I

SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title:	MANUFACTURING PROCESSES
Code No.	MCH 308-5
Program:	MECHANICAL TECHNOLOGY
Semester	FIVE
Date:	MAY 18f 1984
Author:	W. J. ADOLPH

New x Revision:

APPROVED: /£4^r^' Chairperson Date

Manufacturing Process — MCH 308 - 5

Course Name — Course Number

PHILOSOPHY/GOALS:

- The student will demonstrate a basic level knowledge of fundamental manufacturing processes and primary materials, through assignments and tests*
- The student will demonstrate an ability to comprehend textbook material by successfully answering in written form specific objectives provided with minimal instructor assistance.
- The student will develop research habits utilizing the library services in responding to some of the specific objectives.

METHOD OF ASSESSMENT (GRADING METHOD):

Students will be tested on 4 or 5 occasions during the semester. Each test will cover 2 or 3 topics of the course. Numerical grading will provide a final letter grade according to the following:

80 -	100%	A
65 -	79%	B
55 -	65%	C
Less than	55%	R

Tests will be announced at least one week in advance.

TEXTBOOK(S):

Manufacturing Process and Materials for Engineers
Doyle, Keyser, Leach, Schrader, Singer
Second Edition, Prentice Hall.

Competencies ^ Manufacturing Processes

the conclusion of the course, the student must be able to:

1. Use work related terminology.
2. Read and interpret written technical explanations of various manufacturing processes.
3. Prepare and present written explanations of various manufacturing processes.
4. Apply the basic principles of manufacturing processes to the development of practical designs.
5. Conduct destructive tests to determine mechanical and physical properties, process the data and prepare reports.
6. Organize the set-up and calibration of hardness testing and tensile testing equipment.
7. Compare the costs of various alternate methods of production of a part.
8. Exhibit a working knowledge of the basic manufacturing processes of moulding, forming, joining for the commonly used engineering materials.
9. Exhibit a basic understanding of the

    (a) the uses of metrology equipment
    (b) the powder metallurgy process
    (c) plastics and rubber.

Topic No.	Periods	Topic Information	Reference
5	4	Non-Ferrous Metals and Alloys	MP 108-116
		Effects of Alloying on Properties Aluminum and Alloys Copper and Copper Alloys Zinc and Alloys White Metals Nickle Alloys Refractory Metals Precious Metals	
6	8	Foundry Processes	118-171
		The Principles of Sand Casting Making Moulds Cores and Coremaking Pattern Sands and other Mould Ingredients Melting Metals in the foundry Pouring and Cleaning Moulds Shell Mould Casting Metallurgy of Castings Design of Castings	
7	4	Hard Mould Casting Processes	172-192
		Metal mould Casting Processes Plaster Mould Casting Precision Investment Casting Continuous Casting	
8	6	Powder Metallurgy	193-206
		Metal Powders Fabrication Processes Pressing & Compacting Sintering Finishing Operations Metal Composites Design of Powder Metal Parts Comparisons with other Methods	

Topic No.	Periods	Topic Information	Reference
9	4	Plastics and Rubber	207-237
		Plastic Materials Plastic Processing Fibreglass Moulding Design of Moulded Plastic Parts	
1	3	Metals and Alloys	MP 8-21
		Metal Structures Physical Properties Fracture and Failure Metallurgy of Iron and Steel	
2	6	Testing of Engineering Materials	MP 30-51
		The Tensile Test Hardness Testing Notched Bar Impact Testing Bend Tests Fatigue Testing Fracture Toughness Test Nondestructive Testing	
3	4	Heat Treatment of Metals	MP 70-87
		Heat Treatment of Non-Allotropic Alloys Heat Treatment of Steels Quenching Hardening Softening Surface Hardening	
4	4	Alloy Steels	MP 96-100
		Graphitization Carbon Stability Carbon Steels Alloy Steels	

TOPIC 1 - METALS AND ALLOYS

Specific Objectives

The student shall be able to:

Metal Structures

1. Recall the meaning of space lattice by sketching B.C.C. cells in a regular repeating array.
2. Recall by sketching two lattice structures having different orientations by showing the interface of both at a grain boundary.
3. Recall the meaning of allotropic transformation, by using as an example, iron at different temperatures.

Physical Properties

4. Compare the general physical properties of F.C.C., B.C.C. and H.C.P. types of lattice structure.
5. Explain what happens to the lattice structure when metals are deformed at temperatures below the recrystallization temperature, and above.
6. List and explain the kinds of crystalline imperfections.
7. Explain why it is that a cold-worked metal is said to work-hard or strain harden.
8. Explain why a fine grained metal can better respond to stress than a coarse grained metal.
9. Explain why cold working orients the grain in a more suitable direction to carry load.

Fracture

10. Explain the two general manners in which metals fail after sufficient stress.

Type III Equilibrium Diagram

11. State what kinds of metals behave according to the Type III rules*

12. Using diagram 2-11 as an example of the general case, explain slow cooling of the following from the liquid zone.

    (a) A solution of 90% A/10% B
    (b) A solution of 60 A/40 B
    (c) A solution at the eutectic composition

Metallurgy of Iron and Steel

13. Sketch and label the "steel" portion of the iron carbon diagram. Ignore the composition above 2100 F.

14. Explain what happens to the austenite as it cools from 2100 F to room temperature when the concentration is

    (a) hypoeutectoid
    (b) hypereutectoid
    (c) eutectoid

15. List the carbon requirements, tensile strength and elongation for the following:

    (a) automobile fenders
    (b) structural steels
    (c) gears and axles
    (d) railroad rails
    (e) tools and dies

TOPIC 2 - TESTING OF ENGINEERING MATERIALS

Specific Objectives

The student shall:

1. Recall that testing of materials in the context of this topic is restricted to the measurements involved in determining properties such as hardness, strength, toughness and stiffness.

2. Sketch the configuration of the standard 1/2 round tensile test specimen and the metric standard.

3. Describe the method employed in developing an Apparent Stress divided Strain diagram for a ferrous specimen.

4. Given an apparent stress strain diagram of a ferrous metal, indicate on the diagram, the proportional range (Elatic Range) the Proportional Limit, the yield point.

5. Recall that the constant of proportionality between e, the elastic strain and s, the elastic stress is known as Youngs Modulus, and is a measure of the property called "stiffness", and indicates the ability of the metal to "spring back".

6. Recall that the yield point must be exceeded if permanent deformation is to be achieved, and where this quality is used.

7. Draw an Apparent Stress Strain diagram the true stress strain curve and explain why it is so different.

8. Describe a written procedure for determining the property "toughness" from a stress-strain curve.

9. Explain using a S-S curve, how the work hardening co-efficient is determined.

10. Define Hardness as the resistance of a material to penetration, and recall that hardness is a function of the elastic limit and the work hardening co-efficient.

11. Draw a schematic of a Rochwell hardness tester, identify the major features and describe how comparative hardness is determined from this test.

Recall that Notched - Bar Impact testing does not provide a means for studying responses of materials to high velocity loading, but measures the ability of a material to absorb energy - a measure of "toughness".

Describe from recall the standard Charpy impact test, utilizing a sketch like that on page 42 of the text book.

Describe the equipment used and the procedure followed to determine fatigue strengths of a metal.

Describe the mechanism of failure that occurs in fatigue failure.

Solve a testing problem like:

Given: A certain steel alloy specimen

SY = 54,000 psi

E = 30 x 10^6 psc

Cross section 1/2" x 1/2"

Gauge length 4"

and

(a) Applying a 10,000 lb load, determine gauge length after load release.

(b) Assume 0.2% offset, what load would produce a stress in the specimen equal to SY?

TOPIC 3 - HEAT TREATMENT OF METALS

The student will be able to:

1. Recall the meaning of "Heat Treatment" as it applies to ferrous metals.

2. Describe the general process for hardening, being complete by mentioning in the proper context the words "supersaturated" and "decomposition".

3. Explain:

   (a) Coherency hardening
   (b) Aggregate hardening

4. Describe the two major classes of heat treatment:

   (a) Non-allotropic hardening
   (b) Aliotropic hardening

5. Describe the general objectives of "softening of metals".

Heat Treatment of Non-Allotropic Alloys

6. Explain how an alloy that does not change lattice structure can be hardened (precipitation hardening, age hardening, artificial hardening).

7. List the common precipitation hardened alloys•

8. Explain the special hardening procedure applied to 2024 aluminum, and mention the cautions to be observed*

9. Explain how precipitation hardened alloys may be softened for stress relief or full anneal*

Heat Treatment of Steels

10. Sketch the iron carbon diagram, and show the lines labelled A A_{cm} AR_{n_1} C C cm and explain the significance of such lines.

11. Draw lines on the iron-carbon diagram that represent the upper limits of temperature for:

    (a) Normalizing
    (b) Quenching
    (c) Annealing

12, Explain why steel is hardenable, and name and describe the hard product of rapid quenching.

13* Sketch a typical T-T-T diagram as shown in Figure 5-3A, and explain the significance of the two lines A B C , and A D E.

14. Sketch a continuous cooling transformation curve and explain its purpose. Note that Bainite can be disregarded for continuous cooling of carbon steels,

15. Draw a line on the continuous cooling curve that represents the "Critical Cooling Rate".

16. Explain why medium pearlite is harder than coarse pearlite.

17. Explain the heating and cooling process necessary to produce maximum hardness test.

Quenching

18. List six quenching media and state the applications of each.

19. State the physical and structural consequences of hard quenching carbon steels.

20. Explain the procedure called die quenching.

Ways of Hardening Steels

21. Explain the general purposes of hardening and tempering of steels.

22. List and describe the three stages of softening, hardened steel, by referring to temperatures and products.

23. Describe the process called "austempering".

Annealing of Steel

24. Explain the meaning of and reasons for "annealing".

25. Briefly describe the following processes:

    (a) Full annealing
    (b) Normalizing
    (c) Process or commerical annealing
    (d) Cycle annealing

Surface Hardening

26. State the principle reason for surface hardening steel.

27. Describe the following surface hardening methods:

    (a) Induction hardening
    (b) Flame hardening
    (c) Carburizing
    (d) Cyaniding
    (e) Nitriding

TOPIC 4 - ALLOY STEELS

student will be able to:

Define the term "alloy steels".

List the phases found in ferrous alloys.

Explain why carbon is the most important alloying element found in ferrous alloys.

Explain graphitization as it occurs in coded alloys containing more than 2% carbon. Write the dissociation equation.

Explain why some cast irons are much softer than others.

State the functions performed by carbon in steels hardened by quenching and tempering.

State the effects of alloying elements (other than carbon) in slowly cooled steels and list the ferrite strengthening elements and the conditions under which best performance of each is gained.

State the two factors that control graphitization in the cast irons, and explain how these factors are relized in practice.

List the elements which promote:

(a) Graphitization
(b) Carbide stability

State the functions of alloying elements in steels to be hardened by quenching and the advantages gained from such practices.

State the name of the element most economic to the improvement of harden ability.

State how the following features of ferrous metallurgy are gained through selective alloying:

(a) Corrosion resistance
(b) Magnetic properties
(c) Machineability
(d) Toughness

Carbon Steels

13. Explain why carbon steels are so named.

14. State the limits of alloying elements that define carbon steel.

15. List the major features and some uses of:

    (a) Low carbon steel
    (b) Medium carbon steel
    (c) High carbon steel

Alloy Steels

16. List seven classes of alloy steels and write a brief paragraph describing the major features of each.

17. Write the AISI-SAE numbering system code for the following alloy

    (a) Nickels steels with 0.4% carbon
    (b) Chromium steels with 0.4% carbon
    (c) Plain carbon steels of 0.7% carbon

18. Note that with the exception of the low carbon-plain carbon steels, the AISI-SAE steels are always used in the heat treated condition,

19. Record a list of the major groups of alloy tool steel showing designation and type.

20. State the three major types of tool steels, and in point form, identify the characteristics of each.

21. Write a brief paragraph identifying the features and characteristics of the following steels:

    (a) Magnet steels
    (b) Stainless steels
        (i) Austenitic
        (ii) Ferritic
        (iii) Martensitic
        (iv) Precipation - hardenable stainless steels

TOPIC _5 - NON-FERROUS METALS AND ALLOYS

The student will be able to:

1. Explain why pure non-ferrous metals are so important to industry

Effects of Alloying on Properties

2. State the effects of alloying on such properties as:

    (a) Conductivity
    (b) Specific gravity
    (c) Module of elasticity
    (d) Yield, tensile, fatigue strength
    (e) Ductility

Aluminum and Its Alloys

3. In point form, list the major features of aluminum, also identifying the advantages and disadvantages of the metal in process work.

4. In point form, list the major features of aluminum alloys, under the following headings:

    (a) Hardenability
    (b) Room temperature mechanical properties
    (c) Specific strength
    (d) Fabrication of aluminum alloys

5. Write a paragraph outlining the major features and uses of titanium.

6. Write several paragraphs stating the uses and major features of titanium alloys under the following headings:

    (a) Lattice structures
    (b) Alloys with aluminum, vanadium and chromium
    (c) Fabrication

7. List the major features and uses of:

    (a) Magnesium
    (b) Magnesium alloys

Copper Alloys

8. State the uses of pure, unalloyed copper.

9. Explain how copper can be hardened and strengthened,

10. Compare the room temperature$_f$ and elevated temperature performance of copper alloys and aluminum alloys and steel.

11. Define:

    (a) brass
    (b) bronze

12. Compare alpha and beta phase brasses.

13. List the advantages of bronzes to industry.

Fabrication of Copper Alloys

14. List the various methods by which copper alloys can be fabricated.

Zinc and Zinc Alloys

15. Write a brief paragraph identifying the outstanding properties the most important alloying elements and the reasons for alloying.

The White Metals

16. Define "white metal".

17. List the three most important classes of white metals.

18. Write a paragraph discussing "babbits" referring to the microstructure, segregation and fabrication.

Nickel and Its Alloys

19. Write a paragraph about nickel and its alloys, identifying major uses and special alloys.

Refractory Metals

20. In point form, identify the major features and uses of:

    (a) Tungsten
    (b) Tantalum
    (c) Molybdenum
    (d) Beryllium
    (e) Germanium
    (f) Zirconium

21. List the most common precious metals and identify their uses.

TOPIC ([-_ FOUNDRY PROCESSES

Specific Objectives

The student shall:

1. State several applications of founding of metals in automotive engines.
2. State six materials from which moulds can be made.
3. State four major methods of making moulds.
4. State six properties or characteristics which a mould must possess.
5. From a cross sectional view of a three part sand mould, identify:

   (a) Parting Lines
   (b) Bottom Board
   (c) Sprue
   (d) Riser
   (e) Pouring Basin
   (f) Cope, drag, cheeks
   (g) Runner
   (h) Gate
6. State the difference in grain size of metal adjacent to the mould as compared to the majority of the casting and explain why the difference exists.
7. State the functions of:

   1) Gates
   2) Risers
   3) Chills
8. State the three main types of gates, and compare the relative merits of each.
9. State the purpose of "vents".
10. Identify from diagrams, the various hand tools used by the foundryman, and state the various functions of the tools.
11. Describe using written description and diagrams, a procedure for making a casting of a hollow cylinder, closed at one end.

Cores and Coremaking

12. State the function of a core.

13. List and explain the seven properties essential for good cores.

14. List three ways in which a core may be vented.

15. List three kinds of cores used in the foundry.

16. State the major reason for "core shifting" and describe one method for preventing core shifting.

Patterns

17. Explain the purpose of a pattern.

18. Explain the difference between a "loose piece" pattern and a match-plate pattern.

19. State the relative merits of the above type patterns.

20. List the qualities desired in pattern materials.

21. Describe a "sweep" pattern.

22. List three pattern materials and methods that can be used for "short runs" or "one-off" situations,

23. Explain what is meant by

    (a) "shrinkage allowance"
    (b) machining allowance
    (c) Draft
    (d) Filets

Sands and Other Mould Ingredients

24. List the three major components of a moulding sand.

25. State the six major advantages of a "synthetic" sand over natural sand.

26. Define the term permeability and state how permeability is affected by

    (a) Grain size
    (b) Moisture content
    (c) Binder content.

27. List 2 common types of binders.

28. Define the term "green strength" and state how green strength is affected by:

    (a) Grain size
    (b) Moisture Content
    (c) Binder Content.

29. Define Dry Strength.

30. Explain the purpose of a "Mueller",

    (a) Describe "chemical sands".

Core Sands

31. List five properties of a good core sand.

32. Define:

    (a) Collapsibility
    (b) Friability.

33. Describe "water glass" and list the major advantage that it offers as a core material.

Melting Metals in the Foundry

34. Describe in written form the workings of a cupola furnace cycle, starting with the charging of the furnace and ending with final discharge of refuse contents.

35. Explain the source of the difficulty in designing a ferrous metal composition when the metal is to be prepared by cupola.

36. Describe by sketch and written description, a fixed crucible furnace for the preparation of non-ferrous metals.

37. Explain why a layer of dross is advantageous to the aluminum meet.

38. Explain the main purpose of vacuum melting.

Shell Mould Casting

39. Describe one method of making a shell mould and explain the advantages of this type of hard mould.

Metallurgy of Castings

40. Explain what happens as molten cast iron is cooled at a moderate rate to room temperature in terms of the phases formed.

41. Explain in terms of the metal structure, why cast iron has no significant tensile strength,

42. Describe the procedure used to obtain an "open" or soft cast iron,

43. Describe the procedure used to form white cast iron.

44. Describe the physical qualities of white cast iron.

45. Explain how malleable iron is formed, and list its constituents.

46. Explain what is meant by modular cast iron.

47. Explain the effects of the following alloying elements on cast iron

    (1) silicon
    (2) sulphur
    (3) manganese
    (4) phosphorus
    (5) nickel
    (6) chromium
    (7) molybdenum
    (8) copper
    (9) vanadium.

48. Answer questions from the text book, pages 170-171 #'s 7, 9, 10, 11, 25, 27, 29, 32, 33, 36, 38.

TOPIC 7 - HARD MOULD CASTING

Specific Objectives

The student shall:

1. Define the process "permanent mould casting", making reference to type of moulds and pressure.
2. List the four major metals that are cast by the permanent mould process.
3. List six different products cast by the permanent mould process.
4. By recalling the type of mould involved above, describe the mould material, and the properties which make it useful.
5. Explain the process carried out to ensure separation of the casting from the mould.
6. Explain the term "piercing".

Low Pressure Castings

7. Describe one form of low pressure casting, by describing the metal delivery system, and the type of moulds.
8. List the advantages of Low Pressure Casting over hydrostatic casting.

Slush Casting

9. Describe the process called slush casting.
10. List several products of the process.

Die Casting

11. Given a schematic, label the major parts of the process Die Casting, beginning with the metal delivery system and ending with the ejecting mechanism.
12. List four metals which are commonly cast by Die Casting methods, and state the primary reason limiting the process to these metals.
13. List one common metal which is not cast by "Die Casting" and state the reason.

Die Casting Machines

14. List three types of die casting machines and differentiate between them by the method used in performing the metal delivery function,

15. Define flash by making reference to its origin.

Centrifugal Casting

16. Describe in written form, a process used for casting a hollow cylinder by 'centrifugal* methods.

17. List the advantages of "centrifugal casting".

Plaster Mould Casting

18. List five metals commonly cast by the process called Plaster Mould Casting.

19. List the major advantages to casting in Plaster.

20. List the major metallurgical disadvantage.

21. State the main reason that Plaster remained for a long time on unusable material for moulding.

Precision Investment Casting

22. Starting with a metal female mould of a part which is to be cast by "Lost" wax, or "Mercast" process, explain the steps involved in producing a metal casting,

23. State the major disadvantage of the process over "Sand Mould" or "Hard Mould" castings.

24. State several advantages of the process over "Sand Mould" or "Hard Mould" castings.

TOPIC S_ - POWDER METALLURGY

Specific Objectives

The student shall:

1. Define the term powdered metallurgy,
2. List three uses of loose powders in specialized applications.
3. List three metals that can be fabricated only by powdered metallurgical means.
4. List two examples of metals and non-metal combinations which are not obtainable economically.
5. Define the term "cermet".

Metal Powders

6. Describe four methods by which metal powders can be obtained.
7. Describe in terms of pressing, sintering, forming and machining the processes required to manufacture:

    a) Tungsten filament
    b) Cemented Carbide tools
    c) Sell lubricating bearings
    d) Metal filters
    e) Ordinary Ferrous Machine Parts
    f) High strength Machine Parts

Pressing

8. State the purpose and effect of pressure on powdered metal.
9. State the reason that most powders are pressed cold.
10. State why a two punch operation is necessary to press a "T" section.

Other Compacting Methods

11. Describe the "slip cast" method of compacting powder.
12. Describe a process by which porous sheets for bronze filters can be made.

Sintering

13. Describe why a cementel carbide in cobalt is harder at higher temperatures than high speed steel with isolated carbides.

14. State the four mechanisms that are believed to have roles in transporting atoms in a powdered metallurgical part in which neither constituent melts during sintering.

15. State how aluminum alloys can be increased in tensile strength from 50,000 to 100,000 psi by powdered met means.

16. Answer questions page 204, 205, #'s 1, 2, 7, 14, 16, 18.

TOPIC 9_ - PLASTICS AND RUBBER

Specific Objectives

The student shall:

1. Define the term "plastic".
2. Name two natural plastics.
3. State the first plastic discovered and the circumstances surrounding its discovery.
4. List four unique advantages that plastics offer to modern technology.
5. State the range of tensile strength for plastics and reinforced plastics.
6. List four major disadvantages that make plastics inferior to metals.

Plastic Materials

7. Name five elements which combined form synthetic organic compounds.
8. Give an example of an (1) unsaturated and a (2) saturated hydrocarbon.
9. Explain why methane molecules can not be combined.
10. Define "monomer".
11. Define (1) polymerization and (2) co-polymerization.
12. State three conditions under which polymerization can be made to take place.
13. Using ethylene as an example and using a representative drawing, describe the process called "linear addition".
14. Differentiate between thermoplastic and thermo setting materials.
15. List constituents that can be added to give special qualities to plastics.
16. Describe the general procedure for preparing resins of (1) thermo plastic and (2) thermo-setting for the processes of moulding.

Rubber &^ Elastomers

17* State the name of the process which turns latex into usable rubber and name two substances which are necessary to promote the process.

18. By properties of elasticity, differentiate between rubber and elastomers.

19. Describe a silicone by reference to its elemental constituents.

20. List some uses of silicons.

Adhesives

21. Name one natural glue.

22. State the optimum thickness for adhesive effectiveness.

23. Compare the shear strength of a plastic adhesive with that of a properly brazed joint.

24. List the two main steps involved in the manufacture of plastic products.

25. Describe a typical process for moulding a plastic cup using a Thermo plastic.

26. Using a diagram, explain "transfer" moulding.

27. Describe an injector moulding system for a Thermo plastic.

28. Describe a typical process for producing a reinforced plastic moulding using glass fibres.

29. Describe a typical "chopper gun" lamination process.

30. Describe a typical process for forming a plexiglass sign by vacuum form moulding.

31. Describe a typical blow moulding process.

Machine

32. State the general machine settings which would be used to machine a plastic part. Compare with cutting of a specific metal.

33. Solve problems page 237, Numbers 1, 3 and 4.

TOPIC 10 - PRIMARY METAL WORKING PROCESSES

Specific Objectives

The student shall:

General

1. List several forms of the products of primary metal working processes,
2. State two reasons why metals are worked with pressure either in hot or cold conditions.

Hot Working

3. State what happens when a ductile crystalis distorted by working in terms of crystal structure and size.
4. State what would happen if a worked structure is allowed to soak at a temperature above the recrystallization temperature, but below the meeting temperature in terms of the crystal size.
5. List four advantages of pressing or working hot metals considering the qualities of hardness, toughness, force required and shape of product•
6. List three major disadvantages of hot working metals considering the product and the machines involved in the processes.

Cold Working

7. State the processes which precede cold working*
8. State the general advantages to cold working as they apply to size, surface finish and general physical properties of a metal.
9. Explain, using three Stress strain diagrams what happens to the yield point of a metal that is cold rolled during three passes through any deformation arrangement.
10. Explain why annealing and normalizing is sometimes necessary as additional inserted processes during cold rolling or after cold rolling.

Rolling

11. Define the no-slip point and show its relative position on a diagram showing hot metal passing between two rolls.

12. Under what conditions a fresh piece of material cannot be spontaneously showing hot metal passing between two rolls.

13. State a range of roll pressures required related to the yield stress of the metal.

14. State a rule of thumb method for calculating the frictional force between roll and work in the driving direction.

15. Describe a method by which frictional forces and normal pressures can be radically reduced.

16. Draw a "TWO HIGH" and "FOUR HIGH" roll configuration and explain the advantages of both.

17. State the processes that would be involved in producing a slab, starting with an empty ingot mould beside the ingot pouring stand,

18. Define: slabs, blooms and billets by making reference to the different products taken from each.

19. Design a pass practice that would be reasonable to reduce a 27" x 27" ingot to a slab of dimension 12" x 6' using a "bull" pass, a 9" pass and a 6" opening in a two high stand.

Cold Rolling

20. State why a sheet of 0.05 inches in thickness is not produced by hot rolling.

21. Explain the principle of stretch straightening.

Cold Drawing

22. Describe a procedure for preparing a piece of round stock for drawing.

23. Explain why the drawing process is viable - (the basic principle which allows cold drawing).

Manufacture of Pipe and Tubing

24. Describe by sketch, a typical process by which skelp can be made into butt-weld pipe*

25. By sketch and a written description, describe how the Mannesmann process for seamless pipe takes place.

Forging

26. Describe "forging" by making references to the types of products which result.

Hammer Forging

27 State what a "light" blow by the hammer is.

28 Describe the operation of a "helve" hammer.

29, Determine the total energy available from a steam hammer which has a travel of "1" in a mean effective steam pressure of "P" psi, a hammer weight of "W" lbs and a cylinder bore "d" inches.

30 Describe the qualities of a forging die used for manufacturing a part like an automotive connecting rod.

Press Forging

31. State the differences between "press" forging and "drop" forging.

Miscellaneous Forging Methods

32. Describe a process called "high energy forging".

33. Describe how a "button" could be forged onto a rod end.

Extrusion

34. State the basic principle involved in extrusion.

35. State the major advantage of hot extrusion.

36. State the major disadvantages of hot extrusion,

37. By sketch, describe how a telephone cable could obtain an extruded bad sheath.

38. State the major advantage of cold extrusion using aluminum as an example,

39. Answer questions: page 271, #17
page 242, #3, 4, 5, 6, 7, 8, 9.

TOPIC 11 2. METAL SHEARING AND FORMING

Specific Objectives

The student shall:

1. State several products that are the result of processes which shear or form standard, regular shapes.

Metal Shearing Processes

2. Differentiate between the various general shearing processes known specifically as, "cutting off", "parting", "blanking", "piercing", "punching", "slotting", "perforating", "trimming", and "nibbling",

3. Explain how slitting can be done in a continuous operation by means of a diagram.

Principles of Metal Shearing

4. With the aid of a sketch, illustrate the difference between "conventional cutting" and "punching with shear". Comment on the theoretical relative energy required for each.

5. Define (a) shaving
   (b) dinking

6. Define "break clearance".

7. State the mechanism whereby metal can be sheared, by making reference to break clearance, stresses, and crack propagation.

8. Using a force-travel indicator diagram, differentiate between proper and improper clearance between punch and die block.

9. Given a shearing strength and a penetration factor of 500,000 16/in and 40% respectively and recalling the mechanism by which shearing takes place, calculate the force necessary to shear a 2" 0 hole in stock 1 1/2 inch in thickness. Develop the equation from basic principles.

10. From basic principles design an equation for required to punch a hole of diameter D, thickness, shear strength Ss at N strokes per minute assuming a penetration factor "p" and a friction force factor K.

11. Recognize that in addition, the energy required for withdrawal amounts to about 50% of the punching stroke.

12. Recognize that many usable forms of sheet metal result from the punch and die bending processes.

13. Recognize that a bend effectively causes the neutral axis to move a distance of 0.3t to 0.5t in the bent portion.

14. Given the radius of a bent r, the thickness of a material t, and the angles of the bend in degrees, then the length of the original stock required for the bend is:

$$L = 2 \quad (r + 0.4t) \times \frac{\quad}{360}$$

15. Recognize that the phenomenon of "springback" requires that in practice must be increased from 1 to 4 depending on carbon content steels.

16. From basic principles and assuming that for plastic bending, the required force per unit area is twice that required to stress all fibres up to the elastic unit, develop the formula for force required to bend a material of bending strength S and rectangular shape.

17. State the limitations that must be observed when bending metal - to avoid cracking it.

18. List several applications of bent tubes, pipes and other structural shapes.

19. Describe using sketches and written description the process of draw bending of pipe.

20. Describe as above the Roll Extrusion process.

21. Describe using a series of cold forming rolls, how a strip of aluminum siding might be formed. Use 4 roll sets.

Drawing

22. Beginning with metal of 0.25 inch thickness and intending to draw a cup of h = 15" and d = 12", determine:

    (a) the size of the blank.

    (b) and using the practical reductions suggested by Crane, determine the drawing practice of least number of drawing operations.

    (c) find the force and energy for the first draw if S , = 50,000 psi.

TOPIC 12 - WELDING AND ALLIED PROCESSES

Specific Objectives

The student will be able to:

1. State the two major families of welding.
2. Write an explanation of the basic principles of electric arc welding, by making reference to electrodes, arc, plasma, and temperature.
3. Describe materials used in the electrode of:
   a) A non-consumable arc
   b) A consumable arc
4. Define penetration, bead.

Criteria of Arc Welding Performance

5. State the advantages of utilizing high current in welding parent metal thick enough to sustain it.
6. State the result of using a large diameter rod with low current on penetration and fusion.
7. State the cause of coating spalling on electrodes.
8. State the three most obvious hazards of arc welding.
9. State the polarities of the work piece and electrode for:
   a) straight polarity
   b) reverse polarity
10. State the application for:
    a) straight polarity
    b) reverse polarity
11. State the origin of "arc blow" and explain how it can be avoided.

Shielded Electrodes

12. State five functions served by the coating on an electrode.
13. State the typical composition of the electrode.
14. State four of the ingredients that can be found in electrode coatings.

15. According to the standard classification for electrodes, state the meaning of 9030.

16. List the components of a manual metal arc welding set.

17. Explain the difference between a manual and a semi-automatic arc welding set.

18. Describe using a sketch, the heads for:
    a) tungsten arc welding
    b) gas metal arc welding
    c) plasma arc welding

19. Explain electron-beam welding and state under what welding conditions it is practicable.

20. Describe the compositions of a laser beam, how it may be produced and its application to welding.

21. State the principles involved in resistance welding,

22. Define "heat balance" as it applies to resistance welding.

23. State the principles of Thermit Welding. Describe the welding functions that it is most suited to.

Gas Welding

24. State the properties of acetylene which make it desirable as a fuel gas for gas
    a) welding
    b) burning

25. Describe the features and components of a gas welding operation.

26. List the advantages of gas welding over electric arc welding.

27. Define "friction" or "inertia" welding and name an application.

28. List the advantages of ultra sonic welding.

29. Describe the process of explosive welding.

30. Describe the mechanisms thought to take place to effect solid state welding.

31. By making reference to a supplied diagram, showing a metallurgical cross section of a weld, label the diagram, showing the effects of the weld on the micro structure.

32. Describe the causes of cracked weldments and state some remedies.

33. State the causes of inclusions and voids in a weld, and explain how they can be avoided.

34. Explain the effect of hydrogen on a weld.

35. Explain why welding makes metals more suseptible to corrosion.

36. Explain the mechanisms involved in flame cutting of steel.

37. Explain the mechanisms involved in flame cutting cast iron, and state what can be done to improve the flame cutting process.

38. Describe one metal spraying process.

39. Correctly complete problems page 384, numbers 8 and 9.

TOPIC 13 - MEASUREMENT AND INSPECTION

The student shall be able to:

1. Explain the importance of "interchangeable manufacture" to the First Industrial Revolution.
2. Define "quality control"-
3. Define:

    1) population
    2) sample
    3) average
    4) variation
    5) sample distribution
    6) normal distribution
    7) standard deviation

4. Given a set of production measurements, design a bar X chart and a range control chart.
5. Determine a statistical clearance, based upon the statistical deviations in size of bearings and shafts.
6. Calibrate a micrometer using a standard set of precision gauges.
7. Measure a production made carpenter's square for accuracy using metrology equipment.
8. Determine the Airy points for support of a beam using metrology equipment.
9. Calibrate a gauge block using a prism and a standard block.