higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N6

5 December 2023

This marking guideline consists of 10 pages.

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QUESTION 1

$m = \rho V = (1\,800)(60 \times 10^{-3})(6 \times 10^{-3}) = 0{,}648\ kg/m$ ✓

$$v = \frac{\pi N(D+t)}{60} = \frac{\pi(240)(0{,}806)}{60} = 10{,}128\ m/s$$ ✓

$T_c = mv^2 = (0{,}648)(10{,}128)^2 = 66{,}476\ N$ ✓

$T_1 = \sigma \times A = (5 \times 10^6)(0{,}06 \times 0{,}006) = 1\,800\ N$ ✓

$$sin\alpha = \frac{D-d}{2C} = \frac{800-250}{2(900)}$$

$\therefore \alpha = 17{,}792°$ ✓

$\theta = 180 - 2\alpha = 180 - 2(17{,}729) = 144{,}42°$ ✓

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

$$\frac{1\,800 - 66{,}476}{T_2 - 66{,}476} = e^{(0{,}3)(2{,}521)}$$ ✓

$$\frac{1\,733{,}524}{2{,}13} = T_2 - 66{,}476$$

$T_2 = 880{,}337N$ ✓

$$Input\ power\ of\ belt = (T_1 - T_2)v$$
$$= (1\,800 - 880{,}337)10{,}128$$ ✓
$$= 9{,}314kW$$ ✓

$$Velocity\ transmitted\ by\ follower\ (v) = \frac{\pi N(d+t)}{60}$$

$$v = \frac{\pi(700)(0{,}256)}{60} = 9{,}383m/s$$ ✓

$$Output\ power\ of\ belt = (T_1 - T_2)v$$
$$= (1\,800 - 880{,}337)383$$ ✓
$$= 8{,}629\ kW$$ ✓

$P_{loss} = P_{in} - P_{out} = 9\,314 - 8\,629 = 687\ W$ ✓ **[14]**

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QUESTION 2

2.1 $W_{follower} = mg = 120 \times 9{,}81 = 1\,177{,}2\ N$ ✓

$F_{spring} = Sx = (160)(30) = 4\,800\ N$ ✓

$F_{cam} = F_{spring} + F_{\mu} - W_{follower}$

$F_{cam} = 4\,800 + 300 - 1\,177{,}2$ ✓

$F_{cam} = 3\,922{,}8\ N$ ✓ (4)

2.2 $R_{cam} = \frac{d_{cam\ minimum}}{2} + cam\ maximum\ fall = \frac{60}{2} + 30 = 60\ mm$ ✓

$T_{cam} = F_{cam} \times R_{cam} = (3\,922{,}8)(0{,}06) = 235{,}368\ Nm$ ✓

$N_A \times T_A = N_B \times T_B$

$(1\,000)(24) = N_B \times 40$

$N_B = 600r/min$ ✓

$P = \frac{2\pi NT}{60} = \frac{2\pi(600)(235{,}368)}{60}$ ✓ $= 14{,}779\ kW$ ✓ (5)

2.3 $P_{gears} = P_{press} + P_{pump}$

$18\,000 = 14\,779 + P_{pump}$

$P_{pump} = 3{,}221\ kW$ ✓

$v = \frac{\pi ND}{60} = \frac{\pi(600)(0{,}35)}{60} = 10{,}996\ m/s$ ✓

$P_{pump} = (T_1 - T_2)v$

$3\,221 = (T_1 - T_2)10{,}996$

$T_1 - T_2 = 292{,}925$ ✓ ... ... (1)

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

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

$T_1 = 2{,}193T_2$ ✓ ... ... (2)

$Sustitute\ eq\ (2)\ in\ eq\ (1)$

$2{,}196T_2 - T_2 = 292{,}925$

$T_2 = 245{,}536\ N$ ✓

$T_1 = 2{,}193(245{,}536) = 538{,}46\ N$ ✓ (6)

2.4 $P = \dfrac{2\pi NT}{60}$

$18\,000 = \dfrac{2\pi(600)T}{60}$ ✓

$T = 286{,}474\ Nm$ ✓

$PCD_A = mT_A = 8(24) = 192$ ✓

$F_T = \dfrac{2T}{PCD_A} = \dfrac{2(286{,}474)}{0{,}192} = 2\,984{,}156\ N$ ✓

$F_R = F_T tan\psi = 2\,984{,}156 \times \tan 20 = 1\,086{,}144\ N$ ✓

$Bearings\ horizontal\ reaction$

$\Sigma F_{left} = \Sigma F_{right}$

$F_T \times 0{,}2 = R_R \times 0{,}8 + (T_1 + T_2) \times 1$

$2\,984{,}156 \times 0{,}2 = R_R \times 0{,}8 + 783{,}996 \times 1$ ✓

$R_R = 233{,}956\ N\ (right)$ ✓

$\Sigma F_{left} = \Sigma F_{right}$

$(T_1 + T_2) + F_T = R_L + R_R$

$783{,}996 + 2\,984{,}156 = R_L + 233{,}956$

$R_L = 3\,534{,}196\ N\ (right)$ ✓

$Horizontal\ bending\ moments$

$M_{left\ bearing} = F_T \times 0{,}2 = -2\,984{,}156 \times 0{,}2 = -596{,}831$ ✓

$M_{cam} = -F_T \times 0{,}6 + R_L \times 0{,}4$

$= -2\,984{,}156 \times 0{,}6 + 3\,534{,}196 \times 0{,}4 = -376{,}815$ ✓

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$M_{right\ bearing} = (T_1 + T_2) \times 0{,}2 = -156{,}799\ N$ ✓

$Bearings\ vertial\ reactions$

$\Sigma_{cwm} = \Sigma_{A_{cwm}}$

$F_T \times 0{,}4 + W_P \times 1 = F_R \times 0{,}2 + R_R \times 0{,}8$ ✓

$3\ 922{,}8 \times 0{,}4 + 372{,}4 \times 1 = 1\ 086{,}144 \times 0{,}2 + R_R \times 0{,}8$

$R_R = 2\ 180{,}364\ N\ (up)$ ✓

$\Sigma F_{up} = \Sigma F_{down}$

$R_L + R_R = F_R + W_P + F_T$

$R_L + 2\ 180{,}364 = 1\ 080{,}144 + 392{,}4 + 3\ 922{,}8$

$R_L = 3\ 220{,}98\ N\ (up)$ ✓

$Vertical\ bending\ moments$

$M_{left\ bearing} = F_R \times 0{,}2 = -1\ 086{,}144 \times 0{,}2 = -217{,}229\ Nm$ ✓

$M_{cam} = F_R \times 0{,}6 + R_L \times 0{,}4$

$= -1\ 086{,}144 \times 0{,}6 + 3\ 220{,}98 \times 0{,}4 = 636{,}706\ Nm$ ✓

$M_{right\ bearing} = -W_P \times 0{,}2 = -392{,}4 \times 0{,}2 = -78{,}48\ N$ ✓

$Maximum\ bending\ moment\ on\ shaft\ is\ at\ gears$

$M_{max} = \sqrt{{M_H}^2 + {M_V}^2}$

$M_{max} = \sqrt{(376{,}815)^2 + (636{,}706)^2}$ ✓

$M_{max} = 739{,}854\ Nm$ ✓

$T_e = \sqrt{{T_{max}}^2 + {M_{max}}^2}$

$T_e = \sqrt{(286{,}63)^2 + (739{,}854)^2}$ ✓

$T_e = 793{,}43\ Nm$ ✓

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

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$M_e = \frac{1}{2}[739{,}854 + 793{,}43]$

$M_e = 766{,}645\ Nm$ ✓

$T_e = \frac{\pi}{16} d^3 \tau$

$793{,}43 = \frac{\pi}{16} d^3 (45 \times 10^6)$ ✓

$d = 44{,}781\ mm = 45\ mm$ ✓

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

$766{,}645 = \frac{\pi}{32} d^3 (100 \times 10^6)$ ✓

$d = 42{,}743\ mm = 45\ mm$ ✓
$\therefore d = 45\ mm$ ✓ (27)

2.5 $PCD_B = mT_B = 8 \times 40 = 320\ mm$ ✓

$R_{max} = \sqrt{R^2 + 2Rr sin\varphi + r^2 sin^2\varphi}$

$R_{max} = \sqrt{160^2 + 2(160)(96) sin20° + (96^2) sin^2 20°}$ ✓

$R_{max} = 173{,}77\ mm$ ✓

$R_{act} = \frac{D + 2m}{2}$ *or* $R_{act} = R + m$

$R_{act} = \frac{320 + 2(8)}{2} = 168\ mm$ ✓

$No\ interference\ R_{max}\ is\ more\ than\ R_{act}$ ✓ (5)

2.6 $C_V = \frac{6}{6+V}$

$= \frac{6}{6+10{,}996}$

$= 0{,}353$ ✓

$Form\ factor\ (y) = 0{,}107$ ✓ $from\ given\ table$

Working stress

$\sigma = \sigma_O \times C_V = (50 \times 10^6)(0{,}353) = 17{,}65\ MPa$ ✓

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

$2\ 984{,}156 = \pi(8 \times 10^{-3})b(0{,}107)(17{,}65 \times 10^6)$ ✓

$b = 62{,}871\ mm$ ✓

$check\quad b_{min} = 2{,}5 \times \pi \times m = 2{,}5 \times \pi \times 8 = 62{,}832\ mm$ ✓

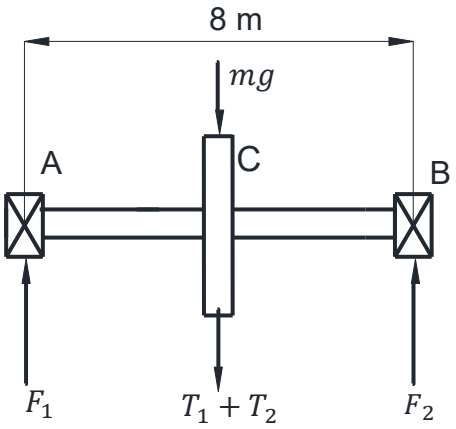
$b_{max} = 4 \times \pi \times m = 4 \times \pi \times 8 = 100{,}53\ mm$ ✓

$The\ face\ width\ is\ not\ suitable, as\ it\ is\ not\ within\ the\ limits.$ ✓

(8)
[55]

QUESTION 3

3.1



$F_{total}(F_1 + F_2) = (T_1 + T_2) + mg$

$F_{total} = (1\,200 + 400) + 40 \times 9{,}81$ ✓

$F_{total} = 1\,992{,}4\ N$ ✓

$F_{each} = \frac{F_{total}}{2} = \frac{1\,992{,}4}{2} = 996{,}2\ N$ ✓

$A = \frac{F_{each}}{P} = \frac{996{,}2}{185 \times 10^3} = 5{,}4 \times 10^{-3} m^2$ ✓

$L = \frac{A}{D} = \frac{5{,}4 \times 10^{-3}}{45 \times 10^{-3}} = 120\ mm$ ✓

$T_{bearing} - T_{ambient} = \frac{1}{2}(T_{oil} - T_{ambient})$

$60 - T_{ambient} = \frac{1}{2}(95 - T_{ambient})$

$T_{ambient} = 25°$ ✓

$\Delta T = T_{bearing} - T_{ambient} = 60 - 25 = 35°$ ✓

$K = 0{,}273$ ✓

$H = \frac{(\Delta T + 18°)^2 \times L \times D}{K}$

$H = \frac{(35 + 18)^2 \times 0{,}12 \times 0{,}045}{0{,}273}$ ✓

$H = 55{,}563\ J$ ✓

$Q = f \times W(\frac{\pi ND}{60})$

$55{,}563 = f(996{,}2)(\frac{\pi \times 900 \times 0{,}045}{60})$ ✓

$f = 0{,}0263$ ✓ (12)

3.2 $k = 0{,}0035$ ✓ $if\ {}^{L}/_{D} = 2{,}67$

$D_{shaft} = 45^{-0{,}025}_{-0{,}050}$

$D_{bearing} = 45^{+0{,}062}_{+0{,}000}$

$C = 45 - 44{,}972$ ✓ $= 0{,}025\ mm$ ✓

$$f = 0{,}326\left(\frac{\mu \times N}{P}\right) \times \frac{D}{C} + k$$

$0{,}0263 = 0{,}326(\frac{\mu(900)}{185 \times 10^3}) \times \frac{45}{0{,}025} \times 0{,}0035$ ✓

$\mu = 0{,}008$ ✓

$SAE\ 30\ oil$ ✓ (6)
[18]

QUESTION 4

4.1 $P = \frac{2\pi NT}{60}$

$P = \frac{2\pi(1\,000)T}{60}$ ✓

$T = 190{,}986\ Nm$ ✓

$R_f = \frac{2}{3}\left[\frac{R^3 - r^3}{R^2 - r^2}\right]$

$R_f = \frac{2}{3}\left[\frac{125^3 - 60^3}{125^2 - 60^2}\right]$

$R_f = 96{,}31\ mm$ ✓

$T = \mu \times F \times R_f \times n$

$190{,}986 = 03F(0{,}09631)(6)$ ✓

$F = 1\,101{,}686\ N$ ✓ (5)

4.2 $Total\ wear(x_T) = 2nx = 2(6)(1{,}1) = 13{,}2\ mm$ ✓

$Total\ reduction\ in\ force\ (F_R) = S_F \times x_T \times n_S$

$F_R = (8)(13{,}2)(6)$ ✓

$F_R = 633{,}6\ N$ ✓

$New\ force\ (F_{new}) = 1\,101{,}686 - 633{,}6 = 468{,}086\ N$ ✓

$T_{new} = \mu \times F_{new} \times R_f \times n$

$T_{new} = 0{,}3(468{,}086)(0{,}09631)(6)$ ✓

$T_{new} = 81{,}146\ Nm$ ✓

$P_{new} = \frac{2\pi NT_N}{60} = \frac{2\pi(1\,000)(81{,}146)}{60}$ ✓

$P_{new} = 8{,}498\ kW$ ✓ (8)

[13]

TOTAL: 100

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