D204 Q5 2004

(a) Compare and contrast the following two iterative calculation methods for complex networks of pipes.

(i) the head balance method (also known as the Hardy Cross or loop method).

(ii) the flow balance method (also known as the quantity balance or nodal method.

Explain briefly how and in what situation each of the methods may be used and state which of the correction methods shown at the end of this question is used in which method.

SOLUTION PART (a)

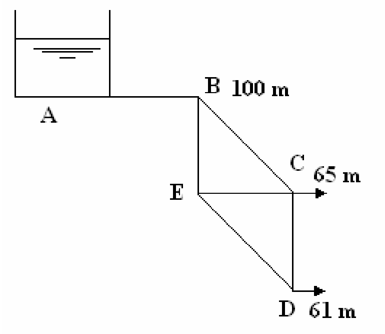
The nodal balance method is used for solving problems involving many pipes with a common junction where the total flow into the junction must be zero. The correction factor used for iteration is

$$\Delta H = \frac{2\,\Delta Q}{\sum Q/h_f}$$

The flow balance method is used for problems with multiple loops where the total head loss around a given loop is zero. The correction factor to be used is

$$\Delta Q = \frac{-\sum h_f}{2\sum h_f/Q}$$

(b) Water is supplied from a large reservoir at A to a pipe network BCDE as shown, in the diagram. The frictional resistances of the various pipes are given by the K value in the table which may be used with the formula $h_f = KQ^2$ to relate the magnitude of head loss h_f in the pipeline to the volumetric flow rate Q. Water is drawn at constant flow rates from the network at nodes C and D. The static heads (elevation + pressure head) at nodes B, C and D are 100m, 65m and 61m respectively above the local datum. Calculate the discharges at C and D and the water level in reservoir A. (The data has been added to diagram to aid the solution)



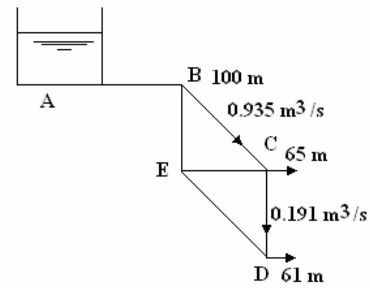
Use no more than 3 iterations and 3 significant figures

TABLE

Pipeline	AB	BC	CD	DE	CE	BE
K s^2m^5	4	40	110	25	25	35

SOLUTION PART (b)

The problem must be solved as two loops with a common pipe EC. First calculate the flows in known pipes.



BC $h_f = 35$ m $Q = (h_f/K)^{1/2} = (35/40)^{1/2} = 0.935\ m^3/s$

CD $h_f = 4$ m $Q = (h_f/K)^{1/2} = (4/110)^{1/2} = 0.191\ m^3/s$

The solution evolves around doing a flow balance at node E.

1st ITERATION Guess $h_E = 80$

PIPE	K	h_f	$Q = (h_f/K)^{1/2}$	Q/h_f
BE	35	20	0.756	0.0378 (into junction)
EC	25	-15	-0.775	0.0516 (out of junction)
ED	25	-19	-0.872	0.0349 (out of junction)
Totals			-0.89	0.135

$$\sum h_f = \frac{2\,\Delta Q}{\sum Q/h_f} = \frac{2 \text{ x } (-0.89)}{0.135} = -13.16$$

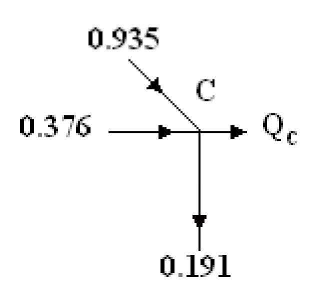
2nd ITERATION Guess h_E = 80 -13.16 = 66.84

PIPE	K	h_f	$Q = (h_f/K)^{1/2}$	Q/h_f
BE	35	20	0.0294	0.0378
EC	25	-15	-0.148	0.0516
ED	25	-19	-0.083	0.0349
Totals			0.219	0.26

$$\sum h_f = \frac{2\,\Delta Q}{\sum Q/h_f} = \frac{2 \text{ x } (0.219)}{0.26} = 1.686$$

3rd ITERATION Guess h_E = 66.84 + 1.69 = = 68.53

PIPE	K	h_f	$Q = (h_f/K)^{1/2}$	Q/h_f
BE	35	20	0.948	0.0301
EC	25	-15	-0.376	0.106
ED	25	-19	-0.549	0.0729
Totals			0.0241	0.23

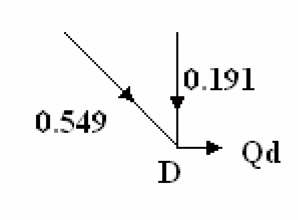


Further iterations will show only minor corrections giving flows of 0.945, -0.388 and -0.557. If these figures are used you get the answers given by the examiner.

We can now calculate Qc and Qd

0.935 + 0.376 – 0.191+ Qc = 0

Qc = -1.12 m^3/s



0.549 + 0.191 + Qd = 0

Qd = -0.74 m^3/s

Total flow from the reservoir is 1.12 + 0.74 = 1.86 m^3/s

Head loss pipe AB is $h_f = kQ^2 = 4 \text{ x } 1.86^2 = 13.8$ m

Head at entrance to pipe is 113.8 m