Coal-Fuelled Combined Cycle Power Plants

Combined cycle power plant, when used as a generic term, refers to a plant which converts heat into mechanical energy in a combined gas and steam turbine process. Combined cycle processes with coal gasification or coal combustion turn solid fuels into a fuel gas or a hot pressurised gas which is then used in the gas and steam turbine processes. Coal-fuelled combined cycle plants will be discussed in detail in the following sections. A start will be made by describing the basic technical features and the characteristic data of combined cycle power plants fuelled by natural gas for the purposes of comparison to coal.

7.1 Natural Gas Fuelled Combined Cycle Processes

The combined cycle process offers a number of advantages over the simpler steam–water only process. These are

- highly efficient generation of electrical power,
- a straightforward process,
- low investment costs and
- a smaller environmental impact.

The only requirement is a fuel gas which is suitable for gas turbines, for example natural gas.

The high efficiency results from combining the high-temperature gas turbine process with the low-temperature steam process. The fuel is fed to the process only via the gas turbine combustion chamber. While it is being combusted with compressed air, hot flue gas is produced under pressure in the combustion chamber. The gas turbine then converts the energy from the pressurised hot flue gas into mechanical energy. This causes the gas to expand, having lost most of its pressure, at low temperature at the turbine outlet. The residual heat from the flue gas has a temperature of 500–600°C and is transferred to the downstream steam process.

In a natural gas fired combined cycle, about two thirds of the electrical power is produced in the gas turbine and one third in the steam turbine. The gas turbine
A combined cycle process is normally called the topping process and the steam process the bottom process. A $T-S$ diagram of the two cycle processes is given in Fig. 7.1.

Figure 7.2 shows a natural gas fuelled combined cycle process. The gas turbine installation consists of a compressor, a combustion chamber and a gas turbine. The steam plant consists of a heat recovery steam generator (HRSG), a steam turbine and the subsequent steam – water cycle.

Gas turbines are available commercially as standard products consisting of an integrated gas turbine, compressor and combustor. They feature a high power density and fixed design data, to which only minor changes can be made. Figure 7.3 shows a sectional view of a modern gas turbine with a capacity of 292 MW$_{el}$. The largest gas turbines today have a capacity of around 340 MW$_{el}$ (Schöler 2007; Ratcliff et al. 2007).