1.5.2 Losses at Sudden Contraction

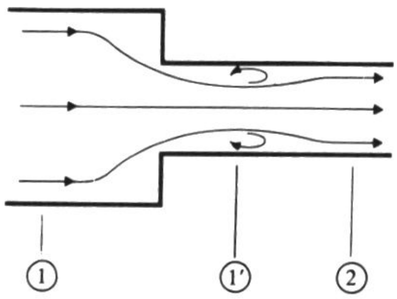


Figure 7: Sudden Contraction

In a sudden contraction, flow contracts from point 1 to point 1', forming a vena contraction. From experiment it has been shown that this contraction is about 40% (i.e. $A_{1'} = 0.6\ A_2$). It is possible to assume that energy losses from 1 to 1' are negligible (no separation occurs in contracting flow) but that major losses occur between 1' and 2 as the flow expands again. In this case Equation 16 can be used from point 1' to 2 to give: (by continuity $u_1 = A_2u_2/A_1 = A_2u_2/0.6A_2 = u_2/0.6$)

$$h_L = \left(1 - \frac{0.6A_2}{A_2}\right)^2 \frac{(u_2/0.6)^2}{2g}$$

$$h_L = 0.44\frac{u_2^2}{2g}$$

Equation 22

i.e. At a sudden contraction $k_L = 0.44$.

1.5.3 Other Local Losses

Large losses in energy in energy usually occur only where flow expands. The mechanism at work in these situations is that as velocity decreases (by continuity) so pressure must increase (by Bernoulli).

When the pressure increases in the direction of fluid outside the boundary layer has enough momentum to overcome this pressure that is trying to push it backwards. The fluid within the boundary layer has so little momentum that it will very quickly be brought to rest, and possibly reversed in direction. If this reversal occurs it lifts the boundary layer away from the surface as shown in Figure 8. This phenomenon is known as **boundary layer separation.**

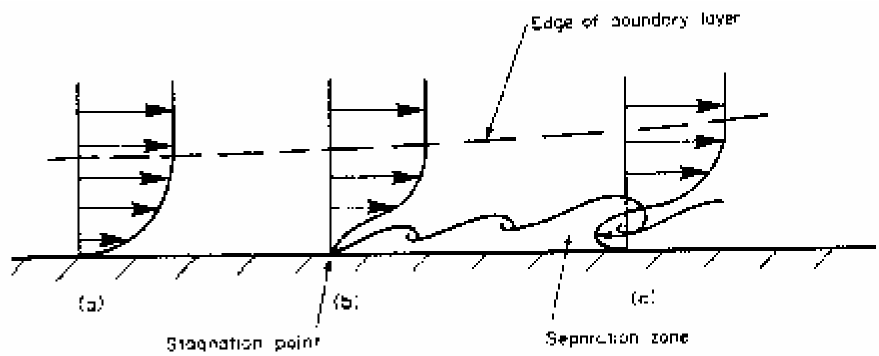
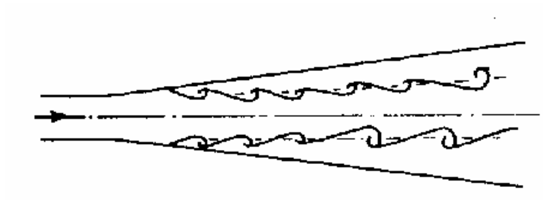


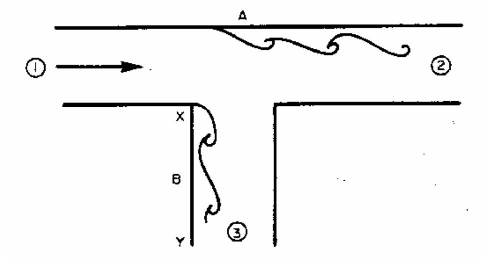
Figure 8: Boundary layer separation

At the edge of the separated boundary layer, where the velocities change direction, a line of vortices occur (known as a vortex sheet). This happens because fluid to either side is moving in the opposite direction. This boundary layer separation and increase in the turbulence because of the vortices results in very large energy losses in the flow. These separating / divergent flows are inherently unstable and far more energy is lost than in parallel or convergent flow.

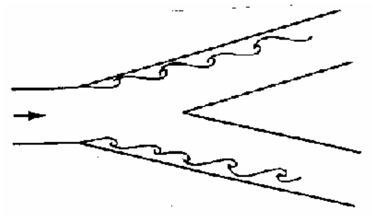
Some common situation where significant head losses occur in pipe are shown in figure 9



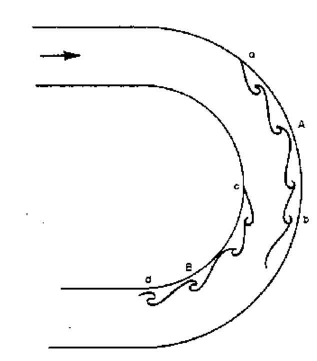
A divergent duct or diffuser



Tee-Junctions



Y-Junctions



Bends

Figure 9: Local losses in pipe flow

The values of k_L for these common situations are shown in Table 2. It gives value that are used in practice.

	k_L value
	Practice
Bellmouth entry	0.10
Sharp entry	0.5
Sharp exit	0.5
90° bend	0.4
90° tees	
In-line flow	0.4
Branch to line	1.5
Gate value (open)	0.25

Table 2: k_L values