4.6.7 TECHNOLOGICAL ASPECTS

Technologically, energy production combustions take place in two general classes of devices: combustion chambers (reciprocating or continuous flow), and boilers. The first are used to produce high pressure and temperature combustion gases that are then expanded, e.g. in a turbine. The latter realize simultaneously in the same chamber combustion and transfer to a fluid of the heat available in exhaust gases. We limit ourselves in what follows to a brief overview of these technologies, which will be discussed in more detail in Part 3.

4.6.7.1 Combustion chambers

For example, the combustion chamber of a gas turbine must satisfy severe constraints: ensure complete combustion of fuel, minimize the pressure drop (which represents an increase in compression), ensure good temperature stability at the turbine inlet, and occupy a volume as small as possible while allowing proper cooling of the walls.

The chart in Figure 4.6.6 is a section of a flame tube type combustion chamber, very commonly encountered in practice.

The compressed air exiting the compressor enters on the left side. It splits into two streams, one that provides wall cooling, the other entering directly into the combustion chamber, where it serves as oxidizer for the fuel injected into the central part. Given the low excess air locally, the flame reaches a high temperature (up to 2500 K) in the primary zone. Through holes at the periphery of the flame tube, the outside air mixes with exhaust gases in the transitional zone, where the temperature drops to around 2000 K, and in the dilution zone, where one seeks to achieve a gas flow temperature as stable as possible to avoid the risk of local or momentary overheating.

In flame tube cylinder chambers, six to twelve tubes of this type are mounted in parallel around the axis of the gas turbine. They are interconnected in order to balance the pressures and enable propagation of the ignition.

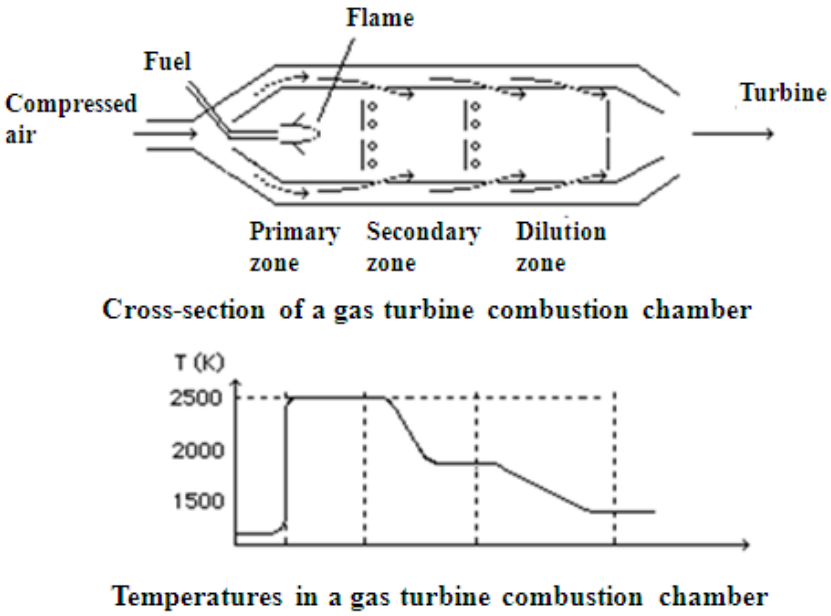

Figure 4.6.6: Sketch of a combustion chamber

These flame tubes are very compact, their dimensions amounting to several tens of centimeters at most. Subjected to intense and high temperature heat fluxes, the materials they contain are resistant steel sheet potentially coated with ceramic.

4.6.7.2 Boilers

Boilers are much larger than combustion chambers, because of the need to transfer fume heat to another fluid, which requires large exchange surfaces. In many applications, this fluid is pressurized water, which vaporizes inside the boiler, which then behaves like a triple heat exchanger as the water passes from liquid form (economizer), vaporizes (vaporizer), and becomes steam (superheater).

There are two main types of boilers, known from the fluid that circulates inside the tubes: fire tube boilers, and water tube boilers.

In the first, the flame develops in a corrugated tube, then the flue gases pass inside tubes, in one or more passes, water being at the outside.

Within the second type, water circulates by natural or forced convection between two drums placed one above the other, through a network of tubes. The flame develops in a furnace lined with tubes that absorb the radiation. A second tube bundle receives heat by convection from the flue gases. The water rises in the tubes subjected to radiation, and falls by the convection assembly.

The fire tube boilers can achieve flue gas temperatures lower (220 to 250 °C) than water-tube boilers (300 °C) without an economizer, which gives them a slightly better efficiency.

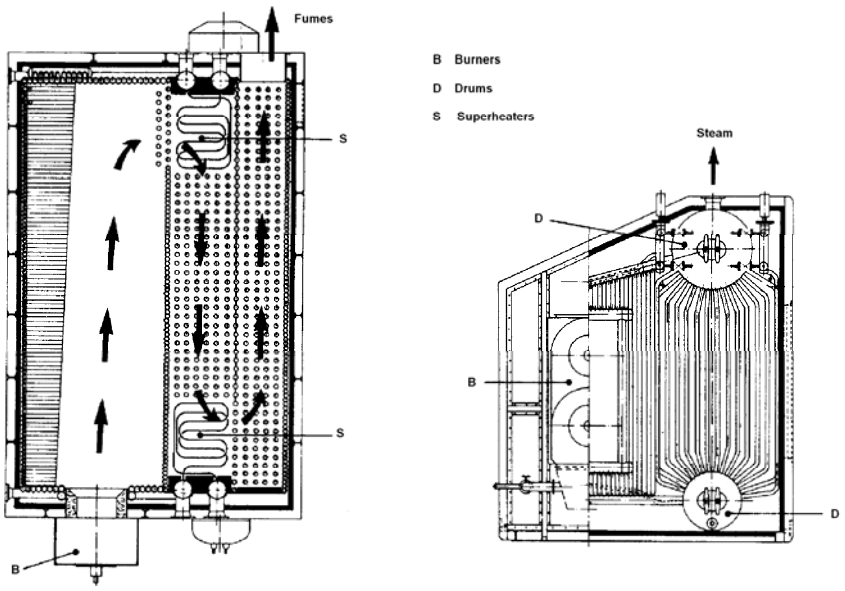

Figure 4.6.7: Industrial boiler (courtesy Techniques de l'Ingénieur - Génie énergétique)

However, the former are limited to capacities lower than the latter, for reasons of mechanical strength and safety (with a very large volume of water under pressure). Their main area of use is the supply of saturated steam under low pressure (<15 bar), and represent over 60% of the French fleet of boilers, against 20-25% for water tube boilers, which are well suited for the supply of superheated steam at medium and high pressure.

A water tube boiler consists of a furnace where the combustion takes place leading to flame temperatures from 1200 to 1500 °C, and whose walls are lined with smooth or finned steel pipes, which contain the pressurized water (50 to 180 bar). Heat is transferred primarily by radiation and by convection. For heat to be transferred, it is necessary that the total tube area is very large, which prohibits the use of high-grade steels: their surface temperature is limited to about 650 °C.

Figure 4.6.7 shows two sectional views of a Carosso water tube steam boiler. The circulation of water between the two large drums D is provided by thermosiphon, vaporization taking place in the tube bundle that connects them.