are the most important characteristics which determine the rate and type of flow and the position at which the metal enters the mould cavity. The dimensional characteristics of any gating system are expressed in terms of gating ratio, $a:b:c$ where a = cross sectional area of sprue or down runner, b = total cross sectional area of runners, and c = total cross sectirnal area· of ingates. The gating ratio used in industries varies widely. It mainly emphasises the general feature of gating system, i.e. whether the system is pressurised in which cross section diminishes towards the casting providing a choke effect (e.g. gating ratio 1:2:4), or non pressurised in which the area increases giving a reverse choke effect (e.g. gating ratio 1:2:1).

In pressurised systems, the rate and distribution of metal flow are more predictable but the metal tends to enter the casting at high velocity giving a jet effect. On the other hand, unpressurised system cause irregular flow of metal and aspiration of air. These factors should be considered with respect to metal cast. However, in general, an ideal system for all purposes would be one in which pressure is sufficient to maintain all passages full just to avoid aspiration of air. The location and dimensions of the gating system are not only important to avoid turbulence, but mould filling is also an important objective, particularly for thin castings. In case of thin castings, the gating system should be so designed as to flush metal rapidιy but progressively through sections, otherwise laps and misruns may be caused. However, in case of thicker castings preventing of turbulence is more important to avoid mould erosion and to obtain proper temperature gradients. Gating system can be computed by the following methods:

(i) For light metals and alloys such as aluminium, magnesium, titanium, etc. and their alloys, the gating system can be designed on the basis of feed metal criterion K_m which is defined by

$$K_m = W/t \tag{7.44}$$

where W = weight of casting in Kg. with gates and risers

and t = time of pouring in seconds.

Experiments show that feeding is adequate for

(i) aluminium alloys when $K_m > 0.3\sqrt{W}$ Kg/sec and

(ii) magnisium alloys when $K_m > 0.2\sqrt{W}$ Kg/sec.

Based on feed metal criterion, the choke area

A_{choke} can be given by

$$A_{\text{choke}} = \frac{K_m \times 1000}{\mu\sqrt{2gh}} \text{ cm}^2 \tag{7.45}$$

If the rate of metal flow is less than 1·7 Kg/sec., one sprue is sufficient, whereas for large castings if the rate exceeds, more than one sprue should be used.

(i) Empirical methods based on stastical treatment of plant data can be used to compute the gating system. These methods establish the relationship between the velocity of metal flow, pouring time, and choke area. One such system given by Dietert is as following:

If the surface area of casting is S, the volume of solidified metal (V_{sol}) during the pouring process will be

$$V_{sol} = x_m S \tag{8.8}$$

and liquid metal $$V_l = V_0 - V_{sol} \tag{8.9}$$

Assuming the volumetric shrinkage of steel in solidification to be equal to approximately 3 pct., the volume of shrinkage cavities in the casting (V_{cc}) is given by

$$V_{cc} = 0.03\,(V_0 - V_{sol}) \tag{8.10}$$

Similarly shrinkage in the riser (V_{cr}) will be

$$V_{cr} = 0.03\,V_r \tag{8.11}$$

where V_r = volume of riser

If the riser is cylindrical of height h and diameter d, then

$$V_{cr} = 0.03\,\frac{\pi d^2 h}{4} \tag{8.12}$$

The total volume of the shrinkage cavity in the riser ($\sum V_{sc}$) will comprise the volumes of shrinkage cavities in the casting and the riser. Hence

$$\sum V_{sc} = V_{cc} + V_{cr} = 0.03\,(V_0 - V_{Sol}) + \frac{0.03\,\pi\,d^2 h}{4} \tag{8.13}$$

The shape of the shrinkage cavity in riser for steel castings obeys a parabolic law and is of conical shape. If n is the ratio between cone base and the riser diameter, then

$$\sum V_{Sc} = \frac{\pi\,(nd)^2\,h}{12} = 0.03\,(V_0 - V_{sol}) + 0.0075\,\pi d^2 h \tag{8.14}$$

with bottom gating cone base is 0.5 d and with top gating the cone base is 0.6 d.

Equations (8.7) and (8.8) can be used to solve equation (8.14) for h,

$$h = \frac{0.0575\,(2V_0 - k\,S\sqrt{t}}{(n^2 - 0.09)\,d^2} \tag{8.15}$$

When pouring time is quite short (for ball or cube shaped castings with high V/A ratio), the expression $kS\sqrt{t}$ tends to zero and can be neglected. Then the equation (8.15) gets simplified as

$$h = \frac{0.115\,V_0}{(n^2 - 0.09)\,d^2} \tag{8.16}$$

In case of large castings of small V/A ratio, the term $kS\sqrt{t}$ becomes nearer to $2V_0$ and the numerator of Eq. (8.15) becomes zero. This will also occur at slow rates of pouring and hence risers are no longer required.

where β = ratio of the cavity volume in the riser to the riser volume (usually 0.1 to 0.13)

V_c = volume of casting

a_{cr} = combined shrinkage of casting and riser

8.3.3 Combined Methods for Calculation of Riser Size

(i) *Merchant's Method*

H.D. Merchant proposed an improvement on the Caine's or N.R.L. methods by introducing solidification shrinkage and shape factors for the risers. He obtained the general relation as follows:

$$\frac{25\,(4P+1)}{A_c} = \frac{PD}{\alpha V_c} - \frac{1.275}{nD^2} \qquad (8.26)$$

where P = diameter to height ratio of riser (H/D)

n = number of risers needed

and α = solidification shrinkage in pct.

(ii) *Heine's Method,*

R.W. Heine developed a suitable method of riser calculation for malleable iron castings. The method is based on the actual measurement of the pipe in a casting and riser system which produces a sound casting. The actual measurement of the pipe can be carried out by (a) filling the pipe with water and measuring the volume, (b) comparing the weight of the riser with the expected weight calculated from the external diamensions, or (c) based on prior knowledge of the casting characteristics of the alloy. The procedure of calculating the riser size is outlined as below taking reference of Fig. 8.5.

(a) Find the weight of the casting.
(b) Find the volume of the feed metal required by the castings which is given by

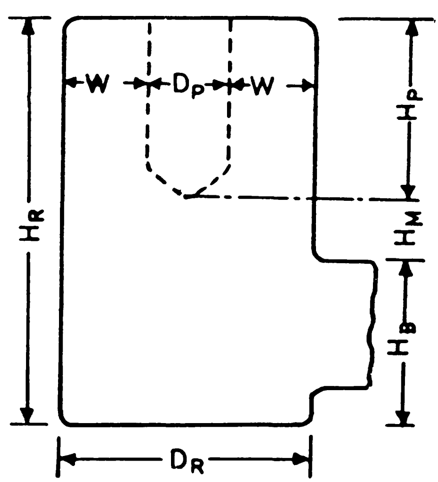

Fig. 8.5 Illustration of the calculation of riser size for maleable iron castings

required, a further check is necessary to verify that the feed volume from the proposed riser will be sufficient under the given conditions.

The modulus calculations for intricate castings are simplified by employing the principle of substitute bodies. The plain shapes are substituted for more elaborate shapes of equivalent modulus on the basis that two bodies of equal modulus will solidify in the same time. Wlodawer has shown that angular and curved bodies of the same ruling dimension have the same modulus as shown by sphere, cylinder, and cube (Fig. 8.6). This figure shows that calculation can be simplified by replacing an irregularly shaped body by one having approximately equivalent mass. Similarly, rings and hallow cylinders can be treated equivalent to bars or plates which they would form on opening out. A number of generalised formulae tables and charts can be used to determine the moduli of the simpler shapes resulting from the break down of a complicated shape.

As shown in Fig. 8.6, the modulus of the most compact bodies (sphere, cube and equiaxed cylinder) is same, i.e. $d/6$ for a ruling dimension d. In case of bars and plates having the same ruling dimension, d, the ratio of modulus to d increases from the minimum represented by most compact bodies towards a limiting value at which end effects become negligible. The progressive change in the modulus with decreasing thickness is represented in Fig. 8.7.

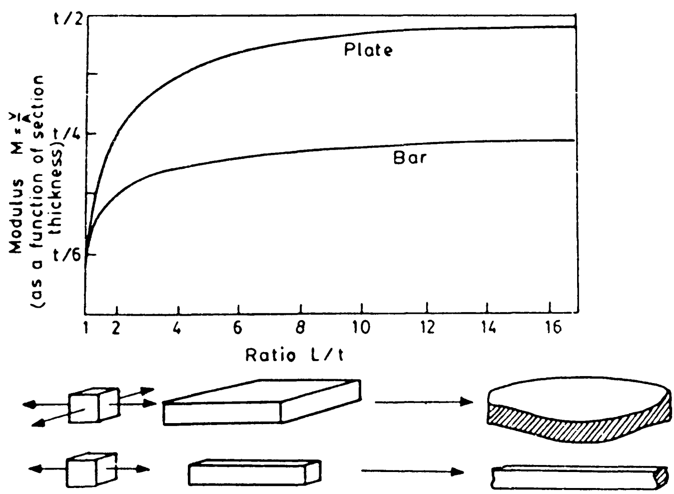

Fig. 8.7 Progressive change in the monulus with deceasing thickness

If end effects are absent, the modulus of a bar of given section can be calculated from the general formula

$$M = \frac{\text{cross sectional area}}{\text{perimeter}} \tag{8.32}$$

or

$$M = \frac{a\,b}{2\,(a + b)} \tag{8.33}$$

where a and b are the cross-sectional dimensions.