GATE 2026 Production and Industrial Engineering Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**100	**Total Questions :**65

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each GATE 2024 paper consists of a total of 100 marks. The examination is divided into two sections – General Aptitude (GA) and the Candidate's Selected Subjects. General Aptitude carries 15 marks, while the remaining 85 marks are dedicated to the candidate's chosen test paper syllabus.
2. GATE 2024 will be conducted in English as a Computer Based Test (CBT) at select centres in select cities. The duration of the examination is 3 hours.
3. MCQs carry 1 mark or 2 marks.
4. For a wrong answer in a 1-mark MCQ, 1/3 mark is deducted.
5. For a wrong answer in a 2-mark MCQ, 2/3 mark is deducted.
6. No negative marking for wrong answers in MSQ or NAT questions.

1. A through hole of 10 mm diameter is to be drilled in a mild steel plate of 30 mm thickness. The selected spindle speed and feed for drilling hole are 600 revolutions per minute (RPM) and 0.3 mm/rev, respectively. Take initial approach and breakthrough distances as 3 mm each. The total time (in minute) for drilling one hole is __________. (Rounded off to two decimal places)

Correct Answer: 0.20

Solution:

Step 1: Understanding the Question:
The problem asks to calculate the total time required to drill a through hole in a steel plate. We are given all the necessary parameters: plate thickness, drill speed, feed rate, and additional distances for approach and breakthrough.

Step 2: Key Formula or Approach:
The total time for drilling (T_m) is calculated by dividing the total length the drill has to travel (L) by the feed rate of the drill (f_m).

$$T_m = \frac{L}{f_m}$$

Where:

- Total drilling length, $L = \text{Plate Thickness} + \text{Approach Distance} + \text{Breakthrough Distance}$

- Feed rate, f_m = Feed per revolution$(f) \times$ Spindle Speed(N)

Step 3: Detailed Explanation:

1. Identify the given data:

- Plate Thickness, $t = 30$ mm
- Spindle Speed, $N = 600$ RPM (revolutions per minute)
- Feed, $f = 0.3$ mm/rev
- Approach Distance, $A = 3$ mm
- Breakthrough Distance, $B = 3$ mm

2. Calculate the total drilling length (L):

$$L = t + A + B$$

$$L = 30\,\text{mm} + 3\,\text{mm} + 3\,\text{mm} = 36\,\text{mm}$$

3. Calculate the feed rate (f_m) in mm per minute:

$$f_m = f \times N$$

$$f_m = 0.3\,\frac{\text{mm}}{\text{rev}} \times 600\,\frac{\text{rev}}{\text{min}} = 180\,\frac{\text{mm}}{\text{min}}$$

4. Calculate the total drilling time (T_m):

$$T_m = \frac{L}{f_m} = \frac{36\,\text{mm}}{180\,\text{mm/min}} = 0.2\,\text{minutes}$$

Step 4: Final Answer:

Rounding off to two decimal places as requested, the total time is 0.20 minutes.

> **Quick Tip**
>
> In drilling time calculations, never forget to include the approach and breakthrough distances to the plate thickness to find the total length the drill must travel. The time is simply total distance divided by speed (feed rate).

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2. In a cold rolling process without front and back tensions, the required minimum coefficient of friction is 0.04. Assume large rolls. If the draft is doubled and roll diameters are halved, then the required minimum coefficient of friction is ________. (Rounded off to two decimal places)

Correct Answer: 0.08

Solution:

Step 1: Understanding the Question:
The question describes a cold rolling process and asks how the required minimum coefficient of friction changes when the draft and roll diameter are altered.

Step 2: Key Formula or Approach:
In a rolling process, for the material to be drawn into the rolls, the bite angle (α) must be less than or equal to the friction angle (λ). The minimum required coefficient of friction (μ) corresponds to the limiting condition where $\mu = \tan(\alpha)$. For small angles, $\tan(\alpha) \approx \alpha$. The bite angle is related to the draft (Δh) and the roll radius (R) by the formula:

$$\alpha \approx \sqrt{\frac{\Delta h}{R}}$$

Therefore, the required minimum coefficient of friction is given by:

$$\mu = \sqrt{\frac{\Delta h}{R}}$$

Step 3: Detailed Explanation:
Let the initial conditions be denoted by subscript 1 and the final conditions by subscript 2. **1. Initial Condition:**

$$\mu_1 = 0.04$$

$$\mu_1 = \sqrt{\frac{\Delta h_1}{R_1}}$$

So, $0.04 = \sqrt{\frac{\Delta h_1}{R_1}}$.
2. Final Condition: The problem states:

- The draft is doubled: $\Delta h_2 = 2\Delta h_1$
- The roll diameters are halved, which means the roll radii are also halved: $R_2 = \frac{R_1}{2}$

Now, we calculate the new required minimum coefficient of friction, μ_2:

$$\mu_2 = \sqrt{\frac{\Delta h_2}{R_2}}$$

Substitute the new values in terms of the initial ones:

$$\mu_2 = \sqrt{\frac{2\Delta h_1}{R_1/2}} = \sqrt{4 \times \frac{\Delta h_1}{R_1}}$$

$$\mu_2 = 2 \times \sqrt{\frac{\Delta h_1}{R_1}}$$

Since $\mu_1 = \sqrt{\frac{\Delta h_1}{R_1}}$, we can write:

$$\mu_2 = 2 \times \mu_1$$

$$\mu_2 = 2 \times 0.04 = 0.08$$

Step 4: Final Answer:
The required minimum coefficient of friction is 0.08.

Quick Tip

For rolling problems, remember the relationship $\mu_{min} = \sqrt{\Delta h/R}$. This allows you to quickly analyze how changes in draft (Δh) or roll radius (R) affect the required friction.

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3. Which one of the following casting defects is caused due to the supply of the molten metal through two gates?

(A) Cold shut
(B) Rat tail
(C) Pin hole
(D) Shift

Correct Answer: (A) Cold shut

Solution:

Step 1: Understanding the Question:
The question asks to identify a specific casting defect that is typically caused by having multiple gates for molten metal entry into the mold cavity.

Step 2: Detailed Explanation:
Let's analyze each defect:

- **(A) Cold shut:** This defect occurs when two streams of molten metal, often flowing from different directions (e.g., from two separate gates), meet within the mold cavity but are too cool to fuse together completely. This results in a discontinuity or a weak spot in the casting that looks like a crack or a seam. This perfectly matches the condition described in the question.
- **(B) Rat tail:** This is a surface defect characterized by an irregular line on the casting surface. It is caused by the compressive failure of the sand at the mold surface due to the expansion of the sand when heated by the molten metal. It is related to sand properties, not the number of gates.
- **(C) Pin hole:** These are small gas cavities located on or just below the surface of the casting. They are caused by the evolution of dissolved gases (like hydrogen) from the molten metal as it cools and solidifies. This is related to the melting practice and gas content, not the gating system design.
- **(D) Shift:** This defect is a mismatch of the top (cope) and bottom (drag) halves of the casting. It is caused by the misalignment of the two halves of the mold, often due to worn-out flask pins or incorrect assembly. It is a molding error, not a flow-related defect.

Step 3: Final Answer:
The defect directly associated with the meeting of two streams of molten metal that have cooled and fail to fuse is a cold shut. Using two gates increases the likelihood of this defect if

the pouring temperature and gating design are not optimal.

Quick Tip

Associate casting defects with their root causes: "Cold" in cold shut refers to the metal streams being too cold to fuse. "Gas" defects (like pin holes, blow holes) are from trapped gases. "Sand" defects (like rat tails, scabs) are from mold sand issues. "Shape" defects (like shift, mismatch) are from mold alignment problems.

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4. The relationship between the hoop stress σ_1 and the longitudinal stress σ_2 of a closed cylindrical thin-walled pressure vessel is

(A) $\sigma_1 = 2\sigma_2$
(B) $\sigma_1 = \frac{1}{3}\sigma_2$
(C) $\sigma_1 = \sigma_2$
(D) $\sigma_1 = \frac{\sigma_2}{2}$

Correct Answer: (A) $\sigma_1 = 2\sigma_2$

Solution:

Step 1: Understanding the Question:
The question asks for the fundamental relationship between the two principal stresses—hoop stress and longitudinal stress—in a thin-walled cylindrical pressure vessel subjected to internal pressure.

Step 2: Key Formula or Approach:
We need to recall the standard formulas for hoop stress (σ_1) and longitudinal stress (σ_2) derived from the equilibrium of forces in a thin-walled cylinder. Let p be the internal pressure, D be the internal diameter, and t be the wall thickness.

- The formula for hoop (or circumferential) stress is: $\sigma_1 = \frac{pD}{2t}$
- The formula for longitudinal (or axial) stress is: $\sigma_2 = \frac{pD}{4t}$

Step 3: Detailed Explanation:
Let's compare the two formulas directly.

$$\sigma_1 = \frac{pD}{2t}$$

$$\sigma_2 = \frac{pD}{4t}$$

We can rewrite the expression for σ_1 in terms of σ_2:

$$\sigma_1 = 2 \times \left(\frac{pD}{4t}\right)$$

Since $\sigma_2 = \frac{pD}{4t}$, we can substitute this into the equation:

$$\sigma_1 = 2\sigma_2$$

Step 4: Final Answer:
The hoop stress in a thin-walled cylindrical pressure vessel is exactly twice the longitudinal stress. This is a fundamental result in the mechanics of materials.

Quick Tip

A simple way to remember the relationship is to think about how a cylinder would fail. It's more likely to split open along its length (due to hoop stress) than to be pulled apart at its ends (due to longitudinal stress). This implies that the hoop stress is the larger of the two. Specifically, Hoop Stress = 2 × Longitudinal Stress. For a thin-walled sphere, the stress is uniform in all directions and equals the longitudinal stress of a cylinder ($pD/4t$).
