1.11.2 An alternative method

An alternative method (although based on the same theory) is shown below using the Darcy equation in terms of Q

$$h_f = \frac{fLQ^2}{3d^5}$$

And the loss equations in terms of Q:

$$h_L = k\frac{u^2}{2g} = k\frac{Q^2}{2gA^2} = k\frac{4^2}{2g\pi^2}\frac{Q^2}{d^2} = 0.0826\,k\frac{Q^2}{d^4}$$

For Pipe 1

$$10 = h_{L\,entry} + hf + h_{L\,exit}$$

$$10 = 0.0826 \times 0.5\frac{Q^2}{0.05^4} + \frac{0.008 \times 100Q^2}{3 \times 0.05^5} + 0.0826 \times 1.0\frac{Q^2}{0.05^4}$$

$$Q = 0.0034\,m^3/s$$

$$Q = 3.4\,litres/s$$

For Pipe 2

$$10 = h_{L\,entry} + hf + h_{L\,exit}$$

$$10 = 0.0826 \times 0.5\frac{Q^2}{0.1^4} + \frac{0.008 \times 100Q^2}{3 \times 0.1^5} + 0.0826 \times 1.0\frac{Q^2}{0.1^4}$$

$$Q = 0.0188\,m^3/s$$

$$Q = 18.8\,litres/s$$

1.12 Branched pipes

If pipes connect three reservoirs, as shown in Figure 17, then the problem becomes more complex. One of the problems is that it is sometimes difficult to decide which direction fluid will flow. In practice solutions are now done by computer techniques that can determine flow direction, however it is useful to examine the techniques necessary to solve this problem.

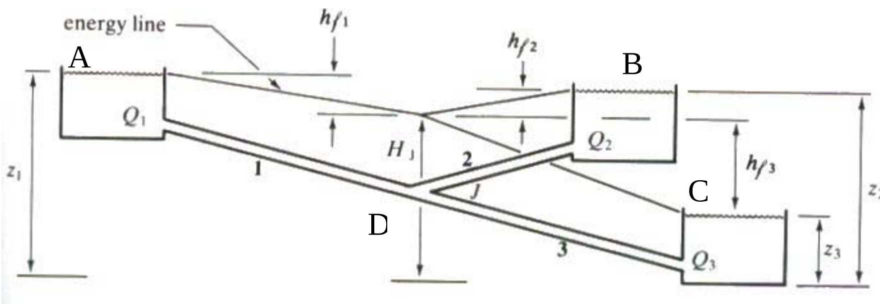

Figure 17: The three reservoir problem

For these problems it is best to use the Darcy equation expressed in terms of discharge – i.e. equation 7.

$$h_f = \frac{fLQ^2}{3d^5}$$

When three or more pipes meet at a junction then the following basic principles apply:

1. The continuity equation must be obeyed i.e. total flow into the junction must equal total flow out of the junction;
2. at any one point there can only be one value of head, and
3. Darcy's equation must be satisfied for each pipe.

It is usual to ignore minor losses (entry and exit losses) as practical hand calculations become impossible – fortunately they are often negligible.

One problem still to be resolved is that however we calculate friction it will always produce a positive drop – when in reality head loss is in the direction of flow. The direction of flow is often obvious, but when it is not a direction has to be assumed. If the wrong assumption is made then no physically possible solution will be obtained.

In the figure above the heads at the reservoir are known but the head at the junction D is not. Neither are any of the pipe flows known. The flow in pipes 1 and 2 are obviously from A to D and D to C respectively. If one assumes that the flow in pipe 2 is from D to B then the following relationships could be written:

$$z_a - h_D = h_{f1}$$

$$h_D - z_b = h_{f2}$$

$$h_D - z_c = h_{f3}$$

$$Q_1 = Q_2 + Q_3$$

The h_f expressions are functions of Q, so we have 4 equations with four unknowns, h_D, Q_1, Q_2 and Q_3 which we must solve simultaneously.