higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N6

14 NOVEMBER 2012

This marking guideline consists of 11 pages.

QUESTION 1

SHAFT

$$PCD_{PINION} = m \times T$$
$$= 8 \times 25$$
$$= 200 \text{ mm} \quad (1)$$

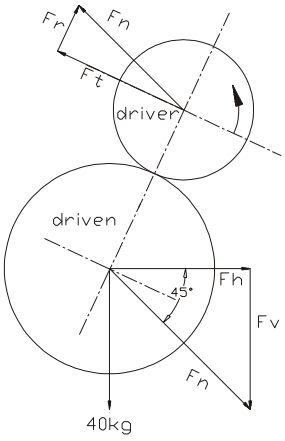
$$P = \frac{2 \times \pi \times N \times T}{60}$$
$$150000 = \frac{2 \times \pi \times 1000 \times T}{60}$$
$$T = 1432,4 \text{ Nm} \quad (1)$$

$$T_{MAX} = 1,2 \times T$$
$$= 1,1 \times 1432,4$$
$$= 1575,6 \text{ Nm} \quad (1)$$

$$T_{MAX_{GEAR}} = 5 \times 1575,6$$
$$= 7878\,Nm \quad (1)$$

$$T = F_T \times R$$
$$1575,6 = F_T \times \frac{0,1}{2}$$
$$F_T = 31513\,N \quad (1)$$

$$Cos20 = \frac{F_T}{F_N}$$
$$F_N = \frac{31513}{Cos20}$$
$$= 33535 \text{ N} \quad (1)$$



(2)

$$Cos45 = \frac{F_H}{33535}$$
$$F_H = 23712,83 \text{ N} \quad (1)$$

$$Sin45 = \frac{F_V}{33535}$$
$$F_V = 23712,83 \text{ N} \quad (1)$$

$$W_{GEAR} = m \times g$$
$$= 40 \times g$$
$$= 392,4 \text{ N} \quad (1)$$

$$F_{GEARVERTICAL} = 23712,83+392,4$$
$$= 24105,23 \text{ N} \quad (1)$$

$$F_{RESULTANT} = \sqrt{23712,83^2 + 24105,23^2}$$
$$= 33813,6 \text{ N} \quad (2)$$

$$BM = 33813,6 \times 0,3$$
$$= 10144,1 \text{ Nm} \quad (1)$$

$$T_E = \sqrt{(M)^2 + (T)^2}$$
$$= \sqrt{(10144,1)^2 + (7878)^2}$$
$$= 12843,88 \text{ Nm} \quad (2)$$

$$M_E = 0,5[M + T_E]$$
$$= 0,5[10144,1+12843,88]$$
$$= 11493,98 \text{ Nm} \quad (2)$$

$$T_E = \pi/16 \times \frac{D^4 - d^4}{D} \times \tau$$
$$12843,88 = \pi/16 \times \frac{(D)^4 - (0,4D)^4}{D} \times 50 \times 10^6$$
$$D = 110,32 \text{ mm} \quad (2)$$

$$M_E = \pi/32 \times \frac{D^4 - d^4}{D} \times \sigma$$
$$11493,98 = \pi/32 \times \frac{(D)^4 - (0,4D)^4}{D} \times 60 \times 10^6$$
$$D = 126 \text{ mm} \quad (2)$$

$$\begin{aligned} Say\ D &= 130\ mm \\ and\ d &= 0,4\times 130 \\ d &= 52\ mm \end{aligned}$$ (1)

GEAR WIDTH

$$\begin{aligned} V &= \frac{\pi \times PCD \times N}{60} \\ &= \frac{\pi \times 0,2 \times 1000}{60} \\ &= 10,47\ m/s \end{aligned}$$ (1)

$$\begin{aligned} C_V &= \frac{6}{6+V} \\ &= \frac{6}{6+10,47} \\ &= 0,364 \end{aligned}$$ (1)

$$y_{PINION} = 0,108 \text{ from tables}$$ (1)

$$\begin{aligned} y_{GEAR} &= 0,154-\left(\frac{0,912}{T}\right) \\ &= 0,154-\left(\frac{0,912}{125}\right) \\ &= 0,147 \end{aligned}$$ (1)

$$\begin{aligned} \sigma_{GEAR} y_{GEAR} \times C_V &= 250\times 10^6 \times 0,147 \times 0,364 \\ &= 13,377\ MPa \end{aligned}$$ (1)

Pinion is weaker and governs design (1)

$$\begin{aligned} F_T &= \pi \times m \times b \times \sigma \times y \\ 31513 &= \pi \times 0,008 \times b \times 12,58\times 10^6 \\ b &= 99,7\ mm \end{aligned}$$ (1)

$$\begin{aligned} b_{MIN} &= 2,5\times \pi \times m \\ &= 2,5\times \pi \times 8 \\ &= 62,83\ mm \end{aligned} \qquad \begin{aligned} b_{MAX} &= 4\times \pi \times m \\ &= 4\times \pi \times 8 \\ &= 100,5\ mm \end{aligned}$$ (3)

Say b = 100 mm (1)

GEAR WHEEL ARMS (1)

$D_{BOSS} = 2 \times 130 = 260$ mm
$L_{BOSS} = 1,5 \times 130 = 195$ mm (2)

$w_{KEY} = 25$ mm
$t_{KEY} = 14$ mm
$L_{KEY} = L_{BOSS}$
$= 195$ mm (3)

$PCD_{GEAR} = m \times Teeth$
$= 8 \times 25 \times 5$
$= 1000\,mm$ (1)

$$L_E = \frac{PCD}{2} - \frac{D_{BOSS}}{2}$$
$$= \frac{1 - 0,26}{2}$$
$= 0,37$ m (1)

$$BM = F_T \times L_E$$
$$= \frac{31513 \times 0,37}{4}$$
$= 2914,95$ Nm (1)

$$Z = \pi/64 \times \frac{a \times b^3}{b/2}$$
$$= \pi/32 \times 0,5 \times b^3$$
$= \pi/64\, b^3$ (1)

$M = \sigma \times Z$
$2914,95 = 16 \times 10^6 \times \pi/64 \times b^3$
$b = 0,15483$ m
Say b $= 156$ mm
a $= 0,5 \times 156$
a $= 78$ mm (2)

$D_{BLANK} = PCD + 2 \times m$
$= 1000 + 2 \times 8$
$D_{BLANK} = 1016$ mm (1)

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QUESTION 2

$$P = \frac{F_A}{A}$$
$$P = \frac{150\times10^3}{\pi/4\left[0,25^2-0,08^2\right]}$$
$$P = 3,4\times10^6$$

$$No\,of\ \text{collars} = \frac{P_{TOTAL}}{P_{SINGLE\ \text{COLLAR}}}$$
$$= \frac{3,4\times10^6}{350\times10^3}$$
$$= 9,7$$
$$= 10 \qquad (2)$$

$$P\times A\times No = F_A$$
$$P\times\pi/4\left[0,25^2-0,08^2\right]\times10 = 150\times10^3$$
$$P = 3,4044\times10^5\ Pa \qquad (2)$$

$$R_f = 2/3\left[\frac{R^3-r^3}{R^2-r^2}\right]$$
$$= 2/3\left[\frac{125^3-40^3}{125^2-40^2}\right]$$
$$= 89,8mm \qquad (1)$$

$$T = \mu\times F_A\times R_f$$
$$= 0,03\times150\times10^3\times0,0898$$
$$= 404,1Nm \qquad (3)$$

$$H_G = \frac{2\times\pi\times N\times T}{60}$$
$$= \frac{2\times\pi\times400\times404,1}{60}$$
$$= 16926,9\text{J/s} \qquad (3)$$

$$H_G = H_D$$
$$= \bar{m}\times SHC\times\Delta T$$
$$16926,9 = \bar{m}\times1,8\times10^3\times30$$
$$\bar{m} = 0,3135kg/s$$

$$\rho = \frac{\bar{m}}{Q}$$
$$800 = \frac{0,3135}{Q}$$
$$Q = 3,92\times10^{-4}\ m^3/s$$
$$= 3,92\times10^{-4}\times1000\times60$$
$$= 23,5\,l/\min$$

(4)
[15]

QUESTION 3

$$R_f = 2/3\left[\frac{R^3-r^3}{R^2-r^2}\right]$$
$$= 2/3\left[\frac{150^3-80^3}{150^2-80^2}\right]$$
$$= 118,55\,mm$$

$$T = \mu\times F_A\times R_f\times N^0$$
$$= 0,4\times8\times1200\times0,011855\times2$$
$$= 910,47\,Nm$$

$$F.O.S = \frac{910,47}{245}$$
$$= 3,72$$

(6)

$$R_f = \frac{R+r}{2}$$
$$= \frac{150+80}{2}$$
$$= 115\,mm$$

$$T = \mu\times F_A\times R_f\times N^0$$
$$= 0,4\times8\times1200\times0,115\times2$$
$$= 883,2\,Nm$$

$$F.O.S = \frac{883,2}{245}$$
$$= 3,6$$

(4)

$$Spring\ force = \frac{1200}{8}$$
$$= 150\,N/mm$$

$$T = \mu \times F_A \times R_f \times N^0$$
$$245 = 0,4 \times 8 \times F_A \times 0,115 \times 2$$
$$F_A = 332,88\,N$$

$$\Delta L = \frac{332,88}{150}$$
$$= 2,219\,mm$$

$$Wear = 6 - 2,219$$
$$= 3,78\,mm \quad (4)$$

$$P = \frac{2 \times \pi \times N \times T}{60}$$
$$= \frac{2 \times \pi \times 900 \times 883,2}{60}$$
$$= 83,24\,kW \quad (1)$$

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QUESTION 4

$$A = d \times L$$
$$= 0,05 \times 0,04$$
$$= 0,002\ m^2 \quad (1)$$

$$P = \frac{F}{A}$$
$$8 \times 10^6 = \frac{F}{0,002}$$
$$F = 16\ kN \quad (1)$$

$$A = b \times d$$
$$= 0,05 \times 0,03$$
$$= 0,0015\ m^2 \quad (1)$$

$$I_{XX} = \frac{b \times d^3}{12}$$
$$= \frac{0,03 \times 0,05^3}{12}$$
$$= 3 \times 10^{-7} \text{ m}^4 \quad (2)$$

$$I_{YY} = \frac{d \times b^3}{12}$$
$$= \frac{0,03^3 \times 0,05}{12}$$
$$= 1,0 \times 10^{-7} \text{ m}^4 \quad (2)$$

$$k_{XX}{}^2 = \frac{I_{XX}}{A}$$
$$= \frac{3 \times 10^{-7}}{0,0015}$$
$$= 2 \times 10^{-4} \text{ m}^2 \quad (1)$$

$$k_{YY}{}^2 = \frac{I_{YY}}{A}$$
$$= \frac{1,0 \times 10^{-7}}{0,0015}$$
$$= 7,5 \times 10^{-5} \text{ m}^2 \quad (1)$$

$$F = \frac{\sigma \times A}{1 + a\left(\frac{L_E}{k}\right)^2}$$
$$16000 = \frac{\sigma \times 0,0015}{1 + 1/7500\left(\frac{0,25^2}{2 \times 10^{-4}}\right)}$$
$$\sigma = 11,111 \text{ MPa} \quad (2)$$

$$F = \frac{\sigma \times A}{1 + a\left(\frac{L_E}{k}\right)^2}$$
$$16000 = \frac{\sigma \times 0,0015}{1 + 1/7500\left(\frac{0,125^2}{7,5 \times 10^{-5}}\right)}$$
$$\sigma = 10,9 \text{ MPa} \quad (2)$$

[13]

QUESTION 5

$$D_E = 750+18$$
$$= 768 \text{ mm}$$

$$d_E = 350+18$$
$$= 368 \text{ mm} \quad (1)$$

$$V = \frac{\pi \times D \times N}{60}$$
$$= \frac{\pi \times 0,368 \times 900}{60}$$
$$= 17,34 \text{ m/s} \quad (1)$$

$$Sin\alpha = \frac{D_E - d_E}{2 \times C}$$
$$= \frac{0,768 - 0,368}{2 \times 1,5}$$
$$\alpha = 7,66^0 \quad (1)$$

$$\theta_{SMALL \text{ PULLEY}} = 180 - 2\alpha$$
$$= 180 - 2 \times 7,66$$
$$= 164,68^0$$

$$\theta = \frac{\pi}{180} \times 164,68$$
$$= 2,874 \text{ radians} \quad (1)$$

$$T_c = \overline{m} \times v^2$$
$$= 0,8 \times 17,34^2$$
$$= 240,58 \text{ N} \quad (1)$$

$$P = (T_1 - T_2)v$$
$$42 \times 10^3 = (T_1 - T_2)17,34$$
$$(T_1 - T_2) = 2421,9 \text{ N}$$
$$T_1 = 2421,9 + T_2 \quad (1)$$

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{\mu\theta}$$
$$= e^{0,4\times 2,874}$$
$$= 3,157$$

$$\frac{T_1 - 240,58}{T_2 - 240,58} = 3,157$$
$$T_1 - 240,58 = (T_2 - 240,58)\times 3,157$$
$$2421,9 + T_2 - 240,58 = 3,157T_2 - 759,49$$
$$2421,9 - 240,58 + 759,49 = 3,157T_2 - T_2$$
$$T_2 = 1363,4 \text{ N} \quad (1)$$

$$T_1 = 2421,9 + T_2$$
$$= 2421,9 + 1363,4$$
$$= 3785,3N$$

$$T_1 = T_{Max} \times w$$
$$w = \frac{3785,3}{30}$$
$$= 126,2 \text{ mm}$$
$$= 127\,mm \quad (1)$$

$$L = \frac{\pi}{2}\left[D_e + d_e\right] + \frac{\left[D_e - d_e\right]^2}{4\times C} + 2\times C$$
$$= \frac{\pi}{2}\left[0,768 + 0,368\right] + \frac{\left[0,768 - 0,368\right]^2}{4\times 1,5} + 2\times 1,5$$
$$= 4,81 \text{ m} \quad (1)$$

[9]

TOTAL: 100