Induced drag predominates at speeds below the point of minimum total drag. When the airplane is operated at the condition of minimum power required, the total drag is 75 percent induced drag and 25 percent parasite drag. Thus, the induced drag is three times as great as the parasite drag when at minimum power required.

VARIATIONS OF THRUST REQUIRED AND POWER REQUIRED

The curves of thrust required and power required versus velocity provide the basis for comprehensive analysis of all the major items of airplane performance. The changes in the drag and power curves with variations of airplane gross weight, configuration, and altitude furnish insight for the variation of range, endurance, climb performance, etc., with these same items.

The effect of a change in weight on the thrust and power required is illustrated by figure 2.2. The primary effect of a weight change is a change in the induced drag and induced power required at any given speed. Thus, the greatest changes in the curves of thrust and power required will take place in the range of low speed flight where the induced effects predominate. The changes in thrust and power required in the range of high speed flight are relatively slight because parasite effects predominate at high speed. The induced effects at high speed are relatively small and changes in these items produce a small effect on the total thrust or power required.

In addition to the general effect on the induced drag and power required at particular speeds, a change in weight will require that the airplane operate at different airspeeds to maintain conditions of a specific lift coefficient and angle of attack. If the airplane is in steady flight at a particular C_L, the airpseed required for this C_L will vary with weight in the following manner:

$$\frac{V_2}{V_1}=\sqrt{\frac{W_2}{W_1}}$$

where

V_1 = speed corresponding to a specific C_L and weight, W_1

V_2 = speed corresponding to the same C_L but a different weight, W_2

For the example airplane of figure 2.2, a change of gross weight from 15,000 to 22,500 lbs. requires that the airplane operate at speeds which are 22.5 percent greater to maintain a specific lift coefficient. For example, if the 15,000-lb. airplane operates at 160 knots for $(L/D)_{max}$, the speed for $(L/D)_{max}$ at 22,500 lbs. is:

$$\begin{aligned} V_2 &= V_1\sqrt{\frac{W_2}{W_1}} \\ &= 160\sqrt{\frac{22{,}500}{15{,}000}} \\ &= (160)\,(1.225) \\ &= 196 \text{ knots} \end{aligned}$$

The same situation exists with respect to the curves of power required where a change in weight requires a change of speed to maintain flight at a particular C_L. For example, if the 15,000-lb. airplane achieves minimum power required at 122 knots, an increase in weight to 22,500 lbs. increases the speed for minimum power required to 149 knots.

Of course, the thrust and power required at specific lift coefficients are altered by changes in weight. At a specific C_L, any change in weight causes a like change in thrust required, e.g., a 50-percent increase in weight causes a 50-percent increase in thrust required at the same C_L. The effect of a weight change on the power required at a specific C_L is a bit more complex because a change in speed accompanies the change