higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T720**(E)**(N23)T

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

23 November 2018 (X-Paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and a formula sheet of 3 pages.

Copyright reserved

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
FLUID MECHANICS N6
TIME: 3 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 the necessary steps for every calculation. All units must be shown in the final answers.
5. Round off your final answers to THREE decimal places.
6. Use $g = 9{,}81\ m/s^2$.
7. ALL sketches in this question paper are not drawn to scale.
8. Write neatly and legibly.

Copyright reserved

QUESTION 1

1.1 Water is flowing at 4 m/s in a parallel pipeline which is 300 mm in diameter.

1.1.1 What is a *parallel pipeline*? (1)

1.1.2 Calculate the rate of flow of water in l/s. (3)

1.2 Define the *continuity of flow* in a piping system. (2)

1.3 A horizontal pipeline increases uniformly from 90 mm to 150 mm in the direction of flow of water. When 80 litres of water is flowing per second, the pressure gauge at the 90 mm diameter section reads 240 kPa.

What would be the reading of the gauge at the 150 mm diameter section? Ignore all friction losses. (8)

1.4 Three pipes with a diameter of d, 1,5 d and 2 d respectively are laid in parallel and connect two reservoirs. The three pipes have the same length and coefficient of friction f. The smallest pipe discharges 50 l/s.

Calculate the discharge (in m^3/s) through each of the other two pipes. (5)

1.5 A 400 mm diameter pipe with a total length of 250 m forming a siphon connects two reservoirs in which the difference in water levels is 35 m. The pipe inlet is efficiently bell-mouthed and the outlet is abrupt. The bend losses in the siphon have been observed to be 0,02 v^2 and the friction coefficient f = 0,06.

Considering only the pipe losses (Darcy), bend losses and losses at the outlet $\left(\frac{v^2}{2g}\right)$, calculate the discharge of the siphon.

(6)
[25]

QUESTION 2

2.1 Define a *wetted perimeter* of a channel. (1)

2.2 A trapezoidal channel with sides of smooth stone is 2 m wide at the base. The ratio of the sides of the channel is from 1 vertical to 3 horizontal. If the depth of the water flow is 1,5 m, determine the flow quantity if the slope of the channel is 3 m/km. Take the constant k as 0,15 and assume C as $\dfrac{87}{1+\dfrac{k}{\sqrt{m}}}$. (10)

2.3 A rectangular notch, 6 m wide, measures flow in a small river. Assume that it is a two-end contraction and that the head of the sill is 220 mm.

Calculate:

2.3.1 The rate of flow by using the Francis formula

2.3.2 The coefficient of discharge

(2 × 3) (6)

2.4 A circular orifice with an area of 600×10^{-6} issues water from the side of a container. The jet strikes the surface of the water 3 m from the side of the container which in turn is 1,5 m above the surface. The coefficient of contraction is 0,68 and the coefficient of velocity is 0,89.

Calculate:

2.4.1 The discharge of the jet in l/s (6)

2.4.2 The horizontal reaction of the jet (3)

[26]

QUESTION 3

3.1 Differentiate between a *reciprocating pump* and a *centrifugal pump* in terms of their main operating parts. (2)

3.2 A single-acting reciprocating pump has a piston with a diameter of 0,45 m and a stroke length of 0,25 m. The pipe diameter is 0,2 m and the water is lifted vertically through a height of 14 m. The pump speed is 55 r/min and the actual quantity of water delivered is 32,5 l/s.

Calculate:

3.2.1 The percentage slip in the pump (4)

3.2.2 The coefficient of discharge (2)

3.2.3 The theoretical power (2)

3.3 A centrifugal pump delivers water at 146 l/s at an operating speed of 1 600 r/min and against a total head of 400 m.

Calculate:

3.3.1 The diameter for the suction and delivery branches assuming the radial flow velocity of water at the suction outlet is 2 m/s and at the delivery outlet is 3 m/s (4)

3.3.2 The number of stages required assuming a head of 200 m per stage (2)

3.3.3 The power input to the pump if the efficiency is 78% (2)

3.4 A fan running at 400 r/min delivers 6 m^3/s air against a static head of a 40 mm water gauge. The power required for this duty is 5 kW. The speed of the fan is decreased to 250 r/min.

Calculate:

3.4.1 The volume of air that the fan will deliver

3.4.2 The static head at which the fan will deliver

3.4.3 The power required

(3 × 2) (6)

[24]

Copyright reserved

QUESTION 4

4.1 The quantity of flow through a vertical shaft Francis turbine is 0,21 m^3/s. The pressure at the inlet is 144 kPa and the diameter is 305 mm. The pressure at the tail water end is -34 kPa at a diameter of 610 mm.

Calculate:

4.1.1 The vertical height between these two points if the effective turbine pressure head is 20 m (8)

4.1.2 The input power supplied to the turbine (2)

4.2 A double jet Pelton wheel develops 6 500 kW at a speed of 480 r/min. The length of the pipeline from the reservoir is 650 m and the water level is 350 m above the jets. The bucket speed is 0,46 of the jet speed, the overall efficiency is 85% and the coefficient of friction f of the pipe is 0,005. Allow 12% for the friction losses in the pipeline. The coefficient of velocity of the jets is 0,98.

Calculate the diameter of:

4.2.1 The bucket circle (6)

4.2.2 The jets (6)

4.2.3 The supply pipe (3)

[25]

TOTAL: 100

Copyright reserved

FLUID MECHANICS N6

FORMULA SHEET

Any applicable formula may also be used.

$$Z_1 + \frac{P_{r1}}{\rho g} + \frac{V_1^2}{2g} = Z_2 + \frac{P_{r2}}{\rho g} + \frac{V_2^2}{2g} + h_L$$

$$hf = \frac{4fLV^2}{2gd}$$

$$hs = \frac{kV^2}{2g}$$

$$hs = \frac{(V_1 - V_2)^2}{2g}$$

$$hs = \frac{V^2}{2g} \times \left(\frac{1}{C_c} - 1\right)^2$$

$$Q = A.C\sqrt{mi}$$

$$Q = 1{,}84\,(L - 0{,}1\,n.H)\,H^{1,5}$$

$$Q = \frac{2}{3}\,Cd\sqrt{2g} \times L \times H^{1,5}$$

$$Q = \frac{8}{15}\,Cd\sqrt{2g} \times \tan\frac{\theta}{2} \times H^{2,5}$$

$$Q = \frac{2}{3}Cd\sqrt{2g}\;H^{1,5}\left(L + \frac{4}{5}\tan\frac{\theta}{2} \times H\right)$$

$$Q = \frac{ALSEN}{60}$$

$$Ha = \frac{L}{g} \times \frac{D^2}{d^2} \times \omega^2 \times r \times \cos\theta$$

$$hf = \frac{4fL}{2gd} \times \left[\frac{D^2}{d^2} \times \omega \times r\right]^2$$

$$hf = \frac{4fL}{2gd} \times \left[\frac{D^2}{d^2} \times \frac{\omega r}{\pi}\right]^2$$

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

$$\frac{P_{r1}}{P_{r2}} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{kW_1}{kW_2} = \left(\frac{N_1}{N_2}\right)^3$$

$$\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\right)^3$$

$$\frac{P_{r1}}{P_{r2}} = \left(\frac{D_1}{D_2}\right)^2$$

$$\frac{kW_1}{kW_2} = \left(\frac{D_1}{D_2}\right)^5$$

$$\frac{P_{r1}}{P_{r2}} = \frac{\rho_1}{\rho_2}$$

$$\frac{kW_1}{kW_2} = \frac{1}{\rho}$$

$$\frac{H_1}{H_2} = \left(\frac{Q_1}{Q_2}\right)^2$$

$$\frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2 \quad ; \quad \frac{w.g._1}{w.g._2} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{H_1}{H_2} = \frac{L_1}{L_2}$$

$$\frac{W_1}{W_2} = \left(\frac{D_1}{D_2}\right)^2$$

$$\frac{N_1^2 D_1^2}{gh_1} = \frac{N_2^2 D_2^2}{gh_2}$$

$$P_r = \frac{kSV^2}{a}$$

$$P = \rho \times g \times Q \times w.g.$$

$$P = \rho \times Q \times u(v - u)\,[1 + n \cos (180° - y)]$$

$$\eta = \frac{u}{gh}\,(v - u)\,[1 + n \cos (180° - y)] \times 100$$

Copyright reserved