Reactions (5.13) to (5.15) are a simplification of the complex system. Several main principles can be understood from a more detailed description of the chemistry. There are two important intermediate compounds: the gaseous silicon monoxide SiO(g) as already mentioned in reaction (5.14) and the solid silicon carbide SiC(s). To interpret the chemistry occurring in the furnace, it is convenient to conceptually split the furnace reaction inner space into an inner hot zone and an outer cooler zone. Liquid silicon is produced in the inner zone, where the dominant chemistry is described by the reactions

$$2SiO_2(l) + SiC(s) = 3SiO(g) + CO(g) \quad (5.16)$$

$$SiO(g) + SiC(s) = 2Si(l) + CO(g) \quad (5.17)$$

The temperature in the inner zone is in the range of 1900 to 2100°C, allowing a high proportion of SiO(g) in this zone, which is absolutely indispensable for further reduction according to reaction (5.17).

In the outer zone, where temperature is below 1900°C, SiO(g) and CO(g) convected away from the inner zone meet and react with free carbon. Consequently, silicon carbide SiC(s) and condensation products of Si(l) in a matrix of SiO_2(s,l) are formed as the partial pressure of SiO(g) drops:

$$SiO(g) + 2C(s) = SiC(s) + CO(g) \quad (5.18)$$

$$2SiO(g) = Si(l) + SiO_2(s) \quad (5.19)$$

A schematic description of the furnace is given in Figure 5.1.

The high-temperature nature of this process implies operation as continuous as possible. Raw materials are therefore fed in small batches with frequent intervals and are judiciously distributed on the top of the charge. Liquid silicon is continuously, or at frequent intervals, drained out from the bottom of the furnace, whereas gas exhaust and fumes are constantly passing through the filter to clean the fumes and recapture the silica.

Liquid crude silicon contains 1 to 3% impurities depending on the raw materials and the type of electrodes. The main impurities are

Fe: 0.2–1%
Al: 0.4–0.7%
Ca: 0.2–0.6%
Ti: 0.1–0.02%
C: 0.1–0.15%

5.3.2 Refining

Most of the applications of silicon as described above request further refining. The crude silicon is therefore tapped as liquid in large ladles (containing up to 10 MT of silicon) and treated when still liquid with oxidative gas and slag-forming additives, mainly silica sand (SiO_2) and lime/limestone ($CaO/CaCO_3$). Other chemicals such as dolomite (CaO–MgO), calcium fluoride (CaF_2) and others are used depending on plant practice and customer requirements. Elements less noble than silicon such as Al, Ca and Mg are oxidised and