How Much Power Could a One Inch Dyson Style Impeller Produce as a Supercritical CO2 Micro Turbine

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https://infinityturbine.com/infinity-turbine-analysis-of-using-a-dyson-type-impreller-for-a-supercritical-co2-turbine.html

An engineering estimate of power output when repurposing a small Dyson style centrifugal impeller as a supercritical CO2 turbine. Assumptions, sizing logic, and realistic power range included.

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Summary

Using a tiny centrifugal impeller of about 1 inch diameter as a turbine with supercritical CO_2 is feasible in principle, but the extractable power is modest and strongly dependent on speed, pressure ratio, passage dimensions, and efficiency. With aggressive but defensible assumptions, the realistic output is on the order of about 1 to 3 kilowatts. Pushing far beyond this risks choking the passages, excessive stresses, or large efficiency losses.

Key assumptions for a first pass estimate

1. Rotor geometry
Diameter about 1.0 inch which is 25.4 millimeters, tip radius about 12.7 millimeters. Effective rim passage height between 0.5 and 1.0 millimeter after allowing for blade thickness and shrouds.

2. Operating point for the working fluid
Supercritical CO_2 near 300 C and 150 bar at turbine inlet, expanding to about 115 bar. This is a pressure ratio of about 1.3. CO_2 density at these conditions is roughly 150 to 170 kilograms per cubic meter. Speed of sound is roughly 300 to 350 meters per second.

3. Rotational speed
100,000 revolutions per minute typical of small high speed blowers. This gives a tip speed around 133 meters per second using tip speed equals pi times diameter times rpm divided by 60.

4. Turbine performance
Small improvised micro hardware tends to low to mid efficiencies. Use a stage isentropic efficiency in the 0.5 to 0.6 band for a first pass.

Temperature and enthalpy drop estimate in text format

Use a simple gas relation to estimate the isentropic temperature drop for an expansion from pressure ratio 1.3 at 300 C. Treat gamma approximately equal to 1.3 and heat capacity cp approximately equal to 0.9 kilojoules per kilogram kelvin for an order of magnitude check.

1. Compute the isentropic temperature ratio using T_2 over T_1 equals pressure ratio to the power of (gamma minus 1) over gamma.
With pressure ratio 1.3 expansion, use p_2 over p_1 equals 1 divided by 1.3 which is about 0.769.
Exponent equals 0.3 divided by 1.3 which is about 0.231.
Temperature ratio is 0.769 raised to 0.231 which is about 0.94.
Temperature drop is about 6 percent of inlet absolute temperature.
With T_1 about 573 kelvin, delta T is about 34 kelvin.

2. Isentropic enthalpy drop equals cp times delta T which is about 0.9 times 34 equals about 30 kilojoules per kilogram.

3. Real enthalpy drop equals isentropic efficiency times isentropic drop