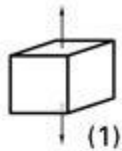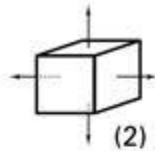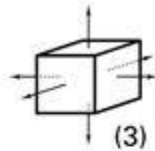# Metal Forming

Classification of States of Stress
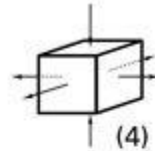

(1) Simple uniaxial tension
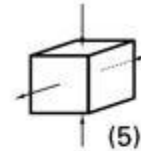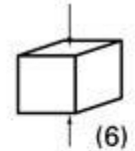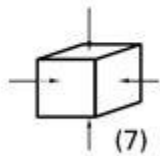
(2) Biaxial tension

(3) Triaxial tension
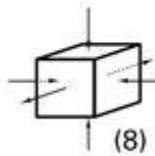
(4) Biaxial tension, compression

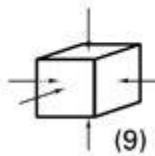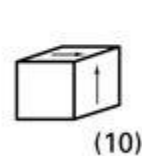(5) Biaxial tension and compression
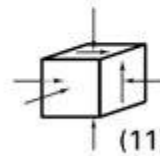
(6) Uniaxial compression
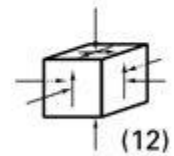
(7) Biaxial compression

(8) Biaxial compression, tension

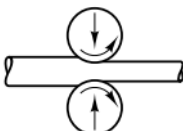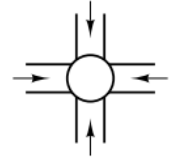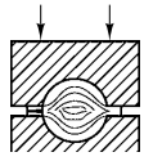(9) Triaxial compression

(10) Pure shear
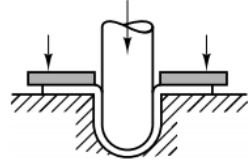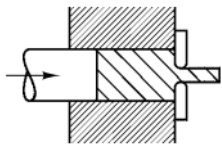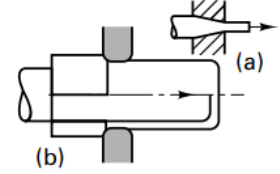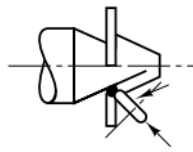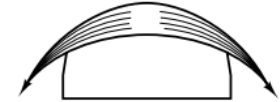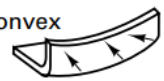
(11) Simple shear with triaxial compression

(12) Biaxial shear with triaxial compression

Classification of Some Forming Operations

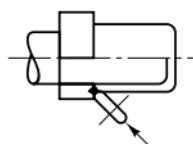| Classification of Some Forming Operations		
Process	Schematic Diagram	State of Stress in Main Part During Forming[a]
Rolling		7
Forging		9
Extrusion		9
Shear spinning		12
Tube spinning		9
Swaging or kneading		7
Deep drawing		In flange of blank, 5 In wall of cup, 1
Wire and tube drawing		8
Stretching		2
Straight bending		At bend, 2 and 7
Contoured flanging	(a) Convex	At outer flange, 6 At bend, 2 and 7
	(a) Concave	At outer flange, 1 At bend, 2 and 7

[a]Numbers correspond to those in parentheses of previous slide's table.

Independent and Dependent Variables Linked

Independent variables	Links	Dependent variables
Starting material		Force or power requirements
Starting geometry	-Experience-	
Tool geometry		Product properties
Lubrication	-Experiment-	Exit temperature
Starting temperature		Surface finish
Speed of deformation	-Modeling-	Dimensional precision
Amount of deformation		Material flow details

Effects of Temperature
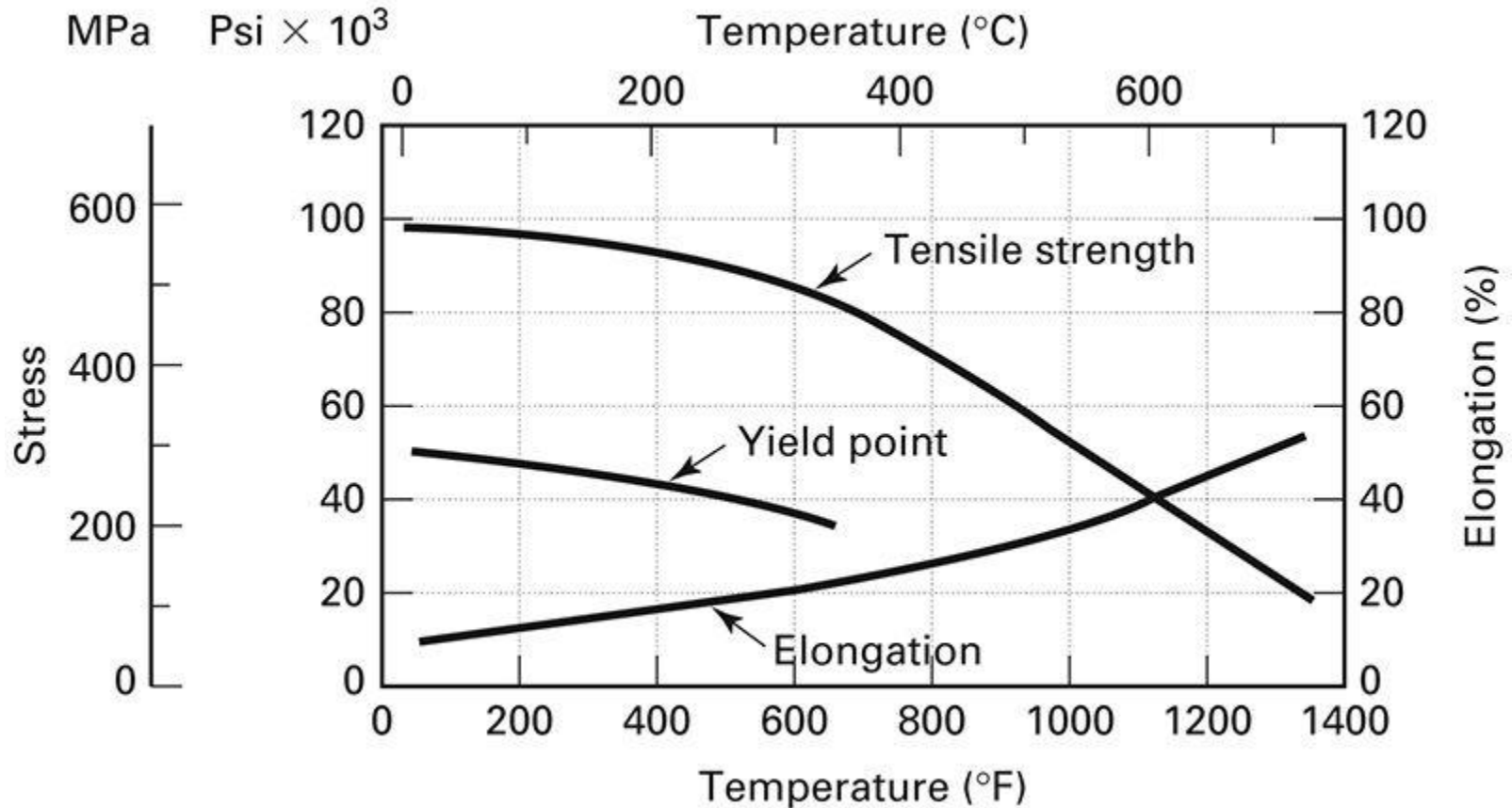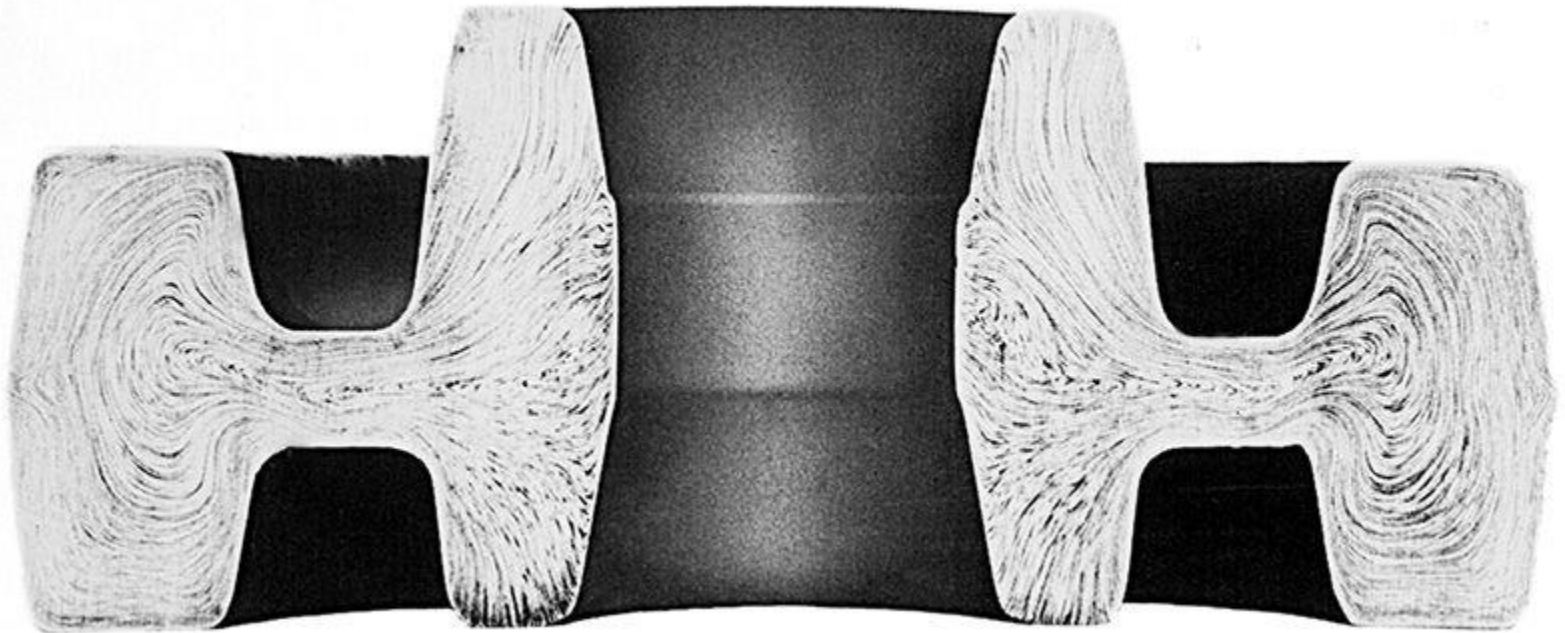
Cast Structure
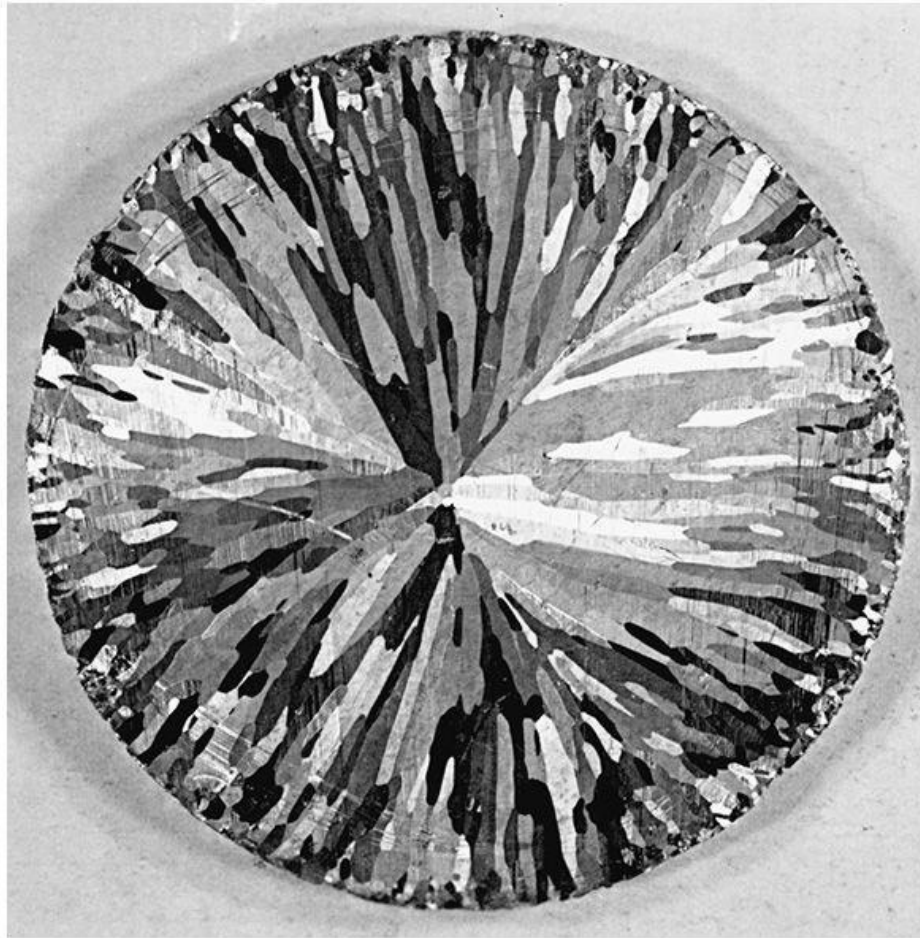
Flow Structure

Springback

Increase in tensile strength due to work hardening. The high-carbon steel will also have more springback.

True stress

0 x_1 x_2 x_3 x_4

True strain
Low-carbon steel

True stress

0 x_1 x_2 x_3

True strain
High-carbon steel
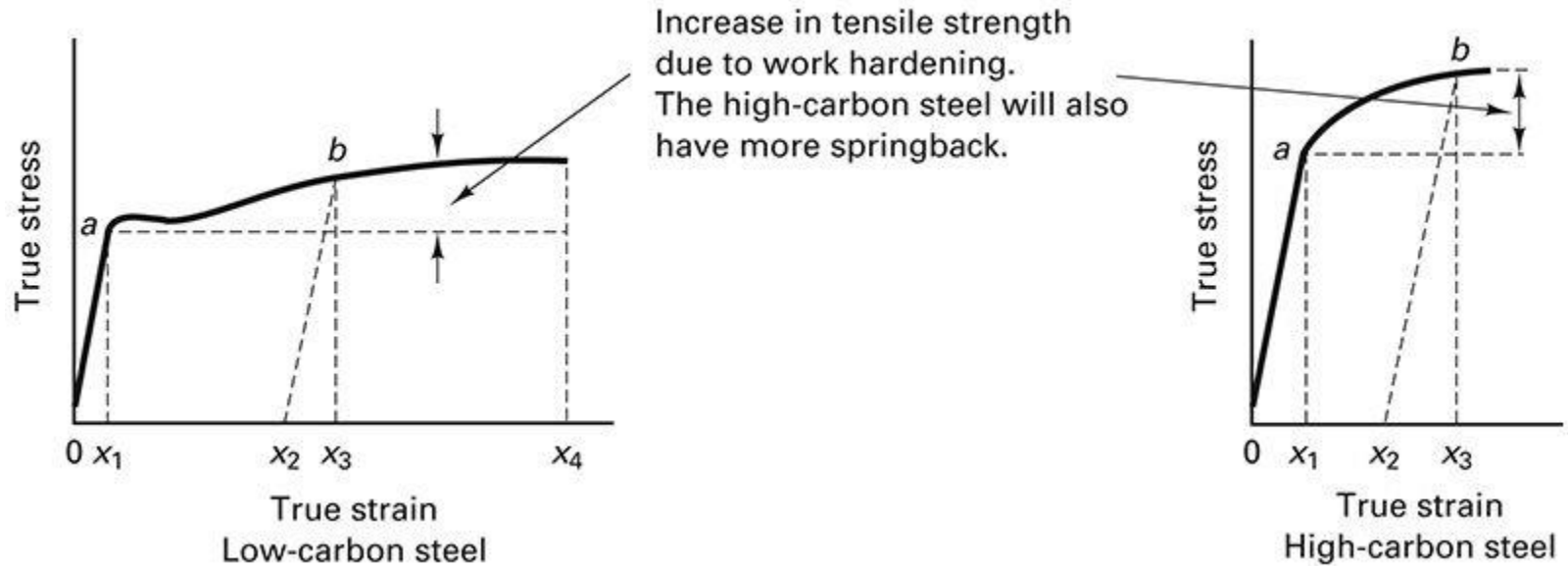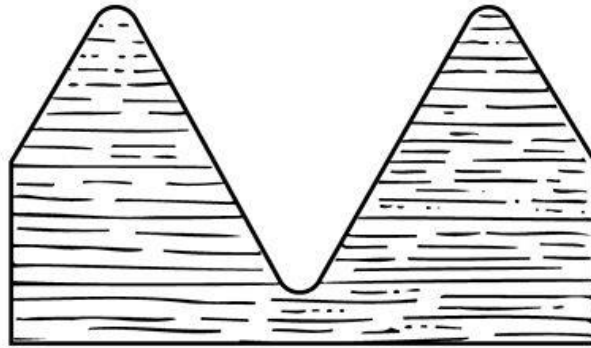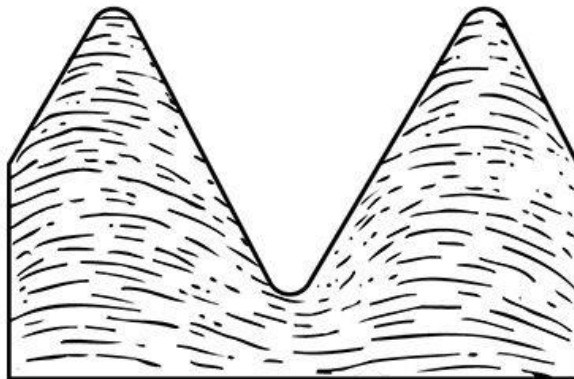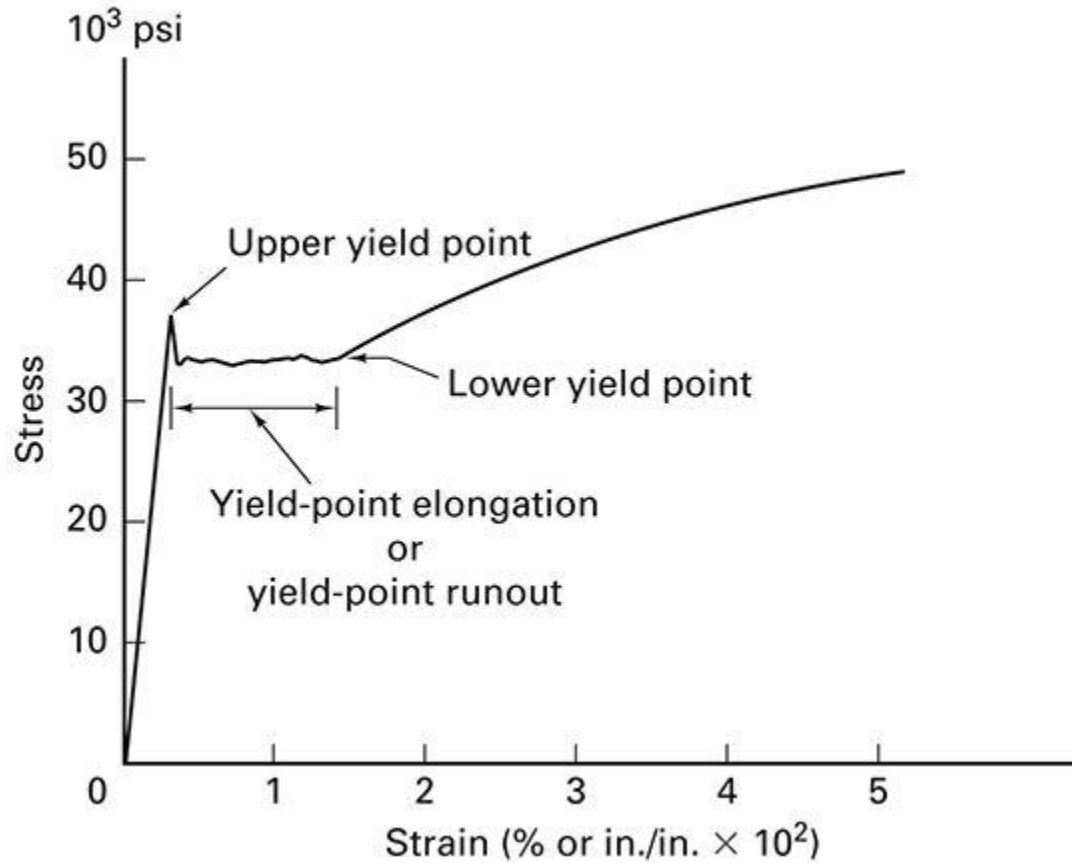
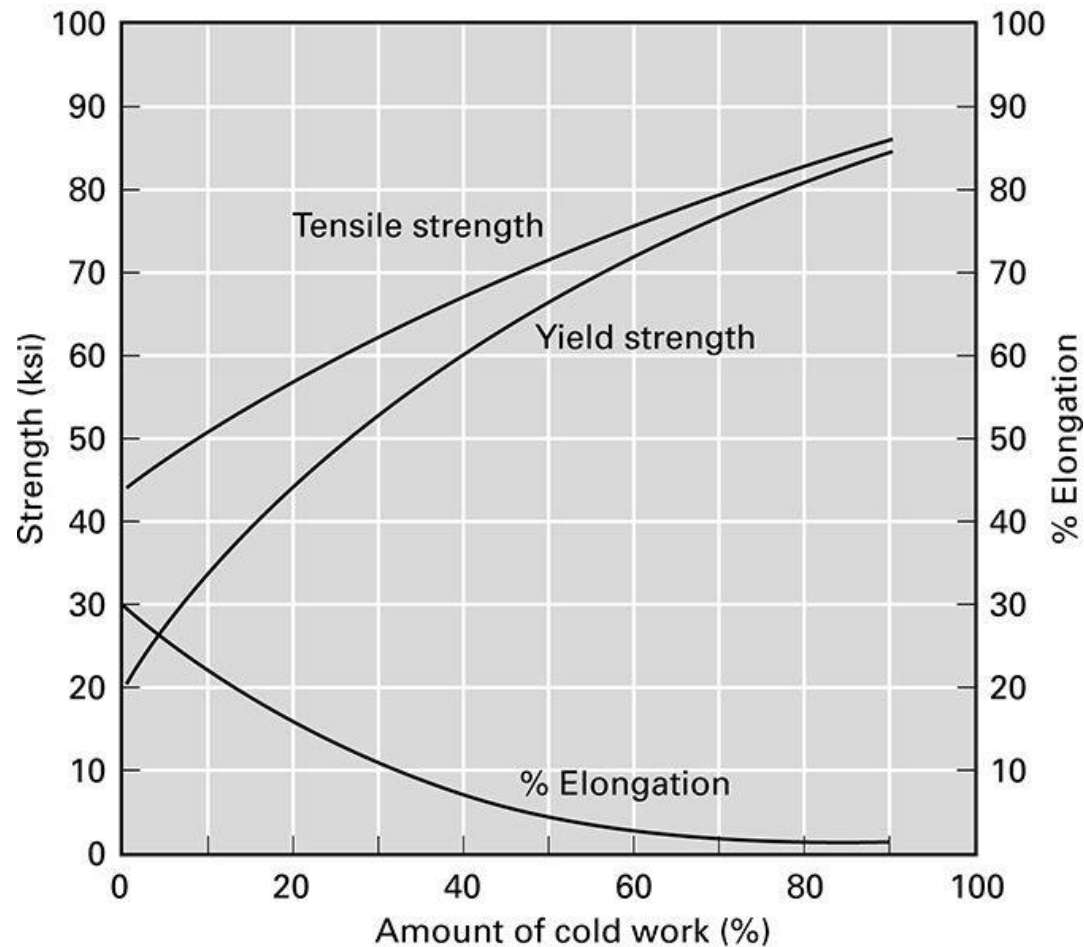# Machined vs. Rolled Threads

(a)

(b)

Luders Bands

Mechanical Properties vs. Cold Work

Yield Strength vs. Temperature