The furnace consists essentially of a crucible filled with quartz and carbon materials. Silicon is freed by the carbothermic reduction of silica according to the overall reaction:

$$SiO_2(s) + 2C(s) = Si(l) + 2CO(g) \tag{5.13}$$

Contrary to what is often claimed in popular articles or reviews, silica sand is currently not used for this purpose. Lumpy quartz (e.g. 10–100 mm) with appropriate purity and thermal resistance is preferred. Carbon raw material generally consists of metallurgical grade coal as well as woodchips and/or charcoal and coke. The metallurgical coal is co-produced with coal used for crude steel production. As a rule this coal needs to be washed in order to remove most of the ash containing unsuitable impurities. Raw materials, both quartz and carbon, are selected in order to achieve high product quality (silicon and silica fumes), to maximise furnace performances and to minimize the environmental damages (i.e. SO_2 and NO_X emissions). The raw material reactivity and the consistency of the mix of raw materials in the charge, for instance its porosity, are extremely important factors in achieving good furnace performance in terms of high material yield, lower power consumption and good product quality.

The raw material mix or charge is heated by means of an intense electric arc sustained between the tip of three submerged electrodes and the electrical ground of the furnace. Although important exceptions exist, the current practice is to run this process in a three-phase current, open and rotating furnace at a working electrical load normally between 10 and 30 MW, depending on the size of the furnace. The tendency is to increase the furnace size and the electrical load in order to achieve higher output and productivity.

Electrodes are also made of carbon. Originally, expensive graphite electrodes were used. They were displaced by pre-baked electrodes, which in turn tend to be replaced by more cost-efficient self-baking electrodes. The electrode technology is an important aspect to the present development of this industry: half a dozen electrode types ranging from pre-baked to self-baking electrodes of Søderberg type are currently used or are in the process of development.

Liquid silicon metal is tapped from the bottom of the furnace, and the thoroughly mixed raw materials are charged on the top. The reaction co-product, carbon monoxide CO(g), is further oxidised to carbon dioxide $CO_2(g)$ in open furnaces and released into the atmosphere. In open furnaces, side-reactions leading to the formation of silica fumes play an important role for the overall economics of the process:

$$Si(l) + \tfrac{1}{2}O_2(g) = SiO(g) \tag{5.14}$$

$$SiO(g) + \tfrac{1}{2}O_2 = SiO_2(s) \tag{5.15}$$

The silica fumes, which consist mainly of very fine particles of amorphous silica less than 1 μm, are passed through filter cloths installed in large bag-house systems adjacent to the furnaces. The collected amorphous finely divided silica finds valuable applications as additives in concrete and refractory. Depending on the quality of the raw materials used and the operational strategy and skills, the silicon yield as metallurgical silicon ranges from 80 to 90%, the balance resulting in silica fume.