Ultra-supercritical Generation

Ultra-supercritical (USC) steam generation represents an increase in steam cycle efficiency. A USC unit operates above supercritical pressure and at advanced steam temperatures above 1,100 degrees Fahrenheit (593°C), resulting in a more efficient steam cycle. This increased efficiency reduces fuel consumption, reagent consumption, solid waste, water use and operating costs.

Supercritical Technology

A subcritical steam generation unit operates at pressures such that water boils first and then is converted to superheated steam. At supercritical pressures, water is heated to produce superheated steam without boiling. Due to the improved thermodynamics of expanding higher pressure and temperature steam through the turbine, a supercritical steam generating unit is more efficient than a subcritical unit.

New Materials Support USC Technology

Early supercritical units — such as AEP’s Philo Unit 6 and Philadelphia Electric’s Eddystone Unit 1 — successfully operated at ultra-supercritical levels. However, due to the unavailability of metals that could tolerate these extreme temperatures, operation at these levels could not be sustained and the units were operated in the supercritical mode instead of the ultra-supercritical mode. This is not true with current material technologies.

Today, recently-developed chrome and nickel-based super alloys are used in the components of the steam generator, turbine and piping systems that are exposed to high temperature steam. The new metals can perform under these prolonged high temperature operating conditions, rendering USC no longer a goal, but a practical design basis.

*Supercritical pressure is a state above the critical pressure of water of 3208 psia. The Critical Point of water (3208 psia and 705°F) is the point at which the vapor and liquid are indistinguishable. At the Critical Point, the addition of heat or pressure will not cause a change of state, and the process of boiling does not occur. A conventional supercritical unit operates at steam pressures typically above 3500 psig (241 Mpa) or higher and steam temperatures of 1000-1050°F (538-649°C). A subcritical unit operates below the critical pressure, typically below 2400 psig (16.5 Mpa).
Improved Efficiencies and Environmental Performance

USC technology is the most efficient steam cycle available today. With efficiencies in the 39 - 40 percent range (approximately 39 - 40 percent of the thermal energy in the fuel comes out as electric power), USC technology requires less fuel than other coal-fired processes to produce the same amount of electricity.

This efficiency touches many aspects of the plant’s operations. Reduced fuel requirements also mean:

- Reduced emissions of sulfur dioxide (SO2), nitrogen oxide (NOx), mercury (Hg), carbon dioxide (CO2) and particulate (PM-10);
- Reduced production of solid waste products such as fly ash; and
- Reduced requirements for commodities used in environmental control equipment such as activated carbon and ammonia.

In addition to improved environmental performance due to reduced coal use, USC technology, paired with state-of-the-art emission control technologies —selective catalytic reduction system for NOx reduction, dry flue gas desulfurization system for SO2 reduction, pulse jet fabric filter (baghouse) technology for particulate removal and activated carbon injection to reduce Hg emissions — results in some of the lowest emissions in the world.

USC and AEP

AEP’s tradition of advancing generation technology began in 1917 with the Windsor Plant in West Virginia, the first major mine-mouth generating unit coupled with long-distance high-voltage transmission to connect the plant with a major load center.

The world’s first supercritical unit, AEP’s Philo Unit 6 in Ohio, operated from 1957 until 1975. This unit pioneered use of supercritical-pressure steam (4,500 psi), use of super-high temperature steam (1,150°F) and use of double-reheat steam. There now are more than 200 supercritical units in operation worldwide.

Today, with more than 17,000 megawatts of supercritical generation, AEP owns and/or operates North America’s largest fleet of high efficiency supercritical coal units.

The company’s focus on generating efficiency continues with its pursuit of ultra-supercritical technologies.