



Combining Mechanical Compression and Heat Addition in Supercritical CO₂ Turbine Power Cycles

Infinity Turbine
LLC

[TEL] +1-608-238-6001 (Chicago)

[Email] greg@infinityturbine.com

<https://infinityturbine.com/combining-mechanical-and-heat-compression-for-sco2-by-infinity-turbine.html>

A technical overview of how mechanical compression and heat addition can be combined to increase power and efficiency in supercritical CO₂ turbine systems. Explains optimal sequencing, compressor design, and thermodynamic benefits for higher generator output.



This webpage QR code

PDF Version of the webpage (maximum 10 pages)

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Introduction

Supercritical carbon dioxide (sCO2) power cycles are gaining attention for their ability to achieve high efficiency, compact design, and compatibility with renewable or waste heat sources. One common question among engineers and system designers is whether mechanical compression and heat addition can be combined to produce more pressure and, ultimately, more shaft power from the turbine generator.

The short answer is yes, but the effectiveness depends on how and where the heat is introduced. Pressurization and heating serve different thermodynamic roles: compression raises pressure, while heating raises enthalpy. The most efficient systems combine both in sequence, not simultaneously.

Step 1: Mechanical Compression Sets the Pressure

Mechanical compression is the primary method for raising CO2 pressure. In a supercritical cycle, compression typically begins at a pressure just above the critical point (7.38 MPa or about 1,070 psi). Because CO2 behaves like a dense fluid at these conditions, compression work is relatively small compared to compressing a gas.

Efficient compressors, especially near the critical region, can achieve significant pressure ratios with minimal work. Multi-stage compressors with intercooling further reduce compression energy requirements, improving overall cycle performance.

Step 2: Add Heat After Compression to Raise Turbine Power

Once the CO2 is compressed, the next step is to add heat at nearly constant pressure. This process increases the turbine inlet temperature (TIT), which directly increases the turbine's available work output.

Heating after compression, rather than before, is crucial. Introducing heat before compression expands the fluid and makes the compressor's job harder. Heating after compression, however, raises enthalpy at high pressure and maximizes energy extraction during expansion.

Typical supercritical CO2 systems use recuperators to recover heat from the turbine exhaust and external heaters (solar, fuel, or electric) to reach the final TIT. The result is a large enthalpy difference across the turbine, producing more shaft horsepower and higher generator output.

Step 3: Use Recuperation to Recycle Waste Heat

Recuperation is key to making combined compression and heating efficient. A recuperator transfers heat from the turbine exhaust to the compressed CO2 before it reaches the main heater. This reduces the external heat energy required and raises the cycle's overall efficiency.

High efficiency power cycle systems allow designers to reach efficiencies above 45 percent even with moderate turbine inlet temperatures.
