THE STEAM AND WATER CIRCUITS. STEAM GENERATION AND USE

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In a conventional thermal power plant, the heat used for steam generation may be obtained by burning a fossil fuel, or it may be derived from the exhaust of a gas turbine. In a nuclear plant the heat may be derived from the radioactive decay of a nuclear fuel. In this chapter we shall be examining the water and steam circuits of boilers and HRSGs, as well as the steam turbines and the plant that returns the condensed steam to the boiler.

In a combined-cycle plant the tubes form part of the HRSG. In either case, the application of the heat causes convection currents to form in the water contained in the tubes, causing it to rise up to a vessel called the drum, in which the steam is separated from the water. In some designs of plant the process of natural circulation is augmented by forced circulation, the water being pumped through the evaporative circuit rather than allowed to circulate by convection.

Here, the steam generation occurs in banks of tubes that are exposed to the radiant heat of combustion. Of course, with HRSG plant no radiant energy is available, since the combustion process occurs within the gas turbine itself) and the heat of the gas-turbine exhaust is transferred to the evaporator tubes by a mixture of convection and conduction. In this type of plant it is common to have two or more steam/water circuits, each with its own steam drum, and in such plant each of these circuits is as described below. The steam leaves the drum and enters a bank of tubes where more heat is taken from the gases and added to the steam, superheating it before it is fed to the turbine. In the diagram this part of the plant, the superheater, comprises a single bank of tubes but in many cases multiple stages of superheater tubes are suspended in the gas stream, each abstracting additional heat from the exhaust gases. In boilers (rather than HRSGs), some of these tube banks are exposed to the radiant heat of combustion and are therefore referred to as the radiant superheater. Others, the con¬vection stages, are shielded from the radiant energy but extract heat from the hot gases of combustion.

After the flue gases have left the superheater they pass over a third set of tubes (called the economiser), where almost all of their remaining heat is extracted to prewarm the water before it enters the drum. Finally the last of the heat in the gases is used to warm the air that is to be used in the process of burning the fuel. (This air heater is not shown in the diagram since it is part of the air and gas plant which is discussed in the next chapter.)

The major moving items of machinery shown in the diagram are the feed pump, which delivers water to the system, and the fan which provides the air needed for combustion of the fuel (in most plants each of these is duplicated). In a combined-cycle plant the place of the combustion-air fan and the fuel firing system is taken by the gas turbine exhaust. In a power-generation station, the steam passes to a turbine after which it has to be condensed back to water, which necessitates the use of a heat exchanger to extract the last remaining vestiges of heat from the fluid and fully condense it into a liquid. Then, entrained air and gas has to be removed from the condensed fluid before it is returned to the boiler.