



Tribology in Cold Rolling

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Tribology in cold rolling: Friction, Wear and Lubrication in 3 PhD-projects

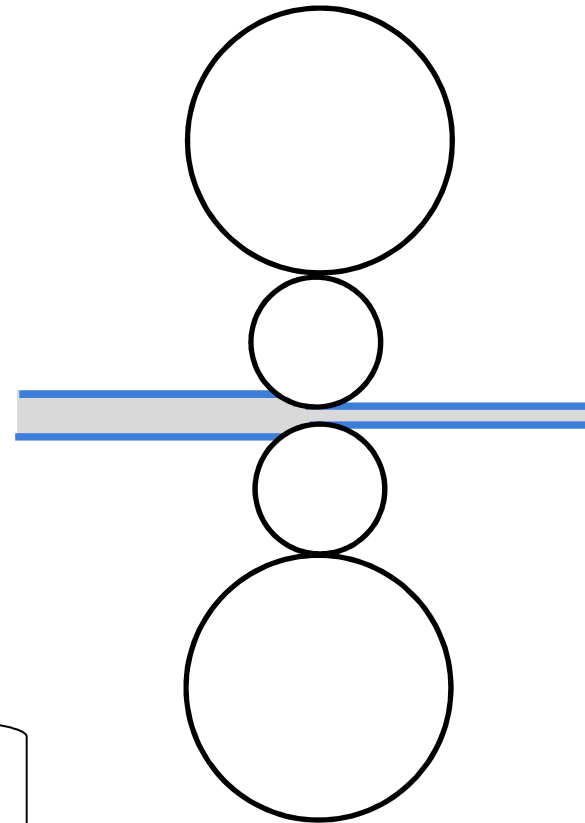
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Tribology in cold rolling: New Developments

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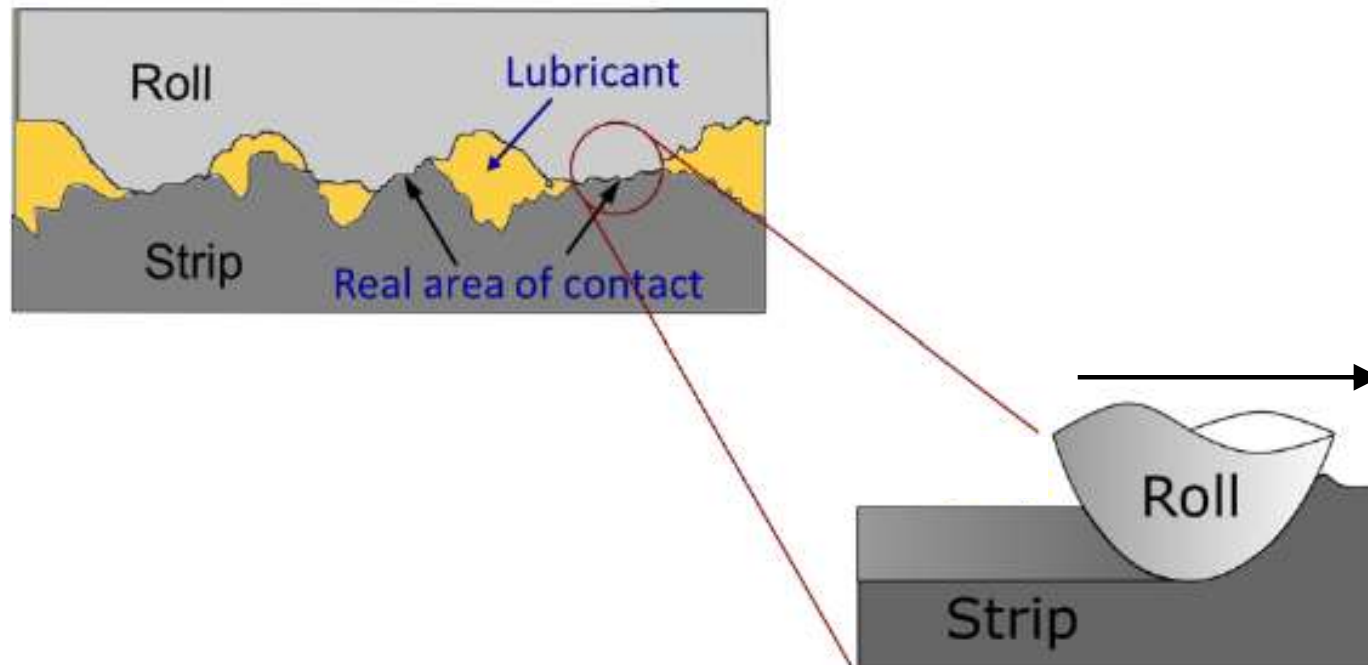
Intro: Cold Rolling Macro-Scale

- Work Roll Speed ~ 20 m/s
- Entry Strip Speed ~ 14 m/s
- Exit Strip Speed ~ 20 m/s
- Pressure ~ 1 GPa
- Lubricated with O/W-emulsion
- Temperature Range ~ 50 - 200 °C
- Plastic deformation of substrate



Interesting Tribological
Contact !!

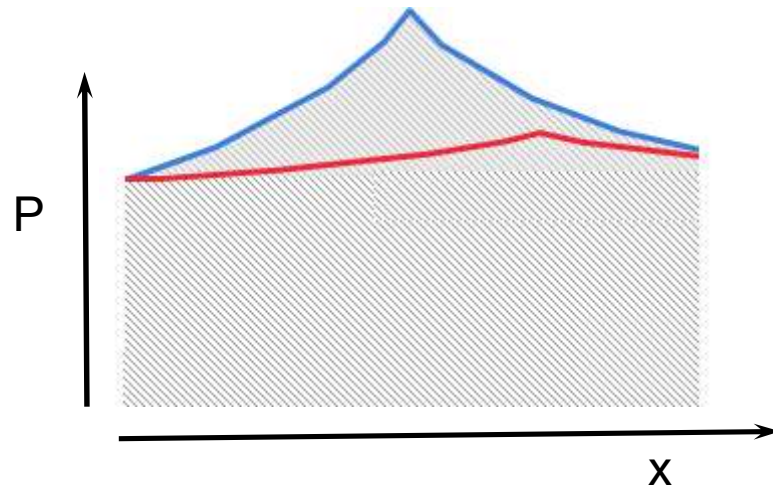
Intro: Cold Rolling Micro-Scale



- Roll/Strip R_a -value ~ 1 micron
- Mixed Lubrication Regime
- Lubricant Film Thickness ~ 1 micron
- Shear rates in lubricant film $\sim 10^7 \text{ s}^{-1}$

Relevance of Friction in Cold Rolling

- Friction is of key importance in cold rolling



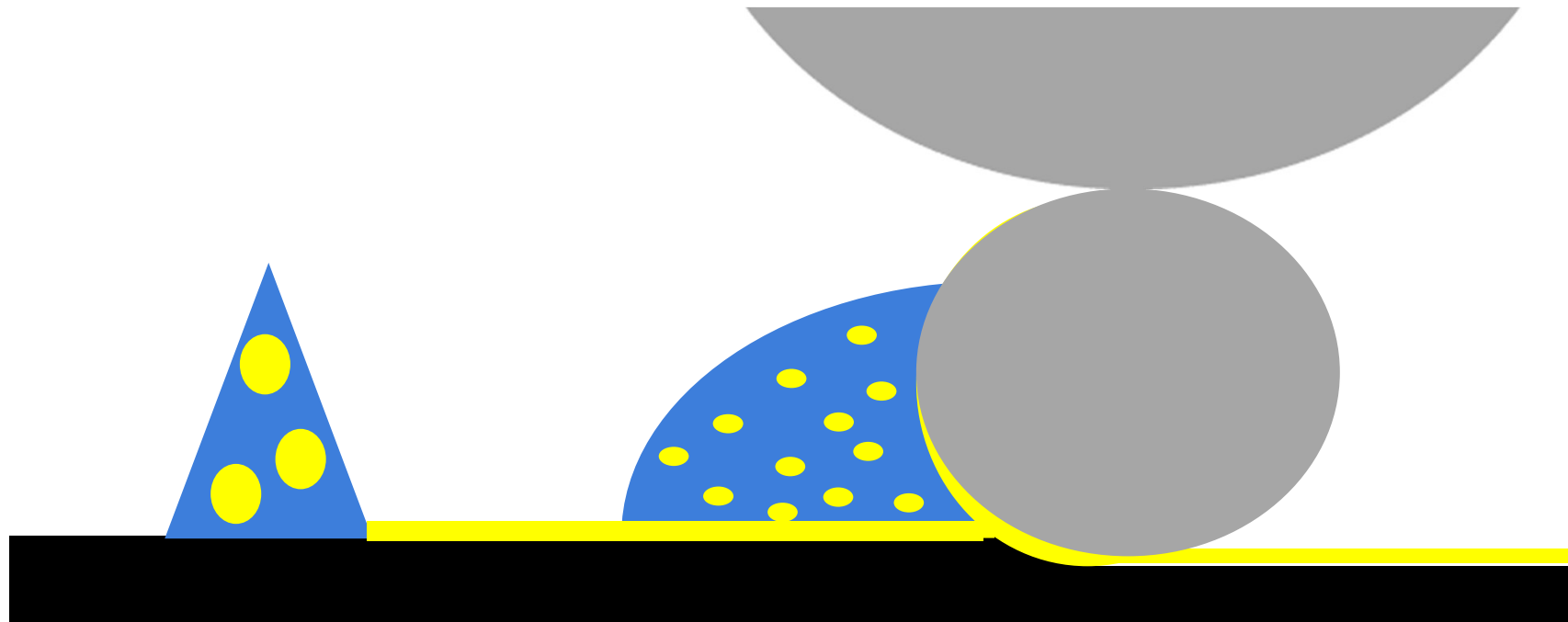
High Friction → Rolling force is high

Low Friction → Rolling force is low

Influence friction on process:

- Friction too low → skidding (work roll slips over material)
- Friction too high → too high rolling force, only small thickness reduction per stand
- Friction not uniform over width → unflatness problems
- Friction not uniform over length → non-uniform thickness

Relevance of Lubrication in Cold Rolling



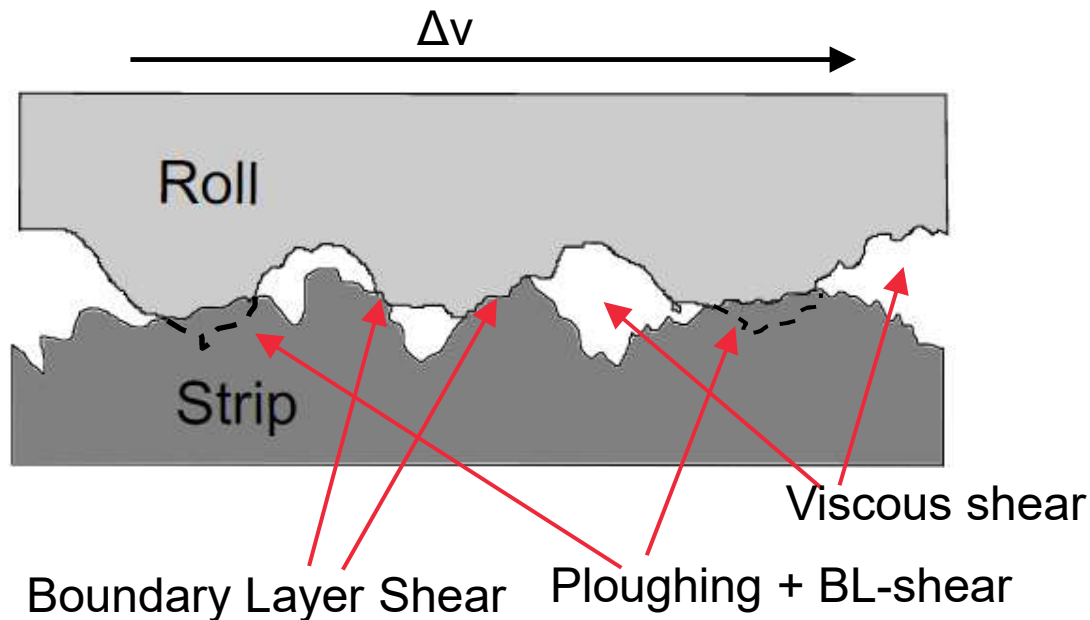
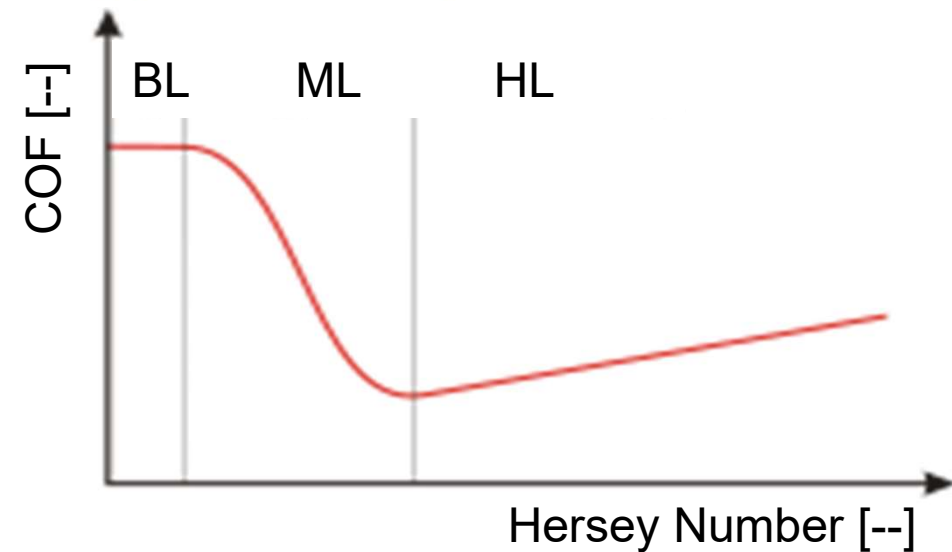
Lubrication Mechanisms:

- Formation of boundary layers
- Hydrodynamic effect

Current Projects 1: Friction in Cold Rolling (Leon Jacobs)

Classical Rolling Models:

$$\tau = \mu \cdot p$$

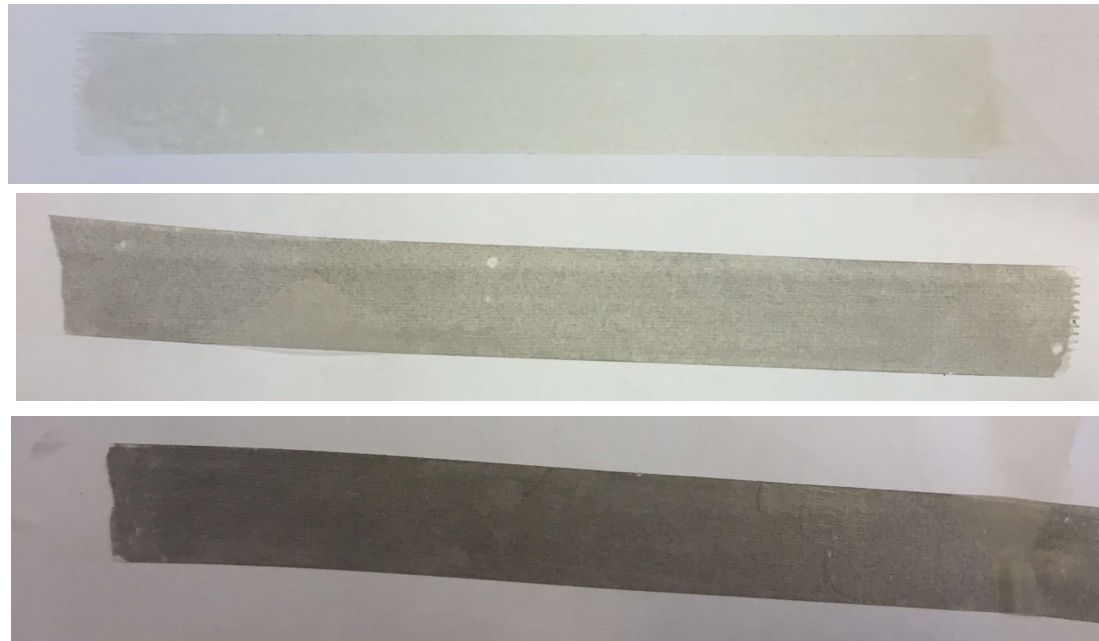


Mixed Lubrication Model:

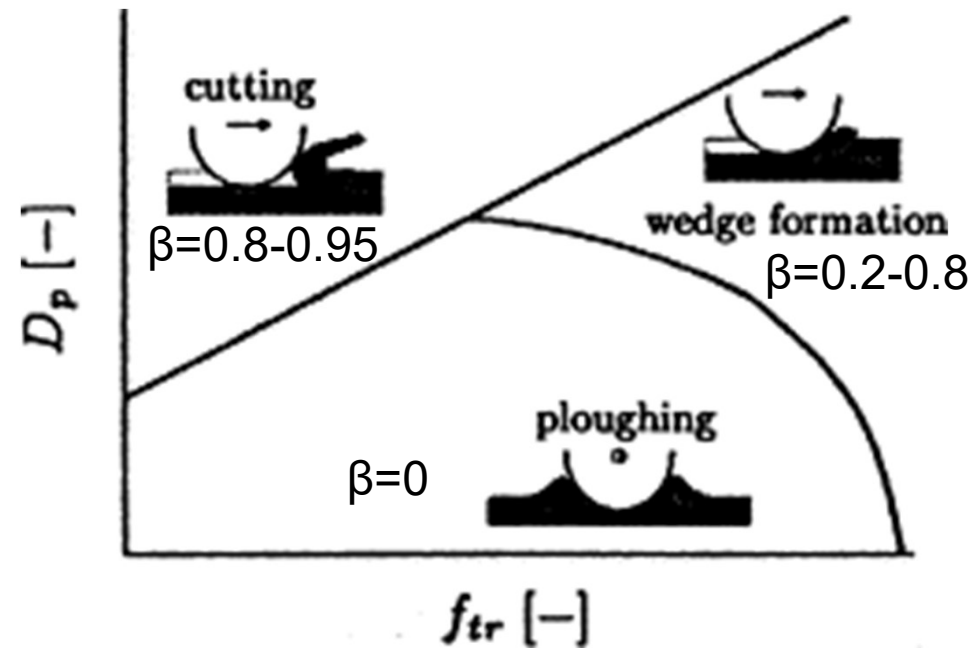
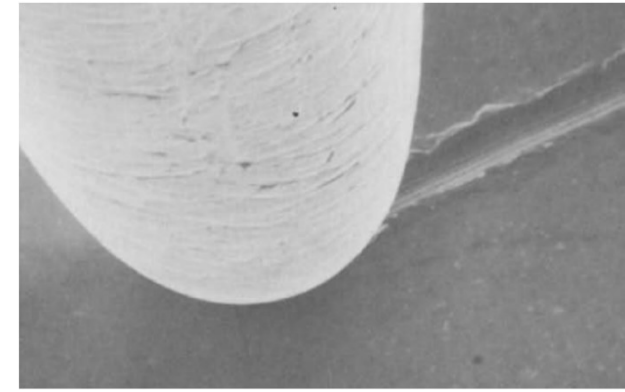
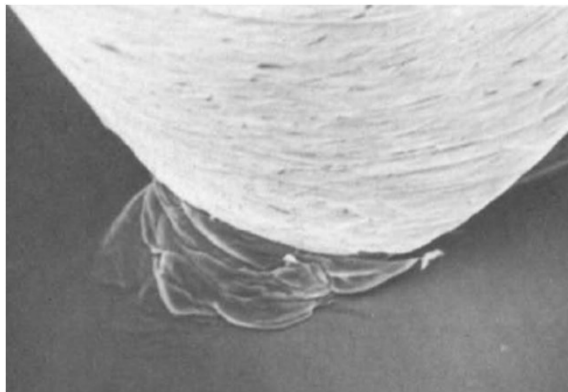
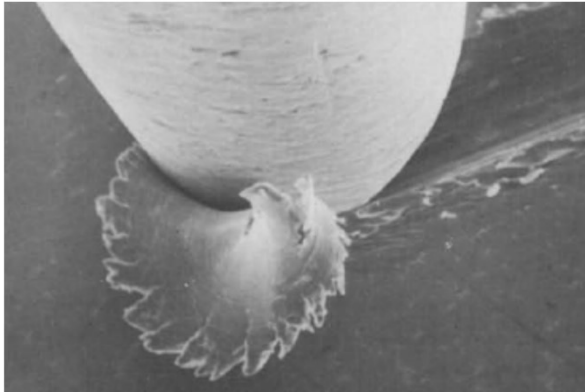
- 1) True contact ratio
- 2) Viscous shear stress
- 3) Shear stress in contact zones

Relevance of Wear in cold rolling

- Impact:
 - Impairs strip surface quality
 - Process issues in subsequent production steps (inspection, coating adhesion, cleaning lines etc).
 - Cr-plating abandoned by REACH-regulations
- Commonly measured with scotch tapes:



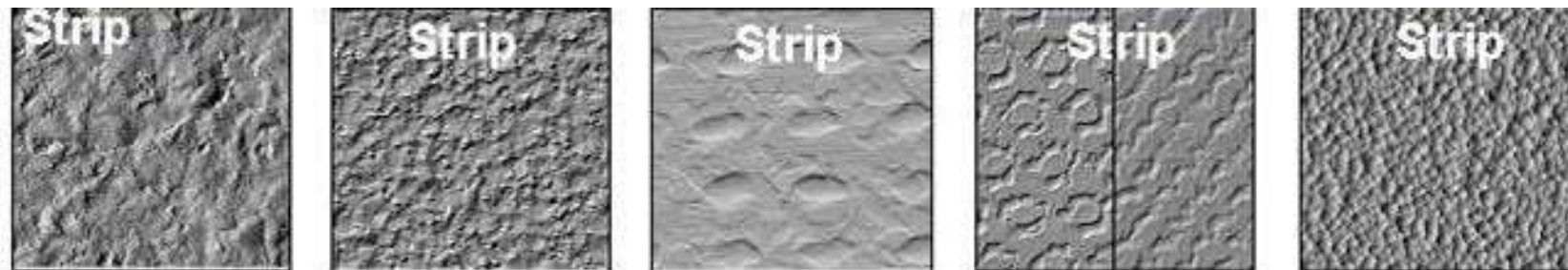
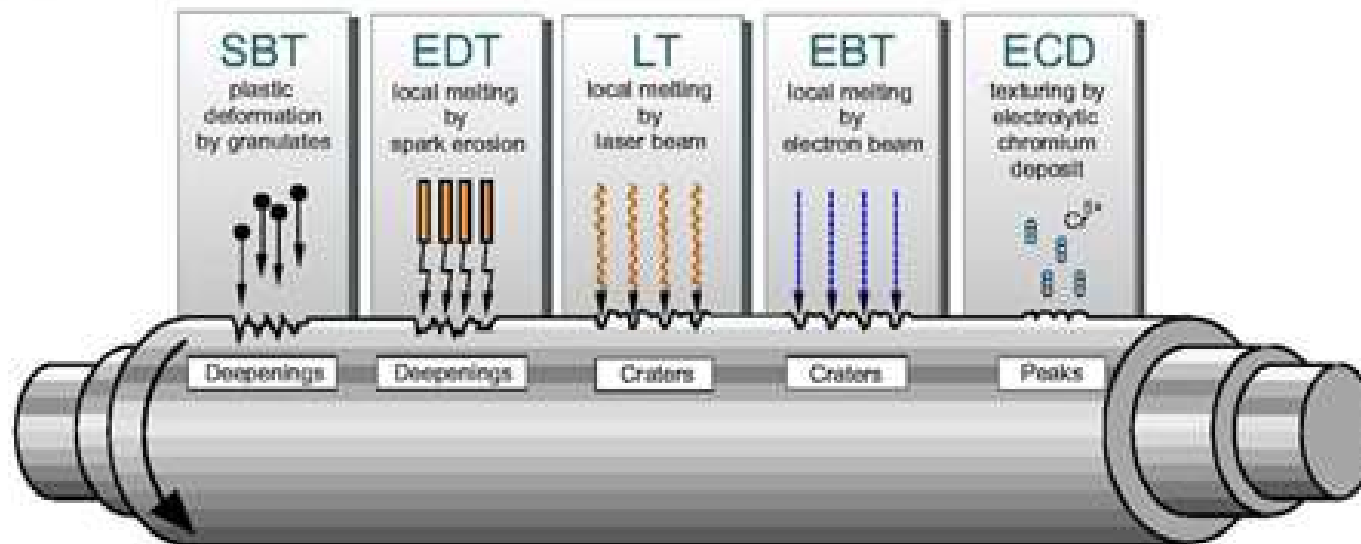
Current Projects 2: Wear in Cold Rolling (Melkamu Mekicha)



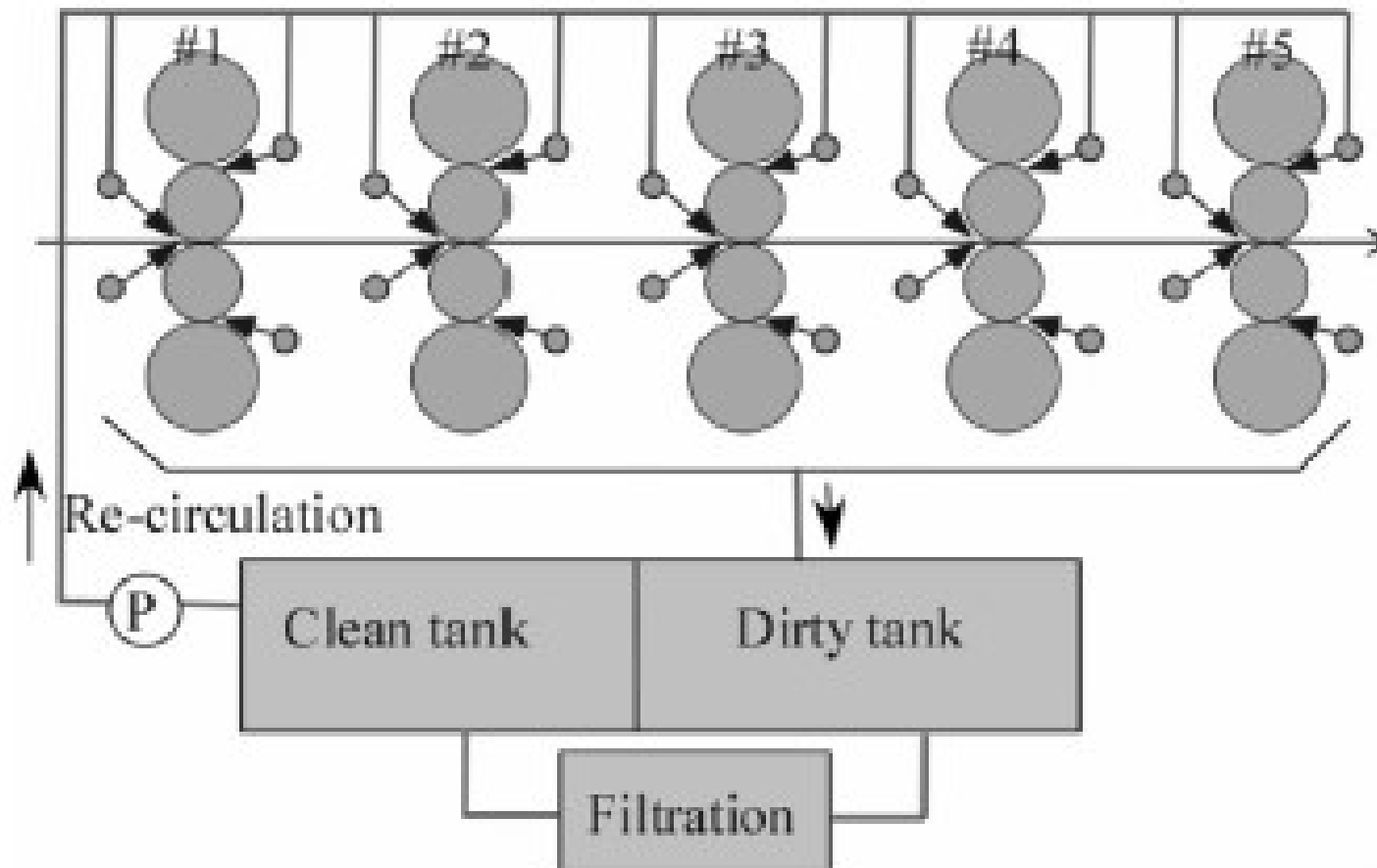
Current Projects 3: Roughness Transfer in Cold Rolling (Bob Beckers)



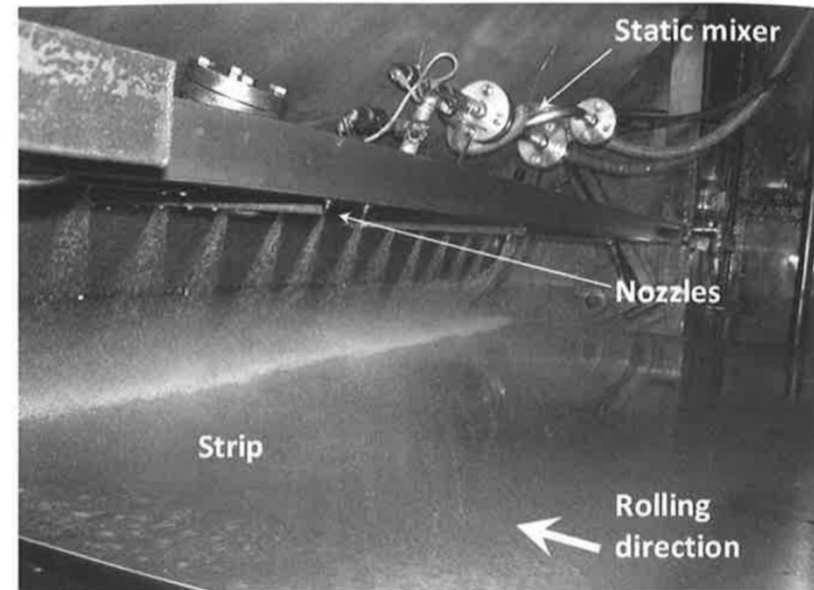
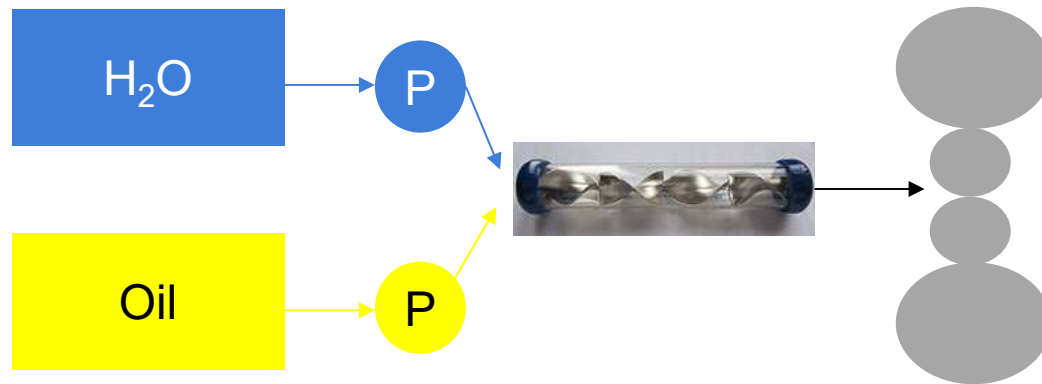
Current Projects 3: Roughness Transfer in Cold Rolling (Bob Beckers)



New developments 1: Flexible Lubrication



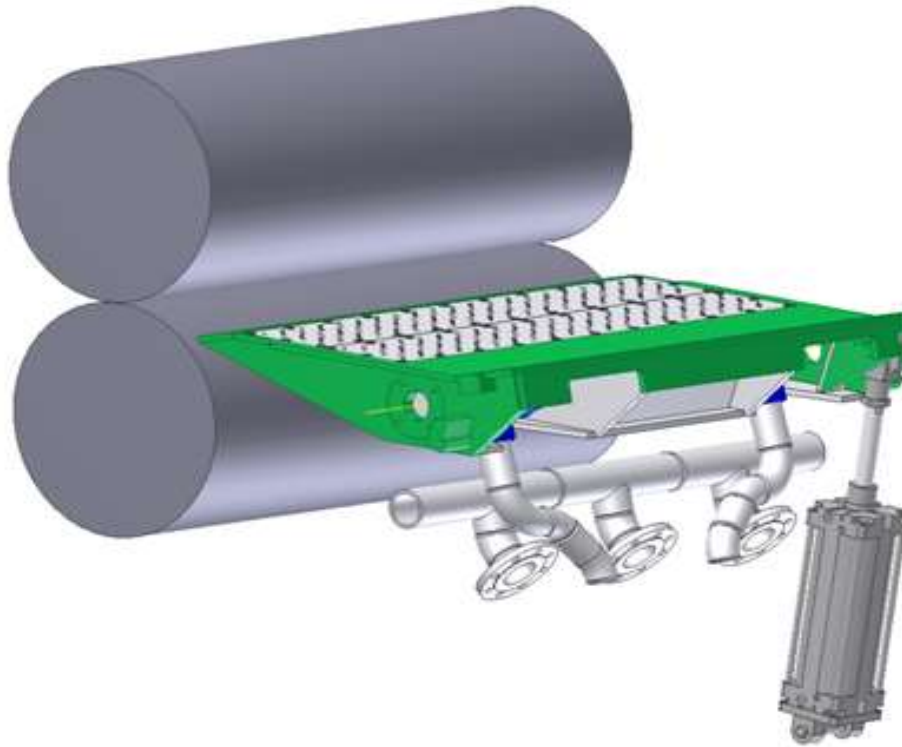
New developments 1: Flexible Lubrication



Advantages:

- Adaptation of friction over work roll campaign length
- Adaptation of friction from coil to coil
- Adaptation of friction during one coil

New developments 2: Strip Cool Table



Advantages:

- Lower strip temperature → chemical binding of oil with steel
- Lower rejection rates on surface defect 'heat scratches'
- Enabling higher production speeds
- Low water pressure