of the expansive force as possible and of scavenging the cylinder as completely and rapidly as possible. The valve is opened considerably before BDC on the power stroke (on some engines at 50° and 75° before BDC) while there is still some pressure in the cylinder. This timing is used so that the pressure can force the gases out of the exhaust port as soon as possible. This process frees the cylinder of waste heat after the desired expansion has been obtained and avoids overheating the cylinder and the piston. Thorough scavenging is very important, because any exhaust products remaining in the cylinder dilute the incoming fuel/air charge at the start of the next cycle.

Exhaust Stroke

As the piston travels through BDC at the completion of the power stroke and starts upward on the exhaust stroke, it begins to push the burned exhaust gases out the exhaust port. The speed of the exhaust gases leaving the cylinder creates a low pressure in the cylinder. This low or reduced pressure speeds the flow of the fresh fuel/air charge into the cylinder as the intake valve is beginning to open. The intake valve opening is timed to occur at 8° to 55° before TDC on the exhaust stroke on various engines.

Two-Stroke Cycle

The two-stroke-cycle engine has re-emerged being used in ultra-light, light sport, and many experimental aircraft. As the name implies, two-stroke cycle engines require only one upstroke and one down stroke of the piston to complete the required series of events in the cylinder. Thus, the engine completes the operating cycle in one revolution of the crankshaft. The intake and exhaust functions are accomplished during the same stroke. These engines can be either air or water cooled and generally require a gear reduction housing between the engine and propeller.

Rotary Cycle

The rotary cycle has a three-sided rotor that turns inside an elliptical housing, completing three of the four cycles for each revolution. These engines can be single rotor or multi rotor and can be air or water cooled. They are used mostly with experimental and light aircraft. Vibration characteristics are also very low for this type of engine.

Diesel Cycle

The diesel cycle depends on high compression pressures to provide for the ignition of the fuel/air charge in the cylinder. As air is drawn in the cylinder, it is compressed by a piston and, at maximum pressure, fuel is sprayed in the cylinder. At this point, the high pressure and temperature in the cylinder causes the fuel to burn increasing the internal pressure of the cylinder. This drives the piston down, turning or driving the crankshaft. Water and air cooled engines that can operate on JET A fuel (kerosene) use a version of the diesel cycle. There are many types of diesel cycles in use including two-stroke and four-stroke diesels.

Reciprocating Engine Power and Efficiencies

All aircraft engines are rated according to their ability to do work and produce power. This section presents an explanation of work and power and how they are calculated. Also discussed are the various efficiencies that govern the power output of a reciprocating engine.

Work

A physicist defines work as force times distance. Work done by a force acting on a body is equal to the magnitude of the force multiplied by the distance through which the force acts.

$$\text{Work (W)} = \text{Force (F)} \times \text{Distance (D)}$$

Work is measured by several standards. The most common unit is called foot-pound (ft-lb). If a one-pound mass is raised one foot, one ft-lb of work has been performed. The greater the mass is and/or the greater the distance is, the greater the work performed.

Horsepower

The common unit of mechanical power is the horsepower (hp). Late in the 18th century, James Watt, the inventor of the steam engine, found that an English workhorse could work at the rate of 550 ft-lb per second, or 33,000 ft-lb per minute, for a reasonable length of time. From his observations came the unit of horsepower, which is the standard unit of mechanical power in the English system of measurement. To calculate the hp rating of an engine, divide the power developed in ft-lb per minute by 33,000, or the power in ft-lb per second by 550.

$$\text{One hp} = \frac{\text{ft-lb per min}}{33{,}000}$$

or

$$\frac{\text{ft-lb per sec}}{550}$$

As stated above, work is the product of force and distance, and power is work per unit of time. Consequently, if a 33,000-lb weight is lifted through a vertical distance of 1 foot in 1 minute, the power expended is 33,000 ft-lb per minute, or exactly 1 hp.

Work is performed not only when a force is applied for lifting; force may be applied in any direction. If a 100-lb weight is dragged along the ground, a force is still being applied to perform work, although the direction of the resulting motion