Flat-Plate Radial-Inflow Turbine for sCO2: 2D Blade Geometry, Sizing Method, and FileMaker Code

Infinity Turbine
LLC

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

[Email] greg@infinityturbine.com

https://infinityturbine.com/sco2-rotor-design-by-infinity-turbine.html

Design a supercritical CO2 radial-inflow turbine that can be laser cut or milled from a flat plate. This guide provides the aerodynamic assumptions, first-cut sizing equations, a practical 2D blade outline based on a logarithmic spiral, and FileMaker Pro code to generate XY coordinates for CAM.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Supercritical Turbine Rotor Design

Rotor body: single flat disc, thickness t.
Blades: cut into the disc as planar wedge airfoils with constant thickness (or 2.5D engraving if you want a slight leading-edge radius).
Geometry: all variation is in-plane (no 3D lean, sweep, or thickness stacking).

Trade-offs: lower diffusion capability and higher loss vs. 3D impellers. Aim for pressure ratio per stage ~1.25–1.5 and keep tip Mach moderate.

Baseline design targets for sCO_2 (flat rotor)

Overall pressure ratio per stage: 1.25–1.5
Flow coefficient $\phi = Vm2/U2$: 0.07–0.10
Loading coefficient $\psi = \Delta h/U2^2$: 0.45–0.60
Slip factor σ: ~0.88–0.92 (backswept)
Exit metal angle β2 (relative): 25–35 deg
Bending safety: t typically 3–8 mm for small rotors; verify with stress calcs.

Rotational layout

1. Pick hub and tip radii: R1e (eye inlet), R2 (impeller tip).
2. Choose blade count Z such that pitch-to-thickness avoids blockage: solidity at mid-span S = chord/pitch ~0.8–1.2.
3. Set inlet metal angle β1 = atan(Vm1/U1) (for zero prewhirl), and exit metal angle β2 backswept 25–35 deg.
4. Use a logarithmic-spiral camber line from near-radial at the inlet to backswept at the exit.

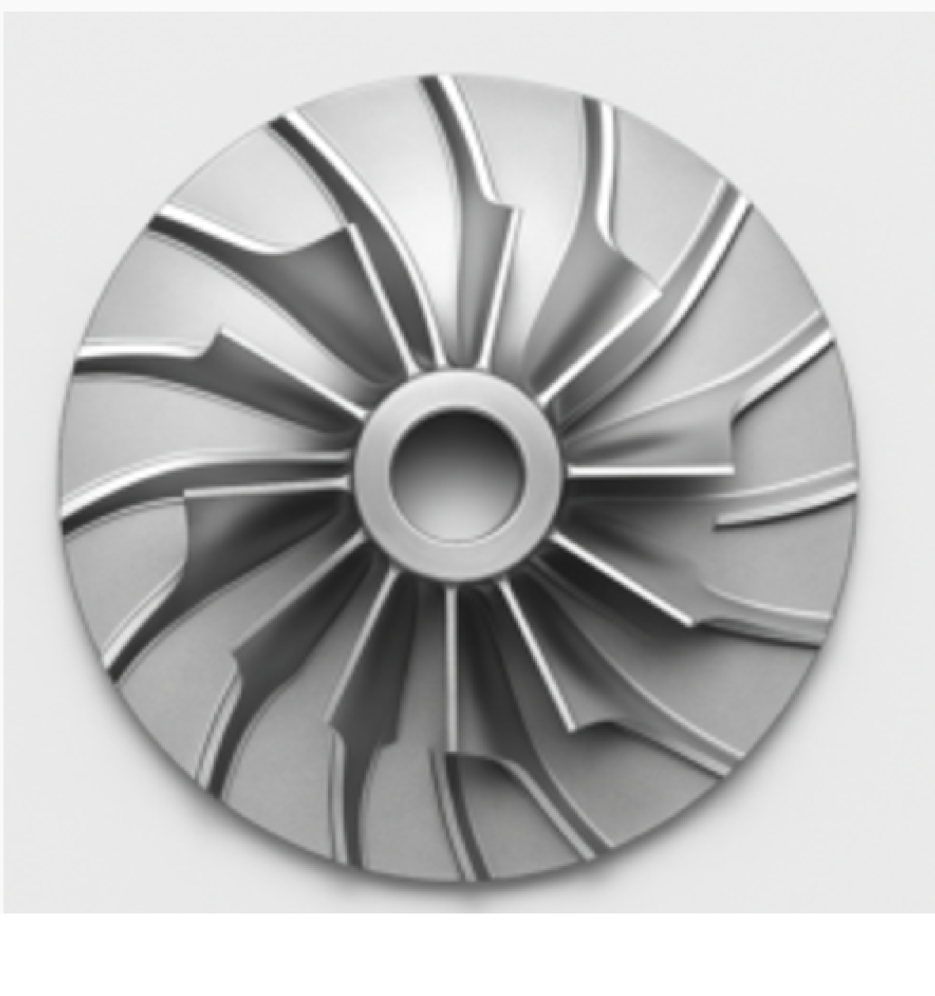
Blade outline you can machine from a flat plate

1) Camber line as a logarithmic spiral

Use polar coordinates with the rotor center as origin.

Spiral: $r(\theta) = r_2 \cdot \exp[a\cdot(\theta - \theta_2)]$
Set the spiral tangent angle at exit equal to your backsweep: α_exit = 90° – β2.
For a log spiral, the tangent angle is constant and equals arctan(1/a).
So choose a = 1 / tan(α_exit).

Define the blade from θ at r (near inlet radius) to θ at r (impeller tip).



Overview

You can build a 2D, flat-plate radial-inflow turbine for supercritical CO2 (sCO2) as a fast, low-cost prototype. Performance will be below that of a fully 3D radial turbine, but for moderate pressure ratio and dense sCO2 it is practical. The strategy mirrors the 2D compressor approach: use a logarithmic-spiral camber line that maintains a constant metal angle, keep relative Mach under control, and match flow area to mass flow at the inlet and exit radii.

What you will define:

Turbine pressure ratio per stage and turbine inlet total temperature.
Tip speed from specific work and loading coefficient.
Inlet radius and blade height from mass flow and density.
Blade metal angles from velocity triangles with near-zero exit swirl.
A 2D blade outline in XY for laser cutting or 2.5D machining.

Target application window

sCO2 radial-inflow turbine, single stage, moderate pressure ratio about 2.0 to 3.5.
Inlet total temperature typically 400 to 700 C for prototypes.
Tip relative Mach target Mrel2 less than about 1.2.
Flat plate thickness t typically 2 to 6 mm depending on diameter and stress.

Key design coefficients

Turbine isentropic efficiency, eta_t: 0.80 to 0.90
Stage loading coefficient, psi_t = delta_h0 over U2^2: 1.0 to 1.6
Flow coefficient at rotor inlet, phi_t = Vm2 over U2: 0.15 to 0.25
Radius ratio rr = R3 over R2: 0.35 to 0.50
Exit swirl: target near zero absolute tangential velocity at exit

First-cut sizing relations

Inputs you should have from your cycle point and property call:

T3_K turbine inlet total temperature, K
P3_Pa turbine inlet total pressure, Pa
PR_t turbine total-to-static pressure ratio P3 over P4
N_rpm shaft speed, rpm
mdot_kg_s mass flow, kg s-1
cp3_J_kgK, k3, Z3, rho2_kg_m3, rho3_kg_m3 sCO2 properties at rotor inlet and exit planes

Overview

You can build a 2D, flat-plate radial-inflow turbine for supercritical CO_2 (sCO_2) as a fast, low-cost prototype. Performance will be below that of a fully 3D radial turbine, but for moderate pressure ratio and dense sCO_2 it is practical. The strategy mirrors the 2D compressor approach: use a logarithmic-spiral camber line that maintains a constant metal angle, keep relative Mach under control, and match flow area to mass flow at the inlet and exit radii.

What you will define:

Turbine pressure ratio per stage and turbine inlet total temperature.
Tip speed from specific work and loading coefficient.
Inlet radius and blade height from mass flow and density.
Blade metal angles from velocity triangles with near-zero exit swirl.
A 2D blade outline in XY for laser cutting or 2.5D machining.

Target application window

sCO_2 radial-inflow turbine, single stage, moderate pressure ratio about 2.0 to 3.5.
Inlet total temperature typically 400 to 700 C for prototypes.
Tip relative Mach target Mrel2 less than about 1.2.
Flat plate thickness t typically 2 to 6 mm depending on diameter and stress.

Key design coefficients

Turbine isentropic efficiency, eta_t: 0.80 to 0.90
Stage loading coefficient, psi_t = delta_h0 over U2^2: 1.0 to 1.6
Flow coefficient at rotor inlet, phi_t = Vm2 over U2: 0.15 to 0.25
Radius ratio rr = R3 over R2: 0.35 to 0.50
Exit swirl: target near zero absolute tangential velocity at exit

First-cut sizing relations

Inputs you should have from your cycle point and property call:

T0_K turbine inlet total temperature, K