MADE EASY

India's Best Institute for IES, GATE & PSUs

Questions to be Challenged in

GATE 2020

Mechanical Engineering

www.madeeasy.in

Corporate Office: 44-A/1, Kalu Sarai, New Delhi - 110016 | **Ph:** 011-45124612, 9958995830

Delhi | Hyderabad | Noida | Bhopal | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

Date of Exam : 01/02/2020 (Forenoon)

Q.15 A sheet metal with a stock hardness of 250 HRC has to be sheared using a punch and a die having a clearance of 1 mm between them. If the stock hardness of the sheet metal increases to 400 HRC, the clearance between the punch and the die should be________ mm.

Ans. (1.26)

Tensile strength ∝ Hardness number

∴ Shear strength = 0.5 tensile strength (Tresca theory)

= 0.577 tensile strength (Von mises theory)

Shear strength ∝ Hardness number

and clearance, $C = 0.0032t\sqrt{\tau}$

$$C \propto \sqrt{\text{Hardness number}}$$

$$\frac{C_2}{C_1} = \sqrt{\frac{(\text{Hardness number})_2}{(\text{Hardness number})_1}}$$

or $C_2 = 1 \times \sqrt{\frac{400}{250}} = 1.265 \text{ mm}$

GATE Ans. Key (1 to 1)

Clearance is sheet metal operation (punching and blanking) depends on two things,

1. Material property that is ultimate shear strength of the material and
2. The thickness of the sheet.

In this question hardness is changing from 250 to 400. In the lecture of IIT Kharagpur, professor R N Ghosh (Lecture 6 and module 6) clearly mentioned the relationship between hardness and strength. They are proportional. And clearance is proportional to square root of ultimate shear strength of the material so if hardness changes from 200 to 400 then clearance must be changed. It cannot remain same. Reference given below:

Module 6: Experimental Tools and Techniques II

Lecture 6: Experimental Tools and Techniques II

"Both BHN and VHN use the similar concept for the measurement of hardness. Therefore for most materials the hardness values are nearly the same up to 500BHN (approximately). Since indentation hardness measures the resistance to deformation it has a direct correlation with tensile strength of the material. The hardness number is approximately 3 times the UTS in MPa. (BHN = VHN = 3). Measurement of hardness is extremely simple and easy. It does not need elaborate sample preparation or machining. A flat surface is good enough. Only VHN needs a little better surface finish with fine emery paper. Hardness measurements using these three scales are very popular for engineering applications. It (Rockwell and VHN) is nearly a non-destructive method of estimating the strength of a material. Whatever technique you use for hardness measurement there are standard conversion tables to help you convert hardness measured on one scale to another".

End of Solution

Q.36 A steel part with surface area of 125 cm^2 is to be chrome coaled through an electroplating process using chromium acid sulphate as an electrolyte. An increasing current is applied to the part according to the following current time relation:

$$I = 12 + 0.2t$$

where, I = current (A) and t = time (minutes). The part is submerged in the plating solution for a duration of 20 minutes for plating purpose. Assuming the cathode efficiency of chromium to be 15% and the plating constant of chromium acid sulphate to be 2.50×10^{-2} mm^3/A·s, the resulting coating thickness on the part surface is ________ μm (round off to one decimal place).

Ans. (5.0)

$$I = 12 + 0.2t$$

After time, 't', Next infinitly small time 'dt' let heat deposited 'dQ'.

$\therefore$ $$dQ = 2.50 \times 10^{-2} \text{ (mm}^3\text{/A.s)} \times 12 + 0.2t \times dt$$

As we have to convert this 's' to 'min'

$\therefore$ $$dQ = 2.50 \times 10^{-2} \text{ (mm}^3/A \times \text{min)} \times 12 + 0.2t \times dt$$

Considering cathode efficiency of 15%

$$dQ = 2.50 \times 10^{-2} \times 60 \times (12 + 0.2t)dt \times 0.15 \text{ mm}^3$$

$\therefore$ In 20 min, $$Q = \int dQ = \int_0^{20} 2.50 \times 10^{-2} \times 60 \times (12 + 0.2t)\, dt \times 0.15$$

$$= 0.225\left[12 + 0.1t^2\right]_0^{20} = 0.225\left[12 \times 20 + 0.1 \times 20^2\right] \text{mm}^3$$

$$= 63 \text{ mm}^3$$

As area os 125 cm^2

Plating thickness, $$t = \frac{63}{125 \times (100)} = 0.00504 \text{ mm} = 5.04 \text{ μm}$$

(As 1 cm^2 = 100 mm^2)

GATE Ans. Key (0 to 0)

In this question if we pass current then at least some plating will be there, it cannot be zero.

End of Solution

Q.43 Consider two cases as below.

Case 1: A company buys 1000 pieces per year of a certain part from vendor 'X'. The changeover time is 2 hours and the price is Rs. 10 per piece. The holding cost rate per part is 10% per year.

Case 2: For the same part, another vendor 'Y" offers a design where the changeover time is 6 minutes, with a price of Rs. 5 per piece, and a holding cost rate per part of 100% per year. The order size is 800 pieces per year from 'X' and 200 pieces per year from 'Y'.

Assume the cost of downtime as Rs. 200 per hour. The percentage reduction in the annual cost for Case 2, as compared to Case 1 is__________ (round off to 2 decimal places).

Ans. (5.32)

Given Data : 1000 pieces/year from 'X'.

Changeover time = 2 hrs.

Cost of downtime = Rs. 200/hour

So, Total cost of downtime

2×200 = Rs. 400/downtime

C = Rs. 10/piece

Holding cost, C_h = 10% of Rs. 10

C_h = Rs. 1/unit/year

So, total cost for Case I :

= Material Cost + Downtime Cost + Inventory Holding Cost

$$= 1000 \times 10 + (1 \times 400) + \frac{1000}{2} \times 1$$

Total cost for case I = Rs. 10,900/-

Case II : Order quantity 800 units from X and 200 units from Y.

For Y : Change overtime = 6 min. = 0.1 hour

Downtime cost = 0.1×200 = Rs. 20/-

Unit cost, C = Rs. 5/piece

Holding cost, C_h = 100% of unit cost = Rs. 5/-

So, total cost for case II :

= Cost for 'X' + Cost for 'Y'

$$= \left(800 \times 10 + 400 + \frac{800}{2} \times 1\right) + \left(200 \times 5 + 20 + \frac{200}{2} \times 5\right)$$

= 8000 + 800 + 1000 + 520

Total cost for case II = Rs. 10,320/-

So, percentage reduction in total cost of case II :

$$= \frac{10900 - 10320}{10900} \times 100 = \frac{580}{10900} \times 100 = 5.32\%$$

GATE Ans. Key (8.19 to 8.23)

End of Solution

Q.49 A slot of 25 mm x 25 mm Is lo be milled in a workpiece of 300 mm length using a side and face milling cutter of diameter 100 mm, width 25 mm and having 20 teeth. For a depth of cut 5 mm, feed per tooth 0.1 mm, cutting speed 35 m/min and approach and over travel distance of 5 mm each, the time required for milling the slot is_______ minutes (round off to one decimal place).

Ans. (8.1)

$$V = \pi DN$$
$$35 = \pi \times 0.100 \times N$$
$$N = \pi \times 111.408 \text{ rpm}$$
$$t = \frac{L + \frac{D}{2} + A + O}{fzN} = \frac{300 + \frac{100}{2} + 5 + 5}{0.1 \times 20 \times 111.408}$$
$$= 1.6157 \text{ min per pass}$$

For 25 mm cuts min 5 mm depth of cut 5 pass needed.

Total machining time = 8.078 min $\simeq$ 8.1 min

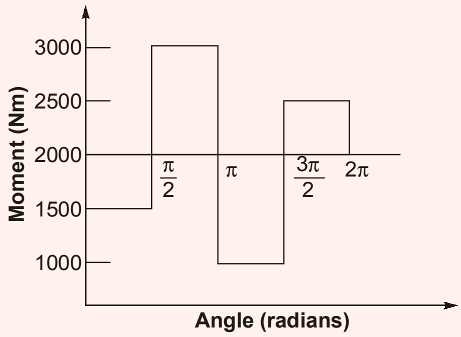
GATE Ans. Key (1.5 to 1.7)

In this milling time estimation question total time of making the slot is asking and only for one pass time is given. 25 mm width can be cut but depth of cut is 5 mm therefore for 25 depth, 5 passes are required. In this question examiner has given time for one pass but asking for cutting time of the slot, so it will be time of 5 passes.

End of Solution

Date of Exam : 01/02/2020 (Afternoon)

Q.29 The turning moment diagram of a flywheel fitted to a fictitious engine is shown in the figure.



The mean turning moment is 2000 Nm. The average engine speed is 1000 rpm. For fluctuation in the speed to be within ±2% of the average speed, the mass moment of inertia of the flywheel is _________ kgm^2.

Ans. (3.58)

$N = 1000$ rpm

$$\omega = \frac{2\pi \times 1000}{60} = 104.7195 \text{ rad/s}$$

$$\Delta E_{max} = \left(\pi - \frac{\pi}{2}\right) \cdot (3000 - 2000) = \left(\frac{\pi}{2} \times 1000\right) \text{J}$$

$$C_s = \pm 2\% = 4\% = 0.04$$

$$\Delta E_{max} = I \cdot \omega^2 \cdot C_s$$

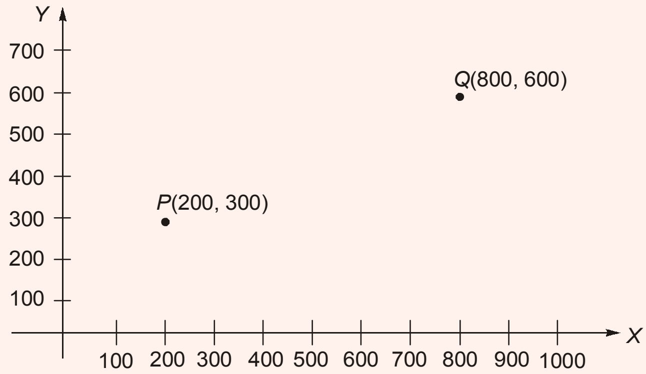
$$\frac{\pi}{2} \times 1000 = I \times (104.7195)^2 \times 0.04$$

$$I = \frac{1570.795}{(104.7195)^2 \times 0.04} = 3.58 \text{ kg-m}^2$$

GATE Ans. Key (745 to 755)

End of Solution

Q.34 A point P on a CNC controlled XY-stage is moved to another point 'Q' using the coordinate system shown in the figure below and rapid positioning command (G00).



A pair of stepping motors with maximum speed of 800 rpm, controlling both the X and Y motion of the stage, are directly coupled to a pair of lead screw, each with a uniform pitch of 0.5 mm. The time needed to position the point 'P' to the point 'Q' is _______ minutes. (round off to 2 decimal places).

Ans. (1.5)

N = 800 rpm, P = 0.5 mm/rev

$$V = N \times P = \text{rev/min} \times \text{mm/rev} = 400 \text{ mm/min}$$

$$\Delta t_x = \frac{600}{400} = 1.5 \text{ min}$$

$$\Delta t_y = \frac{300}{400} = 0.75 \text{ min}$$

There are two stepper motor so both will work till 0.75 min then y axis motor will stop then only x axis motor will run for 0.75 more, so total time will be 1.5 min.

GATE Ans. Key (1.4 to 1.6)

In this Question we have assumed the unit will be mm but it can be cm or m. Then examiner has to give the unit clearly and specifically. Examiner should give correct unit. If we assume different unit then different answer will come.

End of Solution