Gaspar García, CFD portfolio

Caveated

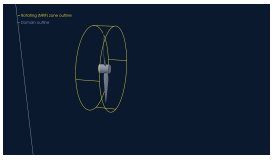
Updated 2026-11-14

A small propeller: tracing a +27.8 % thrust error to the blade pitch, with power still unexplained

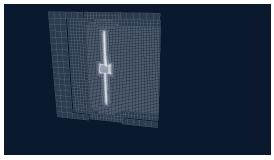
Objective. Reproduce the measured thrust and power of a small retail propeller at one advance ratio with a steady rotating-frame RANS model, and find where the disagreement comes from before tuning anything.

Parameters

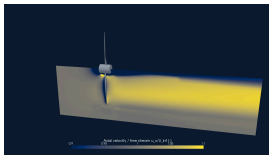
Advance ratio J = V / (n D)	0.523
Rotational speed	4998 rpm (523.389336 rad/s)
Diameter	0.2794 m
Free-stream speed	12.172312 m/s
Chord Reynolds number	6.3×10^4 at three-quarter radius, 2.0×10^4 at the tip
Fluid	Incompressible air, kinematic viscosity 1.5e-05 m^2/s (test temperature not published), density 1.225 kg/m^3
Solver	OpenFOAM v2412, simpleFoam (SIMPLEC) with a multiple-reference-frame rotor zone
Turbulence model	k-omega SST, fully turbulent



1 Geometry



2 Mesh

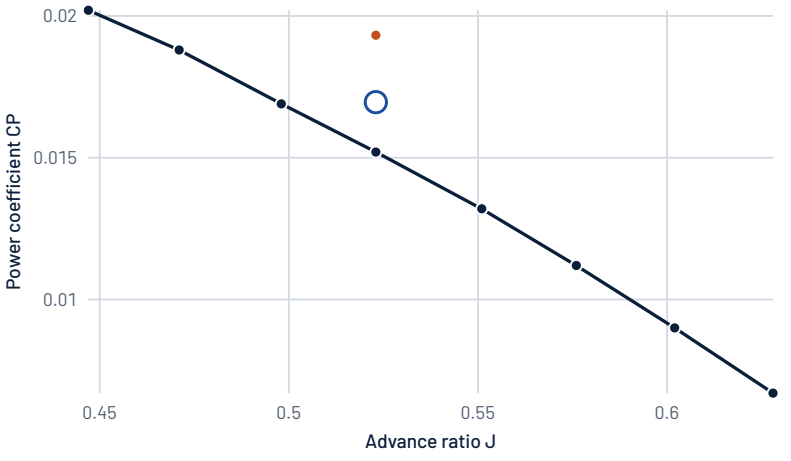


3 Results

Comparison with experiment

Quantity	Experiment	Simulation	Signed difference
CT, re-pitched to 5.5 in (blades and hub)	0.0156	0.01558	−0.11 %
CP, re-pitched to 5.5 in (blades and hub)	0.0152	0.01696	+11.6 %
Efficiency, re-pitched to 5.5 in	0.535	0.481	−10.2 %
CT, table loft 5.80 in	0.0156	0.01994	+27.8 %
CP, table loft 5.80 in	0.0152	0.01932	+27.1 %

Power coefficient CP against Advance ratio J



UIUC propDB (kt0470, 4998 rpm)
Simulation, re-pitched to 5.5 in
Simulation, table loft (5.80 in)

Verdict

The table loft over-predicted thrust and power by +27.8 % and +27.1 %, the signature of too much pitch; re-pitching to the nominal 5.5 in removed the thrust error. Power stays +11.6 % high, unexplained, on one grid with a waived mesh check.

Limits

- The thrust match is not a precision number: 1 % in J is 5.4 % in CT, the pitch is uncertain and the hub is estimated.
- One grid, no numerical uncertainty; checkMesh failed on 2 blade faces (waived, recorded).
- Near-wall cells aft on the chord are far coarser than designed, cause unknown; the case is parked.

1. J. B. Brandt and M. S. Selig (2011), "Propeller Performance Data at Low Reynolds Numbers", 49th AIAA Aerospace Sciences Meeting, AIAA Paper 2011-1255, Orlando, FL.
2. J. B. Brandt (2005), "Small-Scale Propeller Performance at Low Speeds", M.S. thesis, Department of Aerospace Engineering, University of Illinois at Urbana-Champaign.
3. UIUC Propeller Data Site, volume 1: APC 11x5.5E, run kt0470 at 4998 rpm (apce_11x5.5_kt0470_4998.txt) and chord and twist table (apce_11x5.5_geom.txt).

Full page with sources, mesh and numerical accuracy: /cases/propeller-apc-11x55/. Every number is checked against its source file.