TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Engineering · Institute for Fluid Dynamics · Professorship for Turbo Machinery and Jet Propulsion

Ein parametrisches Modell für Verdichterschaufeln zur Abbildung von geometrischen Abweichungen in der numerischen Simulation

LuFo IV
RRD / TU Dresden

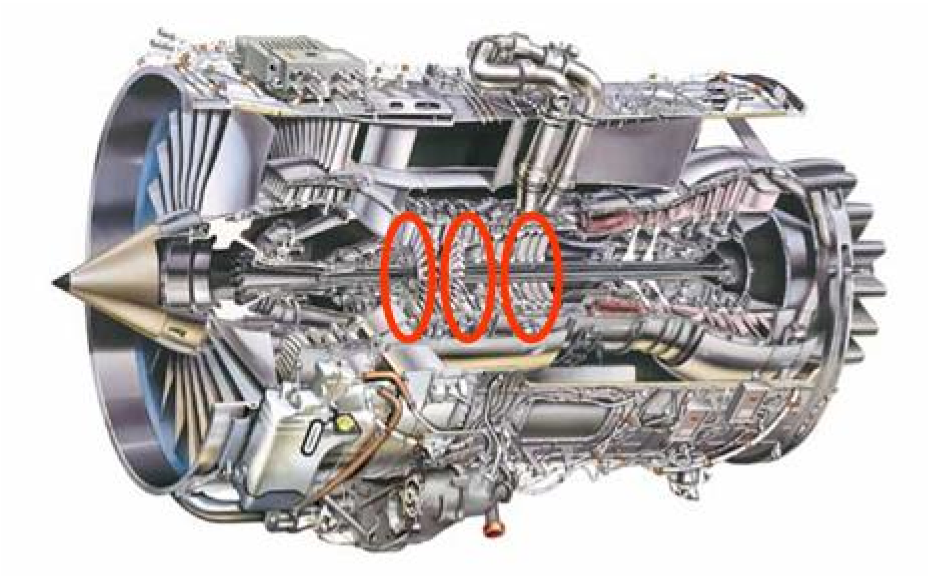
Alexander Lange

Dresden, 10. Oktober 2008

Overview

- Introduction
- Parameter model

Introduction I



target:
influence of manufacturing tolerances on properties of compressor

↓

measurement of HPC blades to obtain geometric variations

↓

simulations

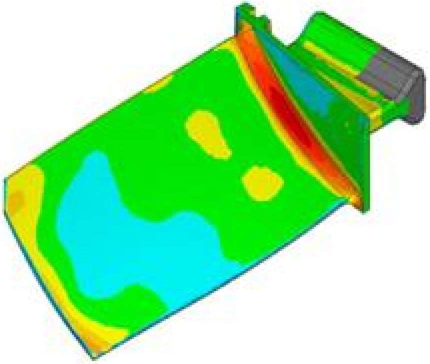
↓

compressor characteristics with scatter

Introduction II

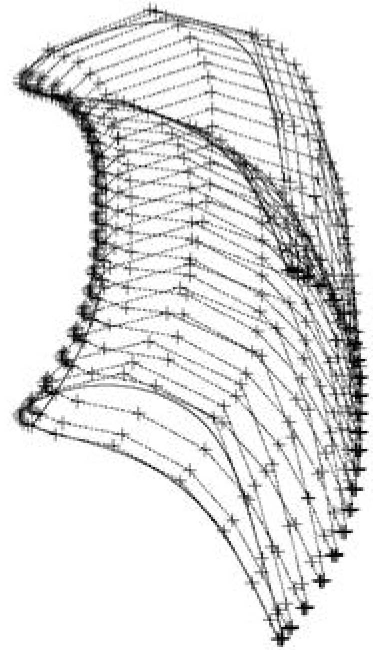
Optical scanning process

- using structured light (Streifenprojektionsverfahren)
- capturing geometry in 3D
- approx. 2mio points
- fully automated process
- registration by blade or foot



getting measured blade in simulation – recently published models:

- update of CAD-geometry
  + same process like regular simulation
  - NURBS-based, nonphysical parameters
- fitting a full 3D parametric blade model
  + analytical geometrical model (allows big deformations)
  + same model as for the design process
  - fitting gap
  - big parameter set
- delta-model using Principal Component Analysis (PCA)
  + PCA allows reduction of degrees of freedom
  + modes are not correlated
  - nonphysical parameters

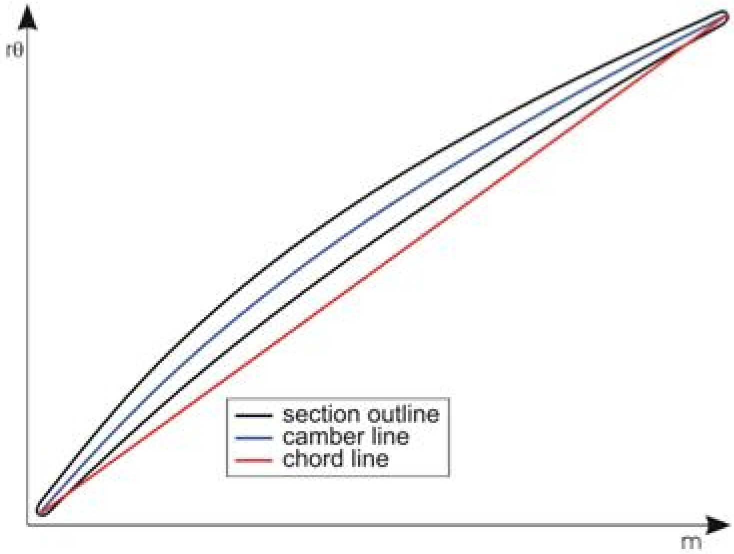


Source: Gräsel et al, 2004 (ASME: DETC2004-57467)

getting measured blade in simulation – developed model:

•Q3D-delta-model using physical parameters

+ delta-model: no fitting process required
+ decomposition into camber line and chord line
+ flexible set of physical parameters
- serves for little differences
- unique morphing tool for profile rebuild required
- correlation between parameters has to be considered



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  - Way from measured blade to parameters
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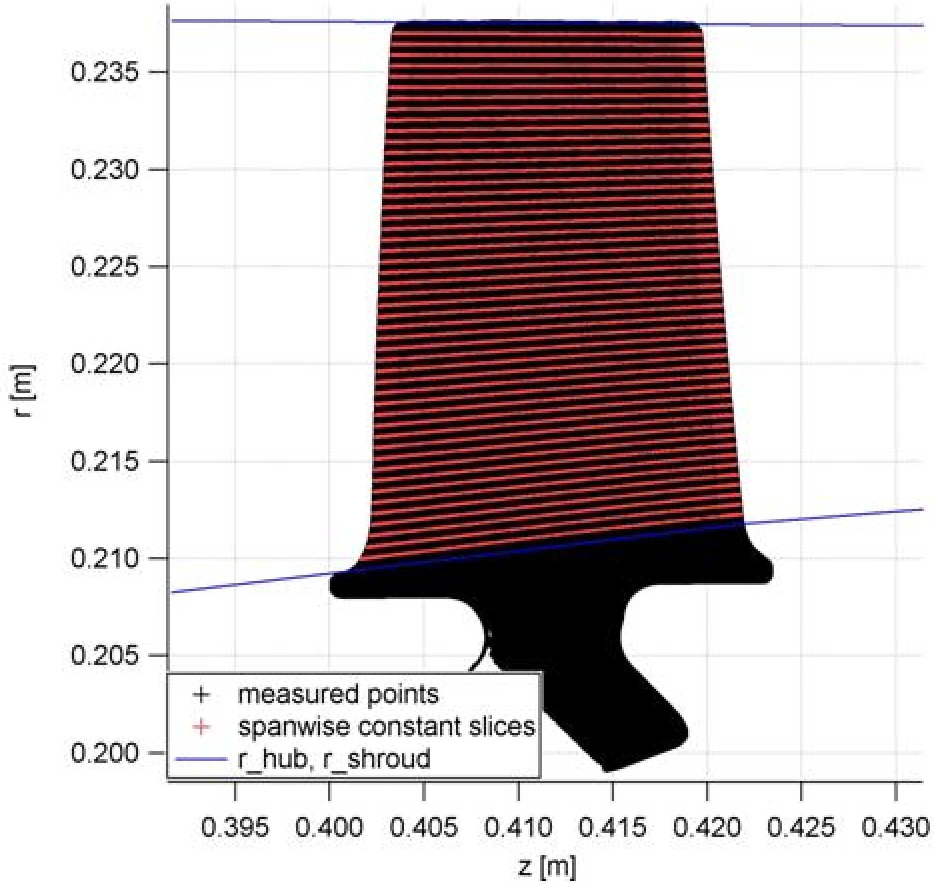
  - Profile rebuild

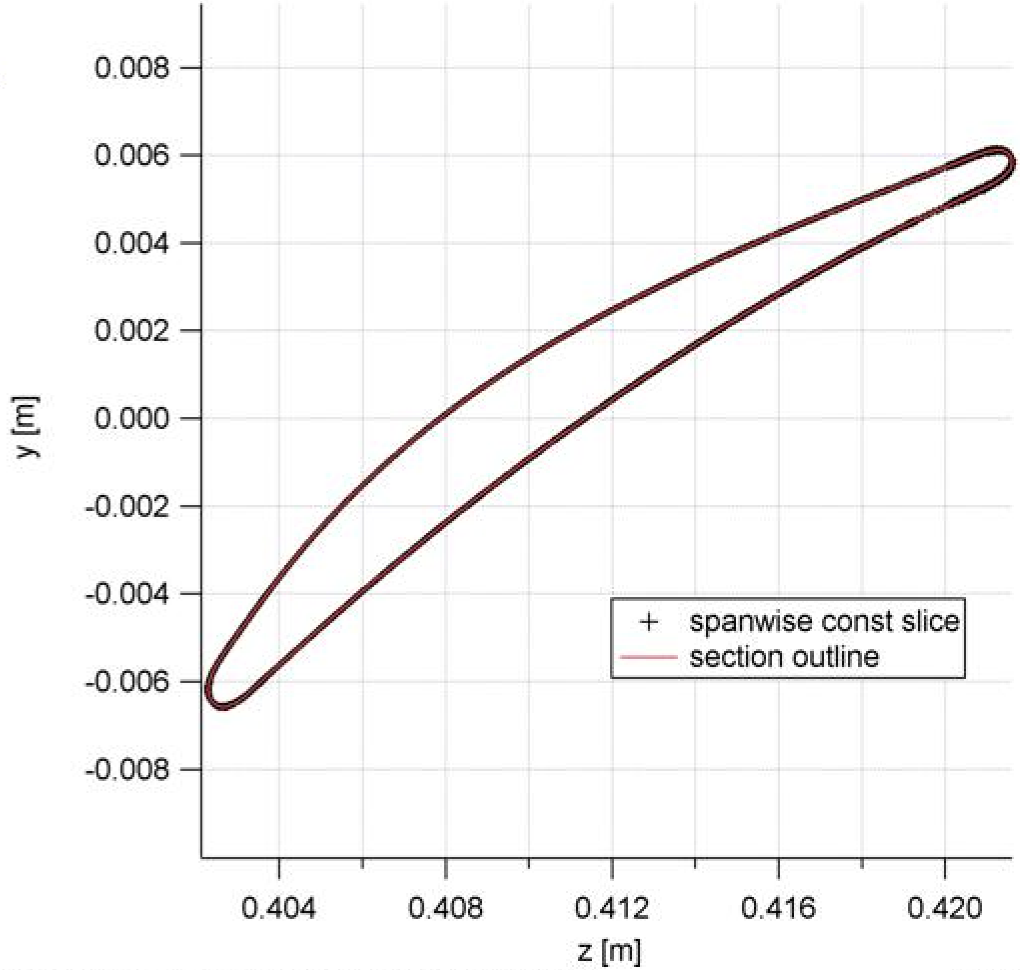
Way from measured data to parameters

1. sorting of discrete points into slices (spanwise constant)



Way from measured data to parameters

1. sorting of discrete points into slices (spanwise constant)
2. section outline trough rotation symmetric face



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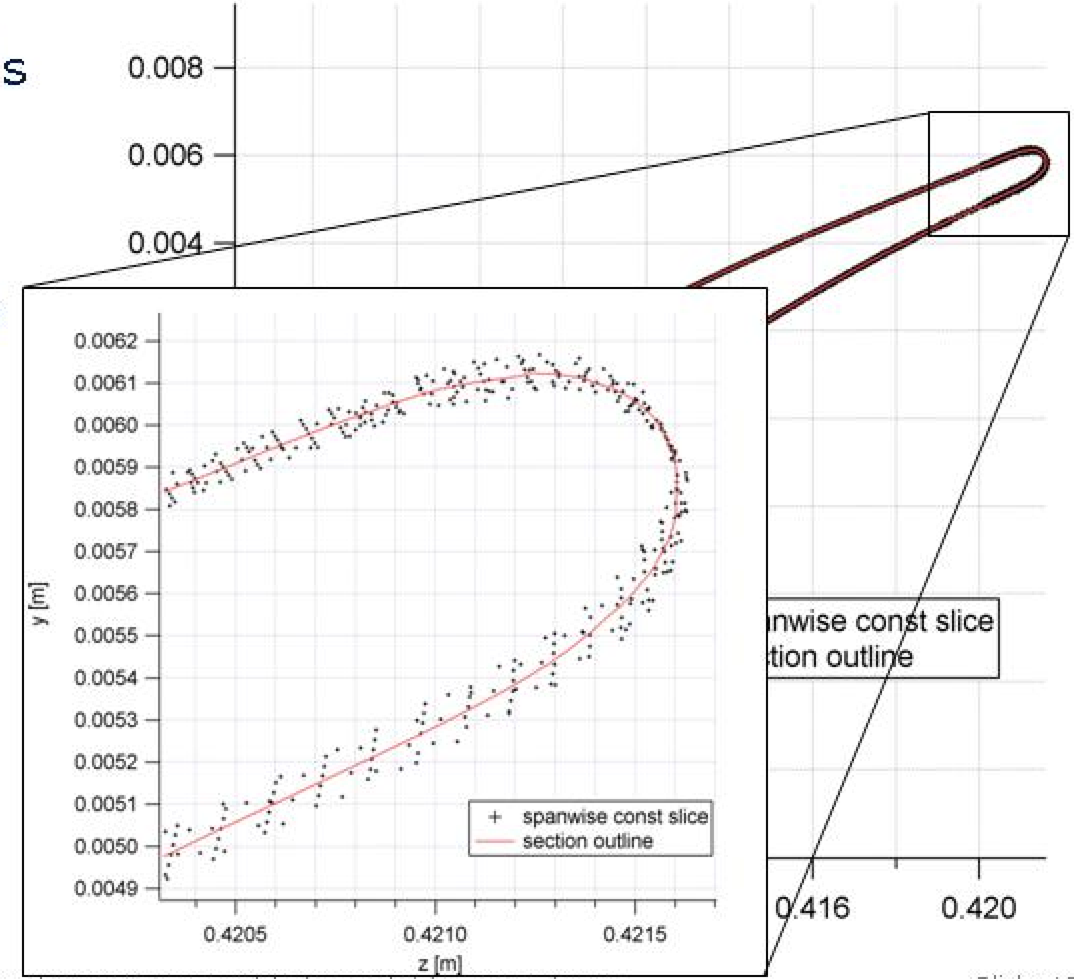
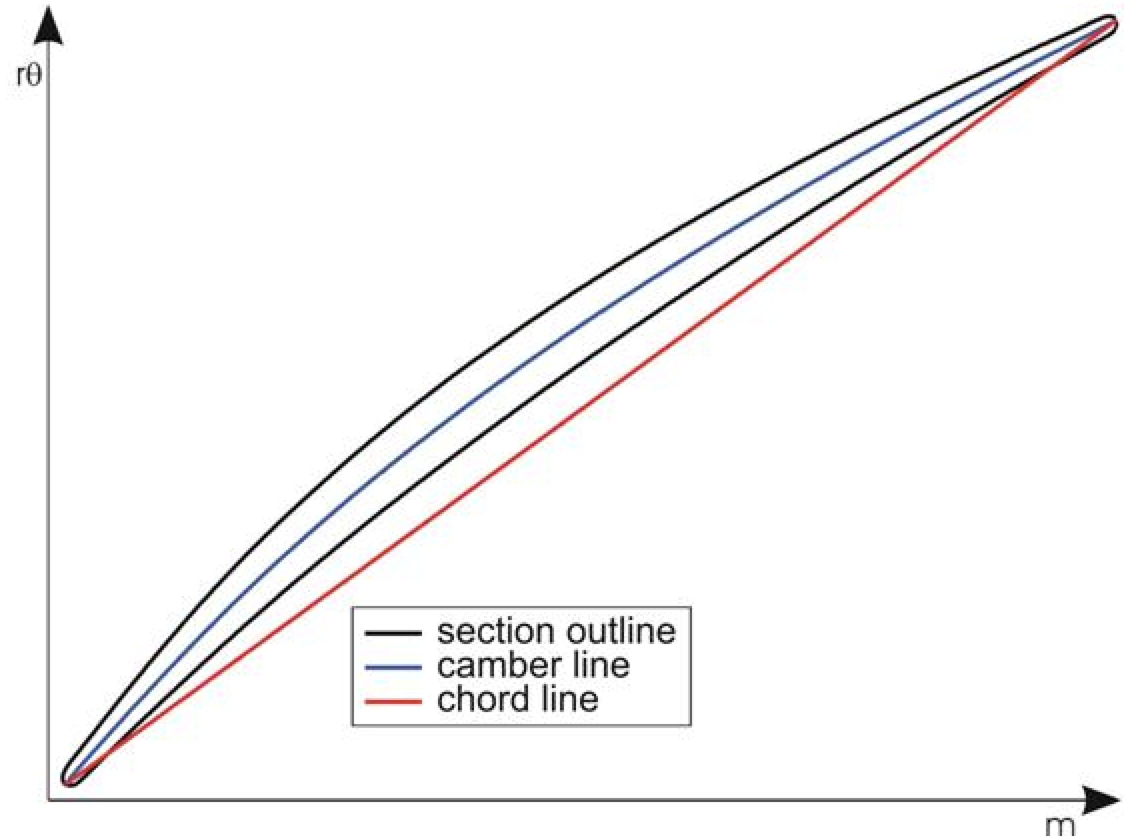


Way from measured data to parameters

1. sorting of discrete points into slices (spanwise constant)
2. section outline trough rotation symmetric face
3. calculation of camber line and chord line



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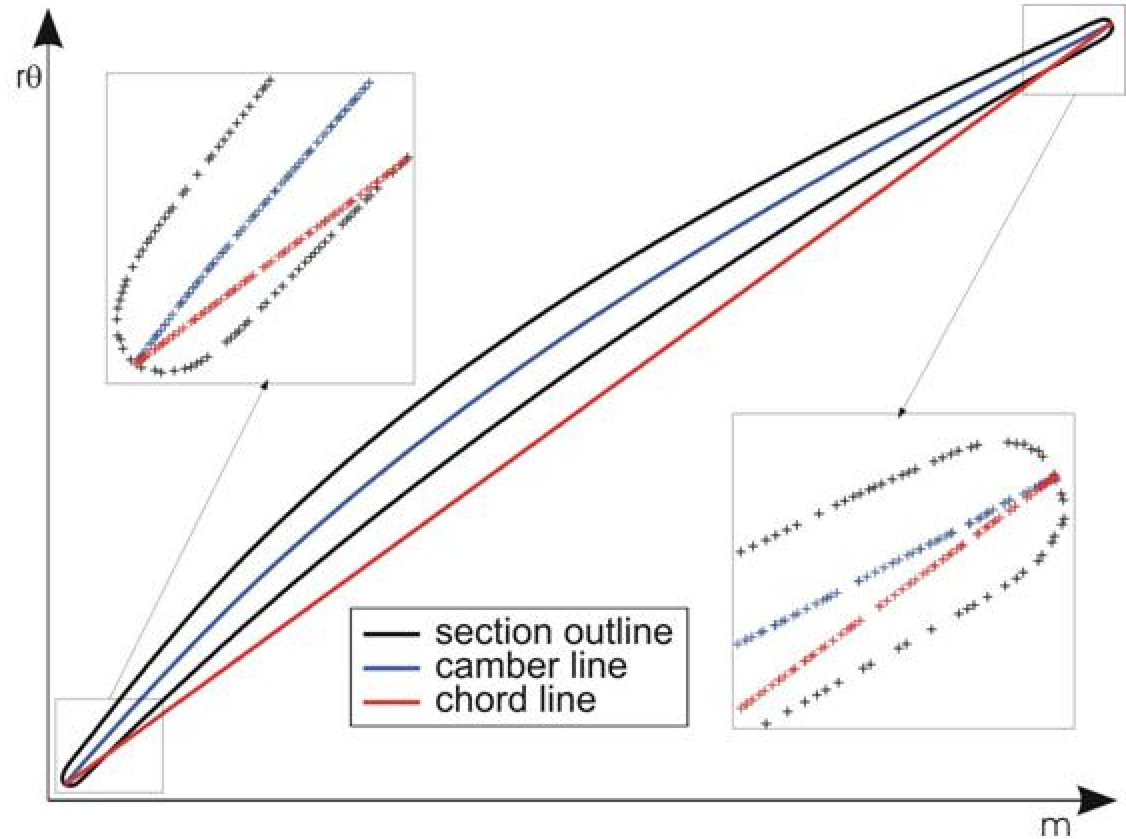
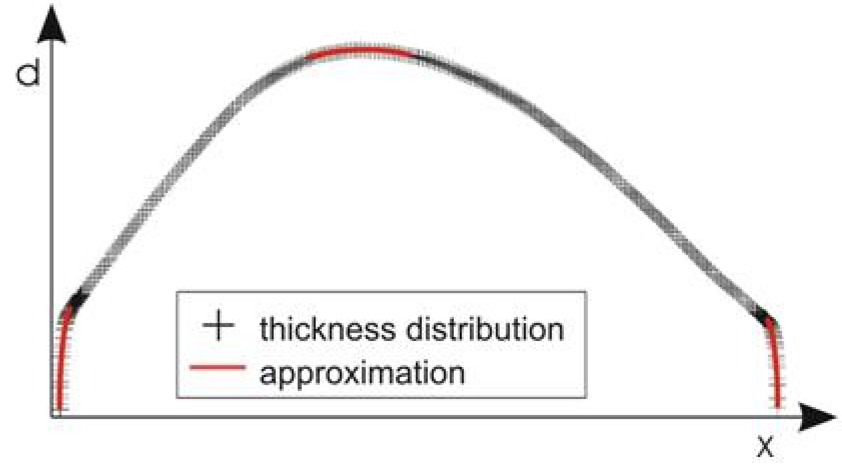
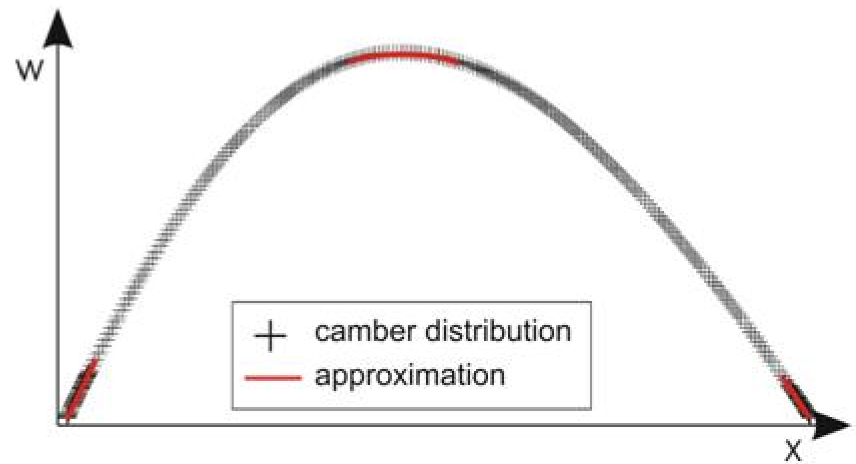


Way from measured data to parameters

1. sorting of discrete points into slices (spanwise constant)
2. section outline trough rotation symmetric face
3. calculation of camber line and chord line
4. calculation of camber and thickness distribution





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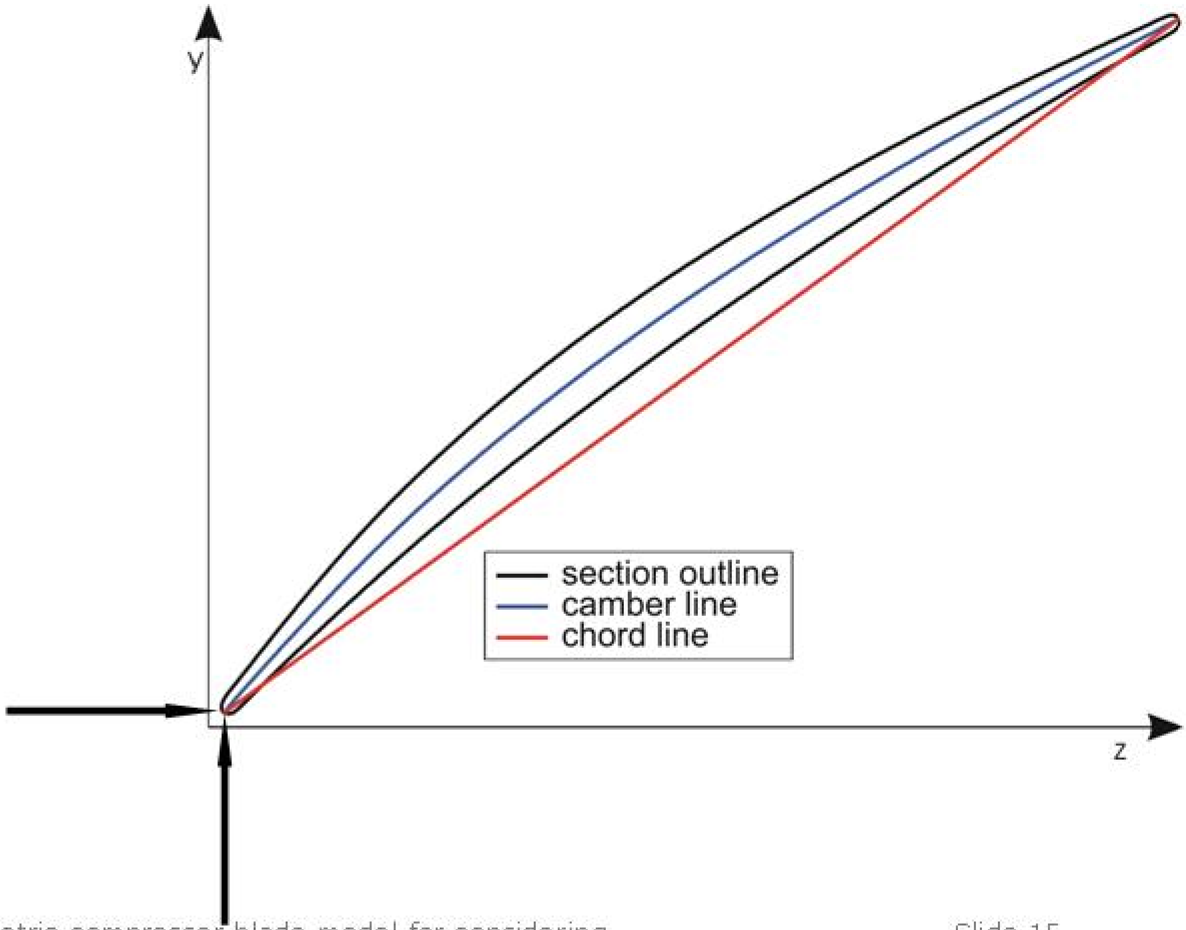
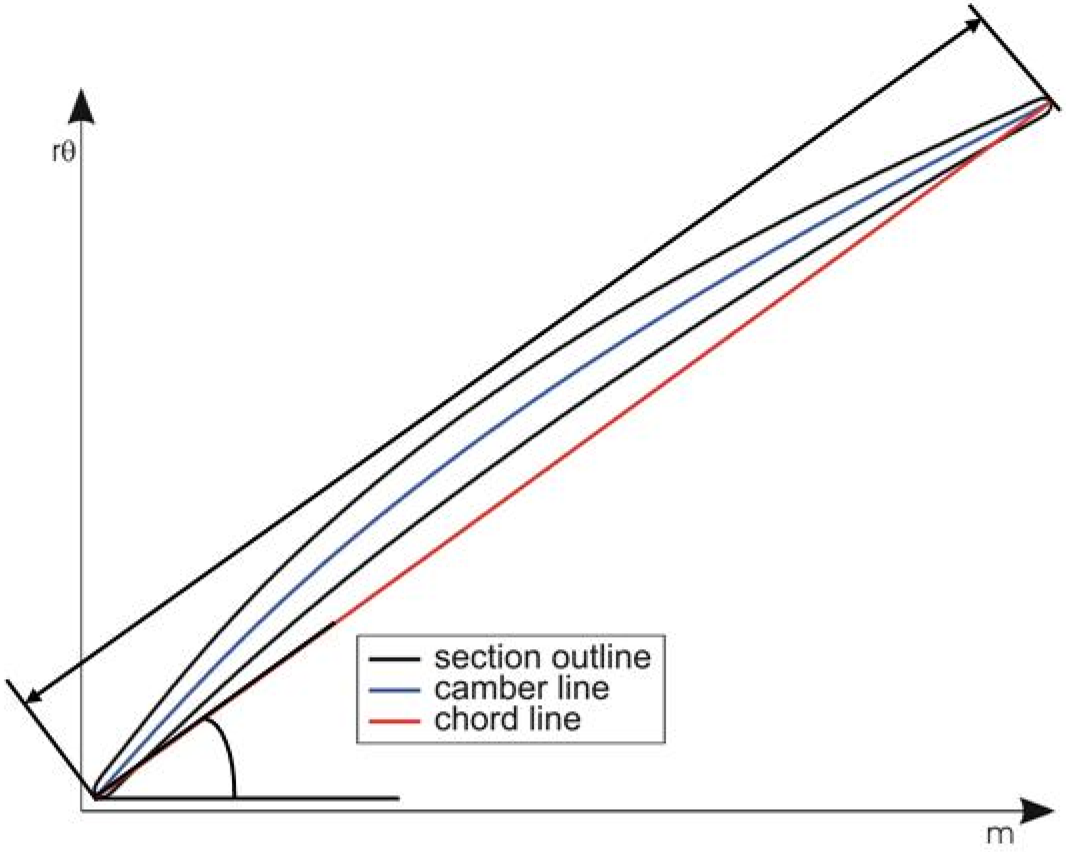
Parameter model

1. axial and tangential position (xyz-system)



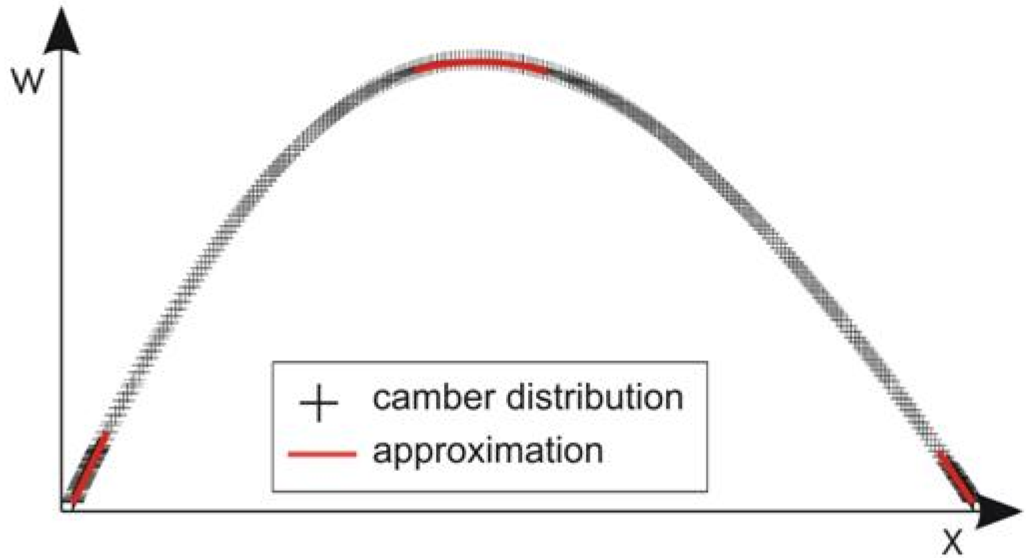
Parameter model

1. axial and tangential position (xyz-system)
2. chord length, stagger angle (r-theta-m-system)



Parameter model

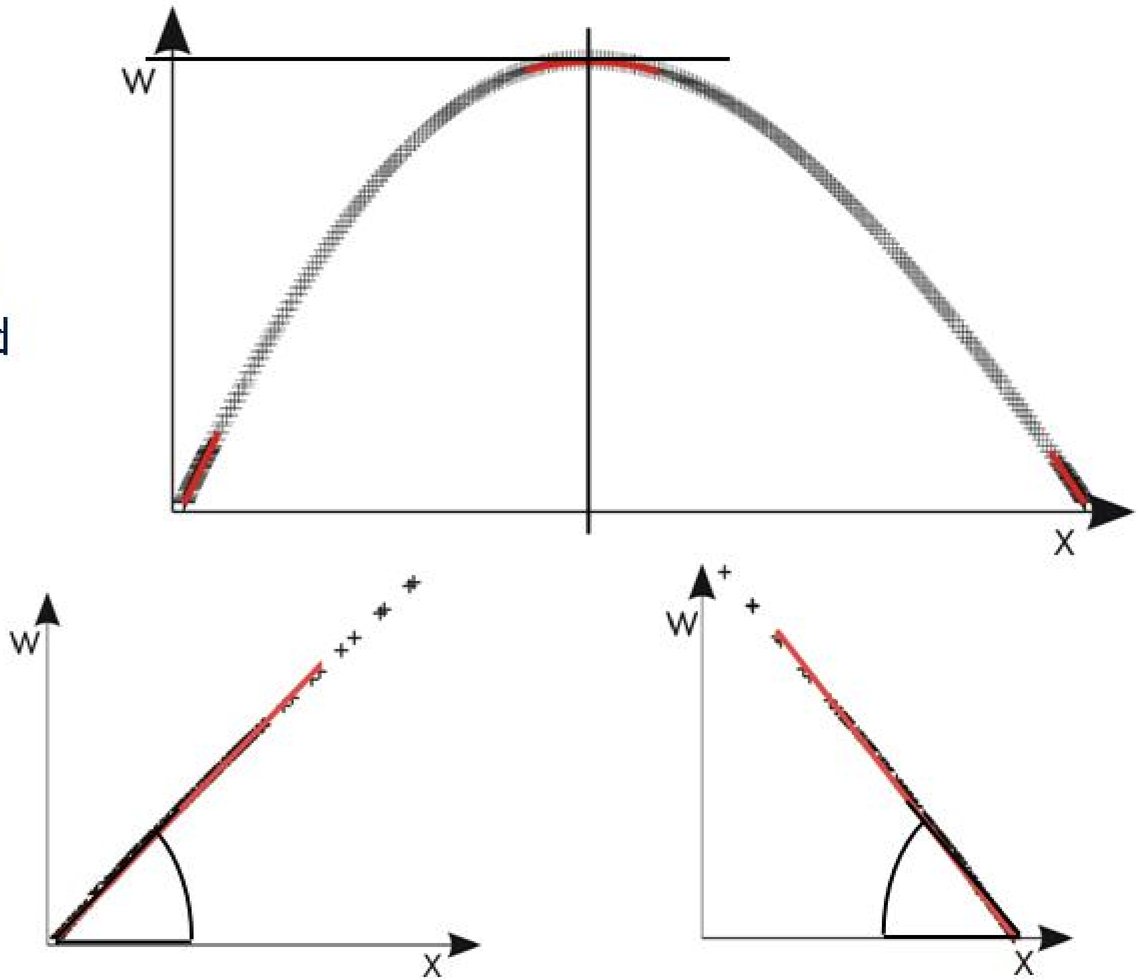
1. axial and tangential position (xyz-system)
2. chord length, stagger angle (r-theta-m-system)
3. camber distribution related parameters



Analysis of measured blades

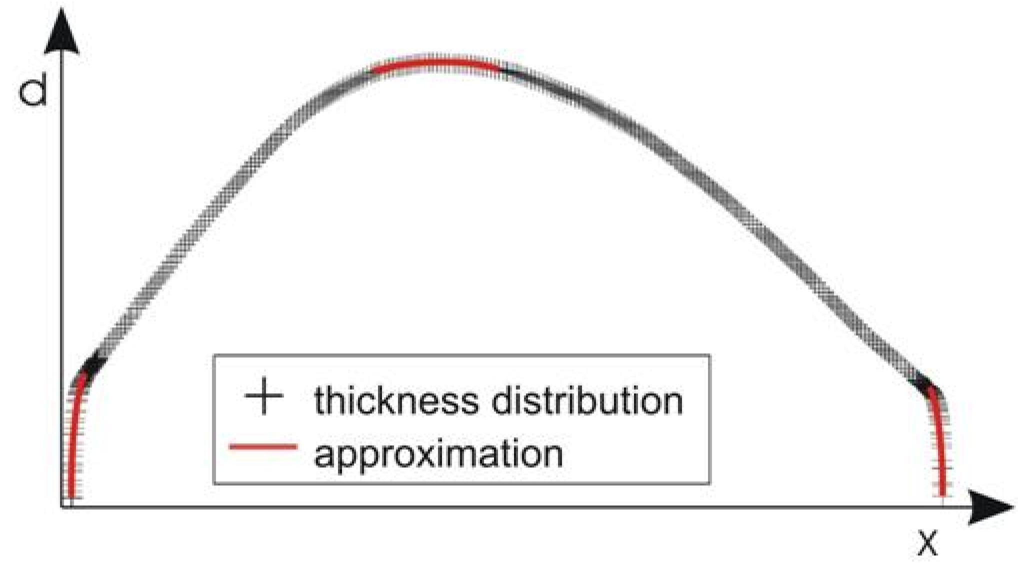
Parameter model

1. axial and tangential position (xyz-system)
2. chord length, stagger angle (r-theta-m-system)
3. camber distribution related parameters



Parameter model

1. axial and tangential position (xyz-system)
2. chord length, stagger angle (r-theta-m-system)
3. camber distribution related parameters
4. thickness distribution related parameters



Parameter model

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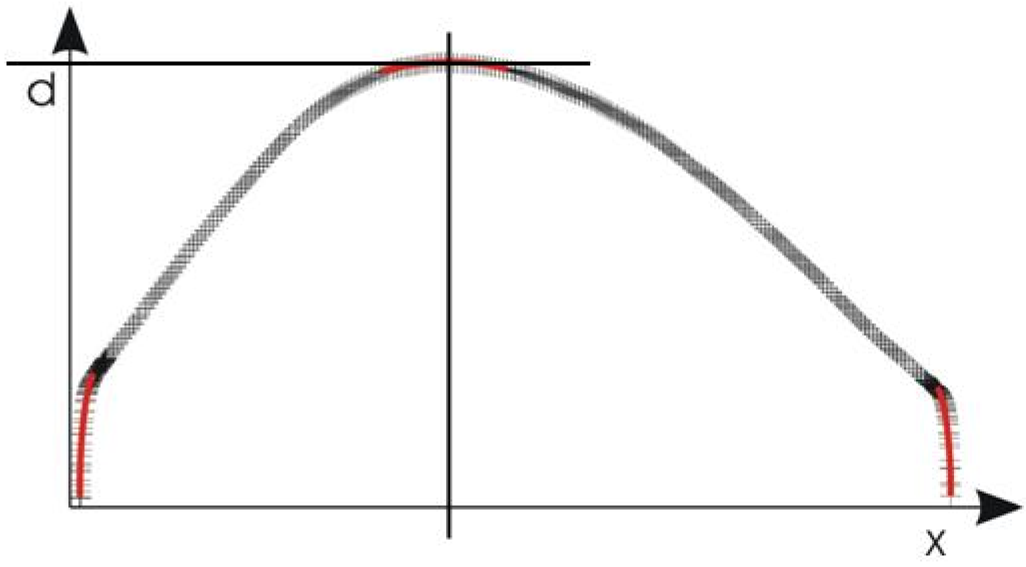
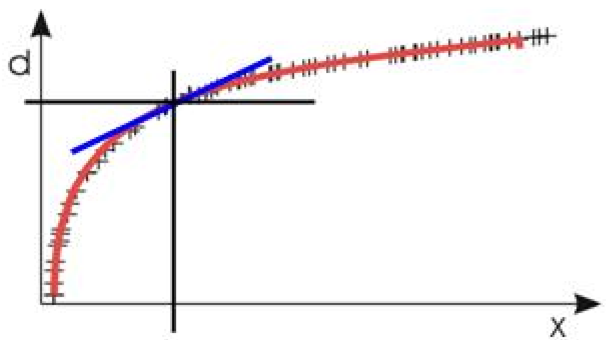
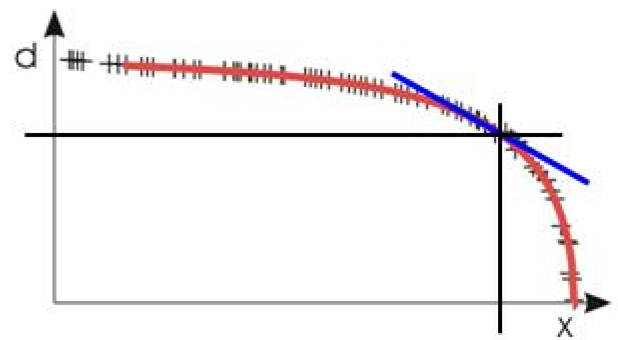
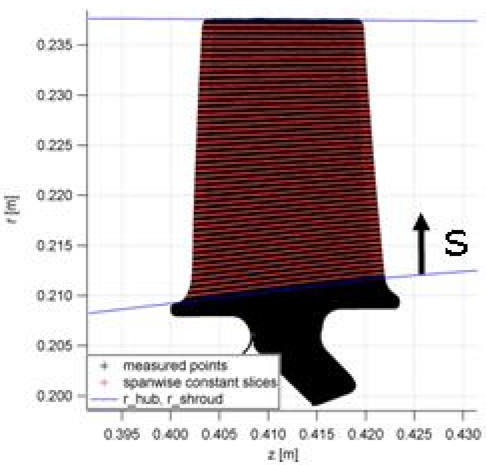


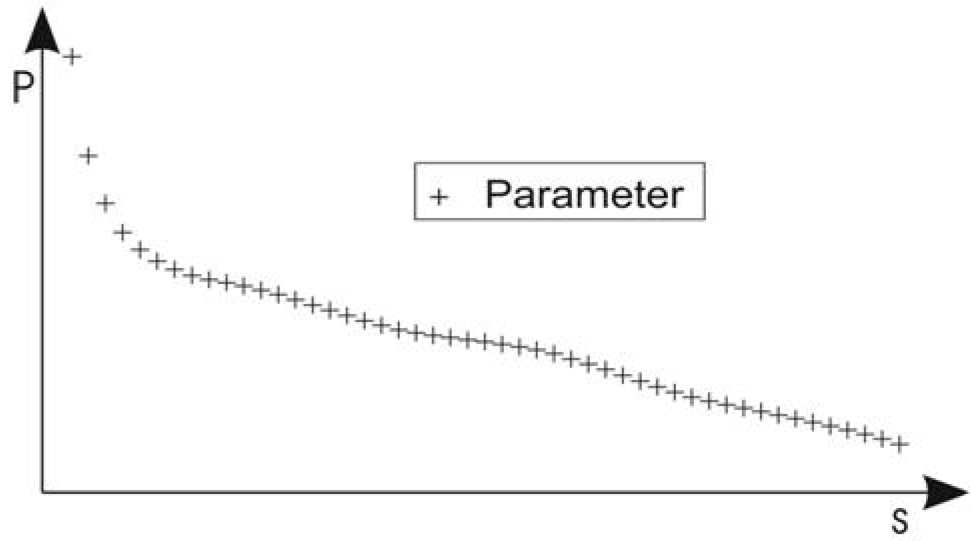




Q3D Model – parameter in spanwise plot

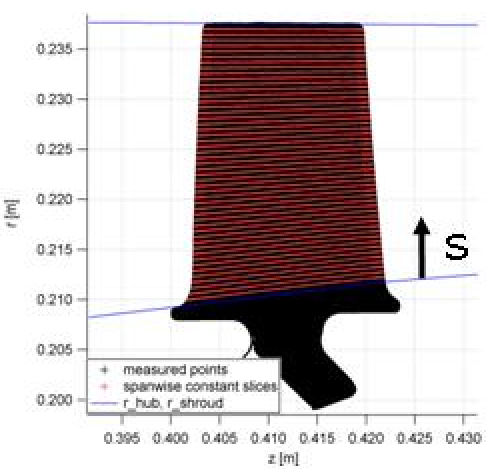
1. ploting parameters over spanwise coordinate

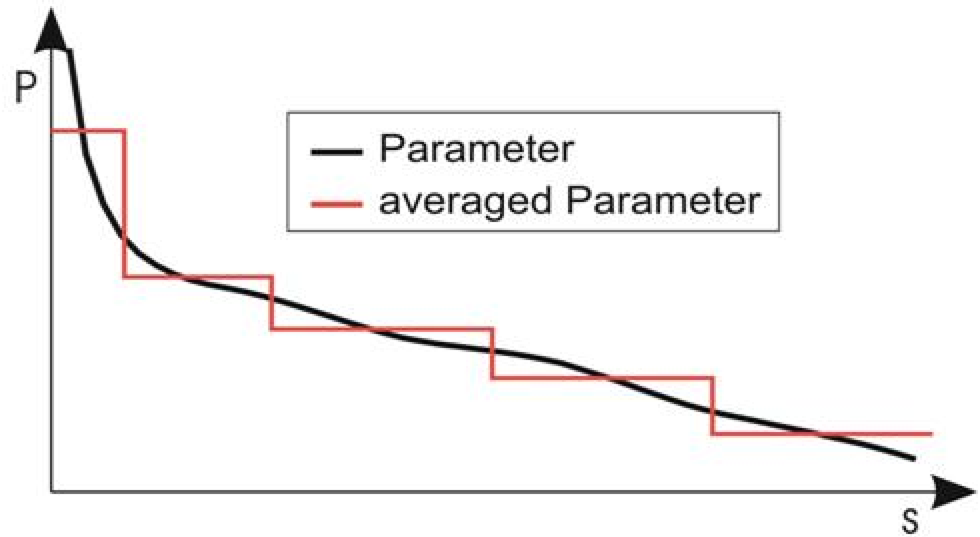




Q3D Model – parameter in spanwise plot

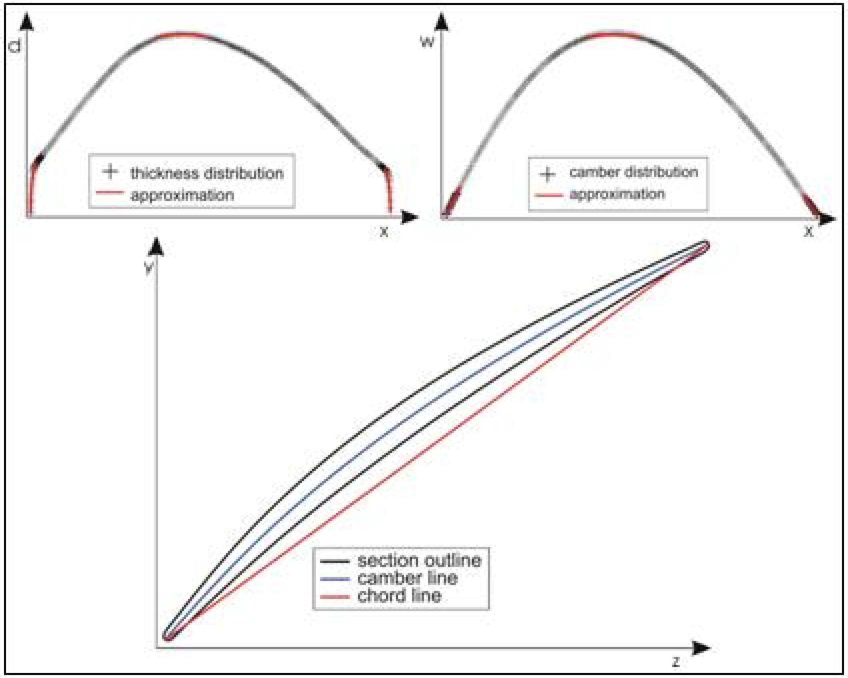
1. ploting parameters over spanwise coordinate
2. averaging over user defined number of sections

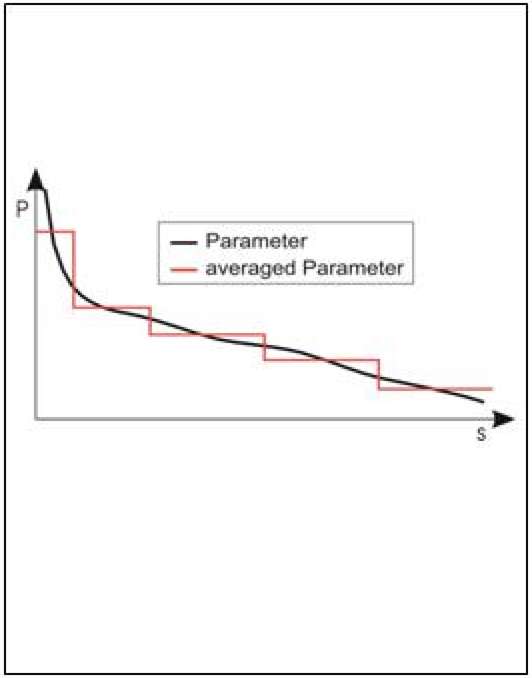


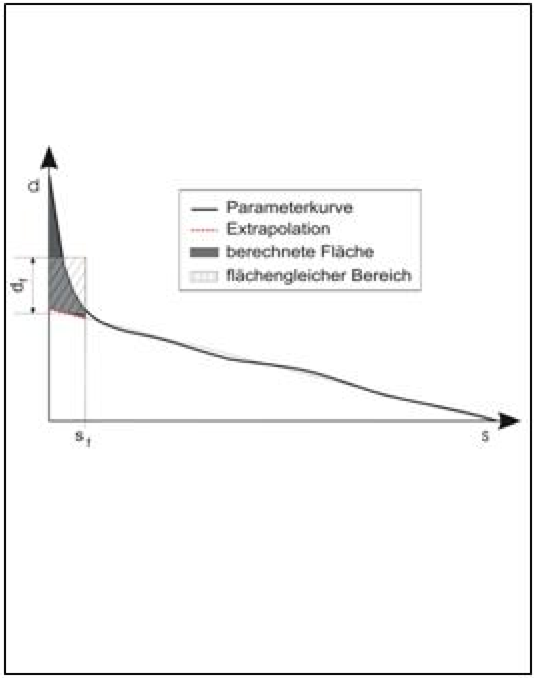


Parameter model – number of parameters for blade

parameters/section (14) * no of sections + parameters for fillet (2)







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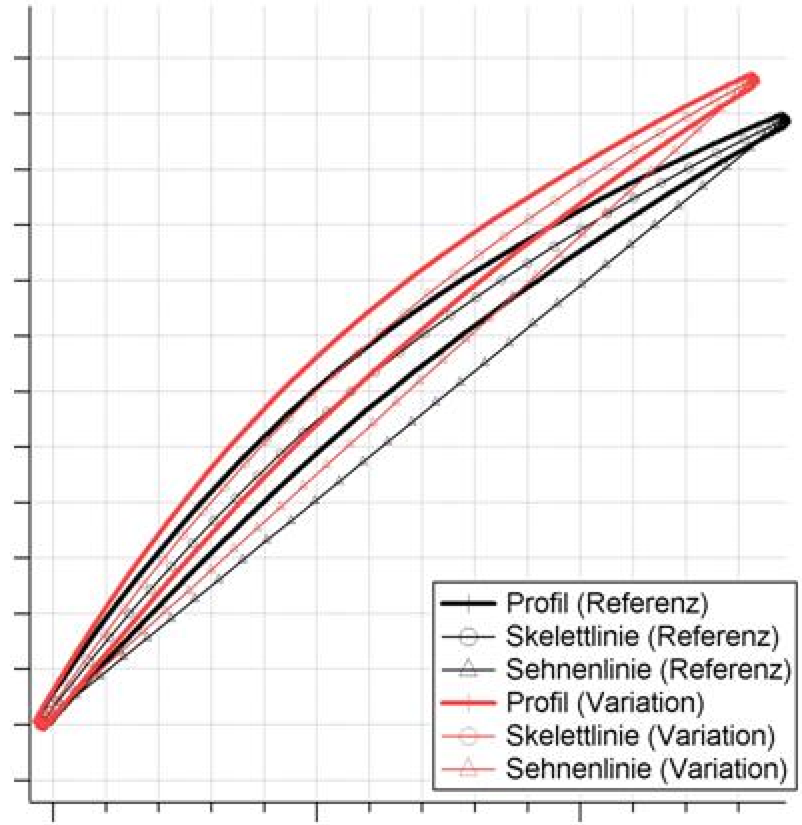
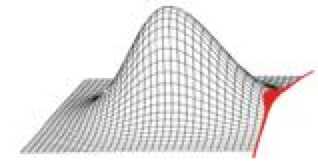
Variation of grid:

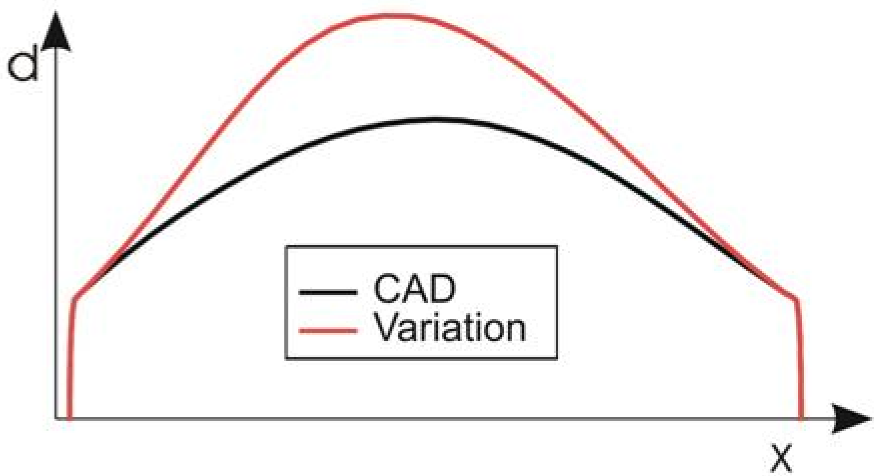
- Calculation of the new profile (original + difference)
- example: variation of stagger angle

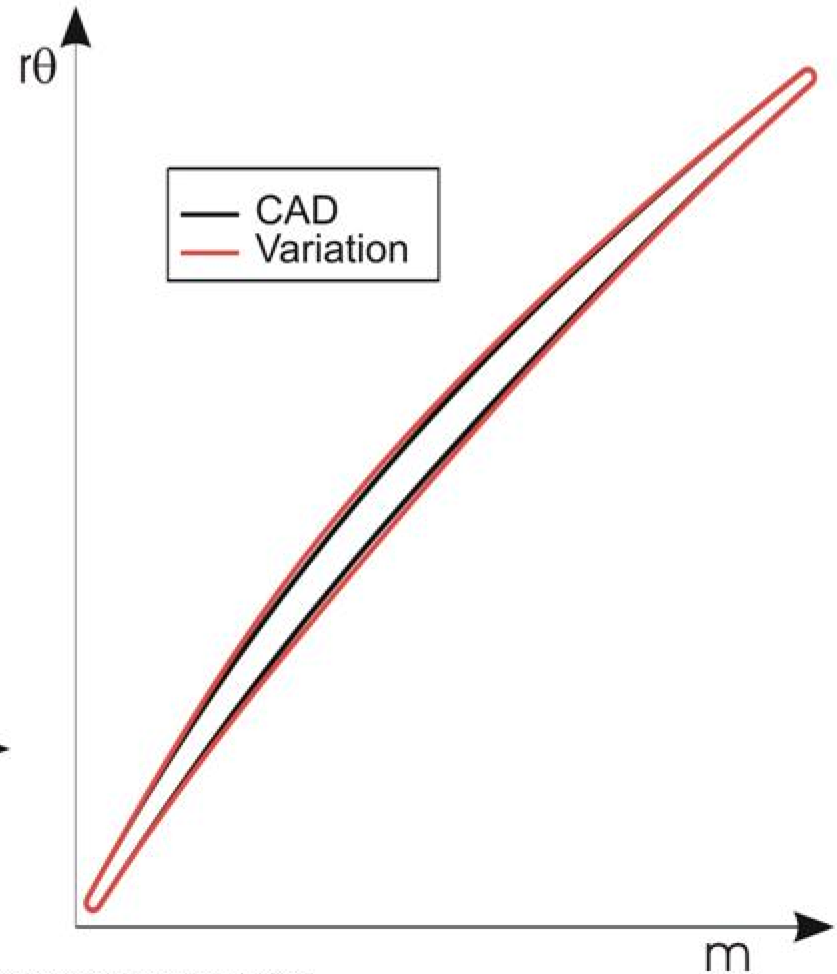


Profile rebuild – example I

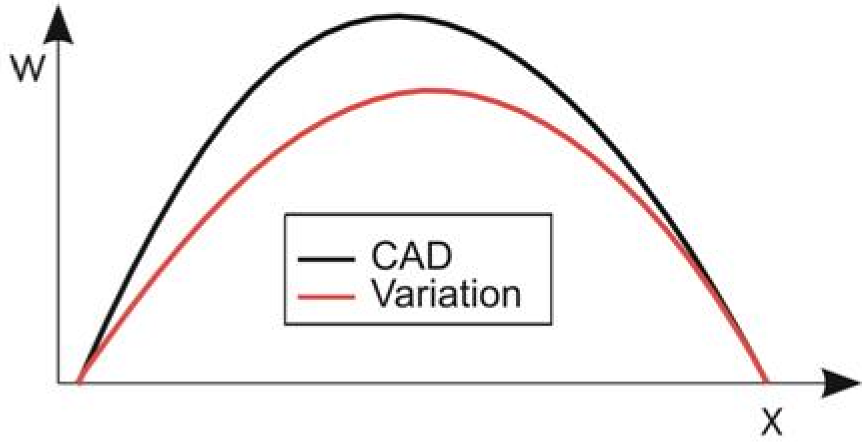


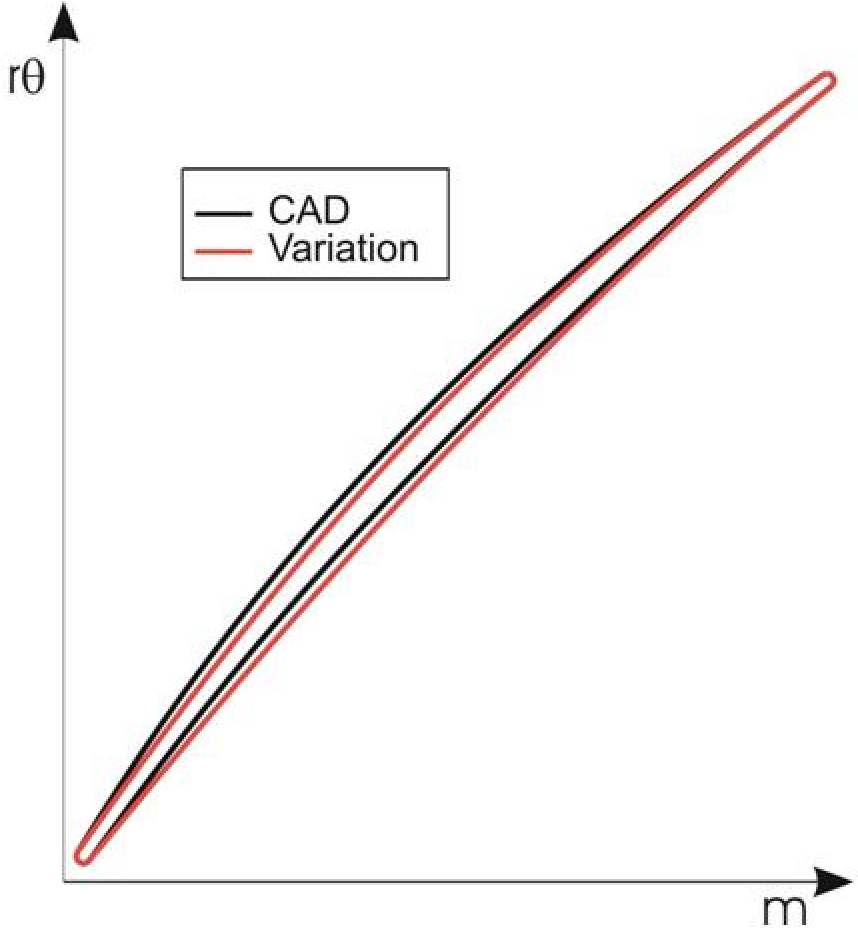
Changing the thickness distribution



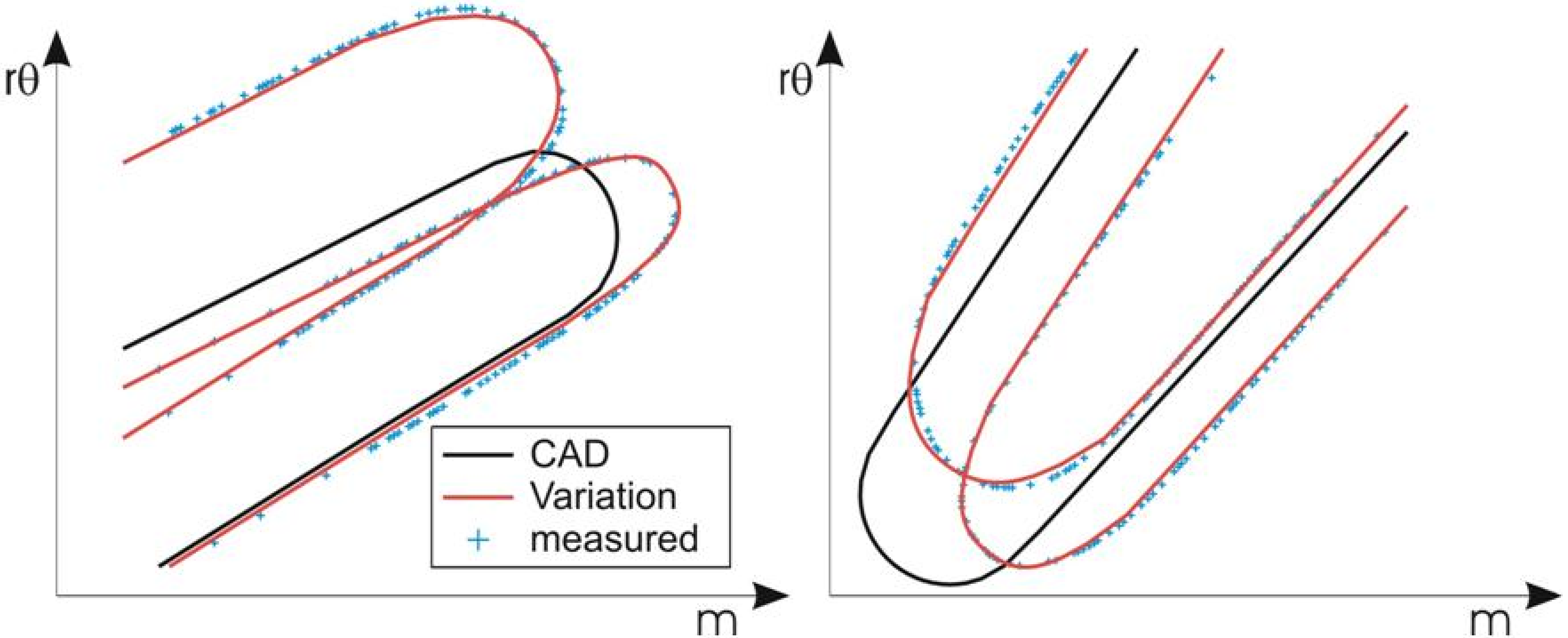


Changing the camber distribution

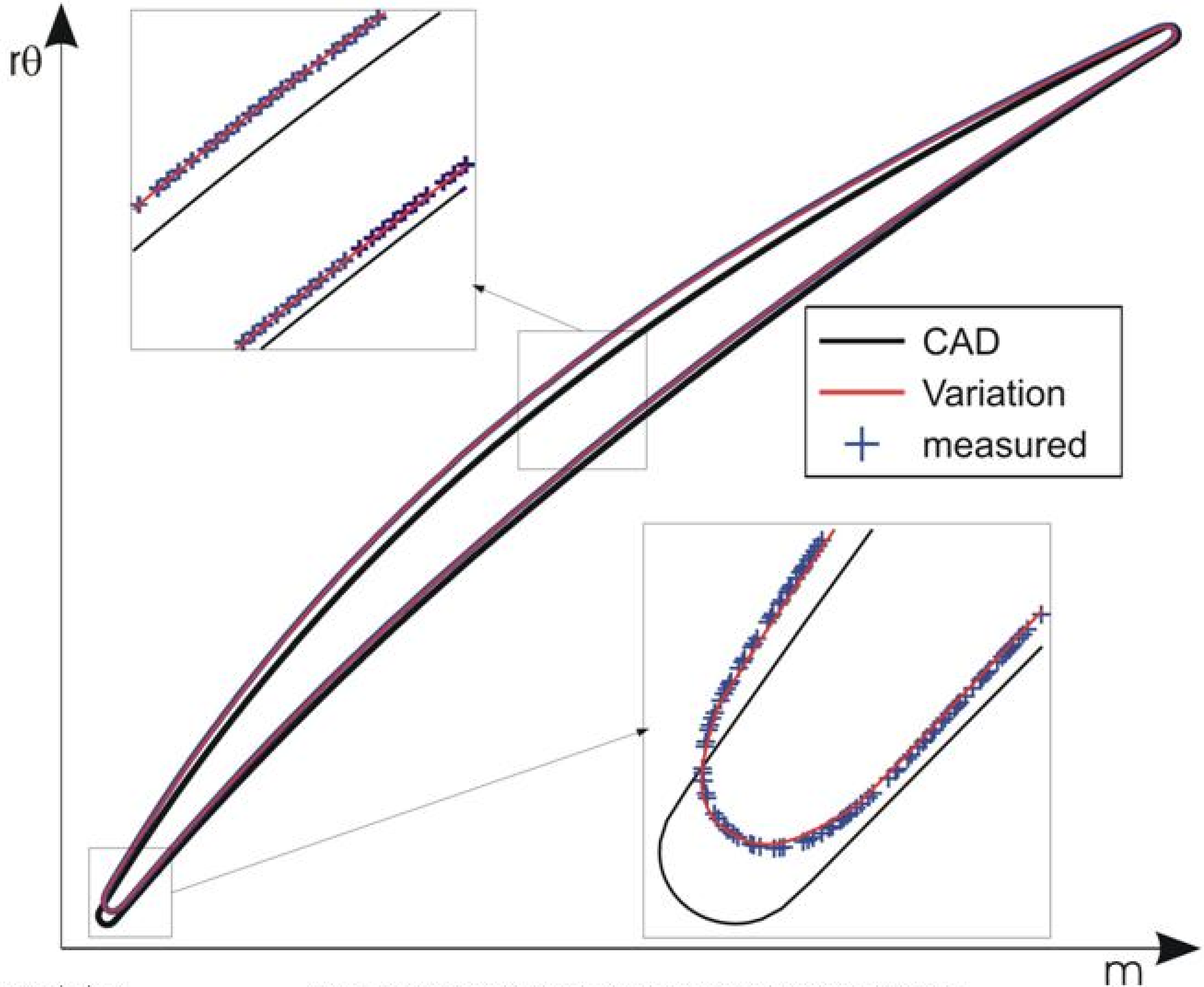




Elliptical Leading Edge and Trailing Edge



Profile rebuild – example IV



Thank you for your Attention!