Chapter 3
Steam Generators

Part 4

Steam Generators Control System

3-13 STEAM-GENERATOR CONTROL

Steam-generator, and indeed total, powerplant control is a rather broad subject that includes instrumentation, data processing and controls for combustion, steam flow, temperature and pressure, drum level, burner sequencing, desulfurization precipitators, ash handling, system integration, start-up and shutdown, and automation. It obviously cannot be covered fully in this textbook. In this section, therefore, we will cover, in a simplified manner, only a few basic control systems that apply to the steam generator. These are: feedwater and drum-level control, steam-pressure control, and steam-temperature control.

Feedwater and Drum-Level Control

- Normally the drum is kept half filled. A sight glass is used to monitor the drum level.
- Water feeding and therefore steam are controlled to meet the turbine load demand.
- The difference between turbine load for example high consumption and drum feedwater level such as low water level will stimulate the drum sensor that would actuate the feedwater sensor and respond in opening the feedwater valve wider to let more water coming.
- This is considered too slow process and it is supplemented by sensors for feedwater and steam. The signals from these two sensors will go to the controller and actuate the valve in the proper direction.

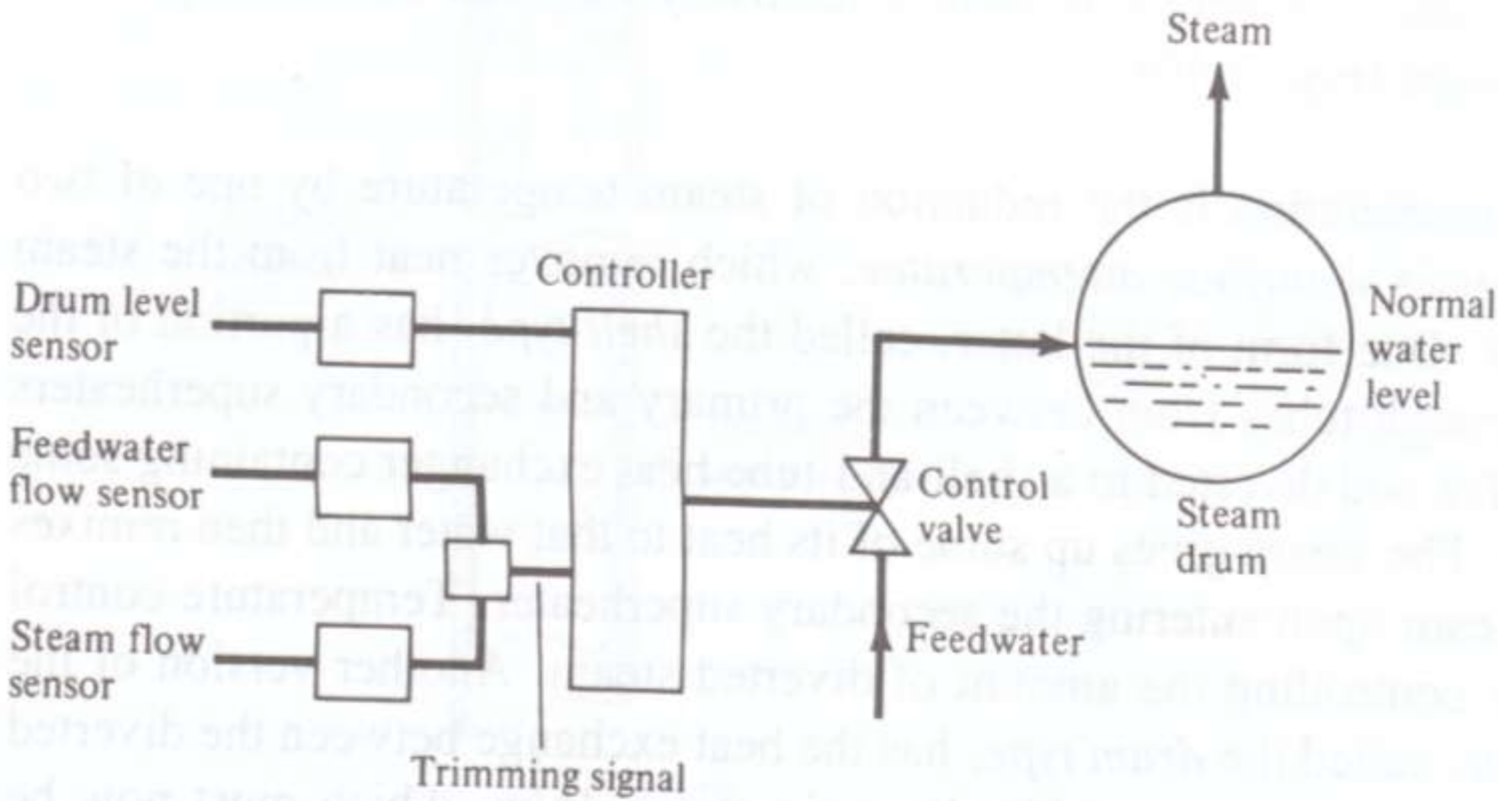

Figure 3-22 Schematic of a three-element feedwater control system.

Steam pressure control

- It is also called boiler master.
- It maintains steam pressure by adjusting fuel and combustion airflows to get the desired pressure. When the pressure drops the flow are increased.
- A steam pressure sensor acts directly on the fuel and forced draft fans.
- Only 5-s delay is allowed to maintain smoke free combustion

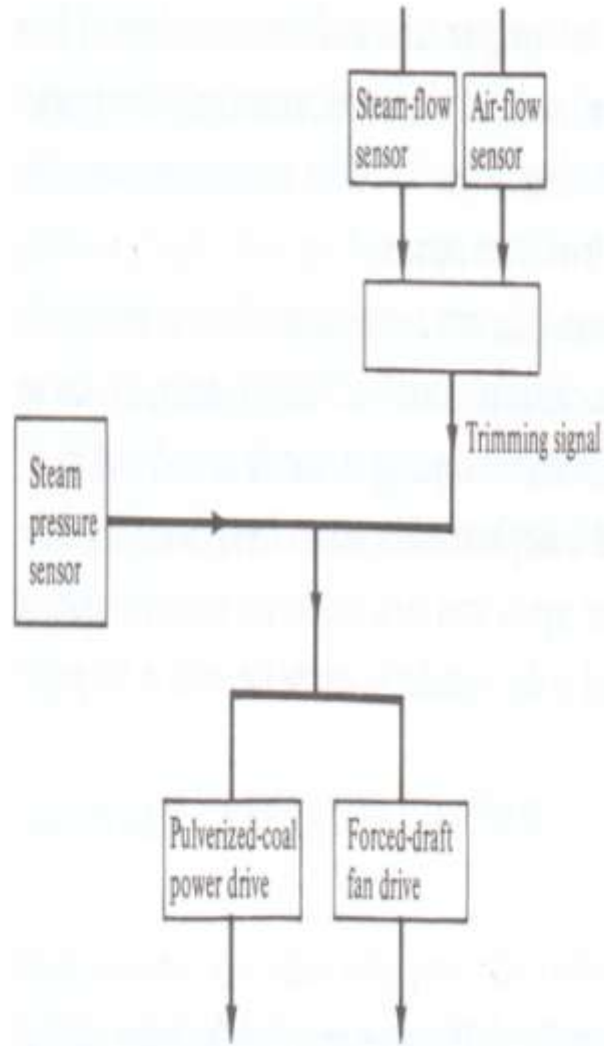

Figure 3-23 Schematic of a steam-pressure control system.

Steam-Temperature Control

It is important to control the temperature of the power plant to keep its performance as high as possible. Temperature fluctuation sometimes occur due to:

1. Build up of slag or ash at the heat transfer surfaces.
2. Changes in load, which are the main fluctuations.
3. Radiant and convective super-heaters and re-heaters and their effect on the load.

It is the super-heaters and re-heaters that needs temperature control, as they are the main components that respond directly to the load change. The saturated steam temperature is already controlled by the boiler pressure

Attemperation

- Attemperation: is the reduction of the steam temperature by the following means:

1. Surface attemperation.
2. Direct contact attemperation (spray).

- Surface attemperation removes heat from the steam by means of heat exchanger, mainly shell type. Steam is diverted from between the primary and secondary super-heaters to the shell where it exchanges heat with the boiling water came from the drum and then reducing its temperature. Temperature control is accomplishes by controlling the amount of diverted steam. Another version occurs in the drum itself, which should now be bigger to accommodate the new function

- Direct contact attemperation occurs by mixing high temperature steam with lower temperature coming from the boiler or the economizer in the line between primary and secondary super-heaters. The water used for mixing should be of very high purity to avoid deposits.

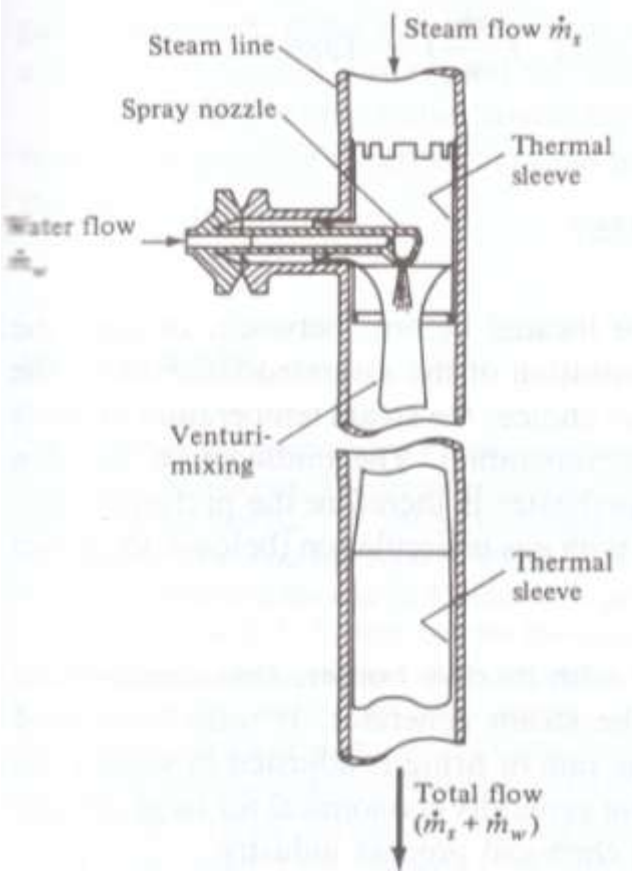

Figure 3-24 A spray attemperator for steam temperatur control.

$$\dot{m}_s h_{s1} + \dot{m}_w h_w = (\dot{m}_s + \dot{m}_w) h_{s2}$$

$\dot{m}_s$ and $\dot{m}_w$ = mass-flow rates of steam and water, respectively, lb_m/h or kg/s

h_s and h_w = specific enthalpies of steam and water, respectively, Btu/lb_m or J/kg

subscripts 1 and 2 refer to steam inlet and exit, respectively

- Temperature is controlled by regulating the amount of spray water to produce a flat temperature curve beyond point a.

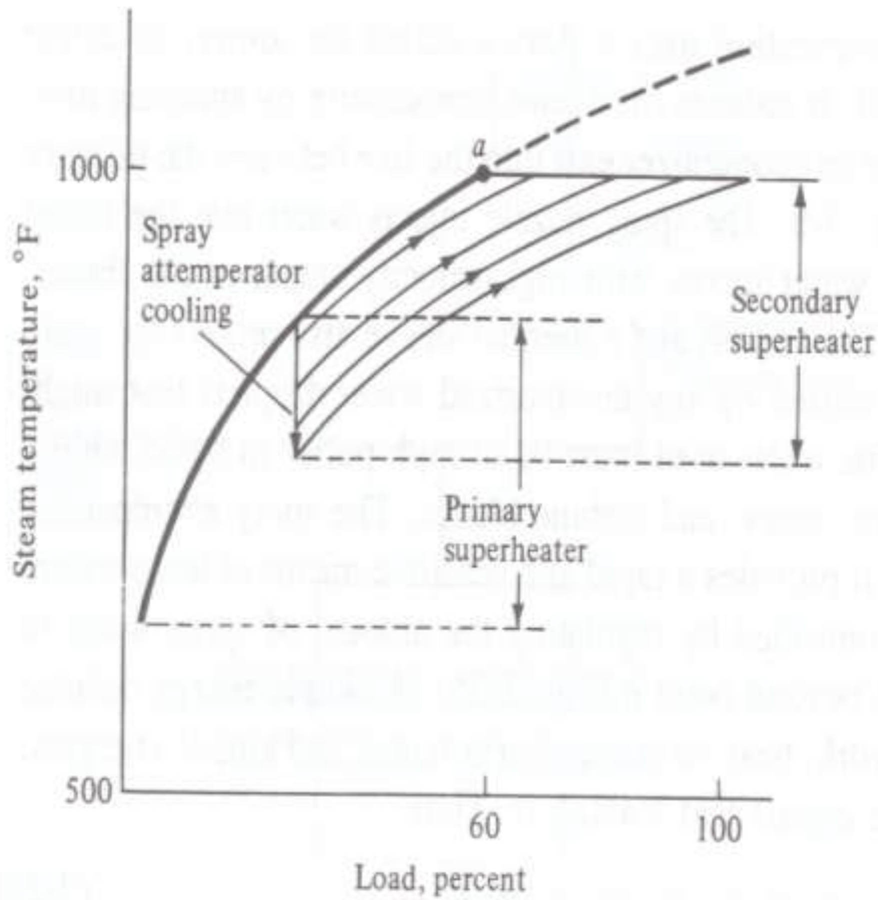

Figure 3-25 Attemperation with oversized primary and secondary superheaters.

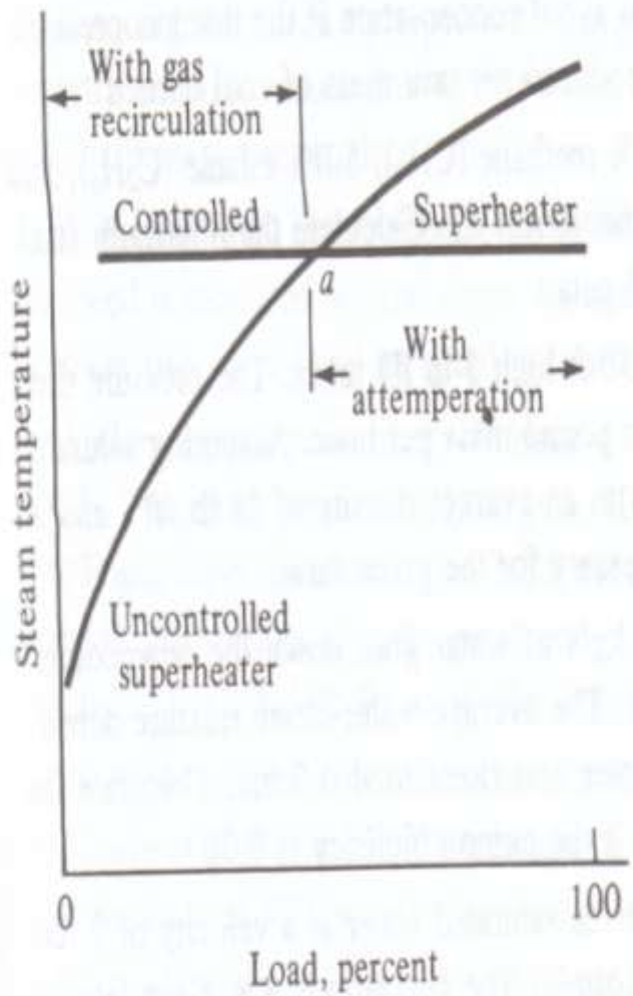

Figure 3-26 Gas recirculation and attemperation in series.

Separately Fired super-heaters

Separately fired superheater A superheater with its own burner, fans, combustion chamber, controls, etc., all independent of the steam generator, is sometimes used and may serve more than one steam drum. The rate of firing is adjusted to yield a flat steam temperature-load curve. This system is not generally economical for large electric generating systems and is usually used in the chemical process industry.

Gas recirculation In this system, gas from some point downstream of the superheater-reheaters, mostly from the economizer outlet but sometimes from the air preheater outlet, is recirculated back to the furnace by means of a gas-recirculation fan (mentioned at the end of Sec. 3-10). The term gas recirculation is restricted to the case where the gas is introduced back to the burning zone, such as before the burners, at the bottom hopper, etc. Gas recirculation to a point downstream of the burning zone is called *gas tempering*. Varying the percentage of recirculated gas alters the heat-absorbing characteristics of the various heat-absorbing surfaces in the steam generators to yield the desired effect and is taken into account in the initial design of the system.

Other types of steam-temperature control are *selecting burners* that give the desired gas temperature, using *tiltable burners* to shift the flame zone in the furnace, *bypassing* a portion of the hot gas around the superheater by dampers, and others.

Regulating reheat outlet steam temperature is necessary for the same reasons as those for regulating superheater outlet temperatures, and the methods used are generally the same.