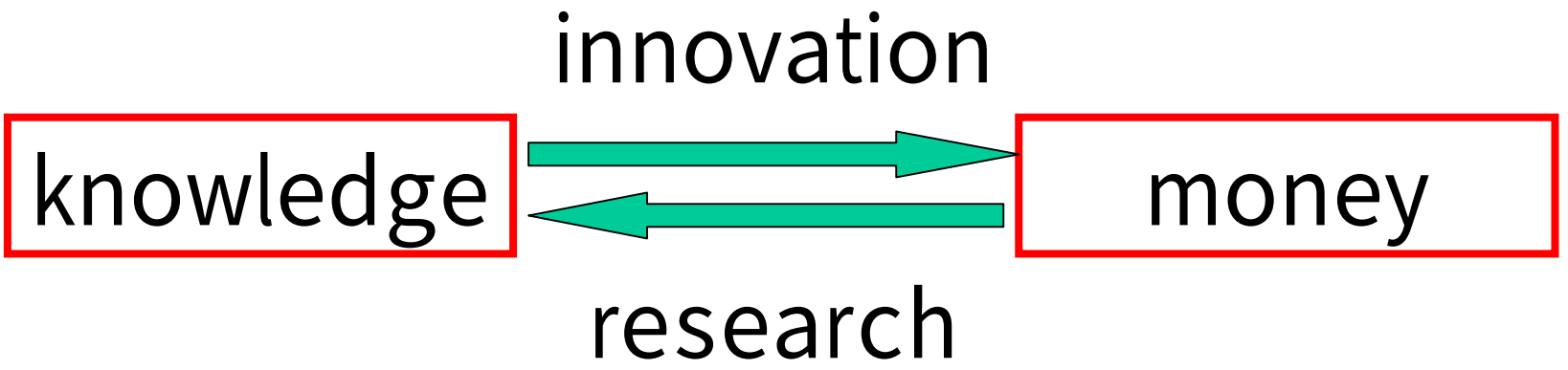
# Questions !

- What is industry?

# Industry (Innovation)




Competitiveness, customer oriented

# Questions !

- What is the role of chemical engineers in polymer industry?

# Role of chemical engineers

- R&D
- Production
- T/s
- Sales & marketing
- Management
- CEO/CTO

# Young chemical engineers…

- Knowledge – problem solving
- Passion
- creativity
- Dream/vision
- Leadership

# What is the problem?