KME 707

Improved steam turbine design for optimum efficiency and reduced cost of ownership

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Prof Magnus Genrup

Background / Motivation

- Industrial turbines – prismatic stators and rotors imposed by manufacturing constraints
- Scope of efficiency improvment – Boxberg plant in Germany

  94 HP efficiency and 96 IP efficiency
- Avenues

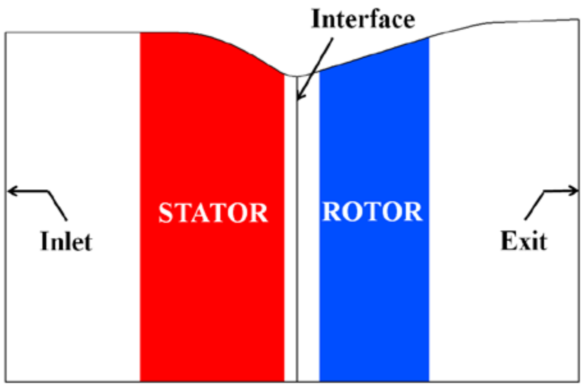
  - 3D geometry features in stators and rotors which can be produced at same cost.

    to minimize secondary and leakage losses

  - Optimized airfoil design

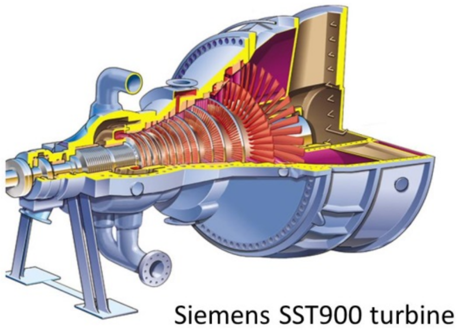
    to minimize profile losses
  - Optimum pitch-to-chord ratio

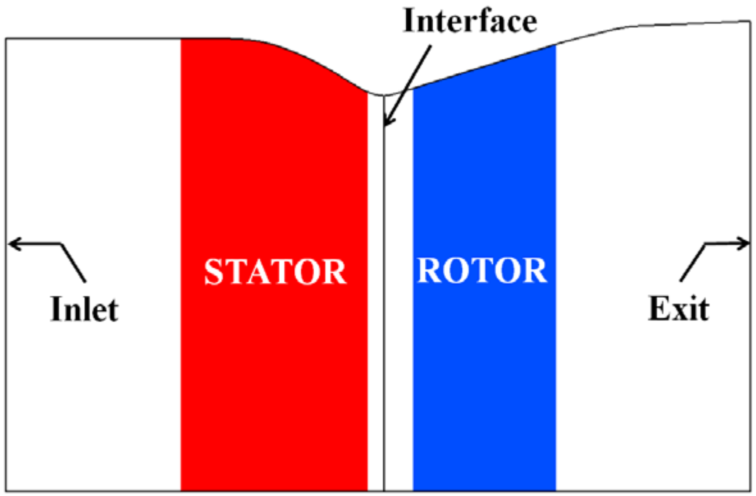
    to minimize profile losses



Case study

CASE :





Concepts Attempted :

Profile Losses

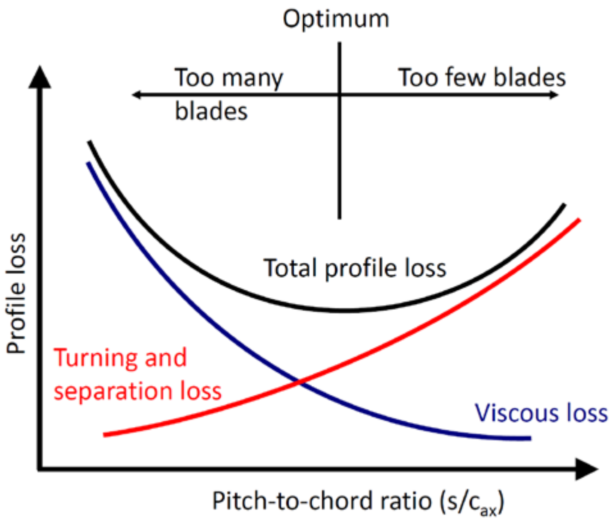
- Airfoil Redesign
- Pitch-to-chord ratio optimization

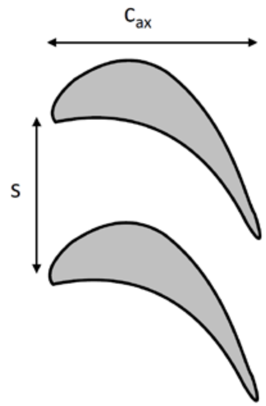
Secondary Losses

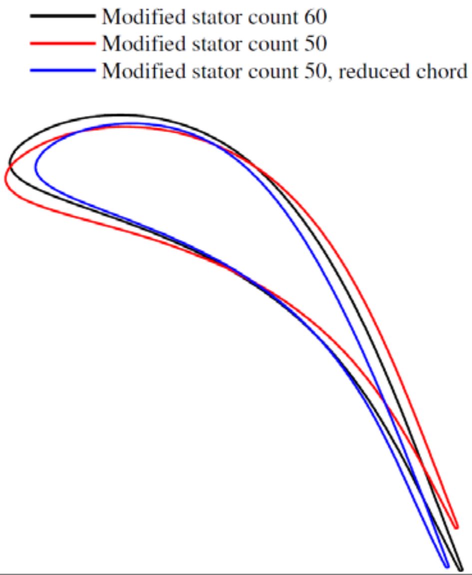
- Vortexing – Stator
- Lean
- Flow path modification

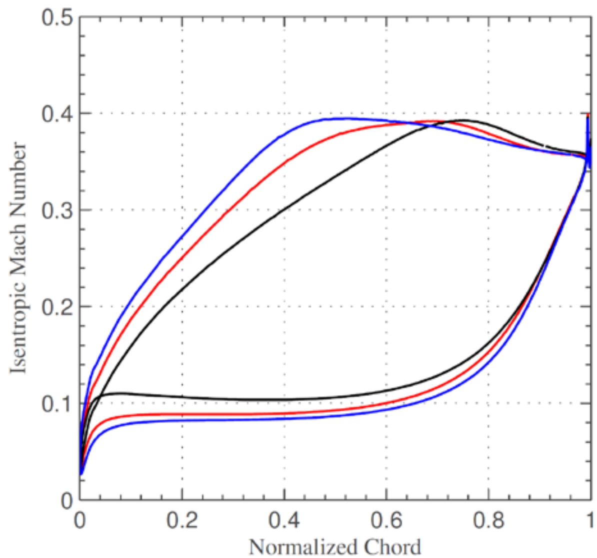
1 % in turbine stage efficiency ≈ 0.4 % section efficiency

Airfoil Design – pitch-to-chord ratio

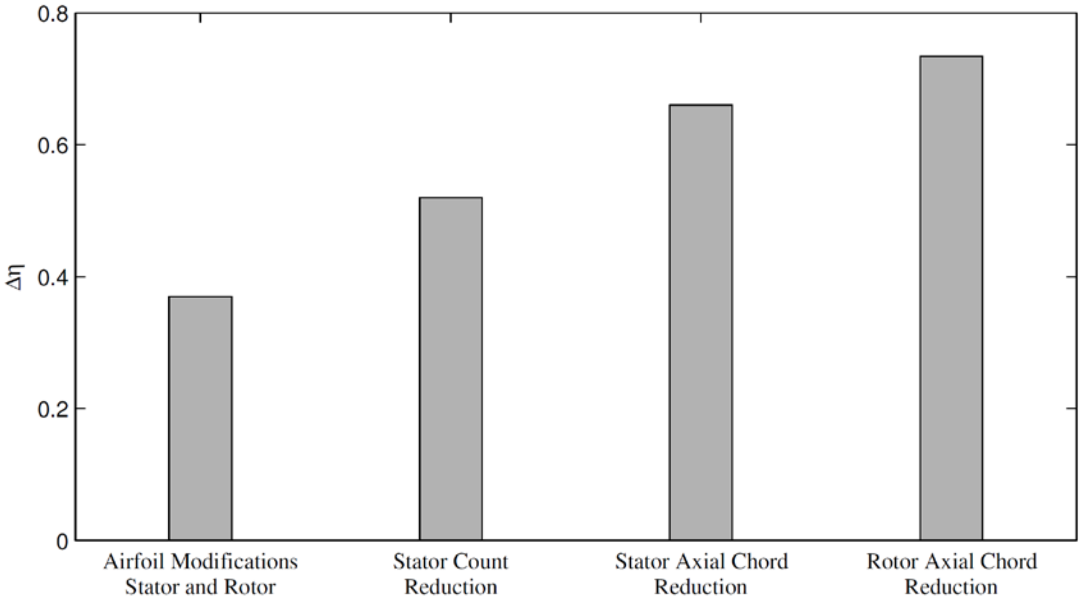








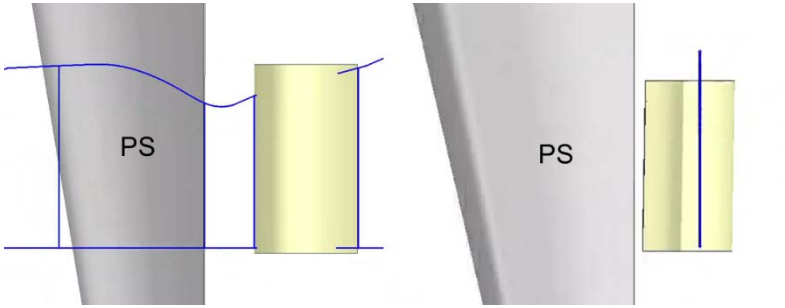
Efficiency summary – High aspect ratio

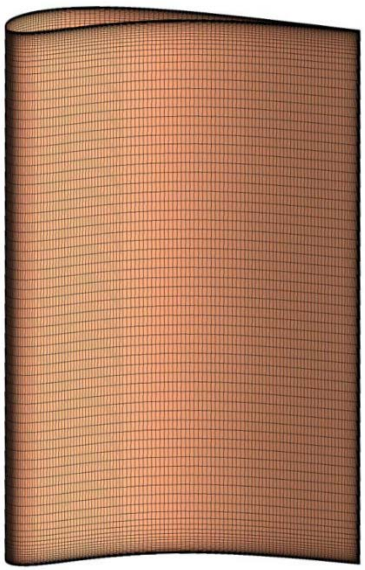


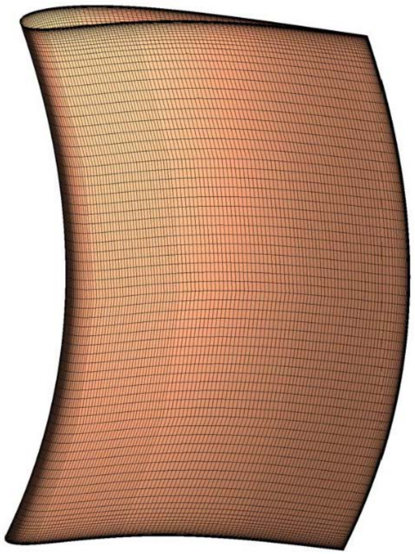
Overall gain in efficiency 0.74 % with airfoil redesign and *s/c* optimization

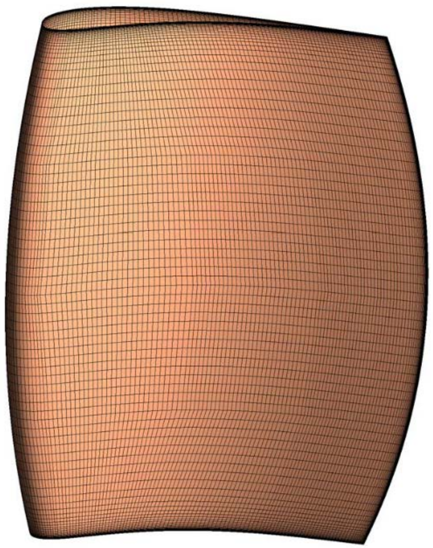
Profile losses are reduced considerably.
Secondary loss reduction is shown by Helicity parameters.

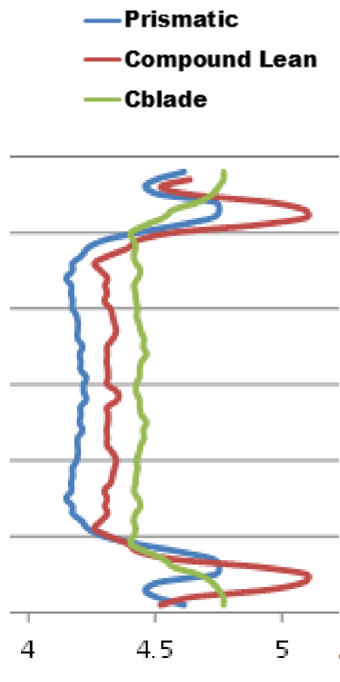
Low Aspect Ratio - Experiments









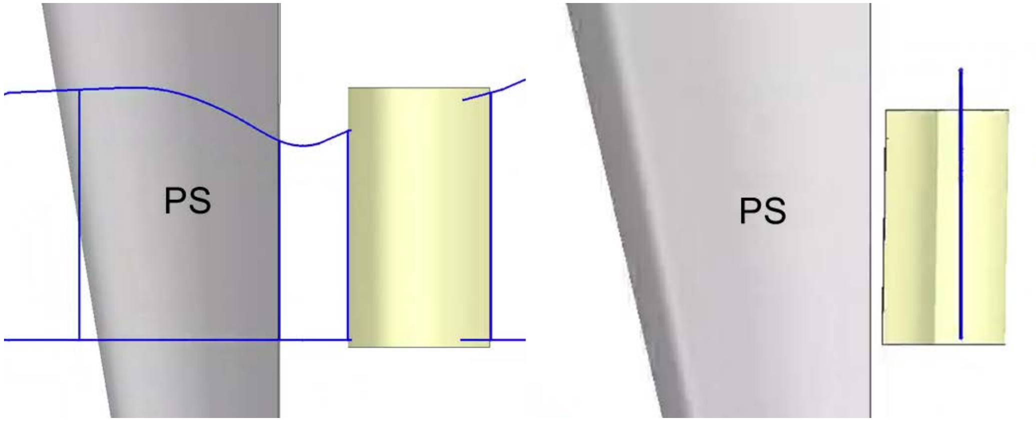


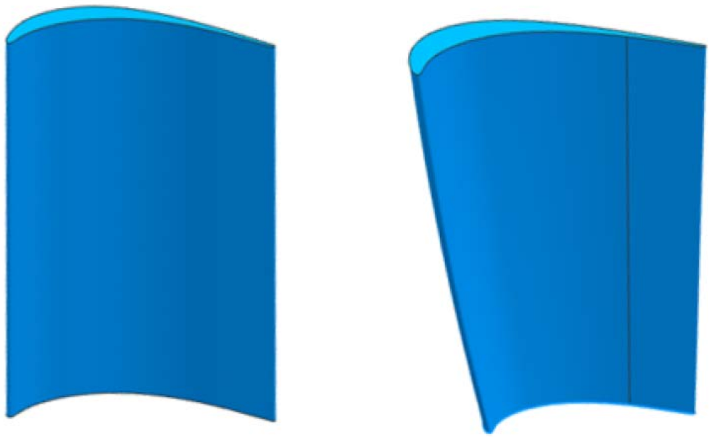
Prismatic

Compound Lean

C-Blade

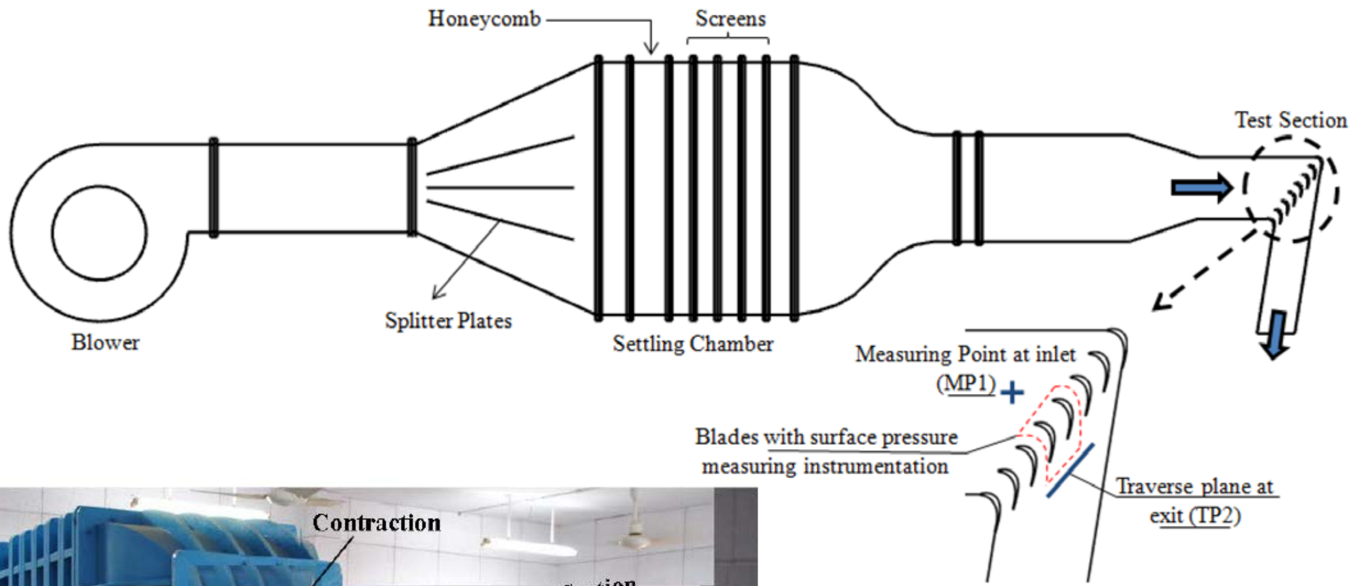
Low Aspect Ratio - Experiments





Constant chord   Varying chord

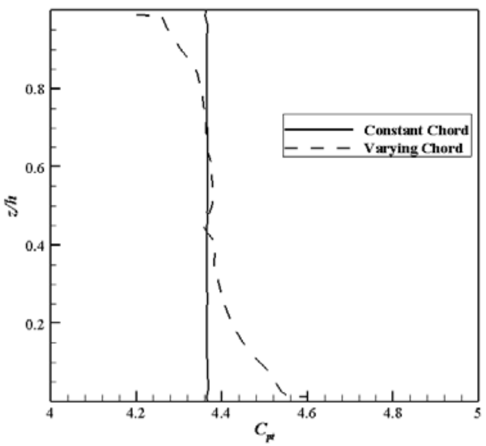
Low Aspect Ratio - Experiments



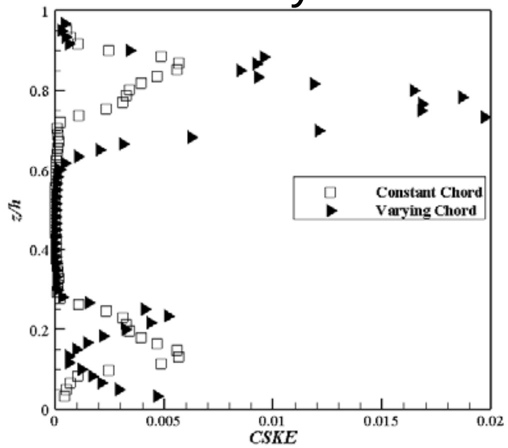
Low speed Wind Tunnel at
Indian Institute of Technology, Bombay

Low Aspect Ratio - Experiments

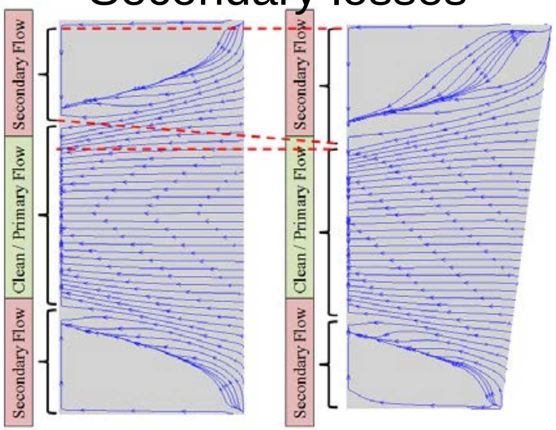
Profile losses



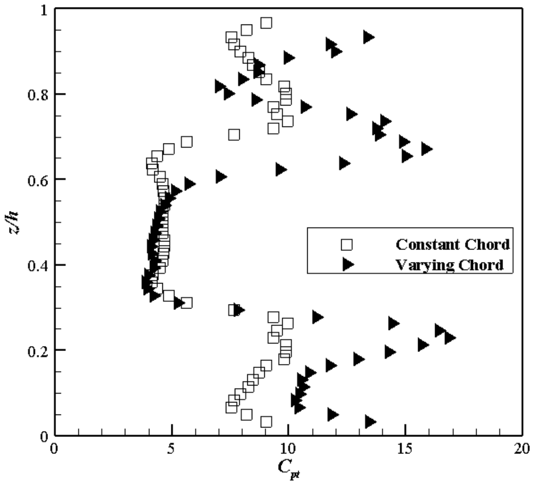
Secondary losses

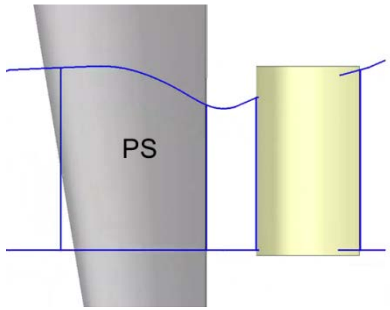


Secondary losses



Overall losses





Summary of publications

ASME GTINDIA2014

GTINDIA2014-8175

Reduction In Secondary Losses In a Turbine Cascade Using Contoured Boundary Layer Fence

TURBO EXPO 2015

GT2015-43235

Vortexing Methods To Reduce Secondary Losses In A Low-Reaction Industrial Turbine Vane

ASME GTINDIA2015

GTINDIA2015-1221

Influence of Compound Lean on an Industrial Steam Turbine stage

TURBO EXPO 2016

GT2016-57138

Efficiency Improvements in an Industrial steam turbine stage – Part I

TURBO EXPO 2016

GT2016-57140

Efficiency Improvements in an Industrial steam turbine stage – Part II

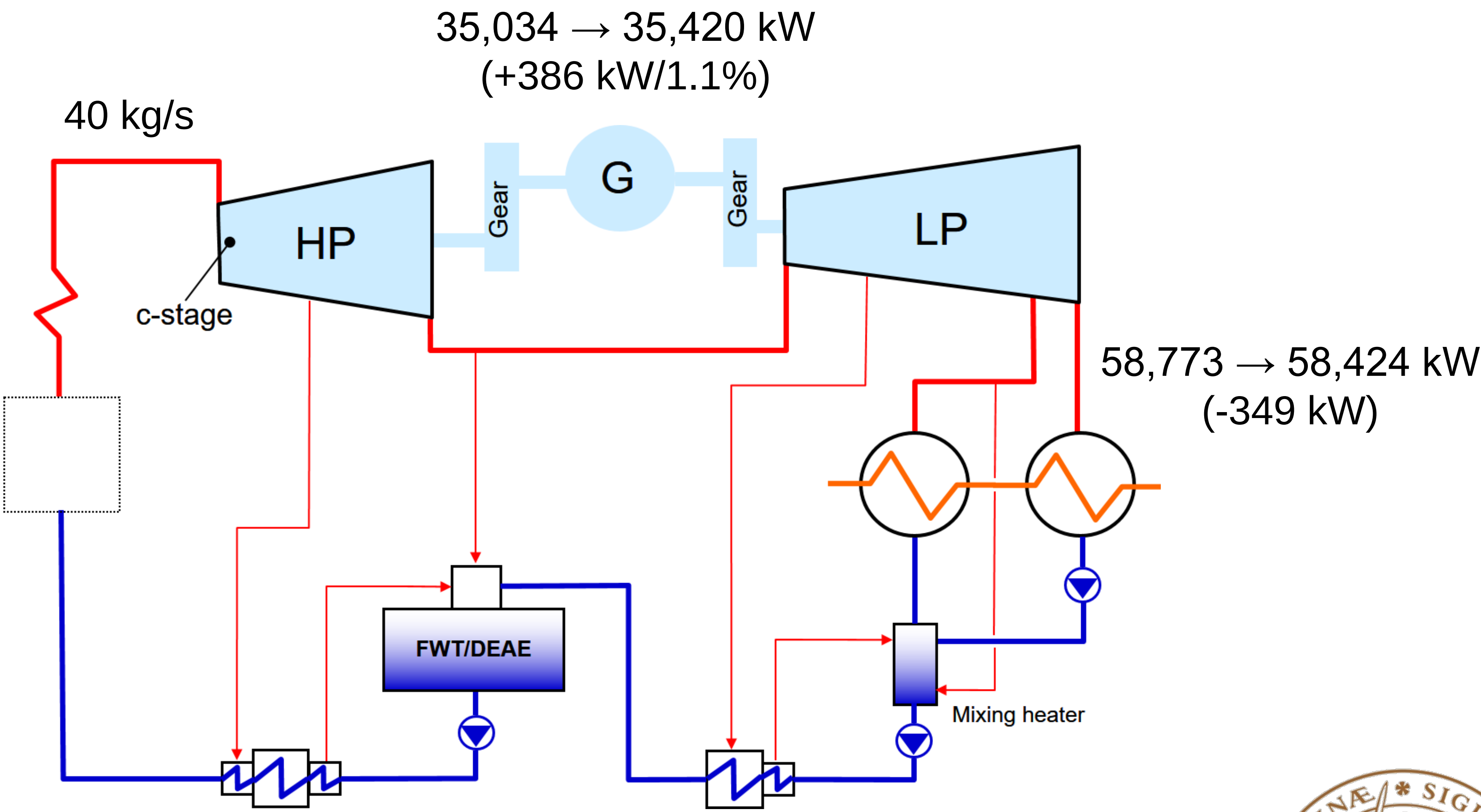
TURBO EXPO 2017

GT2017-63521

Effect Of Spanwise Variation of Chord On The Performance Of A Turbine Cascade

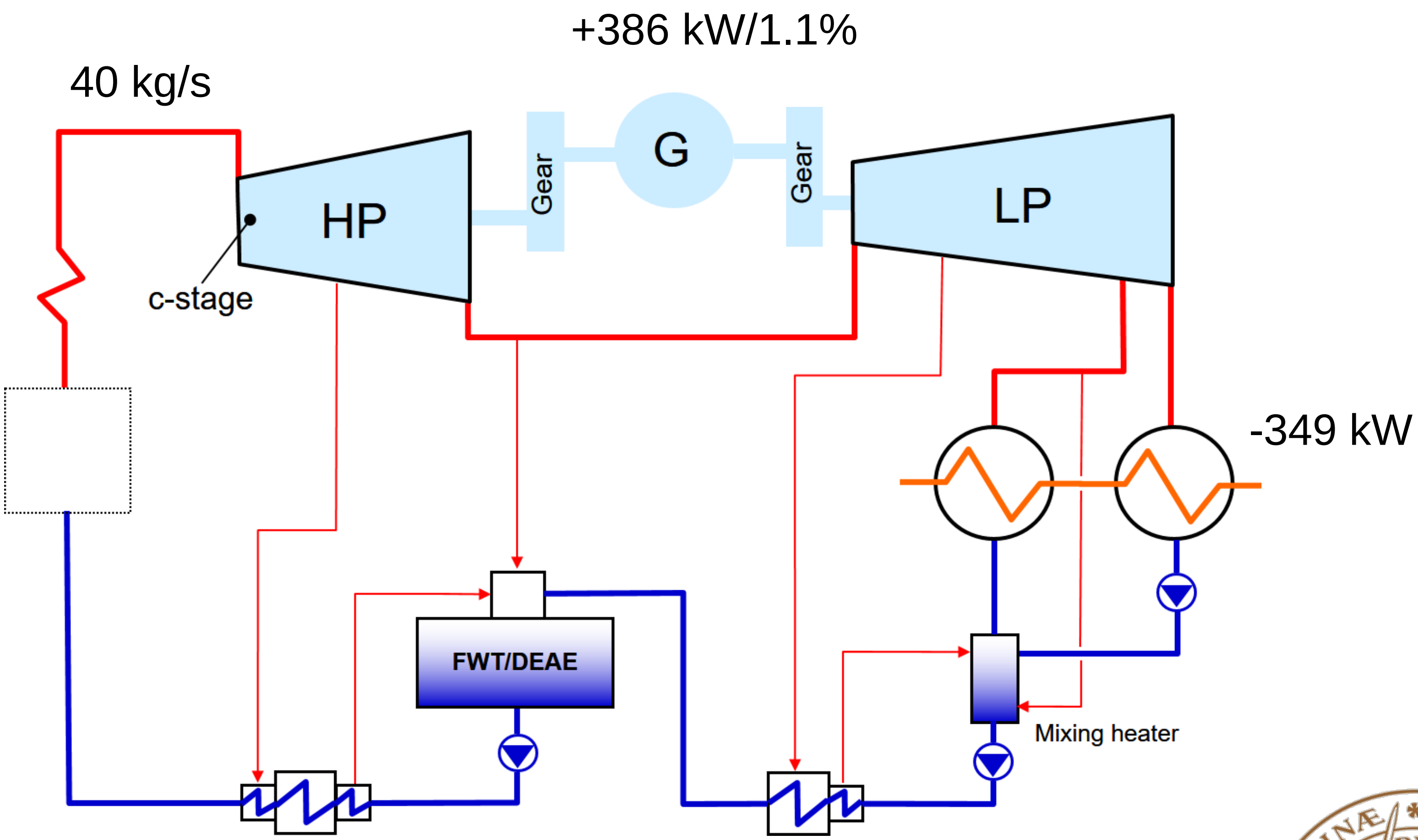
THANK YOU

Performance impact – 97.7 MW boiler load



η_{TH} **35.86 → 36.25**

Performance impact – 97.7 MW boiler load



η_{TH} 35.86 → 36.25 %