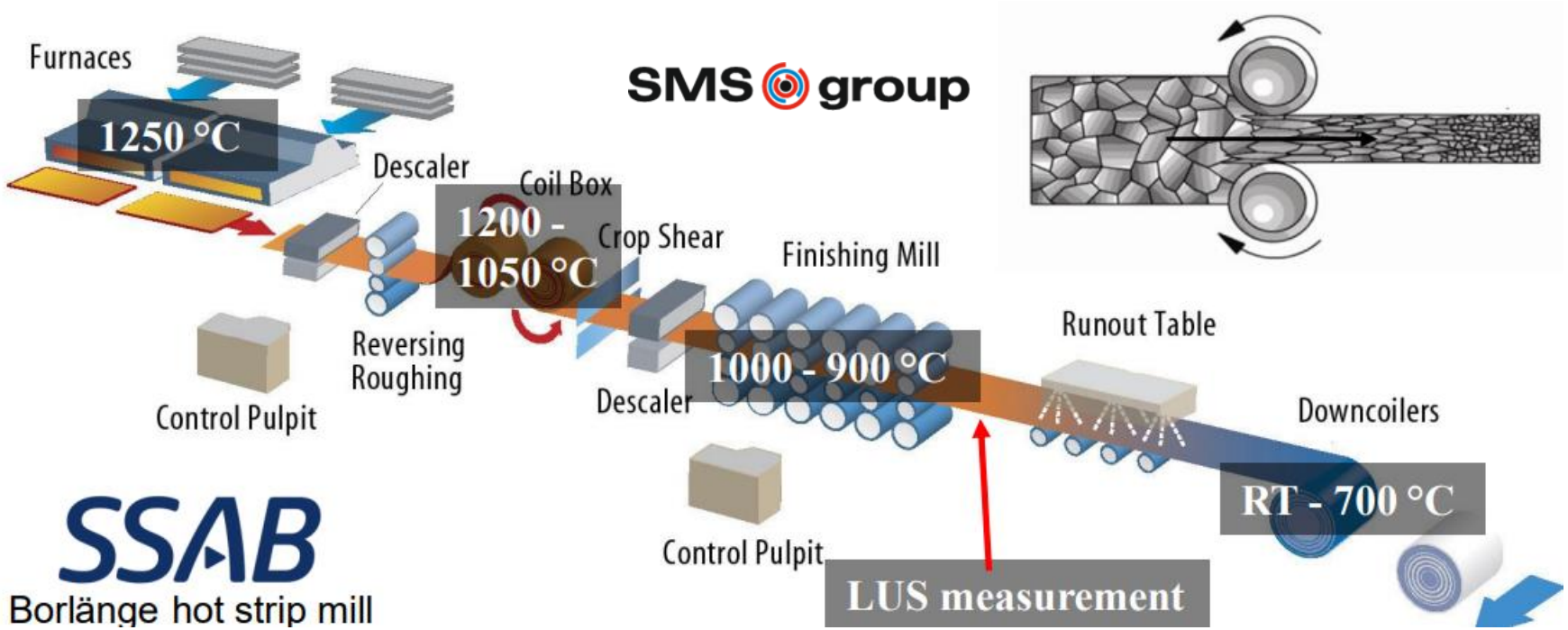

Insights from the online LUS grain size gauge and the potential for future process control

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[3]*Swerim AB, Stockholm, Sweden*
[4]*EMG Automation, Wenden, Germany*

Mikael Malmström et al., Swerim AB, Stockholm, Sweden On-line grain size gauge for the hot strip mill based on laser ultrasonics
5th International Workshop on Laser-Ultrasound for Metals 5-6 May, 2022, Gif-sur-Yvette, France

SMS group

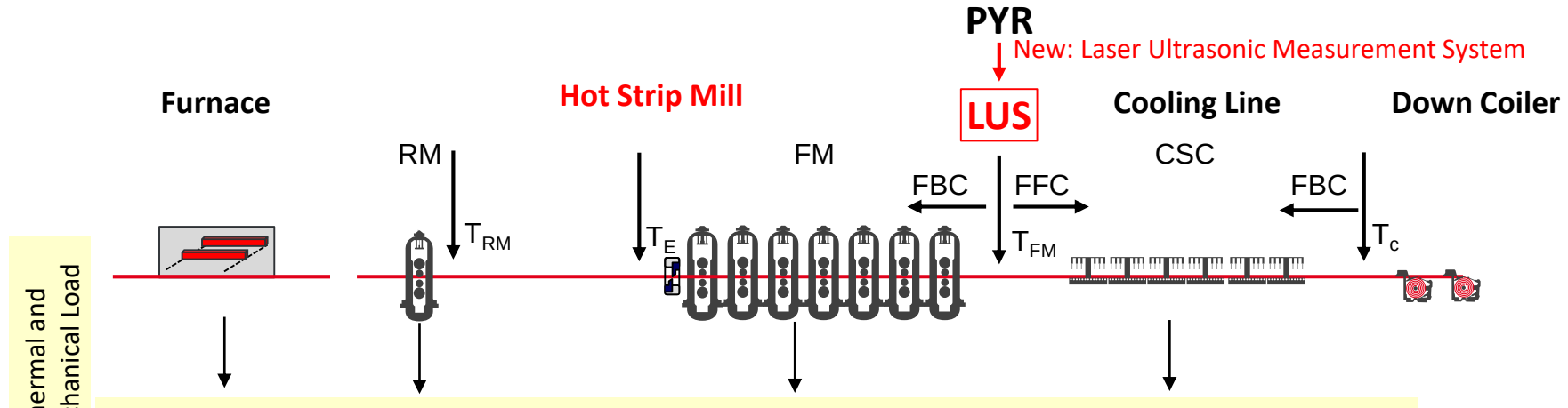
Insights from the online LUS grain size gauge and the potential for future process control

Content

1. Introduction
2. Rolling trials & recalculations
3. Conclusion & outlook

Insights from the online LUS grain size gauge and the potential for future process control

Introduction – General overview of a typical HSM



Current state

- Adherence to the set points in the process steps (rolling, cooling) very important
- Deviations are corrected by control actions in the process models
- No information about microstructure available

New

- LUS device gives information about the microstructure (grain size, recrystallization and phase state,…)

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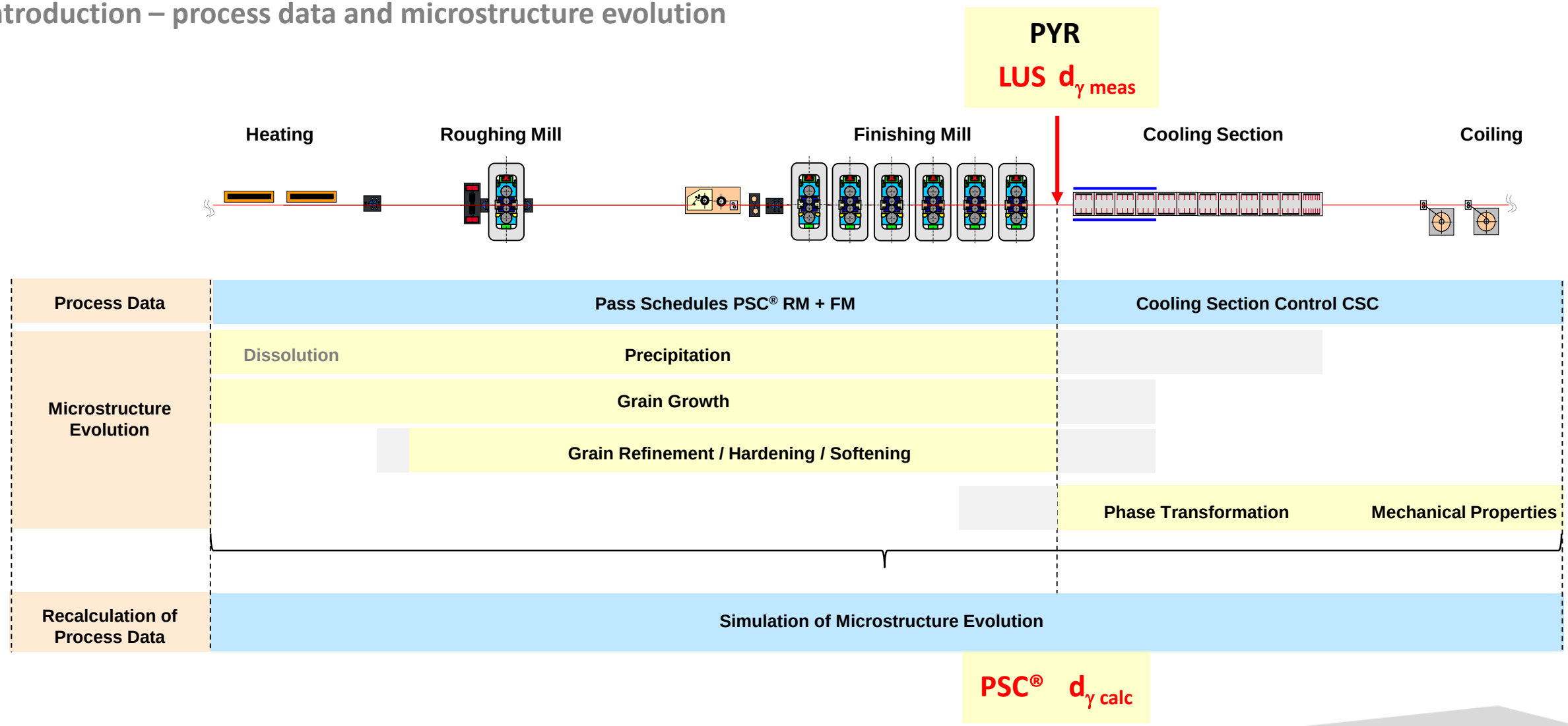
Introduction – process data and microstructure evolution



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Introduction - test installation and commissioning of LUS device at SSAB

Test installation at EMG

Commissioning at SSAB

Insights from the online LUS grain size gauge and the potential for future process control

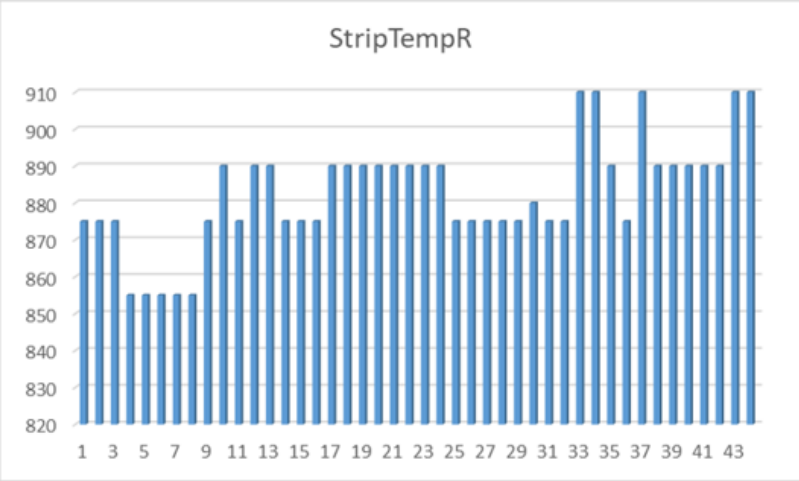
Rolling trials & recalculations – rolling parameters and materials

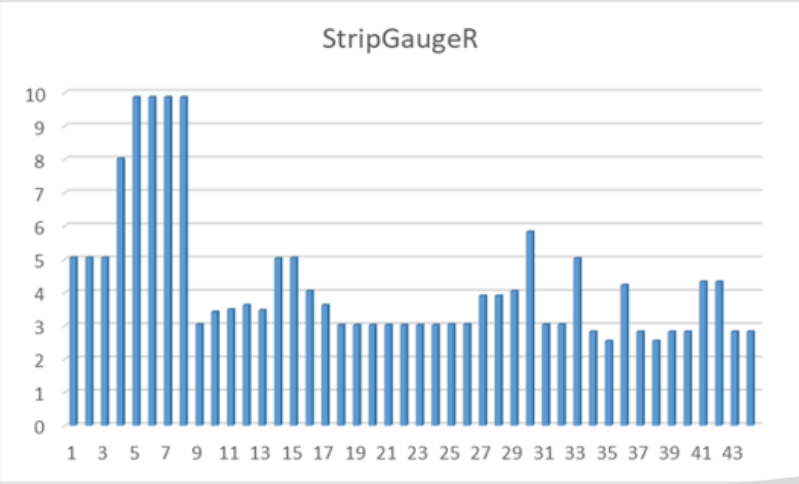
Online LUS grain size measurement

Evaluation of strips

Analysis as function of
- Material
- Thickness
- Finish Rolling temperature

Material:
- Low carbon (LC) steel
- LC – Nb steel
- Mn – Nb steel





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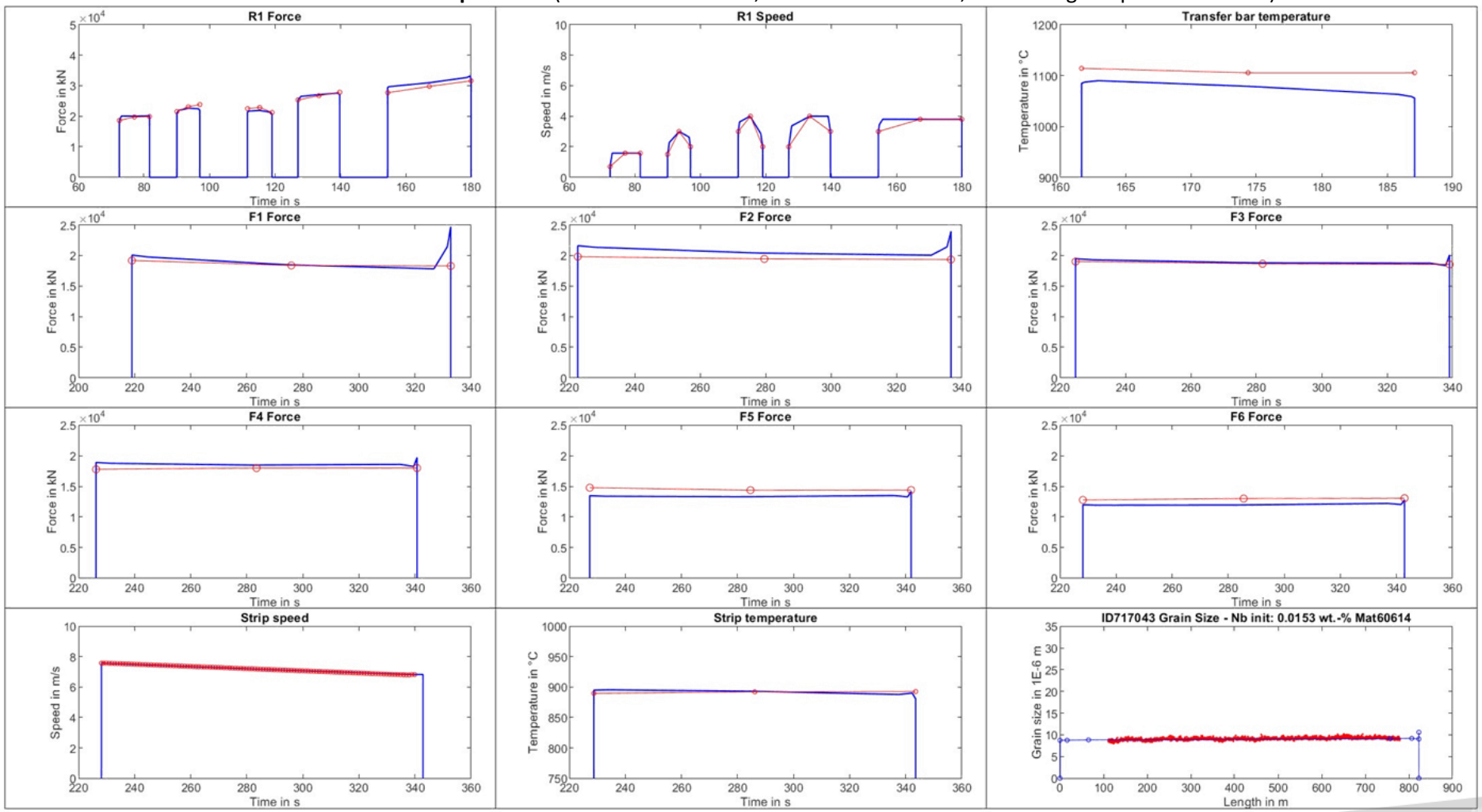
Rolling trials & recalculations – results of recalculation

Strip 717043 (final thickness 3 mm, final width 1265 mm, final rolling temperature 890 °C)



RM
- Force
- Speed
- TB temperature

FM
- Force $F_1 – F_3$

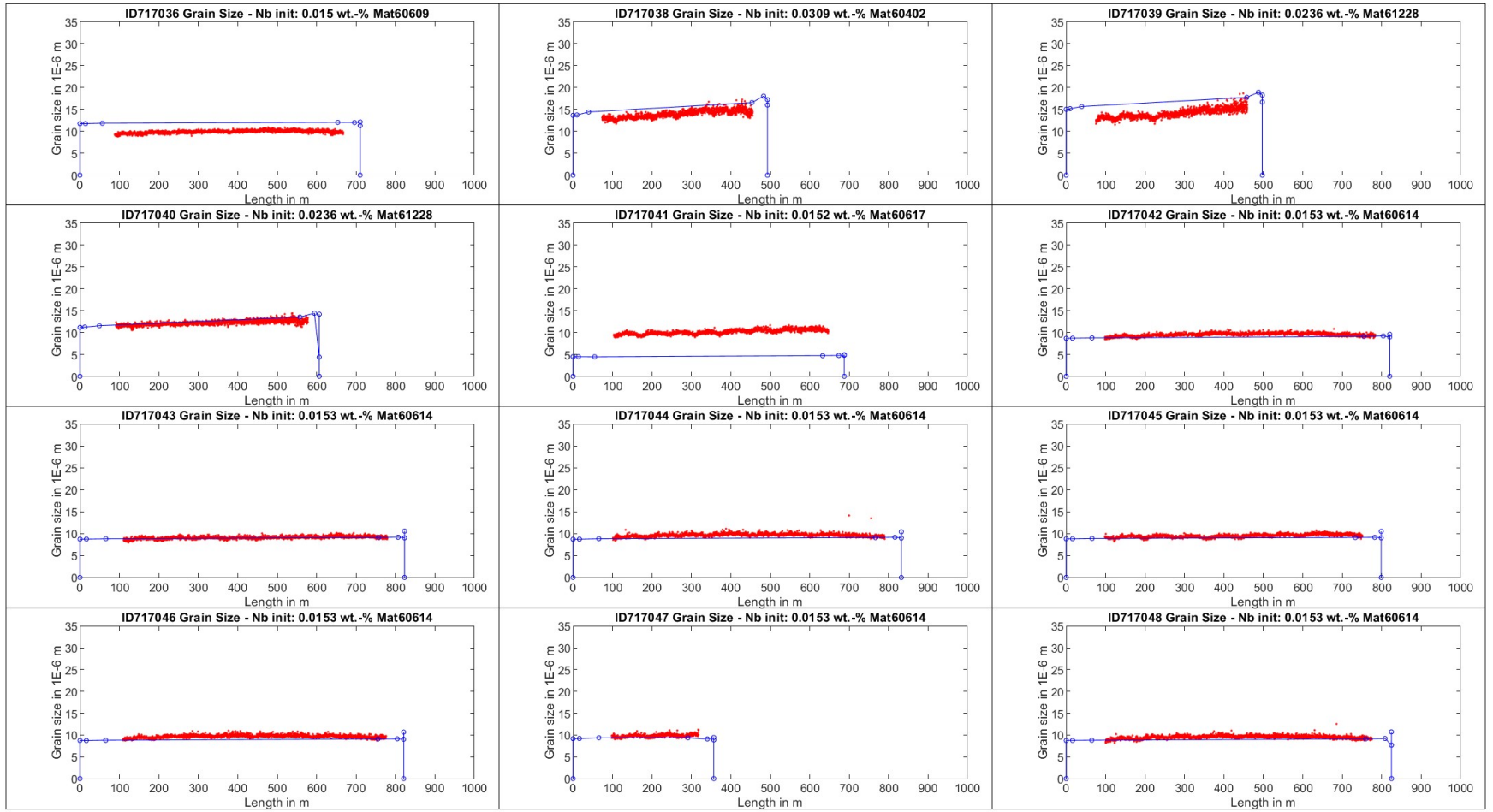
FM
- Force $F_4 – F_6$

FM
- Final speed
- Final temperature
- Austenite grain size

calculated **measured**

Insights from the online LUS grain size gauge and the potential for future process control

Rolling trials and recalculations - measured and calculated austenite grain size



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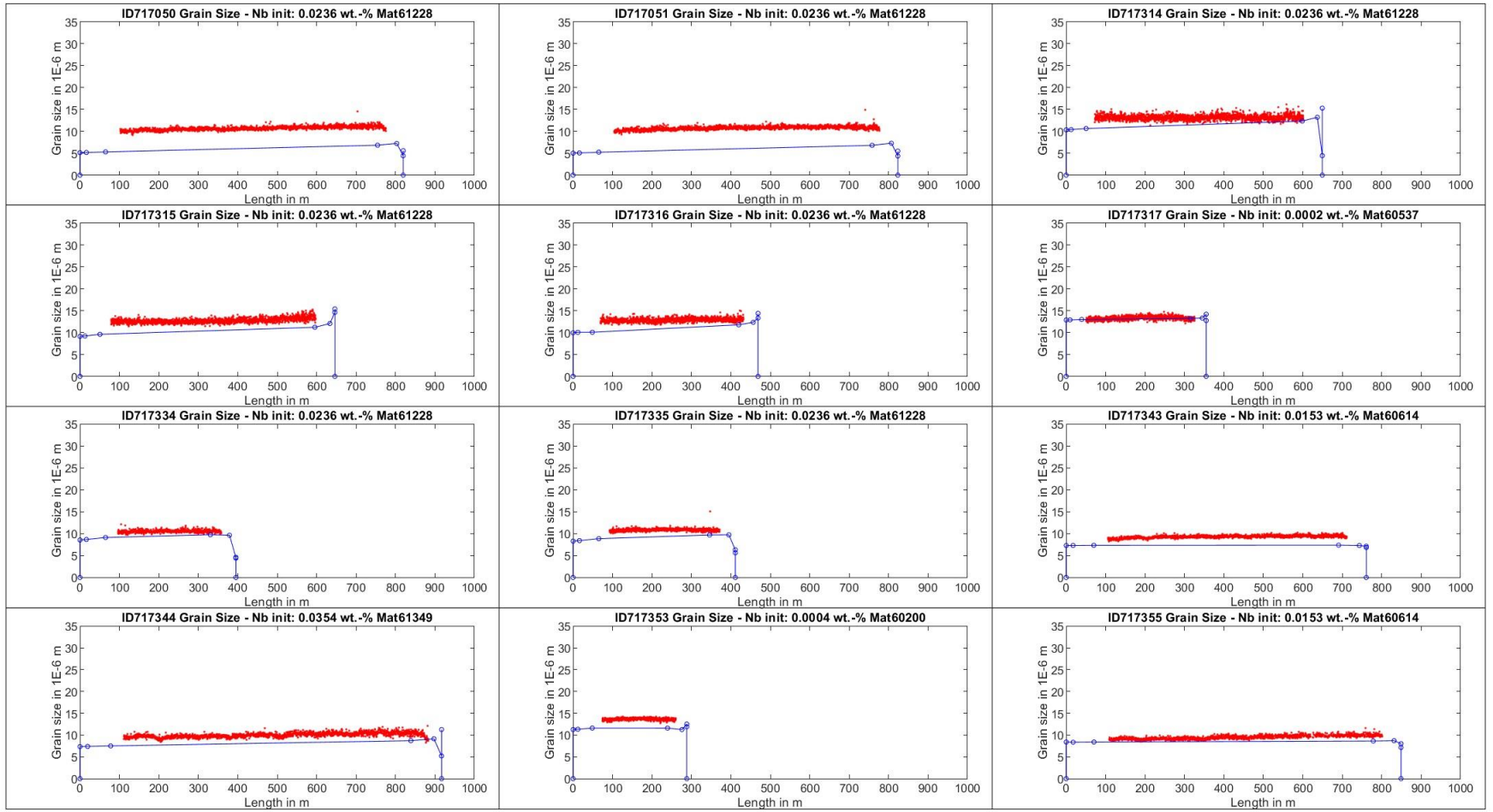
Rolling trials and recalculations - measured and calculated austenite grain size



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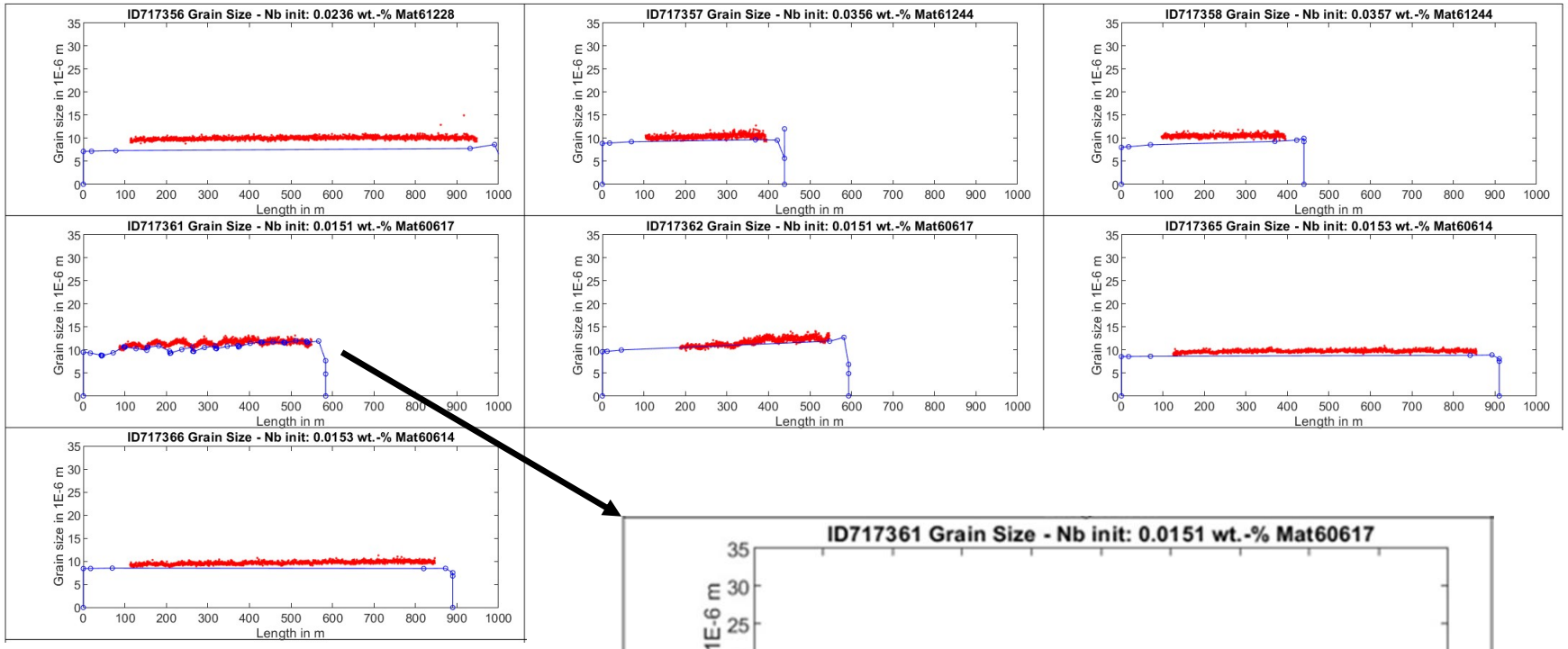
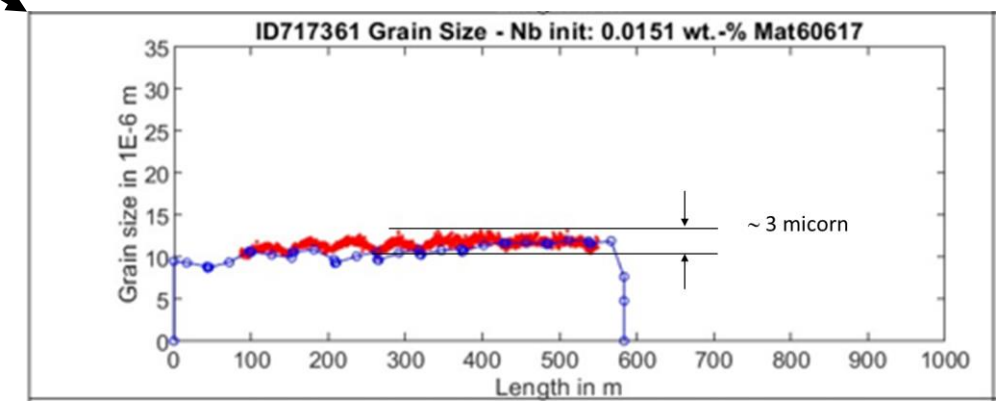
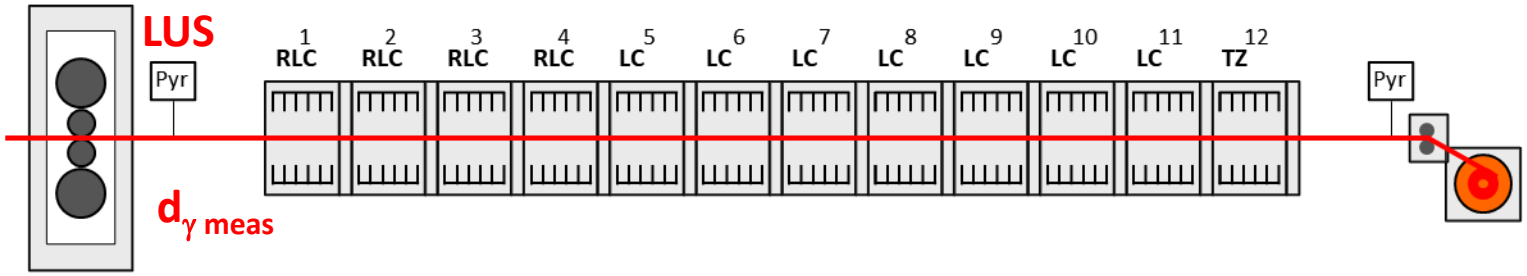
Rolling trials and recalculations – measured and calculated austenite grain size





Insights from the online LUS grain size gauge and the potential for future process control

Rolling trials and recalculations – water amount calculation with CSC



ASTM	Grain size in µm	PA
4	100.00	978.66
5	70.71	931.71
6	50.00	884.77
7.2	33.00	828.42
8	25.00	790.87
9	17.68	743.92
10	12.50	696.97
11	8.84	650.02
12	6.25	603.08

Material	h mm	v m/s	T °C	1	2	3	4	5	6	7	8	9	10	11	12	Water m³/h	T °C
CMn	3.00	6.80	880													3127	597
CMn	5.00	4.50	880													3302	605
CMn	6.00	4.00	880													3652	599
CMn	9.90	2.50	860													3127	627

Current configuration state:
Grain size ~ 33 µm

Material	h mm	v m/s	T °C	1	2	3	4	5	6	7	8	9	10	11	12	Water m³/h	T °C
CMn	3.00	6.80	880													3127	600
CMn	5.00	4.50	880													3418	602
CMn	6.00	4.00	880													3652	602
CMn	9.90	2.50	860													3127	627

LUS measurement:
Grain size ~ 12 - 13 µm

- Temperatures slightly higher
- More water necessary

Insights from the online LUS grain size gauge and the potential for future process control

Conclusion

Roughing Mill RM and Finishing Mill FM:

- Very good agreement between measured and calculated austenite grain size:
  - Almost 77 % of the examined strips show deviations of ± 1 µm
  - Further 21 % with slightly larger deviations of ± 2 - 4 µm
  - Largest deviation of 6 microns has been detected for only one strip
- The reasons for the remaining deviations are subject to investigation:
  - Uncertainties partly exist in the recalculation of process data, especially at RM
  - Check of model approaches describing the microstructure simulation is in progress
  - Besides, strips with pronounced skid marks have to be investigated more in detail

Cooling Section Control CSC:

- Excellent model performance
  - Recalculations of CSC by using measured austenite grain size showed only minor changes in the coiling temperature
  - Only one strip with increased water volumes

Insights from the online LUS grain size gauge and the potential for future process control

Outlook

Next steps:

- Detailed analysis of open points
- Further rolling trials with new LUS device
- LUS measurements at additional positions (e. g. at furnace extraction, between RM and FM, before down coiler, ...)
- Improvement of L2 models
- Measurement of further properties like recrystallized fraction or ferrite grain size
- Integration of LUS device into L2 automation system
- Development of new rolling strategies

Thank You!