IAEA Workshop
Decontamination of Tubings

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Overview

- Naturally Occurring Radioactive Material (NORM)
- Development of scales inside tubing
- Classification and composition of contaminated deposits
- Currently used decontamination technologies
- Decontamination of tubings using vibration
  - Analyses and simulation of scales
  - Tool carrier and influencing factors on force, acceleration and frequencies
  - Decontamination tools
  - Feeding device and jig
- Investigations
  - Preliminary investigation results
  - Main Investigation
- Conclusions

Naturally Occurring Radioactive Material

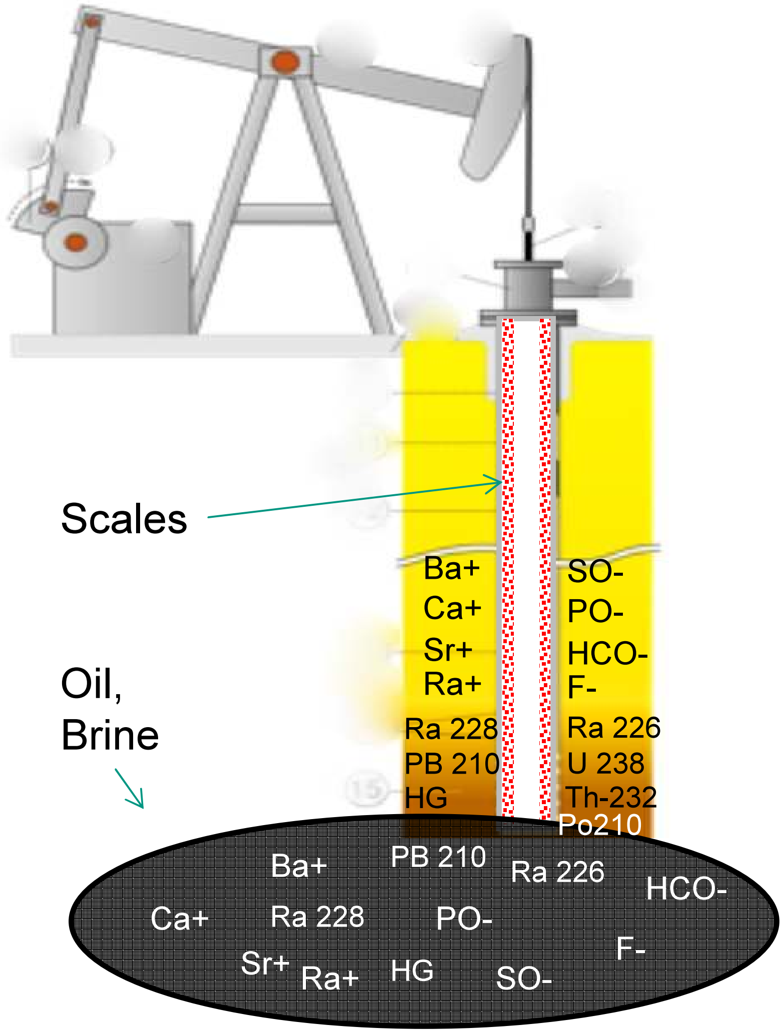
- NORM (Naturally Occurring Radioactive Material)
  - Uranium, Thorium, Potassium and its decay products
- Occurrence of Norm-Material
  - metallurgical industry
  - processing of phosphate
  - ore preparation
  - drinking water purification
  - petrochemical industries
- TENORM (Technologically Enhanced Naturally Occurring Radioactive Materials)
  - Material whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities.

Development of scales inside tubing

- Removal and transportation of radionuclides and ions
- Decrease of solubility of materials inside the liquid because of change in temperature, pressure and ph-value
- Precipitation of NORM and other materials and accumulation in tubings and other installations of a petrochemical facility

$$SO_4^{2-} + Ba^{2+} \longrightarrow BaSO_4 \downarrow$$

- Compounds of Barium, Calciumsulfat, Calciumcarbonat, Strontium, Radium



Classification and composition of contaminated deposits

- Classification of contaminated deposits from the exploration of oil and gas
  - Sludges
  - Scales (highest concentration of radioactivity)
  - produced water
- Composition of the Scales
  - Radioactive Materials (radium, lead, polonium)
  - Toxic Materials (mercury, heavy metals)
  - Consistency
    - Compounds of sulfate und carbonate
    - hard, brittle and dry
    - thickness: up to several millimeters

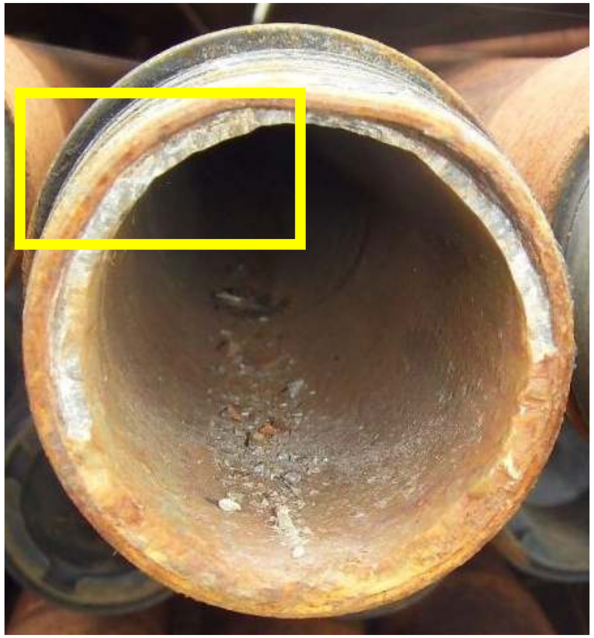
„Scales“ inside tubings used in exploration of naturals gas

Currently used decontamination technologies

- Abrasive-blasting
  - Wet (Jet Blasting)
  - Dry (Sand Blasting)
- Sandblasting of tubings
  - Decontamination of 7km of tubing are causing 30t - 50t of sludges.
  - Dry mass of scales of 7km of tubing are approx.: 15t
  - → Triplication of the contaminated materials through secondary waste

Sandblasting of tubings

Scales from exploration of natural gas



In-situ measuring of scales

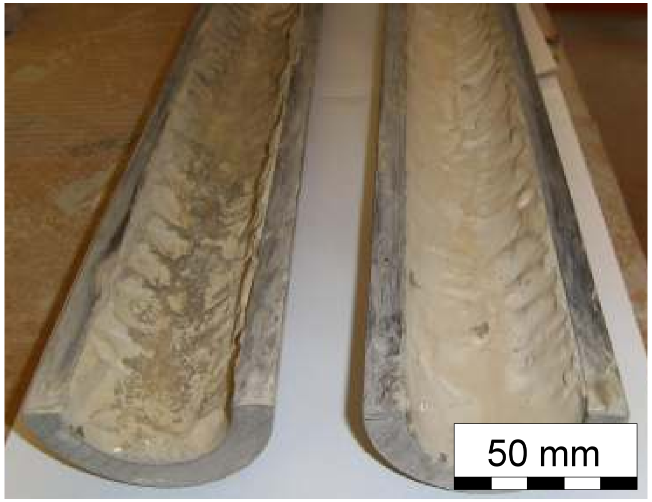
- Hardness according to mohs: 2-3
- Impact tests
- Determined thickness of scales, generally: 1-3 mm

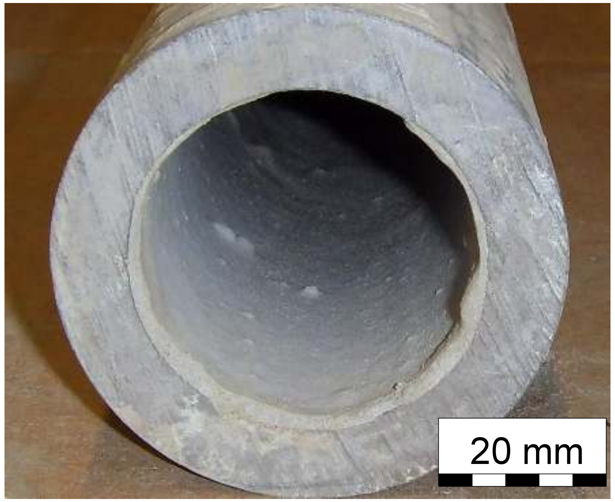
Simulation of scales

- The hazardous nature of the contaminated scales complicates the investigation
- Simulation of scales with similar but uncontaminated materials of the same consistency allows an easy handling
- Challenges:
  - Determine of the mechanical and physical properties and finding proper classification units
    - Hardness
    - Consistency (brittleness, bond strength)
    - Determination of thicknesses
  - Finding of similar material and simulation of different thicknesses inside the tubings

Simulation of scales

- Inorganic material
  - Plastic-modified cement
  - polyester-based two-component filler
  - Cements with different Hardness
- Classification of the scales
  - Measuring of hardness, elasticity and plasticity and bond strength

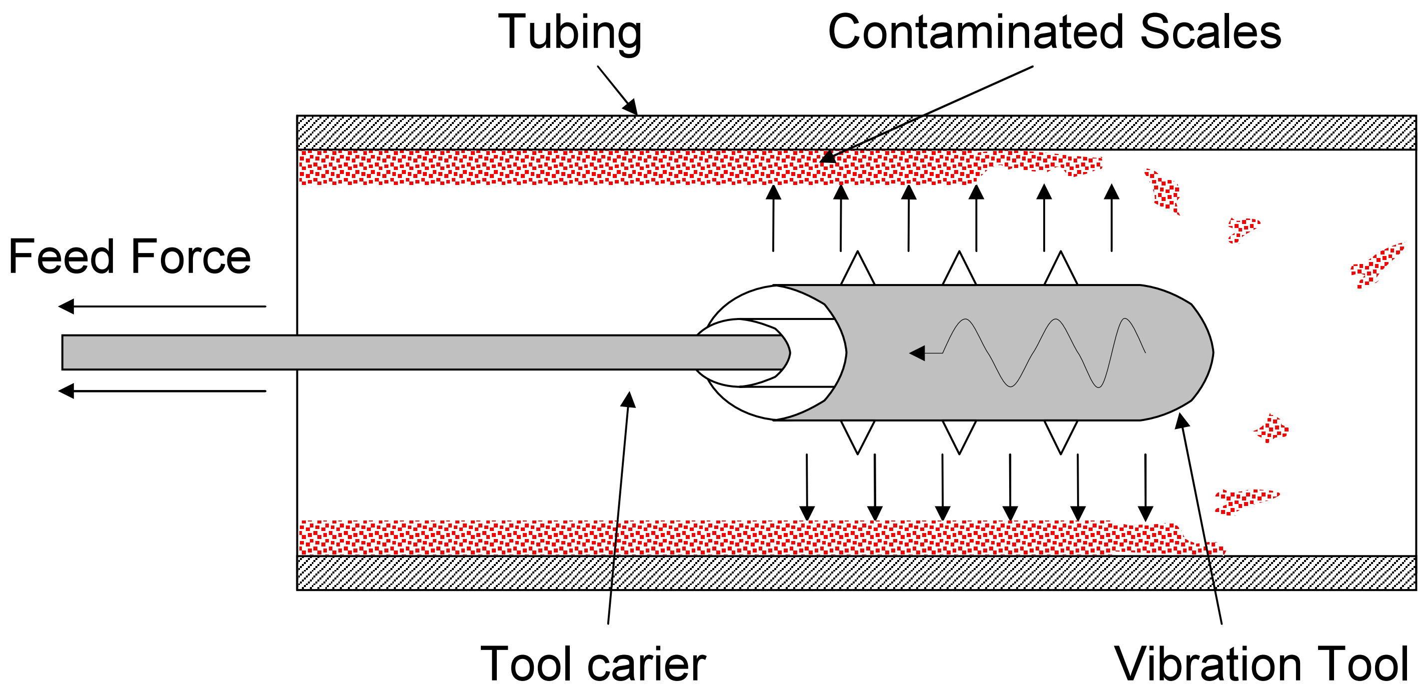




Simulation of scales

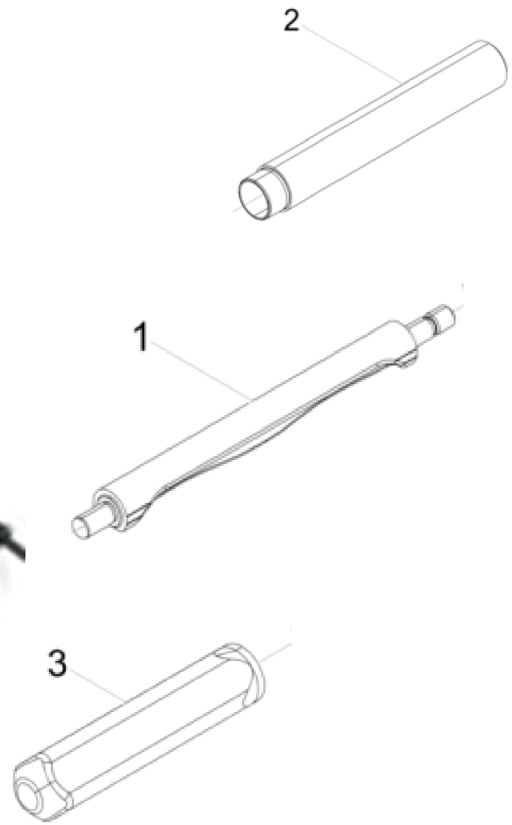
- Application of materials in tubes consiting of two exact halves
- Rotation of the tubes with scales
- Dry season

Decontamination using vibration



Tool carrier

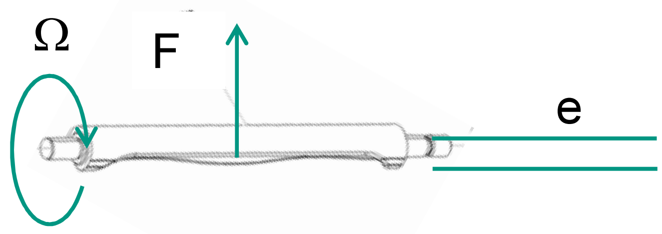
- Unbalanced mass (1) supported inside a tube (2, 3)
- Connected via a flexible shaft to an electric motor
- Freely adjustable rotation speed up to 16500 rev/min
- Vibration and rotation of the tool carrier



Source: wackerneuson.com

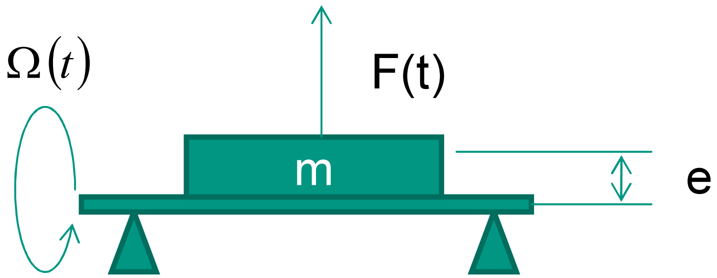
Influencing variables for force and acceleration

- Acceleration $a = e \cdot \Omega^2$
- Force $F = m \cdot a$
- Rotation: $\cos\,(\Omega \cdot t)$



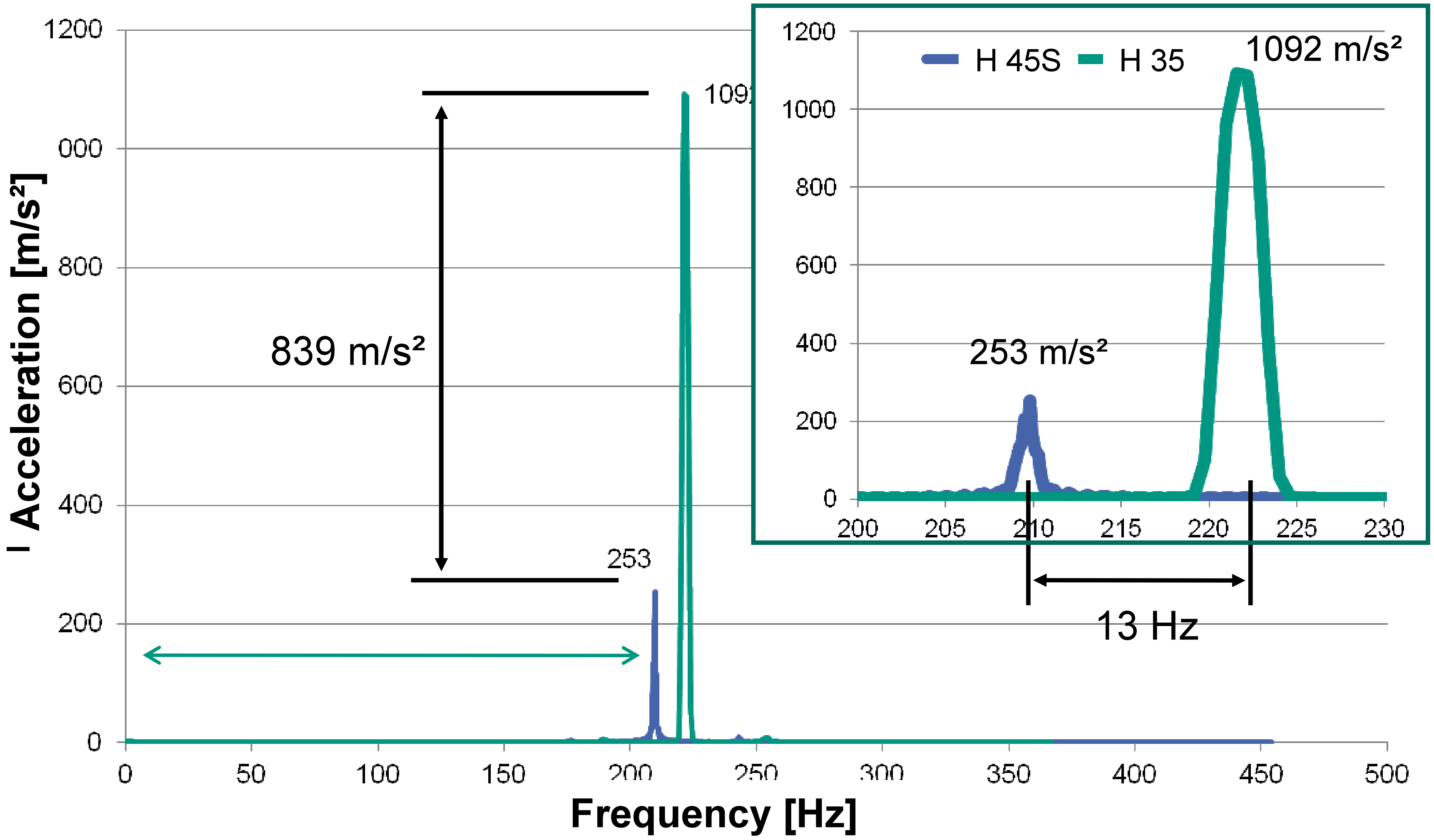
- Force:

$$F(t) = m \cdot e \cdot \Omega^2 \cdot \cos(\Omega \cdot t)$$

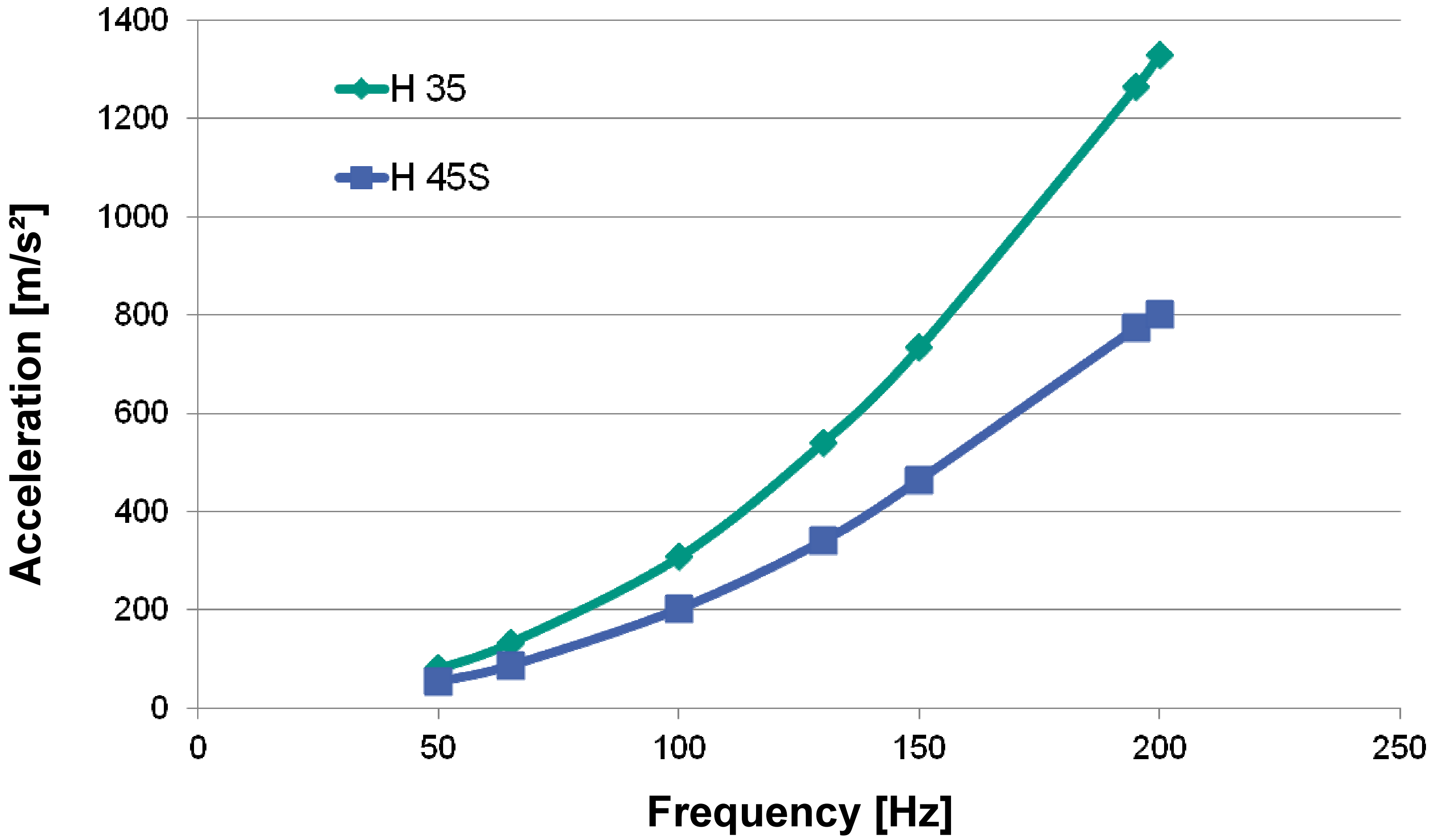


- Increase of the occurring force through:
  - Increase of the rotational speed→ quadratic influence
  - Increase of mass is not always the point, given space conditions can result to a lower eccentricity and therefore a lower force

Different frequencies at the same energy level

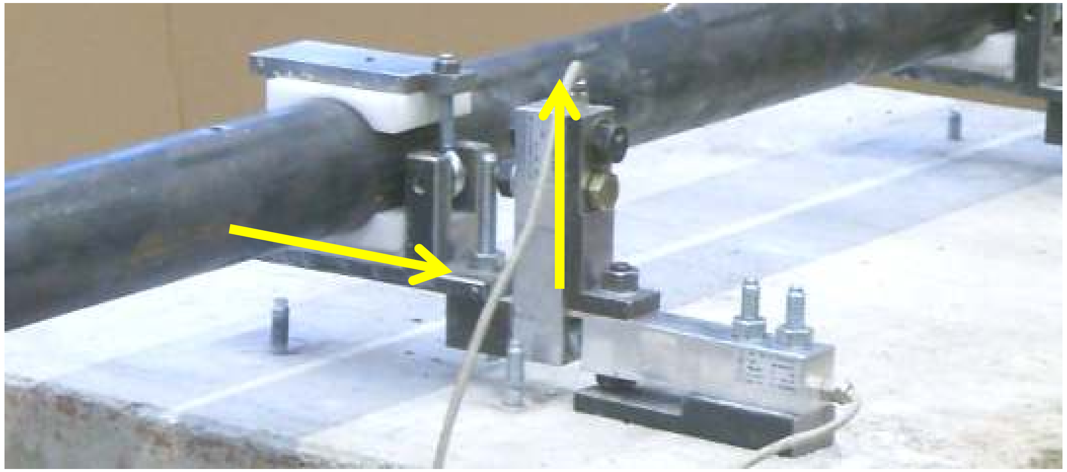


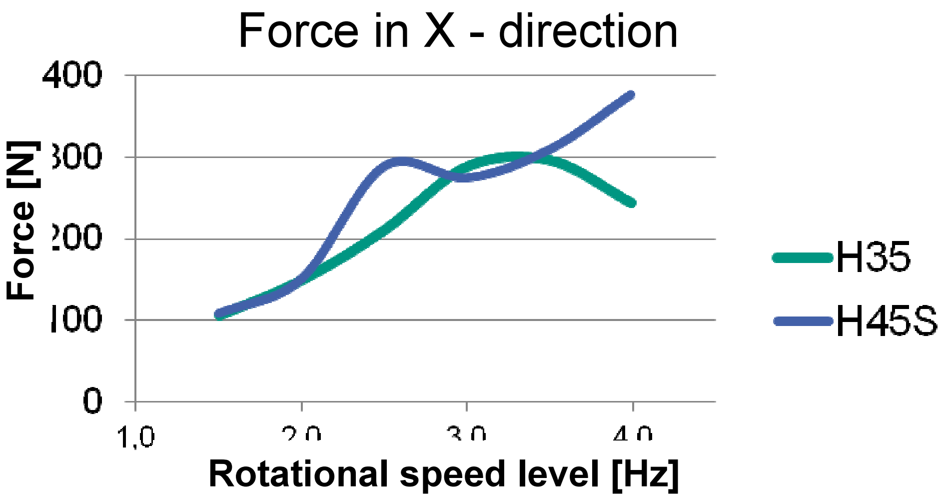
Relationship between frequency and acceleration

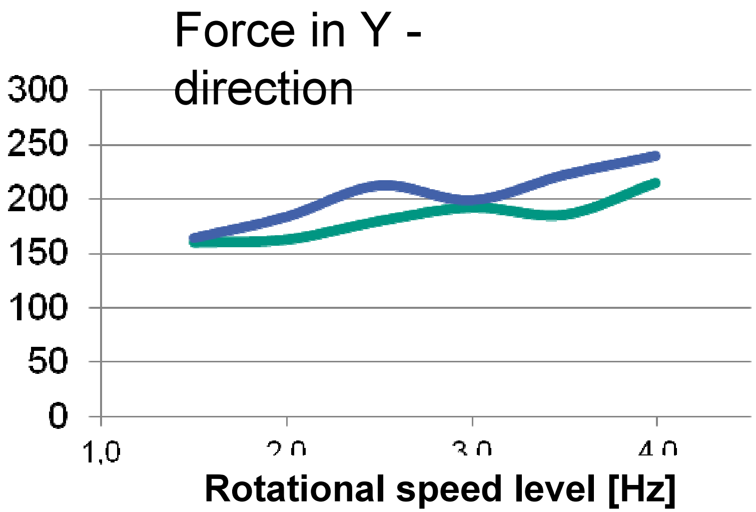


Force measurement on the tube

- shear force sensors
- Force measuring in two different directions

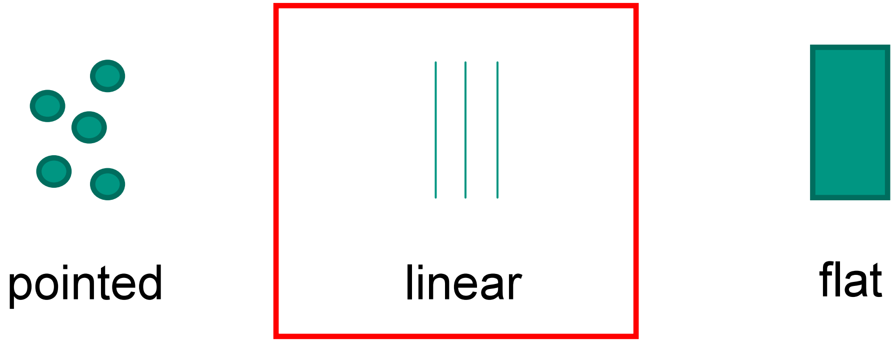




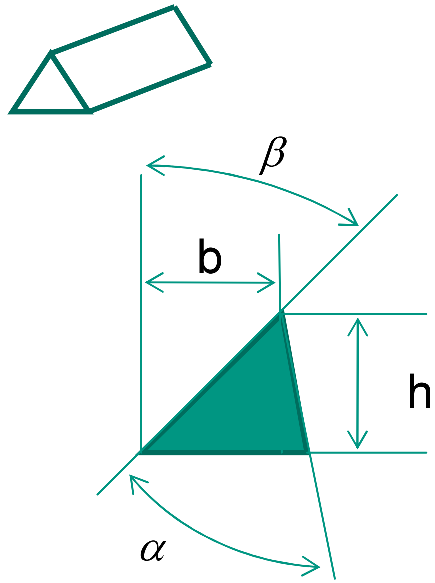


Tool geometry

- Possible forms of contact between tools and scales:

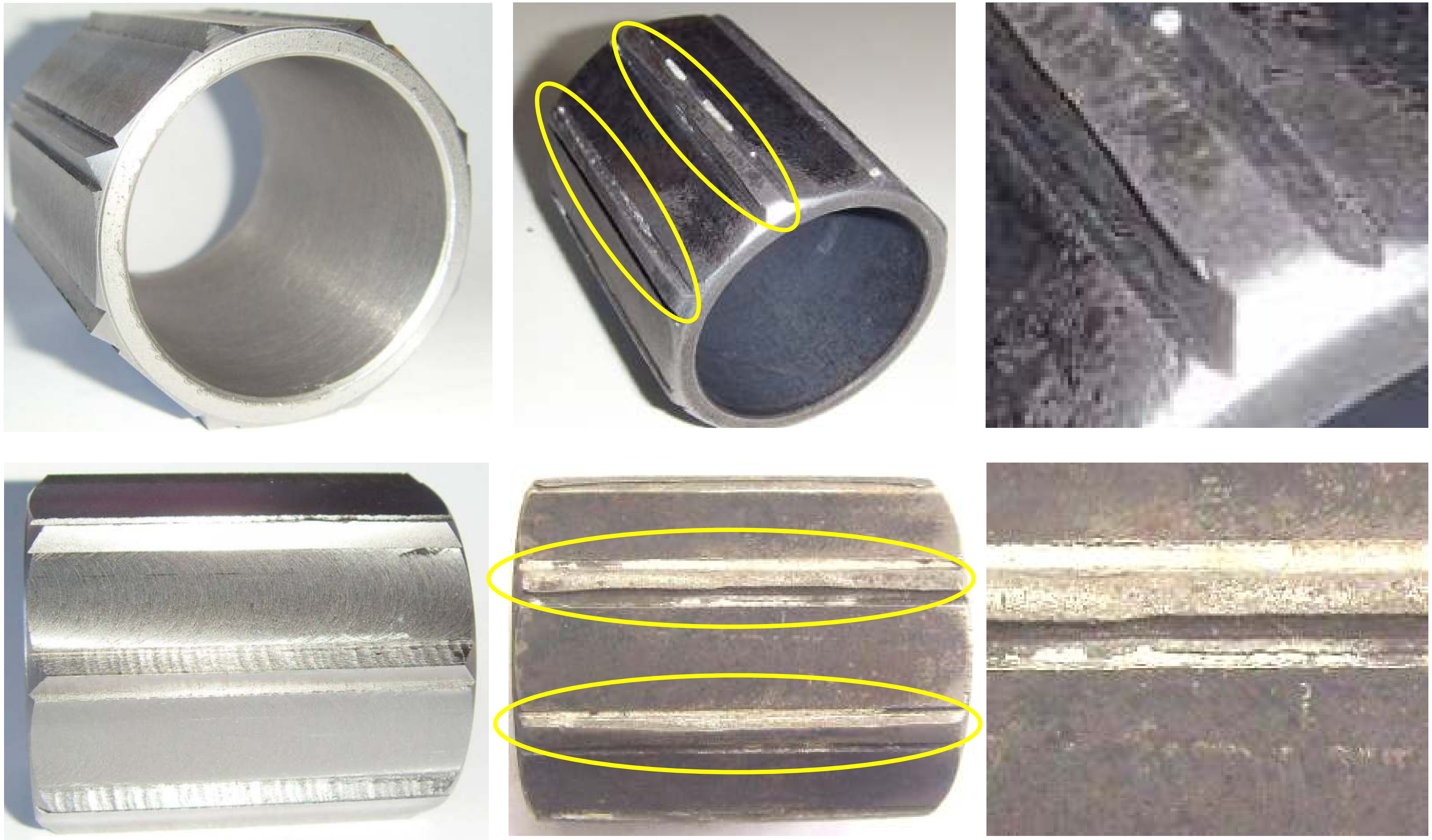


- Factors of influence of a tool with edged geometry
  - Edge angles α
  - Flank angle β
  - Direction of arrangement of the edges (longitudinal, radial, oblique)
  - Length, height and diameter of the tool
  - Number of edges

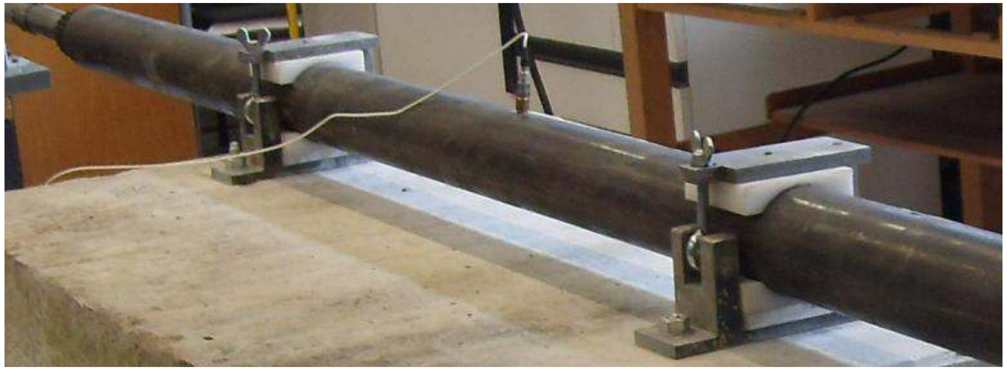


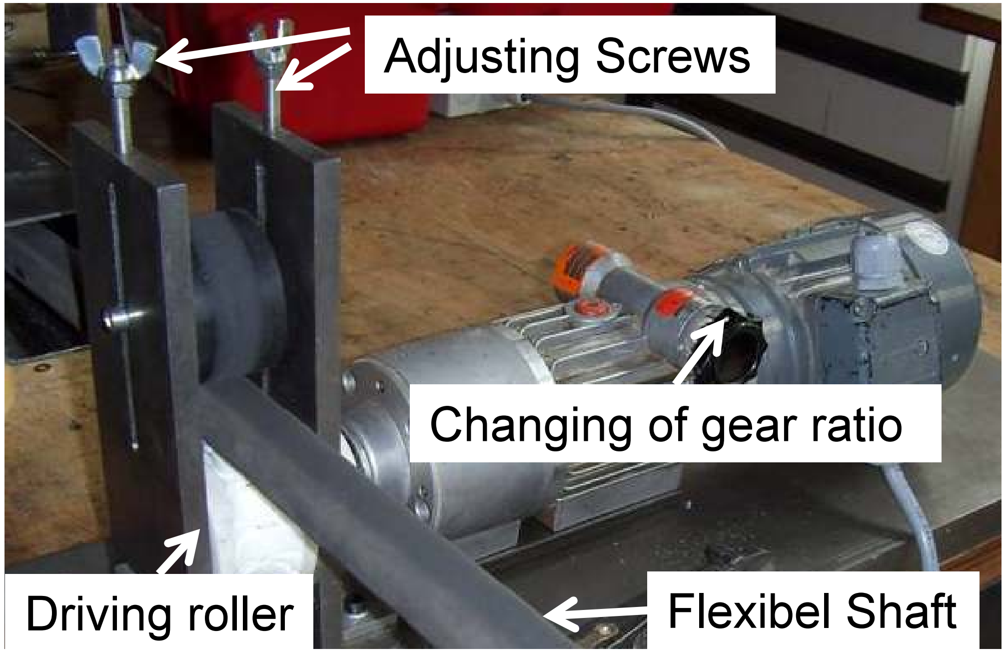
Decontamination tools

Wear signs on the tool after decontamination application and improvement options

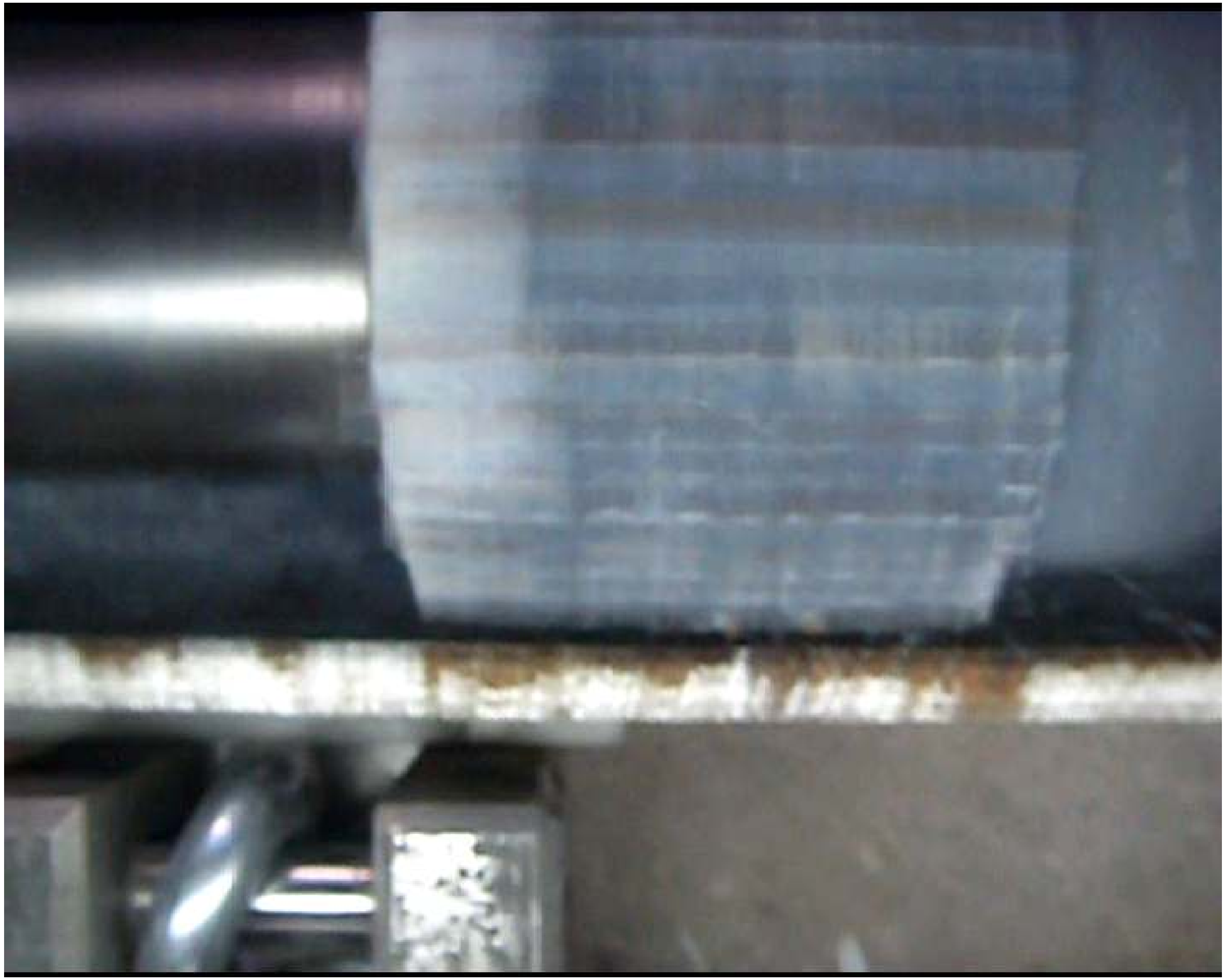


Feeding device and Jig

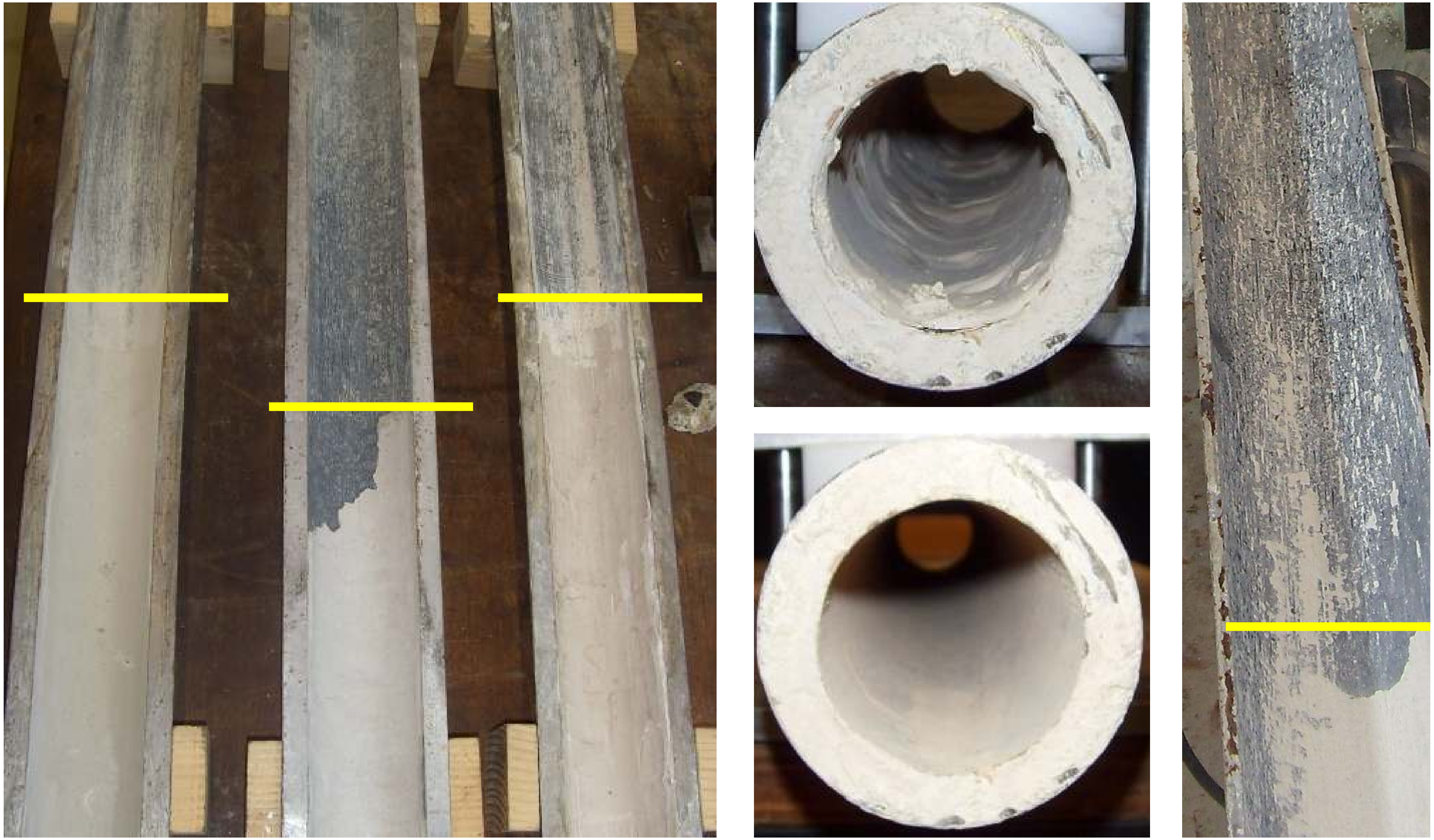




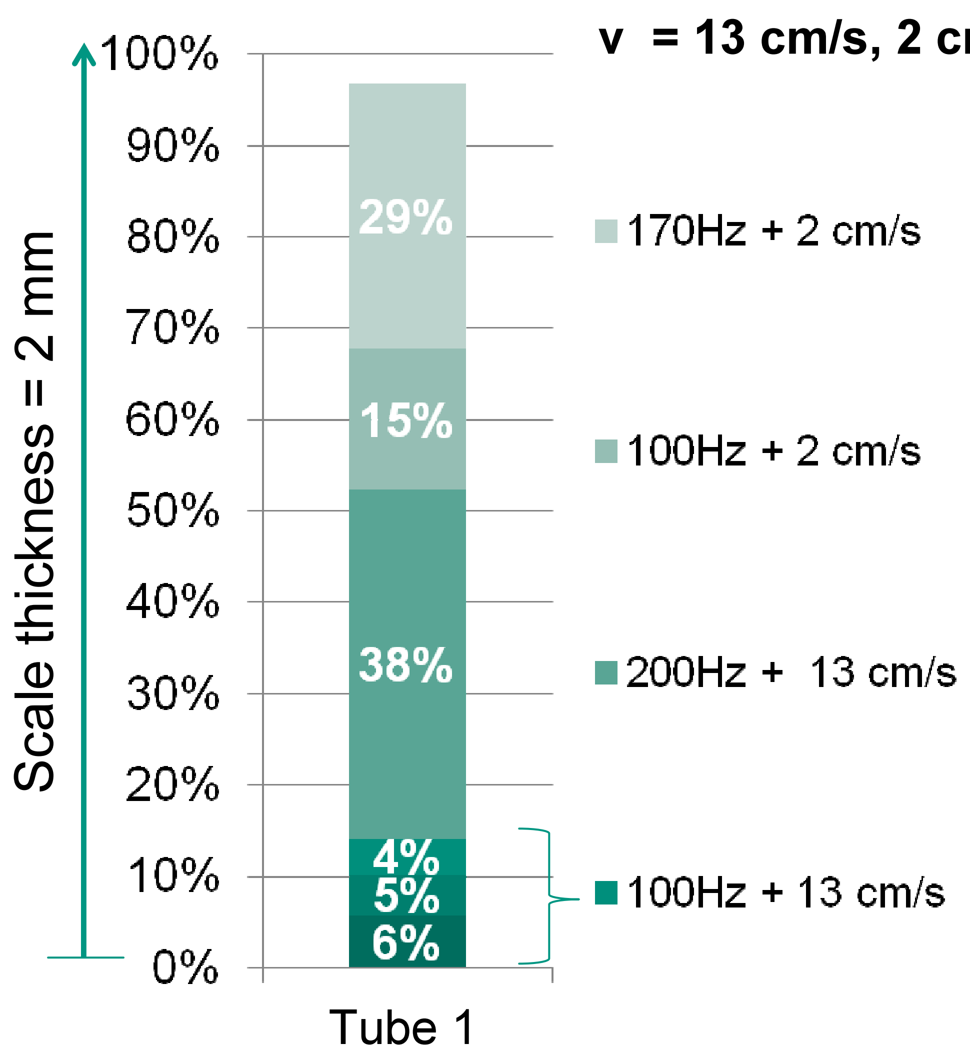
Removal of Scales – ablation process



Before and after

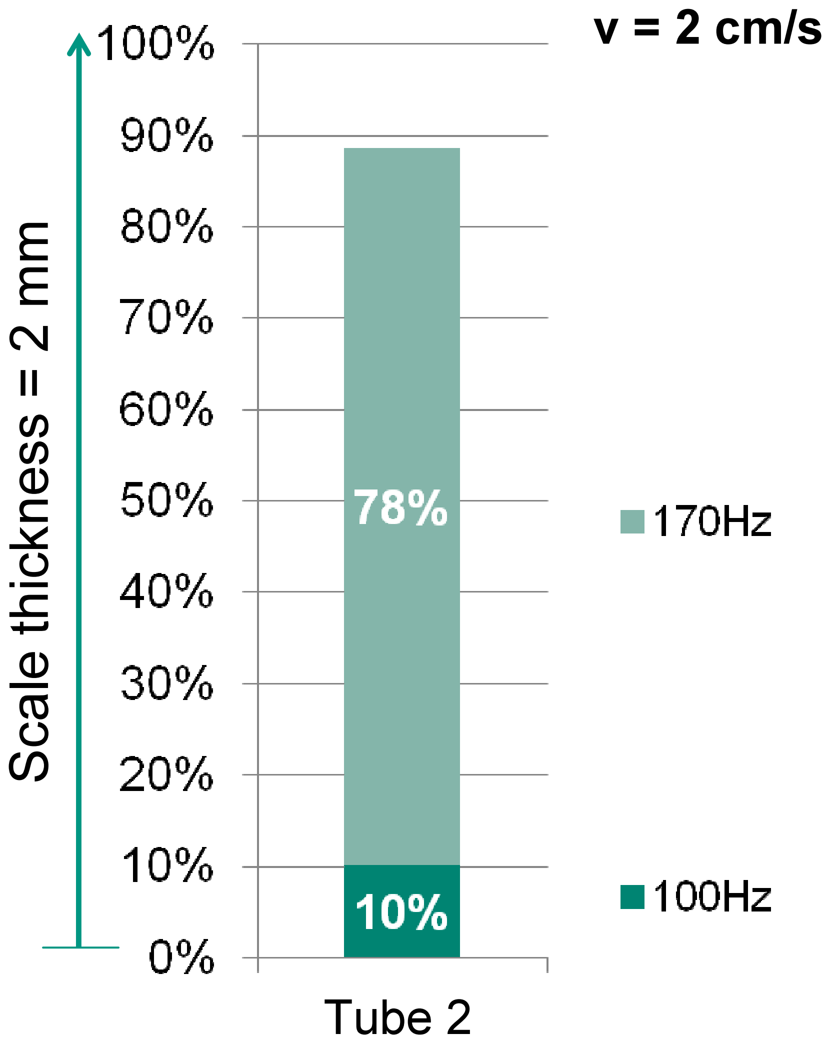


Preliminary investigations to determine the tendency of the influencing factors



- Influence of the frequency at feed rate of v = 13 cm/s
  - Factor 8
- Influence of the frequency at feed rate v = 2 cm/s
  - Factor 2
- 6 experiments in total needed to remove 97 % of the scales

Preliminary investigations to determine the tendency of the influencing factors



- Influence of the frequency at the feed rate of v = 2 cm/s
  - Factor: 8
- Only two experiments in total needed to remove up to 89% of the scales

Main Investigations

Karlsruhe Institute of Technology

- Determination of the influences of the variables
  - Frequency
  - Feed rate/ feeding force
  - Scale thickness
  - Scale hardness
  - Tool geometry
  - Tool carrier
  - Tubing diameter

Main target:

- Removal performance
- Decontamination speed
- Complexity / Efficiency
- Wear

- Development of a model to combine all the different influences between the parameters.

Conclusions

- Environment-friendly decontamination without secondary waste
- Prevention of an accumulation of contaminated dust
- Saving of valuable resources
- Automated decontamination process

- Challenges:
  - Determining the effects of the parameters
  - Increase efficiency of the decontamination process

Thank you for your attention!