Modern Multistage Boiler-Feed Pumps

Following the Power Demand

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World electricity generation is expected to more than double in the period 2007–2030, with fossil fuels remaining the most important sources of energy. A fossil-fuel fired power plant converts the combustion energy of fossil fuels—coal, oil, or natural gas—to produce electricity through a thermodynamic cycle. In order to increase efficiency, thermal power plants operate at ever-increasing temperatures and pressures. Boiler feed pumps (BFP) are essential components of power plants where reliability, efficiency, and operational flexibility are important. New boiler technology that permits generating electricity more efficiently is a main driver for their development.

1 Modern fossil-fuel fired power plants operate more dynamically than conventional base-load plants. Sulzer boiler feed pumps are particularly suitable for cycling operation due to their robust construction and high tolerance of changing conditions.

World coal consumption is forecast to increase at an average annual rate of 2.7% from 2006 to 2030, mainly due to the growth projected for China and India. In 2006, approximately 40% of power generation was coal-fired, a level expected to remain constant until 2030. Natural-gas consumption is projected to increase at an average annual rate of 2.4% until 2030. Its share of total power generation is expected to grow from 18% in 2006 to around 24% in 2030.

Supercritical Power Plants

The efficiency of a thermodynamic cycle increases along with operating temperatures. Above the critical point of a fluid (water: 374 °C, 221 bar), boiling does not occur. Steam power plants that operate with higher water temperatures need to be specially designed. These plants are called supercritical and once-through plants, because boiler water circulates only one time. Supercritical designs have efficiencies in the range of 40–44%; whereas new ultracritical designs reach about 48%. Subcritical fossil-fuel power plants, on the other hand, achieve 36–38% efficiency.

Higher efficiency of thermal power plants results in reduced fuel consumption and lower emissions of carbon dioxide. Most of the plants planned today will therefore have super- or ultracritical boilers, whereas the majority of steam power plants built before 2000 had subcritical boilers.

Efficient Combined-Cycle Plants

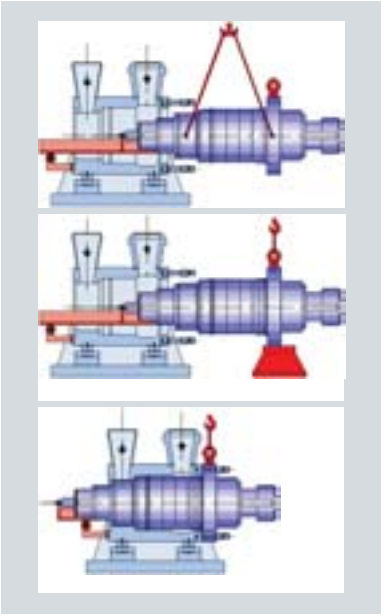
Another important class of fossil power plants uses a gas turbine in conjunction with a steam cycle. In a heat recovery steam generator (HRSG), the exhaust gases of the gas turbine produce the steam that drives a turbine. The efficiency of such a combined-cycle power plant (CCPP) can be as high as 58%. These plants are very quick to construct, though the volatile price of natural gas heavily influences their operating cost.

Cycling Operation

Whereas in the past, thermal power plants used to provide base-load power, cycling (load-following) operation has recently become a standard requirement. This operation involves rapid variations of BFP flow and temperature, as well as frequent stops and start-ups (Fig. 1). In order to fulfill these requirements, BFPs have to be specifically designed and built to be tolerant of changing operating conditions.

No Prewarming

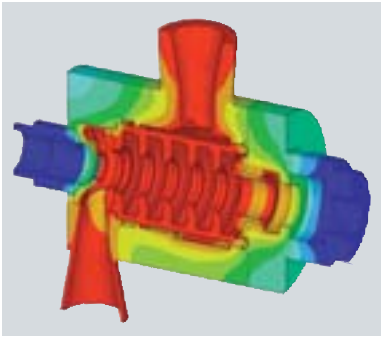
High pressure and temperature in coal-fired power plants pose the main challenges to BFPs. In a modern plant, pressure ranges from 310 to 370 bar, and the temperature of the boiler feed water may reach 230 °C. Sulzer Pumps designed the HPT forged barrel-casing pumps specifically for operation under such conditions (Fig. 2). Due to the high head per stage (500–650 m), impeller and diffuser feature thick shrouds, and a dynamic analysis of the pressure casing using finite-element models ensures their rigidity. Furthermore, the pumps are designed to operate under cyclic thermal conditions without the need for prewarming (Fig. 3).



2 The barrel casing design of Sulzer's HPT pumps allows quick cartridge changes. It thus reduces down-time and increases productivity.

One Feed Pump per Boiler

Larger, more efficient supercritical power stations usually have fewer BFPs with higher power. If a single 100%-capacity pump feeds the



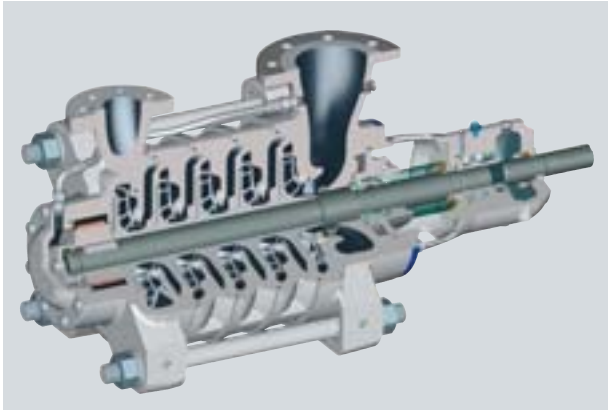
3 Computer-aided analysis of temperature distribution allows the adaptation of the casing design to various operating conditions.

4 The Neurath lignite-fired power plant in Germany will be the world's biggest after its completion in 2010. The picture shows the construction site of one cooling tower. One Sulzer pump will feed each of the two 1100-MW boilers.

boiler, it has to be extremely reliable and must ensure the highest efficiency and maximum availability.

The German utility RWE recently ordered 2 BFPs from Sulzer Pumps with an input of 47.3 MW each for its 2×1100-MW plant in Neurath (Fig. 4). For the Ninghai coal-fired power plant in China (2×1000 MW), Sulzer Pumps provides 4 BFPs—2×50% for each boiler—with an individual power input of 19.4 MW.

5 Sulzer MBN ring section pumps do not require elevated evaporators and can be installed with varying suction and pressure flange orientation. These features ease installation of the pump and simplify piping design.



Fast Start-up Times

Because of once-through HRSGs, today's gas-fired CCPPs operate more efficiently and cycle more frequently than those built a few years ago. Their pumping systems must be highly reliable, often meeting more than a dozen operating conditions as well as up to 200 starts and stops per year. As boiler ramp-up time is critical, the pumps are expected to handle quick thermal changes without failure. This flexibility is possible because there is no high-pressure drum, which would limit the temperature gradients because of the thickness of its walls.

High Pressure—High Efficiency

Although most once-through HRSGs in combined-cycle applications are subcritical, their BFPs have to provide very high pressure. The pumps have to be designed for a maximum allowable working pressure of 270 bar at a temperature of around 210 °C.

Most BFPs in CCPP applications run at a fixed speed synchronous to the frequency of the electric grid. In order to increase the pressure, BFPs designed to serve once-through HRSGs have more stages and shafts with higher torque capacity than conventional feed pumps. The standardized Sulzer Pumps MD range meets the boiler feed requirements in advanced combined-cycle power plants.

Flexible Pumps for Industrial Boilers

Industrial or auxiliary boilers in power plants produce process steam or cogenerate electricity. Most industrial boilers operate with sudden load variations, depending on the demand for process steam, while the load changes in the auxiliary boilers in power plants are related to cycling operation.

Industrial power generation represents around 5% of the electricity production, but the number of boilers is much higher due to their smaller size. Sulzer has a long tradition of supplying BFPs for these applications, especially for those with feed pressures above 40 bar. Sudden load variations, cycling operation, and the wide variety of the BFP services in industrial and auxiliary boiler applications require a very adaptable segmental ring casing pump, e.g., those of the Sulzer MBN range (Fig. 5).

The reliability and availability of BFPs depend on proper application, features and equipment, shop testing, field installation, pump operation training, and routine maintenance work. New, modular, standardized power plants no longer use redundant equipment. To meet the high demands on dependability, Sulzer performs factory pump tests in all critical service pumps prior to shipping, in order to correct any potential problems before they occur in the field. ◀

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