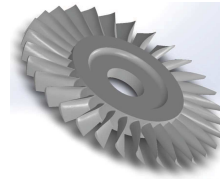


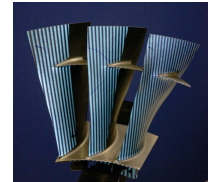
Optical properties of rigid borescopes for measurement purposes under gravitational influences

Motivation

- Diagnosis of hard to reach areas near the base of a Blisk is very important
- Hidden areas of complex geometries make measurements complicated
- No technology for contactless measurement of blisks available yet



Complex shaped machine part (Blisk)



Example of shadowing on a complex object

Objective

- Detection and analysis of deviations based on the individual objects nominal geometry
- Optical measurement of the complete object, especially in hard to reach areas
- High speed measurement and analysis
- Compensation of artifacts caused by lens distortion and bending of the borescope

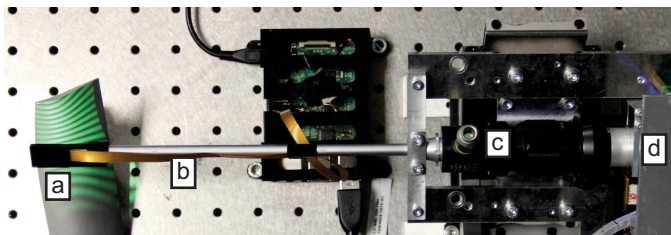
Approach, Setup and Results

Applied principle of measurement

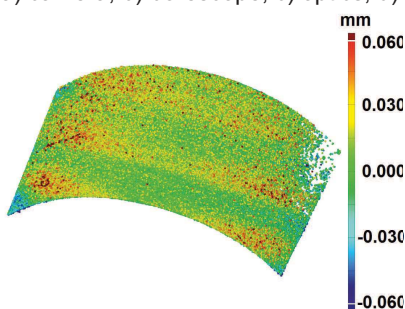
- Fringe projection with borescopes to measure hard to reach areas
- Chip-on-Tip Camera for a small measurement head

Challenges

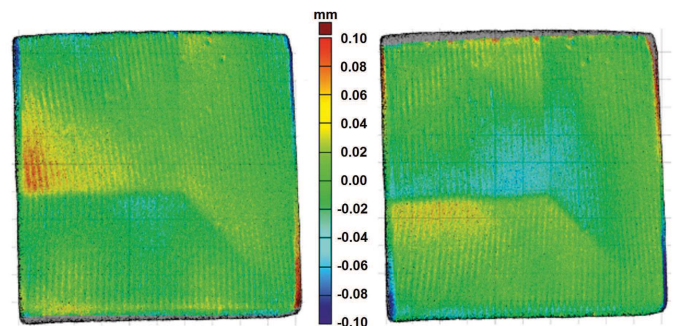
- For full inspection the measurement system has to be rotated around the shaft
- Gravitational effects influence optical properties of the borescope and (external) calibration parameters of the system



Viboscop™: A borescope based fringe projection system:
a) camera, b) borescope, c) optics, d) projector



Measurement of a cylinder standard with radius $r = 6\text{mm}$



Measurement with interpolated pose at -8° and $+12^\circ$

Solution

- Aberrations due to bending have little effect
- The pose is calculated at certain angles
- The pose is interpolated (Rodrigues' formula for rotation matrix)

Acknowledgements



Product-Regeneration

Regeneration of complex capital goods

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