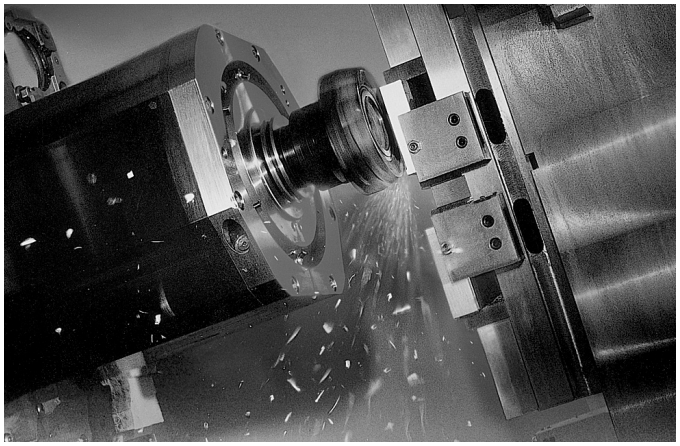


Chapter 29

Other Processes

LEARNING OBJECTIVES

After studying this chapter, students will be able to:

- Discuss the general machining characteristics of various plastics.
- Describe the hazards associated with machining plastics.
- Sharpen cutting tools to machine plastics.
- Describe the five basic operations of chipless machining and their variations.
- Explain how the Intraform process differs from other chipless machining techniques.
- Describe how powder metallurgy parts are produced.
- Relate how powder metallurgy parts can be machined.
- Compare the advantages and disadvantages of various HERF techniques.
- Explain how the science of cryogenics is used in industry, and list some applications.

INSTRUCTIONAL MATERIALS

Text: pages 525–546
Test Your Knowledge Questions, pages 544–546
Workbook: pages 151–154
Instructor's Resource: pages 361–376
Guide for Lesson Planning
Research and Development Ideas
Reproducible Masters:
29-1 Chipless Machining
29-2 Intraform® Process
29-3 Powder Metallurgy Process
29-4 Electrohydraulic Forming
29-5 Pneumatic-Mechanical Forming
29-6 Test Your Knowledge Questions
Color Transparency (Binder/CD only)

GUIDE FOR LESSON PLANNING

This chapter presents a brief overview of several nontraditional machining processes. As each process is presented, have examples of machined products or materials on hand for class examination.

Due to the amount of material covered, it would be advisable to divide this chapter into several segments. Although it has been divided into four parts here, each classroom situation will dictate what division would work best.

Part I—Machining Plastics

Have the class read and study pages 525–531, paying particular attention to the illustrations. Review the assignment and discuss the following:

- An overview of the various plastics and their characteristics.

- Preventing heat buildup when machining plastics.
- Machining the various plastics.
- Why some plastics must be annealed.
- Sharpening cutting tools used for machining plastics.

Part II—Chipless Machining

Have the class read and study pages 531–532. Using Reproducible Masters 29-1 and 29-2, review the assignment and discuss the following:

- An overview of the various chipless machining techniques.
- Use of cold heading technique for making bolts, nuts, screws, and other fasteners.
- The Intraform® machining process.

Part III—Powder Metallurgy (P/M)

Have the class read and study pages 532–537. Using Reproducible Master 29-3, review the assignment and discuss the following:

- Powder metallurgy (P/M) applications.
- The powder metallurgy process.
- Briquetting, sintering, and forging.

Part IV—High-Energy-Rate Forming (HERF)

Have the class read and study pages 537–543. Using Reproducible Masters 29-4 and 29-5, review the assignment and discuss the following:

- An overview of the various high-energy-rate forming processes. (Electrohydraulic, magnetic, and pneumatic-mechanical forming.)
- Stand-off and contact operations.

Part V—Cryogenics

Have the class read and study pages 543–544. Review the assignment and discuss the following:

- Cryogenic applications.
- Treatment of cutting tools.

Technical Terms

Review the terms introduced in the chapter. New terms can be assigned as a quiz, homework, or extra credit. The following list is also given at the beginning of the chapter.

briquetting
chipless machining
cold heading
cryogenic
electrohydraulic forming
explosive forming
high-energy-rate forming
magnetic forming
powder metallurgy
sintering

Review Questions

Assign Test Your Knowledge questions. Copy and distribute Reproducible Master 29-6 or have students use the questions on pages 544–546 and write their answers on a separate sheet of paper.

Workbook Assignment

Assign Chapter 29 of the ***Machining Fundamentals Workbook.***

Research and Development

Discuss the following topics in class or have students complete projects on their own.

Machining Plastics

1. Contact plastics manufacturers and request pamphlets on recommended machining techniques and safety precautions. Place the accumulated material in the technical library.
2. Secure samples of various plastics and demonstrate recommended machining techniques. Point out the differences between machining plastics and metal.
3. Develop a safety program to be followed when machining plastics. It can be in the form of a bulletin board display, pamphlet, or series of safety posters.
4. Review the various metalworking technical magazines and make photocopies of the many uses of plastics in the machine shop. Prepare a term paper on your findings.
5. Visit a machine shop that works plastics. Prepare a term paper on your observations. If possible, secure samples of the products produced.

High-Energy-Rate Forming (HERF)

Students should *not* experiment with explosive forming!

1. Develop a slide presentation showing step-by-step how the various HERF techniques work.

2. Secure information on the various HERF techniques from trade journals and companies making use of HERF. Use the material to create a bulletin board display.
3. Get samples of work produced by HERF. If there are no such companies in your area, use photos from trade magazines and brochures to develop a display panel. Use a sketch of the HERF process employed to produce the particular pieces displayed or pictured.
4. Contact a company using HERF techniques. Request the loan of a film, video tape, or slides that could be used to illustrate HERF.

Chipless Machining

1. Secure samples of work produced by chipless machining. Mount them on a display panel with an illustrated explanation of the process.
2. What does the term *plasticity* mean as it relates to metal and chipless machining?
3. Secure material from companies that use the chipless machining process for the shop technical library. Prepare a display.
4. Contact a company that uses chipless machining and request samples of a product in various stages of manufacture. Prepare a display panel of the samples.

Powder Metallurgy

1. Secure a bearing and a fuel filter made using powder metallurgy technology. Examine the units under a microscope and:
   a. Make a sketch with exaggerated details that shows the structure of each example.
   b. Prepare a transparency of the sketch for use with the overhead projector. Use the projected image to explain your findings to the class.
   c. Have a microphotograph made of the grain structure of each part. Use this to illustrate a presentation on powder metallurgy.
2. Contact a firm that manufactures products using powder metallurgy and request samples of units in the various stages of the manufacturing process. Prepare a bulletin board display.
3. Secure samples of different products made by the powder metallurgy process. Prepare a display panel showing these products and how they are used. For example, fuel filters made by the process have the ability to separate water from gasoline.

Cryogenic Applications

1. Demonstrate shrink fitting two metal parts together. Use dry ice to cool the part. **Caution:** Handle dry ice with insulated gloves and wear protective eyewear and clothing. Dry ice can cause severe burns if *not* handled with caution.
2. Read technical, scientific, and popular magazines for information on cryogenic applications. Since the aerospace and electronics industries make use of cryogenic applications, publications or companies in these fields may provide considerable amounts of material. Prepare a written or oral report on your findings.

TEST YOUR KNOWLEDGE ANSWERS, Pages 544–546

1. a. Nylon
   b. Delrin
   c. Teflon
   d. Lucite and Plexiglas
2. sharp
3. To prevent the first few threads from tearing.
4. annealing
5. chips, distorted
6. Its low coefficient of friction makes it an excellent bearing surface.
7. The dust and fumes given off by some plastics may be irritating to the skin, eyes, and respiratory system. Other plastics have fillers such as asbestos or glass fibers that can be harmful to your health. A dust collector system and filtered dust mask or respirator must be used for operator safety.
8. Laminated plastics consist of layers of reinforcing materials that have been impregnated with synthetic resins, and the layers cured with heat and pressure.
9. Drilling parallel with the laminations should be avoided.
10. cold heading, cold forming
11. There is very little scrap and production speed is increased.
12. dies
13. bolts, nuts, screws, fasteners

14. Any order: forward extrusion, backward extrusion, upsetting, trimming, piercing.
15. inside, cylindrical
16. b. Rifle barrels.
17. P/M, powder metals
18. d. All of the above.
19. In order: mixing metal powders, briquetting or forming, sintering, forging/sizing/coining.
20. d. All of the above.
21. The powder metal part before sintering. When ejected from the die it is quite brittle and fragile and must be handled carefully.
22. Because of shrinkage and distortion caused by the heating operation in the production cycle.
23. Presses the sintered pieces into precise finished dimensions, higher densities, and smoother surface finishes.
24. High-Energy-Rate Forming
25. b. In microseconds, with pressure generated by the sudden application of large amounts of energy.
26. d. All of the above.
27. spring back, HERF
28. Explosive forming makes use of the pressure wave generated by an explosion in a fluid to force the metal against the walls of the die.
29. Any of the following: cannot always form part properly on first shot; noise can be a problem; laws prohibit use of explosives in populated areas; isolated location increases transportation and handling costs; personnel must be highly skilled; high insurance rates.
30. A vacuum is necessary between the work and the die; otherwise, an air cushion would develop, preventing the metal from seating in the die and assuming its proper shape.
31. Stand-off operations and contact operations.
32. Electrohydraulic forming, electricity
33. Electromagnetic forming/magnetic pulse forming.
34. shrink, expand
35. high-pressure gas, punch, die
36. It means to make icy cold.
37. –300°F (–184°C), –460°F (–293°C)
38. One part of the assembly is made slightly oversize and immersed in liquid nitrogen. The diameter is reduced (shrunk) by the extreme temperature drop until it fits easily into its mating part. As it returns to room temperature, the cooled part expands and is locked in place.
39. The parts do not become distorted as they would if they were mechanically pressed together or heated (expanded).
40. To prevent damage from thermal shock.

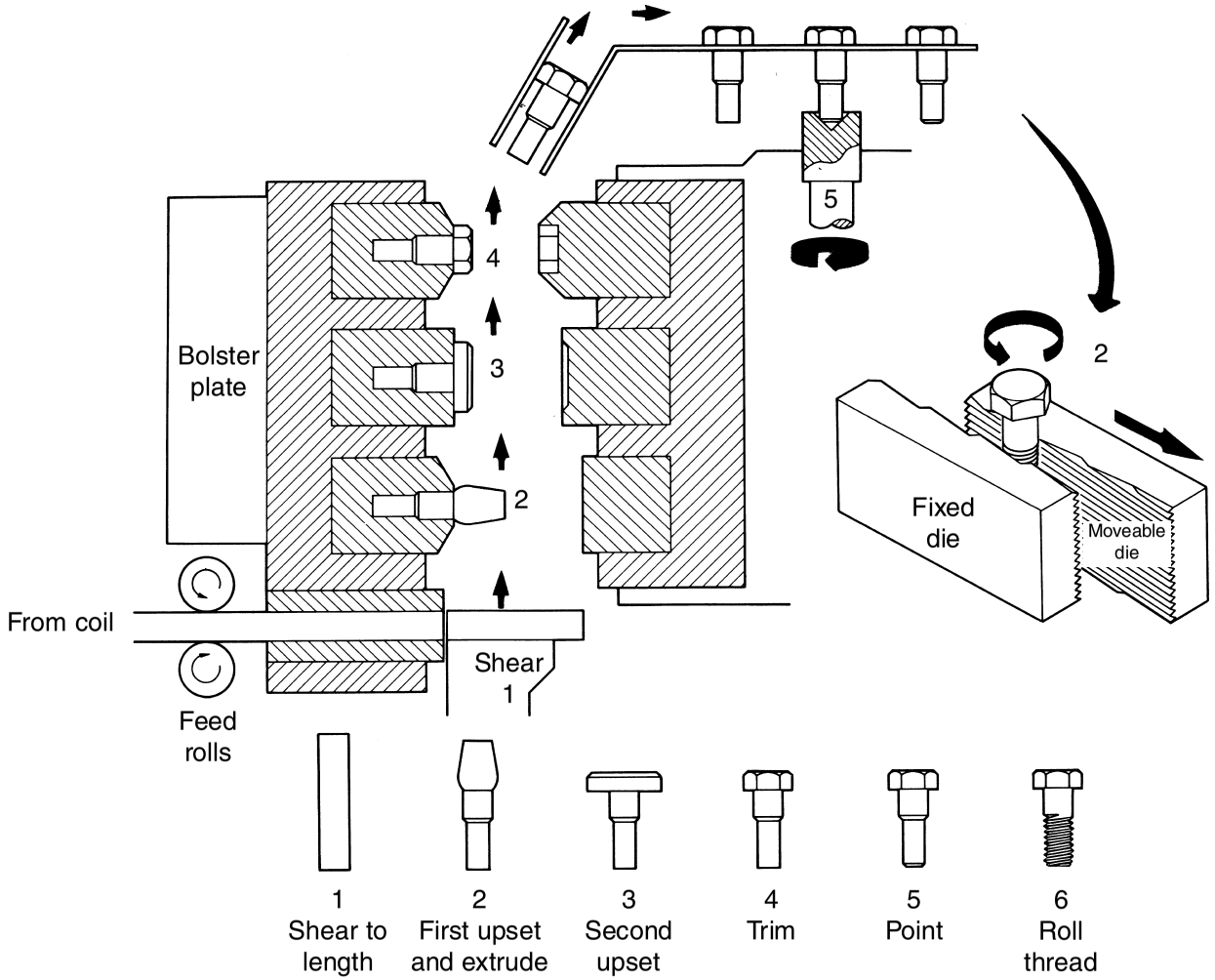
WORKBOOK ANSWERS, Pages 151–154

1. Dust and fumes given off by some plastics may be irritating to the skin, eyes, and respiratory system. Other plastics have fillers such as asbestos and glass fibers which are harmful to your health.
2. Any of the following: high tensile strength, impact resistant, flexible strength, resistance to abrasion, not affected by most chemicals, greases, and solvents.
3. supported
4. soft brass
5. Tools must be kept sharp to prevent the plastic from melting or becoming gummy. Sharp tools also assure a good quality surface finish.
6. annealing
7. It has excellent dimensional stability, high strength, and rigidity. It has low friction, requires minimal use of lubricants, and is very quiet in operation. It is replacing brass and zinc for many applications in the automotive and plumbing industries and is used for parts in business machines.
8. a. the temperature at which it will be used
9. They prevent the heat from dissipating.
10. To deter thermal expansion.
11. Chipless machining forms wire or rod into the desired shape using a series of dies.
12. Cost saving on some jobs, scrap is reduced, and increased production speed.
13. spark plug
14. Sintering is another name for powder metallurgy, a technique used to shape parts from metal powders. It is also the process of transforming the briquette into a strong unit.
15. They are brittle and very fragile.
16. c. the metal tries to return to its original shape
17. Stand-off operations: The charge is located some distance above the work. Its energy is transmitted through a fluid medium, such as water.

Contact operations: The charge is touching the work and the explosive energy acts directly on the metal.

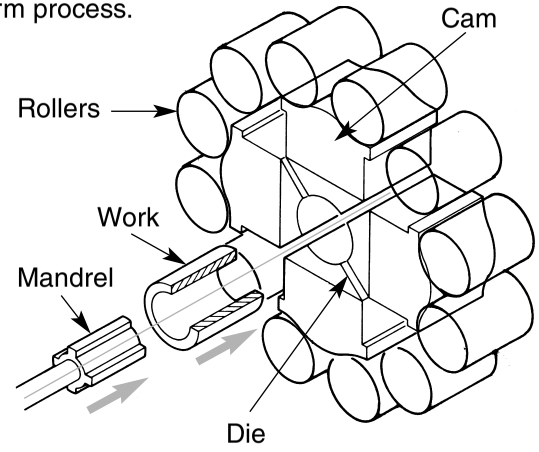
18. An insulated coil is wrapped around or placed within the work. As very high momentary current is passed through the coil, an immense magnetic field is created causing the work to collapse, compress, shrink, or expand depending upon the design of the coil.
19. High-pressure gas is used to accelerate a punch into a die. The forces developed are many times more powerful than those used in conventional forging and are sufficient to shape hard-to-work materials. The metal blank is heated prior to the forming operation and the machine requires less space than the conventional forging press.
20. b. the use of liquid nitrogen as a gas

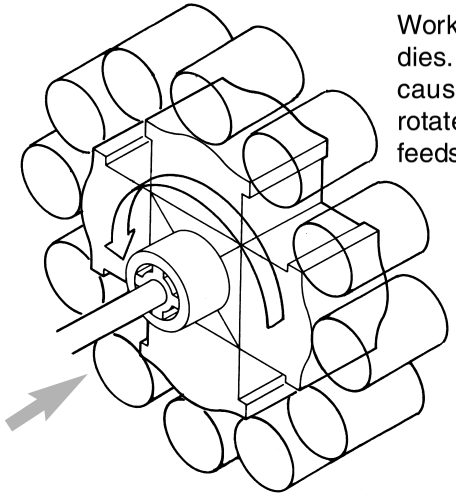
Chipless Machining



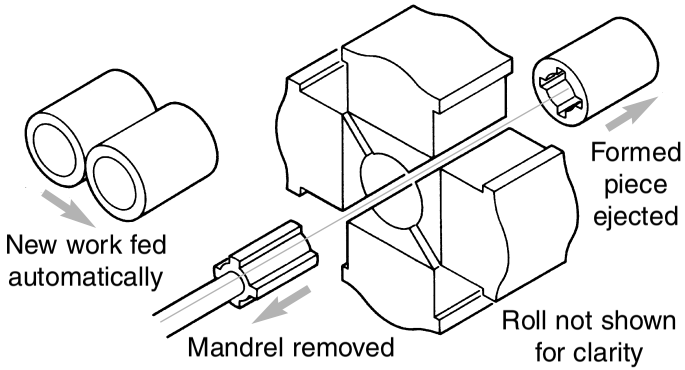
Intraform® Process

A part ready to be shaped by the Intraform process.

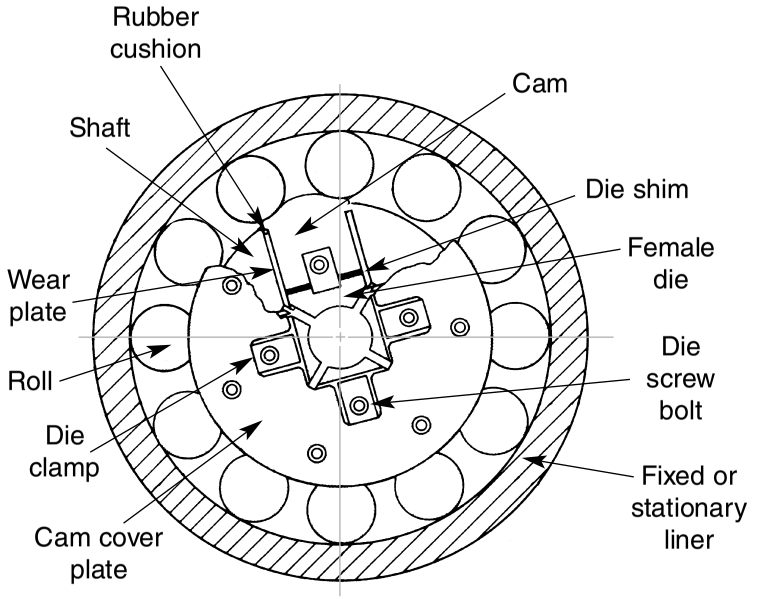




Work and mandrel are placed in the dies. Contact with the rotating dies causes the work and mandrel to rotate at about 80% of die rpm. Work feeds over the mandrel.

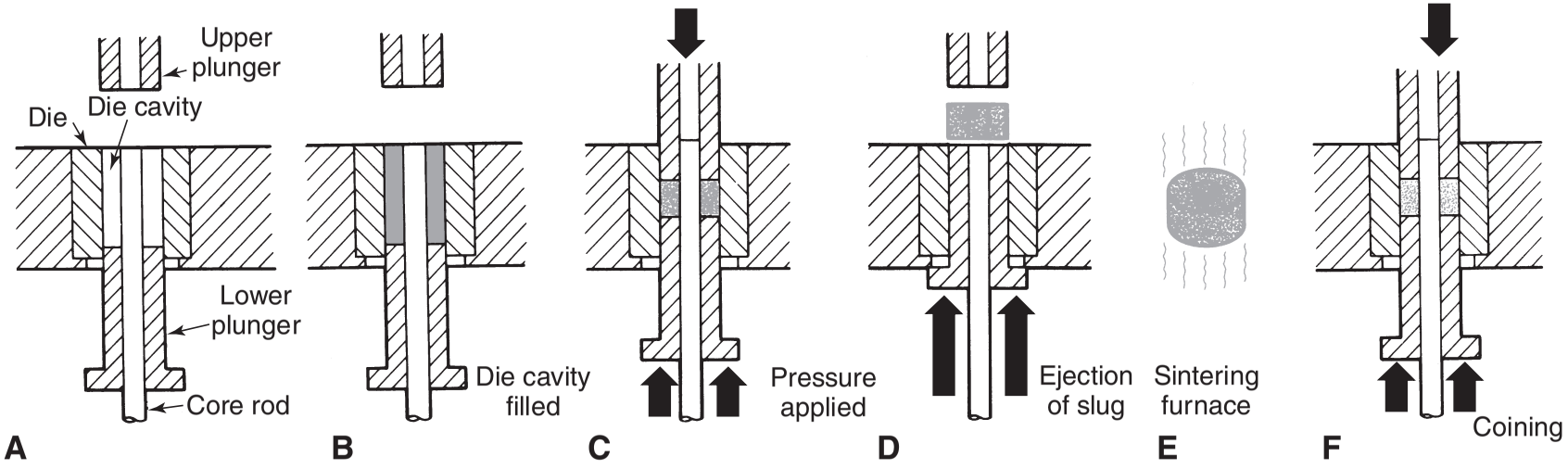


When the operation is completed, the mandrel is retracted. The next piece feeds automatically into position while the formed part is ejected.



Intraform machine die head in open position. Interaction of the cams and rollers squeezes each die more than 1000 times per minute.

Powder Metallurgy Process



Steps in fabricating a part. *A*—Note cross section of die and die cavity. Depth of the cavity is determined by thickness of the required part, and the amount of pressure that will be applied. *B*—Die cavity is filled with proper metal powder mixture. *C*—Pressure as high as 50 tons per square inch is applied. *D*—Briquette or "slug" is pushed from die cavity. *E*—Pieces are then passed through a sintering furnace to convert them into a strong, useful product. *F*—Some pieces can be used as they come from the furnace. Others may require a coining or sizing operation to bring them to exact size and to improve their surface finish.

Electrohydraulic Forming

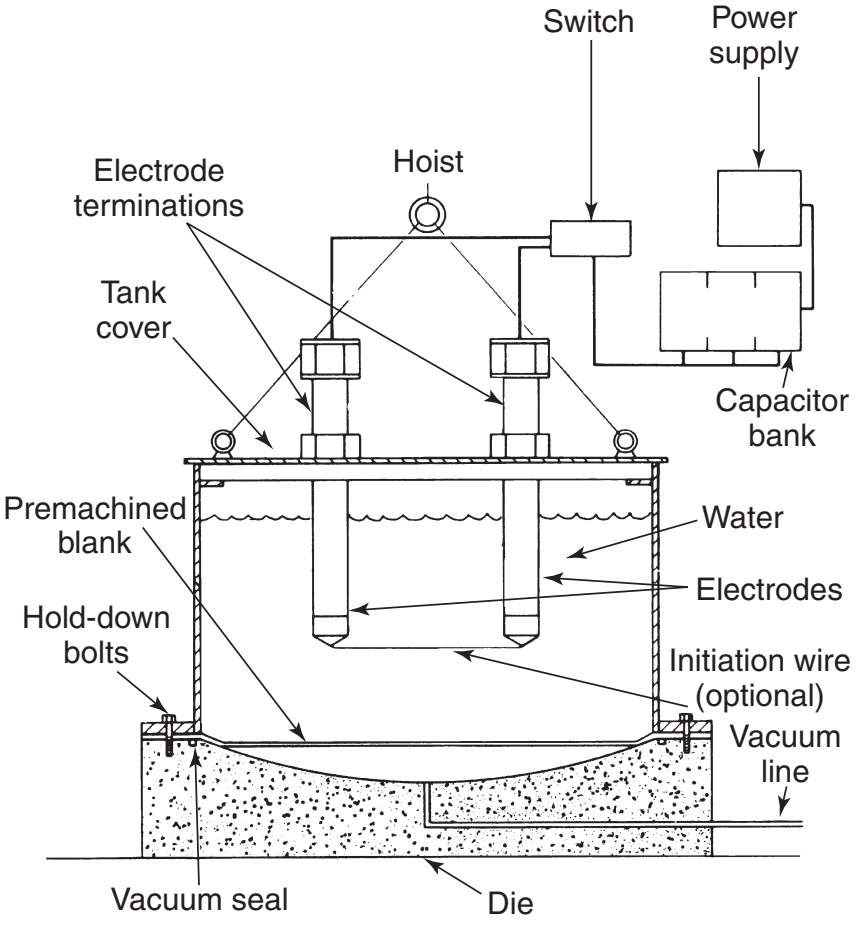
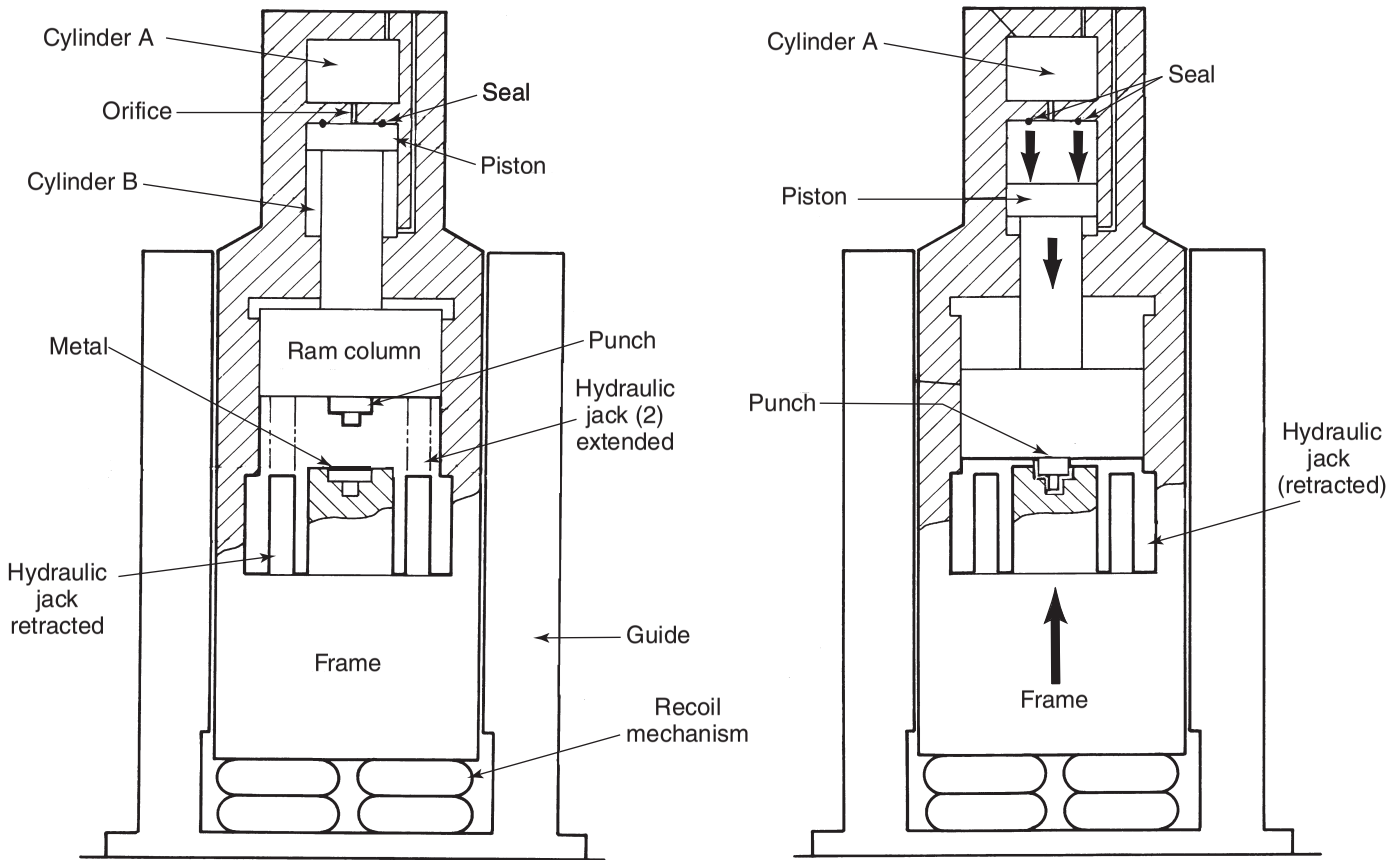


Diagram shows setup for electrohydraulic forming, which uses electrical energy as a source of power for HERF operations.

Pneumatic-Mechanical Forming



Left–Cross-sectional view of a pneumatic-mechanical forming press. The hydraulic jacks extend at the end of each operating cycle to lift ram column back into position for the next cycle. Right–Operation of the press is triggered when pressure in Cylinder A is increased enough to break seal. This sight movement allows high-pressure gas to act instantaneously over entire area of the piston. The ram is driven downward at great speed. At the same time, frame moves upward by reaction of gas pressure over the driven piston. The frame and ram are acted upon with equal thrust so each has equal momentum but in opposite directions. To reset for the next cycle, the jacks lift ram column upward until it seats against the seal.

Other Processes

Name: _____ Date: _____ Score: _____

1. Give a common trade name for each of the following types of plastics.
   a. Polyamide resins: _____
   b. Acetal resins: _____
   c. Fluorocarbon resins: _____
   d. Acrylic resins: _____
2. If plastics are to be machined with any degree of accuracy, the cutting tools must be _____. 2. _____
3. When hand-threading plastics, why is it recommended that the hole or rod be chamfered?

   _____
4. Like metal, many plastics require _____ to ensure against dimensional changes. 4. _____
5. When turning many plastics on a lathe, care must be taken to prevent the _____ from accumulating around the work. If this is not done, heat will build up and cause the plastic to become _____. 5. _____ _____
6. What is unique about Teflon®? _____

   _____
7. Machining plastics can create health problems for the machinist if precautions are not taken. What are these problems and how can they best be handled? _____

   _____

   _____
8. What are laminated plastics? _____

   _____

   _____
9. When drilling laminated plastics, what should be avoided? _____

   _____
10. Chipless machining is also known as _____ or _____. 10. _____ _____
11. How does chipless machining make substantial savings possible? _____

    _____
12. In chipless machining a series of _____ replaces the usual cutting tools of the lathe, drill press, and milling machine. 12. _____

Name: _____

13. Chipless machining is still the most economical way to make _____, _____, _____, and other types of _____. 13. _____

14. List the five basic operations performed by machines making use of the chipless machining process._____

_____

15. *Intraform*® is a chipless machining technique that can form profiles on the _____ of _____ pieces. 15. _____

16. The Intraform® technique has proven to be a practical way to produce: 16. _____
    a. Socket wrenches.
    b. Rifle barrels.
    c. Automotive starter clutch housings.
    d. All of the above.
    e. None of the above.

17. Powder metallurgy, abbreviated _____, is the technique of shaping parts from _____. 17. _____

18. The powder metallurgy process is used to make: 18. _____
    a. Self-lubricating bearings.
    b. Precision machine parts.
    c. Permanent metal filters.
    d. All of the above.
    e. None of the above.

19. List the steps in making a part by the powder metallurgy technique. _____

_____

_____

20. Parts made from metal powder can be: 20. _____
    a. Drilled.
    b. Heat treated.
    c. Turned on a lathe.
    d. All of the above.
    e. None of the above.

21. What is a briquette or "green compact?" _____

_____

_____

Name: _____

22. Why is it often necessary to size, coin, or forge parts made from metal powders after they have been sintered? _____

_____

23. What do the above operations do to the sintered piece? _____

_____

24. The abbreviation HERF means _____

_____.

25. In HERF, metal is shaped: 25. _____
    a. By the slow application of great pressure.
    b. In microseconds, with pressure generated by the sudden application of large amounts of energy.
    c. By conventional forging methods.
    d. All of the above.
    e. None of the above.

26. The pressures needed in HERF are generated by: 26. _____
    a. Detonating explosives.
    b. Releasing compressed gases.
    c. Electromagnetic energy.
    d. All of the above.
    e. None of the above.

27. Many metals tend to _____ to their original shape after being formed by conventional means. This problem is greatly reduced or entirely eliminated when _____ is used to shape the metal. 27. _____

_____

28. What is explosive forming? _____

_____

_____

29. What are some of the disadvantages of explosive forming? _____

_____

_____

_____

30. Why must a vacuum be pulled in the die when explosive forming? _____

_____

_____

31. Depending upon the placement of the explosive, most explosive forming operations fall into two categories. List them. _____

_____

Name: _____

32. _____ is a variation of explosive forming. However, _____ is used in place of the explosive charge to generate the required energy.
32. _____

33. What HERF technique employs a very high electric current passing through an induction coil shaped to produce the required configuration in the work?
33. _____

34. The technique in Question 33 can be used to _____ or _____ on the work to produce the desired shape, depending upon placement of the coil.
34. _____

35. In pneumatic-mechanical forming, _____ is used to accelerate the _____ into the _____.
35. _____

36. What does the term "cryogenic" mean? _____

37. The science of cryogenics deals with temperature starting at _____ (_____) and goes down to temperatures near _____ (_____).
37. _____

38. What does shrink fitting mean? _____

39. Why is it better to use the super-low temperatures of cryogenics, rather than heat, to shrink-fit parts together? _____

40. Why must the cooling of treated cutting tools be done at a slow rate? _____