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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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AUGUST EXAMINATION

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

1 August 2014 (Y-Paper)
13:00–16:00

REQUIREMENTS: Graph paper

This question paper consists of 6 pages and a formula sheet of 2 pages.

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. Write neatly and legibly.

QUESTION 1

1.1 Many factors have to be taken into consideration when designing a Pelton wheel's buckets. The same is true of the construction of the buckets.

1.1.1 Give a brief description of the design of a Pelton wheel bucket and the reason for this design with special reference to the height of the bucket, the cut-away of the outer lip and the tapered ridge in the bucket. (5)

1.1.2 Use a sketch as aid for the description in QUESTION 1.1.1. (3)

1.2 An inward flow turbine has a diameter across the top of the vane tips of 1,7 m and the diameter across the bottom of the vanes is 0,85 m. The turbine wheel runs at a speed of 200 r/min. Water is supplied at 36 m/s through fixed vanes mounted at an angle of 30° to the wheel tangent at the inlet. The water leaves the wheel with an absolute velocity of 3,5 m/s at an angle of 125° to the wheel tangent.

Determine the following:

1.2.1 The inlet and exit angles of the moving vanes to ensure that the water enters and leaves without shock (14)

1.2.2 The velocity of whirl at the inlet and the outlet of the turbine (4)
[26]

QUESTION 2

A great deal of information can be obtained from graphs very quickly. The same is true about characteristic curves of centrifugal pumps. The head/quantity (H–Q) characteristics of a certain centrifugal pump are indicated in the table below.

Delivery in ℓ/s	0	0,5	1	4,5	6	7,5	9	10,5	12	13,5
Head in m	36,3	36,2	35,4	34,4	33	30,5	27,4	24	19,5	14

This particular pump is mounted between two delivery pipes A and B. The static head of pipe A is 18 m while that of pipe B is only 12 m. When pumping through pipe A only, the pump delivers 9 ℓ/s but when pumping through pipe B only, it delivers 10,5 ℓ/s.

2.1 Calculate the friction heads for EACH pipe separately in tabular form. For pipe A from 9 ℓ/s to 3 ℓ/s and for pipe B from 10,5 ℓ/s to 4,5 ℓ/s. (10)

2.2 Sketch the pump characteristic curve on GRAPH PAPER and determine the flow through each pipe when the pump is pumping through both pipes simultaneously. (5)
[15]

QUESTION 3

3.1 A pipeline is used to convey a given quantity of water per second. The cross section of this pipeline changes suddenly.

Determine the ratio of the diameters of the pipe if the head loss at the change in the section is independent of the direction of flow.

Assume the following:

Loss in head due to sudden enlargement = $\dfrac{(V_1 - V_2)^2}{2g}$

Loss in head due to sudden contraction = $\dfrac{0{,}46(V_1)^2}{2g}$

Where V_1 = velocity in the smaller bore pipe.
V_2 = velocity in the larger bore pipe. (6)

3.2 A buried pipeline is used to convey waste water from a mine. The line is 4 km in length and has an inside diameter of 580 mm, but its flow has over the years steadily decreased to 80% of its original flow. This is due to encrustation inside the pipe. It is decided to have the pipe cleaned and then lined with cement mortar, 10 mm thick. The friction constant of this lining is 15% better than it is for the original black piping.

Calculate the percentage increase in the flow of the water that will now be delivered relative to the original quantity, assuming that the total friction loss remains constant and that the static head is negligible. (10)

[16]

QUESTION 4

Due to an expansion of production at a factory a large quantity of waste water has to be removed from the site. A trapezoidal channel is suggested to deliver water at a rate of at least 200 m^3/s.

4.1 Prove, with the aid of a neat sketch, that m = 0,5 d with 30° side slopes from the horizontal. (7)

4.2 Calculate the channel's cross-sectional dimensions (breadth and depth).

C in the Chezy formula = 60 and k = 0,735 in the Bazin formula.

$$C = \frac{87}{1 + \frac{k}{\sqrt{m}}}$$

(8)

4.3 Calculate the channel's slope in percentage. (4)

[19]

QUESTION 5

To be able to supply a sufficient quantity of drinking water to a small town, two identical single-acting plunger pumps are mounted at the reservoir. Each pump is capable of delivering 43 200 litres of water per hour. They are connected in parallel so that they can operate through a common delivery pipeline. The static head is 260 m when one pump only operates and the total pressure head is 285,5 m. Assume the same friction factor for all the pipes, uniform harmonic motion for the plungers and a pump efficiency of 75%.

Calculate the power required when:

5.1 One pump operates by itself (4)

5.2 Both pumps operate simultaneously (5)

[9]

QUESTION 6

6.1 Centrifugal pumps have many advantages over reciprocating and ram pumps.

Name THREE advantages of centrifugal pumps. (3)

6.2 Define the term *wetted perimeter.* (2)

6.3 Briefly explain what is meant by the following pump terms:

6.3.1 Static head of pump

6.3.2 Friction head

6.3.3 Velocity head

6.3.4 Atmospheric head

6.3.5 Separation head

(5 × 2) (10)
[15]

TOTAL: 100

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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