DEPT. OF MECH. AND IND. ENG.

MECH 421/6511 Shaping of Metals and Plastics

LECTURES: Mon-Wed ER- 511-9 at 4:15 to 5:30 pm

FACULTY: Dr. Mamoun Medraj

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Office Hours: **Mon. from 10:00 to 12:00 am. and Fri. from 4:00 to 5:00 pm.**

TEXTBOOKS:

- Fundamentals of Modern Manufacturing – *materials, processes and systems*, Mikell P. Groover, Wiley, 2nd Edition, 2002
- Manufacturing Processes for Engineering Materials, Serope Kalpakjian and Steven R. Schmid, Prentice Hall, 4th Edition, 2003

References:

1. Materials and Processes in Manufacturing, E. Degarmo, J.T. Black and R.A. Kohser, Wiley, 9th Edition, 2002.
2. Mechanical Metallurgy, G.E. Dieter, McGraw-Hill, 3rd Edition, 1986
3. Material Science and Engineering, W.D. Callister, 6th Edition, Wiley, 2002

MECH 421/6511 Shaping of Metals and Plastics

Handouts: are available at

www.me.concordia.ca/~mmedraj/mech421.html

Assessment:	MECH 421	MECH 6511
Lab	15 %	--
Assignments	10 %	15 %
Exams:		
• Midterm	25 %	25 %
• Final	50 %	60 %

- Assignments problems will be collected and marked, Some of them (or similar ones) will be asked in the exams.
- TA and lab instructor: Mr. Haider Al-Kazzaz, email: hkazzaz@yahoo.com

Course Outline

Manufacturing Processes

- Introduction to Mechanical Shaping (1 lecture)
- Review of Mechanical Properties (1 lecture)
- Annealing – Recrystallization
- Forming Process Variables
  - *hot, warm or cold forming*
- Bulk Deformation:
  Rolling, Forging, Extrusion, Drawing
  (5 lectures)
- Sheet metalworking:
  Bending, Shearing, Deep drawing (3 lectures)
- Super Plasticity (1 lecture)
- Forming and Shaping of Plastics:
  Extrusion, Moulding, Thermo-forming (5 lectures)
- Material Removal:
  Machining, Cutting Tools (4 lectures)
- Powder Metallurgy (2 lectures)

$\sum$ = 22 + 1 Midterm + 2 review = 25

What is Manufacturing?

Manufacture is derived from two Latin words *manus* (hand) and *factus* (make); the combination means "made by hand"

"Manufacture" was first coined around 1567 A.D.

Made by hand???!!!

What about the Modern Manufacturing?

For our purposes, manufacturing means production of *hardware*, which ranges from nuts and bolts to digital computers and military weapons, as well as plastic and ceramic products

Why to study manufacturing

Manufacturing Is Important Economically

Manufacturing is a means by which a nation creates wealth

- In the U.S. manufacturing constitutes ~ 20% of GNP
- Government is as much of GNP as manufacturing, but it creates no wealth

U.S. economy:

Sector	% of GNP
Manufacturing	20%
Agriculture, minerals, etc.	5%
Construction & utilities	5%
Service – retail, transportation, banking, communication, education, and government	70%

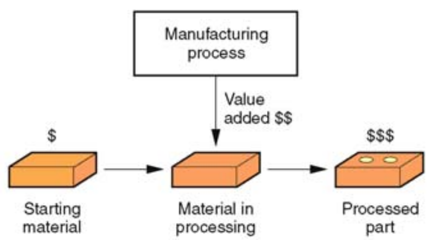
Manufacturing is Important Historically

*To a significant degree, the history of civilization is the history of humans' ability to **make things***

Historically, the importance of manufacturing in the development of civilization is usually underestimated

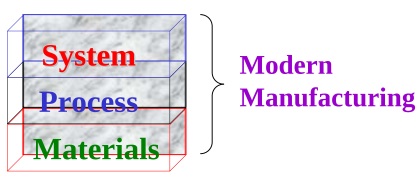
- Throughout history, human cultures that were better at making things were more successful
- Making better tools meant better crafts & weapons
  - Better crafts allowed the people to live better
  - Better weapons allowed them to conquer other cultures in times of conflict

Manufacturing Processes



Manufacturing *adds value* to the material by changing its shape or properties, or by combining it with other materials that have been similarly altered

So, a manufacturing plant consists of a set of *processes* and *systems* (and, of course, people) designed to transform a certain limited range of *materials* into products of increased value



Classes of Materials

There are 3 major classes:

1. Metals

Usually *alloys*, which are composed of two or more elements, at least one of which is metallic

Two basic groups:

a. Ferrous metals - based on iron, comprise ~ 75% of metal tonnage in the world:
   - *Steel = iron-carbon alloy with 0.02 to 2.11% C*
   - *Cast iron = alloy with 2% to 4% C*

b. Nonferrous metals - all other metallic elements and their alloys: aluminum, copper, gold, magnesium, nickel, silver, tin, titanium, etc.

Classes of Materials

2. Polymers

A compound formed of repeating structural units called *mers*, whose atoms share electrons to form very large molecules

Three categories:

1. *Thermoplastic polymers* - can be subjected to multiple heating and cooling cycles without altering their molecular structure
2. *Thermosetting polymers* - molecules chemically transform (cure) into a rigid structure upon cooling from a heated plastic condition
3. *Elastomers* - exhibit significant elastic behavior

Classes of Materials

3. Ceramics

- Molecules based on bonding between metallic and non-metallic elements (including oxides, nitrides, carbides)
- Typically insulating and refractory

Sub-Classes of Materials

Semiconductors (ceramics)
Intermediate electrical properties
Composites (all three classes)
Combinations
Bio Materials (all three major classes)
Materials compatible with body tissue

Factors influencing properties and (Manufacturing) Behavior of Metals

- Atomic Structures
  - Crystal structures: bcc, fcc, hcp
  - Slip, slip planes:b/a ratio, anisotropy
- Imperfections
  - Line: dislocations (strain hardening)
  - Point: vacancy, interstitial (alloys, e.g. Fe-C), impurity (alloys, e.g., Al, Cu)
  - Volume: voids, inclusions (e.g. oxides, carbides, sulfides)
  - Planar: grain boundaries
- Grain boundaries
  - Properties depend on size, large grains are softer (why?) lower strength, hardness, & ductility and produce rough surface after stretching

Factors influencing properties and (Manufacturing) Behavior of Polymerss

- Molecular Structures
  - Linear, branched, crosslinked or network polymers
- Molecular Weight
  - Melting / softening temperatures **increase** with molecular weight (up to ~ 100,000 g/mol)
  - At room temperature, short chain polymers (molar weight ~ 100 g/mol) are liquids or gases, intermediate length polymers (~ 1000 g/mol) are waxy solids,
  - solid polymers have molecular weights of 10^4 - 10^7 g/mol
- Crystallinity
  - Linear polymers form crystals more easily because the molecules can orient themselves readily
  - Degree of Crystallinity ranges from 5 - 95%
  - The higher % Crystallinity → higher strength

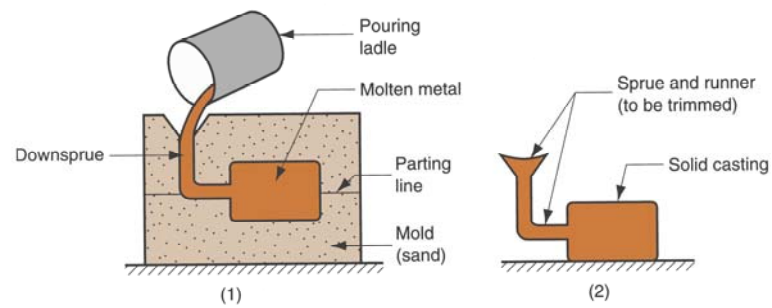
Manufacturing Processes

- Solidification Processes
- Deformation Processes
- Material Removal Processes
- Particulate Processing
- Surface Processing Operations
  - coating, plating.. etc.
- Assembly Operations
  - joining, welding, brazing .. etc.

(Deformation Processes, Material Removal Processes, Particulate Processing } MECH 421/6511)

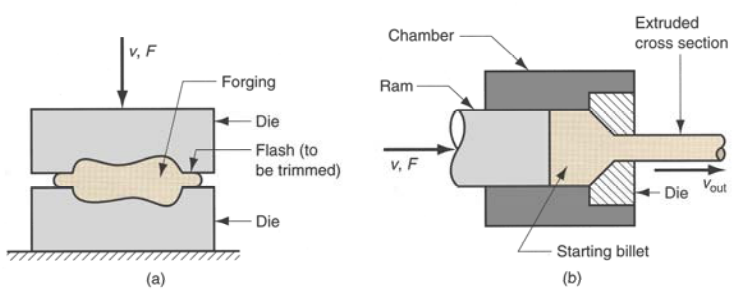
Solidification Processes

- Starting material is heated sufficiently to transform it into a liquid or highly plastic state
- Examples: Casting for metals, molding for plastics



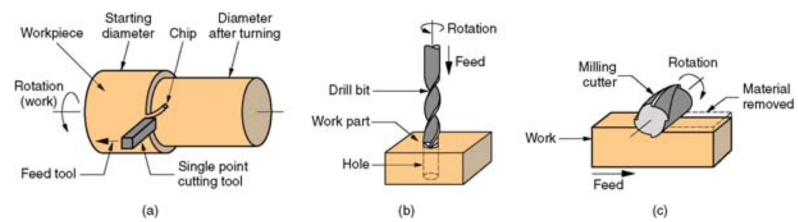
Deformation Processes

- Starting workpart is shaped by application of forces that exceed the yield strength of the material
- Examples: (a) forging, (b) extrusion



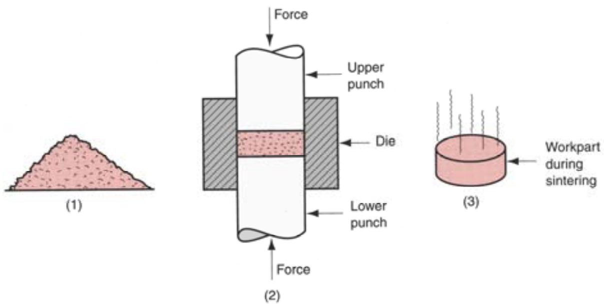
Material Removal Processes

- Excess material removed from the starting workpiece so what remains is the desired geometry
- Examples: machining such as turning, drilling, and milling; also grinding and nontraditional machining processes



Particulate Processing

- Starting materials are powders of metals or ceramics
- Usually involves pressing and sintering, in which powders are first squeezed in a die cavity and then heated to bond the individual particles



Waste in Shaping Processes

It is desirable to minimize waste and scrap in part shaping

- Material removal processes tend to be **wasteful** in the unit operation, simply by the way they work
- Casting and molding usually **waste little** material

- Terminology:
  - *Net shape processes* - when most of the starting material is used and no subsequent machining is required to achieve final part geometry
  - *Near net shape processes* - when minimum amount of machining is required

Next time:

Mechanical Properties: *Plastic Deformation*