Understanding Temperature Drop in Supercritical CO2 Turbines: Key Factors and Example Calculations at 45C, 250C, and 700C

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https://www.infinityturbine.com/temperature-drop-in-a-brayton-cycle-supercritical-co2-turbine-by-infinity.html

Learn how temperature drop occurs in supercritical CO2 turbines, what factors determine it, and how inlet temperatures of 45C, 250C, and 700C influence turbine performance. Includes clear explanations and engineering examples using standard text notation.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Temperature Drop Across a Brayton Cycle Turbine

Supercritical CO2 turbines exhibit unique thermal behavior that depends on inlet temperature, pressure ratio, and turbine efficiency. This article explains what causes temperature drop across the turbine and provides practical examples for inlet temperatures of 45C, 250C, and 700C in modern CO2 Brayton cycle systems.

Introduction

Supercritical CO2 turbines operate under dense fluid conditions that dramatically improve power density and efficiency compared to traditional steam or organic Rankine cycles. A fundamental aspect of turbine operation is the temperature drop from the turbine inlet temperature, also known as TIT, to the exhaust temperature. This temperature drop determines the available enthalpy for power production and directly influences both turbine efficiency and cycle performance.

This article explains what drives the temperature drop in supercritical CO2 turbines and uses three practical example inlet temperatures to illustrate typical values: 45C, 250C, and 700C.

What Determines the Temperature Drop Across an sCO2 Turbine

The temperature drop across a supercritical CO2 turbine is governed by several thermodynamic and mechanical factors. These include:

1. Pressure Ratio

The pressure ratio across the turbine is the primary driver of the temperature drop. A higher pressure ratio creates more expansion and greater enthalpy extraction, which increases the temperature drop. Typical supercritical CO2 turbines operate with pressure ratios between 2.0 and 4.0. Because supercritical CO2 behaves as a real fluid rather than an ideal gas, the relationship between temperature and pressure requires real-fluid expansion calculations, but the principle remains the same.

2. Turbine Isentropic Efficiency

• The isentropic efficiency determines how closely the turbine follows an ideal expansion path.
• Higher efficiency produces a larger temperature drop and more useful work.
• Lower efficiency results in less expansion and a smaller temperature drop.

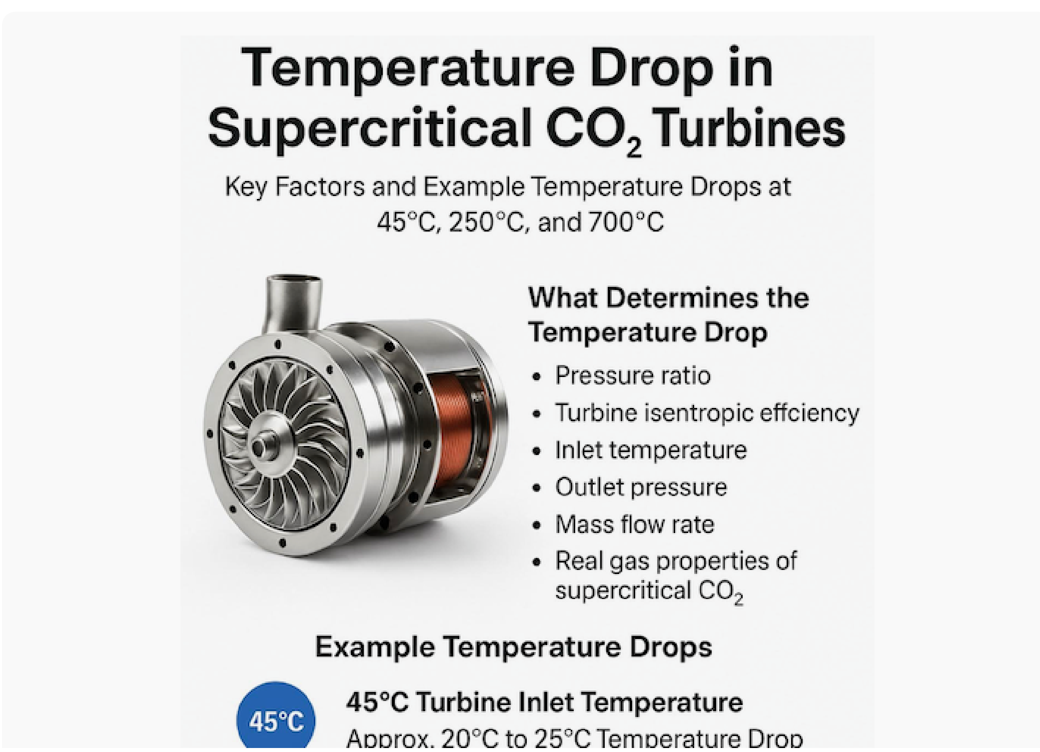
3. Inlet Temperature

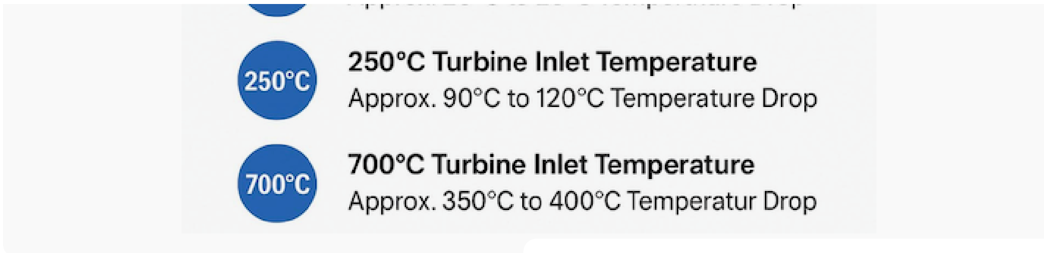
A higher turbine inlet temperature increases the available enthalpy drop. Turbines operating at 500C to 700C typically show much larger temperature drops than those at low temperatures near 50C to 100C.

4. Outlet Pressure

The outlet pressure is often constrained by compressor inlet conditions. Higher outlet pressure reduces the temperature drop, while lower outlet pressure increases it.

5. Mass Flow Rate


Temperature Drop in Supercritical CO_2 Turbines
Key Factors and Example Temperature Drops at 45°C, 250°C, and 700°C
What Determines the Temperature Drop
Pressure ratio
Turbine isentropic effciency
Inlet temperature
Outlet pressure
Mass flow rate
Real gas properties of supercritical CO_2
Example Temperature Drops
45°C
45°C Turbine Inlet Temperature
Approx. 20°C to 25°C Temperature Drop


250°C
250°C Turbine Inlet Temperature
Approx. 90°C to 120°C Temperature Drop
700°C
700°C Turbine Inlet Temperature
Approx. 350°C to 400°C Temperatur Drop