

# Testing of Niobium Sheets for Forming Processes

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ENGINEERING  
DEPARTMENT



# Niobium Sheets under Forming Processes

Tensile Tests

Anisotropy  
Strain Rate  
Cyclic Plasticity

Anisotropy

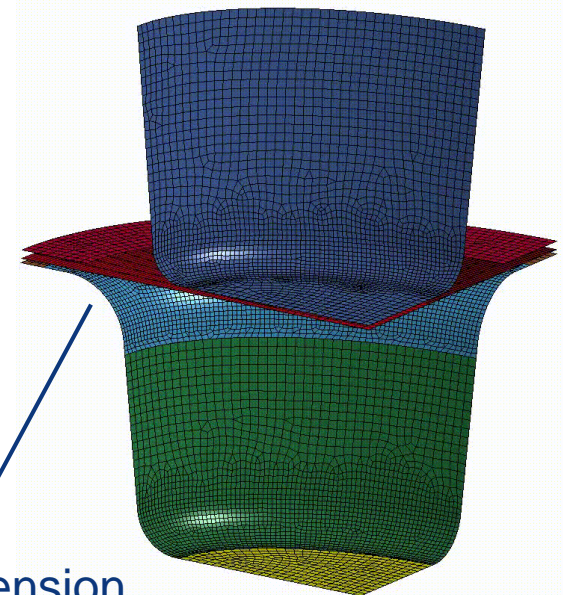
Preferred orientation typically affects sheet metal forming processes.

Strain Rate



Niobium has Body Centred Cubic (BCC) structure:  
Strain Rate Sensitivity (SRS) in the Yield stress.

Cyclic plasticity



Compression + Tension

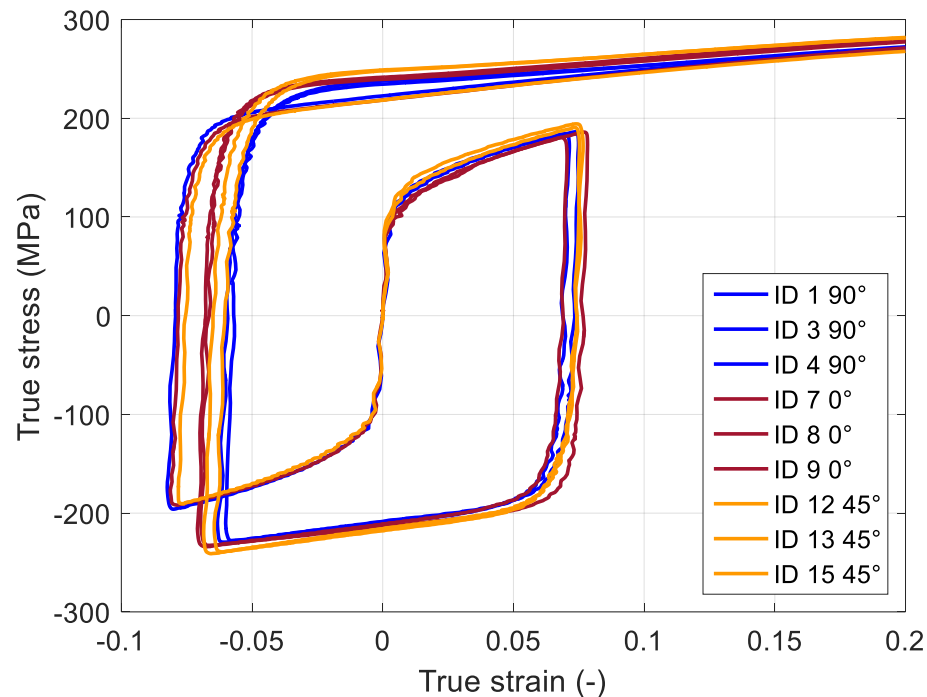
Testing campaign @  
Politecnico di Torino



# Niobium Sheets under Forming Processes

## Cyclic Plasticity

- Tension – compression – tension;
- Compression – tension;



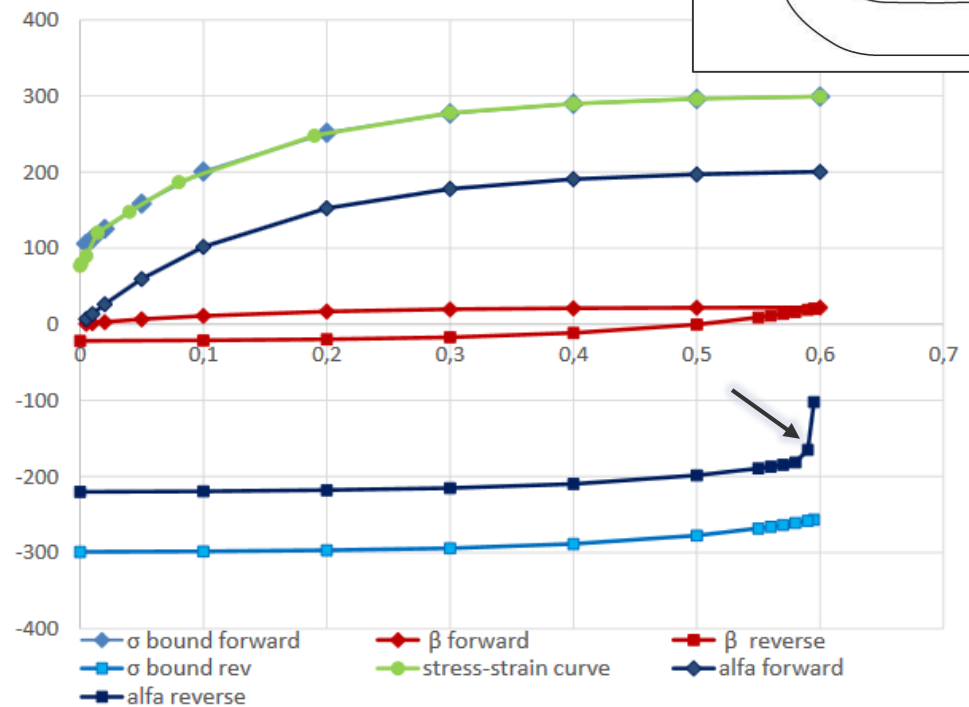
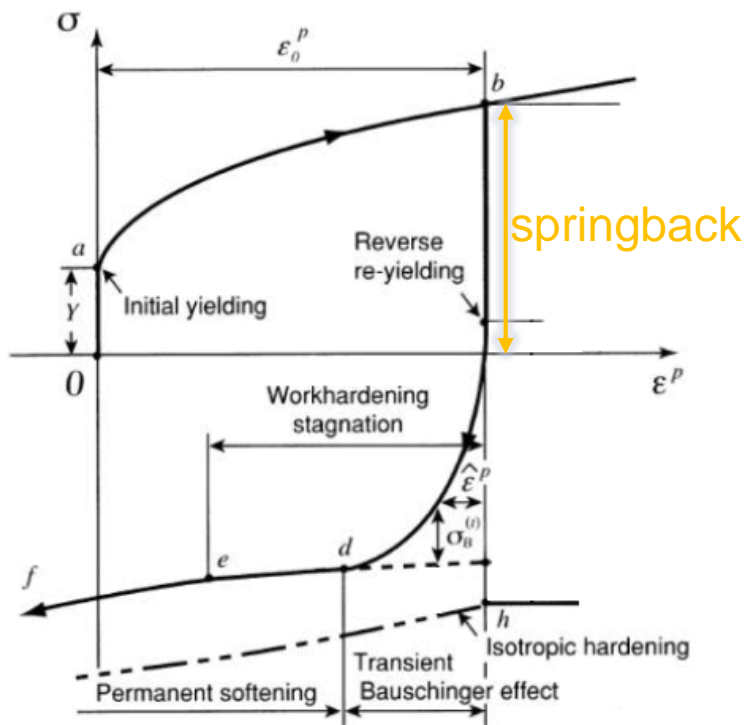
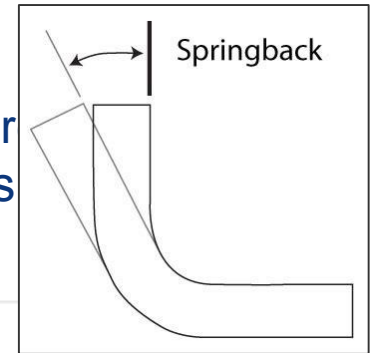
*Courtesy of Politecnico di Torino*

# Niobium Sheets under Forming Processes

## Cyclic Plasticity: non-linear Springback is not relevant

Strain rate: Strain Rate is present but workshop processes are bar

Anisotropy: First indications show it's not present, further testing is



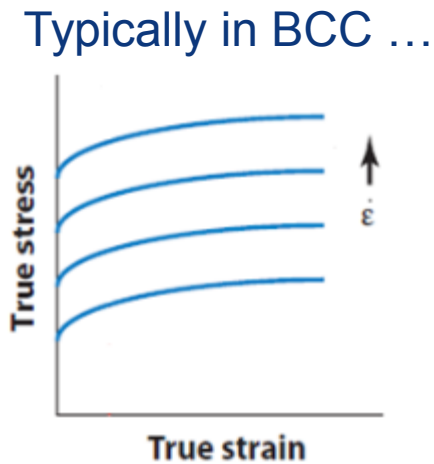
✓ Cyclic Plasticity specific material model based in Yoshida - Uemori

# Niobium Sheets under Forming Processes

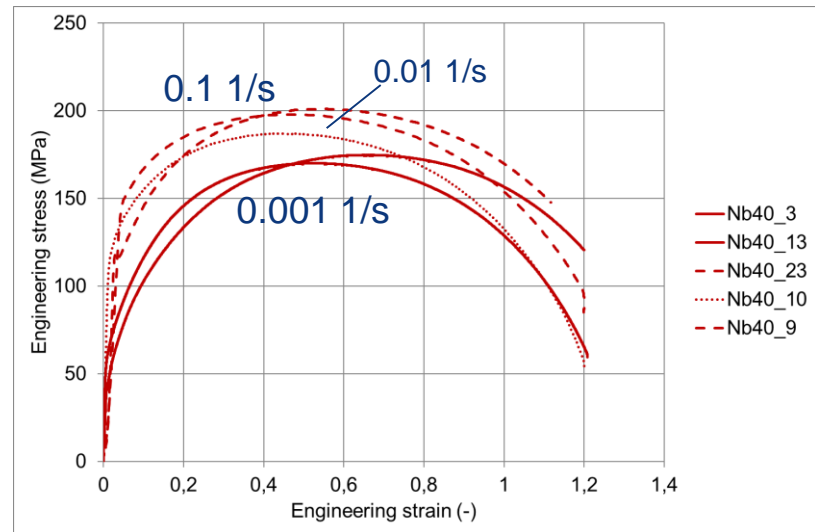
Cyclic Plasticity: non-linear Springback is not relevant

**Strain rate: Strain Rate is present but workshop processes are barely affected**

Anisotropy: First indications show it's not present, further testing is required



In niobium sheets



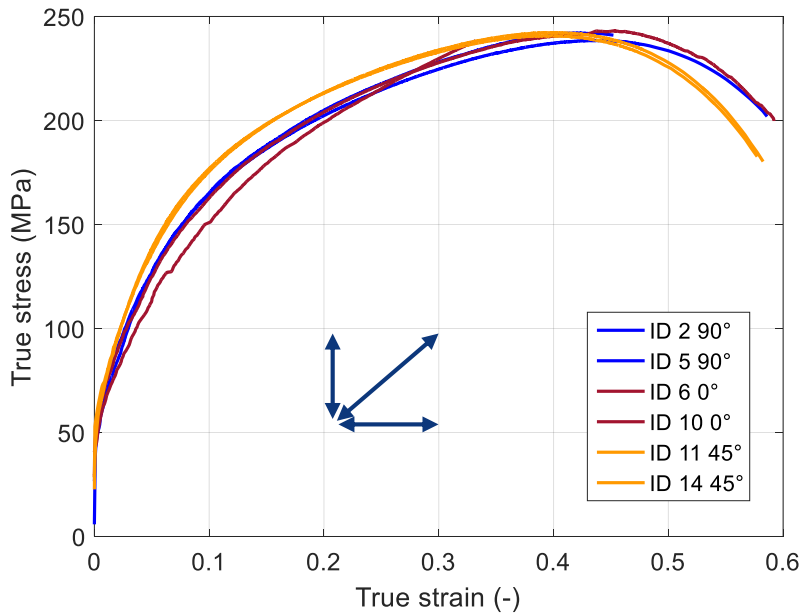
✓ Strain rate specific Cowper – Symonds material model in LS-DYNA

# Niobium Sheets under Forming Processes

Cyclic Plasticity: non-linear Springback is not relevant

Strain rate: Strain Rate is present but workshop processes are barely affected

**Anisotropy: First indications show it's not present, further testing is required**



Deep drawing processes done in the workshop tend to confirm that niobium sheets are isotropic.



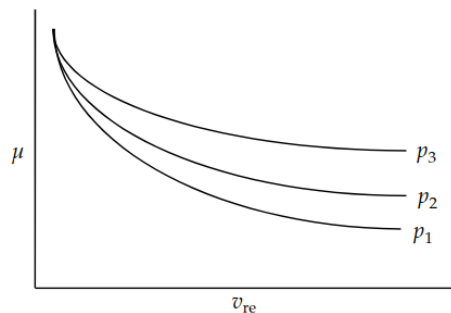
Testing campaign not successful  
New tests being prepared



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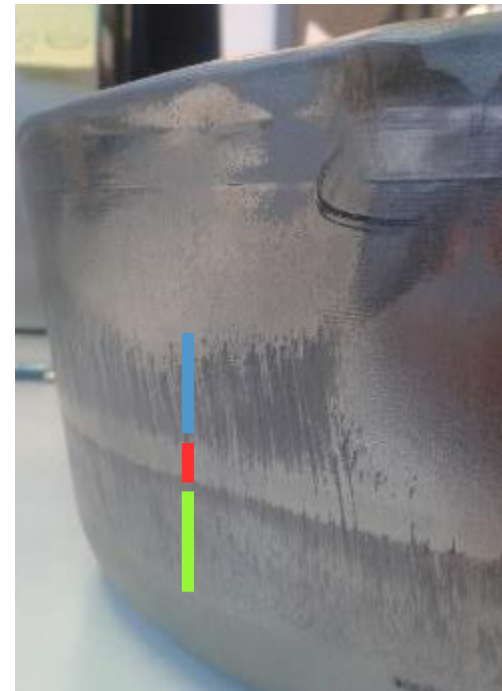
# Ongoing activities

- ✓ Friction coefficient mapping according to tool speeds and surface pressure



**Figure 11-1.** Friction coefficient,  $\mu$ , can be a function of relative velocity and pressure. See Remarks for FS = 2.0.

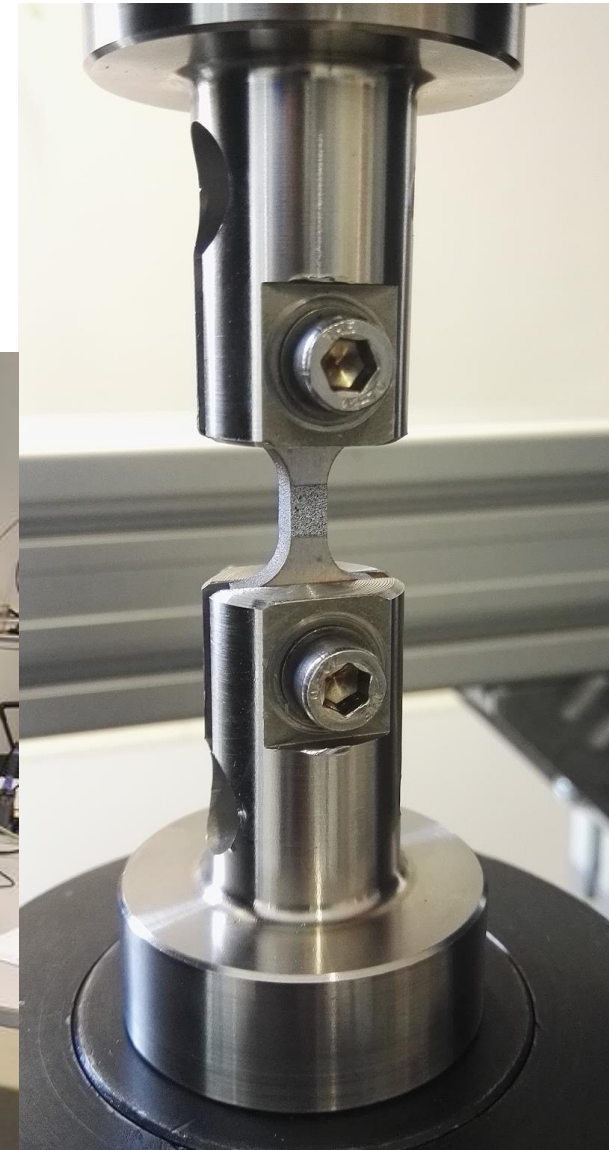
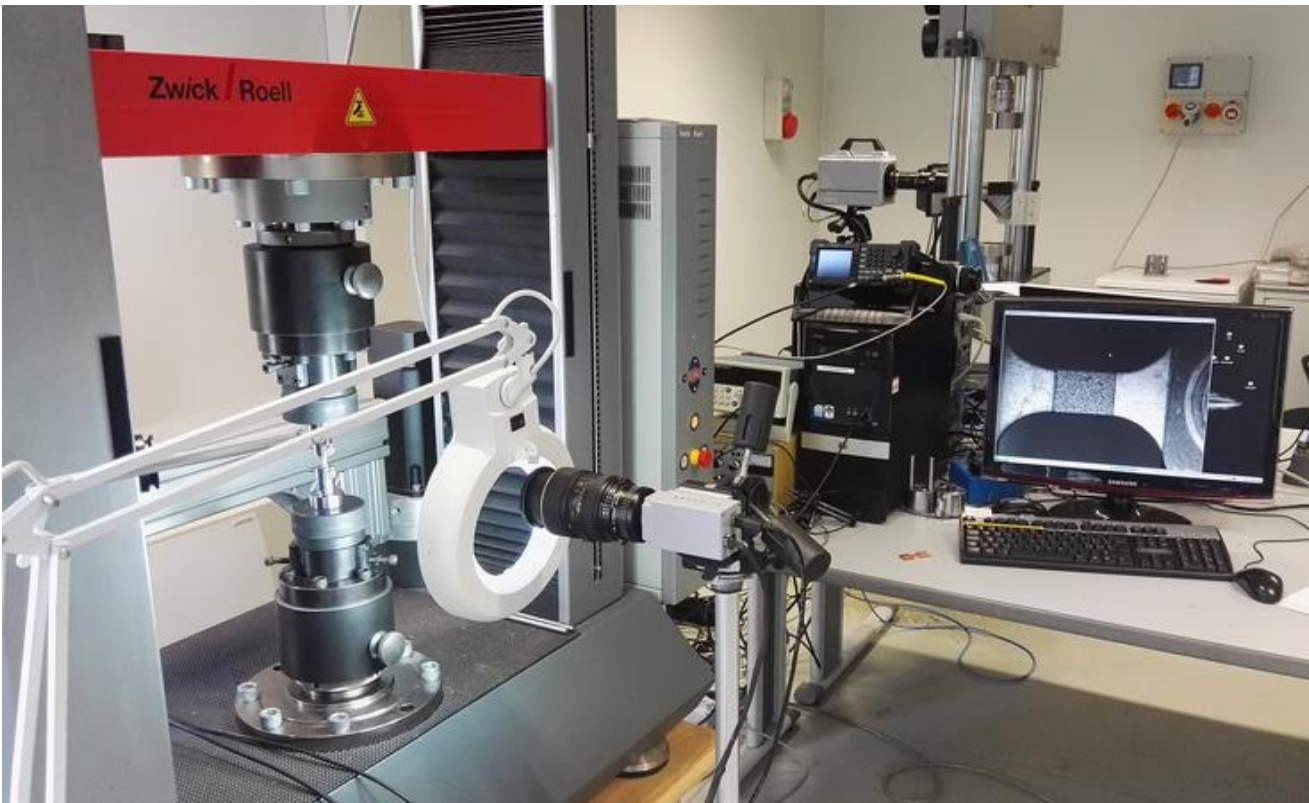
Which pressure is needed for scratches to appear?





# Experimental setup

- ✓ Electromechanical testing machine (100 kN load, 300 mm/min speed)
- ✓ Ad-hoc design of the gripping system
- ✓ Displacement controlled test

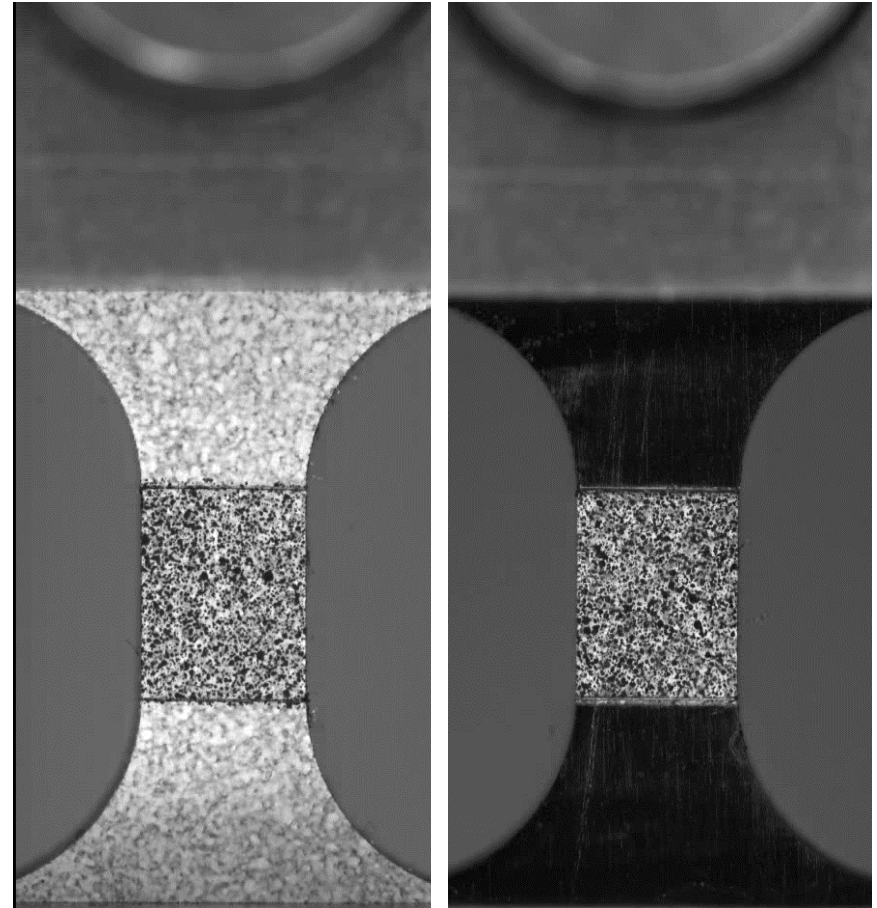


# Strain evaluation with digital image analysis



Monotonic

Cyclic



- ✓ High resolution camera (5 Mpix resolution) in low speed tests 0.001 1/s
- ✓ High speed camera (1 Mpix resolution) in “high” speed test 0.1 1/s