VALVTECHNOLOGIES®

Industry Focus

Subcritical vs. Supercritical Cycles

What is the difference?

What are the key differences between the subcritical units and the supercritical units?

Efficiency: The main advantage and the reason for a higher pressure operation is the increase in the thermodynamic efficiency of the Rankine cycle.

Large subcritical thermal power plants with 170 bar and 540 / 540°C (SH / RH) operate at an efficiency of 38%. Supercritical units operating at 250 bar and 600/615°C can have efficiencies in the range of 42%.

Ultra supercritical units at 300 bar and 615 / 630°C will still increase the efficiency up to 44%. Increase in efficiency directly lead to reductions in unit cost of power and CO_2 emissions.

Operational Flexibility: Most of the supercritical units use the once through technology. This is ideal for sliding pressure operation which has much more flexibility in load changes and controlling the power grid. However this also requires more sensitive and quick responding control systems.

Evaporation End Point: In subcritical units the drum acts as a fixed evaporation end point. The furnace water walls act as the evaporator. Not so in the case of a supercritical unit. The evaporation end point can occur in various levels of the furnace depending on the boiler load. The percentage of superheat in supercritical units is higher than subcritical units. Because of this the furnace tubes act more as superheaters than waterwalls. This necessitates the use of higher grade of materials like alloy steels in the furnace.

Heat Transfer Area: Higher steam temperatures in supercritical units results in a lesser differential temperature for heat transfer. Because of this heat transfer areas required are higher than subcritical units.

Higher superheat steam temperatures entering the HP turbine also mean higher reheater inlet temperatures which again results in a higher heat transfer areas.

Water Chemistry: In supercritical units the water entering the boiler has to be of extremely high levels of purity. Supercritical boilers do not have a steam drum that separates the steam and the water. If the entering water quality is not good, carry over of impurities can result in turbine blade deposits.

Materials: Supercritical power plants use special high grade materials for the boiler tubes. The turbine blades are also of improved design and materials. In fact, the very increase in higher pressure and temperature designs are dependent on the development of newer and newer alloys and tube materials.

The aim of the industry is to achieve power plant efficiencies in the range of 50%.

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Temperature + pressure = high-efficiency; higher efficiency = less emissions

Unit Type	Main Steam/Hot Reheat Conditions	Efficiency
Subcritical: water boiling to steam with pressures below "critical point"	2,400 psig (165 bar) 1050°F - 566°C	38%
Supercritical: water to steam without boiling. Pressure above "critical point".	3,500 psig (241 bar) 1050°F - 582°C)	40%
Advanced supercritical: main steam and hot reheat temperature above 1100°F (593°C)	4,710 psig (325 bar) 1130°F - 630°C	44%
Ultra supercritical: main steam temperatures above 1200°F (649°C)	5,000 psig (345 bar) 1300°F - 704°C	46%