higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

MECHANICAL DRAWING AND DESIGN N5

(8090075)

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09:00–13:00

OPEN-BOOK EXAMINATION

This question paper consists of 5 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
MECHANICAL DRAWING AND DESIGN N5
TIME: 4 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Show ALL steps to achieve as many marks as possible. An incorrect answer which must be carried forward will receive fair consideration.
5. Make sketches freehand and in good proportion in the ANSWER BOOK.
6. Use standard-sized items where applicable.
7. Approximate ALL answers accurately to THREE decimal places.
8. Write neatly and legibly.

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QUESTION 1

A model boiler must be built for Matimba Power Station, which is one of the major electricity-generating power stations in South Africa, to operate at a working pressure of 1 250 kPa. The materials to be used include 10 mm-thick steel plates riveted together by a double-riveted butt joint. The joint is longitudinal and secured with a cover plate outside and inside the boiler. 20 mm-diameter rivets are used at a pitch of 60 mm. Both the boiler and rivets are made of the same material.

The following stresses are given with a safety factor of 4:

Tensile: 420 MPa
Shear: 300 MPa
Compressive: 600 MPa

1.1 Calculate the efficiency of the joint. (12)

1.2 Calculate the maximum permissible diameter of the boiler. (4)
[16]

QUESTION 2

TWO rods of equal diameters are joined together by a knuckle joint. The joint is designed to carry a load of 120 kN in tension. ALL parts are made of steel with allowable stress of 115 MPa in tension, 90 MPa in shear and 190 MPa in compression.

Calculate:

2.1 The diameter of the rods (3)

2.2 The diameter of the pin (3)

2.3 The thickness of the fork ends considering only crushing (2)

2.4 The thickness of the fork eye considering only tearing (2)

2.5 The diameter of the pin head (1)
[11]

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QUESTION 3

3.1 A 60 mm-diameter shaft is connected to a vehicle transmission by means of a splined connection. The number of splines cut into the shaft is 12 and the shaft is revolving at its maximum speed of 50 r/sec. Each spline is 5 mm high and 50 mm long and the allowable pressure on the splines is 5 MPa.

Determine:

3.1.1 The power that can be transmitted based only on the crushing strength of the splines (5)

3.1.2 The force required to slide the hub axially, under full load, if the coefficient of friction is 0,25 (3)

3.2 A hollow shaft with a diameter ratio of 1:0,5 transmits 4 500 kW at 300 revolutions per minute. The maximum torque is 12,5% greater than the mean torque and the maximum angle of twist is limited to 2,5° per metre length of the shaft.

Assume a modulus of rigidity of 85 GPa for the shaft material and calculate the inside and outside diameters of the shaft. Use: $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$. (11)

3.3 Compare the strength of the hollow shaft in QUESTION 3.2 with the strength of a solid shaft with the same mass and length and made of the same material. (12)

[31]

QUESTION 4

The stroke length of a mine locomotive engine is 250 mm. The piston has a diameter of 100 mm and the length of the connecting rod is 500 mm. The pressure developed during the working stroke is 2,5 MPa. Assume tensile and compressive stresses as 100 MPa and 140 MPa respectively.

Consider critical conditions and determine:

4.1 The ratio of the connecting rod length to the crank radius length (3)

4.2 The diameter of the piston rod (3)

4.3 The angle between the piston rod centre line and the crank radius (3)

4.4 The angle between the piston rod centre line and the connecting rod (3)

4.5 The force behind the piston (2)

4.6 The force under the crosshead guide (3)

4.7 The force in the connecting rod (3)

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4.8 The shear stress in the crank pin if the outside diameter of the pin is 30 mm, the inside diameter is 15 mm, the effective length of the pin is 75 mm and assuming the pin to be in double shear (7)

4.9 The crushing stress in the pin in QUESTION 4.8 (3)
[30]

QUESTION 5

A claw coupling is used to join TWO shafts which must transmit a torque of 4 500 Nm. Each half of the coupling has THREE claws. The inside diameter of the claws is 0,75 times the outside diameter.

Consider an overload factor of 12,5% for the design of the coupling and calculate:

5.1 The inside and outside diameters of the claws if the safe shear stress in the claws is 11,25 MPa (9)

5.2 The minimum length of a standard rectangular key that can be used for key coupling under the same design conditions if the allowable crushing stress for the key material is 124 MPa (3)
[12]

TOTAL: 100

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