A rig for sub-idle compressor characteristics

Luis Ferrer-Vidal España-Heredia

l.ferrer-vidal@cranfield.ac.uk

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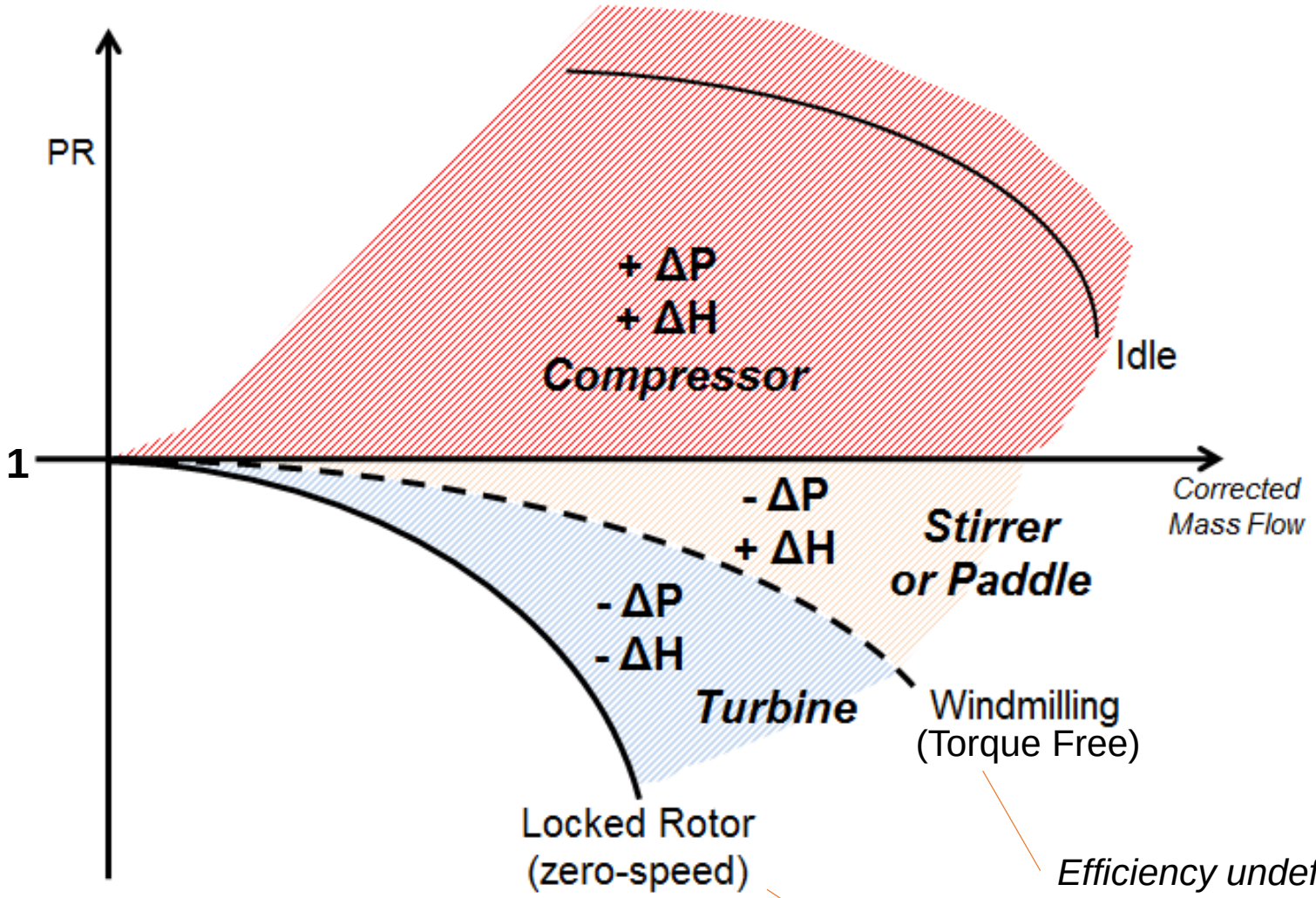
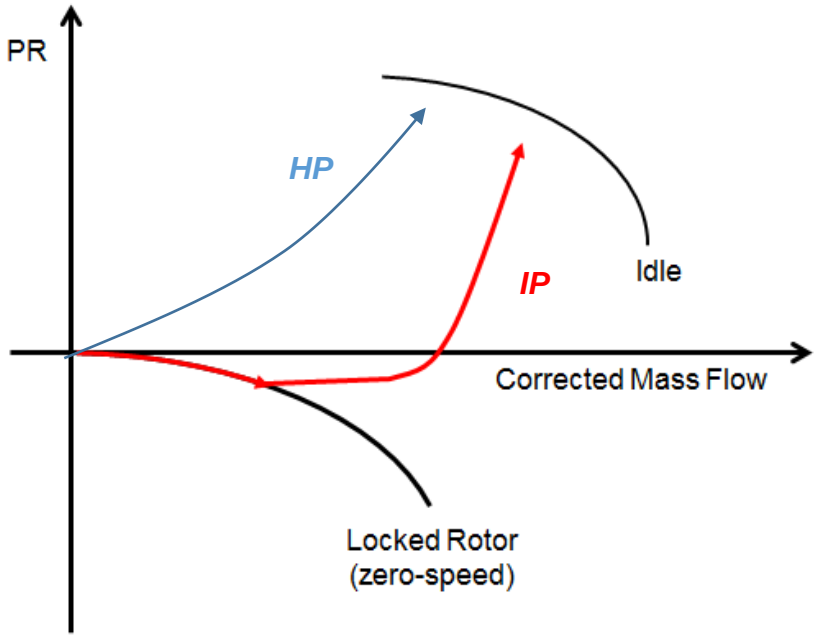
Sub-idle Regime

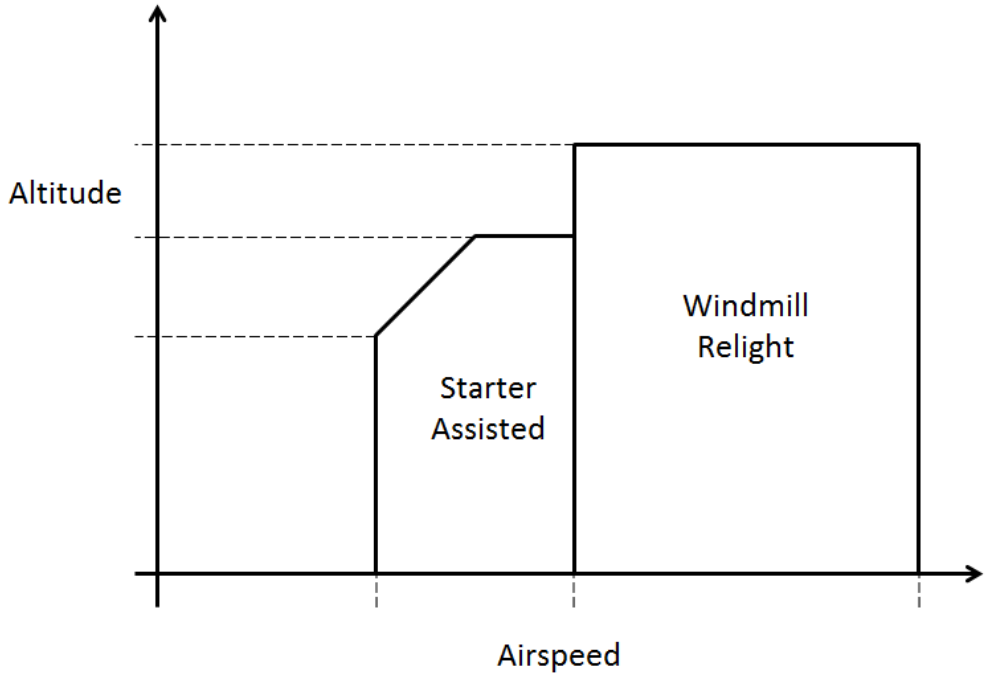


Relevance

Start-up Performance

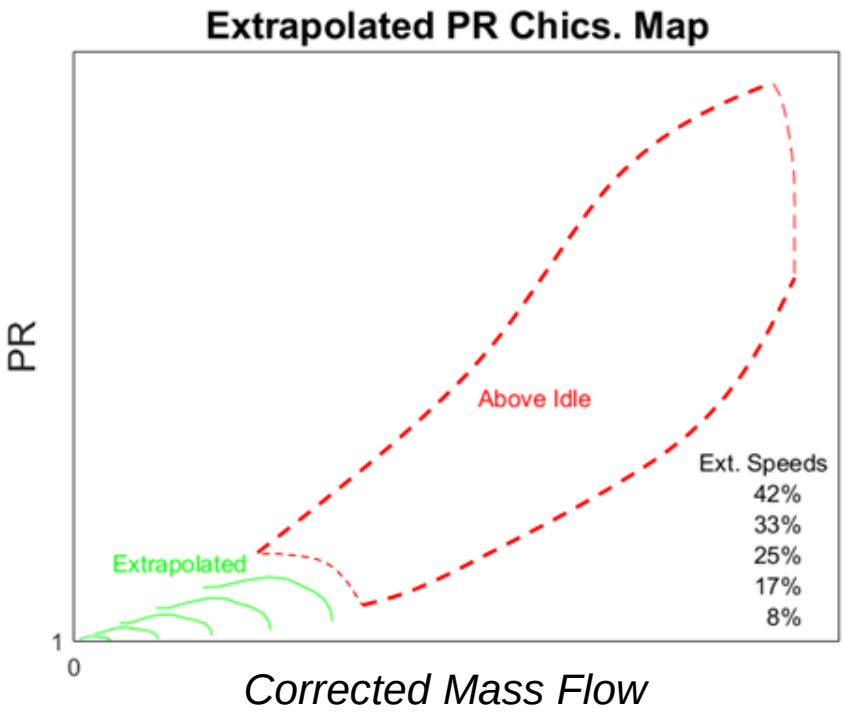


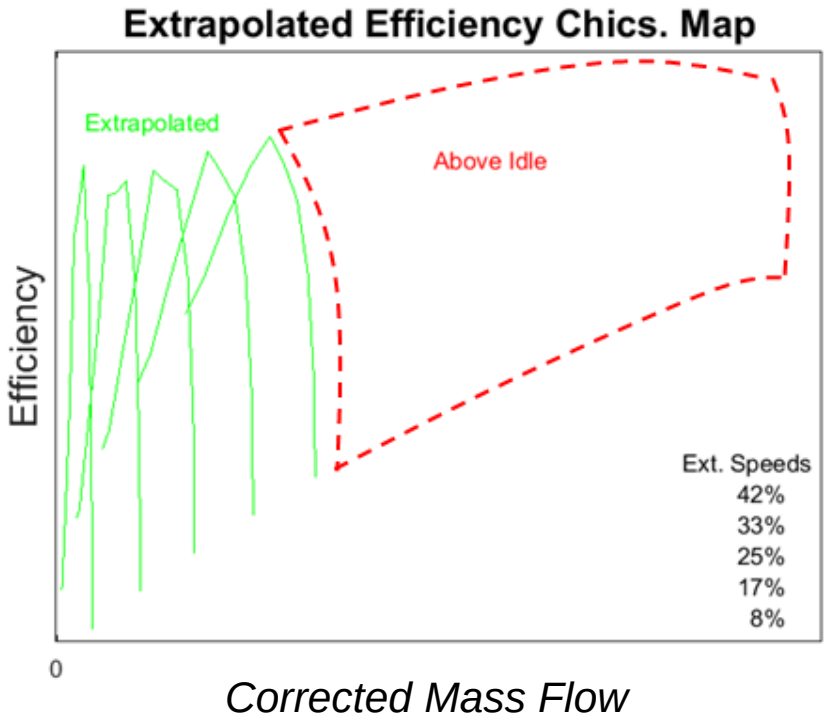
Windmill Performance



- Quick and reliable ground-starts.
- Reliable and predictable inflight re-lights.

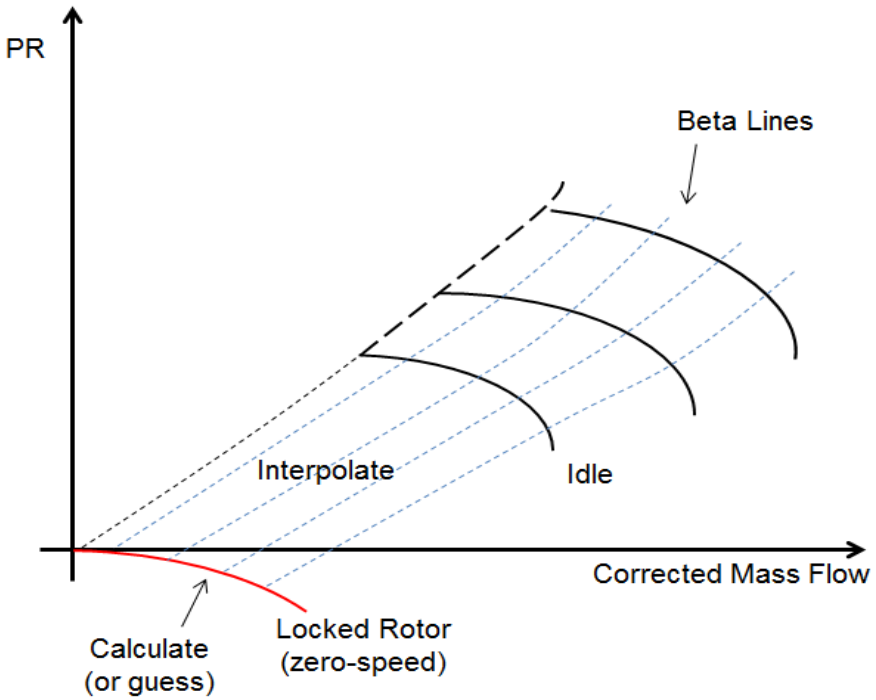
Existing methods

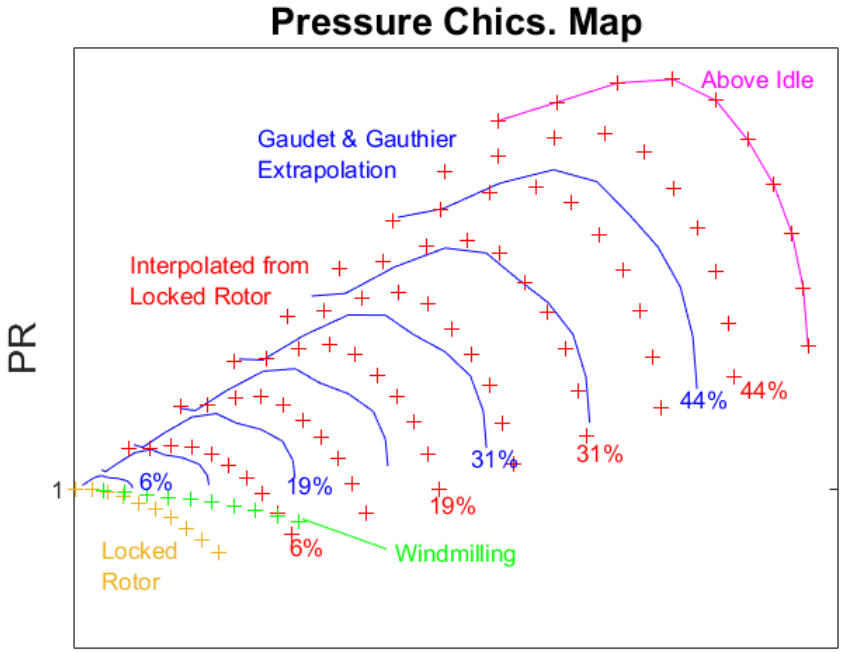




- Typical sub-idle map creation methods rely on extrapolation of existing maps.
- Potential to yield unphysical maps.

Existing methods

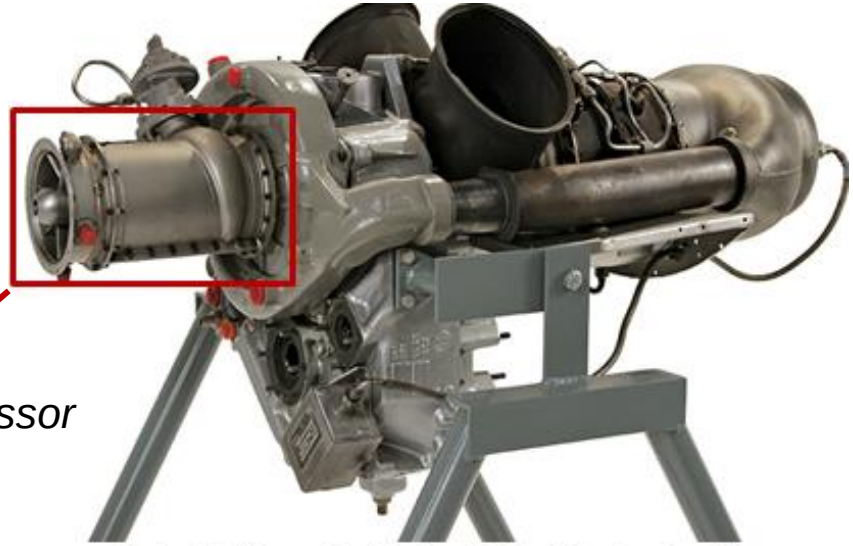




Corrected Mass Flow

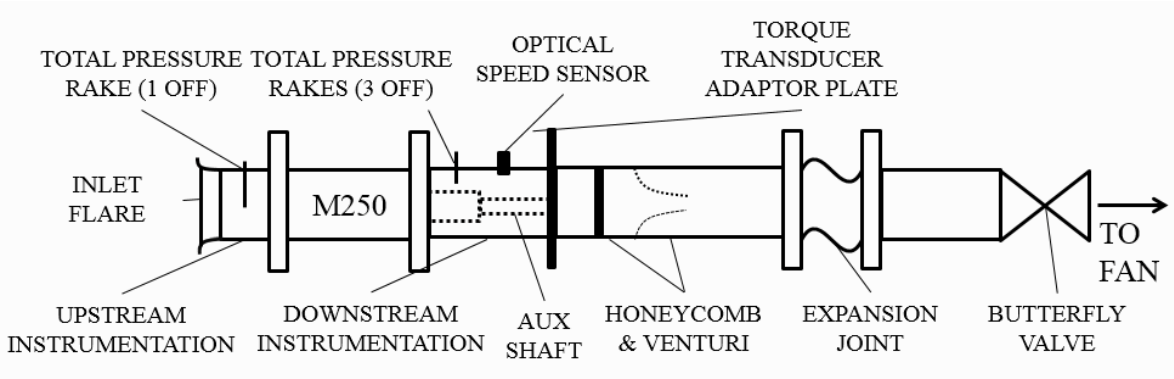
- Improvement by first estimating locked rotor line and interpolating.
  - Need to test if this yields physical results.
  - Need to check locked rotor calculation.

Sub-idle Compressor Rig

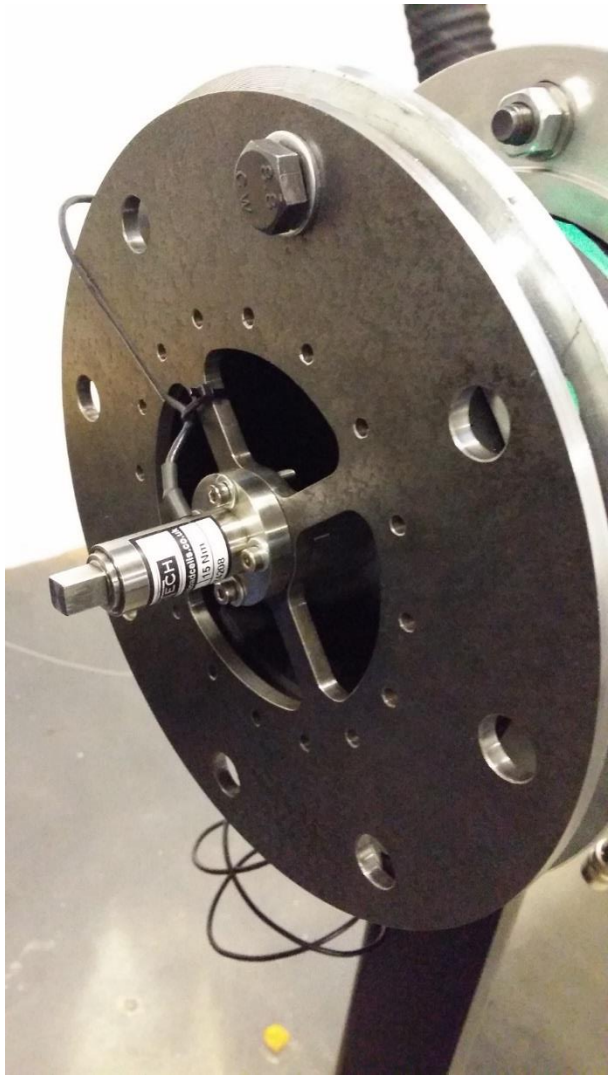


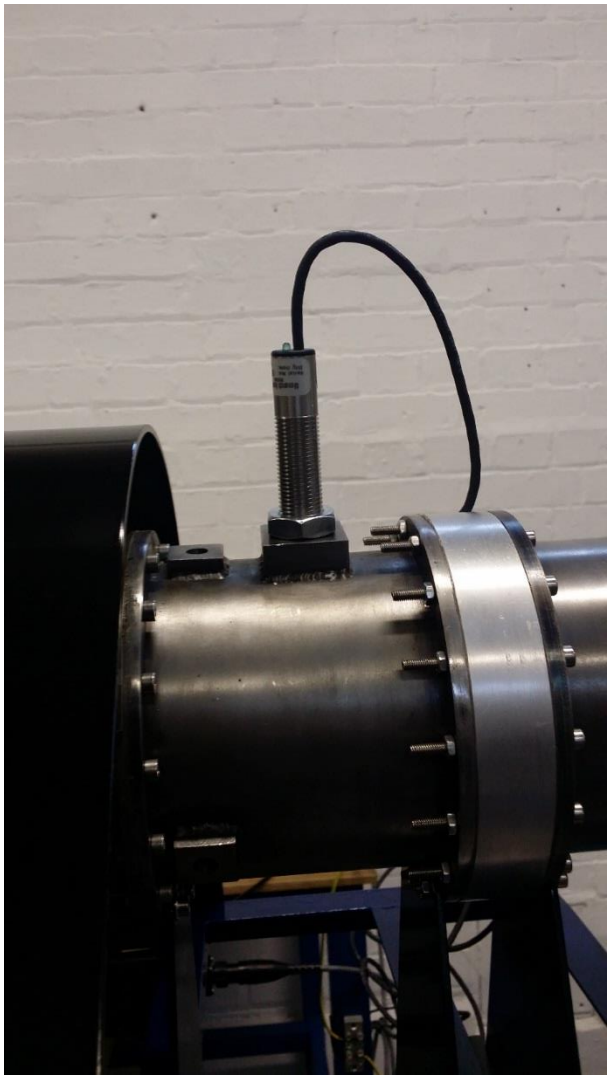
Axial Compressor

Allison M250 Turboshaft



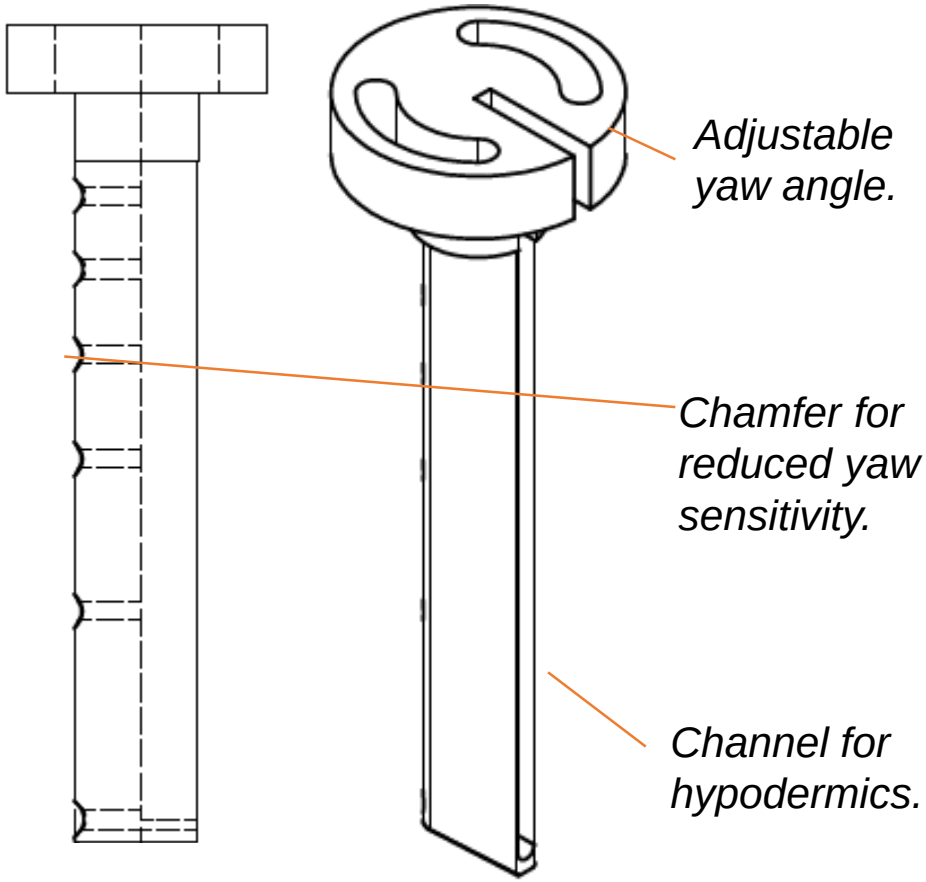
Torque & Speed Measurement



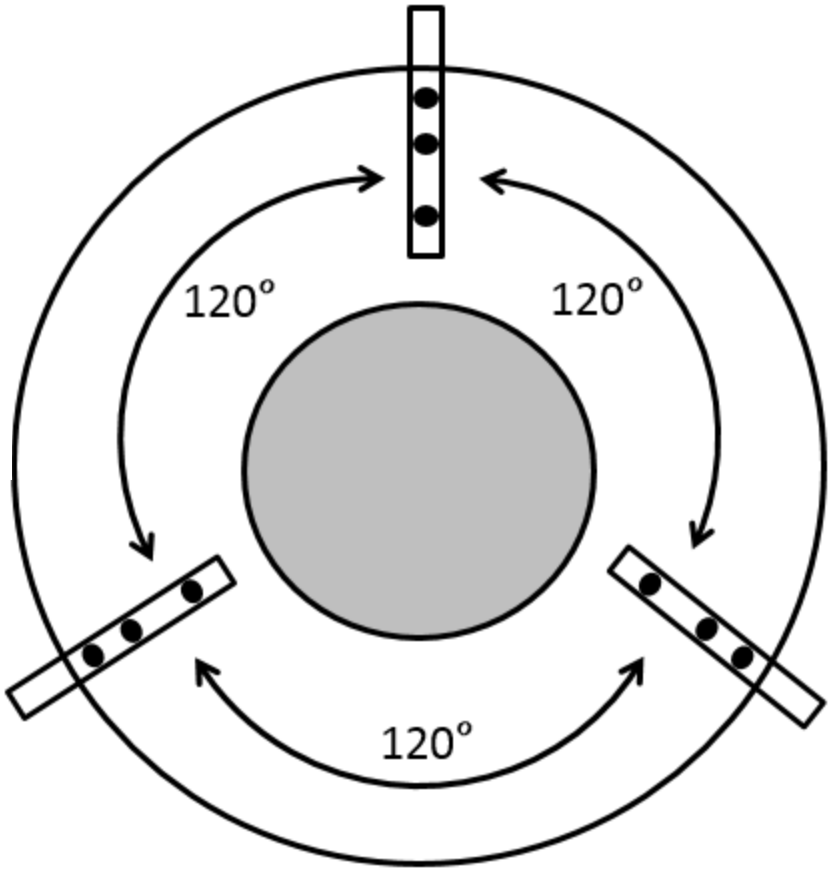


Total Pressure Measurement

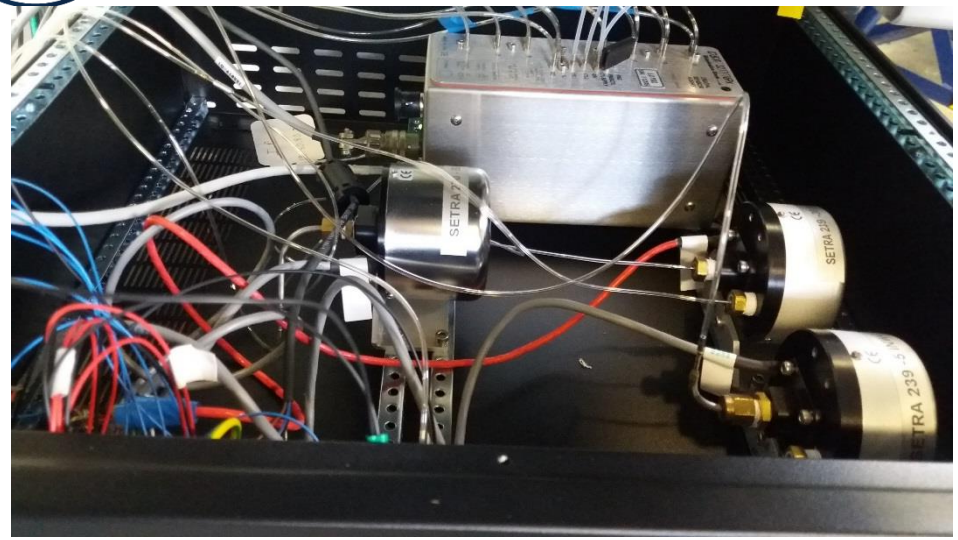
Inlet Total Pressure Rake (x1)

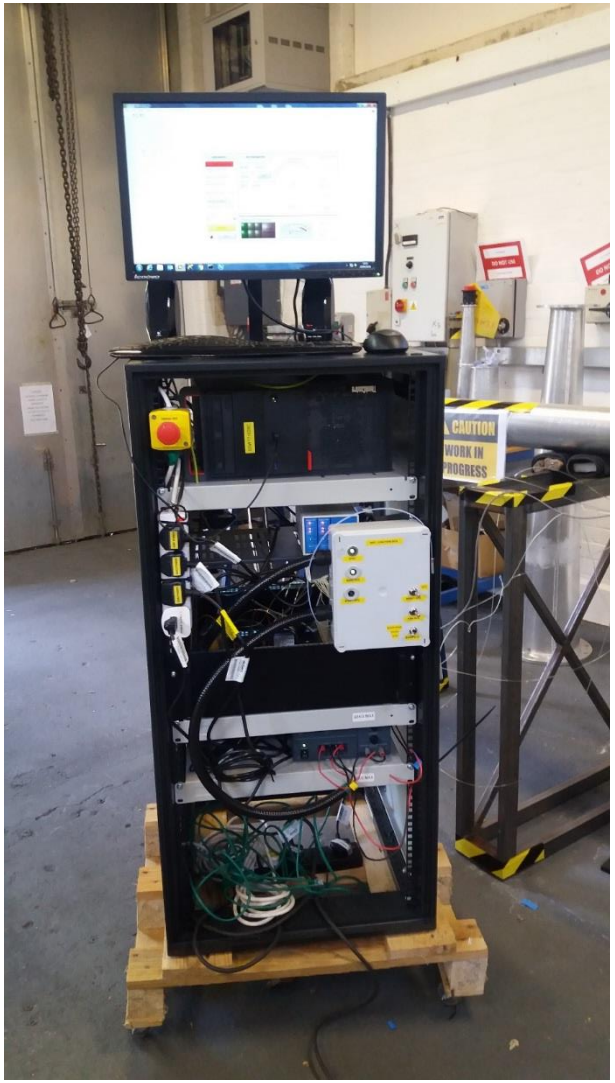


Outlet Total Pressure Rakes (x3)



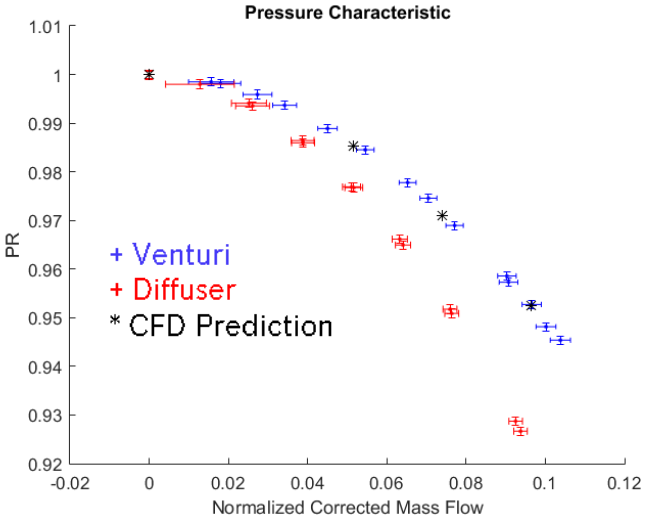
Instrumentation Package

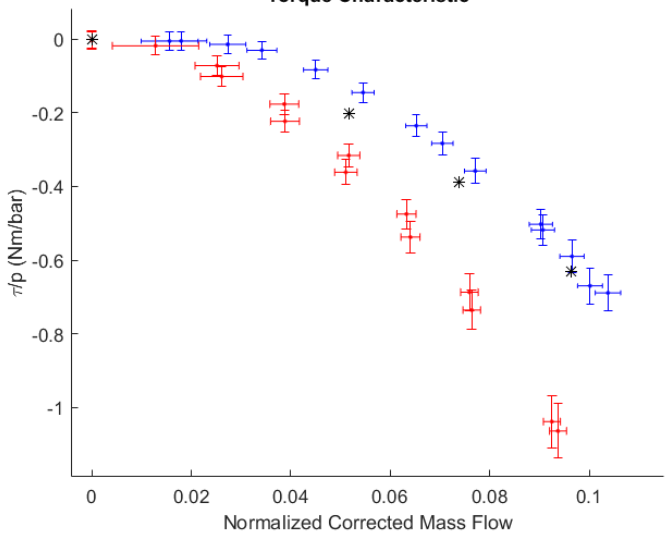




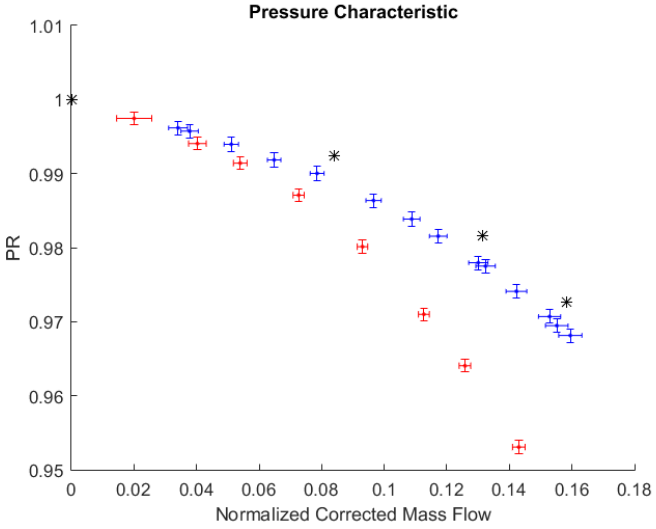
Results

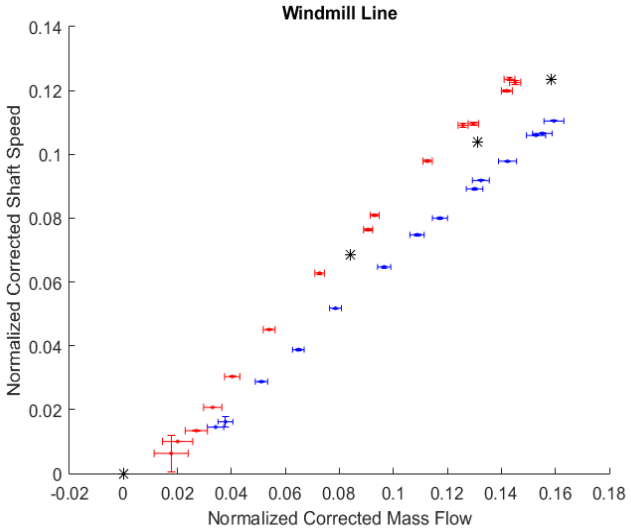
Locked Rotor

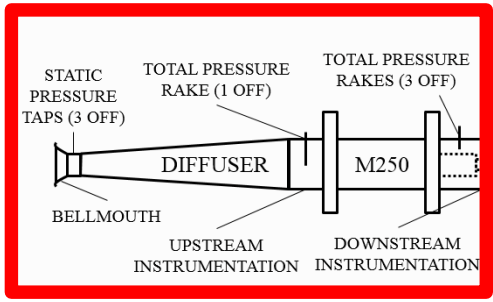


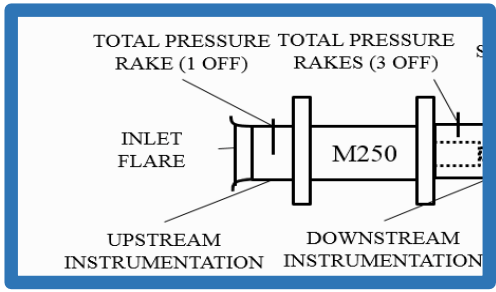


Windmill

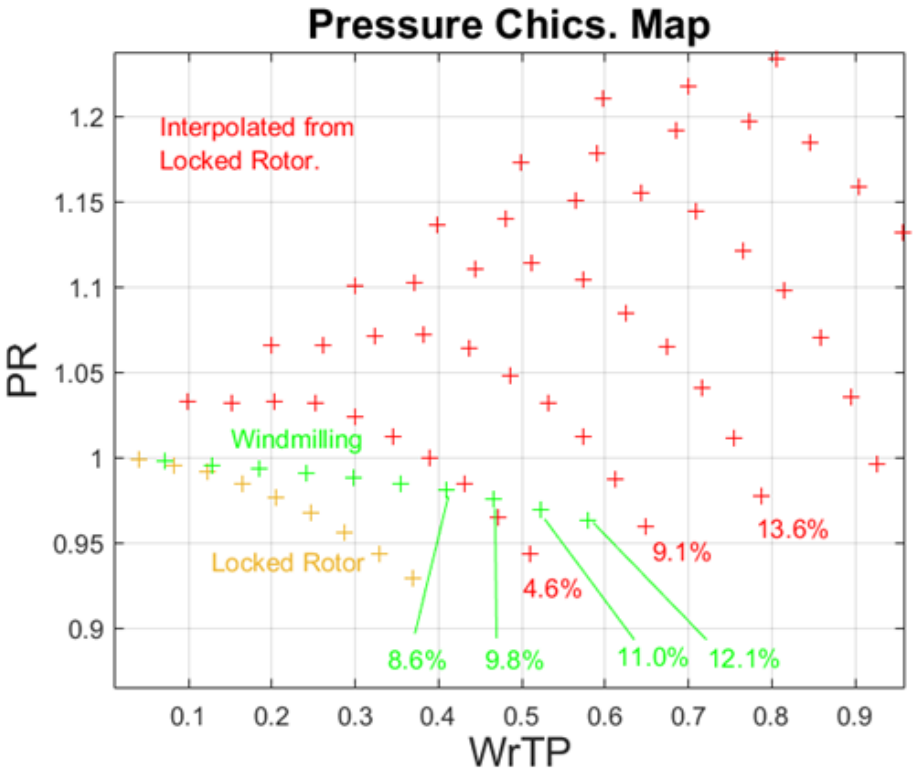


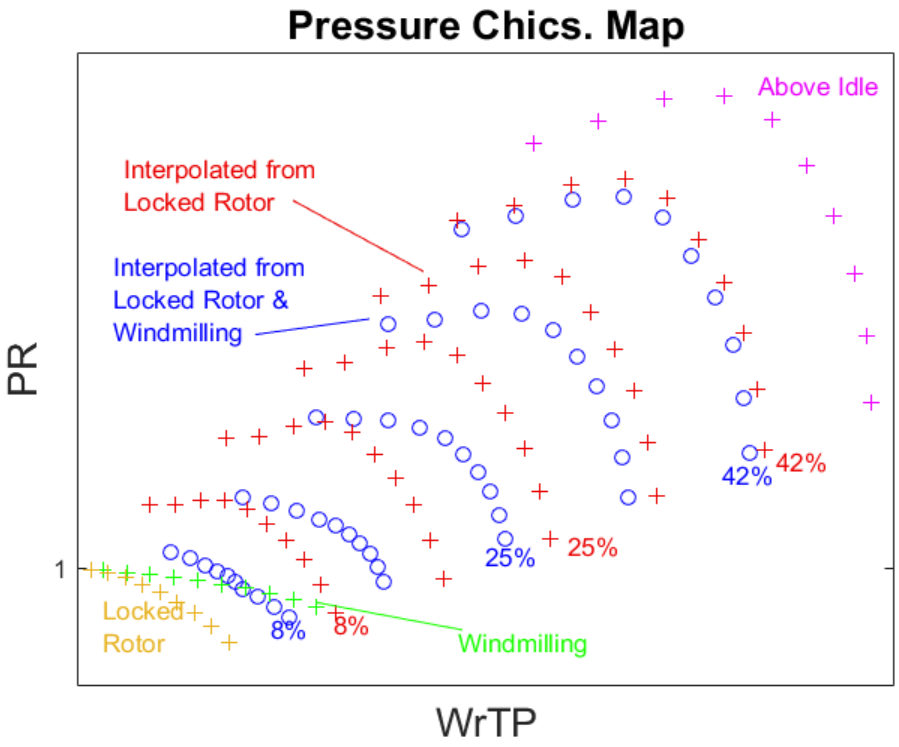






Implications: Interpolation approach

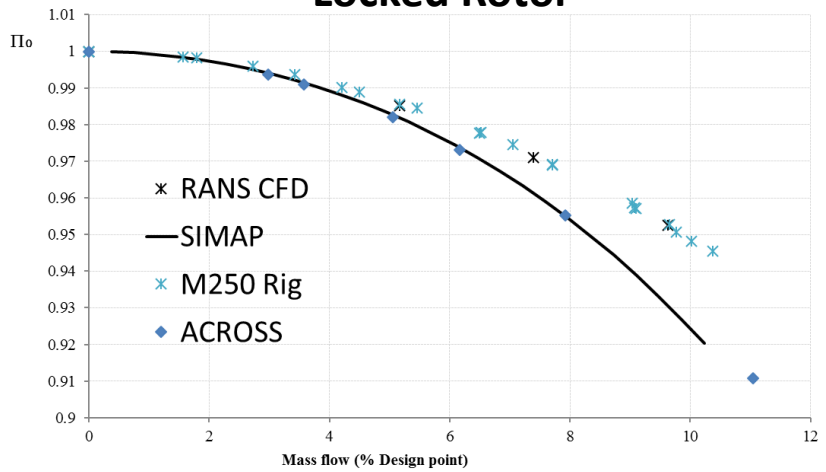


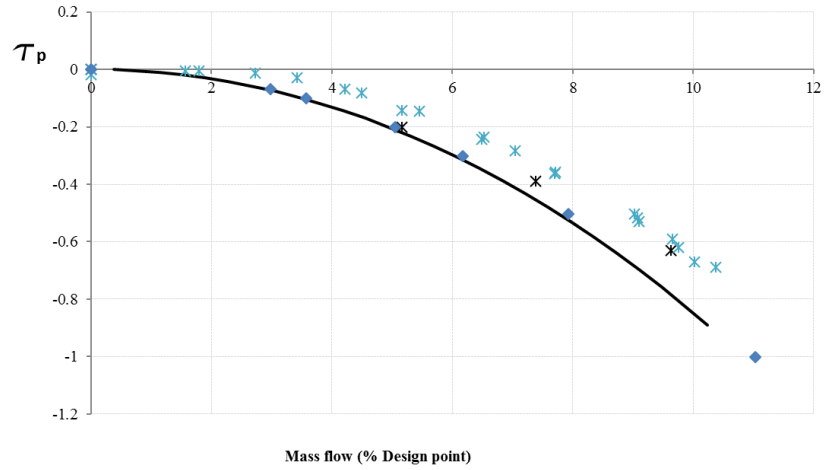


Implications: Testing of low-order models.

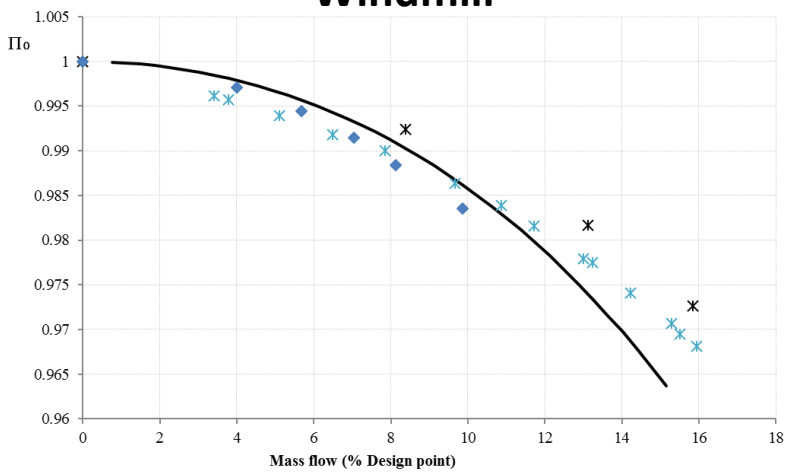
- Based on blade performance correlations developed for sub-idle.

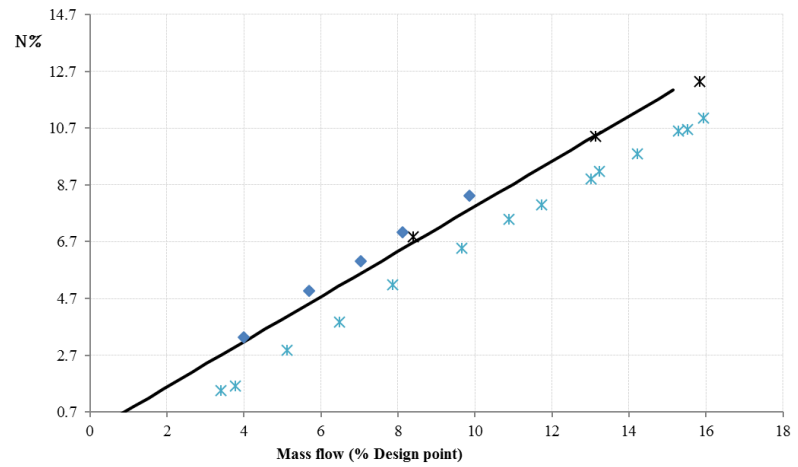
Locked Rotor





Windmill

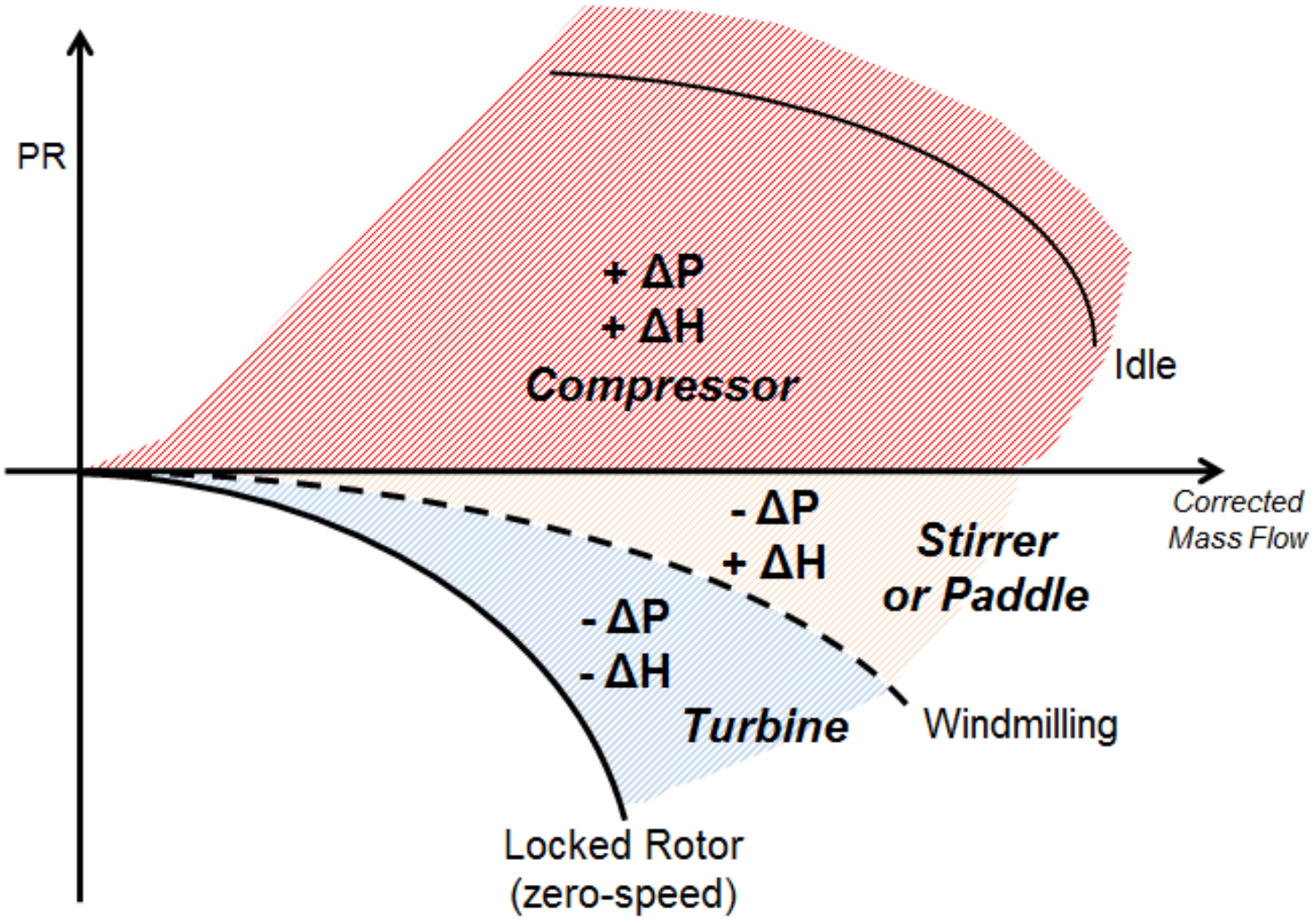




Summary

- Locked rotor and windmill lines measured.
- Challenge: Mass flow requirement on suction rig.
- Linear relationship mass flow – windmill shaft speed.
- Interpolation using only locked rotor did not accurately capture windmill region.
  - Use knowledge of the torque-free point to more accurately capture windmill region.
  - Linear relationship allows single point characterization.
- Platform for checking low-order models.

Thank You.


PR
+ ΔP
+ ΔH
Compressor
Idle
Corrected
Mass Flow
- ΔP
+ ΔH
Stirrer
or Paddle
- ΔP
- ΔH
Turbine
Windmilling
Locked Rotor
(zero-speed)