higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N6

15 April 2020

This marking guideline consists of 9 pages.

Copyright reserved

QUESTION 1

1.1 $$P = \frac{2\pi NT}{60}$$

$$40 \times 10^3 = \frac{2\pi(1\,000)T}{60}\checkmark$$

$$T = 381{,}972\ \text{kNm}\checkmark \quad (2)$$

1.2 $$\omega_1 = \frac{2\pi N}{60}$$

$$\omega_1 = \frac{2\pi(1\,000)}{60}\checkmark$$

$$\omega_1 = 104{,}72\ \text{rad/s}\checkmark$$

$$\omega_2 = \frac{2\pi N}{60}$$

$$\omega_2 = \frac{2\pi(0{,}7)(1\,000)}{60}\checkmark$$

$$\omega_2 = 73{,}3\ \text{rad/s}\checkmark$$

$$F = m\omega^2 r$$

$$F = m(104{,}72)^2(0{,}15)\checkmark$$

$$F = 1\,645m\ \text{N}\checkmark$$

$$S = m\omega^2 r$$

$$S = m(73{,}3)^2(0{,}15)\checkmark$$

$$S = 806{,}02\ \text{rad/s}\checkmark$$

$$T = \mu(F - S)Rn$$

$$381{,}972 = (0{,}3)(1\,645m - 806{,}02m)(0{,}17)(4)\checkmark$$

$$m = 2{,}23\ \text{kg}\checkmark$$

$$F = 1\,645m = 1\,645(2{,}23) = 3\,668{,}35\ \text{N}\checkmark$$

$$S = 806{,}02m = 806{,}02(2{,}23) = 1\,797{,}45\ \text{N}\checkmark \quad (12)$$

Copyright reserved

1.3 $C_{1-2} = \frac{m}{2}[T_A + T_B]$

$168 = \frac{6}{2}[20 + T_B]$✓

$T_B = 36$ teeth✓

$N_B T_B = N_A T_A$

$N_B(36) = (1\,000)(20)$✓

$N_B = 555{,}56$ r/min✓

$C_{2-3} = \frac{m}{2}[T_C + T_D]$

$174 = \frac{6}{2}[18 + T_D]$✓

$T_D = 40$ teeth✓

$N_D T_D = N_C T_C$

$N_D(40) = (555{,}56)(18)$✓

$N_D = 250$ r/min✓

$C_{3-4} = \frac{m}{2}[T_E + T_F]$

$180 = \frac{6}{2}[22 + T_F]$✓

$T_F = 38$ teeth✓

$N_F T_F = N_E T_E$

$N_F(38) = (250)(22)$✓

$N_F = 144{,}74$ r/min✓

Torque transmitted by shaft 2:

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

$40 \times 10^3 = \frac{2\pi(555{,}56)T}{60}$✓

$T = 687{,}54$ kNm✓

Copyright reserved

Torque transmitted by shaft 3:

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

$$40 \times 10^3 = \frac{2\pi(250)T}{60} \checkmark$$

$$T = 1\,527{,}89 \text{ kNm} \checkmark$$

Torque transmitted by shaft 4:

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

$$40 \times 10^3 = \frac{2\pi(144{,}74)T}{60} \checkmark$$

$$T = 2\,639 \text{ kNm} \checkmark$$ (18)

1.4 PCD for each gear:

$$PCD_A = mT_A$$

$$PCD_A = (6)(20)$$

$$PCD_A = 120 \text{ mm} \checkmark$$

$$PCD_B = mT_B$$

$$PCD_B = (6)(36)$$

$$PCD_B = 216 \text{ mm} \checkmark$$

$$PCD_C = mT_C$$

$$PCD_C = (6)(18)$$

$$PCD_C = 108 \text{ mm} \checkmark$$

$$PCD_D = mT_D$$

$$PCD_D = (6)(40)$$

$$PCD_D = 240 \text{ mm} \checkmark$$

$$PCD_E = mT_E$$

$$PCD_E = (6)(22)$$

$$PCD_E = 132 \text{ mm} \checkmark$$

Copyright reserved

$PCD_F = mT_F$

$PCD_F = (6)(38)$

$PCD_F = 228$ mm✓

Checking interference between gears A and B:

$R_{A\,MAX} = \sqrt{R^2 + 2R \times r \times \sin^2\psi + r^2 \times \sin^2\psi}$

$R_{A\,MAX} = \sqrt{(108)^2 + 2(108)(60)\sin^2 20 + (60)^2\sin^2(20)}$✓

$R_{A\,MAX} = 116{,}624$ mm✓

$R_{A\,actual} = \frac{216 + 6 + 6}{2} = 114$ mm✓

$R_{A\,MAX}$ is more than $R_{A\,actual}$ and therefore there is no interference. ✓

Checking interference between gears C and D:

$R_{A\,MAX} = \sqrt{R^2 + 2R \times r \times \sin^2\psi + r^2 \times \sin^2\psi}$

$R_{A\,MAX} = \sqrt{(120)^2 + 2(120)(54)\sin^2 20 + (54)^2\sin^2(20)}$✓

$R_{A\,MAX} = 127{,}5$ mm✓

$R_{A\,actual} = \frac{240 + 6 + 6}{2} = 126$ mm✓

$R_{A\,MAX}$ is more than $R_{A\,actual}$ and therefore there is no interference. ✓

Checking interference between gears E and F:

$R_{A\,MAX} = \sqrt{R^2 + 2R \times r \times \sin^2\psi + r^2 \times \sin^2\psi}$

$R_{A\,MAX} = \sqrt{(114)^2 + 2(114)(66)\sin^2 20 + (66)^2\sin^2(20)}$✓

$R_{A\,MAX} = 123$ mm✓

$R_{A\,actual} = \frac{288 + 6 + 6}{2} = 120$ mm✓

$R_{A\,MAX}$ is more than $R_{A\,actual}$ and therefore there is no interference. ✓ (18)

1.5 Calculating face width for gears A and B:

$$V_A = \frac{\pi ND}{60} = \frac{2\pi(1\,000)(0{,}12)}{60} = 6{,}28 \text{ m/s}\checkmark$$

$$C_v = \frac{3}{3+v} \text{ velocity factor}$$

$$C_v = \frac{6}{6+6{,}28}\checkmark$$

$$C_v = 0{,}323\checkmark$$

$$\sigma_w = C_v \times \sigma_B \text{ working stress}$$

$$\sigma_w = 0{,}323(140 \times 10^6)\checkmark$$

$$\sigma_w = 45{,}22 \text{ MPa}\checkmark$$

$$y = 0{,}154 - \frac{0{,}912}{T} \text{ form factor}$$

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

$$= 0{,}1084\checkmark$$

$$F_T = \frac{2T}{PCD} \text{ tangential force}$$

$$F_T = \frac{2(381{,}972)}{0{,}12}\checkmark$$

$$F_T = 6\,366{,}2 \text{ N}\checkmark$$

$$F_T = \pi \times m \times b \times y \times \sigma_w \text{ face width}$$

$$6\,366{,}2 = \pi(0{,}006)(b)(0{,}1084)(45{,}22 \times 10^6)\checkmark$$

$$b = 68{,}9 \text{ mm}\checkmark$$

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

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

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

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

$$= 4 \times \pi \times 6$$

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

It is suitable and within the limits. ✓ (14)

Copyright reserved

1.6 Vertical reactions:

$F_{r1} = F_T \times \tan\phi$

$F_{r1} = 6\,366{,}2 \times \tan 20°$✓

$F_{r1} = 2\,317{,}1$ N✓

$F_T = \frac{2T}{PCD}$ tangential force

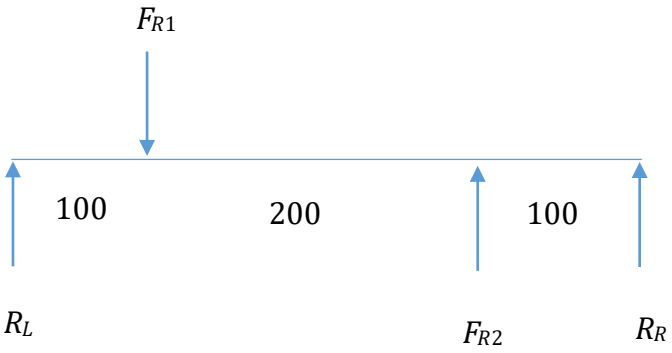
$F_T = \frac{2(687{,}54)}{0{,}108}$ ✓

$F_T = 12\,732{,}2$ N✓

$F_{r2} = F_T \times \tan\phi$

$F_{r2} = 12\,732{,}2 \times \tan 20°$✓

$F_{r2} = 4\,634{,}14$ N✓



$\Sigma cwm = \Sigma acwm$

$F_{r1} \times 100 = R_R \times 400 + F_{r1} \times 300$

$2\,317{,}1 \times 100 = R_R \times 400 + 4\,634{,}14 \times 300$✓

$R_R = 2\,896{,}33$ N (down)✓

$\Sigma Fup = \Sigma Fdown$

$R_L + F_{r2} = F_{r1} + F_R$

$R_L + 4\,634{,}14 = 2\,317{,}1 + 2\,896{,}33$✓

$R_L = 579{,}29$ N (up)✓

$M_B = R_L \times L$ at gear B

$M_B = 579{,}29 \times 0{,}1$✓

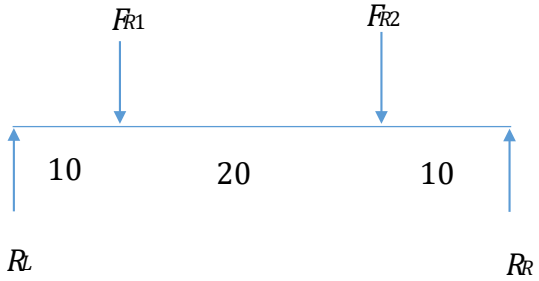
$M_B = 57{,}93$ Nm✓

$M_C = -R_R \times L$ at gear C

$M_C = -2\,896{,}33 \times 0{,}1$✓

$M_C = -289{,}63$ Nm✓

Horizontal reactions:



$\Sigma cwm = \Sigma acwm$

$F_{r1} \times 100 + F_{r2} \times 300 = R_R \times 400$

$6\,366{,}2 \times 100 + 12\,732{,}2 \times 300 = R_R \times 400$✓

$R_R = 11\,140{,}7$ N (up)✓

$\Sigma Fup = \Sigma Fdown$

$R_L + R_R = F_{r1} + F_{r2}$

$R_L + 11\,140{,}7 = 6\,366{,}2 + 12\,732{,}2$✓

$R_L = 7\,957{,}7$ N (up)✓

$M_B = R_L \times L$ at gear B

$M_B = 7\,957{,}7 \times 0{,}1$✓

$M_B = 795{,}77$ Nm✓

$M_C = R_R \times L$ at gear C

$M_C = 11\,140{,}7 \times 0{,}1$✓

$M_C = 1\,114{,}07$ Nm✓

The maximum bending is horizontal and at C.

$M_{Max} = 1\,114{,}07$ Nm✓ (23)

Copyright reserved

1.7 $T_{Max} = 1{,}2 \times T_{Mean}$

$T_{Max} = 1{,}2(687{,}54)$✓

$T_{Max} = 825{,}05\ \text{Nm}$✓ (2)

1.8 $T_e = \sqrt{(M \times k_b)^2 + (T \times k_T)^2}$

$T_e = \sqrt{(1\ 114{,}07 \times 2)^2 + (825{,}05 \times 1{,}5)^2}$✓

$T_e = 2\ 548{,}76\ \text{Nm}$✓

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

$2\ 548{,}76 = \frac{\pi}{16} D^3 (180 \times 10^6)$✓

$D = 41{,}46\ \text{mm}$✓

$\therefore D = 45\ \text{mm}$✓

$M_e = \frac{1}{2}[(M \times k_b) + T_e]$

$M_e = \frac{1}{2}[(1\ 114{,}07 \times 2) + 2\ 548{,}76]$✓

$M_e = 2\ 388{,}45\ \text{Nm}$✓

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

$2\ 388{,}45 = \frac{\pi}{32} D^3 (240 \times 10^6)$✓

$D = 46{,}63\ \text{mm}$✓

$\therefore D = 50\ \text{mm}$✓

The suitable diameter is 50 mm. ✓ (11)
[100]

TOTAL: 100

Copyright reserved