higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N6

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This marking guideline consists of 9 pages.

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QUESTION 1

1.1 $C = \frac{m}{2}(T_A + T_B)$

$m = \frac{PCD}{T_A} = \frac{120}{20}$ ✓

$m = 6$ mm✓

$273 = \frac{6}{2}(20 + T_B)$ ✓

$T_B = 71$ teeth✓

$m = \frac{PCD}{T_B}$

$6 = \frac{PCD}{71}$ ✓

$PCD = 426$ mm✓ (6)

1.2 $R_{A_{MAX}} = \sqrt{R^2 + 2 \times R \times r \times \sin^2 \varphi + r^2 \sin^2 \varphi}$

$= \sqrt{(213)^2 + 2(213)(120)\sin^2 20° + r^2 \sin^2 20°}$ ✓

$= 230{,}29$ mm✓

$R_{A_{ACTUAL}} = \frac{426 + 6 + 6}{2}$

$= 219$ mm✓

There is no interference $R_{A_{MAX}} > R_{A_{ACTUAL}}$ ✓ (4)

1.3 **Velocity:**

$V = \frac{\pi Nd}{60}$ **OR** $V = \frac{\pi ND}{60}$

$= \frac{\pi(900)(0{,}12)}{60}$ ✓ $= \frac{\pi(253{,}521)(0{,}426)}{60}$ ✓

$= 5{,}655$ m/s✓ $= 5{,}655$ m/s✓

Velocity factor:

$$CV = \frac{3}{3 + V}$$

$$= \frac{3}{3 + 5{,}655} \checkmark$$

$$= 0{,}347 \checkmark$$

Working stress:

$$\delta_w = CV \times \delta_o$$

$$= (0{,}347)(140 \times 10^6) \checkmark$$

$$= 48{,}58 \text{ MPa} \checkmark$$

Tangetal force:

$$P = F_T V$$

$$80 \times 10^3 = F_T(5{,}655) \checkmark$$

$$F_T = 14{,}147 \text{ kN} \checkmark$$

Form factor:

$$y = 0{,}154 - (\frac{0{,}912}{T})$$

$$= 0{,}154 - (\frac{0{,}912}{20}) \checkmark$$

$$= 108{,}4 \times 10^{-3} \checkmark$$

$$F_T = \pi \times m \times b \times y \times \theta$$

$$14{,}147 = \pi(600 \times 10^{-3})(b)(0{,}1084)(48{,}58 \times 10^6) \checkmark$$

$$b = 142{,}52 \text{ mm} \checkmark$$

Check the limits:

$b_{MIN} = 2{,}5 \times \pi \times m$

$= 2{,}5 \times \pi \times 6$

$= 47{,}12 \text{ mm} \checkmark$

$b_{MAX} = 4\pi \times m$

$= 4\pi \times 6$

$= 75{,}4 \text{ mm} \checkmark$

Outside limits✓ (15)

1.4 $N_A D_A = N_B D_B$

$N_B = \frac{(900)(120)}{426}$ ✓ $= 253{,}521$ ✓

$T = (\frac{60P}{2\pi N}) \times 1{,}x$

$= \frac{60(80 \times 10^3)}{2\pi(253{,}521)}(1{,}15)$ ✓

$= 3\ 465{,}325$ Nm ✓ (4)

1.5 $P = \frac{2\pi N T_A}{60}$ **OR** $T_B = \frac{T_{MAX}}{1{,}x}$

$80 \times 10^3 = \frac{2\pi(900)T_A}{60}$ $T_B = \frac{3\ 465{,}325}{1{,}15}$ ✓

$T_A = 848{,}826$ Nm ✓ $T_B = 3\ 013{,}335$ Nm ✓

$T_A N_A = T_B N_B$

$(848{,}826)(900) = T_B(253{,}521)$

$T_B = 3\ 031{,}335$ Nm ✓

$\frac{T_1}{T_2} = e^{\mu\theta}$

$\frac{T_1}{T_2} = e^{(0{,}25)(\pi)}$ ✓

$T_1 = 2{,}193T_2$ ✓

$T_B = (T_1 - T_2)R$

$3\ 013{,}335 = (2{,}193T_2 - T_2) - 0{,}2$ ✓

$T_2 = 12\ 629$ N ✓

$T_1 = (2{,}193)T_2$

$T_1 = 27\ 695$ N ✓

$F_H = (T_1 + T_2)\sin 30°$

$= (27\ 695 + 12\ 629) \sin 30°$ ✓

$= 20\ 162$ N✓

Take moments about R_L:

$\Sigma CWM = \Sigma ACWM$

$F_H \times 0{,}3 + F_T \times 0{,}75 = R_R \times 1$✓

$20\ 162 \times 0{,}3 + 14\ 147 \times 0{,}74 = R_R \times 1$

$R_R = 16\ 658{,}85$ N✓

Take moments about R_R:

$\Sigma CWM = \Sigma ACWM$

$R_L \times 1 = F_T \times 0{,}25 + F_H \times 0{,}7$✓

$R_L \times 1 = 14\ 147 \times 0{,}25 + 20\ 162 \times 0{,}7$

$R_L = 17\ 650{,}15$ N✓

Horizontal bending moments:

$M_{(\text{at a pulley})} = R_L \times 0{,}3 = 17\ 650{,}15 \times 0{,}3$✓ $= 5\ 295{,}045$ Nm✓

$M_{(\text{at a flywheel})} = R_L \times 0{,}5 - F_H \times 0{,}2$

$= 17\ 650{,}15 \times 0{,}5 - 20\ 162 \times 0{,}2$✓

$= 4\ 792{,}675$ Nm✓

$M_{(\text{at the gears})} = R_R \times 0{,}25 = 16\ 658{,}85 \times 0{,}25$✓ $= 4\ 164{,}713$ Nm✓

$F_V = (T_1 + T_2) \cos 30°$

$= (27\ 695 + 12\ 629) \cos 30°$ ✓

$= 34\ 922$ N✓

$W_f = mg$

$= (120)(9{,}81)$

$= 1\ 177{,}2\ \text{N}$✓

$F_R = F_T \tan \emptyset$

$= 14\ 147 \tan 20°$ ✓

$= 5\ 149{,}087\ \text{N}$✓

Take moments about R_L:

$\Sigma\text{CWM} = \Sigma\text{ACWM}$

$F_V \times 0{,}3 + W_f \times 0{,}5 = F_R \times 0{,}75 + R_R \times 1$✓

$34\ 922 \times 0{,}3 + 1\ 177{,}2 \times 0{,}5 = 5\ 149{,}087 \times 0{,}75 + R_R \times 1$

$R_R = 7\ 203{,}385\ \text{N}$✓

Take moments about R_R:

$\Sigma\text{CWM} = \Sigma\text{ACWM}$

$R_L \times 1 + F_R \times 0{,}25 = F_V \times 0{,}7 + W_f \times 0{,}5$

$R_L \times 1 + 5\ 149{,}087 \times 0{,}25 = 34\ 922 \times 0{,}7 + 1\ 177{,}2 \times 0{,}5$✓

$R_L = 23\ 746{,}728\ \text{N}$✓

Vertical bending moments:

$M_{(\text{at a pulley})} = R_L \times 0{,}3 = 23\ 746{,}728 \times 0{,}3$✓ $= 7\ 124{,}018\ \text{Nm}$✓

$M_{(\text{at a flywheel})} = R_L \times 0{,}5 - F_V \times 0{,}2$

$= 23\ 746{,}728 \times 0{,}5 - 34\ 922 \times 0{,}2$✓

$= 4\ 888{,}964\ \text{Nm}$✓

$M_{(\text{at the gears})} = R_R \times 0{,}25 = 7\ 203{,}385 \times 0{,}25$✓ $= 1\ 800{,}846\ \text{Nm}$✓

∴ The maximum bending moment is at a pulley.

$M_{MAX} = \sqrt{{F_H}^2 + {F_V}^2}$

$= \sqrt{(5\ 295{,}045)^2 + (7\ 124{,}018)^2}$ ✓

$= 8\ 876{,}324\ \text{Nm}$✓ (36)

1.6 $T_e = \sqrt{M^2 + T^2} = \sqrt{(8\,876{,}324)^2 + (3\,465{,}325)^2}$✓ $= 9\,528{,}778$ Nm✓

$$T_e = \frac{\pi}{16} D^3 \tau_{MAX}$$

$$9\,528{,}778 = \frac{\pi}{16} D^3 (60 \times 10^6)$$✓

$D = 93{,}17$ mm✓

$$M_e = \frac{1}{2}[M + T_e]$$

$$M_e = \frac{1}{2}[8\,876{,}324 + 9\,528{,}778]$$✓

$M_e = 9\,209{,}551$ Nm✓

$$M_e = \frac{\pi}{32} D^3 \sigma_n$$

$$9\,202{,}551 = \frac{\pi}{32} D^3 (100 \times 10^6)$$✓

$D = 97{,}87$ mm✓

$\therefore$ The suitable $D = 97{,}87$ mm✓

$\therefore D = 100$ mm✓ (10)

1.7 **Resultant reaction on the left bearing:**

$$R_L = \sqrt{{R_H}^2 + {R_V}^2}$$

$= \sqrt{(17\,650{,}15)^2 + (23\,746{,}728)^2}$✓

$= 29{,}588$ kN✓

Resultant reaction on the right bearing:

$$R_R = \sqrt{{R_H}^2 + {R_V}^2}$$

$= \sqrt{(16\,658{,}85)^2 + (7\,203{,}385)^2}$✓

$= 18{,}150$ kN✓ (4)

1.8 **Frictional force on the left bearing:**

$F_f = \mu F_R$

$F_f = 0{,}08(29\ 588)$✓

$F_f = 2{,}367\ \text{kN}$✓

Frictional torque on the left bearing:

$T_f = F_f \times R$

$T_f = (2\ 367)(0{,}0475)$✓

$T_f = 112{,}433\ \text{Nm}$✓

Frictional power:

$P_f = \frac{2\pi N T_f}{60}$

$P_f = \frac{2\pi(253{,}521)(112{,}433)}{60}$ ✓

$P_f = 2{,}985\ \text{kW}$✓

Frictional force on the right bearing:

$F_f = \mu F_R$

$F_f = 0{,}08(18\ 150)$✓

$F_f = 1{,}452\ \text{kN}$✓

Frictional torque on the right bearing:

$T_f = F_f \times R$

$T_f = (1\ 452)(0{,}0475)$✓

$T_f = 68{,}97\ \text{Nm}$✓

$P_f = \frac{2\pi N T_f}{60}$

$P_f = \frac{2\pi(253{,}521)(68{,}97)}{60}$ ✓

$P_f = 1{,}831\ \text{kW}$✓ (12)

1.9 $w = \frac{2\pi N}{60} = \frac{2\pi(900)}{69} = 94{,}248 \text{ rad/s}$✓

$F_C = mw^2R$

$= (3{,}2)(94{,}248)^2R$✓

$= 28{,}425 \times 10^3R \text{ N}$

$w = \frac{2\pi N}{60} = \frac{2\pi(400)}{60} = 41{,}888 \text{rad/s}$✓

$S = mw^2R$

$= (3{,}2)(41{,}888)^2R$✓

$= 5{,}615 \times 10^3R \text{ N}$✓

$T_\mu = \mu(F_C - S)R \times n$

$848{,}826 = 0{,}25(28\,425R - 5\,615R)R \times 4$✓

$R = 106{,}88 \text{ mm}$✓

$D = 2R$

$= 2(196{,}88)$✓

$= 394 \text{ mm}$✓ (9)

[100]

TOTAL: 100

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