UNIVERSITY OF JOHANNESBURG

SECOND SEMESTER EXAMINATION 2019

(SUPPLEMENTARY EXAM)

COURSE **:** MECHANICAL ENGINEERING SCIENCE

SUBJECT **:** MANUFACTURING METHODS 3B

COURSE CODE: VVE3B21/VEEMCB3

TYD/TIME **:** 3 hours

PUNTE/MARKS: 100

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MODERATOR **:** PROF. E. T. AKINLABI

This paper consists of 4 pages.

- Requirements : Calculator
- This examination is closed book.
- Answer all questions.

QUESTION 1 [25]

1.1. Explain the difference between "*roughing"* and "*finishing operations"* in machining (4)

1.2. Identify some of the reasons why machining is commercially and technologically important. (4)

1.3 Identify the four forces that act upon chips in the orthogonal metal cutting model but cannot be measured directly in an operation. (4)

1.4 Highlight the reasons why most welding operations are inherently dangerous (5)

1.5 A cutting tool, cutting at 22m/min, gave a life of 1 hour between re-grinds when operating on roughing cuts with mild steel. What will be its probable life when engaged on light finishing cuts?

Take: $n=\frac{1}{8}$ for roughening and $\frac{1}{10}$ for finishing cuts in the Taylor's equation $VT^n=C$.

(7)

QUESTION 2 [20]

2.1 In recent years, conventional machining processes have had to make room for "non-traditional machining processes". There is a clear distinction between conventional and traditional machining processes. Elaborate on this distinction from a tooling as well as material removal point of view (2)

2.2 Highlight FIVE (5) tool-life criteria in production (5)

2.3 What is the difference between hot forming and cold forming? (4)

2.4 (i) Define Cutting fluid (2)

(ii) Give the broad classification of fluids and explain them briefly? (4)

(iii) Enumerate FOUR (4) Functions of cutting Fluid (4)

2.5 A plate that is 250 mm wide and 25 mm thick is to be reduced in a single pass in a two-high rolling mill to a thickness of 20 mm. The roll has a radius = 500 mm, and its speed = 30 m/min. The work material has a strength coefficient = 240 MPa and a strain-hardening exponent = 0.2. Determine (a) roll force, (b) roll torque, and (c) power required to accomplish this operation. (4)

QUESTION 3 [20]

3.1. Differentiate between soft "*product variety"* and "hard product variety" (2)

3.2. Distinguish between "*direct"* and "*indirect extrusion"*, and also comment about The role of friction on both direct and indirect extrusion (4)

3.3. Name some of the steps that can be taken to reduce or eliminate vibration in machining (4)

3.4 Briefly explain the following (i) Water jet cutting

(ii) Abrasive Water jet cutting

(iii.) Abrasive jet cutting (6)

3.4 A single-pass rolling operation reduces a 20-mm-thick plate to 18 mm. The starting plate is 200 mm wide. Roll radius = 250 mm and rotational speed = 12 rev/min. The work metal has a strength coefficient = 600 MPa and a strain hardening exponent = 0.22. Determine (a) roll force, (b) roll torque, and (c) power required for this operation.

(6)

QUESTION 4 **[25]**

4.1 What are the differences between bulk deformation processes and sheet metal forming? Give TWO (2) examples each. (4)

4.2 During inspection and quality testing of welded joints/parts. The following methods were adopted: destructive testing, non-destructive evaluation and visual inspection. Highlight FOUR (4) non-destructive evaluation (NDE) in welding technology. (4)

4.3 Define Weldability and state THREE (3) Characteristics of a good weldability (5)

4.4 Automation can be defined as the technology by which a process or procedure is performed without human assistance. Humans may be present, but the process itself operates under its own self-direction. Name THREE (3) Components of an Automated system. (3)

4.5 Enumerate FOUR (4) Hardware Components of an Automated System (4)

4.6 A billet that is 75 mm long with diameter = 35 mm is direct extruded to a diameter of 20 mm. The extrusion die has a die angle = 75°. For the work metal, K = 600 MPa and n = 0.25. In the Johnson extrusion strain equation, a = 0.8 and b = 1.4. Determine (a) extrusion ratio, (b) true strain (homogeneous deformation), (c) extrusion strain, and (d) ram pressure and force at L = 70 (5)

FORMULA SHEETS

Production Cycle Time Analysis

$$T_c = T_o + T_h + T_t$$

$$T_b = T_{su} + QT_c$$

$$T_p = \frac{T_{su}}{Q} + T_c = \frac{T_{su} + QT_c}{Q} = \frac{T_b}{Q}$$

$$R_p = \frac{60}{T_p}$$

$$R_c = \frac{60}{T_c}$$

Manufacturing Cost Models

$$C_{pc} = C_m + (C_L + C_{eq})T_p + C_t$$

$$C_L = \frac{R_H}{60}(1 + R_{LOH})$$

$$C_{eq} = \frac{IC}{60NH}(1 + R_{OH})$$

$$Q_o = \frac{Q}{1 - q}$$

Material Behaviour in Metal Forming

$$\sigma = K\epsilon^n$$

$$Y_f = K\epsilon^n$$

$$\overline{Y}_f = \frac{K\epsilon^n}{1 + n}$$

Strain Rate Sensitivity

$$\dot{\epsilon} = \frac{v}{h}$$

$$Y_f = C\dot{\epsilon}^m$$

$$Y_f = A\epsilon^n\dot{\epsilon}^m$$

Bulk Deformation Processes in Metalworking

Rolling

$$d = t_o - t_f$$

$$r = \frac{d}{t_o}$$

$$t_o w_o L_o = t_f w_f L_f$$

$$t_o w_o v_o = t_f w_f v_f$$

$$s = \frac{v_f - v_r}{v_r}$$

$$\epsilon = \ln\frac{t_o}{t_f}$$

$$\overline{Y}_f = \frac{K\epsilon^n}{1 + n}$$

$$d_{\max} = \mu^2 R$$

$$F = w\int_0^L p\,dL$$

$$F = \overline{Y}_f w L$$

$$L = \sqrt{R(t_o - t_f)}$$

$$T = 0.5\ FL$$

$$P = 2\pi NFL$$

Rolling

$$\epsilon = \ln \frac{h_o}{h}$$

$$F = Y_f A$$

$$F = K_f Y_f A$$

$$K_f = 1 + \frac{0.4\ \mu D}{h}$$

Extrusion

$$r_x = \frac{A_o}{A_f}$$

$$\epsilon = \ln r_x = \ln \frac{A_o}{A_f}$$

$$p = \overline{Y}_f \ln r_x$$

$$\overline{Y}_f = \frac{K\epsilon^n}{1+n}$$

$$\epsilon_x = a + b \ln r_x$$

$$p = \overline{Y}_f \epsilon_x$$

$$\frac{p_f \pi D_o^2}{4} = \mu p_c \pi D_o L$$

$$\mu p_c \pi D_o L = Y_s \pi D_o L$$

$$p_f = \overline{Y}_f \frac{2L}{D_o}$$

$$p = \overline{Y}_f \left(\epsilon_x + \frac{2L}{D_o}\right)$$

$$F = pA_o$$

$$P = Fv$$

$$K_x = 0.98 + 0.02\left(\frac{C_x}{C_c}\right)^{2.25}$$

$$p = K_x \overline{Y}_f \epsilon_x$$

$$p = K_x \overline{Y}_f \left(\epsilon_x + \frac{2L}{D_o}\right)$$

Wire and Bar Drawing

$$r = \frac{A_o - A_f}{A_o}$$

$$d = D_o - D_f$$

$$\epsilon = \ln \frac{A_o}{A_f} = \ln \frac{1}{1-r}$$

$$\sigma = \overline{Y}_f \epsilon = \overline{Y}_f \ln \frac{A_o}{A_f}$$

$$\overline{Y}_f = \frac{K\epsilon^n}{1+n}$$

$$\sigma_d = \bar{Y}_f \left(1 + \frac{\mu}{\tan \alpha}\right) \phi \ln \frac{A_o}{A_f}$$

$$\phi = 0.88 + 0.12 \frac{D}{L_c}$$

$$D = \frac{D_o + D_f}{2}$$

$$L_c = \frac{D_o - D_f}{2 \sin \alpha}$$

$$F = A_f \sigma_d = A_f \bar{Y}_f \left(1 + \frac{\mu}{\tan \alpha}\right) \phi \ln \frac{A_o}{A_f}$$

$$\sigma_d = \bar{Y}_f \ln \frac{A_o}{A_f} = Y \ln \frac{A_o}{A_f} = Y \ln \frac{1}{1-r} = Y$$

$$\frac{A_o}{A_f} = e = 2.7183$$

$$r_{\max} = \frac{e-1}{e} = 0.632$$

MATERIAL REMOVAL PROCESSES

Theory of metal Machining

$$R_{MR} = vfd$$

$$r = \frac{t_o}{t_c}$$

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$$r = \frac{l_s \sin \phi}{l_s \cos (\phi - \alpha)} = \frac{\sin \phi}{\cos (\phi - \alpha)}$$

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

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

Forces in Metal Cutting

$$\mu = \frac{F}{N}$$

$$\mu = \tan \beta$$

$$\tau = \frac{F_s}{A_s}$$

$$A_s = \frac{t_o w}{\sin \phi}$$

$$F = F_c \sin \alpha + F_t \cos \alpha$$

$$N = F_c \cos \alpha - F_t \sin \alpha$$

$$F_s = F_c \cos \phi - F_t \sin \phi$$

$$F_n = F_c \sin \phi + F_t \cos \phi$$

$$F_c = \frac{S t_o w \cos(\beta - \alpha)}{\sin \phi \cos(\phi + \beta - \alpha)} = \frac{F_s \cos(\beta - \alpha)}{\cos(\phi + \beta - \alpha)}$$

$$F_t = \frac{S t_o w \sin(\beta - \alpha)}{\sin \phi \cos(\phi + \beta - \alpha)} = \frac{F_s \sin(\beta - \alpha)}{\cos(\phi + \beta - \alpha)}$$

$$\tau = \frac{F_c \cos \phi - F_t \sin \phi}{(t_o w / \sin \phi)}$$

$$\phi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$$

Cutting Tool Technology

$$vT^n = C$$

$$vT^n = C\,(T_{\text{ref}}{}^n)$$

$$vT^n f^m = KT_{\text{ref}}{}^n f_{\text{ref}}{}^m$$

Economic and Product Design Considerations in Machining

$$R_i = \frac{f^2}{32NR}$$

$$R_a = r_{ai} R_i$$

$$T_c = T_h + T_m + \frac{T_t}{n_p}$$

$$T_m = \frac{\pi DL}{vf}$$

$$n_p = \frac{T}{T_m}$$

$$n_p = \frac{fC^{1/n}}{\pi DLv^{1/n-1}}$$

$$T_c = T_h + \frac{\pi DL}{fv} + \frac{T_t(\pi DLv^{1/n-1})}{fC^{1/n}}$$

$$v_{\max} = \frac{C}{\left[\left(\frac{1}{n}-1\right)T_t\right]^n}$$

$$T_{\max} = \left(\frac{1}{n}-1\right)T_t$$

$$C_t = \frac{P_t}{n_e}$$

$$C_t = \frac{P_t}{n_g} + T_g C_g$$

$$C_c = C_o T_h + C_o T_m + \frac{C_o T_t}{n_p} + \frac{C_t}{n_p}$$

$$C_c = C_o T_h + \frac{C_o \pi DL}{fv} + \frac{(C_o T_t + C_t)(\pi DLv^{1/n-1})}{fC^{1/n}}$$

$$v_{\min} = C\left(\frac{n}{1-n}\cdot\frac{C_o}{C_o T_t + C_t}\right)^n$$

$$T_{\min} = \left(\frac{1}{n}-1\right)\left(\frac{C_o T_t + C_t}{C_o}\right)$$