Evaluating a Tesla Disc Micro Turbine for Supercritical CO2

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https://infinityturbine.com/infinity-turbine-sco2-tesla-disc-turbine-for-supercritical-co2-power.html

Practical guidance on using a stacked-disc Tesla turbine with supercritical CO2. Learn when it helps, expected efficiencies, sizing heuristics, hardware challenges, and how it compares to bladed micro turbines.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Tesla Disc Turbine vs Conventional Bladed Stages

Here is a practical, engineering-focused take on whether a stacked-disc Tesla design helps compared with conventional bladed stages.

TLDR

A Tesla disc turbine can be made to run on sCO2, but the fluid’s low viscosity means you must use very small inter-disc gaps and high rim speeds to get useful shear traction.
That drives tough manufacturing tolerances, high windage losses, and significant disk stress at micro scale.
For clean, single-phase sCO2, a small bladed radial-inflow or axial stage will usually be more efficient and smaller.
A Tesla stack can make sense if you need extreme foul-tolerance, two-phase acceptance, or you want a very simple rotor with no thin blades.

How a Tesla turbine produces torque

A Tesla rotor transfers momentum through boundary-layer shear instead of pressure forces on blades. Useful traction scales with dynamic viscosity times shear area times velocity gradient across the gap.

Very simple scaling:

Shear stress tau is roughly mu times dv/dy.
For a gap g and a disk surface speed U, the average shear scales like mu times U divided by g.
Torque per disk scales like shear stress times wetted area times radius.

Implication: to get high torque with a low-viscosity working fluid like sCO2 you must make g very small and U large, or stack many discs to increase wetted area.

What sCO2 properties mean for a Tesla rotor

Density: high, typically 80 to 250 kg per cubic meter for 300 C and 100 to 300 bar.
Viscosity: relatively low, often of order 0.05 to 0.08 mPa s near 300 C.
Speed of sound: lower than air at the same temperature, roughly 300 to 350 m per second.
Result: low viscosity hurts boundary layer traction; high density increases windage loss and aerodynamic drag if clearances are generous.

Design response:

Inter-disc gaps often must be in the 0.05 to 0.3 mm range for micro hardware.
Rim speeds must be high while staying subsonic versus local speed of sound and within disk stress limits.

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Overview

Designing micro turbines for supercritical CO2 creates unique sizing challenges. The fluid is dense and has relatively low viscosity, which can force very small flow passages in bladed stages. A Tesla disc turbine, which transfers momentum by boundary layer shear between closely spaced rotating discs, offers a simple rotor with no thin blades and good foul tolerance. This article explains when a Tesla disc stack helps, the tradeoffs you must accept, and how to size a first prototype.

How a Tesla Disc Turbine Works

A Tesla turbine uses boundary layer drag rather than pressure forces on airfoils. Flow is injected tangentially at the disc periphery through nozzles, spirals inward between discs, and exits near the hub. Torque comes from shear traction on the disc faces. With supercritical CO2, you get:

High density, which boosts available power for a given volumetric flow
Low viscosity, which reduces shear traction unless the disc gaps are very small and rim speed is high

Where a Tesla Stack Can Help

1. Manufacturability
Micro bladed turbines can demand hairline throats and tight tip clearances. A disc stack replaces airfoils with flat discs and narrow gaps, which some teams find easier to build and iterate.

2. Debris and two phase tolerance
A disc stack is generally more tolerant of droplets, fine solids, or momentary wet operation than very fine blading.

3. Smooth off design behavior
Torque tends to roll off smoothly with flow changes, avoiding abrupt stall or choke typical of some bladed cascades.

Key Tradeoffs

1. Efficiency headroom
Small Tesla turbines typically achieve lower isentropic efficiency than good bladed micro stages. As a planning band, expect about 30 to 60 percent for careful disc designs, versus about 70 to 85 percent for well executed bladed stages at similar conditions.

2. Gap and tolerance demands
To regain shear with low viscosity CO2, inter disc gaps often need to be about 0.05 to 0.3 millimeter. Holding uniform gaps across a hot rotor is nontrivial.

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