Centrifugal Compressor Bucket Geometry for Supercritical CO2 Turbines

Infinity Turbine LLC

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

[Email] greg@infinityturbine.com

https://infinityturbine.com/centrifugal-compressor-bucket-geometry-for-sco2-by-infinity-turbine.html

A practical method to size centrifugal compressor bucket geometry for supercritical CO2. Includes FileMaker-ready formulas linking temperature, pressure, RPM, and pressure ratio to impeller tip diameter, blade height, and blade metal angles using CO2 properties.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Centrifugal Compressor Bucket Geometry for Supercritical CO2 Turbines

Overview

For an sCO2 turbomachine using a centrifugal compressor, the bucket geometry (impeller blade metal angles and key diameters) is set by the head you must add, the rotational speed, and the flow you must pass at acceptable Mach and incidence. Because CO2 behaves as a dense real gas near the critical region, use CO2 properties at the actual inlet state when sizing.

Below is a compact method that ties pressure ratio, inlet temperature and pressure, and RPM to the main geometry:

Tip speed from required head.
Tip diameter from speed.
Exit meridional velocity from a chosen flow coefficient.
Exit blade height from mass flow and density.
Exit metal angle from the velocity triangle with slip.
Inlet eye diameter from allowable inlet Mach.
Inlet metal angle from the inlet velocity triangle.

Where possible, pass in CO2 property values at the design point (density and k, Z). If you cannot compute them inside FileMaker, precompute with REFPROP/CoolProp and store them as fields.

Design coefficients to choose

Compressor isentropic efficiency, eta_c: 0.70 to 0.85
Head coefficient, psi: 0.45 to 0.70 (total to shaft)
Flow coefficient, phi: 0.06 to 0.12 for dense sCO2
Slip factor, sigma: 0.85 to 0.92 for backswept blades
Inlet Mach limit, M1_max: 0.60 to 0.80 at the eye tip
Hub to tip ratio at eye, htr: 0.35 to 0.50

Variables and constants

Required inputs as FileMaker fields or globals:

T1_K inlet temperature, K
P1_Pa inlet pressure, Pa
PR pressure ratio, P2/P1
N_rpm rotational speed, rpm
mdot_kg_s mass flow, kg s^-1
rho1_kg_m3 CO2 density at inlet, kg m^-3