CCGEx 2016 10 28

Engine optimized turbine design

Nicholas Anton NMGG

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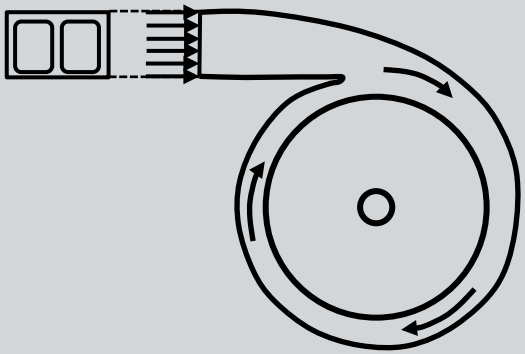
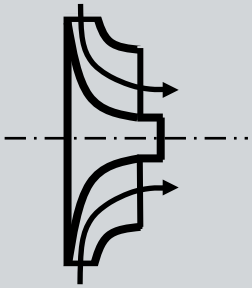
Agenda

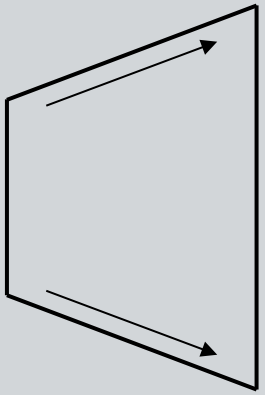
- Introduction and background
- Activities
- Questions

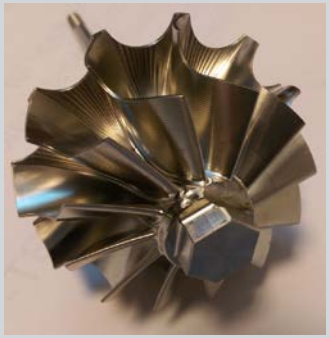
Activities

- Twin-scroll turbocharger turbine stage modelling
  - Method for 1D turbocharger turbine evaluation from gas stand
  - Performance measures, volute, rotor, diffuser…
  - Turbine stage parameters…
  - Design changes…



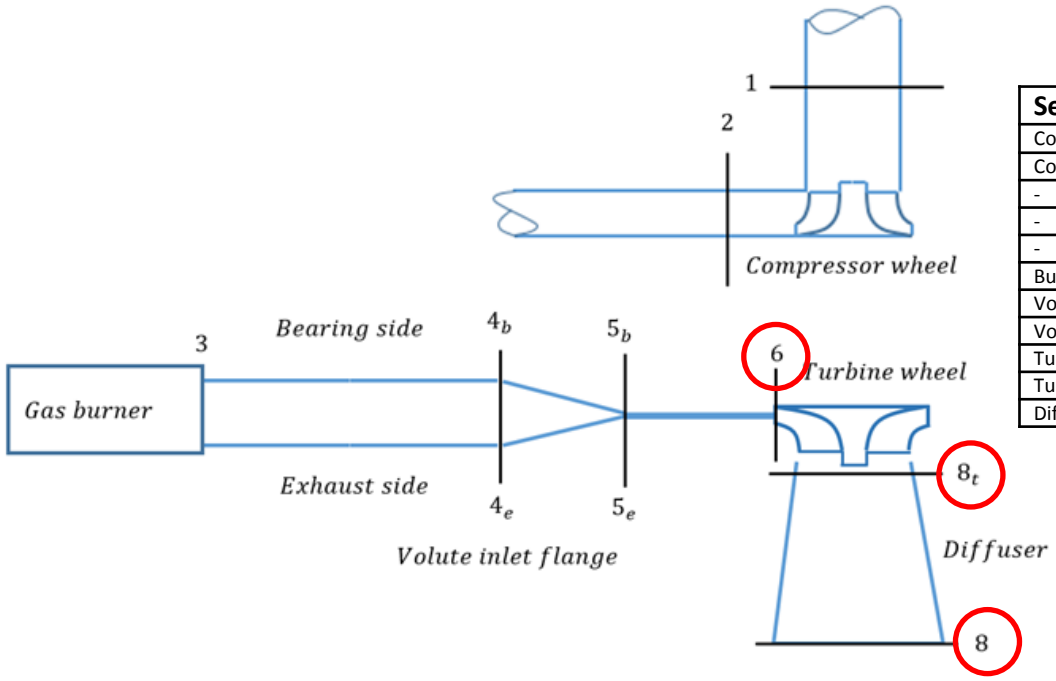






Activities

- Twin-scroll turbocharger turbine stage modelling
  - Gas stand set-up



Section	Measured quantity	Location
Compressor inlet	Total temperature, static pressure	1
Compressor outlet	Total temperature, static pressure	2
-	Compressor mass flow	-
-	Turbine mass flow	-
-	Turbocharger rotational speed	-
Burner outlet	Total temperature	3
Volute inlet	Total pressure, bearing and exhaust side	4
Volute divider outlet	(Total pressure, bearing and exhaust side)	5
Turbine rotor inlet	Static pressure	6
Turbine rotor outlet	Static pressure	8t
Diffuser outlet	Static pressure	8

Locations of measurement positions on gas stand

Activities

- Twin-scroll turbocharger turbine stage modelling
  - Methodology

Input

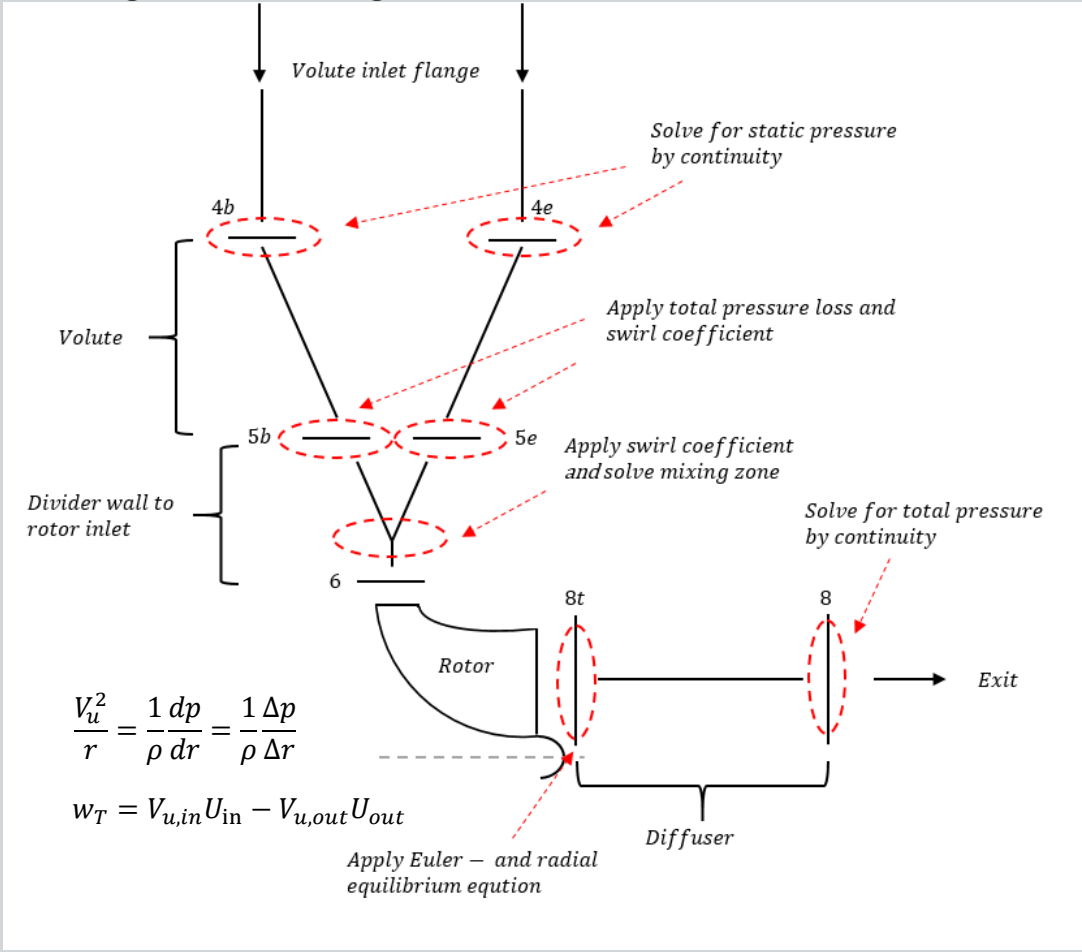
1D meanline approach

Calculate flow state at each section using: 1D continuity, momentum, energy…using iteration

Output

Deduce turbine stage parameters

Sequential volute inlet to diffuser exit



Turbine stage calculation overview

Activities

- Twin-scroll turbocharger turbine stage modelling

  Fully defined turbine stage sections using calculation procedure with inputs/measurements

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Analysis of turbine stage and parts, volute, rotor and diffuser

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Ex. turbine rotor velocity triangles

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Turbine stage parameters

Degree of reaction

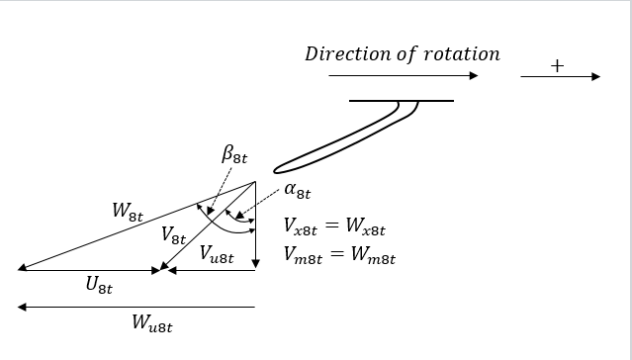
Flow coefficient

Diffuser inlet swirl

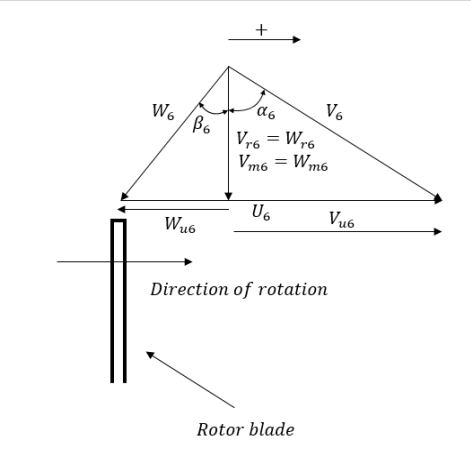
Rotor absolute inlet flow angle

Rotor incidence

Important for determining geometry changes



Outlet velocity triangle turbine rotor



Inlet velocity triangle turbine rotor

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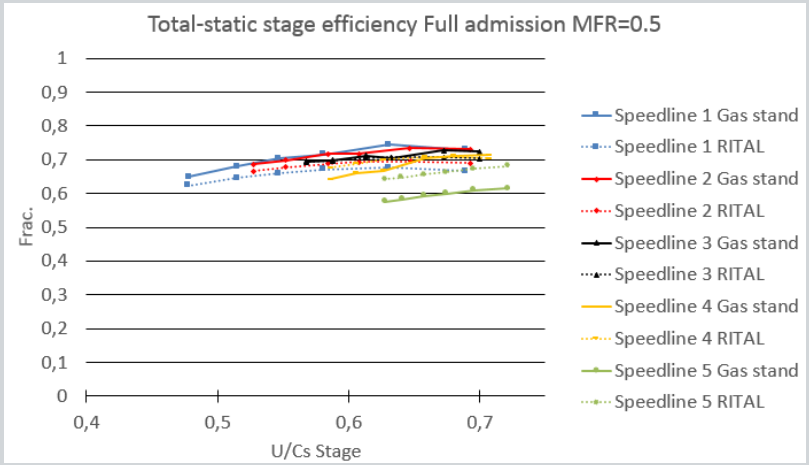
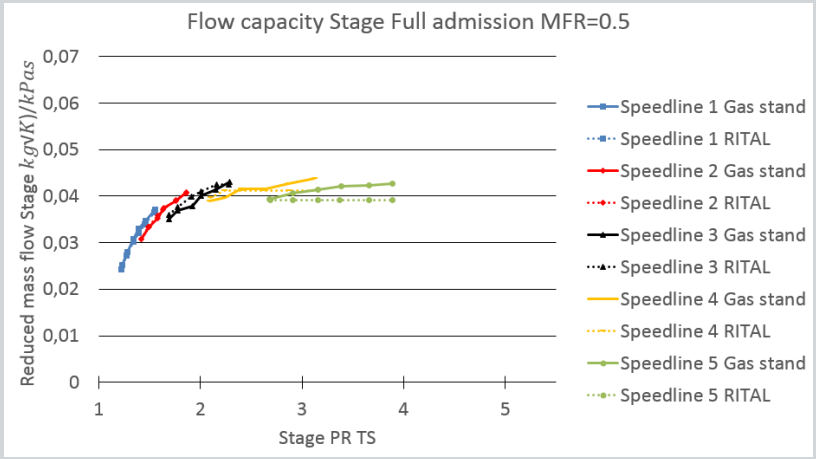
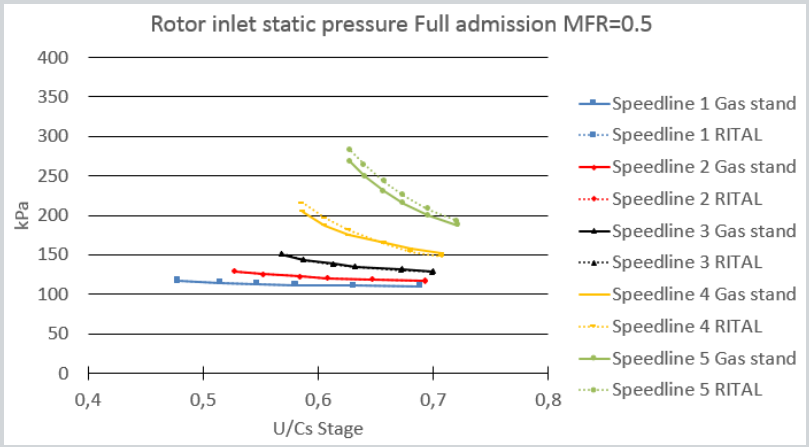
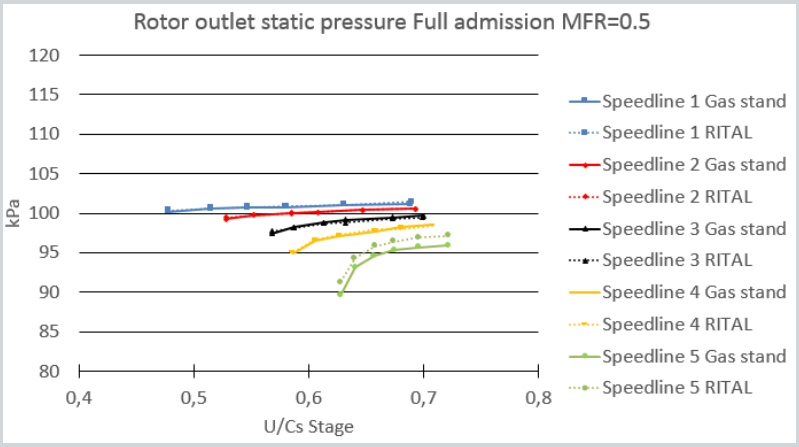
Activities

- Twin-scroll turbocharger turbine stage modelling
  - Validation









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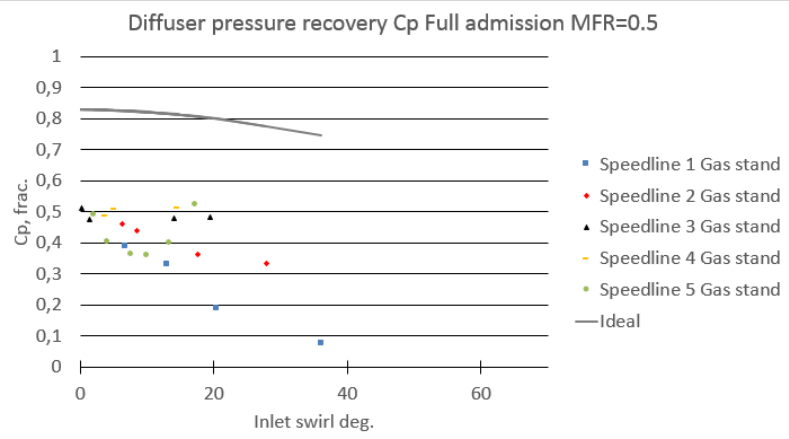
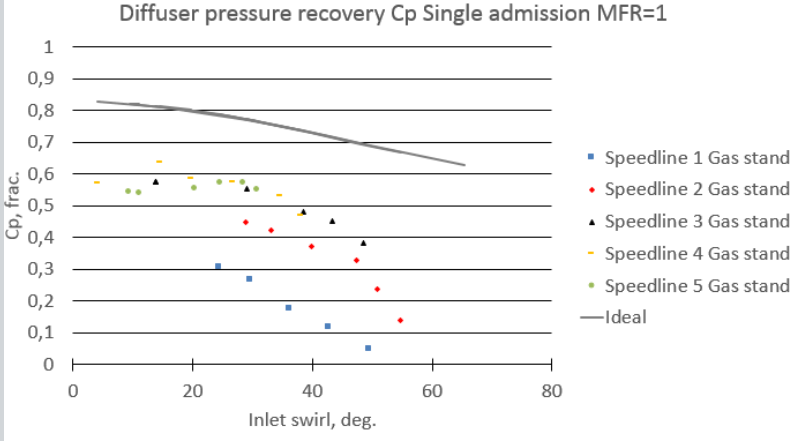
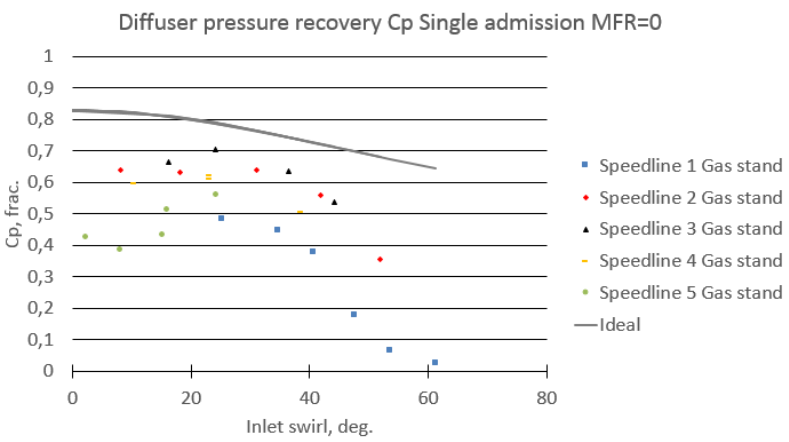
Activities

- Twin-scroll turbocharger turbine stage modelling
  - Results diffuser analysis







$$C_p = \frac{\Delta p_{diffuser}}{p_{0,in} - p_{in}}$$

$C_{p,max}$ generally at some inlet swirl angle 0º-20º
High inlet swirl, decreasing pressure recovery
$C_{p,max} \sim 0.6$

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Activities

- Twin-scroll turbocharger turbine stage modelling

Evaluation	Traditional gas stand	Proposed methodology
Turbine maps	✓	✓
Individual part performance	✗	✓
Comparing data from different gas stands	✗	✓

Validate a turbine design

Propose design changes

Minimize performance uncertainties using data from different gas stands

Future work

- Turbocharger turbine design for Heavy-Duty Otto engine

  - Influence of exhaust volume on turbine design
  - Turbine designpoint parameters and turbine designs
  - Performance in pulsating engine environment
  - Low engine RPM-range focus

Questions!?