KME 707

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

Agenda

- Background
- Case Study
- Work Done
- Publication Summary
- Short Stages
- CFD model setup
- Future work – rotor modification

Background / Motivation

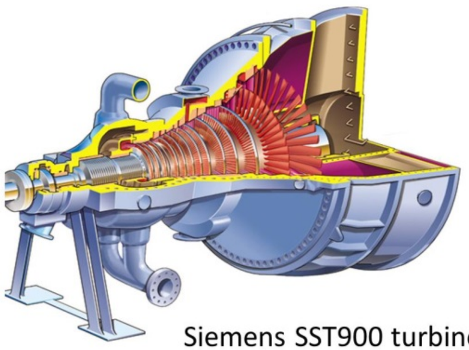
Industrial turbines
Prismatic stators and rotors

Boxberg Power Plant
94 HP and 96 IP
Advanced Blading

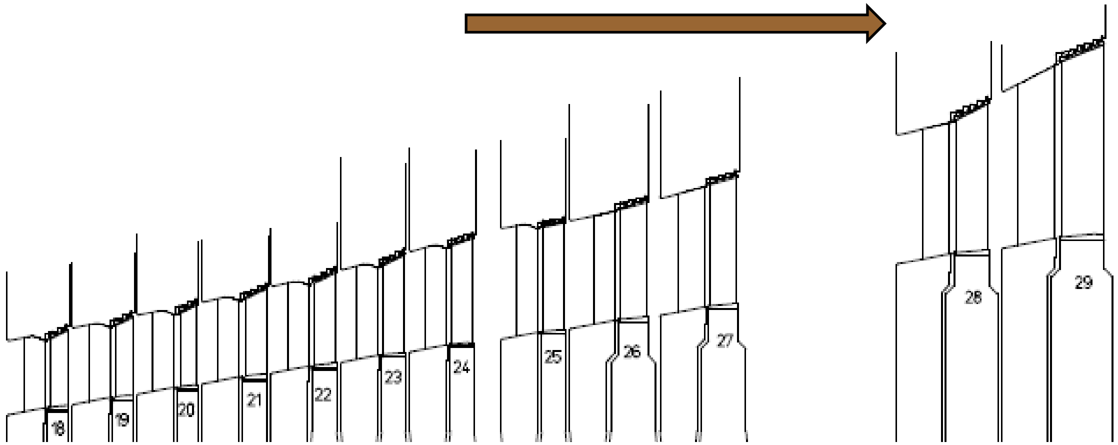
Secondary Losses and leakage losses
- **3D design features at same cost**
- **Vortexing**

Profile Losses
- **Airfoil Design**

Case study



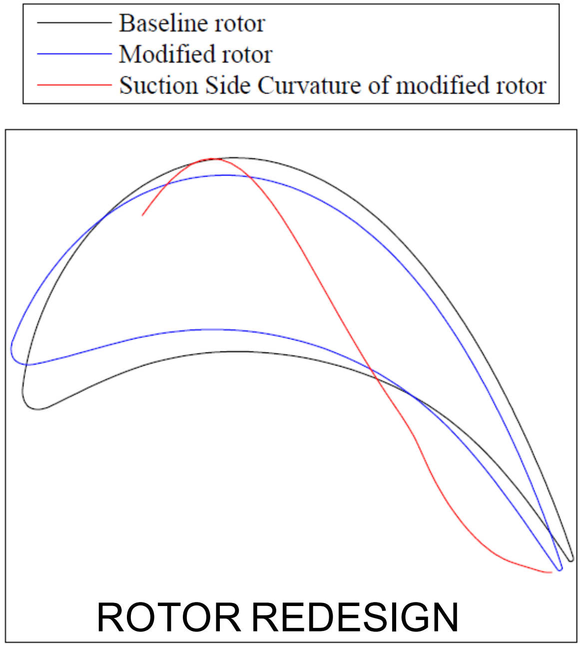
Siemens SST900 turbine

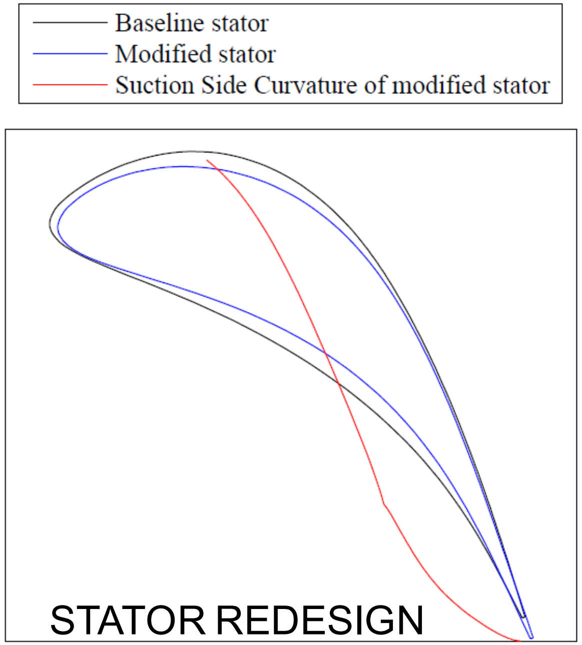


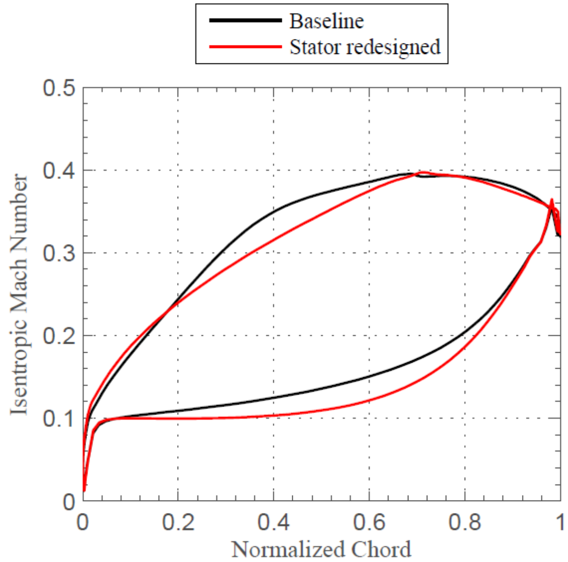
Concepts Attempted :

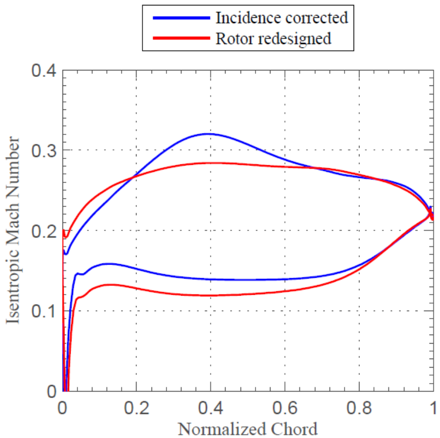
- Vortexing – Stator and Rotor
- Airfoil redesign
- Flow path modification
- Lean

Airfoil Design – High aspect ratio stages









Modifications	$\mathbf{Y}_{stator}$	$\mathbf{Y}_{rotor}$	$\Delta\eta$
Rotor incidence correction	0.0	0.6	0.23
Rotor redesign	0.0	0.8	0.26
Stator redesign	0.14	0.0	0.37

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

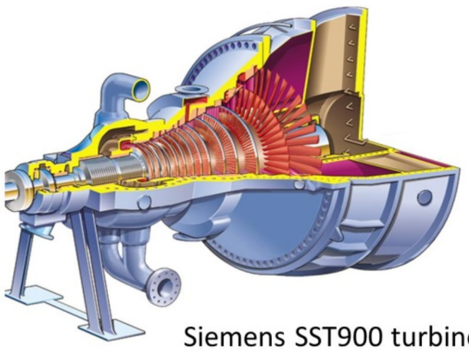
Efficiency Improvements in an Industrial steam turbine stage – Part I

TURBO EXPO 2016

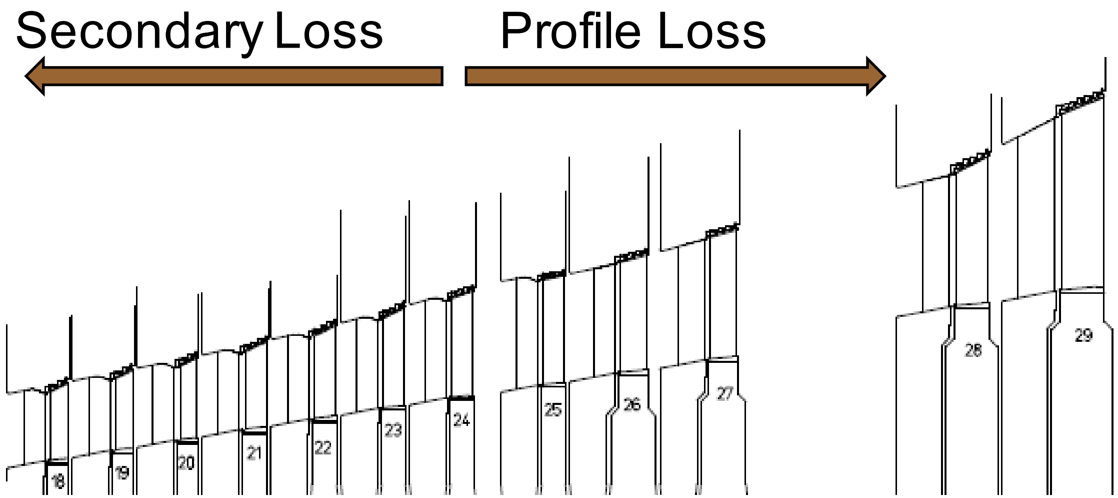
GT2016-57140

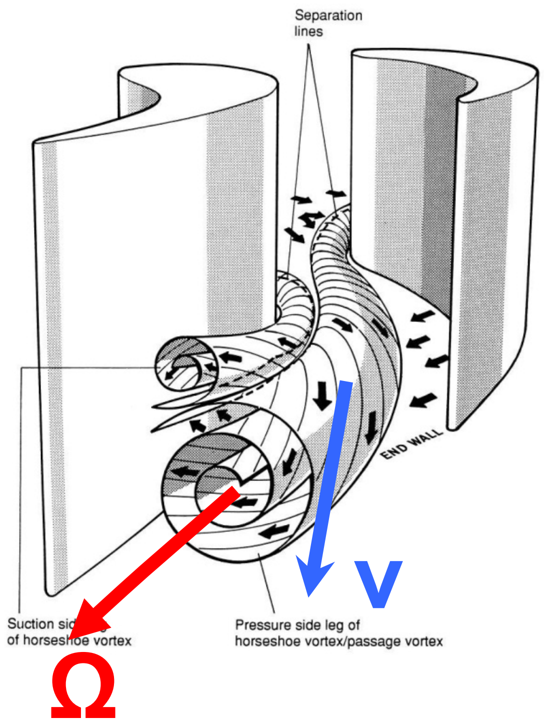
Efficiency Improvements in an Industrial steam turbine stage – Part II

Case study

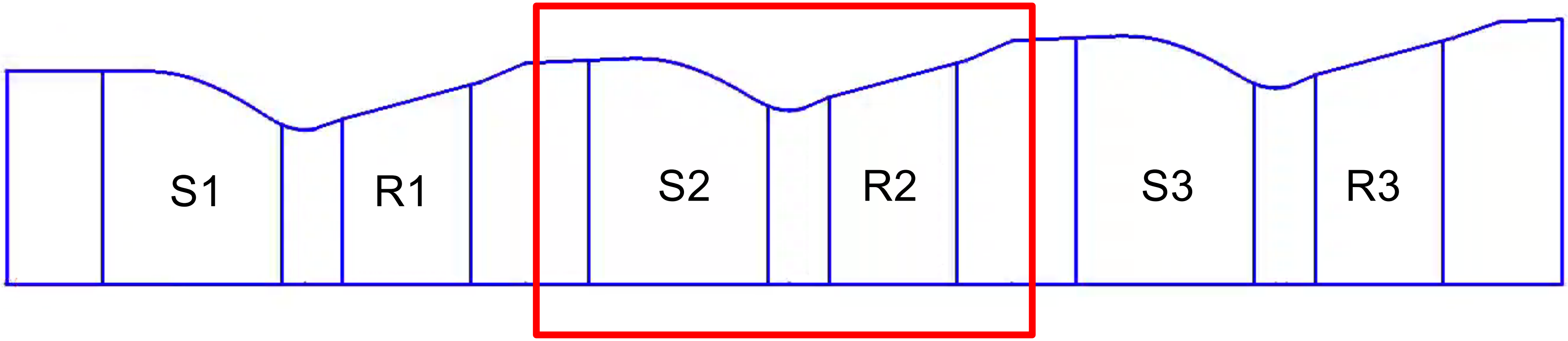


Siemens SST900 turbine





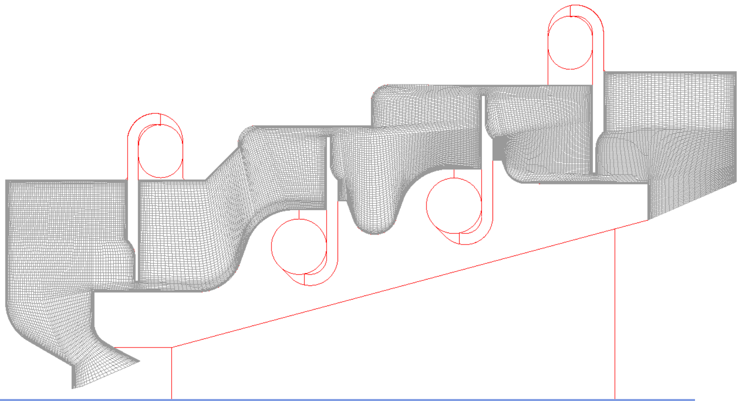
SST900 - HP

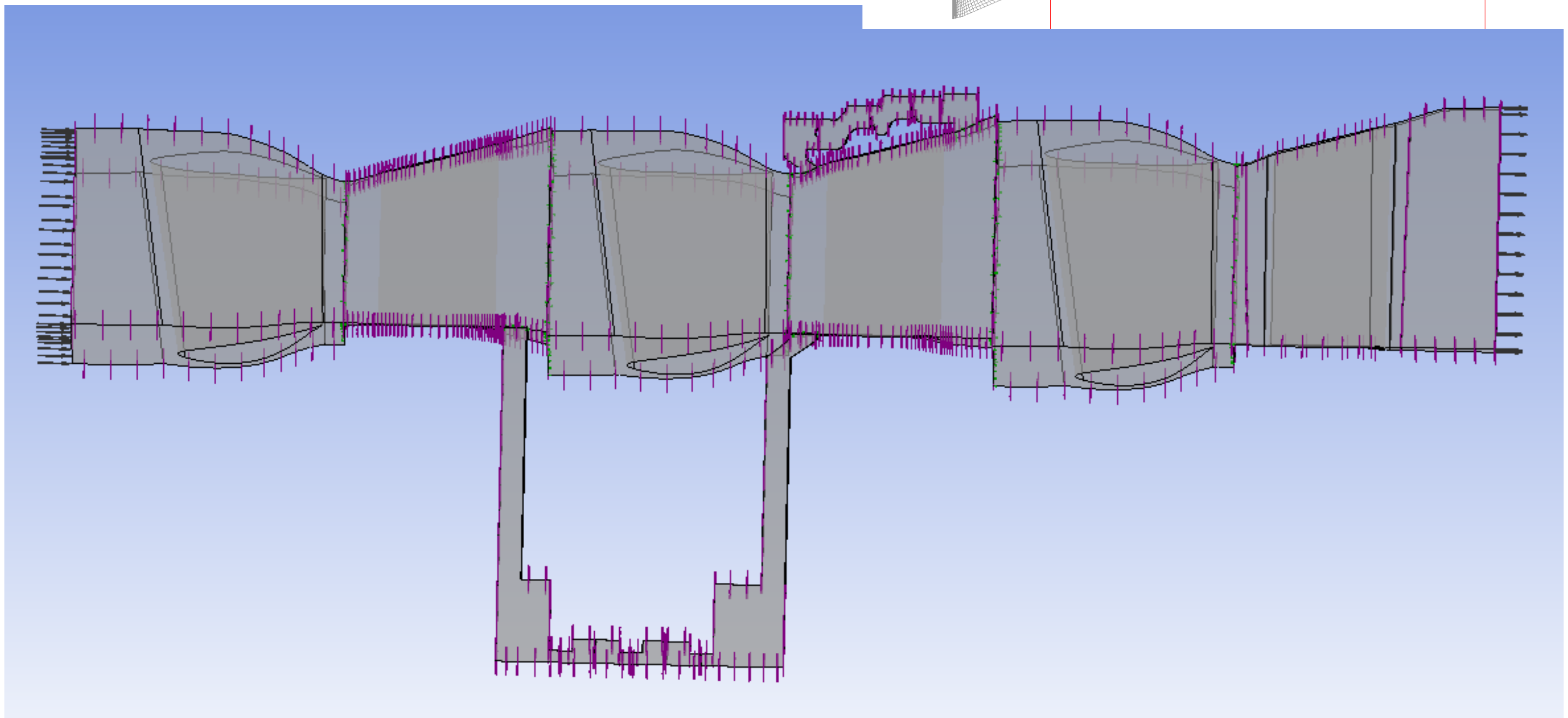


No of blades	32	64	32	64	32	65
pitch / chord	0.761	0.802	0.768	0.810	0.777	0.807
Relative Exit Mach	0.367	0.245	0.378	0.249	0.385	0.257
Reynolds number	9.64×10^6	3.06×10^6	9.2×10^6	2.88×10^6	8.65×10^6	2.75×10^6
Aspect ratio (axial)	1.2	1.3	1.25	1.46	1.37	1.64

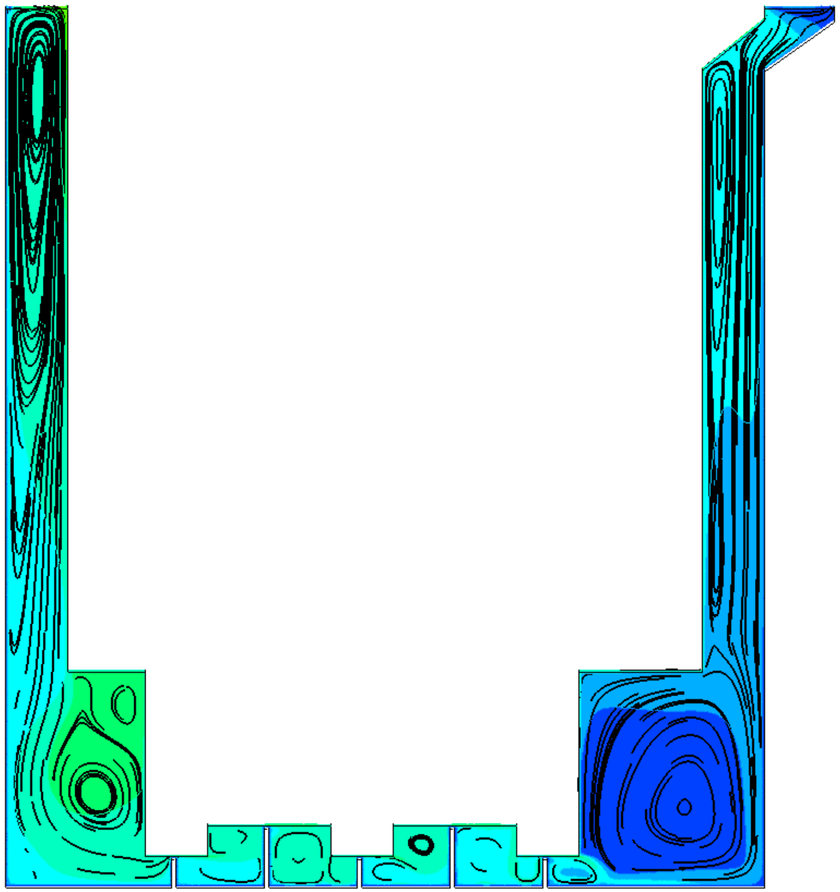
Work Coefficient	1.64	1.64	1.64
Flow Coefficient	0.33	0.32	0.316
Reaction	0.224	0.22	0.23

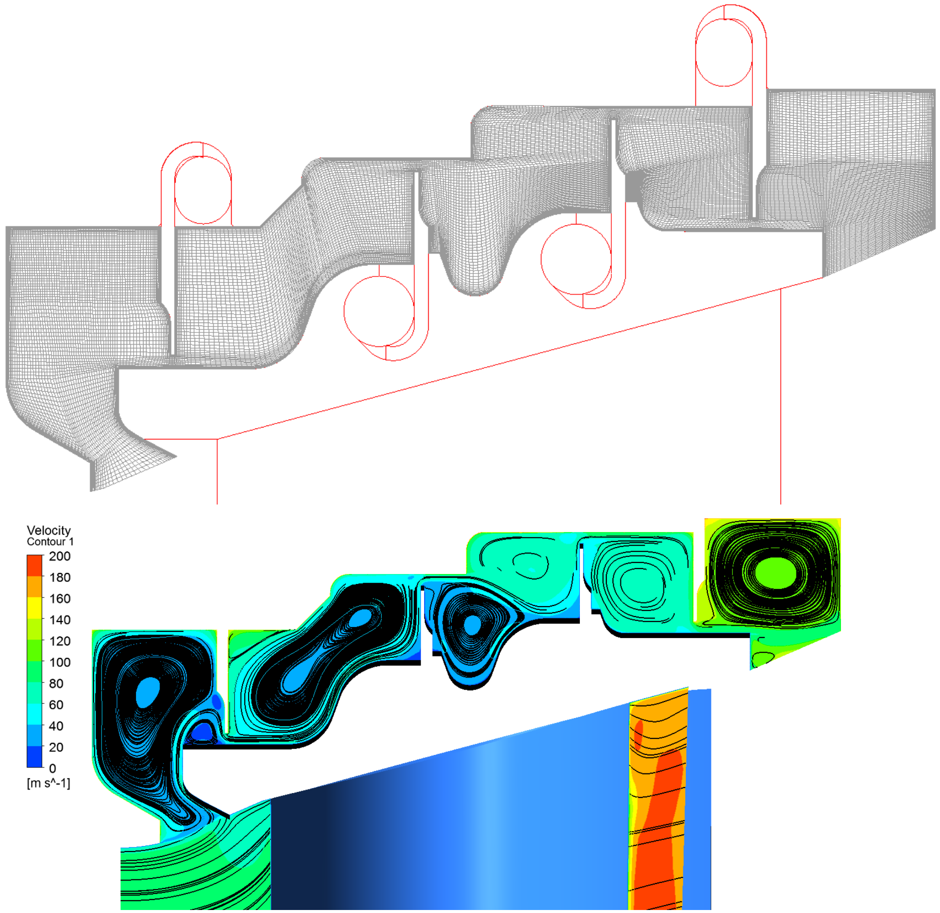
CFD Model setup



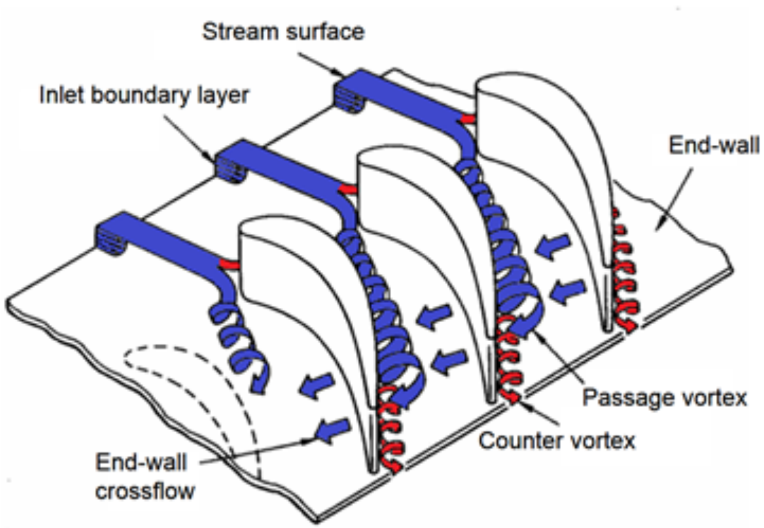


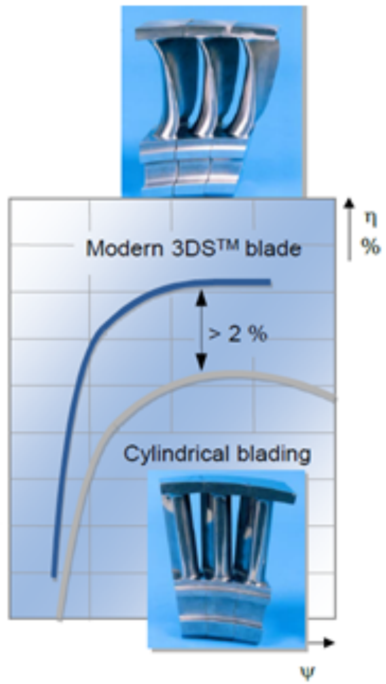
Leakage Flows modelled

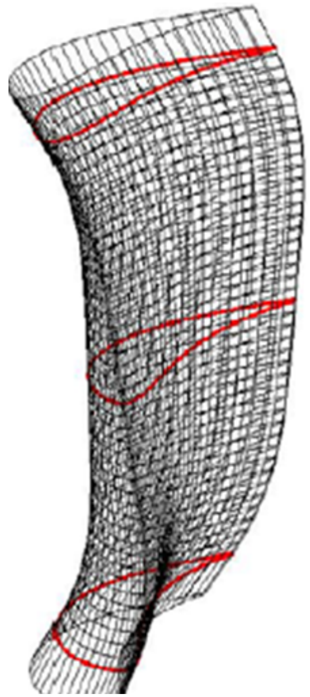




Future work - Rotor

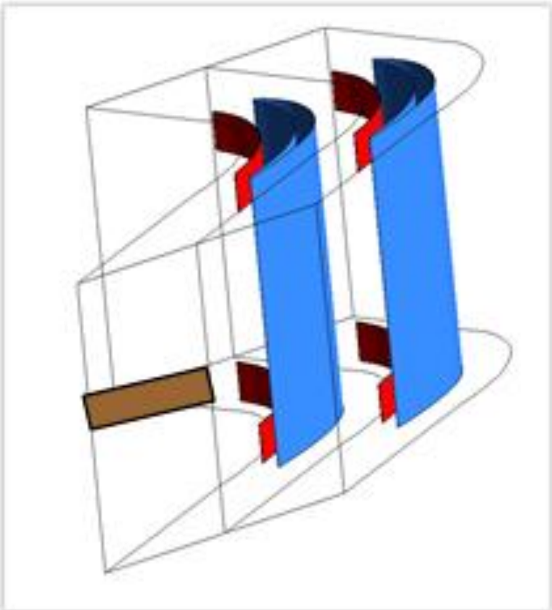


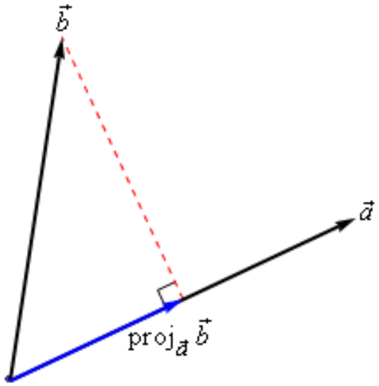




- ❖ Rotor Modifications for maximum benefit
- ❖ Stator Modifications corresponding to Rotor

Secondary loss - quantification





$$\mathrm{proj}_{\vec{a}}\vec{b} = \frac{\vec{a}\cdot\vec{b}}{\|\vec{a}\|^2}\vec{a}$$

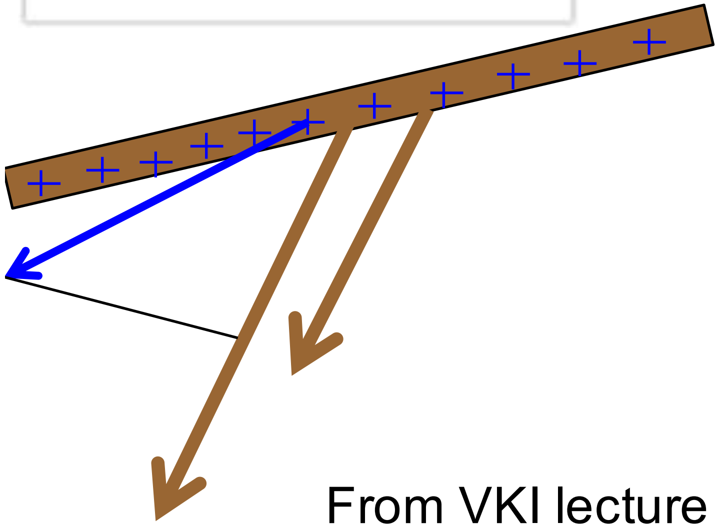
<u>Corral et al.</u>

$$CSKE = \frac{(v_i - v_{pi})^2}{v_{\mathrm{exit}}^2}$$

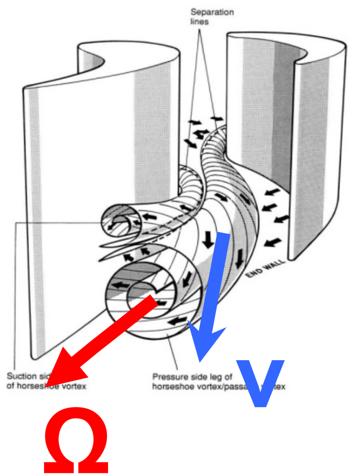
$$v_{pi} = \frac{v_i . v_m}{v_m^2} v_m$$

$$H_i = \frac{|v_i . \Omega_i|}{v_{\mathrm{exit}}^2 / l_c}$$

$$SKEH = CSKE_i \cdot H_i$$



From VKI lecture series : Haller et al



Timelines

	2014											
Task	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Month									**1**	**2**	**3**	**4**
Project start									M1			
Kick-off									M1			
Status report												
Work package 1												
Work package 2												
Academic's												
Final reporting1												
Project end												

	2015											
Task	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Month	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Project start												
Kick-off												
Status report		#1						#2				
Work package 1	D1	D2						D3				
Work package 2								M3				
Academic's								D4				
Final reporting1												
Project end												

Milstolpe		**Månad**
M1	Projektstart/kick-off	1
M2	Optimal bladprofil	4
M3	Licentiatavhandling – Srikanth Deshpande	12
M4	Vridningsfilosofier och optimal tredimensionell stackning	24
M5	Designfilosofi för optimal industriångturbin	30
M6	Doktorsavhandling – Srikanth Deshpande	36

Leverabel		**Månad**
D1	Rapport "Optimala 2D bladprofiler" – 2D koordinater	6
D2	Statusrapport #1	6
D3	Statusrapport #2	12
D4	**Licentiatavhandling – Srikanth Deshpande**	**12**
D5	Statusrapport #3	18
D6	Rapport "Vridningsfilosofier och tredimensionell stackning"	24
D7	Statusrapport #4	24
D8	Rapport "Designfilosofi industriångturbin"	30
D9	Statusrapport #5	30
D10	**Doktorsavhandling – Srikanth Deshpande**	**36**
D11	Slutrapport	36

THANK YOU