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NATURE OF THE DEMAND

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Introduction. 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.

Purpose of this work. The steam generated by the boiler may be used to drive a turbine in a thermal power-plant, or it may be delivered to an industrial process or a district-heating scheme (or it may be provided for a mixture of these uses). Alternatively, the primary purpose of the plant may be to incinerate industrial, domestic or clinical waste, with steam being generated as a valuable by-product, to drive a turbo-generator or to meet a heating demand. In each case, the factor that primarily determines the operation of the plant is the amount of steam that is required. Everything else is subsidiary to this, although it may be closely linked to it.

The common part. 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 convection 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.

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.

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The determinant that controls all the boiler's operations is called the 'master demand'. In thermal power-plant the steam is generated by burning fuel, and the master demand sets the burners firing at a rate that is commensurate with the steam production. This in turn requires the FD fans to deliver adequate air for the combustion of the fuel. The air input requires the products of combustion to be expelled from the combustion chamber by the ID fans, whose throughput must be related to the steam flow. At the same time, water must be fed into the boiler to match the production of steam.

The boiler is a complex, multivariable, interactive process. Each of the above parameters affects and is affected by all of the others.

With all types of power-generating plant, however, the requirement for generation will be set, directly or indirectly, by the grid-control centre (or the «central dispatcher»), and the amount of power that is generated will be related to the local or national demand at that time.

In national networks, power stations are linked together to generate electrical power in concert with one another. Together they must meet a demand that is made up of the combined needs of all the users that are connected to the system (domestic, commercial, agricultural, industrial etc.). The overall demand will vary from minute to minute and day to day in a way that is systematic or random, dictated by economic, operational and environmental factors. This pattern of use relates to the entire network, and the fact that a large number of power generators and users are linked via the network has little bearing on the

overall demand, although the extreme peaks and troughs may well be smoothed out. The interlinking does, however, have operational implications. For example, a sudden failure of one generating plant will instantly throw an extra demand on the others.

Conclusions. The way in which the master demand operates is determined both by the general nature of the plant (is it a power station, an incinerator or a provider of process steam?), and also by the way in which the boiler is configured within the context of the overall plant (is there only one boiler meeting the demand, or are several combined?). The nature of the master demand system depends on the type of plant within which the boiler operates, and it is therefore necessary to examine it separately for each type of application. In the following sections we shall deal with the master demand as used in the following classes of plant:

- power stations;
- combined heat and power (CHP) plants;
- Waste-to-energy (WTE) plants.

A boiler producing steam for an operating turbo-generator has to ensure that the machine continually delivers the required electrical energy to the load. With a combined-cycle gas-turbine plant it is frequently the case that the power generated by the gas turbines is adjusted to meet the demand, with the steam turbine making use of all of the waste heat from the turbines.

References:

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