MINOR LOSSES IN PIPE FLOW

Additional frictional losses occur at pipe entry, valves and fittings, sudden decrease or increase in flow area or where direction of flow changes. The frictional losses other than pipe friction are called minor losses. In a pipe system design, it is necessary to take into account all such losses.

These losses are generally expressed as hf = C $u_m^2/2g$ where C is constant, the value of which will depend on the situation and is called the loss coefficient. The expression is applicable both for laminar and turbulent flows.

(i) Loss of head at entrance: At the entrance from the reservoir into the pipe, losses take place due to the turbulence created downstream of the entrance. Three types of entrances are known.

(a) Bell mouthed: This is a smooth entrance and turbulence is suppressed to a great extent and C = 0.04 for this situation.

(b) Square edged entrance: Though it is desirable to provide a bell mouthed entrance it will not be always practicable. Square edged entrance is used more popularly. The loss coefficient, C = 0.5 in this case.

(c) Reentrant inlet: The pipe may sometimes protrude from the wall into the liquid. Such an arrangement is called reentrant inlet. The loss coefficient in this case is about 0.8.

(ii) Loss of head at submerged discharge: When a pipe with submerged outlet discharges into a liquid which is still (not moving) whole of the dynamic head $u^2/2g$ will be lost. The loss coefficient is 1.0. The discharge from reaction turbines into the tail race water is an example. The loss is reduced by providing a diverging pipe to reduce the exit velocity.

(iii) Sudden contraction: When the pipe section is suddenly reduced, loss coefficient depends on the diameter ratio. The value is 0.33 for D2/D1 = 0.5. The values are generally available in a tabular statement connecting D2/D1 and loss coefficient. Gradual contraction will reduce the loss. For gradual contraction it varies with the angle of the transition section from 0.05 to 0.08 for angles of 10° to 60°.

(iv) Sudden expansion: Here the sudden expansion creates pockets of eddying turbulence leading to losses. The loss of head *hf* is given by

Loss of head = (u1 – u2)2 / 2g.

where u1 and u2 are the velocities in the smaller and larger sections. Gradual expansion will reduce the losses.

(v) Valves and fittings : Losses in flow through valves and fittings is expressed in terms of an equivalent length of straight pipe. For gate valves L = 8D, and for globe valves it is 340 D. For 90° bends it is about 30 D.

LOSSES IN ELBOWS, BENDS AND OTHER PIPE FITTINGS

Fittings like valves, elbows etc. introduce frictional losses either by obstruction or due to secondary flows. The losses may be accounted for by a term equivalent length which will depend on the type of fitting or in terms of ($u^2/2g$) or dynamic head. In the case of bends, the loss is due to the variation of centrifugal force along different stream lines which causes secondary flows. In large bends fitting curved vanes will reduce the loss. The loss will vary with radius of the bend. Globe valves are poorer compared to gate valves with regard to pressure drop.

CONCEPT OF EQUIVALENT LENGTH

For calculation of minor losses it is more convenient to express the pressure drop in fittings, expansion–contraction and at entry in terms of a length of pipe which will at that discharge rate lead to the same pressure drop. This length is known as equivalent length, Le. From the relation knowing C, f and D.

Le um2/2g D = C um2/2g Le can be calculated

As a number of fittings at various positions may be involved causing minor losses in a pipe system, this is a convenient way to estimate minor losses.