Evaluating Jet Pump Integration in CO_2 Power Cycles: Brayton vs Rankine Performance

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https://infinityturbine.com/infinity-turbine-sco2-cycle-leverage-using-a-jet-pump-ejector.html

Analysis of using a jet pump to leverage high-pressure CO_2 feed in Brayton and Rankine cycles. Comparison of energy use, net output, and efficiency for different working fluid regimes.

This webpage QR code

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Introduction

Using CO_2 as a working fluid in power generation or waste heat recovery brings strong potential, especially when employing supercritical or transcritical states. A question arises: can a jet pump (ejector) that uses high-pressure CO_2 feed (before the turbine) serve as the feed pump or partial compressor, reducing the mechanical compression work? How would that affect net cycle output and cost, particularly in gas-only (Brayton) cycles vs Rankine/ORC type cycles with phase change?

Below is a practical assessment of that concept, the benefits and limitations, and how it might perform under various temperature regimes.

What is a Jet Pump / Ejector in this Context

A jet pump or ejector uses a high-pressure motive fluid to entrain a lower-pressure fluid, raising its pressure without a mechanical compressor. In CO_2 cycles, you might imagine:

Having a portion of CO_2 at high pressure (pre-turbine or recycled from turbine exhaust) act as the motive stream;
It entrains lower-pressure CO_2 (from feed or recirculated loop) and raises its pressure to some intermediate value;
This reduces the required work from a conventional compressor or pump.

If properly designed, jet pumps can reduce mechanical energy input, reduce moving parts, and simplify maintenance. However, jet pumps are typically less efficient than mechanical compressors, particularly at high compression ratios, or when motive fluid pressure available is not much higher than the target pressure.

Comparison: Gas-Only (Brayton) vs Phase-Change (Rankine/ORC) Cycles

Below are the two cycle types, followed by evaluation of how jet pump integration might help, and where it runs into limits.

Brayton / Supercritical CO_2 Brayton Cycle

Characteristics:

Working fluid remains gas or supercritical throughout (no condensation to liquid).
Components: compressor(s), heater (heat source), turbine (expansion), cooler (reject heat), often with recuperator(s) or recompression loops to improve efficiency.
Efficiency strongly depends on turbine inlet temperature, pressure ratio, compressor work, heat exchanger effectiveness. (Very sensitive to losses.) ([turn0search11] & [turn0search16])

How a jet pump might be used:

Use motive high-pressure CO_2 (after heater or before turbine) to entrain lower-pressure CO_2 (e.g. from cooler or feed) to reduce compressor load