higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

MACHINES AND PROPERTIES OF METALS N4

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This marking guideline consists of 9 pages.

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QUESTION 1

GIVEN DATA:
Belt type: V-Belt
Pitch Circle Diameter= 300 mm=0,3 m
N=1 300 r/min
Power = 28 kW
V-groove angle is 36^0
Coefficient of friction is 0,2
Belt contact angle of 140°
Maximum allowable tensile load per belt is 900 N.
REQUIRED
NUMBER OF BELTS
Calculations:

BELT SPEED (V)

$$V = \frac{\pi \times D \times N}{60} \quad \checkmark$$

$$V = \frac{\pi \times 0{,}3\text{m} \times 1300\text{r/min}}{60}$$

$$V = 20{,}42\text{m/s} \quad \checkmark$$

CENTRIFUGAL TENSION (T_c)

$$T_c = \text{Mass} \times V^2 \quad \checkmark$$

$$T_c = 0{,}6 \times 20{,}42^2$$

$$T_c = 250{,}2\text{N} \quad \checkmark$$

MAXIMUM PULL ON BELT (T_1)

$$\text{Power} = \text{work done/s} \quad \checkmark$$

$$\text{Power} = (T_1 - T_2) \times \text{distance/s} \quad \checkmark$$

$$28 \times 10^3 = (T_1 - T_2) \times 20{,}42\text{ m/s}$$

$$T_1 - T_2 = \frac{28 \times 10^3\ W}{20{,}42m/s} \quad \checkmark$$

$$T_1 - T_2 = 1371{,}2\text{ N}$$

$$T_1 = 1371{,}2\text{ N} + T_2 \quad ---------- (1)$$

BELT TENSIONS (T_1 AND T_2)

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{\frac{\mu \times \theta}{Sin\frac{\theta}{2}}} \quad \checkmark$$

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{\frac{0{,}2 \times 140^\circ}{Sin\frac{36^\circ}{2} \times 57{,}3}} \quad \checkmark$$

$$\frac{T_1 - T_C}{T_2 - T_C} = e^{1{,}518} \quad \checkmark$$

$$\frac{T_1 - T_C}{T_2 - T_C} = 4{,}859 \quad ---------- (2)$$

Substitute equation (1) in equation (2)

$$\frac{1371{,}2\ \mathrm{N} + \mathrm{T}_2 - 250{,}2N}{\mathrm{T}_2 - 250{,}2\mathrm{N}} = 4{,}859 \quad \checkmark$$

$$1371{,}2\ \mathrm{N} + \mathrm{T}_2 - 250{,}2N = 4{,}859\mathrm{T}_2 - (250{,}2 \times 4{,}859)$$

$$1371{,}2\ \mathrm{N} + \mathrm{T}_2 = 4{,}859\mathrm{T}_2 - 1215{,}73 \quad \checkmark$$

$$\mathrm{T}_2 - 4{,}859\mathrm{T}_2 = -1215{,}73 - 1371{,}2\ \mathrm{N} + 250{,}2N$$

$$-3{,}859\mathrm{T}_2 = -2336{,}73N$$

$$\mathrm{T}_2 = \frac{-2336{,}73N}{-3{,}859} \quad \checkmark$$

$$\mathrm{T}_2 = 605{,}53N$$

From equation 1 find T_1 by substituting $\mathrm{T}_2 = 605{,}53N$

$$\mathrm{T}_1 = 1371{,}2\ \mathrm{N} + \mathrm{T}_2$$

$$\mathrm{T}_1 = 1371{,}2\ \mathrm{N} + 605{,}53$$

$$\mathrm{T}_1 = 1976{,}73\ \mathrm{N} \quad \checkmark$$

NUMBER OF BELTS

$$\text{Maximum Tension} = \text{allowable tension per belt} \times \text{number of belts.}$$

$$\therefore \text{Number of belts} = \frac{Maximum\ tension(\mathrm{T}_1)}{Allowable\ tension\ per\ belt} \quad \checkmark$$

$$\therefore \text{Number of belts} = \frac{1976{,}73N}{660N} \quad \checkmark$$

$$\therefore \text{Number of belts} = 2{,}9998 \quad say\ 3\ belts$$ **[16]**

QUESTION 2

2.1 A roller chain drive operates as a series of sliding✓ bearings. The bushings pivot on the pins and the rollers turn on the bushing,✓ resulting in a smooth operation.✓ (3)

2.2
- It separates the pins and bushing to reduce friction.
- It has a cushioning effect between pins and bushings, chains and sprockets.
- It cools and cleans the chain.

(3)
[6]

QUESTION 3

3.1
- When heavy power is to be transmitted.
- When space is limited.
- When the direction of transmission is to be changed.
- When a difference in rotation frequency is required.
- When a high rotation frequency is required. (Any 2 × 1) (2)

3.2 3.2.1 Whole depth
The whole depth is the total depth of the tooth.✓
Whole depth=Addendum + Dedendum.✓

3.2.2 Working depth
The working depth is equal to two times the addendum.✓
Working depth = (addendum+ dedendum) – Clearance.✓

(2 × 2) (4)
[6]

QUESTION 4

4.1 Clutches transmit power between two co-linear shafts.✓ They obtain a temporary connection between the driver and the driven✓ shaft.✓
A coupling is a permanent connection between the driver and the driven shaft.✓

(4)

4.2 This can be remedied by roughening both contact faces✓ with coarse sandpaper.✓ (2)

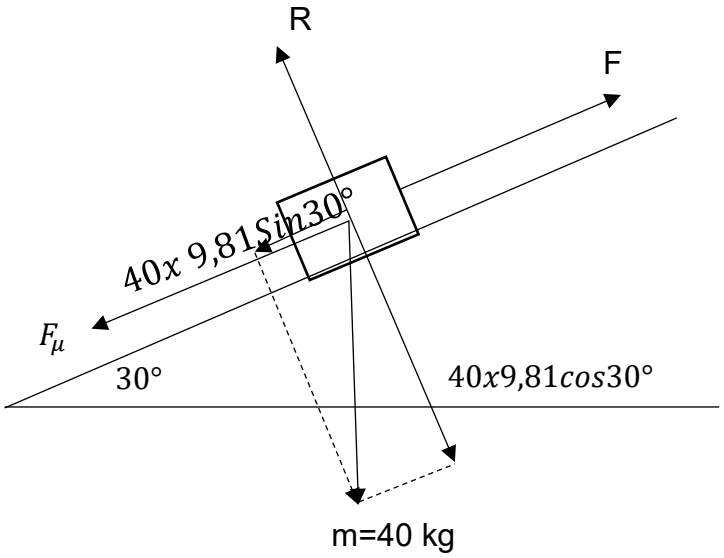
4.3
- Self-aligning couplings.
- Flexible coupling. (2)

[8]

QUESTION 5

5.1
- Causing wear and tear
- Generates heat between the surfaces.
- Consumes energy. (3)

5.2 GIVEN:



$\mu = 0{,}3$

5.2.1 Calculate the weight component perpendicular.

$$W = mg$$
$$= 40 \times 9{,}81$$
$$= 392\text{N} \quad \checkmark$$
$$F = mg \cos \theta$$
$$F = 40 \times 9{,}81 \cos 30° \checkmark$$
$$= 339{,}482\text{N} \checkmark$$ (3)

5.2.2 Calculate weight component parallel

$$F = mg \sin \theta \checkmark$$
$$F = 392 \times \sin 30°$$
$$= 196\text{N} \checkmark$$ (2)

5.2.3 Calculate weight component parallel

$$F_\mu = \mu \times F_{perpendicular\ to\ plane} \checkmark$$
$$F_\mu = 0{,}3 \times 339{,}482$$
$$F_\mu = 101{,}845\text{N} \checkmark$$ (2)

5.2.4 The external force required to hold an object stationary

$$F = F_\mu + F_{parallel\ component} \checkmark$$
$$F = 101{,}845\text{N} + 196\text{N}$$
$$= 297{,}845\text{N}$$ (2)

[12]

QUESTION 6

6.1
- All metal roofs, gutters, downpipes and waste pipes on premises where machinery is used and electricity is supplied, must be earthed.
- All metallic parts of electrical machinery must be either protected with electrical insulation or earthed. (2)

6.2 'No user shall cause every shaft, pulley, wheel, gear, coupling, collar, clutch, friction drum, and the like✓ to be securely fenced or guarded, unless it is in such a position and of such construction as to be as safe to every person as it would be if securely fenced or guarded.
No user shall cause every set screw, key✓ or bolt-on, every revolving shaft, coupling, collar, friction drum, clutch, wheel,✓ pulley, gear, and the like to be so countersunk, enclosed or otherwise guarded as to prevent danger, unless it is so situated as to be as safe as it would be if completely encased.'✓ (4)

6.3
- 'No employer shall permit the use of a portable electrical power tool with a voltage exceeding 42 volts, unless it is provided with an approved earth leakage protection system.'
- 'No employer shall permit the use of an electric power tool, unless such a tool has been provided with an efficient stop-start switch.' (2)

6.4
- 'No user shall allow the use of lifting gear, unless this gear has been soundly manufactured, is of good quality material, is well designed for strength, and is free from defects and flaws.'
- 'No user shall permit the use of machinery for lifting, unless the machinery is thoroughly inspected.' (2)

6.5
- The equipment used in electric arc welding can be dangerous and must, therefore, be handled with care.
- The equipment must be in good condition and must not be used on a wet floor.
- The flash from a welding arc can easily damage an operator's eyes. A face shield should, therefore, be worn.
- Precautions should also be taken to protect other people from being injured by welding flashes.
- Gloves should always be worn during the welding process. (Any 3 × 1) (3)

6.6 'No employer shall allow anybody to work at night unless sufficient lighting (artificial) is provided for such work.✓
The employer shall ensure that no employee work in a factory if it was constructed after current regulations had come into effect and if it has natural light of less than 15% of the floor area. Doorways not provided with glass doors shall not be classified as avenues of natural light.
The employer shall ensure that any means of providing light such as windows, roof lights, and so on, shall be kept clean and in good repair at all times.'✓ (2)
[15]

QUESTION 7

7.1 A – Supply tank
B – Master cylinder
C – Hydraulic cylinder
D – Drum (4)

7.2 Advantages:

- They are self-adjusting.
- Worn disc pads can be replaced easily and quickly.
- Wear on the pads can be easily seen.
- Efficient, even when wet.
- Takes longer before they fade. (Any 2 × 1)

Disadvantages:

- Because they have no servo action, higher operating forces and power are required.
- The higher operating forces complicate the design of the handbrake mechanism. (2 × 1) (4)

7.3

- They must have a high coefficient of friction.
- They must retain their breaking capacity at a temperature of up to 300 °C.
- They must effectively resist wear at the highest speeds, unit pressure and temperatures.
- Their cost must be low. (Any 3 × 1) (3)

[11]

QUESTION 8

8.1

- Copper
- Manganese
- Magnesium (Any 2 × 1) (2)

8.2 8.2.1 This increases not only brittleness, but also wear and abrasion resistance. With the addition of up to 1% of chromium,✓ the tensile strength is raised without reducing the ductility. When approximately 12 to 18% is added, it gives the steel a high corrosion resistance quality.✓

8.2.2 This produces a fine grain and increases the toughness and strength of steel without any loss of ductility.✓ Nickel reduces possible cracking when steel is submerged during heat treatment.✓

(2 × 2) (4)

[6]

QUESTION 9

9.1 Heat treatment is a process to change the physical properties of a metal✓ by heating it up and then cooling it off.✓ (2)

9.2 9.2.1 If steel has been over-heated, it is called 'burnt'. That means that the oxides have been forced and that the steel is ruined.✓ If steel has been only slightly overheated,✓ it can be partially restored by annealing it and then heating it afresh. But its quality will not be as high as that of steel that has been correctly heated from the start.✓ (3)

9.2.2 Because the hottest parts expand more rapidly than the cooler parts, expansion is irregular and the steel is liable to crack✓ when it is quenched.✓ Cracks form owing to the strains that have built up while steel was heated.✓ (3)
[8]

QUESTION 10

10.1 Bessemer converter (1)

10.2 10.2.1 The ability to resist fracture caused by a stretching force. All materials are tenacious to a greater or lesser degree, depending on the cohesion of their particles.

10.2.2 The ability to resist fracture caused by a force that shortens the length of a specimen. A compressible material is able to withstand huge compressive loads.

(2 × 1) (2)

10.3
- Capacities of at least four times that of Bessemer vessels.
- Quality control of the steel is much better than with the Bessemer or open-hearth processes.
- Cleaner steel with a higher carbon content can be produced.
- Bottoms of vessels last much longer than those of Bessemer converters.
- Air pollution is significantly reduced. (Any 3 × 1) (3)

[6]

QUESTION 11

11.1
- The working of a press or lift usually takes only a few seconds. The workpiece then has to be removed and replaced by another.
- The press, therefore, requires the supply of high-pressure water to be intermittent.
- To avoid the installation and operation of large pumps that have to work intermittently, hydraulic systems are generally fitted with accumulators.
- While the pump supplies water at a faster rate than the rate at which it is used, the plunger rises. But when the water demand is greater than the output of the pump, the plunger descends. (4)

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11.2
- A reciprocating piston or plunger operating within a cylindrical barrel.
- An oscillating or rotating blade or a pair of meshing gear wheels working inside a casing as in semi-rotary pumps.
- A rotating vaned wheel such as in centrifugal pumps.
- An air current as in air-lift pumps. (Any 2 × 1) (2)

[6]

TOTAL: 100

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