A4A NDT Forum 2019 Long Beach

Magnetic Particle Inspection of Low Pressure Turbine Shafts

Christian Kalbfell | Lufthansa Technik AG | Engine Services | Sept. 2019

Lufthansa Technik

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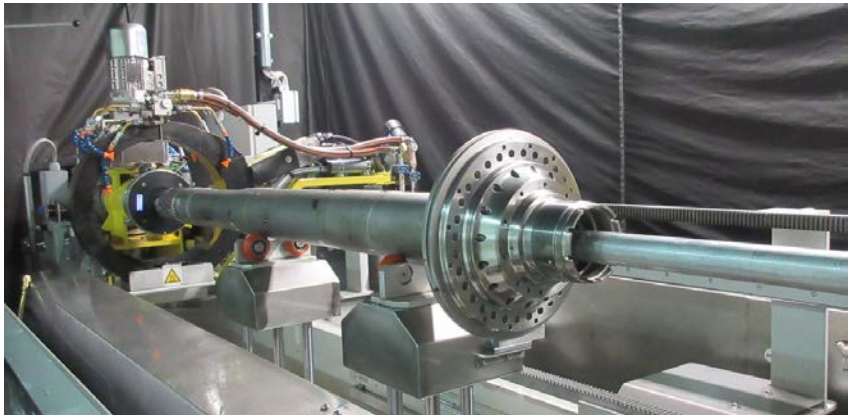


Lufthansa Technik Group – Facts & figures

850+ customers worldwide

23,219 employees worldwide*

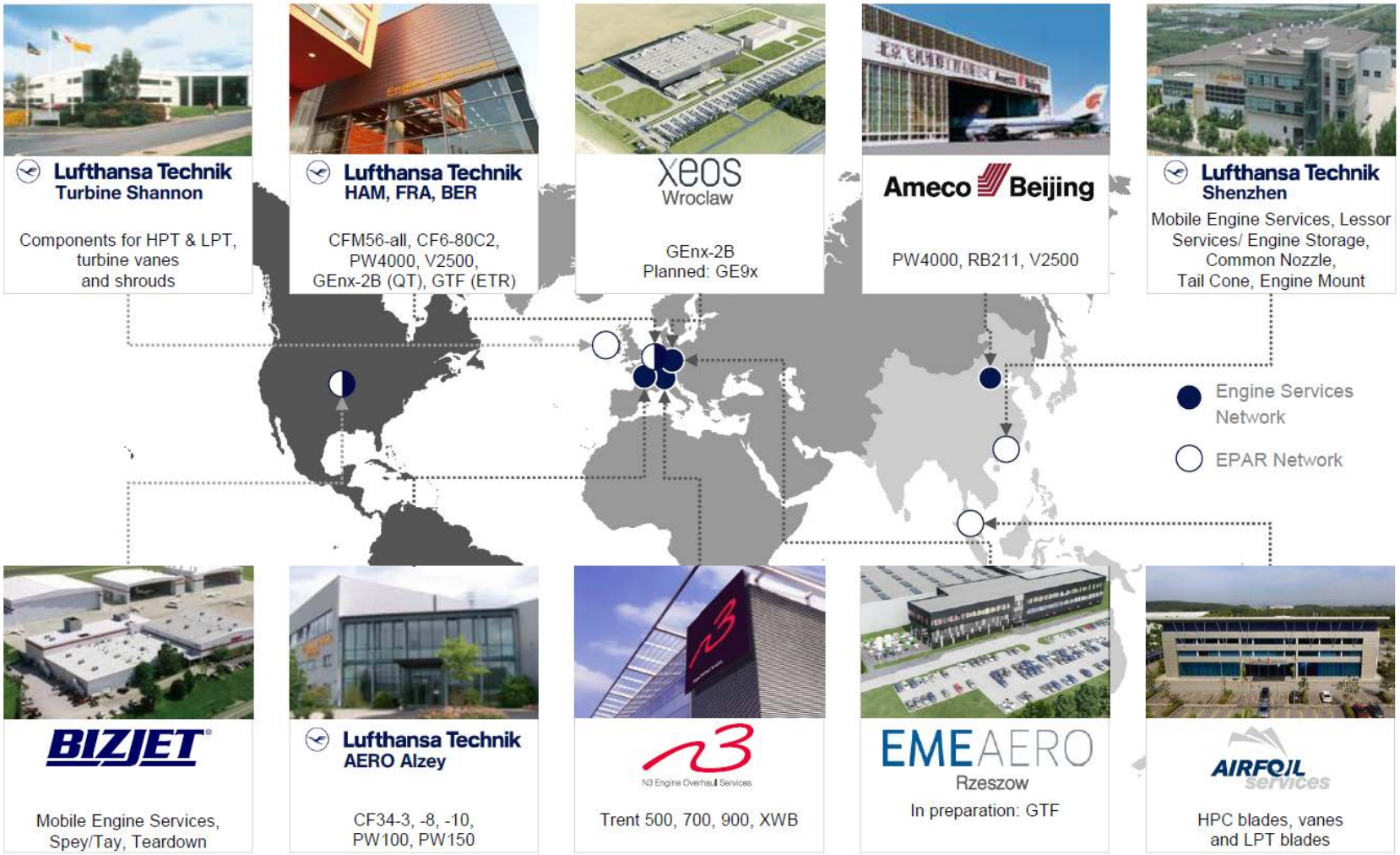
5,131 aircraft under exclusive contracts

5.918 billion € in revenue*

36** subsidiaries and affiliates worldwide

*Lufthansa Technik AG Germany and 21 consolidated companies of Lufthansa Technik Group in 2018; employees as of 31.12.2018; **XEOS is in preparation

Lufthansa Technik Product Division Engines – Our locations



Lufthansa Technik
Product Division Engines

Turnover of Engine Services:

2,900 million

33.000 Engine and APUs overhauls in over 60 years

More than 1.000 overhauls in 2018

Material stock in 2018:

~ 500 m € and

~100 spare engines

Number of employees:

4,600*

11 Engine Services facilities and 7 test cells around the world for ~40 engine and APU types

Parts manufacturing approval and design agency

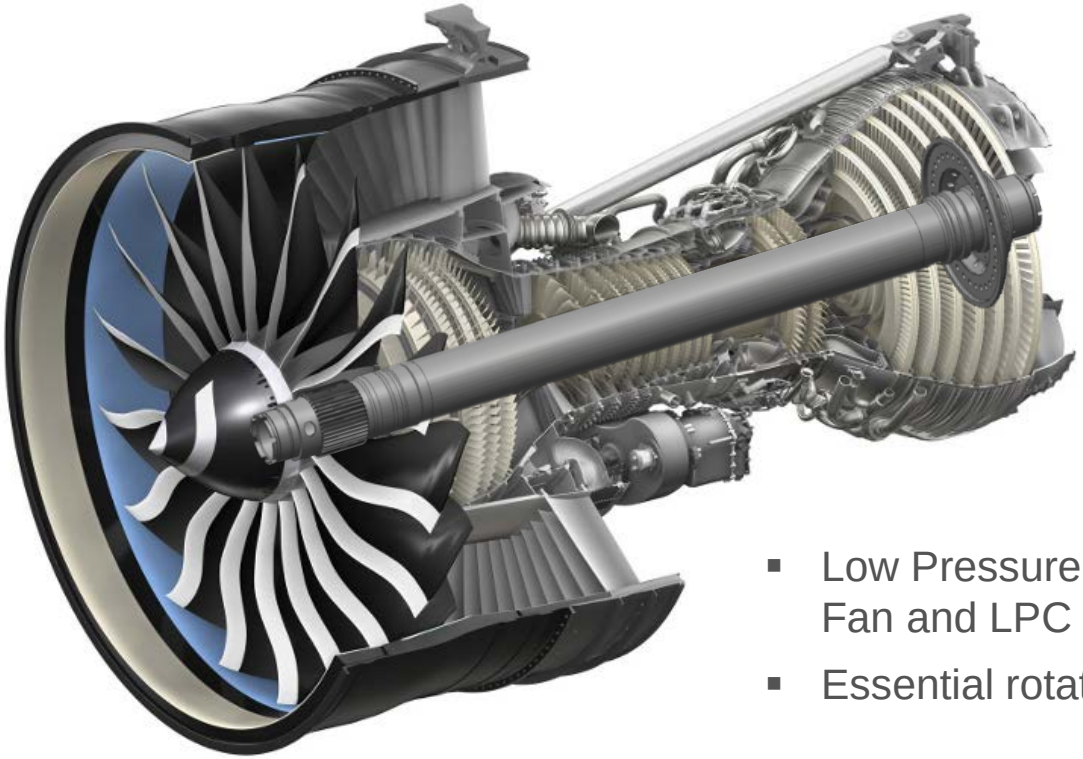
Repair station certificates from 35 countries

Certified by FAA and EASA

* as of 31.01.2019

Low Pressure Turbine Shaft - Introduction

Where to find the LPT Shaft in the engine?



- Low Pressure Turbine Shaft connects Fan and LPC with LPT
- Essential rotating part in jet engine

Setting up MPI for LPT shafts

All instructions we have:
Do a magnetic particle inspection of the LPT Shaft

i.a.w. Engine Manual,
Standard Practice Manual,
ASTM Standards,
etc.

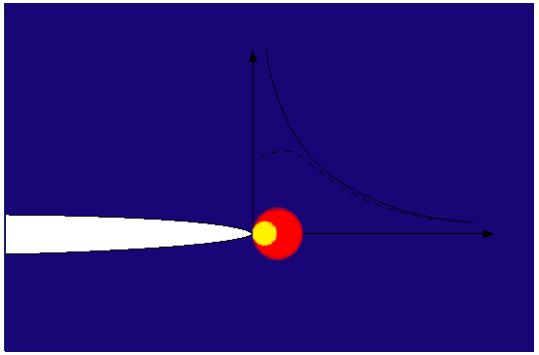
- ➔ Possibility to inspect the LPT Shaft from inside
  - Using UV-light endoscope for inspection of inner part surfaces
- ➔ Need of a known defect LPT Shaft
  - Manufacturing of representative cracks into a LPT shaft for substantiation and parameter development

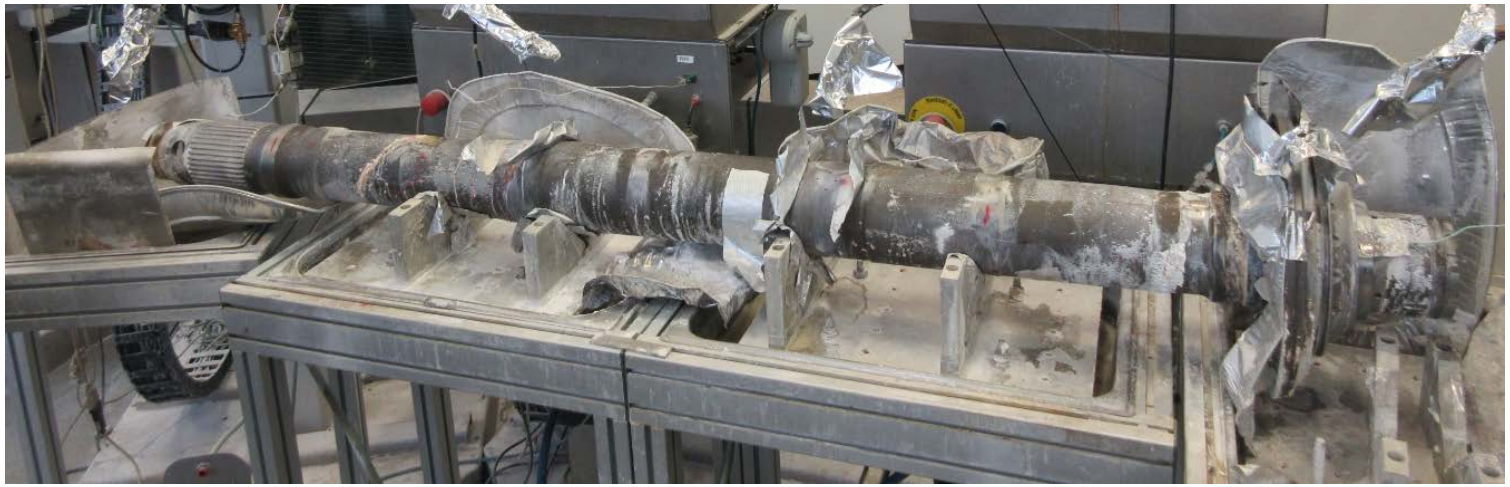
Setting up MPI for LPT shafts

Cracks with in-situ thermal fatigue

Real fatigue cracks manufactured caused by thermal fatigue

- Repeated heating and cooling
- Thermal stresses
- Fatigue
- Cracks

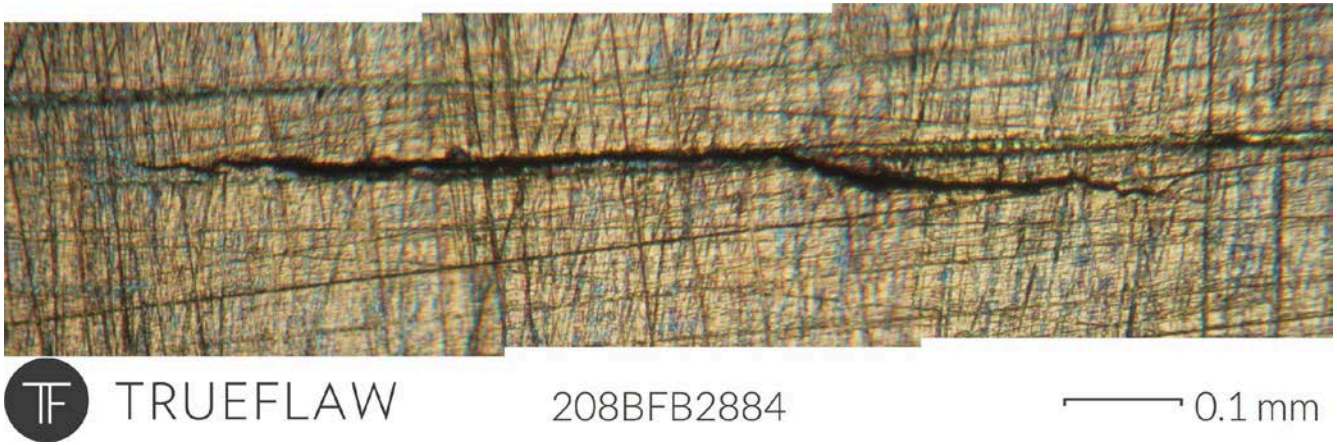




Process of real fatigue cracks manufactured into the shaft

Setting up MPI for LPT shafts

Real cracks are necessary

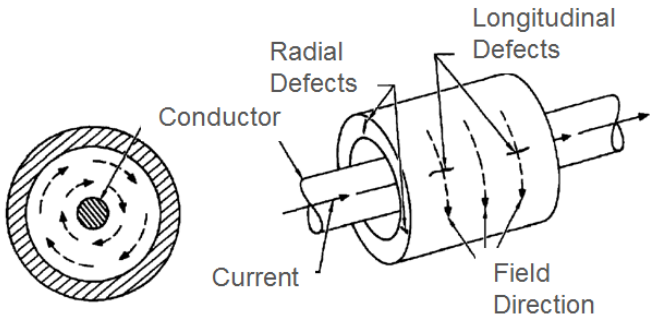


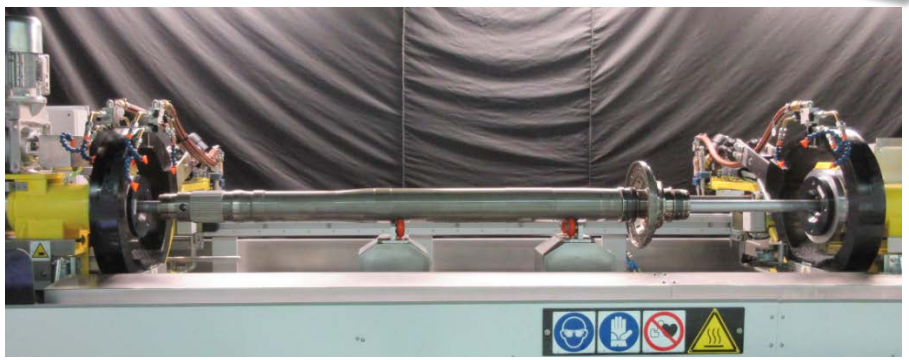
- In developing new methods and application solutions
  - ➔ to see what the method can really do
- In training and maintaining proficiency
  - ➔ to let inspectors know what to look for
- In reliability analysis and performance demonstration
  - ➔ to get reliable and realistic estimates

Setting up MPI for LPT shafts

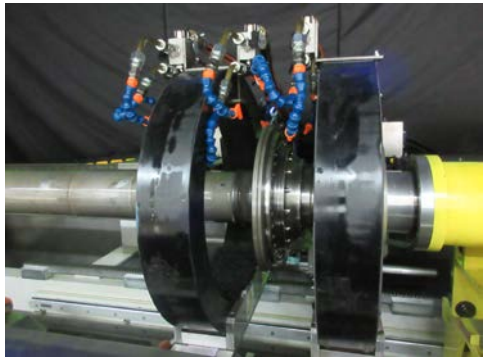
- Step 1 - Circular magnetization by concentric central conductor of inner part
- Step 2 - Circular magnetization by concentric central conductor of outer part

Using full-wave rectified alternating current-FWAC monophase





- Step 3 - Circular magnetization of flange area

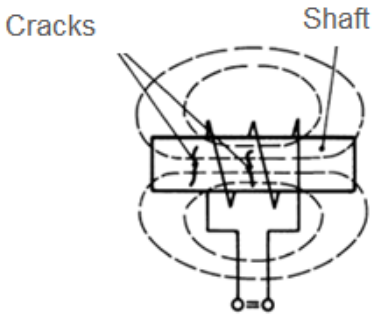


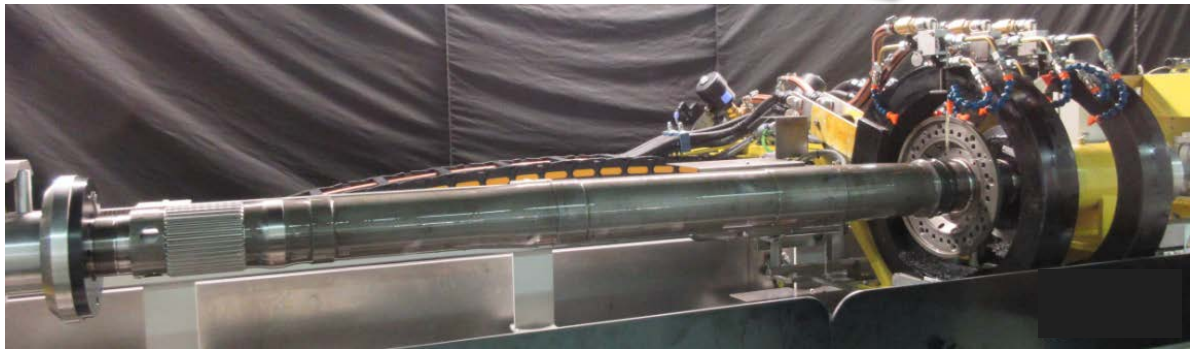
- Step 4 - Demagnetization of the part

Setting up MPI for LPT shafts

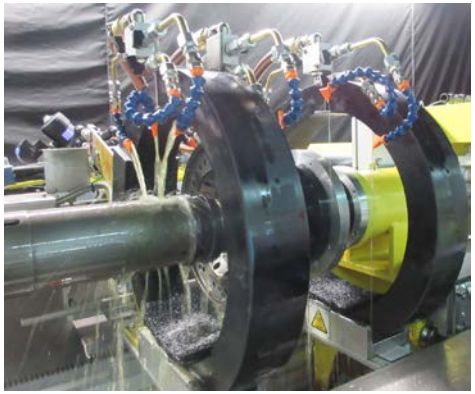
- Step 5 - Longitudinal magnetization by coil of outer part

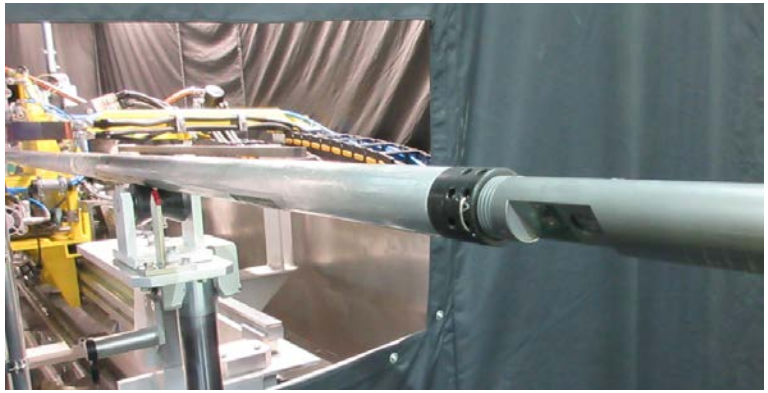
Using full-wave rectified alternating current-FWAC monophase





- Step 6 - Longitudinal magnetization by coil of Inner part





- Step 7 - Longitudinal magnetization by coil of flange area
- Step 8 – Demagnetization of the part

Setting up MPI for LPT shafts

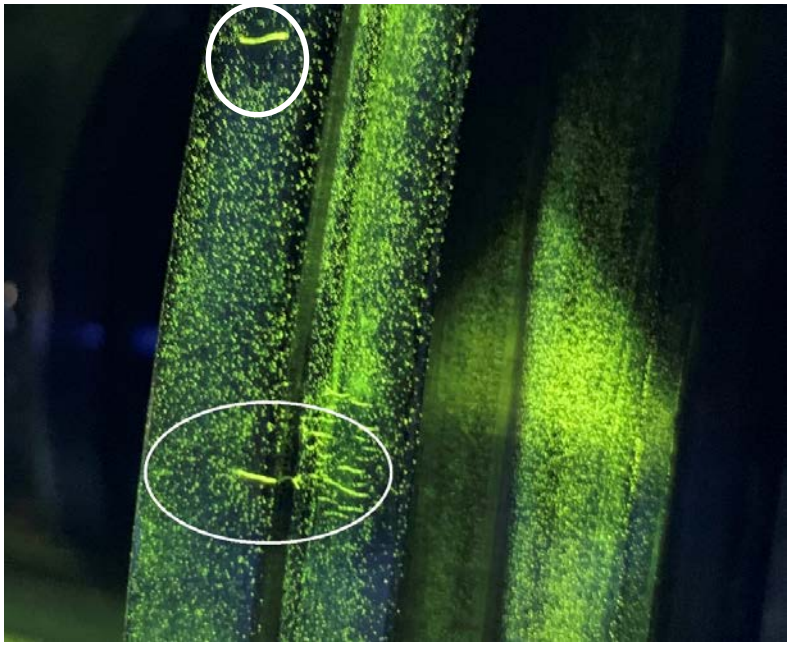
- Sample cracks and other defects on the LPT shaft

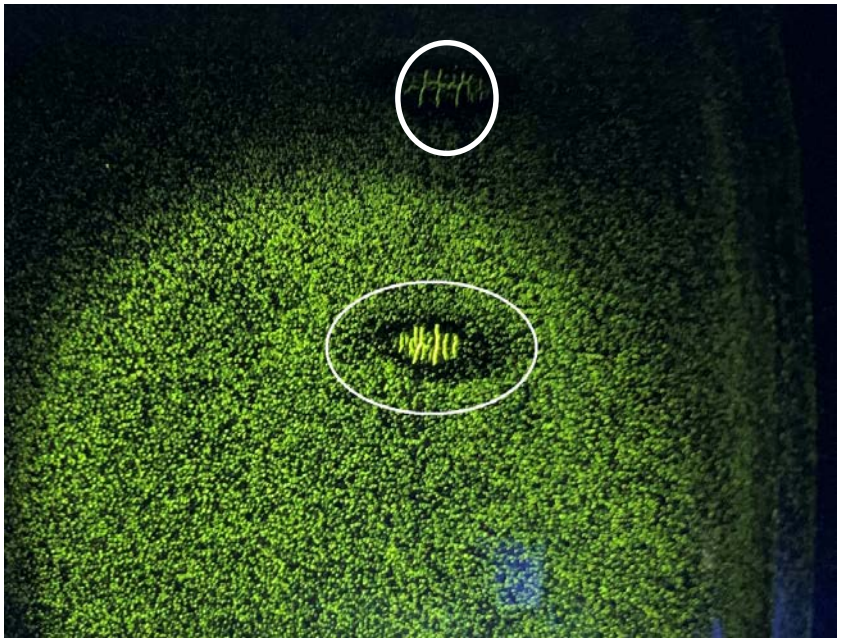
  Longitudinal crack orientation after circular magnetization

Setting up MPI for LPT shafts

- Sample cracks and other defects on the LPT shaft

  Longitudinal and circumferential crack orientation after magnetization

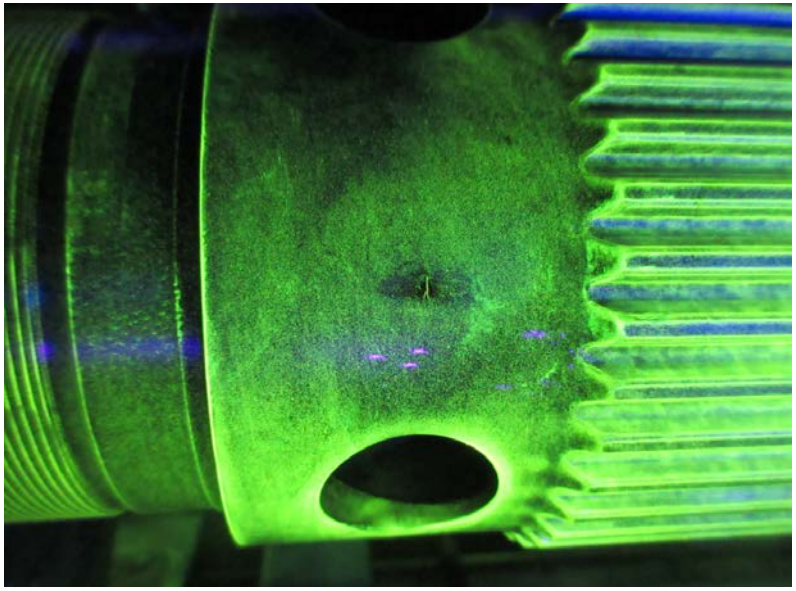


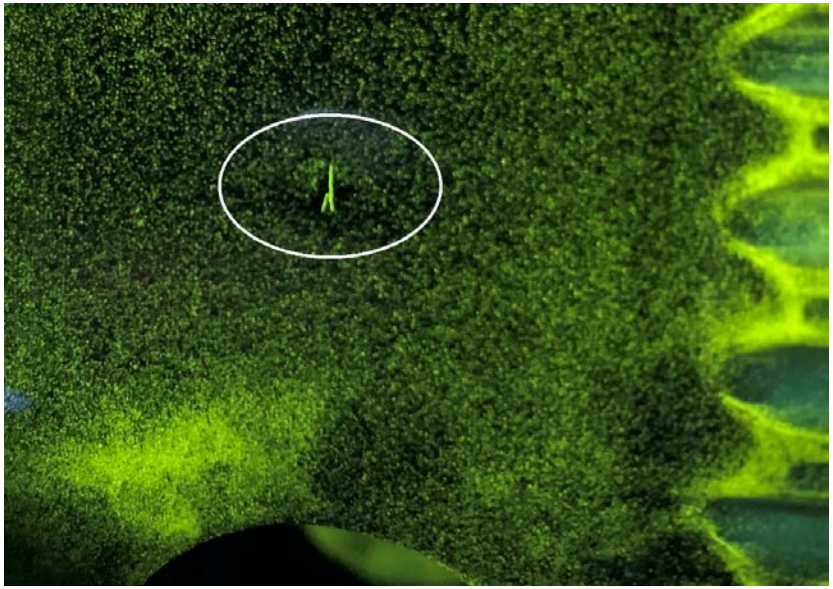


Setting up MPI for LPT shafts

- Sample cracks and other defects on the LPT shaft

  circumferential crack orientation after longitudinal magnetization

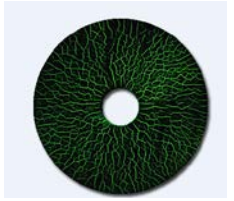




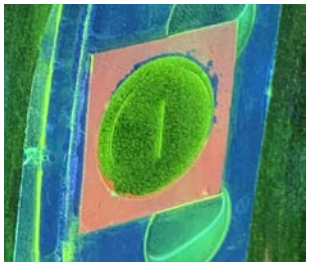
Process and Quality Checks

Business as usual - ASTM E 1444, ASTM E709

- Performance check daily



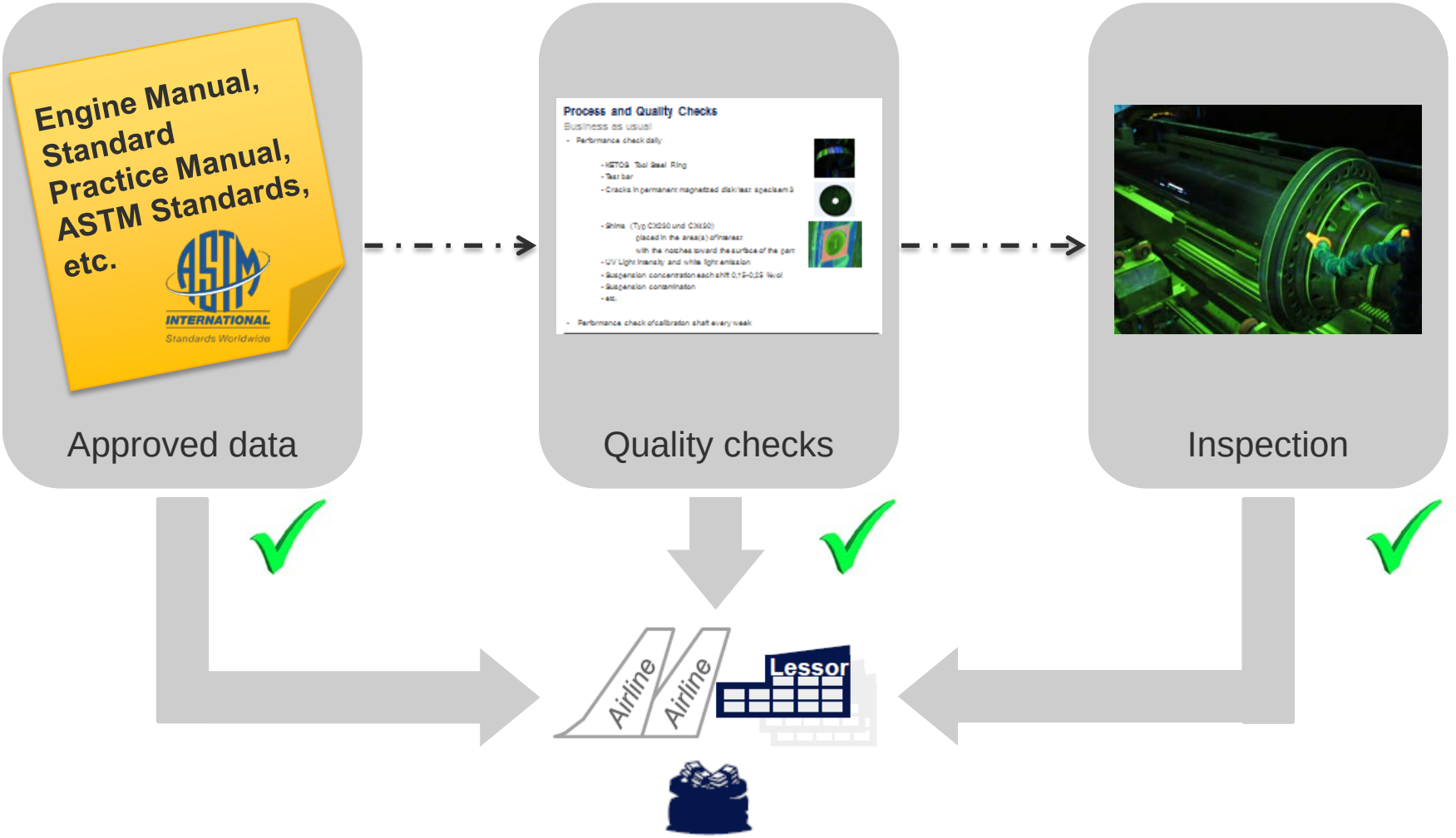
- KETOS Tool Steel Ring
- Test bar
- Cracks in permanent magnetized disk/ test specisem 3



- Shims (Typ CX230 und CX430)
  placed in the area(s) of interest
  with the notches toward the surface of the part
- UV Light intensity and white light emission
- Suspension concentration each shift 0,15-0,25 %vol
- Suspension contamination
- etc.

- Performance check of calibration shaft every week

Magnetic Particle Inspection of LPT Shafts



- Need of real cracks is essential – for setting up this MPI, calibration shaft is a big advantage

Thank you for your attention.

Any questions?

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