GATE SOLVED PAPER - ME
MANUFACTURING ENGINEERING

YEAR 2013

ONE MARK

Q. 1
Match the correct pairs

<table>
<thead>
<tr>
<th>Processes</th>
<th>Characteristics/Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Friction Welding</td>
<td>1. Non-consumable electrode</td>
</tr>
<tr>
<td>Q. Gas Metal Arc Welding</td>
<td>2. Joining of thick plates</td>
</tr>
<tr>
<td>R. Tungsten Inert Gas Welding</td>
<td>3. Consumable electrode wire</td>
</tr>
<tr>
<td>S. Electroslag Welding</td>
<td>4. Joining of cylindrical dissimilar material</td>
</tr>
</tbody>
</table>

(A) P-4, Q-3, R-1, S-2
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-3, R-4, S-1
(D) P-2, Q-4, R-1, S-3

Q. 2
In a rolling process, the state of stress of the material undergoing deformation is

(A) pure compression
(B) pure shear
(C) compression and shear
(D) tension and shear

Q. 3
For a ductile material, toughness is a measure of

(A) resistance to scratching
(B) ability to absorb energy up to fracture
(C) ability to absorb energy till elastic limit
(D) resistance to indentation.

Q. 4
A cube shaped solidifies in 5 min. The solidification time in min for a cube of the same material, which is 8 times heavier than the original casting, will be

(A) 10
(B) 20
(C) 24
(D) 40

Q. 5
A steel bar 200 mm in diameter is turned at a feed of 0.25 mm/rev with a depth of cut of 4 mm. The rotational speed of the workpiece is 160 rpm. The material removal rate in mm³/s is

(A) 160
(B) 167.6
(C) 1600
(D) 1675.5

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TWO MARKS

Q. 6
In a CAD package, mirror image of a 2D point P(5, 10) is to be obtained about a line which passes through the origin and makes an angle of 45° counterclockwise with the X-axis. The coordinates of the transformed point will be

(A) (7.5, 5)
(B) (10, 5)
(C) (7.5, -5)
(D) (10, -5)
Q. 7 Two cutting tools are being compared for a machining operation. The tool life equations are:

Carbide tool: \( VT^{1.6} = 3000 \)

HSS tool: \( VT^{0.6} = 200 \)

where \( V \) is the cutting speed in m/min and \( T \) is the tool life in min. The carbide tool will provide higher tool life if the cutting speed in m/min exceeds

(A) 15.0 (B) 39.4 (C) 49.3 (D) 60.0

Q. 8 During the electrochemical machining (ECM) of iron (atomic weight = 56, valency = 2) at current of 1000 A with 90% current efficiency, the material removal rate was observed to be 0.26 gm/s. If Titanium (atomic weight = 48, valency = 3) is machined by the ECM process at the current of 2000 A with 90% current efficiency, the expected material removal rate in gm/s will be

(A) 0.11 (B) 0.23 (C) 0.30 (D) 0.52

Q. 9 Cylindrical pins of 25\( \frac{1}{mm} \) mm diameter are electroplated in a shop. Thickness of the plating is 30\( \frac{\mu m}{mm} \) micron. Neglecting gage tolerances, the size of the GO gage in mm to inspect the plated components is

(A) 25.042 (B) 25.052 (C) 25.074 (D) 25.084

Common Data For Q. 10 and 11

In orthogonal turning of a bar of 100 mm diameter with a feed of 0.25 mm/rev, depth of cut of 4 mm and cutting velocity of 90 m/min, it is observed that the main (tangential) cutting force is perpendicular to the friction force acting at the chip-tool interface. The main (tangential) cutting force is 1500 N.

Q. 10 The orthogonal rake angle of the cutting tool in degree is

(A) zero (B) 3.58 (C) 5 (D) 7.16

Q. 11 The normal force acting at the chip-tool interface in N is

(A) 1000 (B) 1500 (C) 2000 (D) 2500

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Q. 12 In abrasive jet machining, as the distance between the nozzle tip and the work surface increases, the material removal rate

(A) increases continuously.
(B) decreases continuously.
(C) decreases, becomes stable and then increases.
(D) increases, becomes stable and then decreases.
Q. 13
Match the following metal forming processes with their associated stresses in the workpiece.

<table>
<thead>
<tr>
<th>Metal forming process</th>
<th>Types of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Coining</td>
<td>P. Tensile</td>
</tr>
<tr>
<td>2. Wire Drawing</td>
<td>Q. Shear</td>
</tr>
<tr>
<td>3. Blanking</td>
<td>R. Tensile and compressive</td>
</tr>
<tr>
<td>4. Deep Drawing</td>
<td>S. Compressive</td>
</tr>
</tbody>
</table>

(A) 1-S, 2-P, 3-Q, 4-R  
(B) 1-S, 2-P, 3-R, 4-Q  
(C) 1-P, 2-Q, 3-S, 4-R  
(D) 1-P, 2-R, 3-Q, 4-S

Q. 14
In an interchangeable assembly, shafts of size $25.000^{+0.040}_{-0.010}$ mm mate with holes of size $25.000^{+0.030}_{-0.020}$ mm. The maximum interference (in microns) in the assembly is

(A) 40  
(B) 30  
(C) 20  
(D) 10

Q. 15
During normalizing process of steel, the specimen is heated

(A) between the upper and lower critical temperature and cooled in still air.  
(B) above the upper critical temperature and cooled in furnace.  
(C) above the upper critical temperature and cooled in still air.  
(D) between the upper and lower critical temperature and cooled in furnace.

Q. 16
A CNC vertical milling machine has to cut a straight slot of 10 mm width and 2 mm depth by a cutter of 10 mm diameter between points (0,0) and (100,100) on the XY plane (dimensions in mm). The feed rate used for milling is 50 mm/ min. Milling time for the slot (in seconds) is

(A) 120  
(B) 170  
(C) 180  
(D) 240

Q. 17
A solid cylinder of diameter 100 mm and height 50 mm is forged between two frictionless flat dies to a height of 25 mm. The percentage change in diameter is

(A) 0  
(B) 2.07  
(C) 20.7  
(D) 41.4

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Q. 18
Detail pertaining to an orthogonal metal cutting process are given below

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip thickness ratio</td>
<td>0.4</td>
</tr>
<tr>
<td>Undeformed thickness</td>
<td>0.6 mm</td>
</tr>
<tr>
<td>Rake angle</td>
<td>$+10^\circ$</td>
</tr>
<tr>
<td>Cutting speed</td>
<td>2.5 m/s</td>
</tr>
<tr>
<td>Mean thickness of primary shear zone</td>
<td>25 microns</td>
</tr>
</tbody>
</table>

The shear strain rate in s$^{-1}$ during the process is

(A) $0.1781 \times 10^5$  
(B) $0.7754 \times 10^5$  
(C) $1.0104 \times 10^5$  
(D) $4.397 \times 10^5$
Q. 19
In a single pass drilling operation, a through hole of 15 mm diameter is to be drilled in a steel plate of 50 mm thickness. Drill spindle speed is 500 rpm, feed is 0.2 mm/rev and drill point angle is 118°. Assuming 2 mm clearance at approach and exit, the total drill time (in seconds) is
(A) 35.1
(B) 32.4
(C) 31.2
(D) 30.1

Q. 20
Calculate the punch size in mm, for a circular blanking operation for which details are given below.

<table>
<thead>
<tr>
<th>Size of the blank</th>
<th>25 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of the sheet</td>
<td>2 mm</td>
</tr>
<tr>
<td>Radial clearance between punch and die</td>
<td>0.06 mm</td>
</tr>
<tr>
<td>Die allowance</td>
<td>0.05 mm</td>
</tr>
</tbody>
</table>

(A) 24.83
(B) 24.89
(C) 25.01
(D) 25.17

Q. 21
In a single pass rolling process using 410 mm diameter steel rollers, a strip of width 140 mm and thickness 8 mm undergoes 10% reduction of thickness. The angle of bite in radians is
(A) 0.006
(B) 0.031
(C) 0.062
(D) 0.600

Q. 22
In a DC arc welding operation, the voltage-arc length characteristic was obtained as $V_{arc} = 20 + 5l$ where the arc length $l$ was varied between 5 mm and 7 mm. Here $V_{arc}$ denotes the arc voltage in Volts. The arc current was varied from 400 A to 500 A. Assuming linear power source characteristic, the open circuit voltage and short circuit current for the welding operation are
(A) 45 V, 450 A
(B) 75 V, 750 A
(C) 95 V, 950 A
(D) 150 V, 1500 A

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Q. 23
The maximum possible draft in cold rolling of sheet increases with the
(A) increase in coefficient of friction
(B) decrease in coefficient of friction
(C) decrease in roll radius
(D) increase in roll velocity

Q. 24
The operation in which oil is permeated into the pores of a powder metallurgy product is known as
(A) mixing
(B) sintering
(C) impregnation
(D) infiltration

Q. 25
A hole is of dimension $\phi 9.0_{-0.015}^{+0.010}$ mm. The corresponding shaft is of dimension $\phi 9.0_{-0.003}^{+0.010}$ mm. The resulting assembly has
(A) loose running fit
(B) close running fit
(C) transition fit
(D) interference fit
Q. 26  Green sand mould indicates that  
(A) polymeric mould has been cured  
(B) mould has been totally dried  
(C) mould is green in color  
(D) mould contains moisture  

Q. 27  Which one among the following welding processes uses non-consumable electrode?  
(A) Gas metal arc welding  
(B) Submerged arc welding  
(C) Gas tungsten arc welding  
(D) Flux coated arc welding  

Q. 28  The crystal structure of austenite is  
(A) body centered cubic  
(B) face centered cubic  
(C) hexagonal closed packed  
(D) body centered tetragonal  

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Q. 29  A single-point cutting tool with 12° rake angle is used to machine a steel work-piece. The depth of cut, i.e., uncut thickness is 0.81 mm. The chip thickness under orthogonal machining condition is 1.8 mm. The shear angle is approximately  
(A) 22°  
(B) 26°  
(C) 56°  
(D) 76°  

Q. 30  Match the following non-traditional machining processes with the corresponding material removal mechanisms:  

<table>
<thead>
<tr>
<th>Machining process</th>
<th>Mechanism of material removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Chemical machining</td>
<td>1. Erosion</td>
</tr>
<tr>
<td>Q. Electro-chemical machining</td>
<td>2. Corrosive reaction</td>
</tr>
<tr>
<td>R. Electro-discharge machining</td>
<td>3. Ion displacement</td>
</tr>
<tr>
<td>S. Ultrasonic machining</td>
<td>4. Fusion and vaporization</td>
</tr>
</tbody>
</table>

(A) P-2, Q-3, R-4, S-1  
(B) P-2, Q-4, R-3, S-1  
(C) P-3, Q-2, R-4, S-1  
(D) P-2, Q-3, R-1, S-4  

Q. 31  A cubic casting of 50 mm side undergoes volumetric solidification shrinkage and volumetric solid contraction of 4% and 6% respectively. No riser is used. Assume uniform cooling in all directions. The side of the cube after solidification and contraction is  
(A) 48.32 mm  
(B) 49.90 mm  
(C) 49.94 mm  
(D) 49.96 mm  

Q. 32  The shear strength of a sheet metal is 300 MPa. The blanking force required to produce a blank of 100 mm diameter from a 1.5 mm thick sheet is close to  
(A) 45 kN  
(B) 70 kN  
(C) 141 kN  
(D) 3500 kN
Q. 33  
The material property which depends only on the basic crystal structure is  
(A) fatigue strength  (B) work hardening  
(C) fracture strength  (D) elastic constant

Q. 34  
In a gating system, the ratio 1 : 2 : 4 represents  
(A) sprue base area : runner area : ingate area  
(B) pouring basin area : ingate area : runner area  
(C) sprue base area : ingate area : casting area  
(D) runner area : ingate area : casting area

Q. 35  
A shaft has a dimension, φ35 ± 0.009. The respective values of fundamental deviation and tolerance are  
(A) −0.025, ±0.008  (B) −0.025, 0.016  
(C) −0.009, ±0.008  (D) −0.009, 0.016

Q. 36  
In a CNC program block, N002 G02 G91 X40 Z40......, G02 and G91 refer to  
(A) circular interpolation in counterclockwise direction and incremental dimension  
(B) circular interpolation in counterclockwise direction and absolute dimension  
(C) circular interpolation in clockwise direction and incremental dimension  
(D) circular interpolation in clockwise direction and absolute dimension

Q. 37  
For tool A, Taylor’s tool life exponent (n) is 0.45 and constant (K) is 90. Similarly for tool B, n = 0.3 and K = 60. The cutting speed (in m/min) above which tool A will have a higher tool life than tool B is  
(A) 26.7  (B) 42.5  
(C) 80.7  (D) 142.9

Q. 38  
Two pipes of inner diameter 100 mm and outer diameter 110 mm each are joined by flash-butt welding using 30 V power supply. At the interference, 1 mm of material melts from each pipe which has a resistance of 42.4 Ω. If the unit melt energy is $644 \text{ MJ m}^{-3}$, then time required for welding (in s) is  
(A) 1  (B) 5  
(C) 10  (D) 20

Q. 39  
A taper hole is inspected using a CMM, with a probe of 2 mm diameter. At a height, $Z = 10$ mm from the bottom, 5 points are touched and a diameter of circle (not compensated for probe size) is obtained as 20 mm. Similarly, a 40 mm diameter is obtained at a height $Z = 40$ mm. The smaller diameter (in mm) of hole at $Z = 0$ is
Common Data For Q. 40 and 41

In shear cutting operation, a sheet of 5 mm thickness is cut along a length of 200 mm. The cutting blade is 400 mm long (see fig.) and zero-shear \( (S = 0) \) is provided on the edge. The ultimate shear strength of the sheet is 100 MPa and penetration to thickness ratio is 0.2. Neglect friction.

Q. 40
Assuming force vs displacement curve to be rectangular, the work done (in J) is
(A) 100  (B) 200
(C) 250  (D) 300

Q. 41
A shear of 20 mm \( (S = 0 \text{ mm}) \) is now provided on the blade. Assuming force vs displacement curve to be trapezoidal, the maximum force (in kN) exerted is
(A) 5  (B) 10
(C) 20  (D) 40

Q. 42
Friction at the tool-chip interface can be reduced by
(A) decreasing the rake angle  (B) increasing the depth of cut
(C) decreasing the cutting speed  (D) increasing the cutting speed

Q. 43
Two streams of liquid metal which are not hot enough to fuse properly result into a casting defect known as
(A) cold shut  (B) swell
(C) sand wash  (D) scab

Q. 44
The effective number of lattice points in the unit cell of simple cubic, body centered cubic, and face centered cubic space lattices, respectively, are
(A) 1, 2, 2  (B) 1, 2, 4
(C) 2, 3, 4  (D) 2, 4, 4
Q. 45 Which of the following is the correct data structure for solid models?
(A) solid part → faces → edges → vertices
(B) solid part → edges → faces → vertices
(C) vertices → edges → faces → solid parts
(D) vertices → faces → edges → solid parts

Q. 46 Minimum shear strain in orthogonal turning with a cutting tool of zero rake angle is
(A) 0.0  (B) 0.5  (C) 1.0  (D) 2.0

Q. 47 Electrochemical machining is performed to remove material from an iron surface of 20 mm × 20 mm under the following conditions:
- Inter electrode gap = 0.2 mm
- Supply voltage (DC) = 12 V
- Specific resistance of electrolyte = 2 Ω cm
- Atomic weight of Iron = 55.85
- Valency of Iron = 2
- Faraday’s constant = 96540 Coulombs
The material removal rate (in g/s) is
(A) 0.3471  (B) 3.471  (C) 34.71  (D) 347.1

Q. 48 Match the following:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P.</td>
<td>G05</td>
<td>1. Absolute coordinate system</td>
</tr>
<tr>
<td>Q.</td>
<td>G01</td>
<td>2. Dwell</td>
</tr>
<tr>
<td>R.</td>
<td>G04</td>
<td>3. Spindle stop</td>
</tr>
<tr>
<td>S.</td>
<td>G09</td>
<td>4. Linear interpolation</td>
</tr>
</tbody>
</table>

(A) P-2, Q-3, R-4, S-1  (B) P-3, Q-4, R-1, S-2
(C) P-3, Q-4, R-2, S-1  (D) P-4, Q-3, R-2, S-1

Q. 49 What are the upper and lower limits of the shaft represented by 60 f₀?
Use the following data:
- Diameter 60 lies in the diameter step of 50-80 mm.
- Fundamental tolerance unit, i in μm = 0.45D^{0.13} + 0.001D
- Where D is the representative size in mm;
- Tolerance value for IT 8 = 25i,
- Fundamental deviation for ‘f’ shaft = − 5.5D^{0.41}

(A) Lower limit = 59.924 mm, Upper limit = 59.970 mm
(B) Lower limit = 59.954 mm, Upper limit = 60.000 mm
(C) Lower limit = 59.970 mm, Upper limit = 60.016 mm
(D) Lower limit = 60.000 mm, Upper limit = 60.046 mm
Q. 50
Match the items in Column I and Column II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Metallic Chills</td>
<td>1. Support for the core</td>
</tr>
<tr>
<td>Q. Metallic Chaplets</td>
<td>2. Reservoir of the molten metal</td>
</tr>
<tr>
<td>R. Riser</td>
<td>3. Control cooling of critical sections</td>
</tr>
<tr>
<td>S. Exothermic Padding</td>
<td>4. Progressive solidification</td>
</tr>
</tbody>
</table>

(A) P-1, Q-3, R-2, S-4  
(B) P-1, Q-4, R-2, S-3  
(C) P-3, Q-4, R-2, S-1  
(D) P-4, Q-1, R-2, S-3

Q. 51
The exponent (n) and constant (K) of the Taylor’s tool life equation are

(A) n = 0.5 and K = 540  
(B) n = 1 and K = 4860  
(C) n = −1 and K = 0.74  
(D) n = −0.5 and K = 1.155

Q. 52
What is the percentage increase in tool life when the cutting speed is halved?

(A) 50%  
(B) 200%  
(C) 300%  
(D) 400%

YEAR 2008
ONE MARK

Q. 53
For generating a Coon’s surface we require

(A) a set of grid points on the surface  
(B) a set of grid control points  
(C) four bounding curves defining the surface  
(D) two bounding curves and a set of grid control points

Q. 54
Internal gear cutting operation can be performed by

(A) milling  
(B) shaping with rack cutter  
(C) shaping with pinion cutter  
(D) hobbing

YEAR 2008
TWO MARKS

Q. 55
While cooling, a cubical casting of side 40 mm undergoes 3%, 4% and 5% volume shrinkage during the liquid state, phase transition and solid state, respectively. The volume of metal compensated from the riser is

(A) 2%  
(B) 7%  
(C) 8%  
(D) 9%

Q. 56
In a single point turning tool, the side rake angle and orthogonal rake angle are equal. $\varphi$ is the principal cutting edge angle and its range is $0^\circ \leq \varphi \leq 90^\circ$. The chip flows in the orthogonal plane. The value of $\varphi$ is closest to

(A) $0^\circ$  
(B) $45^\circ$  
(C) $60^\circ$  
(D) $90^\circ$
Q. 57
A researcher conducts electrochemical machining (ECM) on a binary alloy (density 6000 kg/m³) of iron (atomic weight 56, valency 2) and metal (atomic weight 24, valency 4). Faraday's constant = 96500 coulomb/mole. Volumetric material removal rate of the alloy is 50 mm³/s at a current of 2000 A. The percentage of the metal P in the alloy is closest to
(A) 40  (B) 25  
(C) 15  (D) 79

Q. 58
In a single pass rolling operation, a 20 mm thick plate with plate width of 100 mm, is reduced to 18 mm. The roller radius is 250 mm and rotational speed is 10 rpm. The average flow stress for the plate material is 300 MPa. The power required for the rolling operation in kW is closest to
(A) 15.2  
(B) 18.2  
(C) 30.4  
(D) 45.6

Q. 59
In arc welding of a butt joint, the welding speed is to be selected such that highest cooling rate is achieved. Melting efficiency and heat transfer efficiency are 0.5 and 0.7, respectively. The area of the weld cross section is 5 mm² and the unit energy required to melt the metal is 10 J/mm³. If the welding power is 2 kW, the welding speed in mm/s is closest to
(A) 4  
(B) 14  
(C) 24  
(D) 34

Q. 60
In the deep drawing of cups, blanks show a tendency to wrinkle up around the periphery (flange). The most likely cause and remedy of the phenomenon are, respectively,
(A) Buckling due to circumferential compression; Increase blank holder pressure  
(B) High blank holder pressure and high friction; Reduce blank holder pressure and apply lubricant  
(C) High temperature causing increase in circumferential length; Apply coolant to blank  
(D) Buckling due to circumferential compression; decrease blank holder pressure

Q. 61
The figure shows an incomplete schematic of a conventional lathe to be used for cutting threads with different pitches. The speed gear box Uᵥ is shown and the feed gear box Uₛ is to be placed. P, Q, R and S denote locations and have no other significance. Changes in Uᵥ should NOT affect the pitch of the thread being cut and changes in Uₛ should NOT affect the cutting speed.

The correct connections and the correct placement of Uₛ are given by...
(A) Q and E are connected. U₁ is placed between P and Q.
(B) S and E are connected. U₁ is placed between R and S
(C) Q and E are connected. U₁ is placed between Q and E
(D) S and E are connected. U₁ is placed between S and E

Q. 62

A displacement sensor (a dial indicator) measure the lateral displacement of a mandrel mounted on the taper hole inside a drill spindle. The mandrel axis is an extension of the drill spindle taper hole axis and the protruding portion of the mandrel surface is perfectly cylindrical measurements are taken with the sensor placed at two positions P and Q as shown in the figure. The reading are recorded as $R_x = \text{maximum deflection minus minimum deflection}$, corresponding to sensor position at X, over one rotation.

If $R_x = R_0 > 0$, which one of the following would be consistent with the observation?
(A) The drill spindle rotational axis is coincident with the drill spindle taper hole axis
(B) The drill spindle rotational axis intersects the drill spindle taper hole axis at point P
(C) The drill spindle rotational axis is parallel to the drill spindle taper hole axis
(D) The drill spindle rotational axis intersects the drill spindle taper hole axis at point Q

Common Data For Q. 63 and 64

Orthogonal turning is performed on a cylindrical workpiece with the shear strength of 250 MPa. The following conditions are used: cutting velocity is 180 m/min, feed is 0.20 mm/rev, depth of cut is 3 mm, chip thickness ratio = 0.5. The orthogonal rake angle is 7°. Apply Merchant’s theory for analysis.

Q. 63
The shear plane angle (in degree) and the shear force respectively are
(A) 52, 320 N
(B) 52, 400 N
(C) 28, 400 N
(D) 28, 320 N

Q. 64
The cutting and frictional forces, respectively, are
(A) 568 N, 387 N
(B) 565 N, 381 N
(C) 440 N, 342 N
(D) 480 N, 356 N
Common Data For Q. 65 and 66

In the feed drive of a Point-to-Point open loop CNC drive, a stepper motor rotating at 200 steps/rev drives a table through a gear box and lead screw-nut mechanism (pitch=4 mm, number of starts=1). The gear ratio is given by \( U = \frac{1}{4} \). The stepper motor (driven by voltage pulses from a pulse generator) executes 1 step/pulse of the pulse generator. The frequency of the pulse train from the pulse generator is \( f = 10,000 \) pulses per minute.

Q. 65
The basic Length Unit (BLU), i.e, the table movement corresponding to 1 pulse of the pulse generator, is
(A) 0.5 microns  
(B) 5 microns  
(C) 50 microns  
(D) 500 microns

Q. 66
A customer insists on a modification to change the BLU of the CNC drive to 10 microns without changing the table speed. The modification can be accomplished by
(A) changing \( U \) to \( \frac{1}{2} \) and reducing \( f \) to \( \frac{f}{2} \)
(B) changing \( U \) to \( \frac{1}{8} \) and increasing \( f \) to \( 2f \)
(C) changing \( U \) to \( \frac{1}{2} \) and keeping \( f \) unchanged
(D) keeping \( U \) unchanged and increasing \( f \) to \( 2f \)

YEAR 2007

Q. 67
If a particular Fe-C alloy contains less than 0.83% carbon, it is called
(A) high speed steel  
(B) hypoeutectoid steel  
(C) hypereutectoid steel  
(D) cast iron

Q. 68
Which of the following engineering materials is the most suitable candidate for hot chamber die casting ?
(A) low carbon steel  
(B) titanium  
(C) copper  
(D) tin

Q. 69
Which one of the following is a solid state joining process ?
(A) gas tungsten arc welding  
(B) resistance spot welding  
(C) friction welding  
(D) submerged arc welding
Q. 70  In orthogonal turning of a low carbon steel bar of diameter 150 mm with uncoated carbide tool, the cutting velocity is 90 m/min. The feed is 0.24 mm/rev and the depth of cut is 2 mm. The chip thickness obtained is 0.48 mm. If the orthogonal rake angle is zero and the principle cutting edge angle is 90°, the shear angle in degree is
(A) 20.56  (B) 26.56  (C) 30.56  (D) 36.56

Q. 71  Which type of motor is NOT used in axis or spindle drives of CNC machine tools?
(A) induction motor  (B) dc servo motor  (C) stepper motor  (D) linear servo motor

Q. 72  Volume of a cube of side ‘l’ and volume of a sphere of radius ‘r’ are equal. Both the cube and the sphere are solid and of same material. They are being cast. The ratio of the solidification time of the cube to the same of the sphere is
(A) \( \left( \frac{4\pi}{6} \right)^3 \left( \frac{r}{T} \right)^6 \)  (B) \( \left( \frac{4\pi}{6} \right)^3 \left( \frac{r}{T} \right)^3 \)
(C) \( \left( \frac{4\pi}{6} \right)^3 \left( \frac{r}{T} \right) \)  (D) \( \left( \frac{4\pi}{6} \right)^3 \left( \frac{r}{T} \right)^4 \)

Q. 73  In electrodischarge machining (EDM), if the thermal conductivity of tool is high and the specific heat of work piece is low, then the tool wear rate and material removal rate are expected to be respectively
(A) high and high  (B) low and low  (C) high and low  (D) low and high

Q. 74  In orthogonal turning of medium carbon steel, the specific machining energy is 2.0 J/mm³. The cutting velocity, feed and depth of cut are 120 m/min, 0.2 mm/rev, and 2 mm respectively. The main cutting force in N is
(A) 40  (B) 80  (C) 400  (D) 800

Q. 75  A direct current welding machine with a linear power source characteristic provides open circuit voltage of 80 V and short circuit current of 800 A. During welding with the machine, the measured arc current is 500 A corresponding to an arc length of 5.0 mm and the measured arc current is 460 A corresponding to an arc length of 7.0 mm. The linear voltage \( E \) arc length \( L \) characteristic of the welding arc can be given as (where \( E \) is in volt and \( L \) in mm)
(A) \( E = 20 + 2L \)  (B) \( E = 20 + 8L \)
(C) \( E = 80 + 2L \)  (D) \( E = 80 + 8L \)

Q. 76  A hole is specified as 40.050 mm. The mating shaft has a clearance fit with minimum clearance of 0.01 mm. The tolerance on the shaft is 0.04 mm. The maximum clearance in mm between the hole and the shaft is
(A) 0.04  (B) 0.05  (C) 0.10  (D) 0.11
Q. 77  In orthogonal turning of low carbon steel pipe with principal cutting edge angle of 90°, the main cutting force is 1000 N and the feed force is 800 N. The shear angle is 25° and orthogonal rake angle is zero. Employing Merchant’s theory, the ratio of friction force to normal force acting on the cutting tool is
(A) 1.56    (B) 1.25    (C) 0.80    (D) 0.64

Q. 78  Two metallic sheets, each of 2.0 mm thickness, are welded in a lap joint configuration by resistance spot welding at a welding current of 10 kA and welding time of 10 millisecond. A spherical fusion zone extending up to full thickness of each sheet is formed. The properties of the metallic sheets are given as:
- Ambient temperature = 293 K
- Melting temperature = 1793 K
- Density = 7000 kg/m³
- Latent heat of fusion = 300 kJ/kg
- Specific heat = 800 J/kgK
Assume:
(i) contact resistance along sheet interface is 500 micro-ohm and along electrode-sheet interface is zero;
(ii) no conductive heat loss through the bulk sheet materials; and
(iii) the complete weld fusion zone is at the melting temperature.
The melting efficiency (in %) of the process is
(A) 50.37    (B) 60.37    (C) 70.37    (D) 80.37

Q. 79  In open-die forging, disc of diameter 200 mm and height 60 mm is compressed without any barreling effect. The final diameter of the disc is 400 mm. The true strain is
(A) 1.986    (B) 1.686    (C) 1.386    (D) 0.602

Q. 80  The thickness of a metallic sheet is reduced from an initial value of 16 mm to a final value of 10 mm in one single pass rolling with a pair of cylindrical rollers each of diameter of 400 mm. The bite angle in degree will be.
(A) 5.936    (B) 7.936    (C) 8.936    (D) 9.936

Q. 81  Match the correct combination for following metal working processes.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Associated state of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>P: Blanking</td>
<td>1. Tension</td>
</tr>
<tr>
<td>Q: Stretch Forming</td>
<td>2. Compression</td>
</tr>
<tr>
<td>R: Coining</td>
<td>3. Shear</td>
</tr>
<tr>
<td>S: Deep Drawing</td>
<td>4. Tension and Compression</td>
</tr>
<tr>
<td></td>
<td>5. Tension and Shear</td>
</tr>
</tbody>
</table>

(A) P - 2, Q - 1, R - 3, S - 4    (B) P - 3, Q - 4, R - 1, S - 5
(C) P - 5, Q - 4, R - 3, S - 1    (D) P - 3, Q - 1, R - 2, S - 4
The force requirement in a blanking operation of low carbon steel sheet is 5.0 kN. The thickness of the sheet is ‘t’ and diameter of the blanked part is ‘d’. For the same work material, if the diameter of the blanked part is increased to 1.5d and thickness is reduced to 0.4t, the new blanking force in kN is
(A) 3.0  
(B) 4.5  
(C) 5.0  
(D) 8.0

A 200 mm long down sprue has an area of cross-section of 650 mm² where the pouring basin meets the down sprue (i.e at the beginning of the down sprue). A constant head of molten metal is maintained by the pouring basin. The molten metal flow rate is $6.5 \times 10^2$ mm³/s. Considering the end of down sprue to be open to atmosphere and an acceleration due to gravity of $10^4$ mm/s², the area of the down sprue in mm² at its end (avoiding aspiration effect) should be

(A) 650.0  
(B) 350.0  
(C) 290.7  
(D) 190.0

Match the most suitable manufacturing processes for the following parts.

<table>
<thead>
<tr>
<th>Parts</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Computer chip</td>
<td>1. Electrochemical Machining</td>
</tr>
<tr>
<td>Q. Metal forming dies and molds</td>
<td>2. Ultrasonic Machining</td>
</tr>
<tr>
<td>R. Turbine blade</td>
<td>3. Electrodischarge Machining</td>
</tr>
<tr>
<td>S. Glass</td>
<td>4. Photochemical Machining</td>
</tr>
</tbody>
</table>

(A) P - 4, Q - 3, R - 1, S - 2  
(B) P - 4, Q - 3, R - 2, S - 1  
(C) P - 3, Q - 1, R - 4, S - 2  
(D) P - 1, Q - 2, R - 4, S - 3
**Common Data For Q. 85 and Q.86**

A low carbon steel bar of 147 mm diameter with a length of 630 mm is being turned with uncoated carbide insert. The observed tool lives are 24 min and 12 min for cutting velocities of 90 m/min and 120 m/min, respectively. The feed and depth of cut are 0.2 mm/rev and 2 mm respectively. Use the unmachined diameter to calculate the cutting velocity.

**Q. 85**
When tool life is 20 min, the cutting velocity in m/min is
(A) 87  (B) 97  (C) 107  (D) 114

**Q. 86**
Neglect over-travel or approach of the tool. When tool life is 20 min, the machining time in min for a single pass is
(A) 5  (B) 10  (C) 15  (D) 20

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**ONE MARK**

**Q. 87**
An expendable pattern is used in
(A) slush casting  (B) squeeze casting  
(C) centrifugal casting  (D) investment casting

**Q. 88**
The main purpose of spheroidising treatment is to improve
(A) hardenability of low carbon steels  
(B) machinability of low carbon steels  
(C) hardenability of high carbon steels  
(D) machinability of high carbon steels

**Q. 89**
NC contouring is an example of
(A) continuous path positioning  
(B) point-to-point positioning  
(C) absolute positioning  
(D) incremental positioning

**Q. 90**
A ring gauge is used to measure
(A) outside diameter but not roundness  
(B) roundness but not outside diameter  
(C) both outside diameter and roundness  
(D) only external threads

**YEAR 2006**

**TWO MARKS**

**Q. 91**
The ultimate tensile strength of a material is 400 MPa and the elongation up to maximum load is 35%. If the material obeys power law of hardening, then the true stress-true strain relation (stress in MPa) in the plastic deformation range is
(A) \( \sigma = 540 e^{0.30} \)  
(B) \( \sigma = 775 e^{0.30} \)  
(C) \( \sigma = 540 e^{0.35} \)  
(D) \( \sigma = 775 e^{0.35} \)

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Q. 92  In a sand casting operation, the total liquid head is maintained constant such that it is equal to the mould height. The time taken to fill the mould with a top gate is $t_A$. If the same mould is filled with a bottom gate, then the time taken is $t_B$. Ignore the time required to fill the runner and frictional effects. Assume atmospheric pressure at the top molten metal surfaces. The relation between $t_A$ and $t_B$ is

(A) $t_B = \sqrt{2} t_A$  
(B) $t_B = 2t_A$  
(C) $t_B = \frac{t_A}{\sqrt{2}}$  
(D) $t_B = 2\sqrt{2} t_A$

Q. 93  A 4 mm thick sheet is rolled with 300 mm diameter roll to reduce thickness without any change in its width. The friction coefficient at the work-roll interface is 0.1. The minimum possible thickness of the sheet that can be produced in a single pass is

(A) 1.0 mm  
(B) 1.5 mm  
(C) 2.5 mm  
(D) 3.7 mm

Q. 94  In a wire drawing operation, diameter of a steel wire is reduced from 10 mm to 8 mm. The mean flow stress of the material is 400 MPa. The ideal force required for drawing (ignoring friction and redundant work) is

(A) 4.48 kN  
(B) 8.97 kN  
(C) 20.11 kN  
(D) 31.41 kN

Q. 95  Match the item in columns I and II

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.</td>
<td>Wrinkling</td>
</tr>
<tr>
<td>Q.</td>
<td>Orange peel</td>
</tr>
<tr>
<td>R.</td>
<td>Stretcher strains</td>
</tr>
<tr>
<td>S.</td>
<td>Earing</td>
</tr>
</tbody>
</table>

(A) P-6, Q-3, R-1, S-2  
(B) P-4, Q-5, R-6, S-1  
(C) P-2, Q-5, R-3, S-1  
(D) P-4, Q-3, R-1, S-2

Q. 96  In an arc welding process, the voltage and current are 25 V and 300 A respectively. The arc heat transfer efficiency is 0.85 and welding speed is 8 mm/sec. The net heat input (in J/mm) is

(A) 64  
(B) 797  
(C) 1103  
(D) 79700

Q. 97  If each abrasive grain is viewed as a cutting tool, then which of the following represents the cutting parameters in common grinding operations?

(A) Large negative rake angle, low shear angle and high cutting speed  
(B) Large positive rake angle, low shear angle and high cutting speed  
(C) Large negative rake angle, high shear angle and low cutting speed  
(D) Zero rake angle, high shear angle and high cutting speed
Q. 98
Arrange the processes in the increasing order of their maximum material removal rate.
Electrochemical Machining (ECM)
Ultrasonic Machining (USM)
Electron Beam Machining (EBM)
Laser Beam Machining (LBM) and
Electric Discharge Machining (EDM)
(A) USM, LBM, EBM, EDM, ECM
(B) EBM, LBM, USM, ECM, EDM
(C) LBM, EBM, USM, ECM, EDM
(D) LBM, EBM, USM, EDM, ECM

Q. 99
Match the items in columns I and II.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Charpy test</td>
<td>1. Fluidity</td>
</tr>
<tr>
<td>Q. Knoop test</td>
<td>2. Microhardness</td>
</tr>
<tr>
<td>R. Spiral test</td>
<td>3. Formability</td>
</tr>
<tr>
<td>S. Cupping test</td>
<td>4. Toughness</td>
</tr>
<tr>
<td></td>
<td>5. Permeability</td>
</tr>
</tbody>
</table>

(A) P-4, Q-5, R-3, S-2
(B) P-3, Q-5, R-1, S-4
(C) P-2, Q-4, R-3, S-5
(D) P-4, Q-2, R-1, S-3

Common Data For Q. 100 to 102

In an orthogonal machining operation:
Uncut thickness = 0.5 mm
Cutting speed = 20 m/min
Rake angel = 15°
Width of cut = 5 mm  Chip thickness = 0.7 mm
Thrust force = 200 N  Cutting force = 1200 N
Assume Merchant's theory.

Q. 100
The values of shear angle and shear strain, respectively, are
(A) 30.3° and 1.98  (B) 30.3° and 4.23
(C) 40.2° and 2.97  (D) 40.2° and 1.65

Q. 101
The coefficient of friction at the tool-chip interface is
(A) 0.23  (B) 0.46
(C) 0.85  (D) 0.95

Q. 102
The percentage of total energy dissipated due to friction at the tool-chip interface is
(A) 30%  (B) 42%
(C) 58%  (D) 70%
Q. 103 Match the items of List-I (Equipment) with the items of List-II (Process) and select the correct answer using the given codes.

<table>
<thead>
<tr>
<th>List-I (Equipment)</th>
<th>List-II (Process)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Hot Chamber Machine</td>
<td>1. Cleaning</td>
</tr>
<tr>
<td>Q. Muller</td>
<td>2. Core making</td>
</tr>
<tr>
<td>R. Dielectric Baker</td>
<td>3. Die casting</td>
</tr>
<tr>
<td>S. Sand Blaster</td>
<td>4. Annealing</td>
</tr>
<tr>
<td></td>
<td>5. Sand mixing</td>
</tr>
</tbody>
</table>

(A) P-2, Q-1, R-4, S-5  
(B) P-4, Q-2, R-3, S-5  
(C) P-4, Q-5, R-1, S-2  
(D) P-3, Q-5, R-2, S-1

Q. 104 When the temperature of a solid metal increases,  
(A) strength of the metal decreases but ductility increases  
(B) both strength and ductility of the metal decreases  
(C) both strength and ductility of the metal increases  
(D) strength of the metal increases but ductility decreases

Q. 105 The strength of a brazed joint  
(A) decreases with increase in gap between the two joining surfaces  
(B) increases with increase in gap between the two joining surfaces  
(C) decreases up to certain gap between the two joining surfaces beyond which it increases  
(D) increases up to certain gap between the two joining surfaces beyond which it decreases

Q. 106 In order to have interference fit, it is essential that the lower limit of the shaft should be  
(A) greater than the upper limit of the hole  
(B) lesser than the upper limit of the hole  
(C) greater than the lower limit of the hole  
(D) lesser than the lower limit of the hole

Q. 107 A zigzag cavity in a block of high strength alloy is to be finish machined. This can be carried out by using.
(A) electric discharge machining  
(B) electric-chemical machining  
(C) laser beam machining  
(D) abrasive flow machining  

Q. 108  
When 3-2-1 principle is used to support and locate a three dimensional work-piece during machining, the number of degrees of freedom that are restricted is  
(A) 7  
(B) 8  
(C) 9  
(D) 10  

Q. 109  
Which among the NC operations given below are continuous path operations?  
Arc Welding (AW)  
Drilling (D)  
Laser Cutting of Sheet Metal (LC)  
Milling (M)  
Punching in Sheet Metal (P)  
Spot Welding (SW)  
(A) AW, LC and M  
(B) AW, D, LC and M  
(C) D, LC, P and SW  
(D) D, LC, and SW  

Q. 110  
The figure below shows a graph which qualitatively relates cutting speed and cost per piece produced.  

The three curves 1, 2 and 3 respectively represent  
(A) machining cost, non-productive cost, tool changing cost  
(B) non-productive cost, machining cost, tool changing cost  
(C) tool changing cost, machining cost, non-productive cost  
(D) tool changing cost, non-productive cost, machining cost
Q. 111
A mould has a downsprue whose length is 20 cm and the cross sectional area at the base of the downsprue is 1 cm². The downsprue feeds a horizontal runner leading into the mould cavity of volume 1000 cm³. The time required to fill the mould cavity will be
(A) 4.05 s
(B) 5.05 s
(C) 6.05 s
(D) 7.25 s

Q. 112
Spot welding of two 1 mm thick sheets of steel (density = 8000 kg/m³) is carried out successfully by passing a certain amount of current for 0.1 second through the electrodes. The resultant weld nugget formed is 5 mm in diameter and 1.5 mm thick. If the latent heat of fusion of steel is 1400 kJ/kg and the effective resistance in the welding operation is 200 mΩ, the current passing through the electrodes is approximately
(A) 1480 A
(B) 3300 A
(C) 4060 A
(D) 9400 A

Q. 113
A 2 mm thick metal sheet is to be bent at an angle of one radian with a bend radius of 100 mm. If the stretch factor is 0.5, the bend allowance is

(A) 99 mm
(B) 100 mm
(C) 101 mm
(D) 102 mm

Q. 114
A 600 mm × 30 mm flat surface of a plate is to be finish machined on a shaper. The plate has been fixed with the 600 mm side along the tool travel direction. If the tool over-travel at each end of the plate is 20 mm, average cutting speed is 8 m/min., feed rate is 0.3 mm/stroke and the ratio of return time to cutting time of the tool is 1:2, the time required for machining will be
(A) 8 minutes
(B) 12 minutes
(C) 16 minutes
(D) 20 minutes

Q. 115
The tool of an NC machine has to move along a circular arc from (5, 5) to (10, 10) while performing an operation. The centre of the arc is at (10, 5). Which one of the following NC tool path command performs the above mentioned operation?
(A) N010 GO2 X10 Y10 X5 Y5 R5
(B) N010 GO3 X10 Y10 X5 Y5 R5
(C) N010 GO1 X5 Y5 X10 Y10 R5
(D) N010 GO2 X5 Y5 X10 Y10 R5
Q. 116 Two tools $P$ and $Q$ have signatures $5^\circ-5^\circ-6^\circ-6^\circ-8^\circ-30^\circ-0$ and $5^\circ-5^\circ-7^\circ-7^\circ-8^\circ-15^\circ-0$ (both ASA) respectively. They are used to turn components under the same machining conditions. If $h_p$ and $h_q$ denote the peak-to-valley heights of surfaces produced by the tools $P$ and $Q$, the ratio $h_p/h_q$ will be

\[
\begin{align*}
(A) \quad & \frac{\tan 8^\circ + \cot 15^\circ}{\tan 8^\circ + \cot 30^\circ} \\
(B) \quad & \frac{\tan 15^\circ + \cot 8^\circ}{\tan 30^\circ + \cot 8^\circ} \\
(C) \quad & \frac{\tan 15^\circ + \cot 7^\circ}{\tan 30^\circ + \cot 7^\circ} \\
(D) \quad & \frac{\tan 7^\circ + \cot 15^\circ}{\tan 7^\circ + \cot 30^\circ}
\end{align*}
\]

YEAR 2004 ONE MARK

Q. 117 In an interchangeable assembly, shafts of size $25.000 \pm 0.000$ mm mate with holes of size $25.000 \pm 0.000$ mm. The maximum possible clearance in the assembly will be

\[
\begin{align*}
(A) \quad & 10 \text{ microns} \\
(B) \quad & 20 \text{ microns} \\
(C) \quad & 30 \text{ microns} \\
(D) \quad & 60 \text{ microns}
\end{align*}
\]

Q. 118 During the execution of a CNC part program block NO20 GO2 X45.0 Y25.0 R5.0 the type of tool motion will be

\[
\begin{align*}
(A) \quad & \text{circular Interpolation – clockwise} \\
(B) \quad & \text{circular Interpolation – counterclockwise} \\
(C) \quad & \text{linear Interpolation} \\
(D) \quad & \text{rapid feed}
\end{align*}
\]

Q. 119 The mechanism of material removal in EDM process is

\[
\begin{align*}
(A) \quad & \text{Melting and Evaporation} \\
(B) \quad & \text{Melting and Corrosion} \\
(C) \quad & \text{Erosion and Cavitation} \\
(D) \quad & \text{Cavitation and Evaporation}
\end{align*}
\]

Q. 120 Two 1 mm thick steel sheets are to be spot welded at a current of $5000 \text{ A}$. Assuming effective resistance to be $200 \mu\text{m}$ and current flow time of 0.2 second, heat generated during the process will be

\[
\begin{align*}
(A) \quad & 0.2 \text{ Joulle} \\
(B) \quad & 1 \text{ Joulle} \\
(C) \quad & 5 \text{ Joulle} \\
(D) \quad & 1000 \text{ Joulle}
\end{align*}
\]

Q. 121 Misrun is a casting defect which occurs due to

\[
\begin{align*}
(A) \quad & \text{very high pouring temperature of the metal} \\
(B) \quad & \text{insufficient fluidity of the molten metal} \\
(C) \quad & \text{absorption of gases by the liquid metal} \\
(D) \quad & \text{improper alignment of the mould flasks}
\end{align*}
\]

Q. 122 The percentage of carbon in gray cast iron is in the range of

\[
\begin{align*}
(A) \quad & 0.25 \text{ to } 0.75 \text{ percent} \\
(B) \quad & 1.25 \text{ to } 1.75 \text{ percent} \\
(C) \quad & 3 \text{ to } 4 \text{ percent} \\
(D) \quad & 8 \text{ to } 10 \text{ percent}
\end{align*}
\]
Q. 123  GO and NO-GO plug gauges are to be designed for a hole 20.000 mm. Gauge tolerances can be taken as 10% of the hole tolerance. Following ISO system of gauge design, sizes of GO and NO-GO gauge will be respectively
(A) 20.010 mm and 20.050 mm
(B) 20.014 mm and 20.046 mm
(C) 20.006 mm and 20.054 mm
(D) 20.014 mm and 20.054 mm

Q. 124  10 mm diameter holes are to be punched in a steel sheet of 3 mm thickness. Shear strength of the material is 400 N/mm² and penetration is 40%. Shear provided on the punch is 2 mm. The blanking force during the operation will be
(A) 22.6 kN  (B) 37.7 kN
(C) 61.6 kN  (D) 94.3 kN

Q. 125  Through holes of 10 mm diameter are to be drilled in a steel plate of 20 mm thickness. Drill spindle speed is 300 rpm, feed 0.2 mm/rev and drill point angle is 120°. Assuming drill overtravel of 2 mm, the time for producing a hole will be
(A) 4 seconds  (B) 25 seconds
(C) 100 seconds (D) 110 seconds

Q. 126  Gray cast iron blocks 200 × 100 × 10 mm are to be cast in sand moulds. Shrinkage allowance for pattern making is 1%. The ratio of the volume of pattern to that of the casting will be
(A) 0.97  (B) 0.99
(C) 1.01  (D) 1.03

Q. 127  In a 2-D CAD package, clockwise circular arc of radius 5, specified from P₁(15,10) to P₂(10,15) will have its centre at
(A) (10, 10)  (B) (15, 10)
(C) (15, 15)  (D) (10, 15)

Q. 128  In an orthogonal cutting test on mild steel, the following data were obtained
Cutting speed : 40 m/min
Depth of cut : 0.3 mm
Tool rake angle : +5°
Chip thickness : 1.5 mm
Cutting force : 900 N
Thrust force : 450 N
Using Merchant’s analysis, the friction angle during the machining will be
(A) 26.6°  (B) 31.5°
(C) 45°    (D) 63.4°

Q. 129  In a rolling process, sheet of 25 mm thickness is rolled to 20 mm thickness. Roll is of diameter 600 mm and it rotates at 100 rpm. The roll strip contact length will be
(A) 5 mm  (B) 39 mm
(C) 78 mm (D) 120 mm
Q. 130 In a machining operation, doubling the cutting speed reduces the tool life to \( \frac{1}{8} \)th of the original value. The exponent \( n \) in Taylor’s tool life equation \( VT^n = C \), is

(A) \( \frac{1}{8} \)  
(B) \( \frac{1}{4} \)  
(C) \( \frac{1}{3} \)  
(D) \( \frac{1}{2} \)

Q. 131 Match the following

<table>
<thead>
<tr>
<th>Feature to be inspected</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Pitch and Angle errors of screw thread</td>
<td>1. Auto Collimator</td>
</tr>
<tr>
<td>Q. Flatness error of a surface</td>
<td>2. Optical Interferometer</td>
</tr>
<tr>
<td>R. Alignment error of a machine slideway</td>
<td>3. Dividing Head and Dial Gauge</td>
</tr>
<tr>
<td>S. Profile of a cam</td>
<td>4. Spirit Level</td>
</tr>
<tr>
<td></td>
<td>5. Sine bar</td>
</tr>
<tr>
<td></td>
<td>6. Tool maker’s Microscope</td>
</tr>
</tbody>
</table>

(A) P-6 Q-2 R-4 S-6  
(B) P-5 Q-2 R-1 S-6  
(C) P-6 Q-4 R-1 S-3  
(D) P-1 Q-4 R-5 S-2

Q. 132 Match the following

<table>
<thead>
<tr>
<th>Product</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Molded luggage</td>
<td>1. Injection molding</td>
</tr>
<tr>
<td>Q. Packaging containers for Liquid</td>
<td>2. Hot rolling</td>
</tr>
<tr>
<td>R. Long structural shapes</td>
<td>3. Impact extrusion</td>
</tr>
<tr>
<td>S. Collapsible tubes</td>
<td>4. Transfer molding</td>
</tr>
<tr>
<td></td>
<td>5. Blow molding</td>
</tr>
<tr>
<td></td>
<td>6. Coining</td>
</tr>
</tbody>
</table>

(A) P-1 Q-4 R-6 S-3  
(B) P-4 Q-5 R-2 S-3  
(C) P-1 Q-5 R-3 S-2  
(D) P-5 Q-1 R-2 S-4

Q. 133 Typical machining operations are to be performed on hard-to-machine materials by using the processes listed below. Choose the best set of Operation-Process combinations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Deburring (internal surface)</td>
<td>1. Plasma Arc Machining</td>
</tr>
<tr>
<td>Q. Die sinking</td>
<td>2. Abrasive Flow Machining</td>
</tr>
<tr>
<td>R. Fine hole drilling in thin sheets</td>
<td>3. Electric Discharge Machining</td>
</tr>
<tr>
<td>S. Tool sharpening</td>
<td>4. Ultrasonic Machining</td>
</tr>
<tr>
<td></td>
<td>5. Laser beam Machining</td>
</tr>
<tr>
<td></td>
<td>6. Electrochemical Grinding</td>
</tr>
</tbody>
</table>

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Q. 134 From the lists given below choose the most appropriate set of heat treatment process and the corresponding process characteristics

<table>
<thead>
<tr>
<th>Process</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.</td>
<td>Tempering</td>
</tr>
<tr>
<td>Q.</td>
<td>Austempering</td>
</tr>
<tr>
<td>R.</td>
<td>Martempering</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(A) P-3 Q-1 R-5 (B) P-4 Q-3 R-2
(C) P-4 Q-1 R-2 (D) P-1 Q-5 R-4

Q. 135 During heat treatment of steel, the hardness of various structures in increasing order is
(A) martensite, fine pearlite, coarse pearlite, spherodite
(B) fine pearlite, martensite, spherodite, coarse pearlite
(C) martensite, coarse pearlite, fine pearlite, spherodite
(D) spherodite, coarse pearlite, fine pearlite, martensite

Q. 136 Hardness of green sand mould increases with
(A) increase in moisture content beyond 6 percent
(B) increase in permeability
(C) decrease in permeability
(D) increase in both moisture content and permeability

Q. 137 In oxyacetylene gas welding, temperature at the inner cone of the flame is around
(A) 3500°C (B) 3200°C
(C) 2900°C (D) 2550°C

Q. 138 Cold working of steel is defined as working
(A) at its recrystallisation temperature
(B) above its recrystallisation temperature
(C) below its recrystallisation temperature
(D) at two thirds of the melting temperature of the metal

Q. 139 Quality screw threads are produced by
(A) thread milling
(B) thread chasing
(C) thread cutting with single point tool
(D) thread casting
Q. 140  As tool and work are not in contact in EDM process
(A) no relative motion occurs between them
(B) no wear of tool occurs
(C) no power is consumed during metal cutting
(D) no force between tool and work occurs

Q. 141  The dimensional limits on a shaft of 25h7 are
(A) 25.000, 25.021 mm  (B) 25.000, 24.979 mm
(C) 25.000, 25.007 mm  (D) 25.000, 24.993 mm

Q. 142  Hardness of steel greatly improves with
(A) annealing  (B) cyaniding
(C) normalizing  (D) tempering

Q. 143  With a solidification factor of $0.97 \times 10^6$ s/m$^2$, the solidification time (in seconds) for a spherical casting of 200 mm diameter is
(A) 539  (B) 1078
(C) 4311  (D) 3233

Q. 144  A shell of 100 mm diameter and 100 mm height with the corner radius of 0.4 mm is to be produced by cup drawing. The required blank diameter is
(A) 118 mm  (B) 161 mm
(C) 224 mm  (D) 312 mm

Q. 145  A brass billet is to be extruded from its initial diameter of 100 mm to a final diameter of 50 mm. The working temperature of 700°C and the extrusion constant is 250 MPa. The force required for extrusion is
(A) 5.44 MN  (B) 2.72 MN
(C) 1.36 MN  (D) 0.36 MN

Q. 146  A metal disc of 20 mm diameter is to be punched from a sheet of 2 mm thickness. The punch and the die clearance is 3%. The required punch diameter is
(A) 19.88 mm  (B) 19.84 mm
(C) 20.06 mm  (D) 20.12 mm

Q. 147  A batch of 10 cutting tools could produce 500 components while working at 50 rpm with a tool feed of 0.25 mm/rev and depth of cut of 1 mm. A similar batch of 10 tools of the same specification could produce 122 components while working at 80 rpm with a feed of 0.25 mm/rev and 1 mm depth of cut. How many components can be produced with one cutting tool at 60 rpm ?
(A) 29  (B) 31
(C) 37  (D) 42

Q. 148  A thread nut of M16 ISO metric type, having 2 mm pitch with a pitch diameter of 14.701 mm is to be checked for its pitch diameter using two or three number of balls or rollers of the following sizes
(A) Rollers of 2 mm φ  (B) Rollers of 1.155 mm φ
(C) Balls of 2 mm φ  (D) Balls of 1.155 mm φ
Q. 149 Two slip gauges of 10 mm width measuring 1.000 mm and 1.002 mm are kept side by side in contact with each other lengthwise. An optical flat is kept resting on the slip gauges as shown in the figure. Monochromatic light of wavelength 0.0058928 mm is used in the inspection. The total number of straight fringes that can be observed on both slip gauges is

![Optical Flat](image)

(A) 2  (B) 6  (C) 8  (D) 13

Q. 150 A part shown in the figure is machined to the sizes given below

![Part Diagram](image)

\[ P = 35.00 \pm 0.08 \text{ mm}, \quad Q = 12.00 \pm 0.02 \text{ mm}, \quad R = 13.00_{0.04}^{+0.02} \text{ mm} \]

With 100% confidence, the resultant dimension \( W \) will have the specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
<th>(D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.99 \pm 0.03 \text{ mm}</td>
<td>9.99 \pm 0.13 \text{ mm}</td>
<td>10.00 \pm 0.03 \text{ mm}</td>
<td>10.00 \pm 0.13 \text{ mm}</td>
<td></td>
</tr>
</tbody>
</table>

Q. 151 Match the following

<table>
<thead>
<tr>
<th>Working material</th>
<th>Type of Joining</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Aluminium</td>
<td>1. Submerged Arc Welding</td>
</tr>
<tr>
<td>Q. Die steel</td>
<td>2. Soldering</td>
</tr>
<tr>
<td>R. Copper wire</td>
<td>3. Thermit Welding</td>
</tr>
<tr>
<td>S. Titanium sheet</td>
<td>4. Atomic Hydrogen Welding</td>
</tr>
<tr>
<td></td>
<td>5. Gas Tungsten Arc Welding</td>
</tr>
<tr>
<td></td>
<td>6. Laser Beam Welding</td>
</tr>
</tbody>
</table>

(A) P-2 Q-5 R-1 S-3  (B) P-6 Q-3 R-4 S-1  (C) P-4 Q-1 R-6 S-2  (D) P-5 Q-4 R-2 S-6

Common Data For Q. 152 and 153

A cylinder is turned on a lathe with orthogonal machining principle. Spindle rotates at 200 rpm. The axial feed rate is 0.25 mm per revolution. Depth of cut is 0.4 mm. The rake angle is 10°. In the analysis it is found that the shear angle is 27.75°.
Q. 152 The thickness of the produced chip is
(A) 0.511 mm  (B) 0.528 mm
(C) 0.818 mm  (D) 0.846 mm

Q. 153 In the above problem, the coefficient of friction at the chip tool interface obtained using Earnest and Merchant theory is
(A) 0.18  (B) 0.36
(C) 0.71  (D) 0.98

Q. 154 A lead-screw with half nuts in a lathe, free to rotate in both directions has
(A) V-threads  (B) Whitworth threads
(C) Buttress threads  (D) Acme threads

Q. 155 The primary purpose of a sprue in a casting mould is to
(A) feed the casting at a rate consistent with the rate of solidification.
(B) act as a reservoir for molten metal
(C) feed molten metal from the pouring basin to the gate
(D) help feed the casting until all solidification takes place

Q. 156 Hot rolling of mild steel is carried out
(A) at re-crystallization temperature
(B) between 100°C to 150°C
(C) between re-crystallization temperature
(D) above re-crystallization temperature

Q. 157 Which of the following arc welding processes does not use consumable electrodes?
(A) GMAW  (B) GTAW
(C) Submerged Arc Welding  (D) None of these

Q. 158 Trepanning is performed for
(A) finishing a drilled hole
(B) producing a large hole without drilling
(C) truing a hole for alignment
(D) enlarging a drilled hole

Q. 159 The hardness of a grinding wheel is determined by the
(A) hardness of abrasive grains
(B) ability of the bond to retain abrasives
(C) hardness of the bond
(D) ability of the grinding wheel to penetrate the work piece
Q. 160 In centrifugal casting, the impurities are
(A) uniformly distributed
(B) forced towards the outer surface
(C) trapped near the mean radius of the casting
(D) collected at the centre of the casting

Q. 161 The ductility of a material with work hardening
(A) increases (B) decreases
(C) remains unaffected (D) unpredictable

Q. 162 The temperature of a carburising flame in gas welding is ......that of a neutral or an oxidising flame.
(A) lower than (B) higher than
(C) equal to (D) unrelated to

Q. 163 In a blanking operation, the clearance is provided on
(A) the die (B) both the die and the punch equally
(C) the punch (D) neither the punch nor the die

Q. 164 A built-up-edge is formed while machining
(A) ductile materials at high speed (B) ductile materials at low speed
(C) brittle materials at high speed (D) brittle materials at low speed

Q. 165 The time taken to drill a hole through a 25 mm thick plate with the drill rotating at 300 rpm and moving at a feed rate of 0.25 mm/rev is
(A) 10 s (B) 20 s
(C) 60 s (D) 100 s

Q. 166 Shrinkage allowance on pattern is provided to compensate for shrinkage when
(A) the temperature of liquid metal drops from pouring to freezing temperature.
(B) the metal changes from liquid to solid state at freezing temperature
(C) the temperature of solid phase drops from freezing to room temperature
(D) the temperature of metal drops from pouring to room temperature

Q. 167 The cutting force in punching and blanking operations mainly depends on
(A) the modulus of elasticity of metal
(B) the shear strength of metal
(C) the bulk modulus of metal
(D) the yield strength of metal

Q. 168 In ECM, the material removal is due to
(A) corrosion (B) erosion
(C) fusion (D) ion displacement
Q. 169 Two plates of the same metal having equal thickness are to be butt welded with electric arc. When the plate thickness changes, welding is achieved by
(A) adjusting the current  (B) adjusting the duration of current
(C) changing the electrode size  (D) changing the electrode coating

Q. 170 Allowance in limits and fits refers to
(A) maximum clearance between shaft and hole
(B) minimum clearance between shaft and hole
(C) difference between maximum and minimum sizes of hole
(D) difference between maximum and minimum sizes of shaft.

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Q. 171 The height of the downsprue is 175 mm and its cross-sectional area at the base is 200 mm². The cross-sectional area of the horizontal runner is also 200 mm², assuming no losses, indicate the correct choice for the time (in sec) required to fill a mold cavity of volume 10² mm³. (Use g = 10 m/s²).
(A) 2.67  (B) 8.45
(C) 26.72  (D) 84.50

Q. 172 For rigid perfectly plastic work material, negligible interface friction and no redundant work, the theoretically maximum possible reduction in the wire drawing operation is
(A) 0.36  (B) 0.63
(C) 1.00  (D) 2.72

Q. 173 During orthogonal cutting of mild steel with a 10° rake angle, the chip thickness ratio was obtained as 0.4. The shear angle (in degree) evaluated from this data is
(A) 6.53  (B) 20.22
(C) 22.94  (D) 50.00

Q. 174 Resistance spot welding is performed on two plates of 1.5 mm thickness with 6 mm diameter electrode, using 15000 A current for a time duration of 0.25 s. Assuming the interface resistance to be 0.0001 Ω, the heat generated to form the weld is
(A) 5625 W·s  (B) 8437 W·s
(C) 22500 W·s  (D) 33750 W·s

Q. 175 3-2-1 method of location in a jig or fixture would collectively restrict the work piece in n degrees of freedom, where the value of n is
(A) 6  (B) 8
(C) 9  (D) 12

Q. 176 In an NC machining operation, the tool has to be moved from point (5, 4) to point (7, 2) along a circular path with centre at (5, 2). Before starting the operation, the tool is at (5, 4). The correct G and N codes for this motion are
(A) N010 G03 X7.0 Y2.0 I5.0 J2.0  (B) N010 G02 X7.0 Y2.0 I5.0 J2.0
(C) N010 G01 X7.0 Y2.0 I5.0 J2.0  (D) N010 G00 X7.0 Y2.0 I5.0 J2.0

*************
SOLUTION

Sol. 1

Option (A) is correct.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Characteristics/ Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Friction Welding</td>
<td>4. Joining of cylindrical dissimilar materials</td>
</tr>
<tr>
<td>Q. Gas Metal Arc Welding</td>
<td>3. Consumable electrode wire</td>
</tr>
<tr>
<td>R. Tungsten Inert Gas Welding</td>
<td>1. Non-consumable electrode</td>
</tr>
<tr>
<td>S. Electroslag Welding</td>
<td>2. Joining of thick plates</td>
</tr>
</tbody>
</table>

Sol. 2

Option (A) is correct.

Most metal rolling operations are similar in that the work material is plastically deformed by compressive forces between two constantly spinning rolls. Thus in a Rolling process, the material undergoing deformation is in the state of pure biaxial compression.

Sol. 3

Option (B) is correct.

For ductile material, toughness is a measure of ability to absorb energy of impact loading up to fracture.

Sol. 4

Option (B) is correct.

From Can’s relation, Solidification time

\[ t_s = C \left( \frac{\text{volume}}{\text{Surface Area}} \right)^2 \]

where \( C = \text{constant} \)

Case I:

\[ t_{s1} = \left( \frac{a^3}{6a^2} \right)^2 = \left( \frac{a}{6} \right)^2 \]

... (i)

volume of cube = \( a^3 \)

Surface Area of cube = \( 6a^2 \)

Case II:

volume = 8 times

\[ = 8a^3 = 2a \times 2a \times 2a \]

area of one surface = \( 2a \times 2a = 4a^2 \)

where \( 2a = \text{side of cube} \)

So that

\[ t_{s2} = \left( \frac{8a^3}{6 \times 4a^2} \right)^2 = \left( \frac{2a}{6} \right)^2 = 4 \left( \frac{a}{6} \right)^2 \]

... (ii)

From Eq. (i) and (ii), the desired ratio is given by
\[
\frac{t_{s1}}{t_{s2}} = \frac{(a/6)^2}{4(a/6)^2} = \frac{1}{4}
\]
or
\[
t_{s2} = 4t_{s1} = 4 \times 5 = 20 \text{ min}
\]

**Sol. 5**

Option (D) is correct.

\[MRR = \text{feed} \times \text{depth} \times \text{cutting speed}\]

where \[V_c = \omega \times r = \frac{2\pi N}{60} \times r\]

Therefore
\[
MRR = f \times d \times \frac{2\pi N}{60} = 0.25 \times 4 \times \frac{200}{2} \times \frac{2\pi \times 160}{60} = 1675.5 \text{ mm}^3/\text{s}
\]

**Sol. 6**

Option (B) is correct.

From the given condition the 2D point is shown below:

The mirror image of point \(P\) is \(P'\). From the figure

\[DE = OF = 5\] and \[DP = 5\]

Now
\[PB = PD \sin 45^\circ = \frac{5}{\sqrt{2}}\]

and
\[BD = PD \cos 45^\circ = \frac{5}{\sqrt{2}}\]

Now because of mirror image
\[BP = BP' = \frac{5}{\sqrt{2}}\]

From the triangle \(BDP'\)
\[DP' = \sqrt{BD^2 + BP'^2} = \sqrt{\frac{25}{2} + \frac{25}{2}} = 5\]

Similarly for \(y\) coordinate of \(P'\), the symmetricity gives
\[P'G = 5\]

Hence the coordinates of \(P'\) becomes
\[P'(5 + 5, 5)\]
\[P'(10, 5)\]
Sol. 7  Option (B) is correct. 
We have 
For carbide tool : \[ V T^{1.6} = 3000 \] ....(i) 
For HSS tool : \[ V T^{0.6} = 200 \] ....(ii) 
From equation (i) and (ii), we have 
\[ \frac{V T^{1.6}}{V T^{0.6}} = \frac{3000}{200} \] 
or \[ T = 15 \text{ min} \] 
Now for carbide tool 
\[ V = \frac{3000}{T^{1.6}} \]
\[ = \frac{3000}{(15)^{1.6}} = 39.4 \text{ m/min} \]

Sol. 8  Option (C) is correct. 
The material removal rate is given by 
\[ MRR = \frac{IA}{V} \times \eta \] 
where for titanium 
I = current = 2000 A 
A = Atomic weight = 48 
F = Faradays constant = 96500 coulombs 
V = valency = 3 
\[ \eta = \text{Efficiency} = 90\% = 0.90 \] 
So that 
\[ MRR = \frac{2000 \times 48}{96500 \times 3} \times 0.90 \]
\[ = 0.30 \]

Sol. 9  Option (D) is correct. 
Go gauge is always entered into acceptable component, so that it is always made 
for the maximum material unit of the component. 
We have 
\[ \text{Cylindrical pin} = 25 \text{ mm} + \text{plating} = 30 \text{ microns} \] 
Thus maximum thickness of plating 
\[ = 0.03 + 0.002 = 0.032 \text{ mm} \] 
Thus size of GO-gauge is 
\[ = 25.02 + 0.032 \times 2 \]
\[ = 25.084 \text{ mm} \]

Sol. 10  Option (A) is correct. 
Since it is given that the main (tangential) cutting force is perpendicular to 
friction force acting at the chip-tool interface, therefore rake angle

Sol. 11  Option (B) is correct. 
Since normal force is given by 
\[ N = F_C \cos \alpha - F, \sin \alpha \] 
and \[ \alpha = 0^\circ \] (from previous question) 
\[ N = F_C \cos \alpha \] 
or 
\[ N = F_C = 1500 \text{ N} \]
Sol. 12  
Option (D) is correct.

Graph for abrasive jet machining for the distance between the nozzle tip and work surface (l) and abrasive flow rate is given in figure. It is clear from the graph that the material removal rate is first increases because of area of jet increase than becomes stable and then decreases due to decrease in jet velocity.

Sol. 13  
Option (A) is correct.

<table>
<thead>
<tr>
<th>Metal forming process</th>
<th>Types of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Coining</td>
<td>S. Compressive</td>
</tr>
<tr>
<td>2. Wire Drawing</td>
<td>P. Tensile</td>
</tr>
<tr>
<td>3. Blanking</td>
<td>Q. Shear</td>
</tr>
<tr>
<td>4. Deep Drawing</td>
<td>R. Tensile and compressive</td>
</tr>
</tbody>
</table>

Hence, correct match list is, 1-S, 2-P, 3-Q, 4-R

Sol. 14  
Option (C) is correct.

An interference fit for shaft and hole is as given in figure below.

Maximum Interference  
= Maximum limit of shaft − Minimum limit of hole  
= (25 + 0.040) − (25 + 0.020)  
= 0.02 mm = 20 microns

Sol. 15  
Option (C) is correct.

Normalizing involves prolonged heating just above the critical temperature to produce globular form of carbine and then cooling in air.

Sol. 16  
Option (B) is correct.

Given: width (b) = 10 mm, depth = 2 mm  
Distance travelled for cut between points (0, 0) and (100, 100)  
By Pythagoras theorem  
\[ d = \sqrt{100^2 + 100^2} = 141.42 \text{ mm} \]
Feed rate \( f = \frac{50\text{ mm}}{\text{ min}} = \frac{50}{60} = 0.833 \text{ mm/sec} \).

Time required to cut distance \( d \)
\[
 t = \frac{d}{f} = \frac{141.42}{0.833} = 169.7 \approx 170 \text{ sec.}
\]

**Sol. 17**
Option (D) is correct.
Since volume of cylinder remains same, therefore

\[
 \text{Volume before forging} = \text{Volume after forging}
\]
\[
 \pi \frac{d_1^2}{4} \times h_1 = \pi \frac{d_2^2}{4} \times h_2
\]
\[
 \pi \times \frac{100^2}{4} \times 50 = \pi \times \frac{d_2^2}{4} \times 25
\]
\[
 d_2^2 = (100)^2 \times 2
\]
\[
 d_2 = 100 \times \sqrt{2} = 141.42
\]

Percentage change in diameter
\[
 \% \text{ change in } (d) = \left( \frac{d_2 - d_1}{d_1} \times 100 \right) = \frac{141.42 - 100}{100} \times 100 = 41.42\%
\]

**Sol. 18**
Option (C) is correct.
Shear strain rate
\[
 \epsilon = \frac{\cos \alpha}{\cos(\phi - \alpha)} \times \frac{V}{\Delta y}
\]
Where
\[
 \alpha = \text{Rake angle} = 10^\circ
\]
\[
 V = \text{cutting speed} = 2.5 \text{ m/s}
\]
\[
 \Delta y = \text{Mean thickness of primary shear zone} = 25 \text{ microns} = 25 \times 10^{-6} \text{ m}
\]
\[
 \phi = \text{shear angle}
\]
Shear angle,
\[
 \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha}
\]
where \( r = \text{chip thickness ratio} = 0.4 \)
\[
 \tan \phi = \frac{0.4 \times \cos 10^\circ}{1 - 0.4 \sin 10^\circ} = 0.4233
\]
\[
 \phi = \tan^{-1}(0.4233) \approx 23^\circ
\]

Shear Strain rate
\[
 \gamma = \frac{\cos 10^\circ}{\cos(23 - 10^\circ)} \times \frac{2.5}{25 \times 10^{-6}} = 1.0104 \times 10^5 \text{ s}^{-1}
\]

**Sol. 19**
Option (A) is correct.
Drill bit tip is shown as below.
BC = radius of hole or drill bit (R) = \( \frac{15}{2} \) = 7.5 mm

From \( \Delta ABC \)

\[
\tan 59^\circ = \frac{BC}{AB} = \frac{7.5}{AB} \\
AB = \frac{7.5}{\tan 59^\circ} = 4.506 \text{ mm}
\]

Travel distance of drill bit

\( l = \) thickness of steel plate (t) + clearance at approach + clearance at exit + AB

\[l = 50 \text{ mm} + 2 + 2 + 4.506 = 58.506 \text{ mm}\]

Total drill time

\[f = 0.2 \text{ mm/rev} = \frac{0.2 \times \text{rpm}}{60} = \frac{0.2 \times 500}{60} = 1.66 \text{ mm/s}\]

Hence drill time,

\[t = \frac{58.506}{1.66} = 35.1 \text{ sec}\]

Sol. 20
Option (A) is correct.

Punch diameter,

\[d = D - 2c - a\]

where

\[D = \text{Blank diameter} = 25 \text{ mm}\]

\[c = \text{Clearance} = 0.06 \text{ mm}\]

\[a = \text{Die allowance} = 0.05 \text{ mm}\]

Hence,

\[d = 25 - 2 \times 0.06 - 0.05 = 24.83 \text{ mm}\]

Sol. 21
Option (C) is correct.

Given:

\[t_1 = 8 \text{ mm}, d = 410 \text{ mm}, r = 205 \text{ mm}\]

Reduction of thickness,

\[\Delta t = 10\% \text{ of } t_1 = \frac{10}{100} \times 8 = 0.8 \text{ mm}\]

\[y = \frac{\Delta t}{2} = 0.4 \text{ mm}\]

From \( \Delta OPQ \),

\[\cos \theta = \left( \frac{r - y}{r} \right)\]
Angle of bite in radians is

\[ \theta = 3.58 \times \frac{\pi}{180} \text{ rad} = 0.062 \text{ rad}. \]

**Alternate Method:**

Angle of bite, \( \theta = \tan^{-1}\left[\sqrt{\frac{t_i - t_f}{r}}\right] \)

Where,  
- \( t_i \) = Initial thickness = 8 mm
- \( t_f \) = Final reduced thickness = 8 - 8 \times \frac{10}{100} = 7.2 mm
- \( r \) = radius of roller = \( \frac{410}{2} \) = 205 mm

\[ \theta = \tan^{-1}\left[\sqrt{\frac{8 - 7.2}{205}}\right] = 3.5798^\circ \]

And in radians,  
\[ \theta = 3.5798 \times \frac{\pi}{180} = 0.0624 \text{ rad}. \]

Sol. 22

Option (C) is correct.

From power source characteristic,

\[ \frac{V}{OCV} + \frac{l}{SCC} = 1 \quad \text{ ...(i)} \]

where,
- \( V \) = Voltage
- \( OCV \) = Open circuit voltage
- \( SCC \) = Short circuit current
- \( I \) = Current.

From voltage arc length characteristic

\( V_{arc} = 20 + 5I \)

For \( l_1 = 5 \text{ mm} \), \( V_1 = 20 + 5 \times 5 = 45 \text{ V} \)

For \( l_2 = 7 \text{ mm} \), \( V_2 = 20 + 5 \times 7 = 55 \text{ V} \)

and  
\[ I_1 = 500 \text{ Amp. and } I_2 = 400 \text{ Amp.} \]

Substituting these value in Eq. (i)

\[ \frac{V_1}{OCV} + \frac{l_1}{SCC} = 1 \]
\[ \frac{45}{OCV} + \frac{500}{SCC} = 1 \quad \text{ ... (ii)} \]
\[ \frac{V_2}{OCV} + \frac{l_2}{SCC} = 1 \quad \Rightarrow \quad \frac{55}{OCV} + \frac{400}{SCC} = 1 \quad \text{ ... (iii)} \]

Solving Eq. (ii) and (iii), we get

\[ OCV = 95 \text{ V} \]
\[ SCC = 950 \text{ Amp.} \]

Sol. 23

Option (A) is correct.

The main objective in rolling is to decrease the thickness of the metal.

The relation for the rolling is given by

\[ F = \mu P \]

Where;
- \( F \) = tangential frictional force
- \( \mu \) = Coefficient of friction
Normal force between the roll and work piece

Now, from the increase in \( \mu \), the draft in cold rolling of sheet increases.

Sol. 24
Option (C) is correct.
If the pores in a sintered compact are filled with an oil, the operation is called as impregnation. The lubricants are added to the porous bearings, gears and pump rotors etc.

Sol. 25
Option (C) is correct.
In transition fit, the tolerance zones of holes and shaft overlap.

| Upper limit of hole | 9 + 0.015 = 9.015 mm |
| Lower limit of hole | 9 + 0.000 = 9.000 mm |
| Upper limit of shaft | 9 + 0.010 = 9.010 mm |
| Lower limit of shaft | 9 + 0.001 = 9.001 mm |

Now, we can easily see from figure dimensions that it is a transition fit.

Sol. 26
Option (D) is correct.
A green sand mould is composed of a mixture of sand (silica sand, \( \text{SiO}_2 \)), clay (which acts as binder) and water.
The word green is associated with the condition of wetness or freshness and because the mould is left in the damp condition, hence the name “green sand mould”.

Sol. 27
Option (C) is correct.
GTAW is also called as Tungsten Inert Gas Welding (TIG). The arc is maintained between the work piece and a tungsten electrode by an inert gas. The electrode is non-consumable since its melting point is about 3400°C.

Sol. 28
Option (B) is correct.
Austenite is a solid solution of carbon in \( \gamma \)-iron. It has F.C.C structure. It has a solid solubility of upto 2% C at 1130°C.

Sol. 29
Option (B) is correct.
Given: \( \alpha = 12^\circ \), \( t = 0.81 \text{ mm} \), \( t_c = 1.8 \text{ mm} \)

Shear angle,

\[
\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} \quad \ldots (i)
\]

Chip thickness ratio,

\[
r = \frac{t}{t_c} = \frac{0.81}{1.8} = 0.45
\]

From equation (i),

\[
\tan \phi = \frac{0.45 \cos 12^\circ}{1 - 0.45 \sin 12^\circ},
\]

\[
\phi = \tan^{-1}(0.486) = 25.91^\circ = 26^\circ
\]
Sol. 30
Option (A) is correct.

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</table>

So, correct pairs are, P-2, Q-3, R-4, S-1

Sol. 31
Option (A) is correct.
Given: \( a = 50 \text{ mm}, V = a^3 = (50)^3 = 125000 \text{ mm}^3 \)
Firstly side undergoes volumetric solidification shrinkage of 4%.
So, Volume after shrinkage,

\[
V_1 = 125000 - 125000 \times \frac{4}{100} = 120000 \text{ mm}^3
\]

After this, side undergoes a volumetric solid contraction of 6%.
So, volume after contraction,

\[
V_2 = 120000 - 120000 \times \frac{6}{100} = 112800 \text{ mm}^3
\]

Here \( V_2 \) is the combined volume after shrinkage and contraction.
Let at volume \( V_2 \), side of cube is \( b \).
So,

\[
b^3 = 112800 = \sqrt[3]{112800} = 48.32 \text{ mm}
\]

Sol. 32
Option (C) is correct.
Given: \( \tau = 300 \text{ MPa}, D = 100 \text{ mm}, t = 1.5 \text{ mm} \)
Blanking force

\[
F_b = \tau \times \text{Area} = \tau \times \pi D t = 300 \times 10^6 \times 3.14 \times 100 \times 1.5 \times 10^{-6} = 141300 \text{ N} = 141.3 \text{ kN} \approx 141 \text{ kN}
\]

Sol. 33
Option (C) is correct.
Fracture strength be a material property which depends on the basic crystal structure. Fracture strength depends on the strength of the material.

Sol. 34
Option (A) is correct.
Gate Ratio is defined as the ratio of sprue base area, followed by the total runner area and the total ingate area. The sprue base area is taken is unity.
So,

\[
1:2:4 = \text{Sprue base area} : \text{Runner area} : \text{Total ingate area}
\]

Sol. 35
Option (D) is correct.
We know that, shaft tolerance

\[
= \text{Upper limit of shaft} - \text{Lower limit of shaft} = (35 - 0.009) - (35 - 0.025) = 34.991 - 34.975 = 0.016
\]

Fundamental deviation for basic shaft is lower deviation.

\[
= -0.009
\]

Sol. 36
Option (C) is correct.

\[
\text{GO2} \text{ represent circular interpolation in clockwise direction.} \quad \text{G91} \text{ represent incremental dimension.}
\]

Sol. 37
Option (A) is correct.
For Tool A,

\[
n = 0.45, K = 90
\]
For Tool B, \( n = 0.3, K = 60 \)

Now, From the Taylor's tool life equation \( (VT^n = K) \)

For Tool A, \( V_T A_{0.45} = 90 \) \( ...(i) \)

For Tool B, \( V_T B^{0.3} = 60 \) \( ...(ii) \)

Dividing equation (i) by equation (ii), we get
\[
\left( \frac{V_A}{V_B} \right) \times \frac{T_{A0.45}}{T_{B0.3}} = \frac{90}{60} \]

Let \( V \) is the speed above which Tool A will have a higher life than Tool B. But at \( V \), \( T_A = T_B \)

Then
\[
V_A = V_B = V \text{ (let)}
\]

\( T_A = T_B = T \) (let)

So, from equation (iii)
\[
\frac{T_{A0.45}}{T_{B0.3}} = \frac{3}{2} \Rightarrow T^{0.45-0.3} = \frac{3}{2}
\]

\( T = \left( \frac{3}{2} \right)^{\frac{1}{0.15}} = 14.92 \text{ min.} \)

From equation (i),
\[
V \times T^{0.45} = 90
\]

\( V = 26.67 \text{ m/ min} \approx 26.7 \text{ m/ min} \)

Sol. 38

Option (C) is correct.

Given : \( d_1 = 100 \text{ mm} \), \( d_2 = 110 \text{ mm} \), \( V = 30 \text{ Volt} \), \( R = 42.4 \Omega \), \( E_u = 64.4 \text{ MJ/ m}^3 \)

Each pipe melts 1 mm of material. So, thickness of material melt,
\( t = 2 \times 1 = 2 \text{ mm} \)

Melting energy in whole volume is given by
\[
Q = \text{Area} \times \text{thickness} \times E_u = \frac{\pi}{4} (d_2^2 - d_1^2) \times t \times E_u
\]

\[
Q = \frac{\pi}{4} [(110)^2 - (100)^2] \times 10^{-6} \times 2 \times 10^{-3} \times 64.4 \times 10^6
\]

\[
= 212.32 \text{ J} \]

The amount of heat generated at the contacting area of the element to be weld is,
\[
Q = I^2 R t = \frac{V^2}{R} t \quad \text{ and } \quad I = \frac{V}{R}
\]

\[
t = \frac{Q \times R}{V^2}
\]

Substitute the values, we get
\[
t = \frac{212.32 \times 42.4}{(30)^2} = 10 \text{ sec}
\]

Sol. 39

Option (A) is correct

Draw a perpendicular from the point \( A \) on the line \( BF \), which intersect at point \( C \).

Let
\[
\text{Angle } \angle BAC = \theta
\]
\[
\frac{AE}{x} = \theta
\]

Now, take the right angle triangle \( \triangle ABC \),
\[
\tan \theta = \frac{BC}{AC} = \frac{10}{30} = \frac{1}{3} \]

...(i)

From the same triangle \( \triangle ADE \),
\[
\tan \theta = \frac{x}{DE} = \frac{x}{10}
\]
Put the value of \( \tan \theta \), from the equation (i),

So,

\[
\frac{1}{3} = \frac{x}{10} \Rightarrow x = \frac{10}{3} \text{ mm}
\]

\[= 3.33 \text{ mm} \]

Now, diameter at \( Z = 0 \) is,

\[d = 20 - 2x\]

\[= 20 - 2 \times 3.333 = 13.334 \text{ mm}\]

**Sol. 40**

Option (B) is correct.

**Given :** \( t = 5 \text{ mm}, L = 200 \text{ mm}, \tau_s = 100 \text{ MPa} \)

Penetration to thickness ratio \( \frac{P}{t} = 0.2 = \sigma \)

Force vs displacement curve to be rectangle,

So, Shear area,

\[A = (200 + 200) \times 5 = 2000 \text{ mm}^2\]

Work done,

\[W = \tau \times A \times k \times t\]

Substitute the values, we get

\[W = 100 \times 10^6 \times 2000 \times 10^{-6} \times 0.2 \times 5 \times 10^{-3}\]

\[= 100 \times 2 \times 0.2 \times 5 = 200 \text{ Joule}\]

**Sol. 41**

Option (B) is correct.

**Given :** Shear \( S = 20 \text{ mm} \)

Now force vs displacement curve to be trapezoidal.

So, maximum force is given by,

\[F_{max} = \frac{W}{(kt + \text{Shear})} = \frac{200}{(0.2 \times 5 + 20) \times 10^{-3}}\]

\[= \frac{200}{21 \times 10^{-3}} = 9.52 \times 10^3 \approx 10 \text{ kN}\]

**Sol. 42**

Option (D) is correct.

The cutting forces decrease with an increase in cutting speed, but it is substantially smaller than the increase in speed. With the increase in speed, friction decreases at the tool chip interface. The thickness of chip reduces by increasing the speed.

**Sol. 43**

Option (A) is correct.

Two streams of liquid metal which are not hot enough to fuse properly result into a casting defect known as cold shut. This defect is same as in sand mould casting. The reasons are :-

(i) Cooling of die or loss of plasticity of the metal.

(ii) Shot speed less.

(iii) Air-vent or overflow is closed.
Option (B) is correct.

(i) Simple Cubic
Effective no. of Lattice
\[
\frac{1}{8} \times 8 = 1
\]

(ii) BCC
Effective no. of Lattice
\[
\frac{1}{8} \times 8 + 1 = 2
\]

(iii) FCC
Effective no. of Lattice
\[
\frac{1}{8} \times 8 + \frac{1}{2} \times 6 = 4
\]

Option (C) is correct.
Correct data structure for solid models is given by,
Vertices → edges → faces → solid parts

Option (D) is correct.
Given : \( \alpha = 0^\circ \)

We know that, shear strain
\[
s = \cot \phi + \tan(\phi - \alpha)
\]
\[
\alpha = 0^\circ
\]
So,
\[
s = \cot \phi + \tan \phi
\]

For minimum value of shear strain differentiate equation (i) w.r.t. \( \phi \)
\[
ds = \frac{d}{d\phi}(\cot \phi + \tan \phi) = -\cosec^2 \phi + \sec^2 \phi
\]

Again differentiate w.r.t. to \( \phi \),
\[
\frac{d^2s}{d\phi^2} = -2 \cosec \phi \times (-\cosec \phi \cot \phi) + 2 \sec \phi \times (\sec \phi \tan \phi)
\]
\[
= +2 \cosec^2 \phi \cot \phi + 2 \sec^2 \phi \tan \phi
\]

Using the principle of minima - maxima and put \( \frac{ds}{d\phi} = 0 \) in equation(ii)
\[-\cosec^2 + \sec^2 \phi = 0
\]
\[-\frac{1}{\sin^2 \phi} + \frac{1}{\cos^2 \phi} = 0
\]
\[
\frac{\cos^2 \phi - \sin^2 \phi}{\sin^2 \phi \times \cos^2 \phi} = 0
\]
\[
\cos^2 \phi - \sin^2 \phi = 0
\]
\[
\cos 2\phi = 0
\]
\[
2\phi = \cos^{-1}(0) = \frac{\pi}{2}
\]
\[
\phi = \frac{\pi}{4}
\]

From equation (iii), at \( \phi = \frac{\pi}{4} \)
\[
\left( \frac{d^2s}{d\phi^2} \right)_{\phi = \frac{\pi}{4}} = 2 \cosec^2 \frac{\pi}{4} \times \cot \frac{\pi}{4} + 2 \sec^2 \frac{\pi}{4} \tan \frac{\pi}{4}
\]
\[
\left( \frac{d^2s}{d\phi^2} \right)_{\phi = \frac{\pi}{4}} = 2 \times 2 \times 1 + 2 \times 2 \times 1 = 8
\]
\[
\left(\frac{d^2 s}{d\phi^2}\right)_{\phi=\frac{\pi}{4}} > 0
\]

Therefore it is minimum at \( \phi = \frac{\pi}{4} \), so from equation (i),

\[
(s)_{\text{min}} = \cot \frac{\pi}{4} + \tan \frac{\pi}{4} = 1 + 1 = 2
\]

Sol. 47
Option (A) is correct.
Given : \( L = 0.2 \) mm, \( A = 20 \) mm \( \times \) 20 mm = 400 mm\(^2\), \( V = 12 \) Volt
\( \rho = 2 \) \( \Omega \) cm = \( 2 \times 10 \) \( \Omega \) mm, \( Z = 55.85 \), \( v = 2 \), \( F = 96540 \) Coulombs
We know that Resistance is given by the relation
\[
R = \frac{\rho L}{A} = \frac{2 \times 10 \times 0.2}{20 \times 20} = 0.01 \Omega
\]
\[
I = \frac{V}{R} = \frac{12}{0.01} = 1200 \text{ A}
\]
Rate of mass removal
\[
m = \frac{I \cdot Z}{V} = \frac{1200 \times 55.85}{96540} = 0.3471 \text{ g/sec}
\]

Sol. 48
Option (C) is correct.

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<td>1. Absolute coordinate system</td>
</tr>
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</table>

So, correct pairs are, P-3, Q-4, R-2, S-1

Sol. 49
Option (A) is correct.
Since diameter 60 lies in the diameter step of 50 – 80 mm, therefore the geometric mean diameter.
\[
D = \sqrt{50 \times 80} = 63.246 \text{ mm}
\]

Fundamental tolerance unit.
\[
i = 0.45D^{1/3} + 0.001D = 0.45(63.246)^{1/3} + 0.001 \times 63.246
\]
\[
= 1.856 \mu \text{m} = 0.00186 \text{ mm}
\]
Standard tolerance for the hole of grades 8 (IT 8)
\[
= 25i = 25 \times 0.00186 = 0.0465 \text{ mm}
\]
Fundamental deviation for ‘f’ shaft
\[
e_f = -5.5D^{0.41} = -5.5(63.246)^{0.41}
\]
\[
= -30.115 \mu \text{m} = -0.030115 \text{ mm}
\]
Upper limit of shaft = Basic size + Fundamental deviation
\[
= 60 - 0.030115 = 59.970 \text{ mm}
\]
Lower limit of shaft = Upper limit – Tolerance = 59.970 – 0.0465
Sol. 50
Option (D) is correct.

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</table>

So, correct pairs are P-4, Q-1, R-2, S-3

Sol. 51
Option (A) is correct.

Given: \( V_1 = 60 \text{ m/min}, \ T_1 = 81 \text{ min}, \ V_2 = 90 \text{ m/min}, \ T_2 = 36 \text{ min}. \)

From the Taylor’s tool life Equation

\[ VT^n = \text{Constant (K)} \]

For case (I),

\[ V_1T_1^n = K \]

\[ 60 \times (81)^n = K \] \( \text{...(i)} \)

For case (II),

\[ V_2T_2^n = K \]

\[ 90 \times (36)^n = K \] \( \text{...(ii)} \)

Dividing equation (i) by equation (ii),

\[ \frac{60 \times (81)^n}{90 \times (36)^n} = \frac{K}{K} = 1 \]

\[ \left( \frac{81}{36} \right)^n = \frac{90}{60} \]

\[ \left( \frac{9}{4} \right)^n = \left( \frac{3}{2} \right) \]

Taking (log) both the sides,

\[ n \log \left( \frac{9}{4} \right) = \log \left( \frac{3}{2} \right) \]

\[ n \times 0.3522 = 0.1760 \]

\[ n = 0.5 \]

Substitute \( n = 0.5 \) in equation (i), we get

\[ K = 60 \times (81)^{0.5} = 540 \]

So,

\[ n = 0.5 \text{ and } K = 540 \]

Sol. 52
Option (C) is correct.

Take, \( n = 0.5 \) \( \{\text{from previous part}\} \)

From Taylor’s tool life equation

\[ VT^n = C \]

\[ VT^{0.5} = C \]

\[ V = \frac{1}{\sqrt{T}} \] \( \text{...(i)} \)

Given that cutting speed is halved

\[ V_2 = \frac{1}{2}V_1 \quad \Rightarrow \quad \frac{V_2}{V_1} = \frac{1}{2} \]

Now, from equation (i),

\[ \frac{V_2}{V_1} = \sqrt{\frac{T_1}{T_2}} \]

\[ \frac{1}{2} = \sqrt{\frac{T_1}{T_2}} \]
\[ \frac{1}{4} = \frac{T_1}{T_2} \]
\[ \frac{T_2}{T_1} = 4 \quad \Rightarrow T_2 = 4T_1 \]

Now, percentage increase in tool life is given by
\[ \frac{T_2 - T_1}{T_1} \times 100 = \frac{4T_1 - T_1}{T_1} \times 100 \]
\[ = \frac{3T_1}{T_1} \times 100 = 300\% \]

Sol. 53
Option (C) is correct.
Coon's surface is obtained by blending four boundary curves. The main advantage of Coon's surface is its ability to fit a smooth surface through digitized points in space such as those used in reverse engineering.

Sol. 54
Option (C) is correct.
Internal gear cutting operation can be performed by shaping with pinion cutter. In the case of 'rotating pinion type cutter', such an indexing is not required, therefore, this type is more productive and so common.

Sol. 55
Option (B) is correct.
Since metal shrinks on solidification and contracts further on cooling to room temperature, linear dimensions of patterns are increased in respect of those of the finished casting to be obtained. This is called the "Shrinkage allowance". The riser can compensate for volume shrinkage only in the liquid or transition stage and not in the solid state.
So, Volume of metal that compensated from the riser \( = 3\% + 4\% = 7\% \)

Sol. 56
Option (D) is correct.
Interconversion between ASA (American Standards Association) system and ORS (Orthogonal Rake System)
\[ \tan \alpha_k = \sin \phi \tan \alpha - \cos \phi \tan i \]
where
\[ \alpha_k = \text{Side rake angle} \]
\[ \alpha = \text{orthogonal rake angle} \]
\[ \phi = \text{principle cutting edge angle} = 0 \leq \phi \leq 90^\circ \]
\[ i = \text{inclination angle} \ (i = 0 \text{ for ORS}) \]
\[ \alpha_k = \alpha \ (\text{Given}) \]
\[ \tan \alpha_k = \sin \phi \tan \alpha - \cos \phi \tan(0^\circ) \]
\[ \tan \alpha_k = \sin \phi \tan \alpha \]
\[ \tan \frac{\alpha_k}{\tan \alpha} = \sin \phi \]
\[ 1 = \sin \phi \]
\[ \phi = \sin^{-1}(1) = 90^\circ \]

Sol. 57
Option (B) is correct.
Given: \( \rho = 6000 \text{ kg/m}^3 = 6 \text{ gm/cm}^3 \), \( F = 96500 \text{ coulomb/mole} \)
\( \text{MRR} = 50 \text{ mm}^3/\text{s} = 50 \times 10^{-3} \text{ cm}^3/\text{s}, I = 2000 \text{ A} \)
For Iron: Atomic weight = 56
Valency = 2
For Metal P: Atomic weight = 24
Valency = 4

The metal Removal rate

\[ \text{MRR} = \frac{el}{F \rho} \]

\[ 50 \times 10^{-3} = \frac{e \times 2000}{96500 \times 6} \]

\[ e = \frac{50 \times 10^{-3} \times 96500 \times 6}{2000} = 14.475 \]

Let the percentage of the metal P in the alloy is \( x \).

So,

\[ \frac{1}{14.475} = \frac{100 - x}{100} \times \frac{V_{Fe}}{A_{u}} + \frac{x}{100} \times \frac{V_{P}}{A_{w}} \]

\[ \frac{1}{14.475} = \left(1 - \frac{x}{100}\right) \frac{1}{28} + \frac{x}{100} \times \frac{1}{6} \]

\[ \frac{1}{14.475} = x \left[ \frac{1}{600} - \frac{1}{2800} \right] + \frac{1}{28} \]

\[ \frac{1}{14.475} - \frac{1}{28} = x \times \frac{11}{8400} \]

\[ \frac{541}{16212} = \frac{11x}{8400} \]

\[ x = \frac{541 \times 8400}{16212 \times 11} \approx 25 \]

Sol. 59

Option (B) is correct.

Given : \( \eta_{m} = 0.5 \), \( \eta_{h} = 0.7 \), \( A = 5 \text{ mm}^2 \), \( E_{u} = 10 \text{ J/mm}^3 \), \( P = 2 \text{ kW} \), \( V \text{ (mm/s)} = ? \)

Total energy required to melt,

\[ E = E_{u} \times A \times V = 10 \times 5 \times v = 50 \text{ VJ/sec} \]

Power supplied for welding,

\[ P_{s} = P \times \eta_{h} \times \eta_{m} = 2 \times 10^{3} \times 0.5 \times 0.7 \]

\[ = 700 \text{ W} \]

From energy balance,
Energy required to melt = Power supplied for welding
\[ 50V = 700 \Rightarrow V = 14 \text{ mm/sec} \]

Sol. 60
Option (A) is correct.
Seamless cylinders and tubes can be made by hot drawing or cupping.
The thickness of the cup is reduced and its length increased by drawing it through a series of dies having reduced clearance between the die and the punch. Due to reduction in its thickness, blanks shows a tendency to wrinkle up around the periphery because of buckling due to circumferential compression an due to this compression blank holder pressure increases.

Sol. 61
Option (C) is correct.
The feed drive serves to transmit power from the spindle to the second operative unit of the lathe, that is, the carriage. It, thereby converts the rotary motion of the spindle into linear motion of the carriage.
So, Q and E are connected & Uₜ is placed between Q and E.

Sol. 62
Option (C) is correct.
A dial indicator (gauge) or clock indicator is a very versatile and sensitive instrument. It is used for:
(i) determining errors in geometrical form, for example, ovality, out-of-roundness, taper etc.
(ii) determining positional errors of surface
(iii) taking accurate measurements of deformation.
Here equal deflections are shown in both the sensor P and sensor Q. So drill spindle rotational axis is parallel to the drill spindle tape hole axis.

Sol. 63
Option (D) is correct.
Given:
- \( \tau_s = 250 \text{ MPa} \)
- \( V = 180 \text{ m/min} \)
- \( f = 0.20 \text{ mm/rev} \)
- \( d = 3 \text{ mm} \)
- \( r = 0.5 \)
- \( \alpha = 7^\circ \)
We know from merchant’s theory,
Shear plane angle
\[ \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} \]
\[ = \frac{0.5 \cos 7^\circ}{1 - 0.5 \sin 7^\circ} = \frac{0.496}{0.915} = 0.54 \]
\[ \phi = \tan^{-1}(0.54) = 28.36 \approx 28^\circ \]
Average stress on the shear plane area are
\[ \tau_s = \frac{F_s}{A_s} \]
\[ \Rightarrow F_s = \tau_s \times A_s \]
where, \( A_s \) is the shear plane area
\[ = \frac{bt}{\sin \phi} \]
for orthogonal operation \( b \times t = d \times f \)
So,
\[ F_s = \frac{\tau_s \times d \times f}{\sin \phi} = \frac{250 \times 3 \times 0.20}{\sin 28^\circ} = 319.50 \approx 320 \text{ N} \]

Sol. 64
Option (B) is correct.
Now we have to find cutting force \( (F_c) \) and frictional force \( (F_t) \).
From merchant’s theory,
\[ 2\phi + \beta - \alpha = 90^\circ \]
\[ \beta = 90^\circ + \alpha - 2\phi = 90^\circ + 7^\circ - 2 \times 28^\circ = 41^\circ \]
We know that
\[ \frac{F_c}{F_s} = \frac{\cos(\beta - \alpha)}{\cos(\phi + \beta - \alpha)} \]
\[ F_s = \text{Share force} \]
\[ F_c = 320 \times \frac{\cos(41^\circ - 7^\circ)}{\cos(28^\circ + 41^\circ - 7^\circ)} = 320 \times 1.766 \approx 565 \text{ N} \]
And

\[ F_s = F_c \cos \phi - F_t \sin \phi \]

So,

\[ F_t = \frac{F_c \cos \phi - F_s}{\sin \phi} = \frac{565 \times \cos 28^\circ - 320}{\sin 28^\circ} = \frac{178.865}{0.47} = 381.56 \text{ N} \approx 381 \text{ N} \]

Sol. 65
Option (B) is correct.

Given: \( N = 200 \text{ step/rev.}, p = 4 \text{ mm}, U = \frac{1}{4}, f = 10000 \text{ Pulse/min.} \)

In a CNC machine basic length unit (BLU) represents the smallest distance.

Revolution of motor in one step = \( \frac{1}{200} \text{ rev./step} \)

Movement of lead screw = \( \frac{1}{200} \times \frac{1}{4} = \frac{1}{800} \text{ rev. of load screw} \)

Movement from lead screw is transferred to table.

i.e. Movement of table = \( \frac{1}{800} \times \text{Pitch} = \frac{1}{800} \times 4 = \frac{1}{200} \)

= 0.005 = 5 microns.

Sol. 66
Option (C) is correct.

We know

\[ \text{BLU} = \text{Revolution of motor} \times \text{Gear ratio} \times \text{pitch} \]

\[ = \frac{1}{200} \times \frac{1}{2} \times 4 = \frac{1}{100} = 10 \text{ micros} \]

We see that \( f \) is unchanged and value of Gear ratio is changed by \( 1/2 \).

Sol. 67
Option (B) is correct.

The carbon alloy having less than 2% carbon are called "steels" and those containing over 2% carbon are called cast irons.

Now, steel may further be classified into two groups.

(i) Steels having less than 0.83% carbon are called "hypo-eutectoid steels"

(ii) Those having more than 0.83% carbon called "hyper-eutectoid steels"

Sol. 68
Option (D) is correct.

The hot chamber die casting process is used for low melting temperature alloys. Tin is a low melting temperature alloy.

Sol. 69
Option (C) is correct.

Friction welding is defined as “A solid state welding process wherein coalescence is produced by heat obtained from mechanically induced sliding motion between rubbing surfaces.

Sol. 70
Option (B) is correct.

Given: \( D = 150 \text{ mm}, V = 90 \text{ m/min}, f = 0.24 \text{ mm/rev.} \)

\( d = 2 \text{ mm}, t_c = 0.48 \text{ mm, } \alpha = 0^\circ, \lambda = 90^\circ \)

Uncut chip thickness,

\[ t = f \sin \lambda = 0.24 \times \sin 90^\circ = 0.24 \text{ mm} \]

Chip thickness ratio,

\[ r = \frac{t}{\frac{d}{2}} = \frac{0.24}{0.48} = \frac{1}{2} \]

From merchant’s theory,

Shear angle,

\[ \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} = \frac{0.5 \cos 0^\circ}{1 - 0.5 \times \sin 0^\circ} = 0.5 \]

\[ \phi = \tan^{-1}(0.5) = 26.56^\circ \]
Sol. 71
Option (C) is correct.
A spindle motor is a small, high precision, high reliability electric motor that is used to rotate the shaft or spindle used in machine tools for performing a wide range of tasks like drilling, grinding, milling etc.
A stepper motor have not all these characteristic due to change of direction of rotation with time interval.

Sol. 72
Option (D) is correct.
According to Caine’s relation
Solidification time,
\[ T = q \left( \frac{V}{A} \right)^2 \]
Where : \( V = \) Volume, \( A = \) Surface area, \( Q = \) Flow rate
\( q = \) constant of proportionality depends upon composition of cast metal
Using the subscript \( c \) for the cube and subscript \( s \) for the sphere.
Given : \( V_c = V_s \) So, \( T \propto \frac{1}{A^2} \)
So,
\[ \frac{T_c}{T_s} = \left( \frac{A_s}{A_c} \right)^2 = \left( \frac{4\pi r^2}{\frac{4}{3}\pi r^3} \right)^2 = \frac{4\pi}{6l^2} \cdot \frac{l^4}{T} \]

Sol. 73
Question (A) is correct.
Metal removal rate depends upon current density and it increases with current. The MRR increase with thermal conductivity also
Wear ratio = \( \frac{\text{Volume of metal removed work}}{\text{Volume of metal removed tool}} \)
The volume of metal removed from the tool is very less compare to the volume of metal removed from the work.
So, Wear ration \( \propto \) volume of metal removed work.
Hence, both the wear rate and MRR are expected to be high.

Sol. 74
Option (D) is correct.
Given : \( E = 2J/\text{mm}^3, \ V = 120\text{ m/min, } f = 0.2 \text{ mm/rev.} = t, d = 2 \text{ mm} = b \)
The specific energy, \( E = \frac{F_c}{b \cdot t} \)
In orthogonal cutting \( b \times t = d \times f \)
\[ F_c = E \times b \times t = E \times d \times f \]
\[ = 2 \times 10^9 \times 2 \times 10^{-9} \times 0.2 \times 10^{-3} = 800 \text{ N} \]

Sol. 75
Option (A) is correct.
Given : \( OCV = 80 \text{ V, SCC} = 800 \text{ A} \)
In Case (I) : \( I = 500 \text{ A and } L = 5.0 \text{ mm} \)
And in, Case (II) : \( I = 460 \text{ A, and } L = 7.0 \text{ mm} \)
We know that, for welding arc,
\[ E = a + bL \] ...(i)
And For power source,
\[ E = OCV - \frac{OCV}{SCC} \cdot I = 80 - \left( \frac{80}{800} \right) I \] ...(ii)
Where : \( I = \text{Arc current, } E = \text{Arc voltage} \)
For stable arc, Welding arc = Power source
\[ 80 - \left( \frac{80}{800} \right) I = a + bL \] ...(iii)
Find the value of $a$ & $b$, from the case (I) & (II)

For case (I), $I = 500\ A, L = 5\ mm$

So, \[ 80 - \left( \frac{80}{800} \right) \times 500 = a + 5b \]
\[ 80 - 50 = a + 5b \]
\[ a + 5b = 30 \] \quad ...(iv)

For case II, $I = 460\ A, L = 7\ mm$

So, \[ 80 - \left( \frac{80}{800} \right) \times 460 = a + 7b \]
\[ 80 - 46 = a + 7b \]
\[ a + 7b = 34 \] \quad ...(v)

Subtracting equation (iv) from equation (v),
\[ (a + 7b) - (a + 5b) = 34 - 30 \]
\[ 2b = 4 \quad \Rightarrow b = 2 \]

From equation (iv), put $b = 2$
\[ a + 5 \times 2 = 30 \quad \Rightarrow a = 20 \]

Substituting the value of $a$ & $b$ in equation (i), we get
\[ E = 20 + 2L \]

Option (C) is correct.

Given : Hole, $40.0000\ mm$

- Minimum hole size $= 40\ mm$
- Minimum clearance $= 0.01\ mm$
- Maximum size of hole $= 40 + 0.050 = 40.050\ mm$
- Tolerance of shaft $= 0.04\ mm$

Given that the mating shaft has a clearance fit with minimum clearance of 0.01 mm.

So, \[ \text{Maximum size of shaft} = \text{Minimum hole size} - \text{Minimum clearance} \]
\[ = 40 - 0.01 = 39.99\ mm \]

And \[ \text{Minimum size of shaft} = \text{Maximum shaft size} - \text{Tolerance of shaft} \]
\[ = 39.99 - 0.04 = 39.95\ mm \]

Maximum clearance,
\[ c = \text{Maximum size of hole} - \text{Minimum size of shaft} \]
\[ = 40.050 - 39.95 = 0.1\ mm \]
Sol. 77
Option (C) is correct.
Given: \( \lambda = 90^\circ, \ F_c = 1000 \text{ N}, \ F_t = 800 \text{ N}, \ \phi = 25^\circ, \ \alpha = 0^\circ \)
We know that, from the merchant’s theory,
\[
\frac{\text{Friction force}}{\text{Normal force}} = \mu = \frac{F_c \tan \alpha + F_t}{F_c - F_t \tan \alpha}
\]
Substitute the values, we get
\[
\frac{F}{N} = \frac{1000 \tan 0^\circ + 800}{1000 - 800 \tan 0^\circ} = \frac{800}{1000} = 0.80
\]

Sol. 78
Option (C) is correct.
Given: \( w = 2 \text{ mm}, \ l = 10 \text{ kA} = 10^4 \text{ A}, \ t = 10 \text{ milli second} = 10^{-2} \text{ sec} \)
\( T_a = 293 \text{ K}, \ T_m = 1793 \text{ K}, \ \rho = 7000 \text{ kg/m}^3, \ L_f = 300 \text{ kJ/kg} \)
\( c = 800 \text{ J/kg K}, \ R = 500 \text{ micro ohm} = 500 \times 10^{-6} \text{ ohm} \)
Radius of sphere, \( r = 2 \text{ mm} = 2 \times 10^{-3} \text{ m} \)
Heat supplied at the contacting area of the element to be welded is
\[ Q_s = I^2 R t = (10^4)^2 \times 500 \times 10^{-6} \times 10^{-2} = 500 \text{ J} \]
as fusion zone is spherical in shape.
Mass,
\[ m = \rho \times v = 7000 \times \frac{4}{3} \times 3.14 \times (2 \times 10^{-3})^3 = 2.344 \times 10^{-4} \text{ kg} \]
Total heat for melting (heat input)
\[ Q_i = mL_f + mc(T_m - T_a) \]
Where \( mL_f = \text{Latent heat} \)
Substitute the values, we get
\[ Q_i = 2.344 \times 10^{-4} \times (300 \times 10^3 + 800(1793 - 293)) = 2.344 \times 10^{-4} \times (300 \times 10^3 + 800 \times 1500) = 351.6 \text{ J} \]
Efficiency \( \eta = \frac{\text{Heat input (Q_i)}}{\text{Heat supplied (Q_s)}} \times 100 \)
\[ \eta = \frac{351.6 \times 100}{500} = 70.32\% \approx 70.37\% \]

Sol. 79
Option (C) is correct.
Given: \( d_i = 200 \text{ mm}, \ h_i = l_i = 60 \text{ mm}, \ d_f = 400 \text{ mm} \)
Volume of disc remains unchanged during the whole compression process.
So,
\[ \text{Initial volume} = \text{Final volume.} \]
\[ \frac{\pi d_i^2}{4} \times l_i = \frac{\pi d_f^2}{4} \times l_f \]
\[ \frac{l_f}{l_i} = \frac{d_i^2}{d_f^2} \]
\[ l_f = 60 \times \left( \frac{200}{400} \right)^2 = 60 \times \frac{1}{4} = 15 \text{ mm} \]
Strain,
\[ \varepsilon = \frac{\Delta l}{l_i} = \frac{l_i - l_f}{l_i} = \frac{60 - 15}{15} = 3 \]
True strain,
\[ \varepsilon_0 = \ln(1 + \varepsilon) = \ln(1 + 3) = 1.386 \]

Sol. 80
Option (D) is correct.
Let, \( \text{Bite angle} = \theta \)
\[ D = 400 \text{ mm}, \ t_i = 16 \text{ mm}, \ t_f = 10 \text{ mm} \]
Bite angle,
\[ \tan \theta = \sqrt{\frac{t_1 - t_2}{R}} = \sqrt{\frac{16 - 10}{200}} = \sqrt{0.03} \]
\[ \theta = \tan^{-1}(0.173) = 9.815^\circ \approx 9.936^\circ \]

**Sol. 81**
Option (D) is correct.

<table>
<thead>
<tr>
<th>Processes</th>
<th>Associated state of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Blanking</td>
<td>3. Shear</td>
</tr>
<tr>
<td>Q. Stretch Forming</td>
<td>1. Tension</td>
</tr>
<tr>
<td>R. Coining</td>
<td>2. Compression</td>
</tr>
<tr>
<td>S. Deep Drawing</td>
<td>4. Tension and Compression</td>
</tr>
</tbody>
</table>

So, correct pairs are, P-3, Q-1, R-2, S-4

**Sol. 82**
Option (A) is correct.
Blanking force \( F_b \) is directly proportional to the thickness of the sheet ‘t’ and diameter of the blanked part ‘d’.
\[ F_b \propto d \times t \]
\[ F_b = \tau \times d \times t \] ...(i)

For case (I) : \( F_{b1} = 5.0 \text{ kN}, d_1 = d, t_1 = t \)
For case (II) : \( d_2 = 1.5d, t_2 = 0.4t, F_{b2} = ? \)
From equation (i)
\[ \frac{F_{b2}}{F_{b1}} = \frac{d_2 t_2}{d_1 t_1} \]
\[ F_{b2} = 5 \times \frac{1.5d \times 0.4t}{d \times t} = 3 \text{ kN} \]

**Sol. 83**
Option (C) is correct.
Let molten metal enters at section 1st and leaves the object at section 2nd

Given : \( A_1 = 650 \text{ mm}^2, Q = 6.5 \times 10^5 \text{ mm}^3/\text{ sec}, g = 10^4 \text{ mm/ sec}^2 \)
Now, for section 1st, flow rate
\[ Q = A_1 V_1 \]
\[ V_1 = \frac{Q}{A_1} = \frac{6.5 \times 10^5}{650} = 1000 \text{ mm/ sec} \]

Applying Bernoulli’s equation at section 1st and 2nd.
\[ \frac{p_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{p_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 \]
But \( p_1 = p_2 = \text{atmosphere pressure} \)
So,

\[
\frac{V_1^2}{2g} + Z_1 = \frac{V_2^2}{2g} + Z_2
\]

\[
\frac{(1000)^2}{2 \times 10^4} + 200 = \frac{V_2^2}{2 \times 10^4} + 0
\]

\[
(50 + 200) \times 2 \times 10^4 = V_2^2
\]

\[
V_2^2 = 500 \times 10^4 = 5 \times 10^6
\]

\[
V_2 = 2.236 \times 10^3 \text{ mm/ sec} = 2236 \text{ mm/ sec}
\]

We know that, flow rate remains constant during the process (from continuity equation). So, for section 2nd

\[
Q = A_2 V_2
\]

\[
A_2 = \frac{Q}{V_2} = \frac{6.5 \times 10^5}{2236} = 290.7 \text{ mm}^2
\]

Option (A) is correct.

<table>
<thead>
<tr>
<th>Parts</th>
<th>Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Computer chip</td>
<td>4. Photochemical Machining</td>
</tr>
<tr>
<td>Q. Metal forming dies and molds</td>
<td>3. Electrodischarge Machining</td>
</tr>
<tr>
<td>R. Turbine blade</td>
<td>1. Electrochemical Machining</td>
</tr>
<tr>
<td>S. Glass</td>
<td>2. Ultrasonic Machining</td>
</tr>
</tbody>
</table>

So, correct pairs are, P-4, Q-3, R-1, S-2

Option (B) is correct.

Given : \( T_1 = 24 \text{ min}, T_2 = 12 \text{ min} \), \( V_1 = 90 \text{ m/min} \), \( V_2 = 120 \text{ m/min} \)

We have calculate velocity, when tool life is 20 minute.

First of all we the calculate the values of \( n \), From the Taylor’s tool life equation.

\[ VT^n = C \]

For case 1st and 2nd, we can write

\[
V_1 T_1^n = V_2 T_2^n
\]

\[
\left( \frac{T_1}{T_2} \right)^n = \frac{V_2}{V_1}
\]

\[ \left( \frac{24}{12} \right)^n = \frac{120}{90} \]

\[ (2)^n = 1.33 \]

\[ n \log 2 = \log 1.33 \]

\[ n \times 0.301 = 0.124 \]

\[ n = 0.412 \]

For \( V_3 \), we can write from tool life equation,

\[
V_3 T_3^n = V_3 T_3^n
\]

\[ 90 \times (24)^{0.412} = V_3 (20)^{0.412} \]

\[ 333.34 = V_3 \times 3.435 \]

\[ V_3 = 97 \text{ m/min} \]

Option (C) is correct.

Given : \( D = 147 \text{ mm}, l = 630 \text{ mm}, f = 0.2 \text{ mm/rev} \)

\( d = 2 \text{ mm} \), \( V_3 = 97 \text{ m/min} \)

\[
\text{Machining time } t = \frac{l}{fN}
\]
\[ V = \pi DN \text{ m/min} \]

So,
\[
t = \frac{1 \times \pi \times D}{V} = \frac{0.63 \times 3.14 \times 0.147}{0.2 \times 10^{-2} \times 97} = 15 \text{ min}
\]

Sol. 87
Option (D) is correct.
Investment casting uses an expandable pattern, which is made of wax or of a plastic by molding or rapid prototyping techniques. This pattern is made by injecting molten wax or plastic into a metal die in the shape of the pattern.

Sol. 88
Option (D) is correct.
Spheroidizing may be defined as any heat treatment process that produces a rounded or globular form of carbide. High carbon steels are spheroidized to improve machinability, especially in continuous cutting operations.

Sol. 89
Option (A) is correct.
NC contouring is a continuous path positioning system. Its function is to synchronize the axes of motion to generate a predetermined path, generally a line or a circular arc.

Sol. 90
Option (A) is correct.
Ring gauges are used for gauging the shaft and male components i.e. measure the outside diameter. It does not able to measure the roundness of the given shaft.

Sol. 91
Option (B) is correct.
Given: \( \sigma_u = 400 \text{ MPa}, \frac{\Delta L}{L} = 35\% = 0.35 = \varepsilon_0 \)

Let, true stress is \( \sigma \) and true strain is \( \varepsilon \).

True strain, \( \varepsilon = \ln(1 + \varepsilon_0) = \ln(1 + 0.35) = 0.30 \)

True stress, \( \sigma = \sigma_0 (1 + \varepsilon_0) = 400(1 + 0.35) = 540 \text{ MPa} \)

We know, at Ultimate tensile strength, \( n = \varepsilon = 0.3 \)

Relation between true stress and true strain is given by,
\[
\sigma = K \varepsilon^n \tag{i}
\]

\[
K = \frac{\sigma}{\varepsilon^n} = \frac{540}{(0.30)^{0.3}} = 774.92 \approx 775
\]

So, From equation (i)
\[
\sigma = 775 \varepsilon^{0.3}
\]

Sol. 92
Option (B) is correct.
We know that, Time taken to fill the mould with top gate is given by,
\[
t_A = \frac{A_m H_m}{A_g \sqrt{2g H_g}}
\]

Where
\( A_m = \text{Area of mould} \)
\( H_m = \text{Height of mould} \)
\( A_g = \text{Area of gate} \)
\( H_g = \text{Height of gate} \)

Given that, total liquid head is maintained constant and it is equal to the mould height.
So,
\( H_m = H_g \)
\[ t_a = \frac{A_m \sqrt{H_m}}{A_g \sqrt{2g}} \] ...(i)

Time taken to fill with the bottom gate is given by,
\[ t_B = \frac{2A_m}{A_g \sqrt{2g}} \times \left( \sqrt{H_g} - \sqrt{H_g - H_m} \right) \]
\[ = \frac{2A_m}{A_g \sqrt{2g}} \times \sqrt{H_m} \quad H_m = H_g \] ...(ii)

Dividing equation (ii) by equation (i),
\[ \frac{t_B}{t_a} = 2 \]
\[ t_B = 2t_a \]

Sol. 93  Option (C) is correct.
Given : \( t_i = 4 \) mm, \( D = 300 \) mm, \( \mu = 0.1 \), \( t_r = ? \)

We know that,
For single pass without slipping, minimum possible thickness is given by the relation.
\[ (t_i - t_r) = \mu^2 R \]
\[ t_r = t_i - \mu^2 R = 4 - (0.1)^2 \times 150 = 2.5 \text{ mm} \]

Sol. 94  Option (B) is correct.
Given, \( d_i = 10 \) mm, \( d_f = 8 \) mm, \( \sigma_0 = 400 \text{ MPa} \)
The expression for the drawing force under frictionless condition is given by
\[ F = \sigma_{\text{mean}} A_i \ln\left(\frac{A_i}{A_f}\right) \]
\[ = 400 \times 10^6 \times \frac{\pi}{4} \times (0.008)^2 \ln\left[ \frac{1}{2} \left(0.001\right)^2 \right] \]
\[ = 20996 \times \ln(1.5625) = 8.968 \text{ kN } \approx 8.97 \text{ kN} \]

Sol. 95  Option (D) is correct.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P.</strong> Wrinkling</td>
<td>4. Insufficient blank holding force</td>
</tr>
<tr>
<td><strong>Q.</strong> Orange peel</td>
<td>3. Large grain size</td>
</tr>
<tr>
<td><strong>R.</strong> Stretcher strains</td>
<td>1. Yield point elongation</td>
</tr>
<tr>
<td><strong>S.</strong> Earing</td>
<td>2. Anisotropy</td>
</tr>
</tbody>
</table>

So correct pairs are, P-4, Q-3, R-1, S-2

Sol. 96  Option (B) is correct.
Given, \( V = 25 \text{ Volt}, \ I = 300 \text{ A}, \ \eta = 0.85, \ V = 8 \text{ mm/sec} \)

We know that the power input by the heat source is given by,
\[ P = \text{Voltage } \times I \]

Heat input into the work piece \( = P \times \text{efficiency of heat/transfer} \)
\[ H_i = \text{Voltage } \times I \times \eta = 25 \times 300 \times 0.85 = 6375 \text{ J/sec} \]

Heat energy input \((J/mm) = \frac{H_i}{V} \)
\[ H_i (J/mm) = \frac{6375}{8} = 796.9 \approx 797 \text{ J/mm} \]

(D) Zero rake angle, high shear angle and high cutting speed
Sol. 97  
Option (A) is correct.  
In common grinding operation, the average rake angle of the grains is highly negative, such as $-60^\circ$ or even lower and smaller the shear angle. From this, grinding chips undergo much larger deformation than they do in other cutting process. The cutting speeds are very high, typically $30 \text{ m/s}$.

Sol. 98 
Option (D) is correct.

Process | Metal Removal Rate (MRR) (in mm$^3$/sec)
---|---
1. ECM | 2700
2. USM | 14
3. EBM | 0.15
4. LBM | 0.10
5. EDM | 14.10

So the processes which has maximum MRR in increasing order is, LBM, EBM, USM, EDM, ECM.

Sol. 99  
Option (D) is correct.

| Column I | Column II |
---|---|
P. Charpy test | 4. Toughness |
Q. Knoop test | 2. Microhardness |
R. Spiral test | 1. Fluidity |
S. Cupping test | 3. Formability |

So, correct pairs are, P-4, Q-2, R-1, S-3.

Sol. 100  
Option (D) is correct.

Given: $t = 0.5 \text{ mm}$, $V = 20 \text{ m/ min}$, $\alpha = 15^\circ$, $w = 5 \text{ mm}$, $t_c = 0.7 \text{ mm}$, $F_t = 200 \text{ N}$, $F_c = 1200 \text{ N}$

We know, from the merchant’s theory

Chip thickness ratio, $r = \frac{t}{t_c} = \frac{0.5}{0.7} = 0.714$

For shear angle,

$$\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha}$$

Substitute the values, we get

$$\tan \phi = \frac{0.714 \cos 15^\circ}{1 - 0.714 \sin 15^\circ} = \frac{0.689}{0.815} = 0.845$$

$$\phi = \tan^{-1}(0.845) = 40.2^\circ$$

Shear strain,

$$s = \cot \phi + \tan(\phi - \alpha)$$

$$s = \cot(40.2^\circ) + \tan(40.2^\circ - 15^\circ)$$

$$s = \cot 40.2^\circ + \tan 25.2 = 1.183 + 0.470 = 1.65$$

Sol. 101  
Option (B) is correct.

From merchants, theory

$$\mu = \frac{F_c \sin \alpha + F_t \cos \alpha}{F_c \cos \alpha - F_t \sin \alpha} = \frac{F_c \tan \alpha + F_t}{F_c - F_t \tan \alpha}$$

$$= \frac{1200 \tan 15^\circ + 200}{1200 - 200 \times \tan 15^\circ} = \frac{521.539}{1146.41} = 0.455 \approx 0.46$$

Sol. 102  
Option (A) is correct.
We know, from merchant’s theory, frictional force of the tool acting on the tool-chip interface is

\[ F = F_c \sin \alpha + F_t \cos \alpha = 1200 \sin 15^\circ + 200 \cos 15^\circ = 503.77 \text{ N} \]

Chip velocity,

\[ V_c = \frac{\sin \phi}{\cos(\phi - \alpha)} \times V = \frac{\sin(40.2^\circ)}{\cos(40.2^\circ - 15^\circ)} \times 20 = 14.27 \text{ m/ min} \]

Total energy required per unit time during metal cutting is given by,

\[ E = F_c \times V = 1200 \times \frac{20}{60} = 400 \text{ Nm/ sec} \]

Energy consumption due to friction force \( F \),

\[ E_f = F \times V_c = 503.77 \times \frac{14.27}{60} \text{ Nm/ sec} = 119.81 \text{ Nm/ sec} \]

Percentage of total energy dissipated due to friction at tool-chip interface is

\[ E_d = \frac{E_f}{E} \times 100 = \frac{119.81}{400} \times 100 \approx 30\% \]

Sol. 103

Option (D) is correct.

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So, correct pairs are, P-3, Q-5, R-2, S-1

Sol. 104

Option (A) is correct.

When the temperature of a solid metal increases, its intramolecular bonds are brake and strength of solid metal decreases. Due to decrease its strength, the elongation of the metal increases, when we apply the load i.e. ductility increases.

Sol. 105

Option (D) is correct.

We know that,

The strength of the brazed joint depend on (a) joint design and (b) the adhesion at the interfaces between the workpiece and the filler metal.

The strength of the brazed joint increases up to certain gap between the two joining surfaces beyond which it decreases.

Sol. 106

Option (A) is correct.
The interference is the amount by which the actual size of a shaft is larger than the actual finished size of the mating hole in an assembly.

For interference fit, lower limit of shaft should be greater than the upper limit of the hole (from figure).

Sol. 107
Option (B) is correct.

In ECM, the principal of electrolysis is used to remove metal from the workpiece. The ECM method has also been developed for machining new hard and tough materials (for rocket and aircraft industry) and also hard refractory materials.

Sol. 108
Option (C) is correct.

According to 3-2-1 principle, only the minimum locating points should be used to secure location of the work piece in any one plane.

(A) The workpiece is resting on three pins A, B, C which are inserted in the base of fixed body.

The workpiece cannot rotate about the axis XX and YY and also it cannot move downward. In this case, the five degrees of freedom have been arrested.

(B) Two more pins D and E are inserted in the fixed body, in a plane perpendicular to the plane containing, the pins A, B and C. Now the workpiece cannot rotate about the Z-axis and also it cannot move towards the left. Hence the addition of pins D and E restrict three more degrees of freedom.

(C) Another pin F in the second vertical face of the fixed body, arrests degree of freedom 9.

Sol. 109
Option (A) is correct.

Arc welding, Laser cutting of sheet and milling operations are the continuous path operations.

Sol. 110
Option (A) is correct.

Machining cost = Machining time \times Direct labour cost.

If cutting speed increases then machining time decreases and machining cost also decreases and due to increase in cutting speed tool changing cost increases.

So,\
Curve 1 \rightarrow Machining cost \\
Curve 2 \rightarrow Non-productive cost \\
Curve 3 \rightarrow Tool changing cost

Sol. 111
Option (B) is correct.

Given: l = 20 cm = 0.2 m, A = 1 cm² = 10⁻⁴ m²

V = 1000 cm³ = 1000 \times 10⁻⁶ m³ = 10⁻³ m³

Velocity at the base of sprue is,

\[ V = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.2} = 1.98 \text{ m/sec} \]

From the continuity equation flow rate to fill the mould cavity is,

\[ \dot{Q} = \text{Area} \times \text{Velocity} = AV \]

\[ \frac{V}{t} = AV \quad v = \text{Volume} \]

\[ t = \frac{v}{AV} = \frac{10^{-3}}{10^{-4} \times 1.98} = \frac{10}{1.98} = 5.05 \text{ sec}. \]
Sol. 112
Option (C) is correct.

Given:
\[ \rho = 8000 \text{ kg/m}^3, \quad t = 0.1 \text{ sec}, \quad d = 5 \text{ mm}, \quad w = 1.5 \text{ mm}, \quad L_f = 1400 \text{ kJ/kg}, \quad R = 200 \mu \Omega \]

First of all calculate the mass,
\[ \rho = \frac{m}{V} \]
\[ m = \rho \times V = \rho \times \frac{\pi}{4} d^2 \times t \]
\[ = 8000 \times \frac{\pi}{4} \times (5 \times 10^{-3})^2 \times 1.5 \times 10^{-3} \]
\[ = 235.5 \times 10^{-6} \text{ kg} = 2.35 \times 10^{-4} \text{ kg} \]

Total heat for fusion,
\[ Q = mL_f \]
\[ L_f = \text{Latent heat} \]
\[ = 2.35 \times 10^{-4} \times 1400 \times 10^3 = 329 \text{ J} \] ... (i)

We also know that, the amount of heat generated at the contacting area of the element to be welded is,
\[ Q = l^2 R t \]
\[ 329 = l^2 \times 200 \times 10^{-6} \times 0.1 \]

From equation (i)
\[ l^2 = \frac{329}{200 \times 10^{-7}} = 16.45 \times 10^6 \]
\[ l = \sqrt{16.45 \times 10^6} = 4056 \text{ A} \approx 4060 \text{ A} \]

Sol. 113
Option (C) is correct.

Given:
\[ \alpha = 1 \text{ radian} \times \frac{180}{\pi} = \left(\frac{180}{\pi}\right)^\circ, \quad r = 100 \text{ mm}, \quad k = 0.5, \quad t = 2 \text{ mm} \]

Here,
\[ r > 2t \]
So,
\[ k = 0.5t \]

Bend allowance
\[ B = \frac{\alpha}{360} \times 2\pi (r + k) \]
\[ = \frac{180}{\pi} \times \frac{2\pi}{360} (100 + 0.5 \times 2) = 101 \text{ mm} \]

Sol. 114
Option (B) is correct.

Given:
Side of the plate = 600 mm, \( V = 8 \text{ m/min} \), \( f = 0.3 \text{ mm/ stroke} \)

The tool over travel at each end of the plate is 20 mm. So length travelled by the tool in forward stroke,
\[ L = 600 + 20 + 20 = 640 \text{ mm} \]

Number of stroke required
\[ = \frac{\text{Thickness of flat plate}}{\text{Feed rate/ stroke}} \]
\[ = \frac{30}{0.3} = 100 \text{ strokes} \]

Distance travelled in 100 strokes is,
\[ d = 640 \times 100 \]
\[ = 64000 \text{ mm} = 64 \text{ m} \]

So, Time required for forward stroke
\[ t = \frac{d}{v} = \frac{64}{8} = 8 \text{ min} \]

Return time \( = \frac{1}{2} \times 8 = 4 \text{ min} \)

Machining time, \( T_M = \text{Cutting time} + \text{Return time} \\
= 8 + 4 = 12 \text{ min} \)

Option (A) is correct.

Sol. 116

Option (B) is correct.

Tool designation or tool signature under ASA, system is given in the order. Back rake, Side rake, End relief, Side relief, End cutting edge angle, Side cutting edge angle and nose radius that is \( \alpha_b - \alpha_s - \alpha_e - \alpha_s - C_e - C_s - R \)

Given : For tool \( P \), tool signature, \( 5^\circ - 5^\circ - 6^\circ - 6^\circ - 8^\circ - 30^\circ - 0 \)

For tool \( Q \), \( 5^\circ - 5^\circ - 7^\circ - 7^\circ - 8^\circ - 15^\circ - 0 \)

We know that,

\[ h = \frac{\text{feed}}{\tan(SCEA) + \cot(ECEA)} = \frac{f}{\tan(C_e) + \cot(C_s)} \]

For tool \( P \), \( h_P = \frac{f}{\tan 30^\circ + \cot 8^\circ} \)

For tool \( Q \), \( h_Q = \frac{f}{\tan 15^\circ + \cot 8^\circ} \)

for same machining condition \( f_P = f_Q \)

Hence, \( h_P = \frac{\tan 15^\circ + \cot 8^\circ}{\tan 30^\circ + \cot 8^\circ} \)

Option (C) is correct.

We know that maximum possible clearance occurs between minimum shaft size and maximum hole size.
Maximum size of shaft = 25 + 0.040 = 25.040 mm
Minimum size of shaft = 25 - 0.100 = 24.99 mm
Maximum size of hole = 25 + 0.020 = 25.020 mm
Minimum size of hole = 25 - 0.000 = 25.00 mm

25.020 - 24.99 = 0.03 mm = 30 microns

Sol. 118
Option (A) is correct.

Given: NO20 GO2 X 45.0 Y 25.0 R 5.0
Here term X 45.0 Y 25.0 R 5.0 will produce circular motion because radius is consider in this term and GO2 will produce clockwise motion of the tool.

Sol. 119
Option (A) is correct.

In EDM, the thermal energy is employed to melt and vaporize tiny particles of work material by concentrating the heat energy on a small area of the work-piece.

Sol. 120
Option (D) is correct.
Given: \( I = 5000 \ A, R = 200 \ \mu \Omega = 200 \times 10^{-6} \ \Omega, \Delta t = 0.2 \ \text{second} \)
Heat generated, \( H_g = I^2(R \Delta t) = (5000)^2 \times 200 \times 10^{-6} \times 0.2 \)
\[ = 25 \times 10^6 \times 40 \times 10^{-6} = 1000 \ \text{Joule} \]

Sol. 121
Option (B) is correct.
Two streams of liquid metal which are not hot enough to fuse properly result into a casting defect, known as Misrun/cold shut.
It occurs due to insufficient fluidity of the molten metal.

Sol. 122
Option (C) is correct.
Gray cast iron is the most widely used of all cast irons. In fact, it is common to speak of gray cast iron just as cast iron.
It contains 3 to 4% C and 2.5 % Si.

Sol. 123
Option (B) is correct.

For hole size = 20.000 mm
Maximum hole size = 20.000 + 0.050 = 20.050 mm
Minimum hole size = 20.000 + 0.010 = 20.010

So, Hole tolerance = Maximum hole size - Minimum hole size
\[ = 20.050 - 20.010 = 0.040 \ \text{mm} \]

Gauge tolerance can be 10% of the hole tolerance (Given).
So, Gauge tolerance = 10% of 0.040
\[ = \frac{10}{100} \times 0.040 = 0.0040 \ \text{mm} \]

Size of Go Gauge = Minimum hole size + Gauge tolerance
\[ = 20.010 + 0.0040 = 20.014 \ \text{mm} \]

Size of NO-GO Gauge = Maximum hole size - Gauge tolerance
\[ = 20.050 - 0.004 = 20.046 \ \text{mm} \]

Sol. 124
Option (A) is correct.

Given: \( d = 10 \ \text{mm}, \ t = 3 \ \text{mm}, \ \tau_s = 400 \ \text{N/mm}^2, \ t_1 = 2 \ \text{mm}, \ p = 40\% = 0.4 \)
We know that, when shear is applied on the punch, the blanking force is given by,
\[ F_B = \pi dt \left(\frac{t \times p}{t_1}\right) \times \tau_s \]
\[ \text{Where } t \times p = \text{Punch travel} \]
Substitute the values, we get

\[ F_B = 3.14 \times 10 \times 3 \left( \frac{3 \times 0.4}{2} \right) \times 400 \]
\[ = 94.2 \times 0.6 \times 400 = 22.6 \text{ kN} \]

**Sol. 125**

Option (B) is correct

Given: \( D = 10 \text{ mm} \), \( t = 20 \text{ mm} \), \( N = 300 \text{ rpm} \), \( f = 0.2 \text{ mm/rev} \).

Point angle of drill, \( 2\alpha_p = 120^\circ \) \( \Rightarrow \alpha_p = 60^\circ \)

Drill over-travel = 2 mm

We know that, break through distance,

\[ A = \frac{D}{2\tan\alpha_p} = \frac{10}{2\tan 60^\circ} = 2.89 \text{ mm} \]

Total length travelled by the tool,

\[ L = t + A + 2 = 20 + 2.89 + 2 = 24.89 \text{ mm} \]

So, time for drilling,

\[ t = \frac{L}{f \cdot N} = \frac{24.89}{0.2 \times 300} = 0.415 \text{ min} \]
\[ = 0.415 \times 60 \text{ sec} = 24.9 \approx 25 \text{ sec} \]

**Sol. 126**

Option (D) is correct.

Given: Dimension of block = 200 \( \times \) 100 \( \times \) 10 mm

Shrinkage allowance, \( X = 1\% \)

We know that, since metal shrinks on solidification and contracts further on cooling to room temperature, linear dimensions of patterns are increased in respect of those of the finished casting to be obtained.

So,

\[ v_c = 200 \times 100 \times 10 = 2 \times 10^5 \text{ mm}^3 \]

Shrinkage allowance along length,

\[ S_L = L \cdot X = 200 \times 0.01 = 2 \text{ mm} \]

Shrinkage allowance along breadth,

\[ S_B = 100 \times 0.01 = 1 \text{ mm} \]

or Shrinkage allowance along height,

\[ S_H = 10 \times 0.01 = 0.1 \text{ mm} \]

Volume of pattern will be

\[ v_p = [(L + S_L) \cdot (B + S_B) \cdot (S + S_H)] \text{ mm}^3 \]
\[ = 202 \times 101 \times 10.01 \text{ mm}^3 = 2.06 \times 10^5 \text{ mm}^3 \]

So,

\[ \frac{\text{Volume of Pattern}}{\text{Volume of Casting}} v_p \frac{10^6}{2 \times 10^5} = 1.03 \]

**Sol. 127**

Option (C) is correct

\[ y \text{-axis} \]

\[ P_2(10,15) \quad Q(15,15) \quad P_1(15,10) \]

\[ X \text{-axis} \]

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From the figure, the centre of circular arc with radius 5 is
\[ [15, (10 + 5)] = [15, 15] \quad \text{From point } P_1 \]
\[ [(10 + 5), 15] = [15, 15] \quad \text{From point } P_2 \]

Sol. 128

Option (B) is correct.

Given: \( V = 40 \text{ m/min}, \, d = 0.3 \text{ mm}, \, \alpha = 5^\circ, \, t = 1.5 \text{ mm}, \, F_c = 900 \text{ N}, \)
\( F_t = 450 \text{ N} \)

We know from the merchant’s analysis

\[
\mu = \frac{F}{N} = \frac{F_c \sin \alpha + F_t \cos \alpha}{F_c \cos \alpha - F_t \sin \alpha}
\]

Where \( F = \) Frictional resistance of the tool acting on the chip.
\( N = \) Force at the tool chip interface acting normal to the cutting face of the tool.

\[
\mu = \frac{900 \tan 5^\circ + 450}{900 - 450 \tan 5^\circ} = \frac{528.74}{860.63} = 0.614
\]

Now, Frictional angle,
\[
\beta = \tan^{-1} \mu = \tan^{-1}(0.614) = 31.5^\circ
\]

Sol. 129

Option (B) is correct.

Given: \( t_s = 25 \text{ mm}, \, t_r = 20 \text{ mm}, \, D = 600 \text{ mm}, \, N = 100 \text{ rpm} \)

Let, Angle substended by the deformation zone at the roll centre is \( \theta \) in radian
and it is given by the relation.

\[
\theta(\text{radian}) = \sqrt{\frac{t_s - t_r}{R}} = \sqrt{\frac{25 - 20}{300}} = \sqrt{0.0166} = 0.129 \text{ radian}
\]

Roll strip contact length is
\[
L = \theta \times R = \text{Angle} = \frac{\text{Arc}}{R}
\]
\[
L = 0.129 \times 300 = 38.73 \text{ mm} = 39 \text{ mm}
\]

Sol. 130

Option (C) is correct.

Given: \( VT^n = C \)

Let \( V \) and \( T \) are the initial cutting speed & tool life respectively.

Case (I) : The relation between cutting speed and tool life is,
\[
VT^n = C \quad \text{...(i)}
\]

Case (II) : In this case doubling the cutting speed and tool life reduces to \( \frac{1}{8} \)th of original values.

So,
\[
(2V) \times (\frac{T}{T^n})^n = C \quad \text{...(ii)}
\]

On dividing equation (i) by equation (ii),
\[
\frac{VT^n}{2V(\frac{T}{T^n})^n} = 1
\]
\[
T^n = 2(\frac{T}{T^n})^n
\]
\[
\frac{1}{2} = (\frac{1}{8})^n
\]
\[
(\frac{1}{2})^n = (\frac{1}{8})^n
\]
Compare powers both the sides,

\[ 1 = 3^n \quad \Rightarrow n = \frac{1}{3} \]

Option (B) is correct.

<table>
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<th>Instrument</th>
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<td>5. Sine bar</td>
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<tr>
<td>Q. Flatness error of a surface</td>
<td>2. Optical Interferometer</td>
</tr>
<tr>
<td>R. Alignment error of a machine slideway</td>
<td>1. Auto collimator</td>
</tr>
<tr>
<td>S. Profile of a cam</td>
<td>6. Tool maker's Microscope</td>
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</table>

So, correct pairs are, P-5, Q-2, R-1, S-6

Option (B) is correct.

<table>
<thead>
<tr>
<th>Product</th>
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<tr>
<td>Q. Packaging containers for Liquid</td>
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<tr>
<td>R. Long structural shapes</td>
<td>2. Hot rolling</td>
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<tr>
<td>S. Collapsible tubes</td>
<td>3. Impact extrusion</td>
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</table>

So, correct pairs are, P-4 Q-5 R-2 S-3

Option (D) is correct.

<table>
<thead>
<tr>
<th>Operation</th>
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<td>Q. Die sinking</td>
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<td>R. Fine hole drilling in thin sheets</td>
<td>5. Laser beam Machining</td>
</tr>
<tr>
<td>S. Tool sharpening</td>
<td>6. Electrochemical Grinding</td>
</tr>
</tbody>
</table>

So, Correct pairs are, P-2, Q-3, R-5, S-6

Option (C) is correct.

<table>
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<tr>
<th>Process</th>
<th>Characteristics</th>
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<tr>
<td>P. Tempering</td>
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</tr>
<tr>
<td>Q. Austempering</td>
<td>1. Austenite is converted into bainite</td>
</tr>
<tr>
<td>R. Martempering</td>
<td>2. Austenite is converted into martensite</td>
</tr>
</tbody>
</table>

So, correct pairs are, P-4, Q-1, R-2

Option (D) is correct.

Steel can be cooled from the high temperature region at a rate so high that the austenite does not have sufficient time to decompose into sorbite or troostite. In this case the austenite is transformed into martensite. Martensite is ferromagnetic, very hard & brittle.
So hardness is increasing in the order,
Sphero → Coarse Pearlite → Fine Pearlite → Martensite

**Sol. 136**

Option (C) is correct.

Permeability or porosity of the moulding sand is the measure of its ability to permit air to flow through it.

So, hardness of green sand mould increases by restricting the air permitted in the sand i.e. decrease its permeability.

**Sol. 137**

Option (B) is correct.

In OAW, Acetylene \((C_2H_2)\) produces higher temperature (in the range of \(3200^\circ C\)) than other gases, (which produce a flame temperature in the range of \(2500^\circ C\)) because it contains more available carbon and releases heat when its components \((C \& H)\) dissociate to combine with \(O_2\) and burn.

**Sol. 138**

Option (C) is correct.

Cold forming or cold working can be defined as the plastic deforming of metals and alloys under conditions of temperature and strain rate.

Theoretically, the working temperature for cold working is below the recrystallization temperature of the metal/alloy (which is about one-half the absolute melting temperature.)

**Sol. 139**

Option (D) is correct.

Quality screw threads are produced by only thread casting.

Quality screw threads are made by die-casting and permanent mould casting are very accurate and of high finish, if properly made.

**Sol. 140**

Option (D) is correct.

In EDM, the thermal energy is employed to melt and vaporize tiny particles of work-material by concentrating the heat energy on a small area of the work-piece.

A powerful spark, such as at the terminals of an automobile battery, will cause pitting or erosion of the metal at both anode & cathode. No force occurs between tool & work.

**Sol. 141**

Option (B) is correct.

Since 25 mm lies in the diameter step 18 & 30 mm, therefore the geometric mean diameter,

\[
D = \sqrt{18 \times 30} = 23.24 \text{ mm}
\]

We know that standard tolerance unit,

\[
i (\text{microns}) = 0.45 \sqrt{D} + 0.001D
\]

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\[ i = 0.45 \sqrt[3]{23.24} + 0.001 \times 23.24 = 1.31 \text{ microns} \]

Standard tolerance for hole ‘h’ of grade IT 7,
\[ \text{IT 7} = 16i = 16 \times 1.31 = 20.96 \text{ microns} \]

Hence, lower limit for shaft = Upper limit of shaft – Tolerance
\[ = 25 - 20.96 \times 10^{-3} \text{ mm} = 24.979 \text{ mm} \]

**Sol. 142**

Option (B) is correct.

Hardness is greatly depend on the carbon content present in the steel.

Cyaniding is case-hardening with powered potassium cyanide or potassium ferrocyanide mixed with potassium bichromate, substituted for carbon. Cyaniding produces a thin but very hard case in a very short time.

**Sol. 143**

Option (B) is correct.

Given : \( q = 0.97 \times 10^6 \text{ s/m}^2 \), \( D = 200 \text{ mm} = 0.2 \text{ m} \)

From the cane’s relation solidification time,
\[ T = q \left( \frac{V}{A} \right)^2 \]

Volume
\[ V = \frac{4}{3} \pi R^3 \]

Surface Area
\[ A = 4 \pi R^2 \]

So,
\[ T = 0.97 \times 10^6 \left( \frac{4}{3} \pi R^3 \right)^2 = 0.97 \times 10^6 \left( \frac{R}{3} \right)^2 \]
\[ = \frac{0.97}{9} \times 10^6 \left( \frac{0.2}{2} \right)^2 = 1078 \text{ sec} \]

**Sol. 144**

Option (C) is correct.

Given : \( d = 100 \text{ mm} \), \( h = 100 \text{ mm} \), \( R = 0.4 \text{ mm} \)

Here we see that \( d > 20r \)

If \( d \geq 20r \), blank diameter in cup drawing is given by,
\[ D = \sqrt{d^2 + 4dh} \]

Where,
\[ D = \text{diameter of flat blank} \]
\[ d = \text{diameter of finished shell} \]
\[ h = \text{height of finished shell} \]

Substitute the values, we get
\[ D = \sqrt{(100)^2 + 4 \times 100 \times 100} = \sqrt{50000} \]
\[ = 223.61 \text{ mm} \approx 224 \text{ mm} \]

**Sol. 145**

Option (B) is correct.

Given : \( d_i = 100 \text{ mm} \), \( d_l = 50 \text{ mm} \), \( T = 700 \degree \text{C} \), \( k = 250 \text{ MPa} \)

Extrusion force is given by,
\[ F_e = k \ln \left( \frac{A_i}{A_f} \right) = k \frac{\pi}{4} d^2 \ln \left( \frac{\pi d^2}{4 d_f^2} \right) = k \frac{\pi}{4} d^2 \ln \left( \frac{d}{d_f} \right)^2 \]

Substitute the values, we get

\[ F_e = 250 \times \frac{\pi}{4} (0.1)^2 \ln \left( \frac{0.1}{0.05} \right)^2 \]

\[ = 1.96 \ln 4 = 2.717 \text{ MN} \approx 2.72 \text{ MN} \]

Sol. 146
Option (A) is correct.

Given: \( D = 20 \text{ mm}, t = 2 \text{ mm}, \) Punch or diameter clearance = 3%

Required punch diameter will be,

\[ d = D - 2 \times (3\% \text{ of thickness}) \]

\[ = 20 - 2 \times \frac{3}{100} \times 2 = 19.88 \text{ mm} \]

Sol. 147
Option (A) is correct.

Given: For case (I):
\( N = 50 \text{ rpm}, f = 0.25 \text{ mm/rev.}, d = 1 \text{ mm} \)

Number of cutting tools = 10
Number of components produce = 500

So, Velocity
\[ V_1 = N \times f = 50 \times 0.25 \]

= 12.5 mm/ min.

For case (II):
\( N = 80 \text{ rpm}, f = 0.25 \text{ mm/rev.}, d = 1 \text{ mm} \)

Number of cutting tools, = 10
Number of components produce = 122

So, Velocity
\[ V_2 = N \times f = 80 \times 0.25 = 20 \text{ mm/ min} \]

From the tool life equation between cutting speed & tool life, \( VT^n = C \),

\[ V_1T_1^n = V_2T_2^n \]

where \( C = \text{constant} \) \( ...(i) \)

Tool life = Number of components produce \( \times \) Tool constant

For case (I),
\[ T_1 = 500k \]

For case (II),
\[ T_2 = 122k \]

From equation (i),

\[ 12.5 \times (500k)^n = 20 \times (122k)^n \]

\[ \frac{(500k)^n}{(122k)^n} = \frac{20}{12.5} = 1.6 \]

Taking log both the sides,

\[ n \ln \left( \frac{500}{122} \right) = \ln (1.6) \]

\[ n(1.41) = 0.47 \]

\[ n = 0.333 \]

Let the no. of components produced be \( n_1 \) by one cutting tool at 60 r.p.m. So, tool life,
\[ T_3 = n_1k \]

Velocity, \( V_3 = 60 \times 0.25 = 15 \text{ mm/ min} \)

feed remains same

Now, tool life \( T_1’ \) if only 1 component is used,
\[ T_1’ = \frac{500k}{10} \]
So, \( V_1(T_1)^n = V_3(T_3)^n \)
Substitute the values, we get
\[
V_1 \left( \frac{500k}{10} \right)^n = 15(n_1k)^n \\
\left( \frac{50k}{n_1k} \right) = 12.5 \\
\frac{50}{n_1} = (1.2)^{1/0.33} = 1.73 \\
n_1 = \frac{50}{1.73} = 28.90 \approx 29
\]
Sol. 148
Option (B) is correct.
Given : \( p = 2 \text{ mm}, d = 14.701 \text{ mm} \)
We know that, in case of ISO metric type threads,
\[ 2\theta = 60^\circ \Rightarrow \theta = 30^\circ \]
And in case of threads, always rollers are used.
For best size of rollers, \( d = \frac{p}{2} \sec \theta = \frac{2}{2} \sec 30^\circ = 1.155 \text{ mm} \)
Hence, rollers of 1.155 mm diameter \((1.155\phi)\) is used.
Sol. 149
Option (D) is correct.
The total number of straight fringes that can be observed on both slip gauges is 13.
Sol. 150
Option (A) is correct.
Given : \( P = 35.00 \pm 0.08 \text{ mm}, Q = 12.00 \pm 0.02 \text{ mm} \)
\[
R = 13.00^+0.04_-0.02 \text{ mm} = 13.01 \pm 0.03 \text{ mm}
\]
From the given figure, we can say
\[
P = Q + W + R \\
W = P - (Q + R) \\
= (35.00 \pm 0.08) - [(12.00 \pm 0.02) + (13.01 \pm 0.03)] \\
= (35 - 12 - 13.01) + 0.08 - 0.02 - 0.03 \\
= 9.99^+0.03_-0.03 = 9.99 \pm 0.03 \text{ mm}
\]
Sol. 151
Option (D) is correct.

<table>
<thead>
<tr>
<th>Working material</th>
<th>Type of Joining</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Aluminium</td>
<td>5. Gas Tungsten Arc Welding</td>
</tr>
<tr>
<td>Q. Die steel</td>
<td>4. Atomic Hydrogen Welding</td>
</tr>
<tr>
<td>R. Copper Wire</td>
<td>2. Soldering</td>
</tr>
<tr>
<td>S. Titanium sheet</td>
<td>6. Laser Beam Welding</td>
</tr>
</tbody>
</table>

So, correct pairs are, P - 5, Q - 4, R - 2, S - 6
Sol. 152
Option (A) is correct
Given : \( N = 200 \text{ rpm}, f = 0.25 \text{ mm/revolution}, d = 0.4 \text{ mm}, \alpha = 10^\circ, \)
\( \phi = 27.75^\circ \)
Uncut chip thickness, \( t = f(\text{feed, mm/rev.}) = 0.25 \text{ mm/rev.} \)
Chip thickness ratio is given by,
\[ r = \frac{t}{t_c} = \frac{\sin \phi}{\cos(\phi - \alpha)} \]

Where,
\[ t_c = \text{thickness of the produced chip.} \]
So,
\[ t_c = \frac{t \times \cos(\phi - \alpha)}{\sin \phi} = \frac{0.25 \times \cos(27.75 - 10)}{\sin(27.75)} = 0.511 \text{ mm} \]

Alternate :
We also find the value of \( t_c \) by the general relation,
\[ \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} \]
where
\[ r = \frac{t}{t_c} \]

Sol. 153
Option (D) is correct.
We know that angle of friction,
\[ \beta = \tan^{-1} \mu \]
or,
\[ \mu = \tan \beta \]
For merchant and earnest circle, the relation between rake angle (\( \alpha \)), shear angle (\( \phi \)) and friction angle (\( \beta \)) is given by,
\[ 2\phi + \beta - \alpha = 90^\circ \]
\[ \beta = 90^\circ + \alpha - 2\phi \]
\[ = 90^\circ + 10^\circ - 2 \times 27.75^\circ = 44.5^\circ \]
Now, from equation (i),
\[ \mu = \tan(44.5^\circ) = 0.98 \]

Sol. 154
Option (D) is correct.
A lead-screw with half nuts in a lathe, free to rotate in both directions had Acme threads. When it is used in conjunction with a split nut, as on the lead screw of a lathe, the tapered sides of the threads facilitate ready engagement and disengagement of the halves of the nut when required.

Sol. 155
Option (C) is correct.
From the pouring basin, the molten metal is transported down into the mould cavity by means of the sprue or downgate. It is a vertical channel that connects the pouring basin with runners and gates.

Sol. 156
Option (D) is correct.
Hot rolling of metal means working of metals when heated sufficiently (above the recrystallizing temperature) to make them plastic and easily worked.

Sol. 157
Option (B) is correct.
GTAW is also called as Tungsten Inert Gas welding (TIG). The electrode is non consumable since its melting point is about 3400°C.

Sol. 158
Option (B) is correct.
In trepanning, the cutting tool produces a hole by removing a disk-shaped piece (core), usually from flat plates. A hole is produced without reducing all the material removed to chips, as is the case in drilling. Such drills are used in deep-hole drilling machines for making large hollow shafts, long machine tool spindles etc.
Sol. 159 Option (B) is correct.
Because each abrasive grain usually removes only a very small amount of material at a time, high rates of material removal can be achieved only if a large number of these grains act together. This is done by using bonded abrasives, typically in the form of a grinding wheel. The abrasive grains are held together by a bonding material which acts as supporting posts or brace between the grains and also increases the hardness of the grinding wheel.

Sol. 160 Option (D) is correct.
Centrifugal casting is the method of producing castings by pouring the molten metal into a rapidly rotating mould. Because of density differences, lighter elements such as dross, impurities and pieces of the refractory lining tend to collect at the centre of the casting. This results in better mould filling and a casting with a denser grain structure, which is virtually free of porosity.

Sol. 161 Option (B) is correct.
Work hardening is when a metal is strained beyond the yield. An increasing stress is required to produce additional plastic deformation and the metal apparently becomes stronger and more difficult to deform. Work hardening reduces ductility, which increases the chances of brittle failure.

Sol. 162 Option (B) is correct.
A carburising flame is obtained when an excess of acetylene is supplied than which is theoretically required. This excess amount of acetylene increases the temperature of the flame. So, the temperature of a carburising flame in gas welding is higher than that of a neutral or an oxidising flame.

Sol. 163 Option (C) is correct.
The punch size is obtained by subtracting the clearance from the die-opening size. Clearance is the gap between the punch and the die. (From the figure)

Sol. 164 Option (B) is correct.
When machining ductile materials, conditions of high local temperature and extreme pressure in the cutting zone and also high friction in the tool chip interface, may cause the work material to adhere or weld to the cutting edge of the tool forming the built-up edge. Low-cutting speed contributes to the formation of the built-up edge. Increasing the cutting speed, increasing the rake angle and using a cutting fluid contribute to the reduction or elimination of built-up edge.
Sol. 165 Option (B) is correct.

Given: \( t = 25 \text{ mm}, \quad N = 300 \text{ rpm}, \quad f = 0.25 \text{ mm/rev} \)

We know, time taken to drill a hole,

\[
T = \frac{t}{N} = \frac{25}{0.25 \times 300 \times 60} = \frac{25}{0.25 \times 5} = 20 \text{ sec}
\]

Sol. 166 Option (C) is correct.

Since metal shrinks on solidification and contracts further on cooling to room temperature, linear dimensions of patterns are increased in respect of those of the finished casting to be obtained. This is called the “shrinkage allowance”.

So, the temperature of solid phase drops from freezing to room temperature.

Sol. 167 Option (B) is correct.

The blanking force is given by the relation,

\[ F_b = \tau \times d \times t \]

Where, \( \tau = \) shear strength of material.

Sol. 168 Option (D) is correct.

In ECM, the principal of electrolysis is used to remove metal from the workpiece. The material removal is due to ion displacement. The principal of electrolysis is based on Faraday’s law of electrolysis.

Sol. 169 Option (C) is correct.

Electric arc welding is “a welding process wherein coalescence is produced by heating with an arc, with or without the use of filler metals. No filler metal is used in butt weld. So, when the plate thickness changes, welding is achieved by changing the electrode size.

Sol. 170 Option (A) is correct.

Allowance is an intentional difference between the maximum material limits of mating parts. For shaft, the maximum material limit will be its high limit and for hole, it will be its low limit. So, allowance refers to maximum clearance between shaft and hole.

Sol. 171 Option (A) is correct.

Given: \( H_g = 175 \text{ mm}, \quad A_g = 200 \text{ mm}^2, \quad v_m = 10^6 \text{ mm}^3, \quad g = 10 \text{ m/ sec}^2 = 10^4 \text{ mm/sec}^2 \)

Time required to fill the mould is given by,

\[
t = \frac{v_m}{A_g \sqrt{2gH_g}} = \frac{10^6}{200 \times \sqrt{2} \times 10^4 \times 175} = 2.67 \text{ sec}
\]

Sol. 172 Option (B) is correct.

The maximum reduction taken per pass in wire drawing, is limited by the strength of the deformed product. The exit end of the drawn rod will fracture at the die exit, when

\[
\frac{\sigma_a}{\sigma_0} = 1, \text{ if there is no strain hardening.}
\]

For zero back stress, the condition will be,

\[
\frac{1 + B}{B} \left[ 1 - (1 - RA)^B \right] = 1 \tag{i}
\]

In wire drawing, co-efficient of friction of the order 0.1 are usually obtained.

Now, \( B = \mu \cot \alpha \)
\[ \mu = 0.1 \text{ and } \alpha = 6^\circ \]
\[ B = \mu \cot 6^\circ = 0.9515 \]

From equation (i),
\[ 1 - (1 - RA)^B = \frac{B}{1 + B} = \frac{0.9515}{1 + 0.9515} = 0.49 \]
\[ (1 - RA)^B = 0.51 \]
\[ 1 - RA = (0.51)^{\frac{1}{B}} = 0.49 \]
\[ RA = 1 - 0.49 = 0.51 \]

The approximate option is (B).

**Sol. 173**
Option (C) is correct.

Given :
\[ \alpha = 10^\circ, \quad r = 0.4 \]

Shear angle
\[ \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} = \frac{0.4 \cos 10^\circ}{1 - 0.4 \sin 10^\circ} = 0.4233 \]
\[ \tan \phi = 0.4233 \]
\[ \phi = \tan^{-1}(0.4233) = 22.94^\circ \]

**Sol. 174**
Option (A) is correct.

Given :  
\[ I = 15000 \text{ A, } \quad t = 0.25 \text{ sec, } \quad R = 0.0001 \Omega \]

The heat generated to form the weld is,
\[ Q = I^2 R t = (15000)^2 \times 0.0001 \times 0.25 = 5625 \text{ W \cdot sec} \]

**Sol. 175**
Option (C) is correct.

According to 3-2-1 principle, only the minimum locating points should be used to secure location of the work piece in any one plane.

(A) The workpiece is resting on three pins A, B, C which are inserted in the base of fixed body.

The workpiece cannot rotate about the axis XX and YY and also it cannot move downward. In this case, the five degrees of freedom have been arrested.

(B) Two more pins D and E are inserted in the fixed body, in a plane perpendicular to the plane containing, the pins A, B and C. Now the workpiece cannot rotate about the Z-axis and also it cannot move towards the left. Hence the addition of pins D and E restrict three more degrees of freedom.

(C) Another pin F in the second vertical face of the fixed body, arrests degree of freedom 9.

**Sol. 176**
Option (B) is correct.

Given :  
Initial point (5, 4), Final point (7, 2), Centre (5, 4)

So, the G, N codes for this motion are N010 GO2 X 7.0 Y 2.0 15.0 J 2.0

where,
\[ \text{GO2} \rightarrow \text{Clockwise circular interpolation} \]
\[ X 7.0 Y 2.0 \rightarrow \text{Final point} \]
\[ 15.0 J 2.0 \rightarrow \text{Centre point} \]

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