Tomsk Polytechnic University

V.N.Kozlov

TECHNOLOGY of MECHANICAL ENGINEERING

Part 1

Workbook

Tomsk 2001

UDK 621.91.002(075)

V.N.Kozlov. Technology of Mechanical Engineering. Part 1. Workbook. Tomsk: TPU Press, 2001, 52 pp.

This workbook is devoted to fixing of accuracy in mechanical engineering and bases of the theory of cutting action.

This workbook is prepared at the TPU Department of Mechanical Engineering.

It is recommended for foreign students following the Bachelor Degree Program in Mechanical Engineering at the Tomsk Polytechnic University.

Reviewed by: V.F. Skvorsov, the head of the department “Technology of Mechanical Engineering, Cutting and Tools”

TO THE STUDENT

The discipline "Technology of mechanical engineering" is studied on the senior rate for the bachelor level in 7 and 8 semesters and is divided into two parts. The parts "Fixing of accuracy in mechanical engineering and bases of the theory of cutting action" are studied in the seventh semester (3 credits). The part second "Technological opportunities of machine tools and designing of technological processes" is studied in the eighth semester (3 credits). At the end of each semester the examination by the appropriate parts is stipulated.

This workbook is written in according with the textbook "Technology of Mechanical Engineering", part 1. The material in the Workbook is presented in the same order and with the same section division as in the textbook. The Workbook contains exercises which must fulfill. This workbook covers the topics to be studied in 5 terms:

1. Measurements and measuring tools.
2. Inspection of surface form, disposition of surfaces and surface finish.
3. Tolerances and fits.
4. Cutting tools.
5. Bases of the cutting action.

1. Measurements and Measuring Tools

1. For what purposes are the following measuring tools used? Describe the main principles of action:
   1) Rules

   _____
   _____
   _____

   2) Caliper rules

   _____
   _____
   _____

   3) Rule depth gages

   _____
   _____
   _____

   4) Combination depth and angle gages

   _____
   _____
   _____

   5) Squares

   _____
   _____
   _____

   6) Combination sets

   _____
   _____
   _____

   7) Protractor heads

   _____
   _____
   _____

8) Center heads

_____
_____
_____

9) Die maker’s squares

_____
_____
_____

10) Cylindrical squares

_____
_____
_____

11) Calipers

_____
_____
_____

12) Center gages

_____
_____
_____

13) Radius gages

_____
_____
_____

14) Machinist’s vises

_____
_____
_____

15) Scribers

_____
_____
_____

16) Dividers

_____
_____
_____

17) Prick punches

_____
_____
_____

18) Center punches

_____
_____
_____

19) Surface plates

_____
_____
_____

20) Straightedges

_____
_____
_____

21) V-blocks

_____
_____
_____

22) Telescoping gages

_____
_____
_____

23) Small-hole gages

_____
_____
_____

24) Adjustable parallels

_____
_____
_____

2. Enumerate principal parts of micrometer.

_____
_____
_____

3. Enumerate the principal characteristics of a micrometer.

4. The readings on the micrometer are of 12.45 mm and 12.95 mm. Explain it.

5. For what purposes are the outside, inside and depth micrometers used? Describe the main principle of action.

6. For what purposes are the vernier calipers used? Enumerate its principal kinds.

7. Show vernier reading of 121.35 mm. Explain it.

8. For what purposes is the universal bevel protractor used? Show reading of 12°45′. Explain it.

_____
_____
_____
_____
_____
_____

9. For what purposes are the dial indicating instruments used? Enumerate its principal kinds.

_____
_____
_____
_____
_____

10. How to check and set the indicating hole gage?

_____
_____
_____
_____
_____

11. For what purposes are the gage blocks used? Describe the procedure for building the gage block combinations (for example, 125.673 mm).

_____
_____
_____
_____
_____
_____
_____
_____
_____

12. For what are the purposes limits gages used? Enumerate its principal kinds.

_____
_____
_____
_____
_____
_____

13. For what purposes are the toolmaker's microscopes and optical comparators used?

_____
_____
_____
_____

14. For what purposes is the sine bar used? How to establish the angle of 25°?

_____
_____
_____
_____
_____

2. Inspection of Surface Form, Disposition of Surfaces and Surface Finish

1. Complete the following sentences:

1.1. Deviation from the straight is

_____
_____
_____
_____
_____

1.2. Deviation from the flatness is

_____
_____
_____
_____
_____

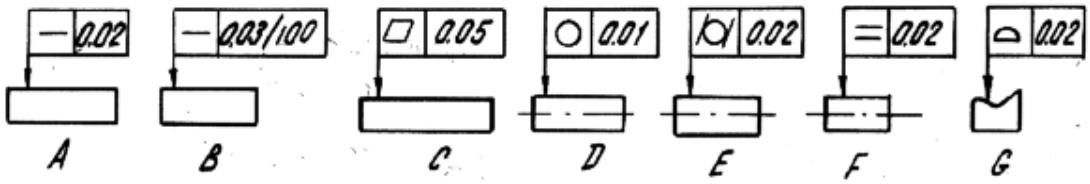
1.3. The levels of relative geometrical accuracy are established depending on

_____
_____
_____
_____
_____
_____
_____
_____

1.3. Deviation from the roundness is

_____
_____
_____
_____
_____

2. Explain the following symbols:



_

A_____
_____
_____

B_____
_____
_____

C_____
_____
_____

D_____
_____
_____

E_____
_____
_____

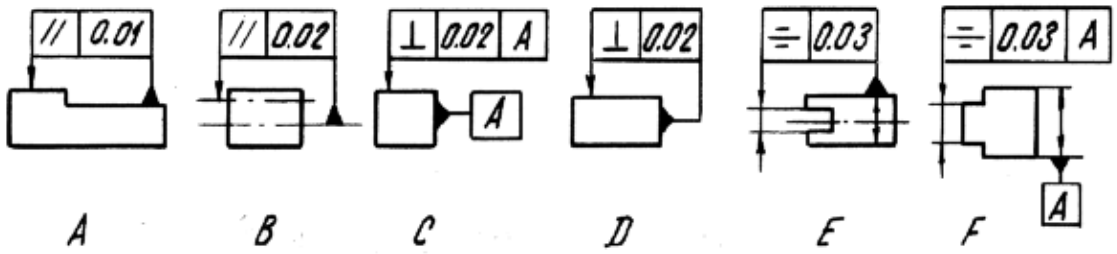
F_____
_____
_____

G_____
_____
_____

3. Deviation of the disposition of a surface or a profile is

_____
_____
_____
_____
_____
_____

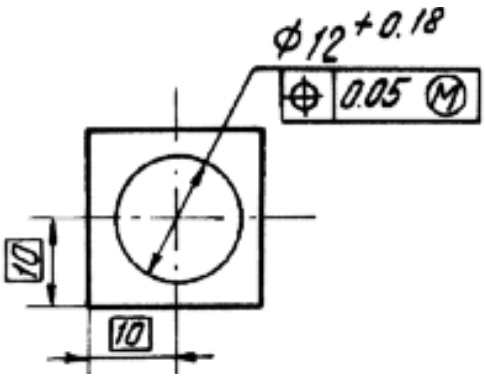
4. Explain the following symbols:



A_____
_____
_____
B_____
_____
_____
C_____
_____
_____
D_____
_____
_____
E_____
_____
_____
F_____
_____
_____

5. The dependent tolerance is
_____
_____
_____
_____

6. Explain the following symbol:



_____
_____
_____
_____
_____
_____
_____

7. Explain the following symbols:

_

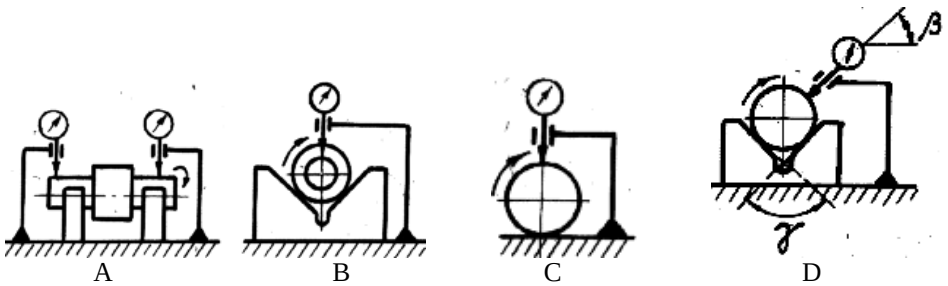
A_____
_____
_____
_____

B_____
_____
_____
_____

C_____
_____
_____
_____

D_____
_____
_____
_____

8. Explain the following schemes of the deviation measurements:



A_____
_____

_____
_____
B_____
_____
_____
_____
C_____
_____
_____
_____
D_____
_____
_____
_____
_____

9. Complete the following sentences:

1) The roughness average is

_____
_____
_____
_____

Ra =

2) The roughness sampling length ℓ is

_____
_____
_____

3) The standard values of the roughness sampling length ℓ are (mm):

_____
_____
_____

4) The height of the profile roughness by ten points is

_____
_____
_____
_____

Rz =

5) The roughness spacing on the centerline is

_____
_____
_____

S_m =

10. How to measure the flatness of a surface using an optical flat?

_____
_____
_____
_____
_____

3. Tolerances and Fits

1. How to measure a part (d=75.1 mm) by the method of relative measurements?

_____
_____
_____
_____
_____
_____

2. Complete the following sentences:

1) The actual size is

_____
_____

2) The basic size is

_____
_____

3) The fundamental deviation is

_____
_____

4) The tolerance is

_____
_____

3. Define deviations of the tolerance zones:

1) 60g6
2) 60g7
3) 60G6
4) 60G7
5) 60h6
6) 60H6
7) 60s7

4. Define the minimum and maximum clearances for the fit 20H7/g6

_____
_____
_____
_____

5. Define the limiting interferences for the fit 80H7/s7

_____
_____
_____

6. Define the limiting interference and clearance for the fit 50H7/n6

_____
_____
_____

7. Define the limiting interference and clearance for the rolling bearing fits 30B0/n6 and 70H7/b0

_____
_____
_____
_____
_____

8. Define the deviations of shaft group tolerance zones for the fit with $S_{max}<[S_{max}]=18$ μm and $S_{min}> [S_{min}]=2$ μm for the basic size 20 mm when we can produce parts with tolerance T=16 μm. Use the method of selective assembly.

_____
_____
_____
_____
_____

_____
_____

Answer: 1-st gr. $20^{-0.002}_{-0.01}$ mm
2-nd gr. $20^{+0.006}_{-0.002}$ mm

9. Define the deviations of limit gages to check the shaft and the hole of the fit 30H7/g6.

_____
_____
_____
_____
_____
_____
_____
_____

Answer: 30H7 NOT-GO $\rightarrow 30.023_{-0.004}$ mm
30H7GO $\rightarrow 30.005_{-0.004}$ mm
$30H7GO_{wear} \rightarrow 30.005_{-0.007}$ mm
30g6 NOT-GO $\rightarrow 29.978^{+0.004}$ mm
30g6 GO $\rightarrow 29.988^{+0.004}$ mm
$30g6\ GO_{wear} \rightarrow 29.988^{+0.007}$ mm

10. Define the deviations of tolerance zones for the slot free junction with the basic size 6 mm.

_____
_____
_____
_____

Answer: Shaft slot $\rightarrow 6H9(^{+0.03})$ mm
Hole slot $\rightarrow 6D10(_{+0.03}{}^{+0.078})$ mm
Key $\rightarrow 6h9(_{-0.03})$ mm

11. Write a lubrication of the slit junction for centring on an external diameter if the slit junction has 8 slit, external diameter 50 mm, the internal diameter is 46 mm, the slit width is 7 mm. (for example: d-8 x 36H7/e8 x 40H12/a11 x 7D9/f8.)

_____
_____
_____

Answer: D-8 x 46H12/a11 x 50H7/e8 x 7D9/f8.

12.Write the work size of corner 20° for grade tolerance 17.

_____

Answer: 20°±1°.

13.Complete the following sentences:

1) The major diameter of a screw thread is

_____

_____

2) The minor diameter is

_____

_____

3) The pitch diameter is

_____

_____

4) The pitch is

_____

_____

5) The lead is

_____

_____

6) The angle of a thread is

_____

_____

7) The lead angle is

_____

_____

8) The depth of engagement is

_____

_____

_____

9) The length of engagement is

_____

_____

_____

14. Define limit diameters of a screw and a nut for the thread junction M16 x 2–7H/6g.

Answer: $D_{min} = 16$ mm

$d = 16^{-0.038}_{-0.318}$ mm

$D_2 = 14.701^{+0.265}$ mm

$d_2 = 14.701^{-0.038}_{-0.163}$ mm

$D_1 = 13.835^{+0.475}$ mm

$d_{1max} = 13.707$ mm

15. Where is the square thread used?

16. Why the square thread cannot be made efficiently with dies, taps or milling cutters?

17. Where is the acme thread used?

18. Why can the acme thread be made efficiently with dies, taps or milling cutters?

19. Why are the Brown and sharpe worm threads used in worm gear drive systems?

_____
_____

20. Why must a pipe compound be used to seal the clearance space which exists between the crests and roots of the mating threads?

_____
_____
_____

21. Where are the straight pipe threads (NPS) sometimes used?

_____
_____
_____
_____

22. Where are the American standard Dryseal pipe threads (NPTF) used?

_____
_____
_____
_____

23. How are the processes of cutting internal and external threads called?

_____
_____
_____
_____

24. What kind of measuring tools can be used for measuring and checking threads?

_____
_____
_____
_____

25. What is the peculiarity of all the methods of the pitch diameter measurement?

_____
_____
_____
_____

26. What profile has a not-go gage and why?

_____
_____
_____
_____

27. What profile has a go gage and why?

_____
_____
_____

28.What types of gears do you know?

_____
_____
_____
_____

29.What is the module of gear?

_____
_____
_____

30.What is the circular pitch?

_____
_____
_____

31.How to calculate the module?

_____
_____
_____

32. What is the base circle?

_____
_____
_____
_____

32.What is the pitch circle?

_____
_____
_____
_____

33.What is the pitch line?

_____
_____
_____
_____

34.What is the line of action?

_____
_____
_____

35.What is the pressure angle?

_____
_____
_____

36.What are the basic forms (or curves) used for gear teeth?

_____
_____
_____

37.Why are the SI metric 20° and the American Standard 20° gears not interchangeable?

_____
_____
_____

38.What norms of accuracy do you know?

_____
_____
_____

39.What is the kinematics error of a gear?

_____
_____
_____

40.What parameters of the kinematics accuracy of gears do you know?

_____
_____
_____
_____
_____
_____
_____

41. What parameters of the smoothness of work of gears do you know?

_____
_____
_____

42. What parameters of the transfer teeth contact do you know?

43.What kinds of interfaces determining various values $j_{n\,min}$ are established?

44.What kinds of the tolerances T_{jn} are established for a lateral clearance?

45.How to define the lateral clearance $j_{n\ min}$ for compensating the temperature deformations?

46.What does 7-6-7-Ca/V -128 mean?

47.What is necessary to mark on the assembly drawings?

48. What is necessary to mark on the design drawings?

49. What is the histogram?

50. What kind of curves for probability density functions *y* of random variable *x* do you know?

51. What formula is used to calculate an average square-law mistake?

52. What is the dispersion of measurements?

53. What is the factor of variance?

54. What is a confidence level?

55. What is a confidence interval?

56. What are the typical mean-square errors used in practical measurements? Explain why.

57. What is the Student factor?

58. What characteristics are needed to describe the random errors?

59. What does the confidence level α depend on in the table of the Student factor?

60. We have received the values 50.1; 50.3; 50.4; 50.3; 49.9 mm (five measurements of a hole diameter). It is required to define the confidence level where the average arithmetic differs from true value no more than on 0.08 mm.

Answer: 75%

61. We have made five measurements of a hole diameter and calculated the arithmetic mean D_m =50.2 mm and the standard deviation $S_{m=5}$=0.14 mm. It is required to define the least number of measurements n, for which the divergence from true value would not exceed ±0.1 mm with probability not less than 98 %.

Answer: 53 measurements

62. How to construct the experimental diagram taking into account the errors of determining the coordinates of points?

63.Can the least squares method recommend the kind of approximating function?

64.Why a diagram is presented sometimes in double logarithmic coordinates?

65.A meter stick (read to the nearest mm) is used to measure a length of 120 mm. What is the absolute uncertainty? What is the relative uncertainty?

Answer: ±5 mm; 0,4%.

66.A travelling microscope can be read to 0.1 mm. What is the precision of the measurement of a distance of 10 mm?

Answer: 0,5%.

67.What is the smallest distance which can be measured using a meter stick (read to mm) so that the uncertainty shall not exceed (a) 1 per cent, (b) 5 per cent?

Answer: 50 mm; 10 mm.

68. A distance of 20 mm must be measured to 1 per cent. (a) Would a meter stick be suitable? (b) Would a travelling microscope (read to 0.1 mm) be suitable?

Answer: a) No; b) Yes.

69. A barometer reading normal atmospheric pressure can be read to 0.1 mm. What is the precision?

Answer: 0,007%.

70. An ammeter reading 0-5 amp is graduated in 0.1 amp. Assuming that it is read to the nearest scale division, what is the precision of measurement (a) at full scale? (b) at 1 amp?

Answer: a) 1%; b) 5%.

71. It is stated that today is 5.4° warmer than yesterday. Both measurements were made on the same thermometer read to 0.2°. What is the precision of this statement?

Answer: 3,7%.

72. A density measurement gives the following figures: mass, 24.32 g ± 0.005; volume, 10.2 ± 0.05 cc. What is the absolute uncertainty in the density?

Answer: 0.012 g cc^{-1}.

73. Repeated measurements of the diameter of a wire of circular cross section gave the mean of 0.41 mm with the sample standard deviation of 0.07. What is the sample standard deviation of the resulting calculation of the cross-sectional area?

Answer: 0.045.

74. The coefficient of linear expansion α of a solid is to be measured using the equation

$$\ell=\ell_0(1+\alpha\cdot\Delta T).$$

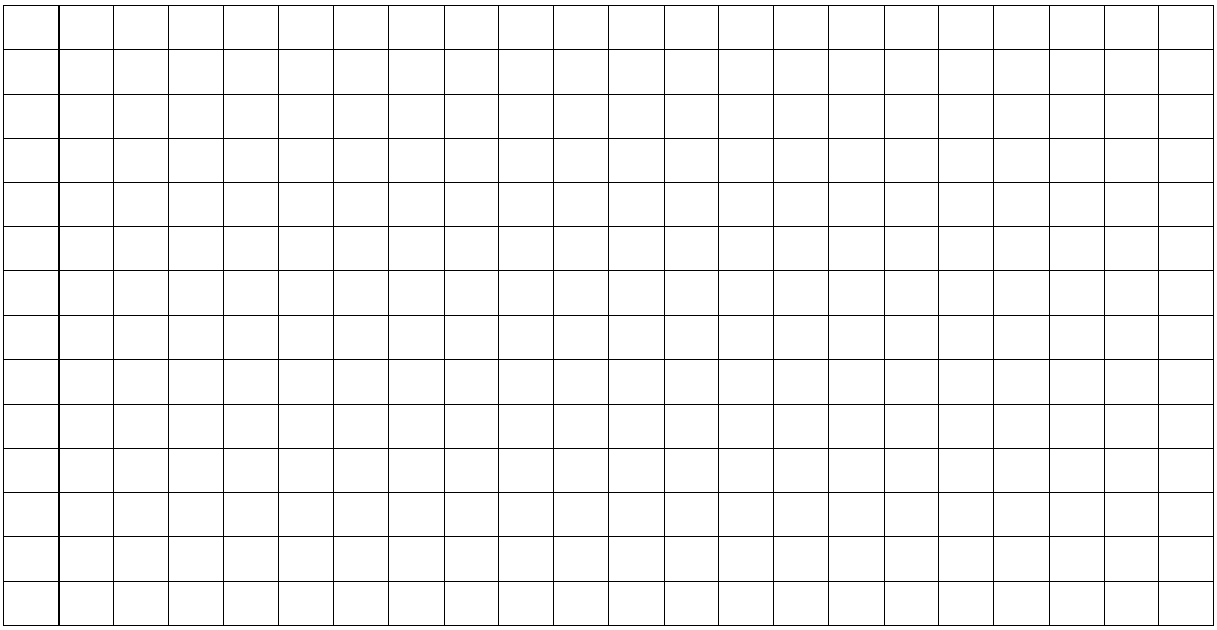
The length ℓ_0 is about 500 mm and the expansion $\ell-\ell_0$ can be measured to 0.05 mm. Knowing that α is about 2×10^{-5} and neglecting the uncertainties in measuring ℓ_0 and ΔT, calculate the minimum temperature rang ΔT which will permit α to be measured to 10 %.

Answer: approximately 50°.

75. The following observations of angles (in minutes of arc) were made while measuring the thickness of a liquid helium film. Assume that the observations show random uncertainty and that they are a sample from a Gaussian universe.

34	35	45	40	46
38	47	36	38	34
33	36	43	43	37
38	32	38	40	33
38	40	48	39	32
36	40	40	36	34

Draw the histogram of the observations.



76. Identify the mode and the median for this histogram.

Answer: between 38 and 39; 38.

77. Calculate the mean.

Answer: 38.30.

78. Calculate the best estimate of the universe standard deviation.

Answer: 4.388.

79. Calculate the standard deviation in the mean.

Answer: 0.801.

80. Calculate the standard deviation of the standard deviation.

Answer: 0.576.

81. Within which limits does a single reading have (a) a 68 % chance of falling, and (b) which limits give a 95 % chance?

Answer: a) ±4.388 about the universe mean.
b) ±8.776 about the universe mean.

82. Within which limits does the mean have (a) a 68 % chance, and (b) a 95 % chance of falling?

Answer: a) ±0.801 about the universe mean.
b) ±1.602 about the universe mean.

3. Cutting Tools

1. What principles are the edged cutting tools based on to cut metals?

2. How can the cutting tools be classified? (3 kinds of classification.)

3. What types of the single-point tools do you know?

4. Why are the inserted tools (indexable throwaway inserts) widely used?

5. What types of the tool bits do you know?

6. What are the differences between the various types of metal-cutting tools?

7. What elements and surfaces of the cutting tools do you know? (Enumerate 9 elements and surfaces.) Describe them.

8. What is the true rake angle of a tool?

9. What is the toolholder angle?

10.The side-relief angle is

11.The main back angle is

12.The end-relief angle is

_____
_____
_____
_____

13.What are the working angles?

_____
_____
_____
_____

14.The grinding angle is

_____
_____
_____
_____

15.What is the side cutting edge angle?

_____
_____
_____

16.What is the end cutting edge angle?

_____
_____
_____

17.Why should only the required amount of end or side relief be used?

_____
_____
_____
_____
_____

18.What are the end- and side-relief angles fairly standard for turning many common metals with high-speed steel tools?

_____
_____
_____

19.What are the end- and side-relief angles used for turning many common metals with tungsten-carbide tools?

_____
_____
_____
_____

20.The back-rake angle is

_____
_____
_____

21.What is the positive rake angle?

_____
_____
_____
_____

22.The side rake angle is

_____
_____
_____

23.The main front angle is

_____
_____
_____
_____

24.The angle of keenness is

_____
_____
_____
_____

25. The main angle in the plan is

_____
_____
_____

26.For what purpose are the chip breakers used?

_____
_____
_____

27.What types of chip breakers do you know?

_____
_____
_____
_____
_____
_____
_____
_____
_____

28.What do you know about the most important properties of cutting tool material?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

29.What do you know about the advantages and disadvantages of a high-carbon tool steel?

_____
_____
_____
_____

30.What cutting tools are made of a high-carbon tool steel?

_____
_____
_____

31. What do you know about the advantages and disadvantages of a high-speed steel?

_____
_____
_____
_____

32.What do you know about the types of high-speed steel?

33.What are the coated high-speed steel tools?

34.What cutting tools are made of a high-speed steel?

35.What are the cast alloys?

36.Where are the cast alloys used?

37.What are the advantages and disadvantages of the cast alloys in comparison with the high-speed steels?

38.What are the cemented carbides?

39.What are the two basic groups of carbide materials?

40. What are the advantages and disadvantages of the cemented carbides in comparison with the high-speed steels?

41.How does the amount of cobalt of the cemented carbides affect the hardness of a cutting tool?

42. What are the factors that influence the hardness, wear resistance, and impact toughness of the carbides and how?

43. What are the eight classifications used in grouping machining applications for cemented-carbide cutting tools according to the Carbide Industry Classification System?

44. What are the coated carbides?

45. What precautions should be executed when using the of cemented-carbide cutting tools?

46. What are the cermet cutting tools?

47. What are the ceramic cutting tools?

48. What are the advantages and disadvantages of the ceramic and cermet in comparison with the cemented-carbides?

49. What are the advantages and disadvantages of diamonds in comparison with the cemented-carbides?

50. What are the general rules which should be followed as a guide in selecting cutting speeds for cutting tools made of different materials?

5. Bases of the Cutting Action

1. What is the depth of cut?

2. What is the cutting speed?

3. What is the cutting feed?

4. What are the coarse and finer feeds?

5. What is the shear plane?

6. What is the shear angle?

7. What do you know about the components of a cutting force for a lathe tool?

8. What do you know about the basic types of chips?

9. What are the advantages and disadvantages of the continuous chips?

10. What is the built-up edge?

11. What are the factors which tend to minimize the formation of chips with a built-up edge?

12. What are the factors which contribute to the formation of discontinuous type chips?

13.How does the built-up end influence the roughness of a processed surface?

14.How to calculate a cutting speed?

15. How to calculate the cutting force?

16.Where does the wear of cutting tool take place on the cutting edge?

17.How can the causes of wear be classified?

18. Draw the distribution of temperature in a cutting tool in the main cross section.

19.What do you know about the principal functions of cutting fluids?

20.What do you know about the basic types of cutting fluids?

21. What are the principal purposes of a cutting fluid at high speeds?

22. What are the components used for straight cutting oils?

23. Enumerate the useful properties of straight cutting oils.

24. What does the term “transparent oils” mean?

25. What are the advantages and disadvantages of the two basic types of mineral cutting oils?

26. What are the emulsifiable oils?

_____
_____

27. What are the advantages and disadvantages of the emulsifiable oils?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

28. What can other types of cutting fluids and means beside the straight cutting oils, the emulsifiable oils, and the chemical or synthetic cutting fluids be used in machining metals?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

29. Enumerate the principal factors which can be used as a guide in selecting a cutting fluid for a particular application?

_____
_____
_____
_____
_____
_____
_____
_____
_____

30. How many classified groups of metals are there according to their approximate machinability ratings?

31. What do you know about the commonly used lathe tool bits and their applications?

32. What does the amount of relief angle depend on?

33. What are the average tool angles for single-point high-speed steel tools used for cutting medium-carbon steel?

34. What are the average tool angles for single-point high-speed steel tools used for cutting cast iron (hard)?

_____
_____

35. What are the average tool angles for single-point high-speed steel tools used for cutting aluminum?

_____
_____
_____
_____

36. What are the recommended angles for single-point carbide tools used for cutting aluminum?

_____
_____
_____
_____

37. What are the recommended angles for single-point carbide tools used for cutting carbone steels SAE 1025?

_____
_____
_____
_____
_____

38. What are the recommended angles for single-point carbide tools used for cutting stainless steel, hardenable?

_____
_____
_____
_____
_____

39. What are the recommended angles for single-point carbide tools used for cutting high-nickel alloys?

_____
_____
_____
_____
_____

40. What are the recommended angles for single-point carbide tools used for cutting titanium alloys?

41. What are the recommended angles for the angular-shoulder chip breaker used for cutting carbone steels?

42. What are the recommended dimensions for the groove chip breaker used for cutting carbone steels?

43. What is the height at which a lathe tool should be set?

44. What precautions should be followed when using the carbide materials?

45. What is the shortening of a chip?

46. How to estimate the plastic deformation in the cutting?

47. Why is the actual main front (or side-rake) angle γ_a increased from cutting speed 5 to 35 mpm?

48. What are the disadvantages and advantages of the built-up end appearance?

49. What cutting speeds are used for cutting the medium-carbon steels with H.S.S. cutting tool?

_____
_____
_____

50. What cutting speeds are used for cutting the medium-carbon steels with a carbide cutting tool?

_____
_____
_____

51. What cutting speeds are used for cast iron cutting with a carbide cutting tool?

_____
_____
_____

52. What is the main cause of cutting tool wear?

_____
_____
_____
_____
_____

53. What is the tool life usually used?

_____
_____
_____
_____
_____
_____

54. Why are the cutting fluids used in grinding operations?

_____
_____
_____
_____
_____
_____
_____
_____
_____

Contents

V.V. Konev