26.1. Why are the nontraditional material removal processes

important?

26.2. There are four categories of nontraditional

machining processes, based on principal energy

form. Name the four categories.

26.3. How does the ultrasonic machining process work?

26.4. Describe the water jet cutting process.

26.5. What is the difference between water jet cutting,

abrasive water jet cutting, and abrasive jet cutting?

26.6. Name the three main types of electrochemical

machining.

26.7. Identify the two significant disadvantages of electrochemical

machining.

26.8. How does increasing discharge current affect metal

removal rate and surface finish in electric discharge

machining?

26.9. What is meant by the term overcut in electric

discharge machining?

26.10. Identifytwomajordisadvantagesofplasmaarccutting.

26.11. What are some of the fuels used in oxyfuel cutting?

26.12. Name the four principal steps in chemicalmachining.

26.13. What are the three methods of performing the

masking step in chemical machining?

26.14. What is a photoresist in chemical machining?

26.15. (Video) What are the three layers of a part’s

surface after undergoing EDM?

26.16. (Video) What are two other names for ram type

EDMs?

26.17. (Video) Name the four subsystems in a RAM

EDM process.

26.18. (Video) Name the four subsystems in a wire EDM

process.

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MULTIPLE CHOICE QUIZ

There are 17 correct answers in the following multiple choice questions (some questions have multiple answers that are

correct). To attain a perfect score on the quiz, all correct answers must be given. Each correct answer is worth 1 point. Each

omitted answer or wrong answer reduces the score by 1 point, and each additional answer beyond the correct number of

answers reduces the score by 1 point. Percentage score on the quiz is based on the total number of correct answers.

26.1. Which of the following processes use mechanical

energy as the principal energy source (three correct

answers): (a) electrochemical grinding, (b) laser

beam machining, (c) conventional milling, (d) ultrasonic

machining, (e) water jet cutting, and

(f) wire EDM?

26.2. Ultrasonic machining can be used to machine both

metallic and nonmetallic materials: (a) true or

(b) false?

26.3. Applications of electron beam machining are limited

to metallic work materials because of the need

for the work to be electrically conductive: (a) true

or (b) false?

26.4. Which one of the following is closest to the temperatures

used in plasma arc cutting: (a) 2750\_C

(5000\_F), (b) 5500\_C (10,000\_F), (c) 8300\_C

(15,000\_F), (d) 11,000\_C (20,000\_F), or (e)

16,500\_C (30,000\_F)?

26.5. Chemical milling is used in which of the following

applications (two best answers): (a) drilling holes

with high depth-to-diameter ratio, (b) making intricate

patterns in thin sheet metal, (c) removing

material to make shallow pockets in metal,

(d) removing metal from aircraft wing panels,

and (e) cutting of plastic sheets?

26.6. Etch factor is equal to which of the following in

chemical machining (more than one): (a) anisotropy,

(b) CIt, (c) d/u, and (d) u/d; where C ¼

specific removal rate, d ¼ depth of cut, I ¼ current,

t ¼ time, and u ¼ undercut?

26.7. Of the following processes, which one is noted for

the highest material removal rates: (a) electric

discharge machining, (b) electrochemical machining,

(c) laser beam machining, (d) oxyfuel cutting,

(e) plasma arc cutting, (f) ultrasonic machining, or

(g) water jet cutting?

26.8. Which one of the following processes would be

appropriate to drill a hole with a square cross

section, 0.25 inch on a side and 1-inch deep in a

steel workpiece: (a) abrasive jet machining,

(b) chemical milling, (c) EDM, (d) laser beam

machining, (e) oxyfuel cutting, (f) water jet cutting,

or (g) wire EDM?

26.9. Which of the following processes would be appropriate

for cutting a narrow slot, less than 0.015 inch

wide, in a 3/8-in-thick sheet of fiber-reinforced

plastic (two best answers): (a) abrasive jet machining,

(b) chemical milling, (c) EDM, (d) laser beam

machining, (e) oxyfuel cutting, (f) water jet cutting,

and (g) wire EDM?

26.10. Which one of the following processes would be

appropriate for cutting a hole of 0.003 inch diameter

through a plate of aluminum that is 1/16 in

thick: (a) abrasive jet machining, (b) chemical milling,

(c) EDM, (d) laser beam machining, (e) oxyfuel

cutting, (f) water jet cutting, and (g) wire

EDM?

26.11. Which of the following processes could be used to

cut a large piece of 1/2-inch plate steel into two

sections (two best answers): (a) abrasive jet

machining, (b) chemical milling, (c) EDM, (d) laser

beam machining, (e) oxyfuel cutting, (f) water jet

cutting, and (g) wire EDM?

PROBLEMS

Application Problems

26.1. For the following application, identify one or more

nontraditional machining processes that might be

used, and present arguments to support your selection.

Assume that either the part geometry or the

work material (or both) preclude the use of conventional

machining. The application is a matrix of

0.1 mm (0.004 in) diameter holes in a plate of

3.2 mm (0.125 in) thick hardened tool steel. The

matrix is rectangular, 75 by 125 mm (3.0 by 5.0 in)

with the separation between holes in each direction¼

1.6 mm (0.0625 in).

26.2. For the following application, identify one or more

nontraditional machining processes that might be

used, and present arguments to support your selection.

Assume that either the part geometry or the

work material (or both) preclude the use of conventional

machining. The application is an engraved

aluminum printing plate to be used in an offset

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printing press to make 275 \_ 350 mm (11 \_ 14 in)

posters of Lincoln’s Gettysburg address.

26.3. For the following application, identify one or more

nontraditional machining processes that might be

used, and present arguments to support your selection.

Assume that either the part geometry or the

work material (or both) preclude the use of conventional

machining. The application is a through-hole

in the shape of the letter L in a 12.5mm(0.5 in) thick

plate of glass. The size of the ‘‘L’’ is 25 \_ 15mm(1.0

\_ 0.6 in) and the width of the hole is 3 mm (1/8 in).

26.4. For the following application, identify one or more

nontraditional machining processes that might be

used, and present arguments to support your selection.

Assume that either the part geometry or the

work material (or both) preclude the use of conventional

machining. The application is a blind-hole in

the shape of the letter G in a 50 mm (2.0 in) cube of

steel. The overall size of the ‘‘G’’ is 25 \_ 19mm(1.0

\_ 0.75 in), the depth of the hole is 3.8 mm (0.15 in),

and its width is 3 mm (1/8 in).

26.5. Much of the work at the Cut-Anything Company

involves cutting and forming of flat sheets of fiberglass

for the pleasure boat industry.Manual methods

based on portable saws are currently used to perform

the cutting operation, but production is slow and

scrap rates are high. The foreman says the company

should invest in a plasmaarc cuttingmachine, but the

plant manager thinks it would be too expensive.

What do you think? Justify your answer by indicating

the characteristics of the process that make PAC

attractive or unattractive in this application.

26.6. A furniture company that makes upholstered

chairs and sofas must cut large quantities of fabrics.

Many of these fabrics are strong and wear-resistant,

which properties make them difficult to cut. What

nontraditional process(es) would you recommend

to the company for this application? Justify your

answer by indicating the characteristics of the

process that make it attractive.

Electrochemical Machining

26.7. The frontal working area of the electrode in anECM

operation is 2000 mm2. The applied current ¼ 1800

amps and the voltage ¼ 12 volts. The material being

cut is nickel (valence ¼ 2), whose specific removal

rate is given in Table 26.1. (a) If the process is 90%

efficient, determine the rate of metal removal in

mm3/min. (b) If the resistivity of the electrolyte ¼

140 ohm-mm, determine the working gap.

26.8. In an electrochemicalmachining operation, the frontalworking

area of the electrode is 2.5 in2.Theapplied

current ¼ 1500 amps, and the voltage ¼ 12 volts. The

material being cut is pure aluminum, whose specific

removal rate is given in Table 26.1. (a) If the ECM

process is90%efficient, determine the rate of metal

removal in in3/hr. (b) If the resistivity of the electrolyte

¼ 6.2 ohm-in, determine the working gap.

26.9. Asquare hole is to be cut usingECMthrough a plate

of pure copper (valence¼1) that is 20mmthick.The

hole is 25mmon each side, but the electrode used to

cut the hole is slightly less that 25 mm on its sides to

allow for overcut, and its shape includes a hole in its

center to permit the flow of electrolyte and reduce

the area of the cut. This tool design results in a

frontal area of 200mm2. The applied current¼ 1000

amps. Using an efficiency of 95%, determine how

long it will take to cut the hole.

26.10. A 3.5 in diameter through hole is to be cut in a

block of pure iron (Valence ¼ 2) by electrochemical

machining. The block is 2.0 in thick. To speed

the cutting process, the electrode tool will have a

center hole of 3.0 in which will produce a center

core that can be removed after the tool breaks

through. The outside diameter of the electrode is

undersized to allow for overcut. The overcut is

expected to be 0.005 in on a side. If the efficiency

of the ECM operation is 90%, what current will

be required to complete the cutting operation in

20 minutes?

Electric Discharge Machining

26.11. An electric discharge machining operation is being

performed on two work materials: tungsten and tin.

Determine the amount of metal removed in the

operation after 1 hour at a discharge current of

20 amps for each of these metals. Use metric units

and express the answers in mm3/hr. From Table 4.1,

the melting temperatures of tungsten and tin are

3410\_C and 232\_C, respectively.

26.12. An electric discharge machining operation is being

performed on two work materials: tungsten and zinc.

Determine the amount of metal removed in the

operation after 1 hour at a discharge amperage ¼

20 amps for each of thesemetals.UseU.S.Customary

units and express the answer in in3/hr. FromTable 4.1,

the melting temperatures of tungsten and zinc are

6170\_F and 420\_F, respectively.

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26.13. SupposetheholeinProblem26.10weretobecutusing

EDMrather than ECM.Using a discharge current ¼

20 amps (which would be typical forEDM), howlong

would it take to cut the hole? From Table 4.1, the

melting temperature of iron is 2802\_F.

26.14. A metal removal rate of 0.01 in3/min is achieved in

a certain EDM operation on a pure iron workpart.

What metal removal rate would be achieved on

nickel in this EDM operation if the same discharge

current were used? The melting temperatures of

iron and nickel are 2802\_Fand 2651\_F, respectively.

26.15. In a wire EDM operation performed on 7-mmthick

C1080 steel using a tungsten wire electrode

whose diameter ¼ 0.125 mm, past experience suggests

that the overcut will be 0.02 mm, so that the

kerf width will be 0.165 mm. Using a discharge

current ¼ 10 amps, what is the allowable feed rate

that can be used in the operation? Estimate the

melting temperature of 0.80% carbon steel from

the phase diagram in Figure 6.4.

26.16. AwireEDMoperation is to be performed on a slab

of 3/4-in-thick aluminum using a brass wire electrode

whose diameter ¼ 0.005 in. It is anticipated

that the overcut will be 0.001 in, so that the kerf

width will be 0.007 in. Using a discharge current ¼

7 amps, what is the expected allowable feed rate

that can be used in the operation? The melting

temperature of aluminum is 1220\_F.

26.17. A wire EDM operation is used to cut out punchand-

die components from 25-mm-thick tool steel

plates. However, in preliminary cuts, the surface

finish on the cut edge is poor. What changes in

discharge current and frequency of discharges

should be made to improve the finish?

Chemical Machining

26.18. Chemical milling is used in an aircraft plant to create

pockets in wing sections made of an aluminumalloy.

The starting thickness of one workpart of interest is

20 mm. A series of rectangular-shaped pockets

12 mm deep are to be etched with dimensions 200

mm by 400 mm. The corners of each rectangle are

radiused to 15 mm. The part is an aluminum alloy

and the etchant is NaOH. The penetration rate for

this combination is 0.024mm/min and the etch factor

is 1.75. Determine (a) metal removal rate in mm3/

min, (b) time required to etch to the specified depth,

and (c) required dimensions of the opening in the

cut and peel maskant to achieve the desired pocket

size on the part.

26.19. In a chemical milling operation on a flat mild steel

plate, it is desired to cut an ellipse-shaped pocket to

a depth of 0.4 in. The semiaxes of the ellipse are a ¼

9.0 in and b ¼ 6.0 in.Asolution of hydrochloric and

nitric acids will be used as the etchant. Determine

(a) metal removal rate in in3/hr, (b) time required

to etch to depth, and (c) required dimensions of the

opening in the cut and peel maskant required to

achieve the desired pocket size on the part.

26.20. Inacertainchemicalblankingoperation,asulfuricacid

etchant is used to remove material from a sheet of

magnesium alloy. The sheet is 0.25 mm thick. The

screen resist method of masking was used to permit

highproductionratestobeachieved.Asit turnsout,the

process is producing a large proportion of scrap. Specified

tolerances of \_0.025 mm are not being achieved.

The foreman in the CHM department complains that

there must be something wrong with the sulfuric acid.

‘‘Perhaps the concentration is incorrect,’’ he suggests.

Analyze the problem and recommend a solution.

26.21. In a chemical blanking operation, stock thickness of

the aluminumsheet is 0.015 in. The pattern to be cut

out of the sheet is a hole pattern, consisting of a

matrix of 0.100-in diameter holes. If photochemical

machining is used to cut these holes, and contact

printing is used tomake the resist (maskant) pattern,

determine the diameter of the holes that should be

used in the pattern.