TATA STEEL

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EPIC digital meeting 09 Oct 2023

Optical Measurement Technologies at Tata Steel

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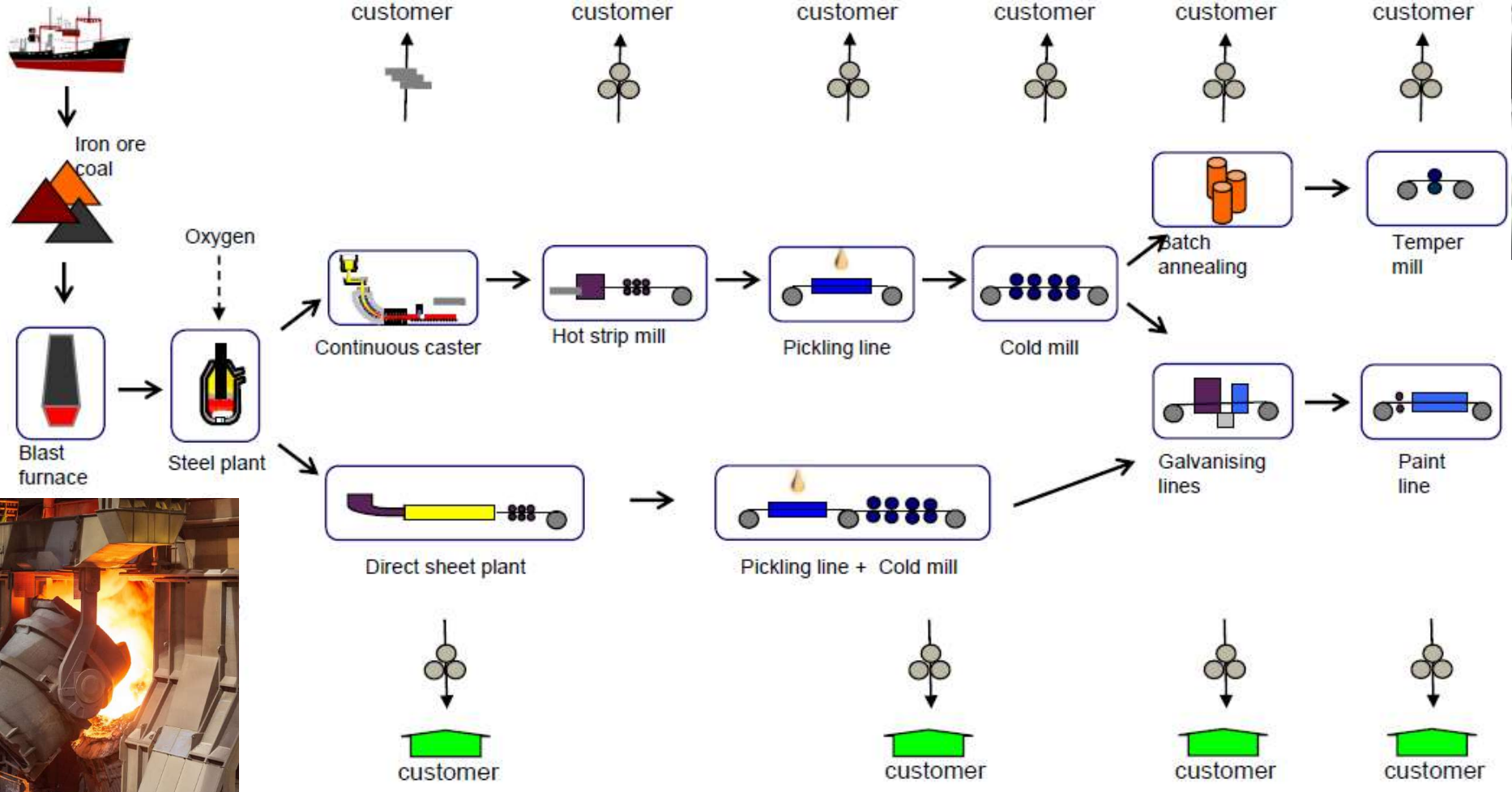
Tata Steel IJmuiden, The Netherlands

Integrated steel production: from Iron & Steel making → steel coils

Steel making
Converter

Steel coils
Storage hall for dispatch

Integrated steel production: from Iron & Steel making → steel coils

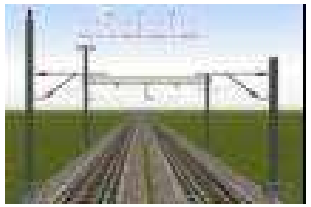


Products













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Surface Topology

Why is Surface Topology important?

For manufacturing process:

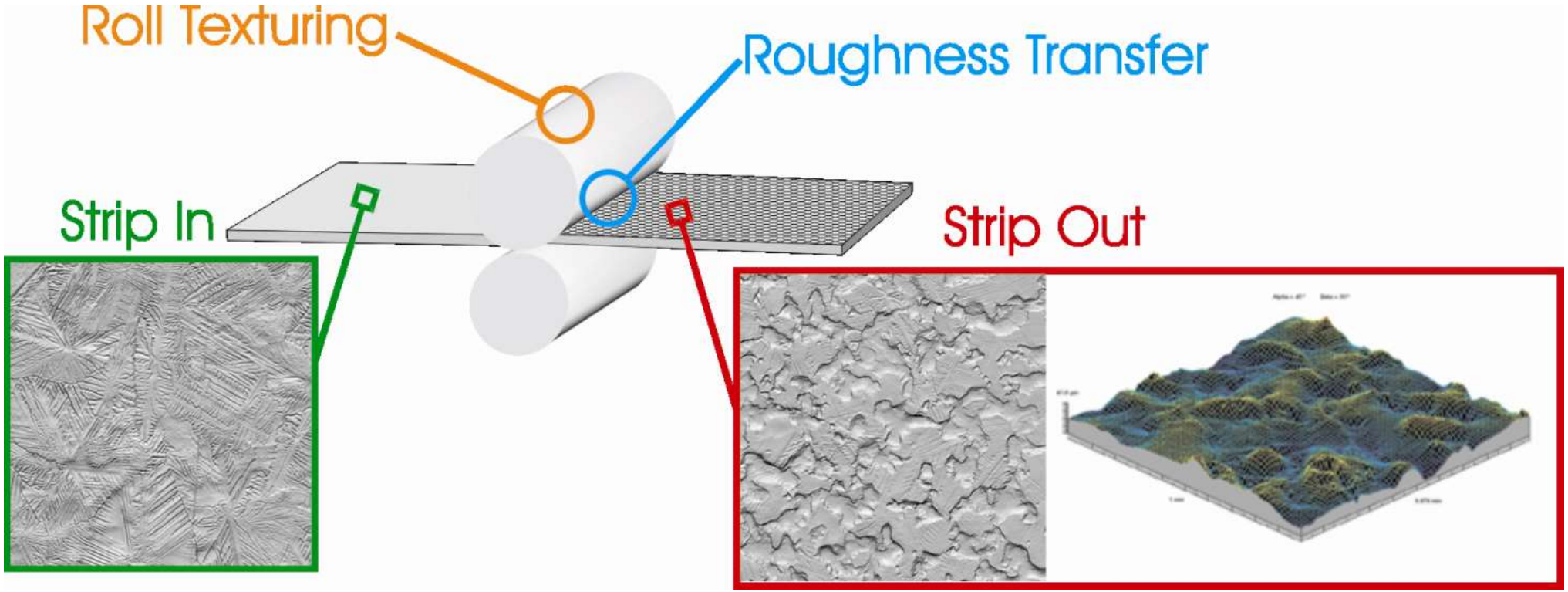
- Throughout the process route surface roughness plays a key role in process control and product quality
- Product Surface Finish highly dependent on through route processing

For end user:

- Press/forming
- Process steps
- Paint usage
- Product appearance
- Product saleability

How the Surface Texture is formed?

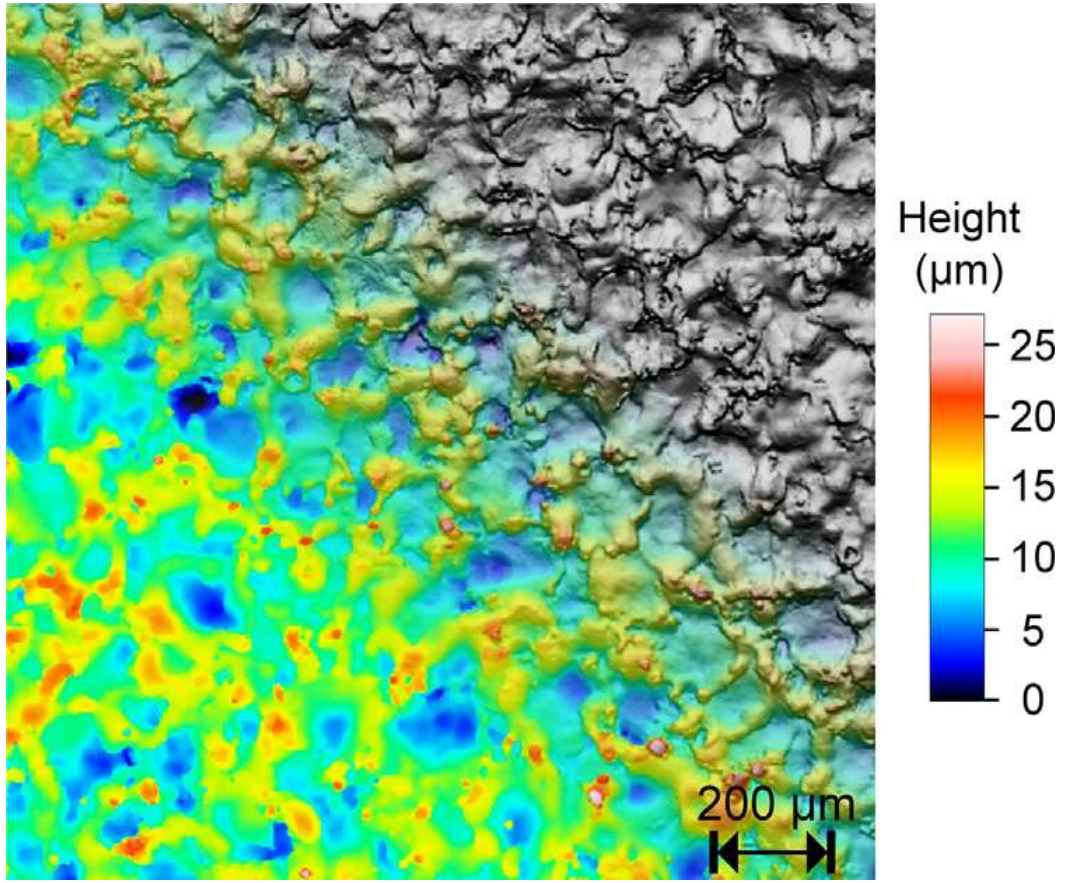
- (cold) rolling operations



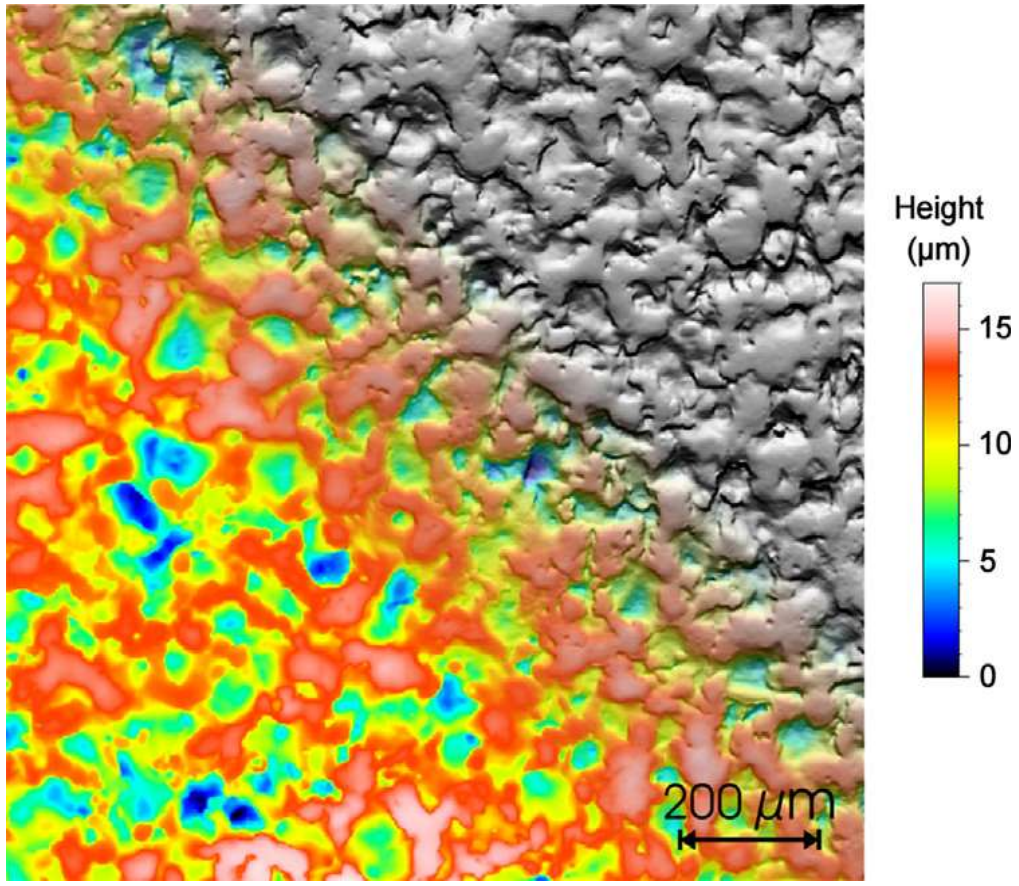
Effect of wear of the work roll: evolution of roll texture

Roll surface topography (grey) and heights (coloured) of ...

Fresh work roll



Worn work roll (after 4000 m cold rolling of HDG strip)

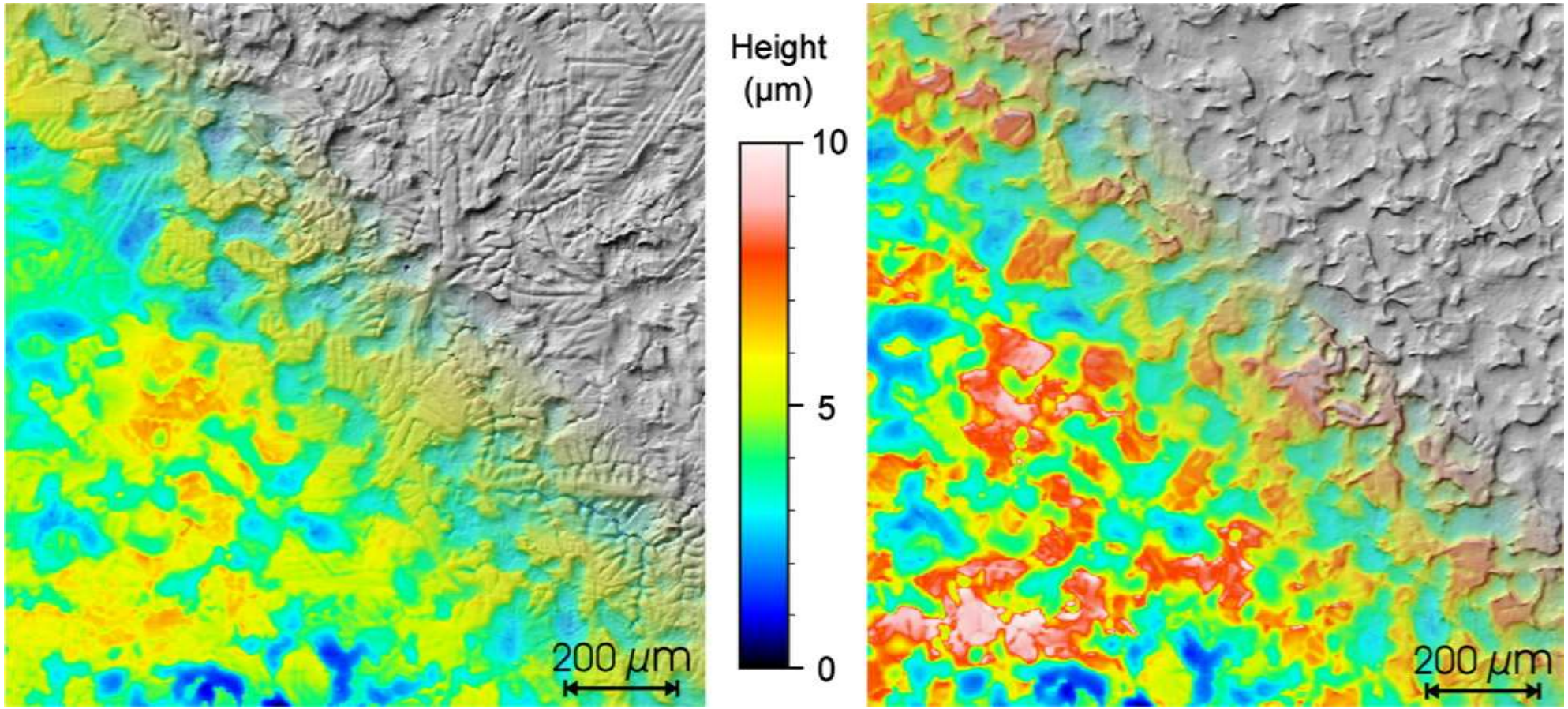


Pictures courtesy of D.J. Wentink, Tata Steel R&D

Effect of force of the work roll on the strip

Strip surface topography (grey) and heights (coloured) of ...

Specific roll force: 0.8 kN/mm2



Specific roll force: 1.45 kN/mm2

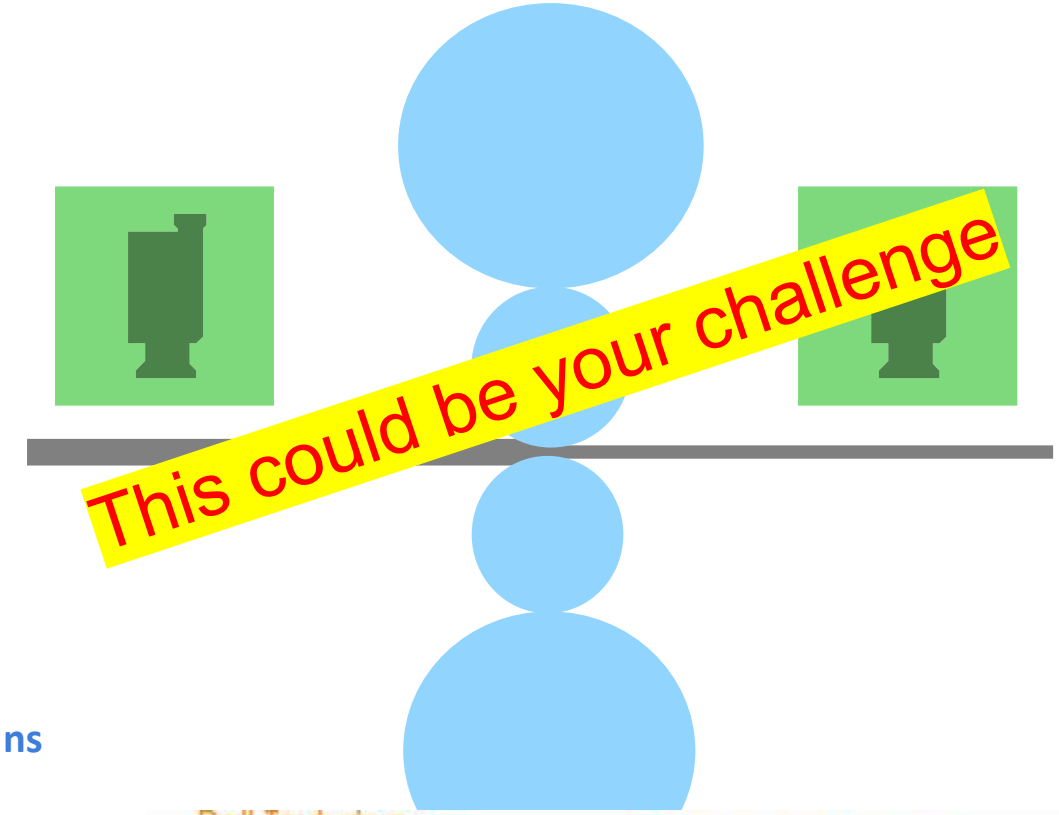
Pictures courtesy of D.J. Wentink, Tata Steel R&D

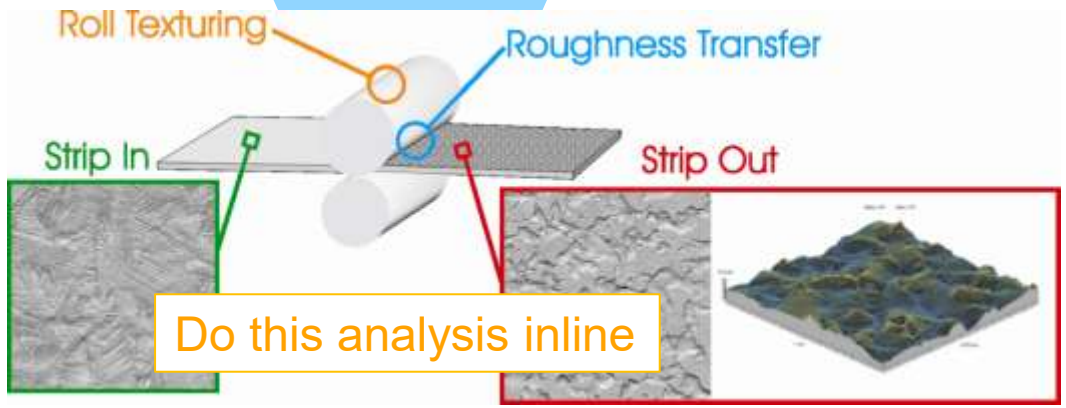
What is our ambition ?

- **Inspect the surface topology before and after the rolling process**
  - Inline & real-time
  - Use data as input to control loop

- **Challenges:**
  - Line-speed = 3 – 7 m/s

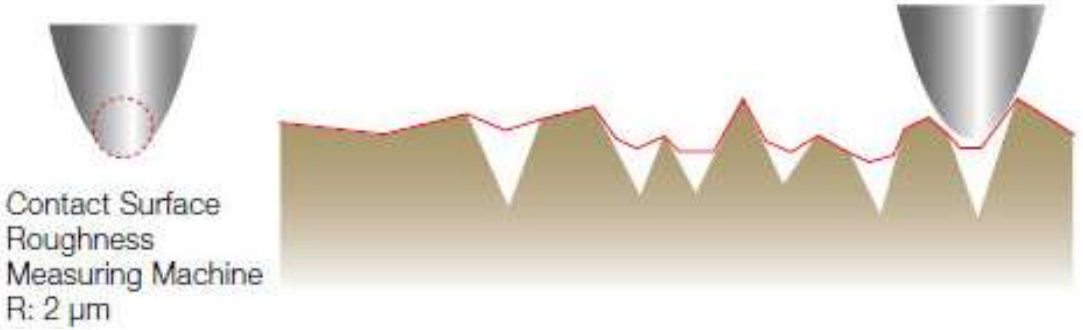
    “motion blur”:
    For 1 μm lateral resolution need for snap shot $\Delta t < 200$ ns
  - Vibrations in the production line (reference) & object

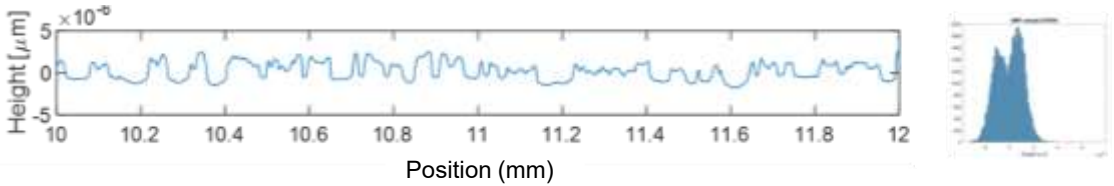




Standard reference measurement (used for product release)

Mechanical Stylus Only for off-line measurement





Principle:

- Contacting needle follows surface;
  Displacement of needle is recorded

Issues:

- Need to consider limits of contacting measurement (limited lateral resolution due to tip radius).
- Sensitive to tip diameter, skid, contact force, friction, speed, tip wear …
- Statistical nature of certain surfaces require averaging over multiple profiles.

Quantity	value
Height resolution Δz	< 0.1 µm
Lateral resolution Δx, Δy	1 µm
Roughness Ra → Bandpass size:	8.0 µm - 2.5 mm
Roughness Ra → Line length:	12.5 mm
Roughness Ra → Typical range:	0.3 – 3 µm
Waviness W → Bandpass size:	2.5 mm - 8.0 mm (*)
Waviness W → Line length:	40 mm
Waviness W → Typical range:	0.2 – 0.6 µm
Typical speed:	1 mm/s

(*) Also other ranges are used, depending on application

Lab techniques to evaluate surface topology

Requirements:

- Performance similar to / better than reference (stylus)

Optical Stylus (scan of point measurement):

- Laser triangulation
- Laser confocal
- Chromatic confocal

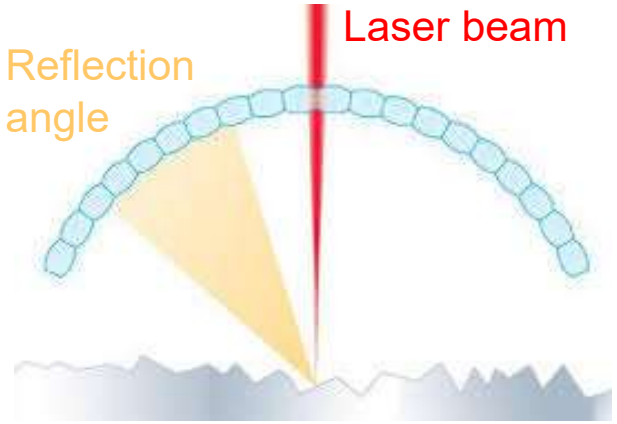
Optical *Imaging* of topology:

- Confocal imaging
- White Light Interferometry
- Optical Coherence Tomography
- Holography

Example of confocal imaging of surface topology of work roll

Techniques to monitor surface topology inline (only line profiles)

1. Angular resolved scattering



ARS instrument installed inline
- 250 nsec / measurement
- 100 mm distance from steel strip

2. ns-pulsed laser triangulation

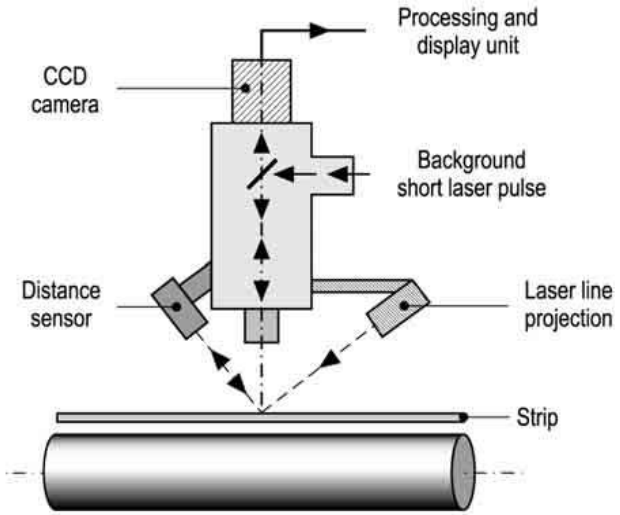


Image of laserline on galvanised steel
- Only recording when in focus
- Roughness & waviness parameters

Status inline topometry development

These solutions (on previous slide) have been evaluated in manufacturing conditions:

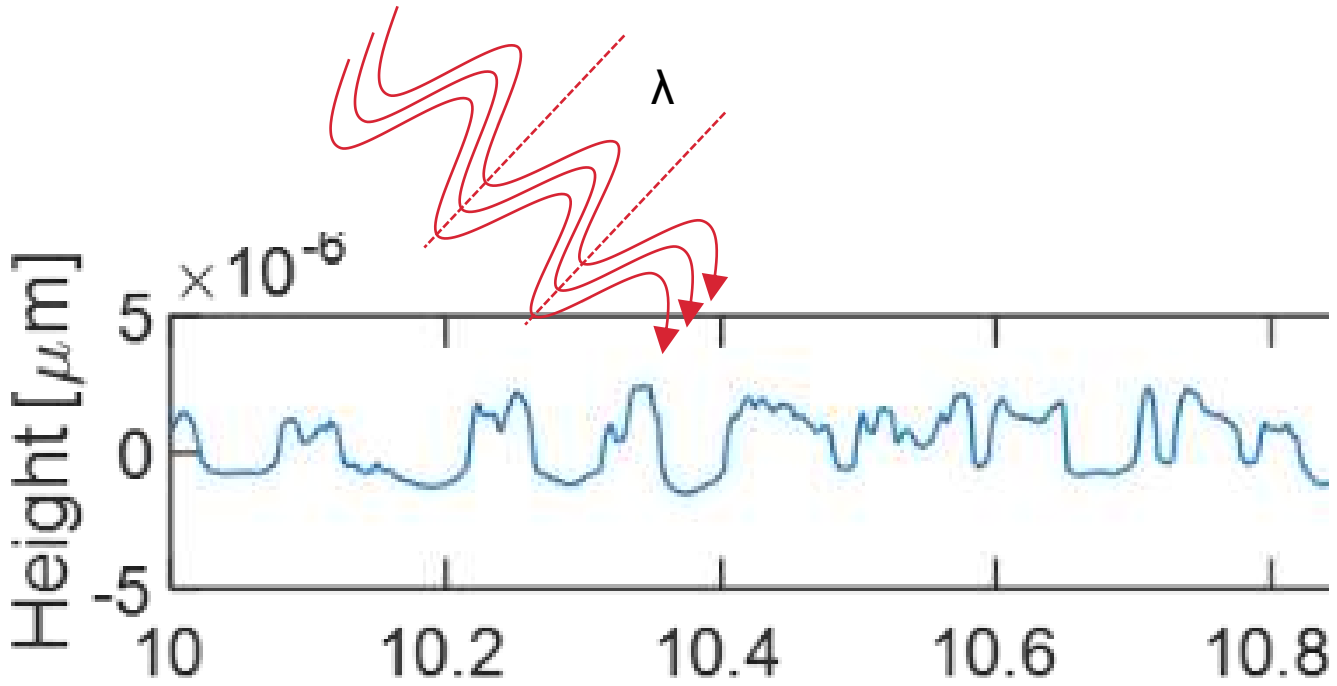
- Useful to obtain trends in roughness during production
- However: no reliable reproduction of surface profile
  - Not suitable for product release

Also other techniques evaluated in lab:

- Speckle imaging
- White light Interferometry
- Wave front sensing

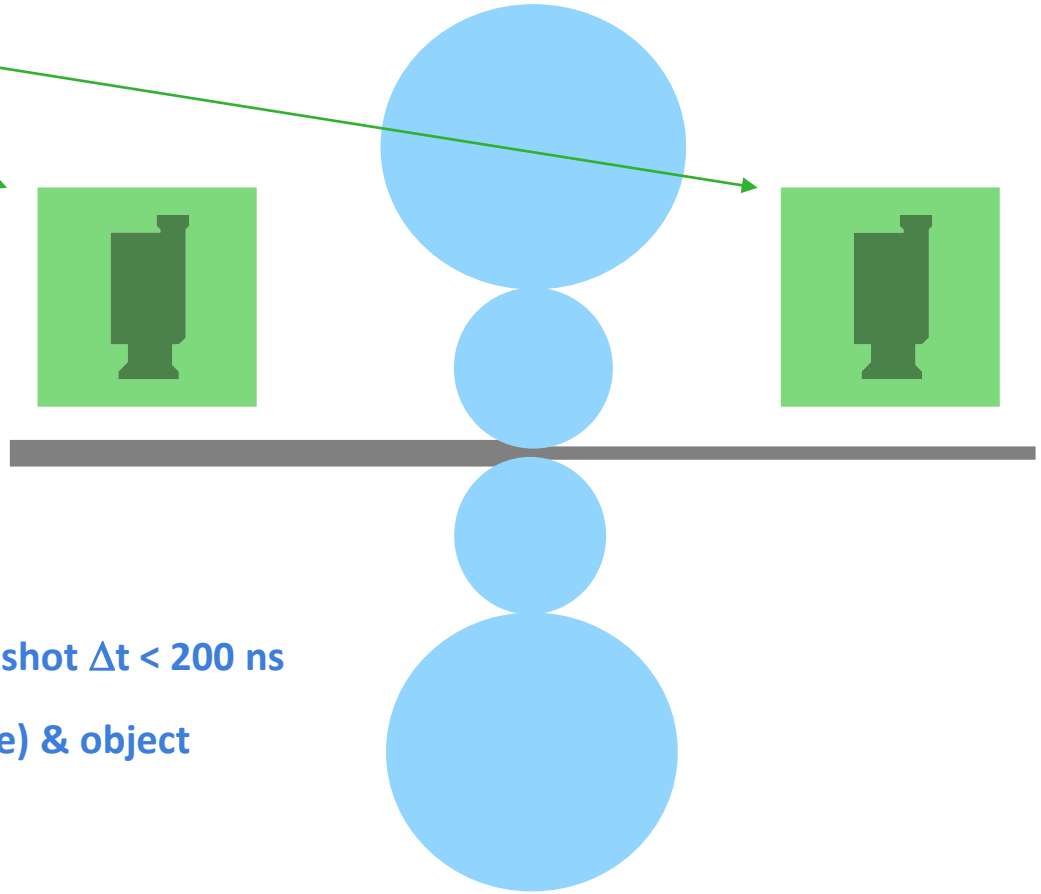
General difficulty:

- Roughness and Optical wavelength are of same order of magnitude
  - Mix of diffuse, specular & multiple scattering → complex!



Your challenge ?

- Inspect the surface topology before and after the rolling process
  - Inline & real-time



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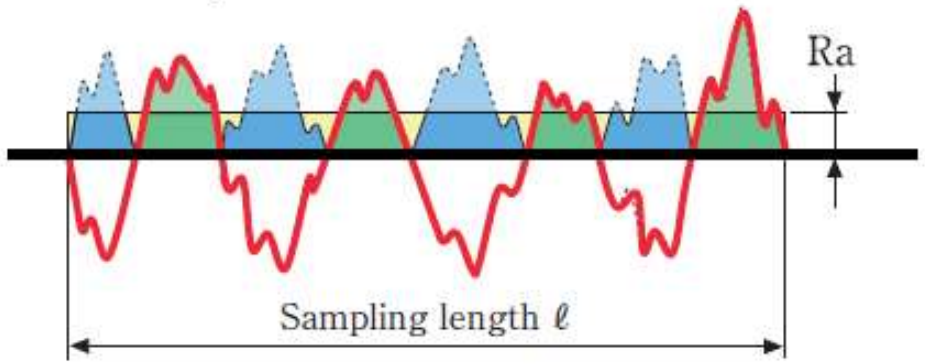
QUESTIONS ?

On the definition of Roughness

Roughness (Ra):
mean of absolute amplitudes [µm]

$$Ra = \frac{1}{\ell}\int_0^{\ell} |Z(x)|\,dx$$



What does “roughness” say about the surface?