30.2 Oxyfuel-gas Welding

Oxyfuel-gas welding (OFW) is a general term to describe any welding process that uses a **fuel gas** combined with *oxygen* to produce a flame, which is the source of the heat required to melt the metals at the joint. The most common gas-welding

process uses *acetylene*; the process is known as *oxyacetylene–gas welding* (OAW) and is typically used for structural metal fabrication and repair work.

Developed in the early 1900s, OAW utilizes the heat generated by the combustion of acetylene gas (C_2H_2) in a mixture with oxygen. The heat is generated in accordance with a pair of chemical reactions. The primary combustion process, which occurs in the inner core of the flame (Fig. 30.1), involves the following reaction:

$$C_2H_2 + O_2 \rightarrow 2CO + H_2 + \text{Heat}. \tag{30.1}$$

This reaction dissociates the acetylene into carbon monoxide and hydrogen and produces about one-third of the total heat generated in the flame. The secondary combustion process is

$$2CO + H_2 + 1.5O_2 \rightarrow 2CO_2 + H_2O + \text{Heat}. \tag{30.2}$$

This reaction consists of the further burning of both the hydrogen and the carbon monoxide, and produces about two-thirds of the total heat. The temperatures developed in the flame can reach 3300°C. Note from Eq. (30.2) that the reaction also produces water vapor.

Types of Flames. The proportion of acetylene and oxygen in the gas mixture is an important factor in oxyfuel–gas welding. At a ratio of 1:1 (i.e., when there is no excess oxygen), the flame is considered to be *neutral* (Fig. 30.1a). With a higher oxygen supply, the flame can be harmful (especially for steels), because it oxidizes the metal; for this reason, a flame with excess oxygen is known as an **oxidizing flame** (Fig. 30.1b). Only in the welding of copper and copper-based alloys is an oxidizing flame desirable, because in those situations, a thin protective layer of *slag* (compounds of oxides) forms over the molten metal. If the oxygen is insufficient for full combustion, the flame is known as a **reducing**, or **carburizing, flame** (Fig. 30.1c).

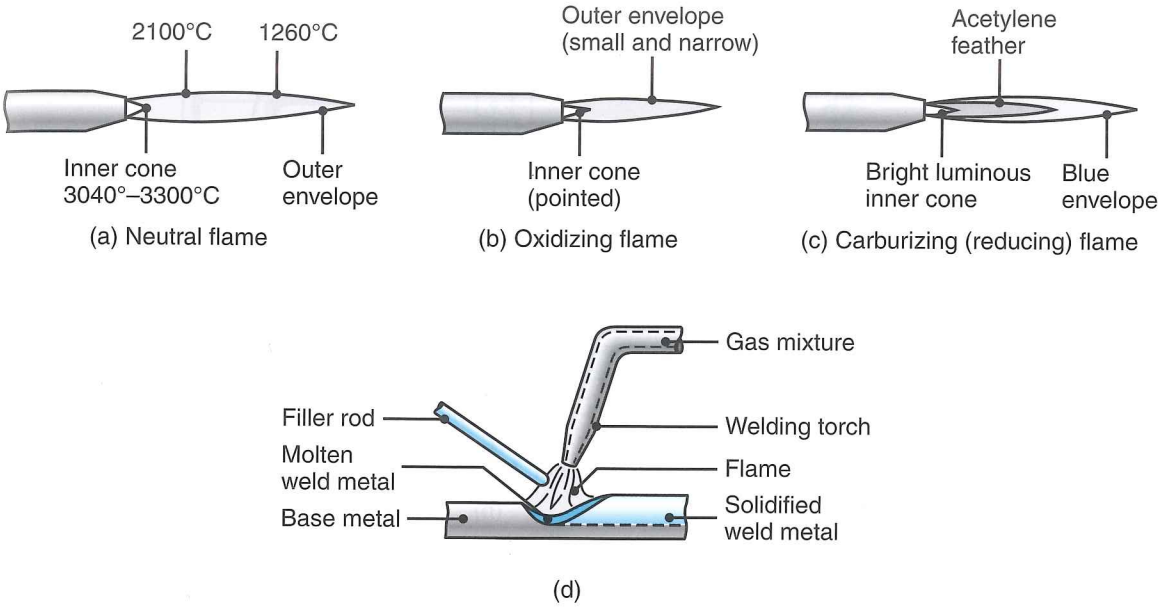

FIGURE 30.1 Three basic types of oxyacetylene flames used in oxyfuel–gas welding and cutting operations: (a) neutral flame; (b) oxidizing flame; and (c) carburizing, or reducing, flame. The gas mixture in (a) is basically equal volumes of oxygen and acetylene. (d) The principle of the oxyfuel–gas welding process.

The temperature of a reducing flame is lower, hence such a flame is suitable for applications requiring low heat, as in brazing and soldering (Chapter 32) and flame-hardening (Table 4.1) operations.

Other fuel gases, such as hydrogen and methylacetylene propadiene, also can be used in oxyfuel–gas welding. However, the temperatures developed by these gases are lower than those produced by acetylene, hence they are used for welding metals with low melting points, such as lead, and parts that are thin and small.

Filler Metals. *Filler metals* are used to supply additional metal to the weld zone during welding, and are available as **filler rods** or **wire** (Fig. 30.1d) and may be bare or coated with **flux**. The purpose of the flux is to retard oxidation of the surfaces of the parts being welded, by generating a gaseous shield around the weld zone. The flux also helps to dissolve and remove oxides and other substances from the weld zone, thus making the joint stronger. The *slag* developed (compounds of oxides, fluxes, and electrode-coating materials) protects the molten puddle of metal against oxidation as the weld cools.

Welding Practice and Equipment. Oxyfuel–gas welding can be used with most ferrous and nonferrous metals for almost any workpiece thickness, but the relatively low heat input limits the process to thicknesses of less than 6 mm. Small joints made by this process may consist of a single-weld bead; deep-V groove joints are made in multiple passes. Cleaning the surface of each weld bead prior to depositing a second layer over it is important for joint strength and in avoiding defects (see Section 30.9). Wire brushes (hand or power) may be used for this purpose.

The equipment for oxyfuel–gas welding basically consists of a **welding torch**, connected by hoses to high-pressure gas cylinders and equipped with pressure gages and regulators (Fig. 30.2). The use of safety equipment, such as proper goggles

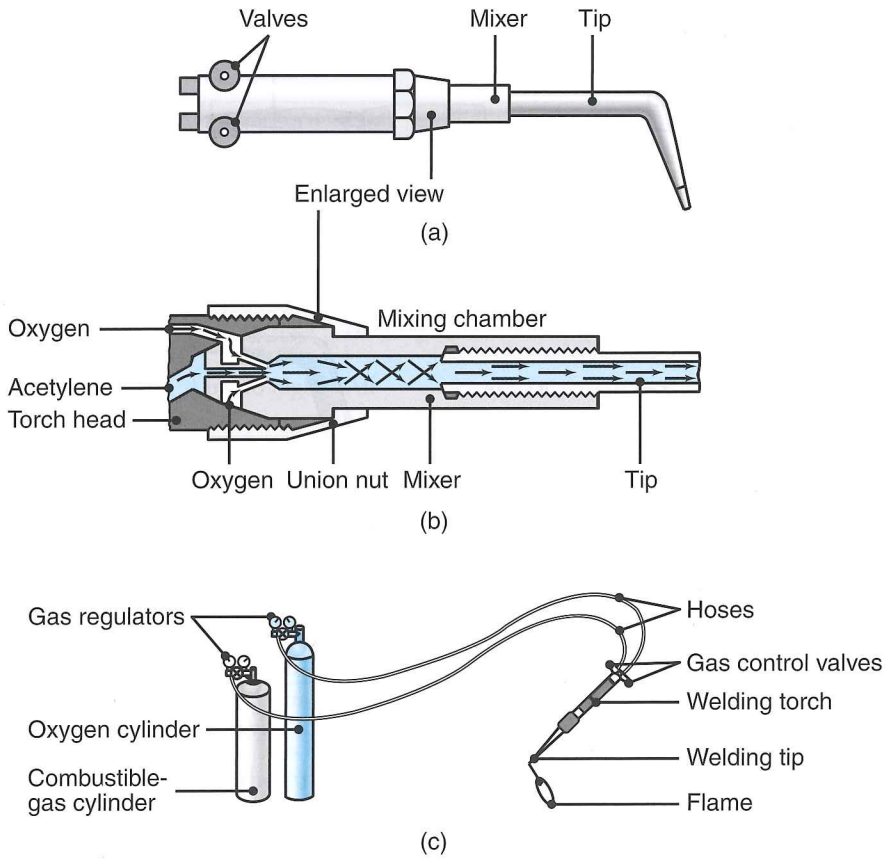

FIGURE 30.2 (a) General view of, and (b) cross-section of, a torch used in oxyacetylene welding. The acetylene valve is opened first; the gas is lit with a spark lighter or a pilot light. Then the oxygen valve is opened and the flame adjusted. (c) Basic equipment used in oxyfuel-gas welding. To ensure correct connections, all threads on acetylene fittings are left handed, whereas those for oxygen are right handed. Oxygen regulators usually are painted green and acetylene regulators red.

with shaded lenses, face shields, gloves, and protective clothing, is essential. Proper connection of the hoses to the cylinders also is an important safety issue; oxygen and acetylene cylinders have different threads, so that the hoses cannot be connected to the wrong cylinders. The low equipment cost is an attractive feature of this process. Although it can be mechanized, the operation is essentially manual, and therefore slow; however, the advantages of being portable, versatile, and economical for simple and low-quantity work.