3D Scanning of WWER-type nuclear power plants components

M. Kroc

Conference CORE, 20.11. 2025, Řež

Content

1. 3D scanning equipment
2. Examples of a 3D scanning inspections at NPP
3. Examples of a 3D scanning inspections at FPP
4. Conlusions

NDT laboratories

3D scanning

3D scanning equipment

Hexagon Romer Arm with scanner RS4 (2018)

Accuracy 0.063 mm
Scan speed 0,75 million points/s

Hexagon Romer Arm with scanner AS1 (2023)

Accuracy 0.047 mm
Scan speed 1,2 million points/s

Handheld scanner Creaform HandyScan Black Elite+

Accuracy 0.035 mm
Scan speed 1,8 million points/s

3D scanning equipment

Leica AT 960

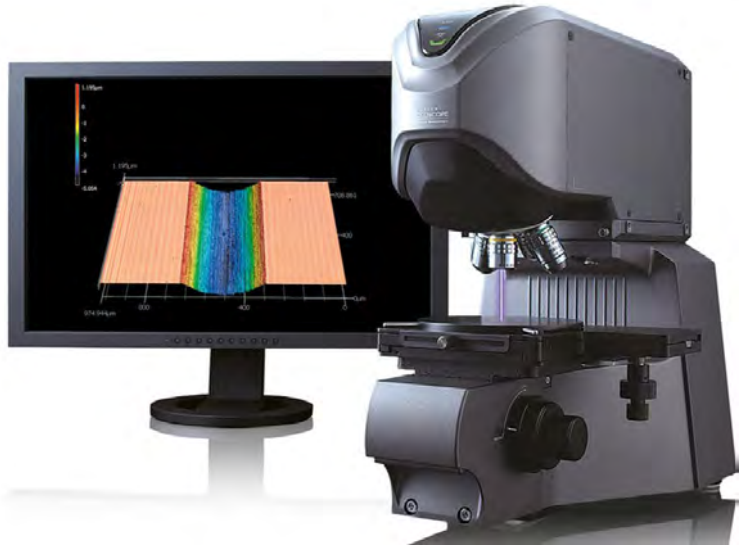
Accuracy 0.047 mm
Scan speed 1,2 million points/s
Range 60 m

Leica RTC360

3 mm (10 m) in 1 minute and 51 seconds,
6 mm (10 m) in 51 seconds,
12 mm (10 m) in 26 seconds
Range 130 m

Laser profiler Keyence VK X-100

Accuracy 10-50 x
Scan speed 1 µm in the Z axes



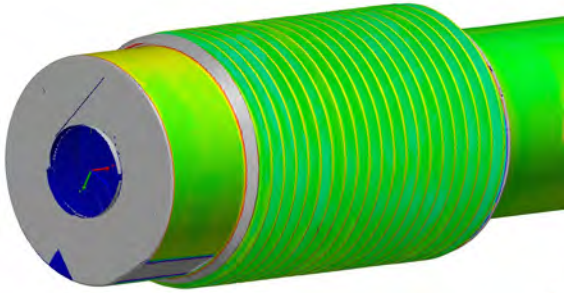
Examples of applications at NPP

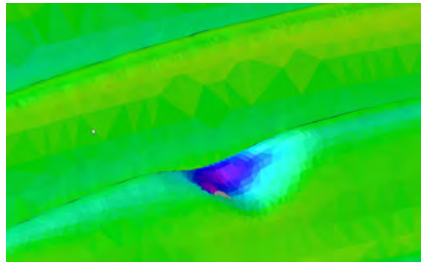
MCP bolts

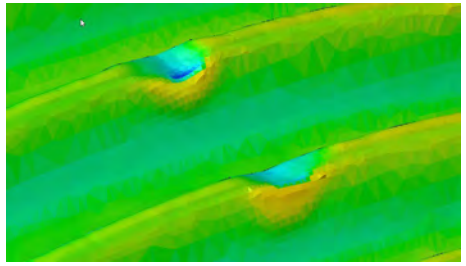
Corrosion monitoring of bolts of the Main Circulating Pumps at Dukovany NPP.

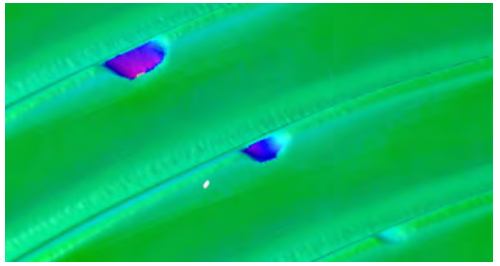
Measurement of the depth of corrosion pits, dents and surface damage over the entire surface area of bolts.

Evaluation according to established criteria.









examples of defects found

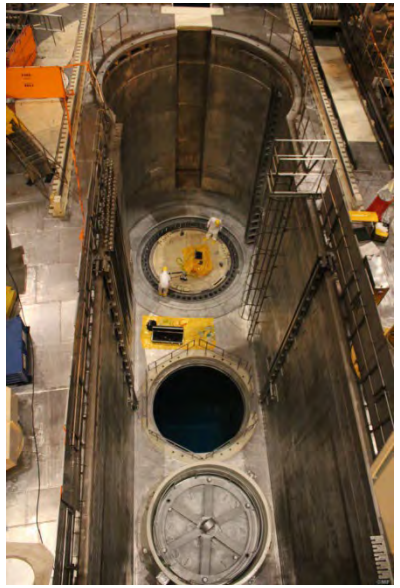
CAD data

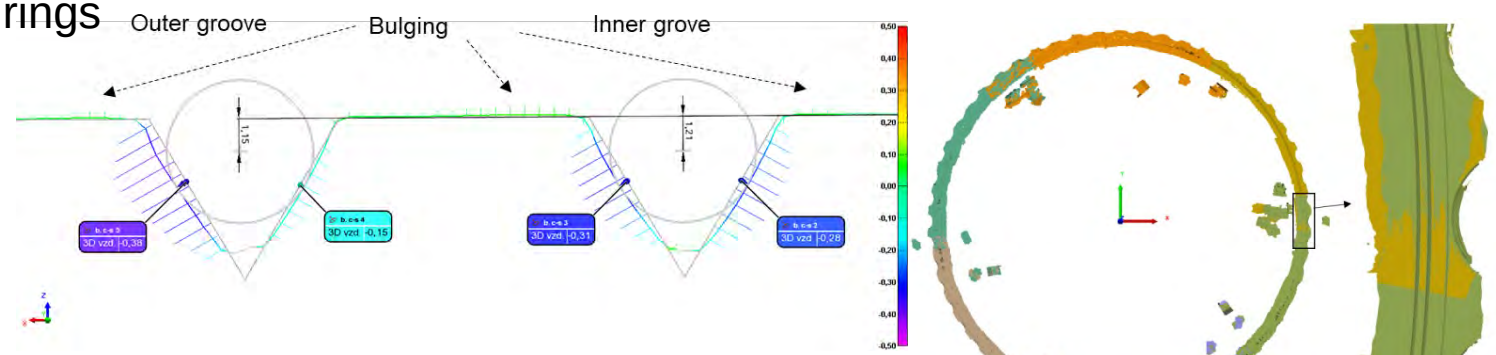
Main pressure boundary of the NPP RPVs

Assessment of the state of groove geometry for sealing rings to seal the main pressure boundary of reactor pressure vessels (RPV) of Temelin and Dukovany NPPs.

The output from the 3D measurement is used for:

- recommendations for choosing the right thickness of the new sealing rings.
- monitoring the development of pressure marks from the sealing rings on the RPV groove geometry and on the opposite surface on the reactor lid.
- in addition, it is possible to analyze other defects in this area caused, for example, by handling sealing rings



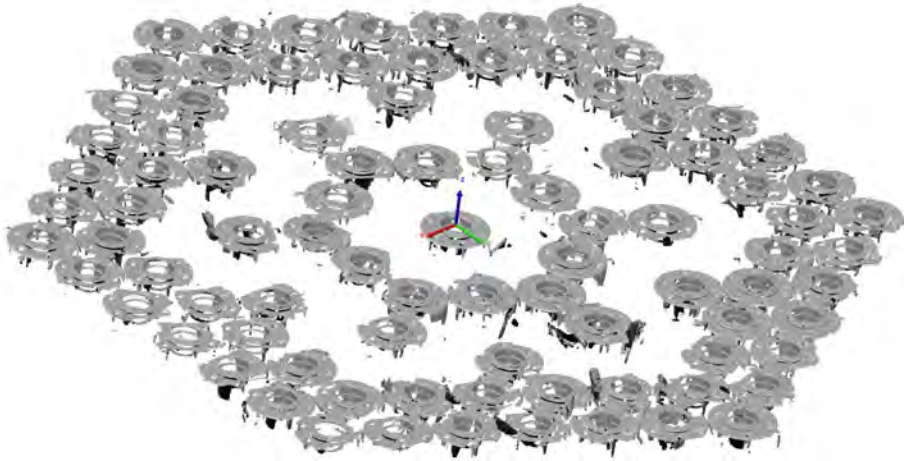


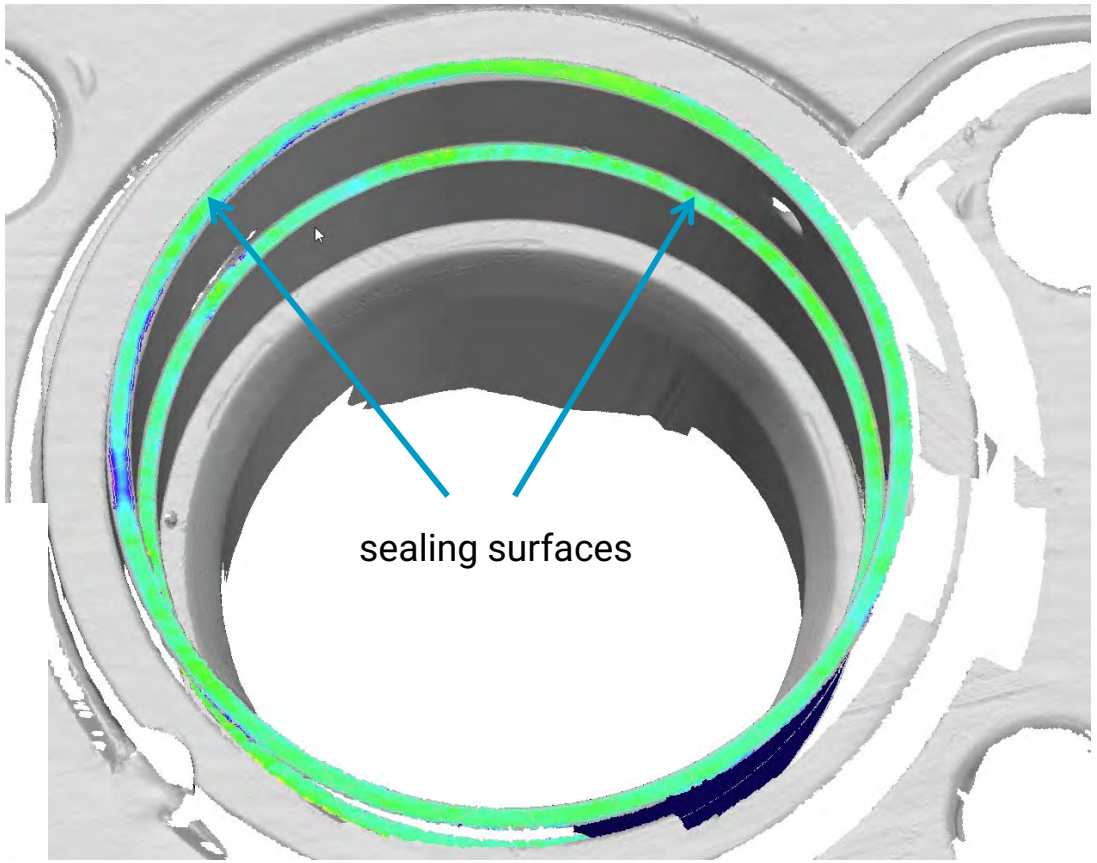
Sealing surfaces of Temelín NPP flanges

Assessment of the geometry of two sealing surfaces of the nozzles on the reactor pressure vessel cover of the Temelín NPP

Two types of 3D measurement :

1. Measurement of imprints and deformations on each of the two sealing surfaces.
2. Measurement of mutual distance and flatness deviations of these sealing surfaces.

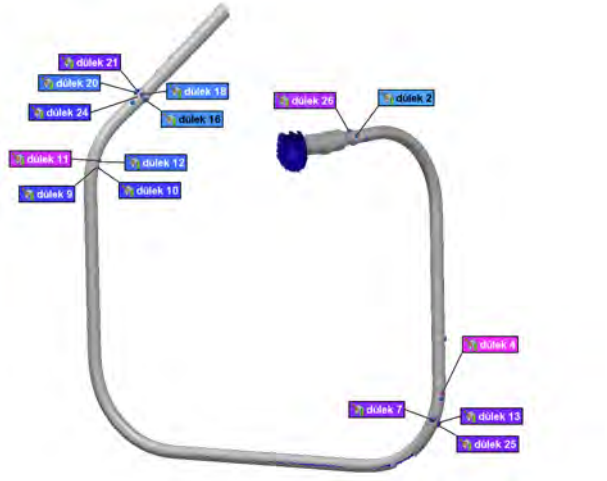


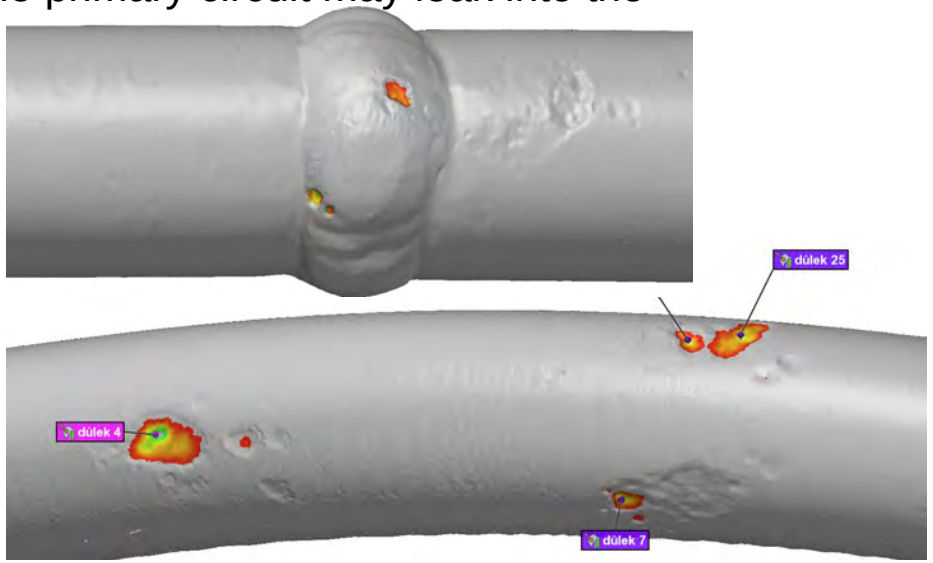


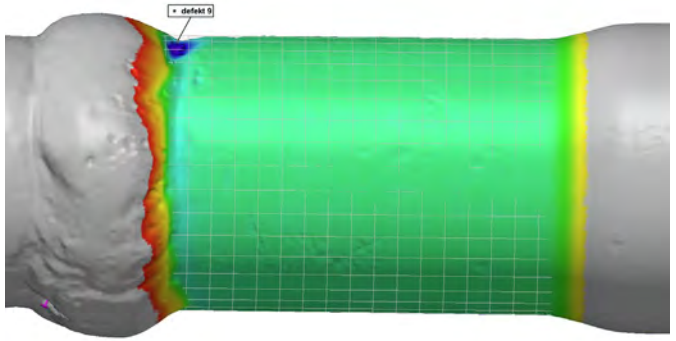
Tubes on the secondary side of the steam generator

Monitoring of pitting corrosion of ferritic steel pipelines (venting pipelines and pipelines for checking the tightness of the gap between two seals in the primary collectors) on the secondary side of the steam generator of Temelin NPP.

The evaluation of the dimensions of the corrosion pits (depth, width) and the position on the outer surface of the pipes is carried out because, in the event of a leak, the coolant of the primary circuit may leak into the secondary circuit.







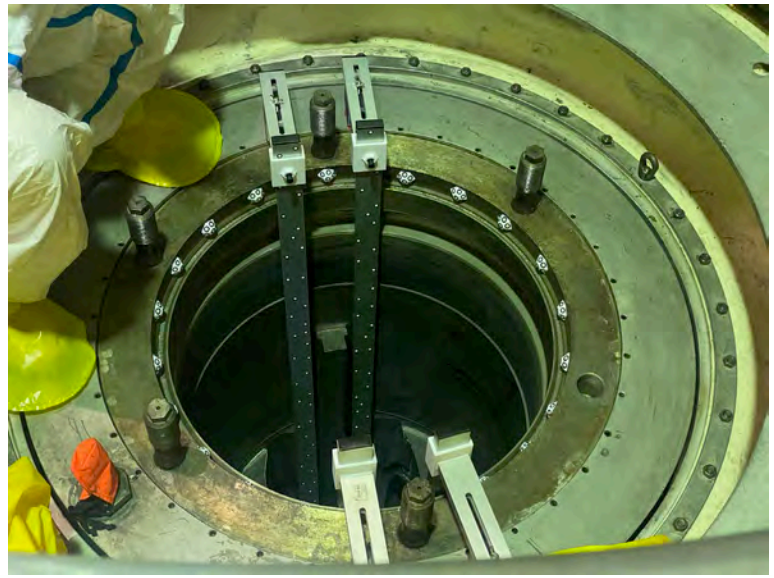
CVŘ Research Centre Řež

UJV Group
PEOPLE I INNOVATION I TECHNOLOGY

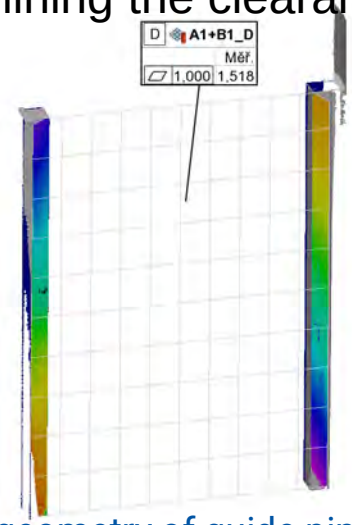
Guide groove of the wedge of the main closing valves of primary circuit

Evaluation of defects of the guide groove on the side wall of the wedge of the main closing valve

- 100% of the surface of the guide pins of the shaft and wedge scanned
- Shaft depth approx. 1.5 m
- Evaluation of pressure marks and mechanical damage to guide pins
- Determining the clearance between the groove and the pins

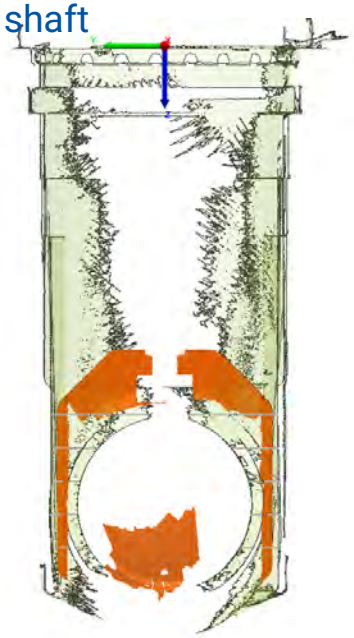


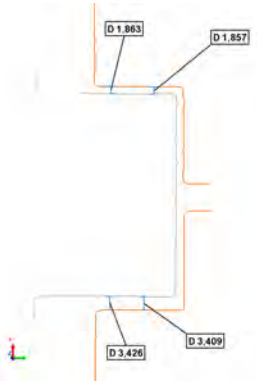
wedge

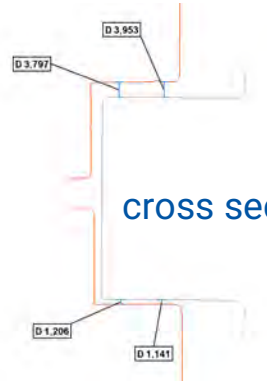


geometry of guide pins

scanned shaft





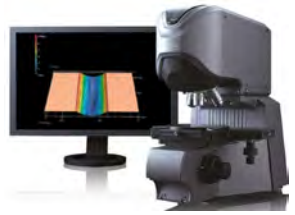


cross secitons

CVŘ Research Centre Řež

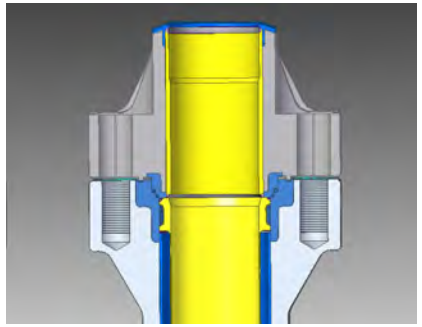
UJV Group
PEOPLE I INNOVATION I TECHNOLOGY

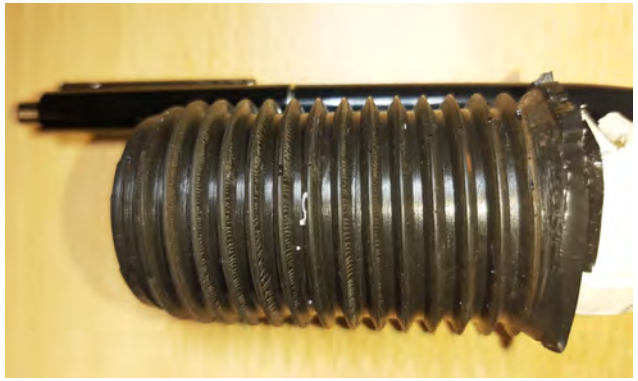
Threaded holes of the flanges of the control rod assemblies

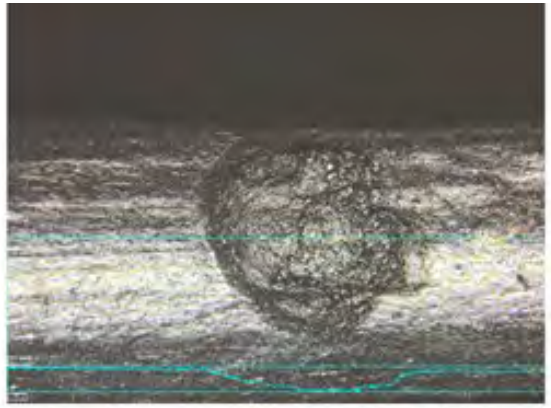


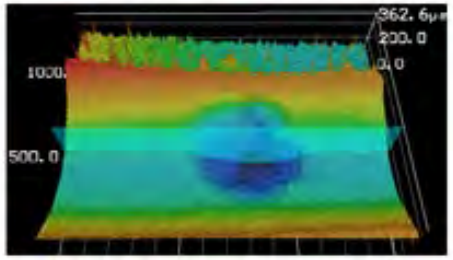
Replicas of the threaded holes of the flanges of the control rod assemblies located on the reactor cover of Dukovany NPP.

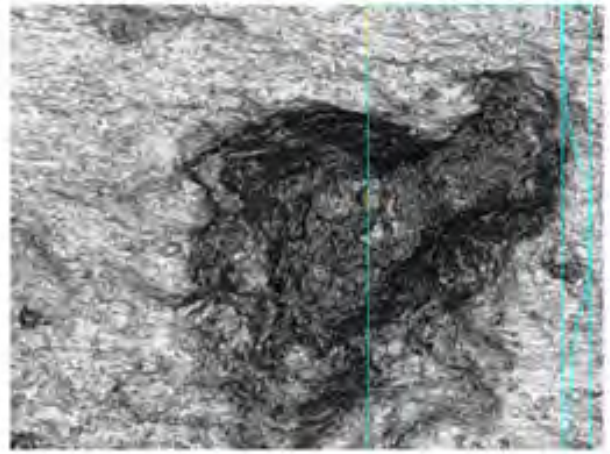
After the discovery of corrosion products in the threaded holes, there was a need to quantify the defects found.
A replica of the thread is taken, on which the largest corrosion or mechanical defects are searched for using a stereo magnifying glass. In these places, the depth and size of the defect is precisely measured using a laser profilometer.

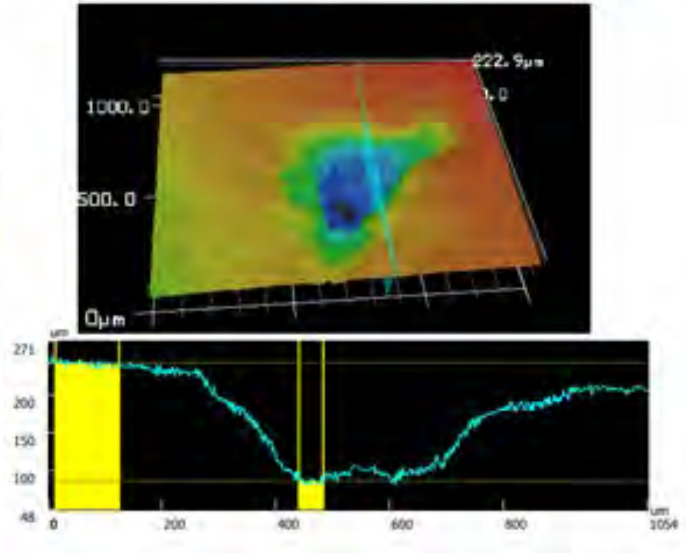












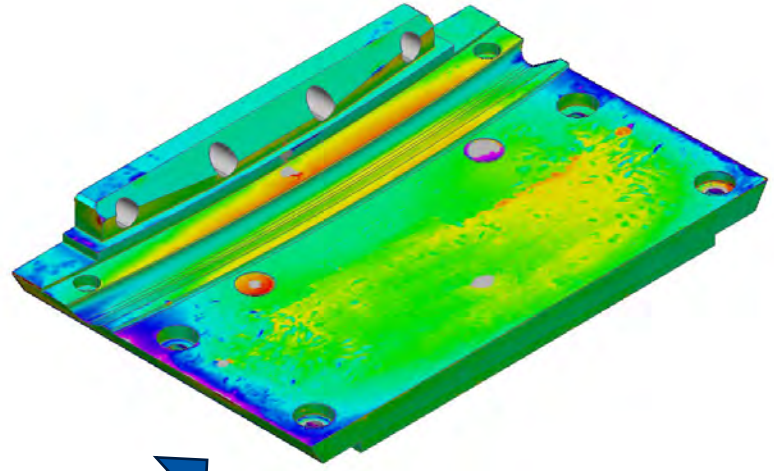
CVŘ Research Centre Řež

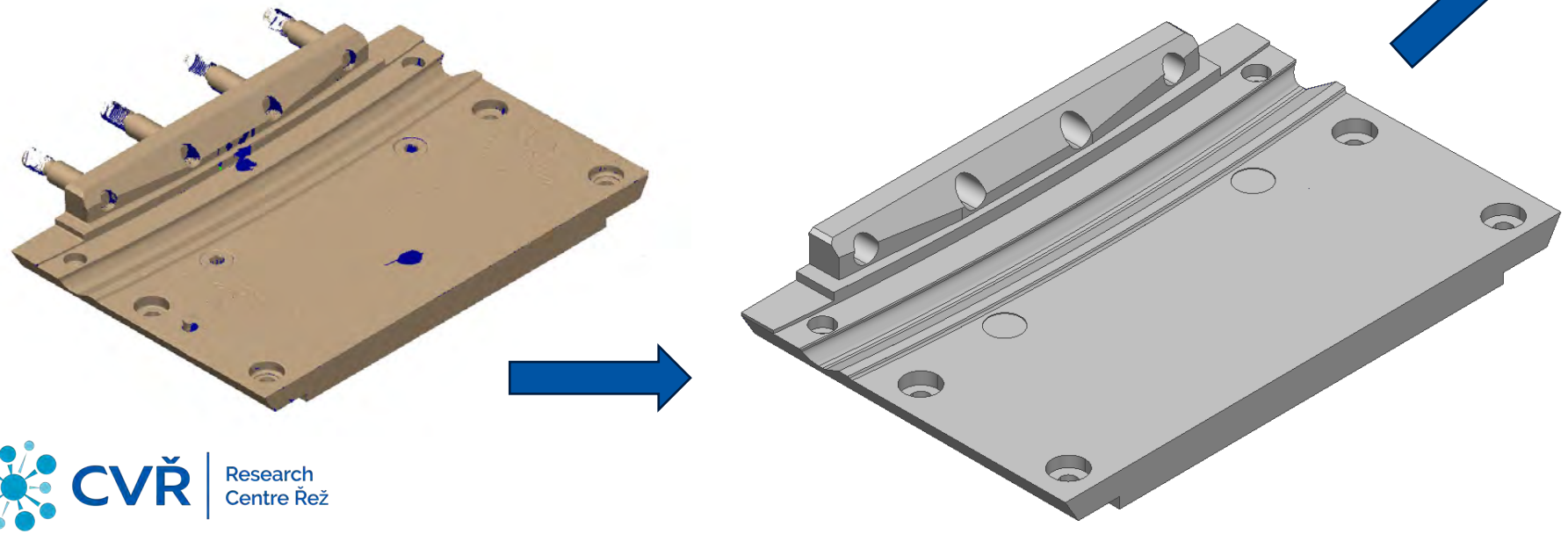
UJV Group
PEOPLE | INNOVATION | TECHNOLOGY

Segment of the counterflange of the reactor shaft

Creation of a CAD model of the counterflange (bridge) segment

- 3D scan of the bridge
- 3D scan of the base seating surface
- Reverse engineering – creation of the CAD model
- 3D scan of a model made of wood-plastic composite
- Comparison of deviations between the manufactured model and the scan of the original part





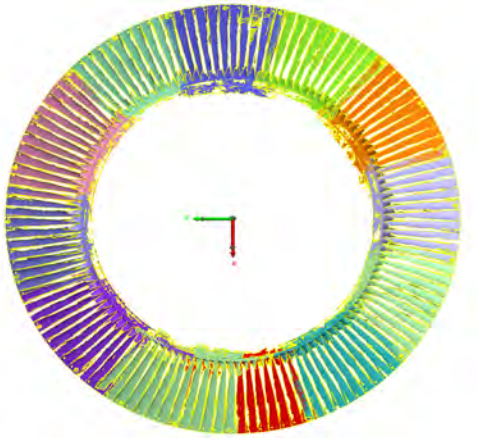
Examples of applications at FPP

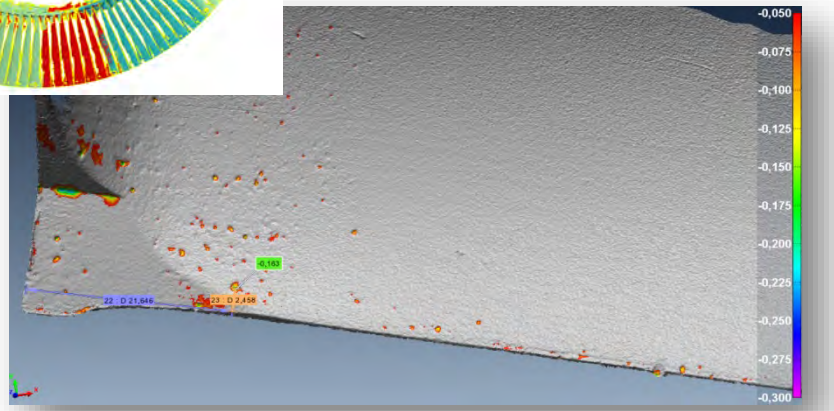
3D scanning of steam turbine blades

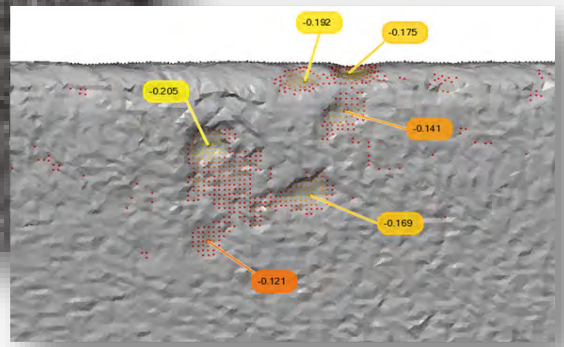
Identification of distribution and size of corrosion pits at fossil power plants turbines.

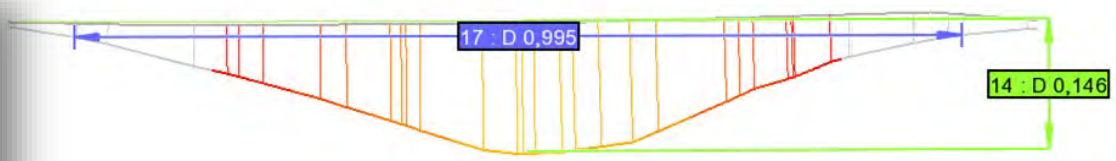
Evaluation of the criticality of individual blades in terms of remain servis life with the risk of fatigue fracture.

Accident prevention by exchange rotor blades on end of servis life.









CVŘ Research Centre Řež

UJV Group
PEOPLE I INNOVATION I TECHNOLOGY

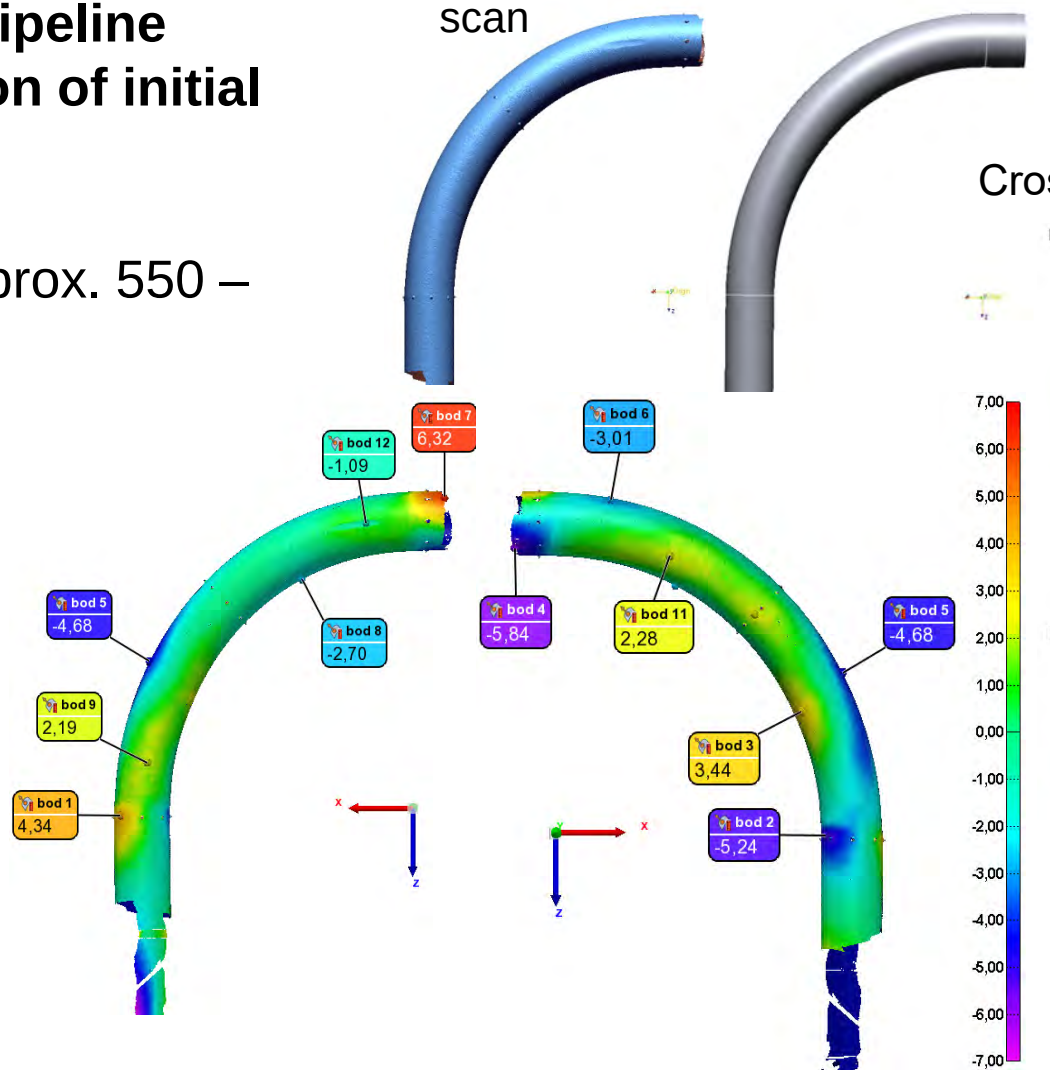
3D scanning of steam pipelines

Measurement of steam pipeline deformation and detection of initial creep damage.

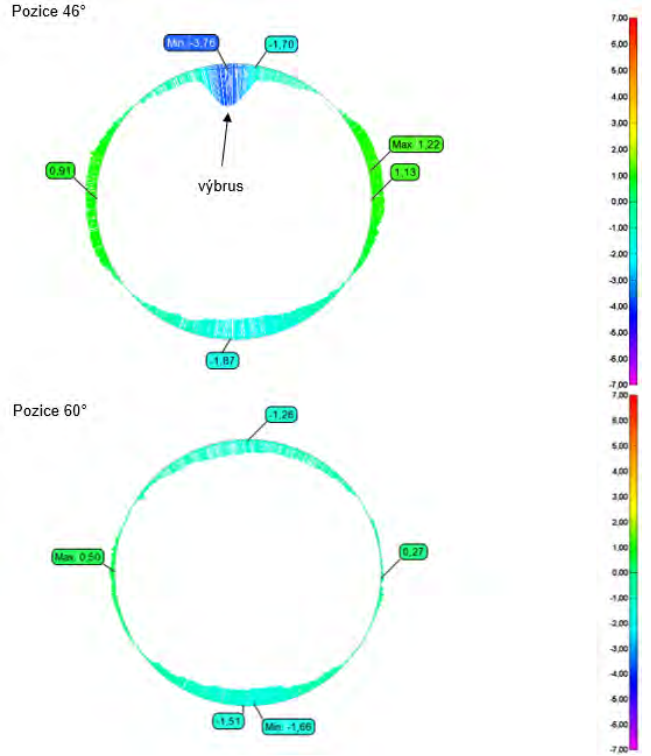
Operating temperature approx. 550 – 650 ºC

scan

3D model



Cross section in positions 46º and 60º



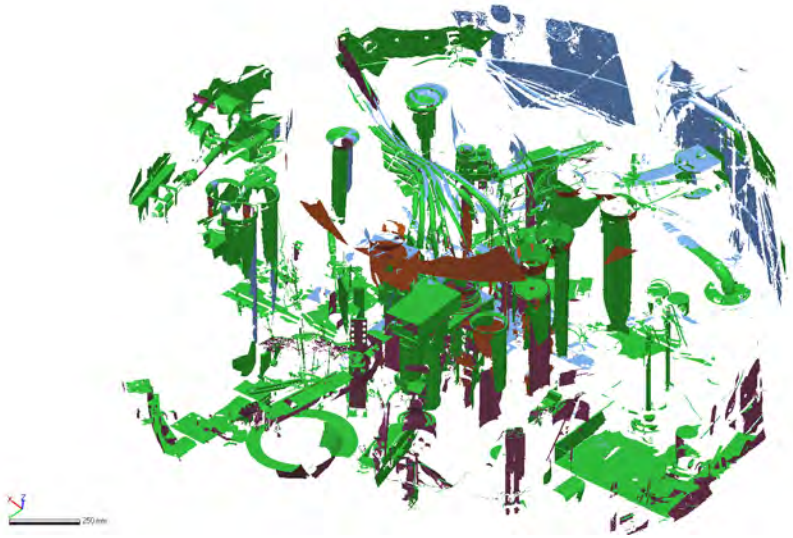
CVŘ Research Centre Řež

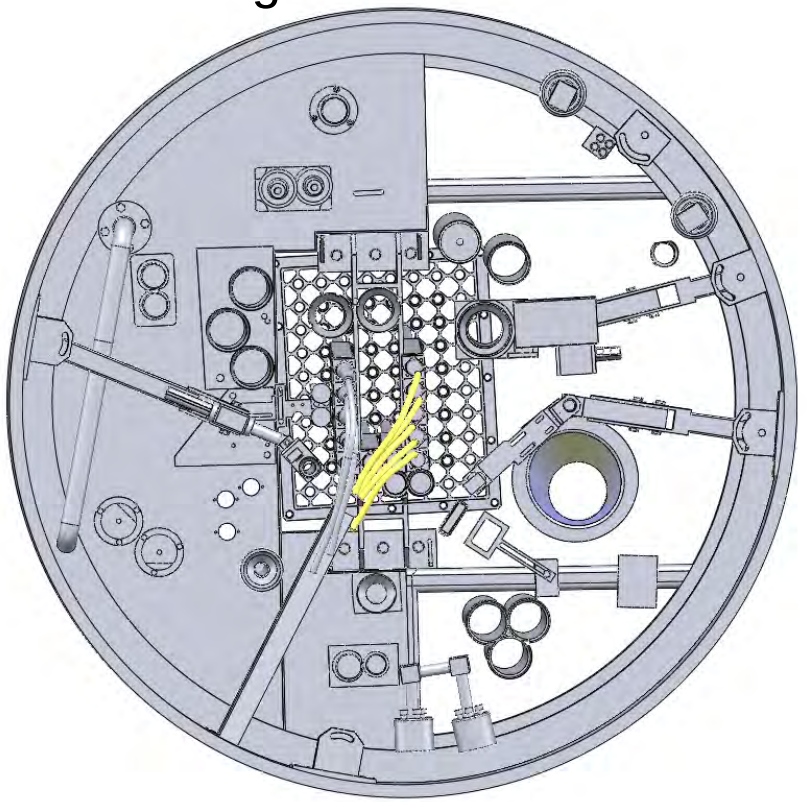
UJV Group
PEOPLE I INNOVATION I TECHNOLOGY

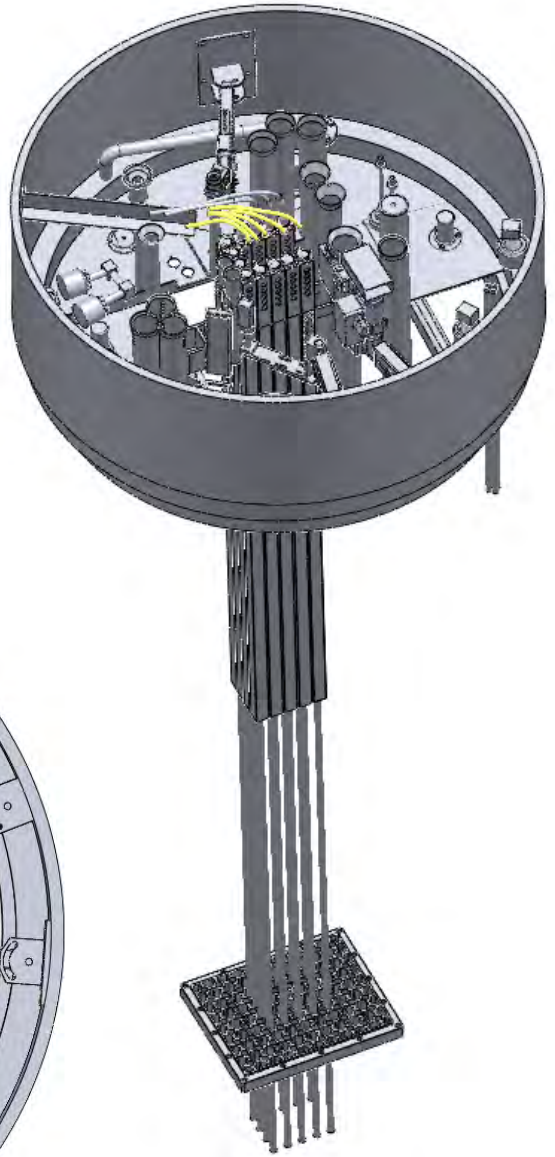
Reverse engineering – LVR 15

Using two devices, the entire structure of the research reactor above the surface was scanned (Leica AT960 + Romer Arm se skenerem AS1 XL)

The main components of the reactor below the creation level were also added to the model, but only from the drawing documentation.

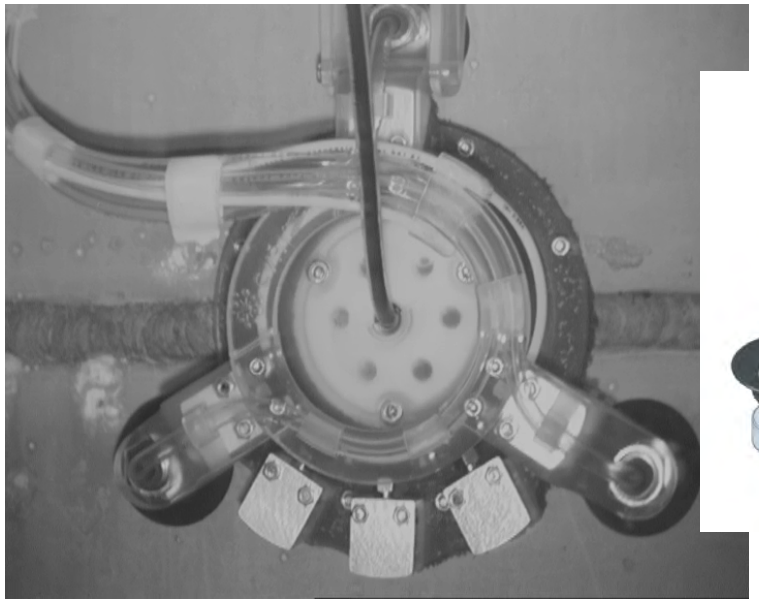


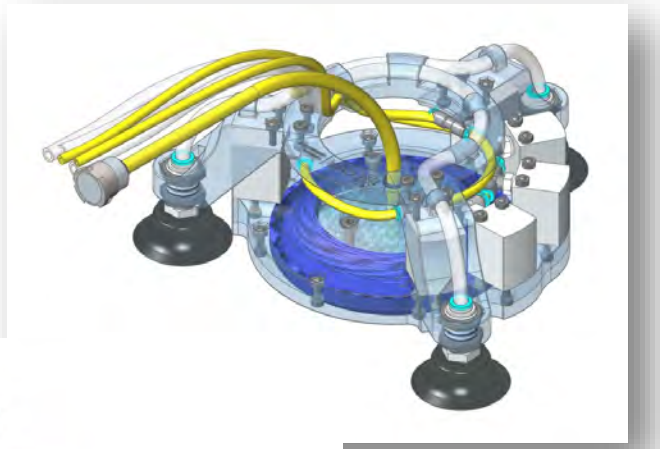


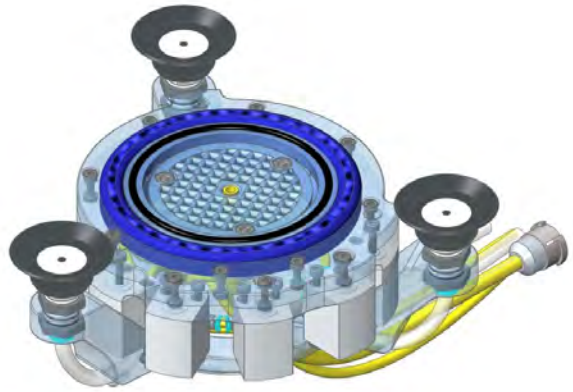


3D scanning - taking replicas underwater

Diagnostic equipment for taking replicas in inaccessible nuclear facilities underwater







Conclusions

For all the above-mentioned applications of 3D scanning in power plants, either minor or major research was required before its deployment as part of the in-service program of the power plant.

Certain applications even required their verification. In these cases, the ENIQ methodology principles were applied.

3D scanning can be characterized as a new inspection method that provides a new type of results to evaluate the current state of components. Along with the ongoing development of scanners, which will continuously improve their accuracy, this method will be used increasingly often

Thank you for your attention

M. Kroc
Conference CORE, 20.11. 2025, Řež