Multivariate process control and real time sensors in practical use

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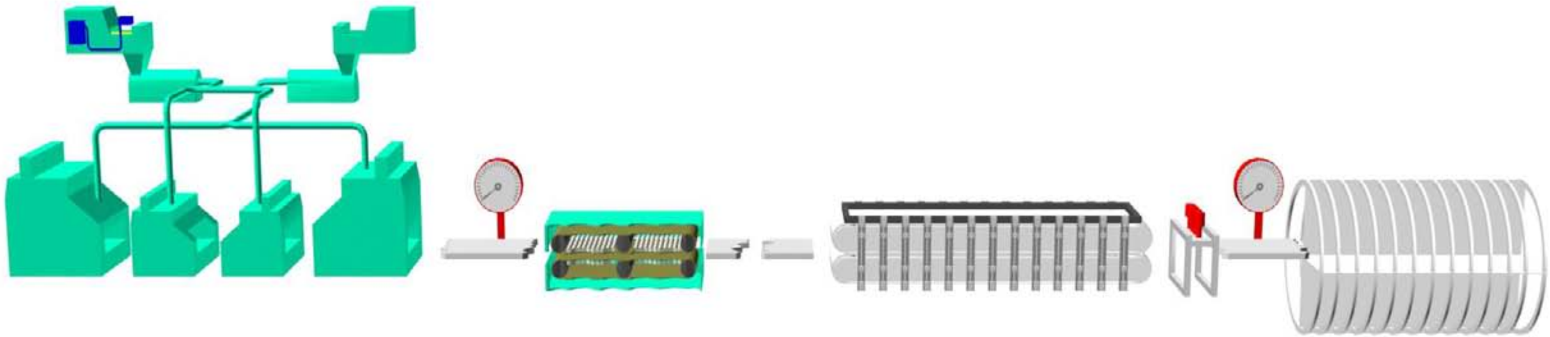
Process control

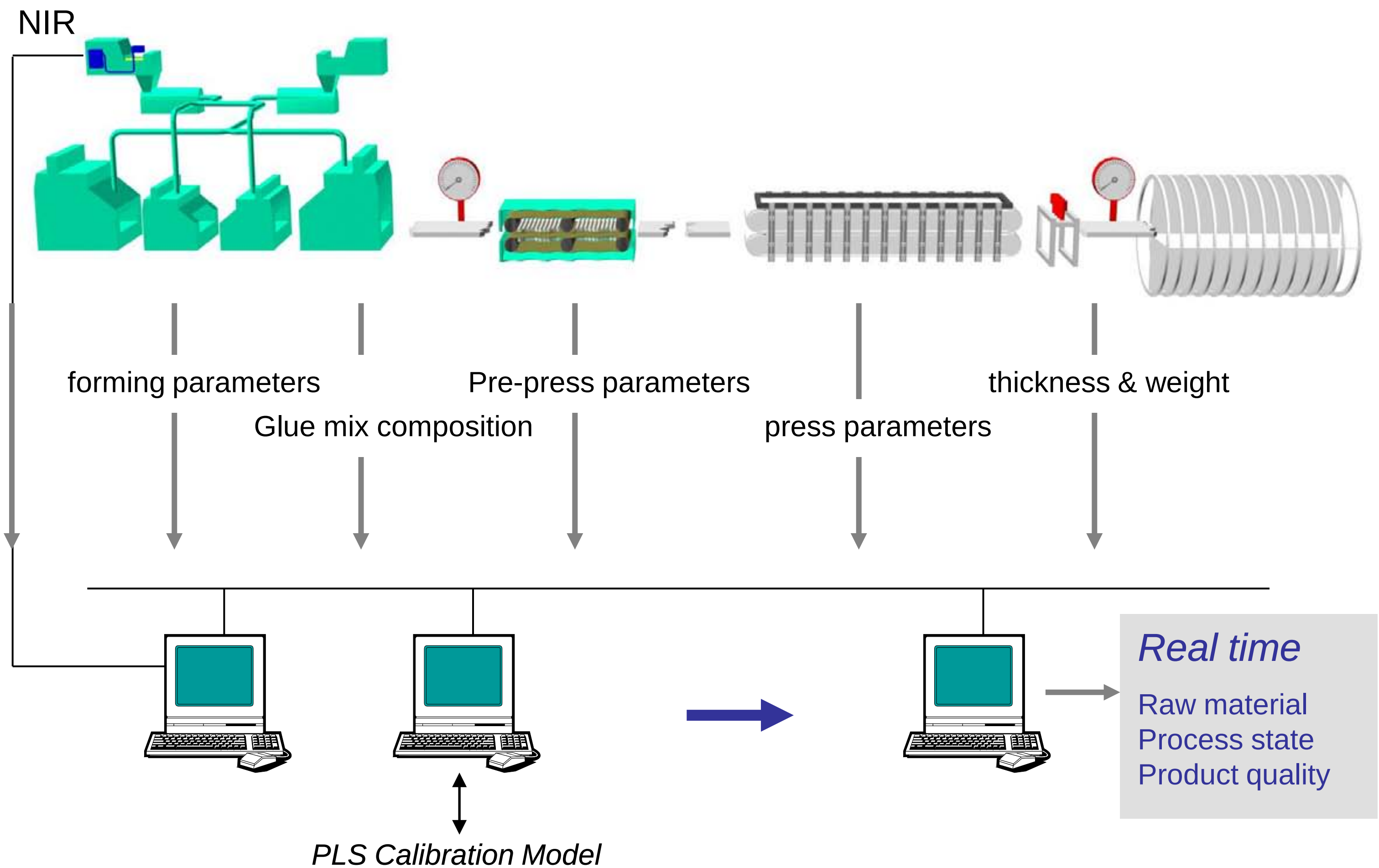


Parameters available for process monitoring and optimization

Raw material	*Process*	*Process output*	*Quality*
Lab measurements Sensors Specifications	Automation Lab measurements Sensors Manual	Volume Productivity	Lab measurements Sensors Customer feedback

Production management and process operators

The BoardModel vision

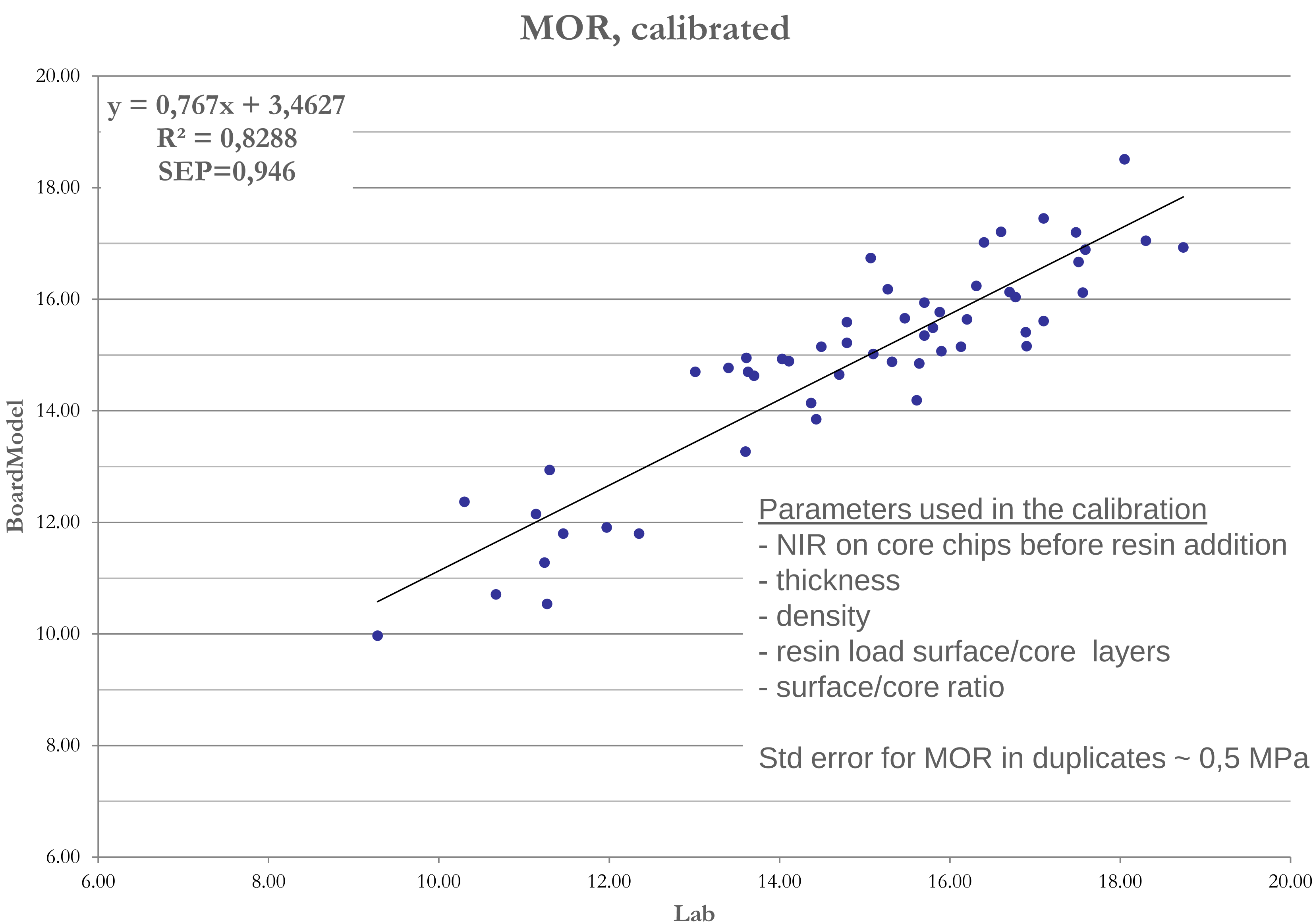


$k_1^{1}*density+k_1^{2}*surface\ chips+k_1^{3}*wax\ core+k_1^{4}*thickness+k_1^{5}*resin\ core+k_1^{6}*resin\ surf+k_1^{7}*NIR=MOR+C1$

$k_2^{1}*density+k_2^{2}*surface\ chips+k_2^{3}*wax\ core+k_2^{4}*thickness+k_2^{5}*resin\ core+k_2^{6}*resin\ surf+k_2^{7}*NIR=E\ module+C2$

$k_3^{1}*density+k_3^{2}*surface\ chips+k_3^{3}*wax\ core+k_3^{4}*thickness+k_3^{5}*resin\ core+k_3^{6}*resin\ surf+k_3^{7}*NIR=IB+C3$

$k_4^{1}*density+k_4^{2}*surface\ chips+k_4^{3}*wax\ core+k_4^{4}*thickness+k_4^{5}*resin\ core+k_4^{6}*resin\ surf+k_4^{7}*NIR=TSW+C4$



Parameters used in the calibration

- NIR on core chips before resin addition
- thickness
- density
- resin load surface/core layers
- surface/core ratio

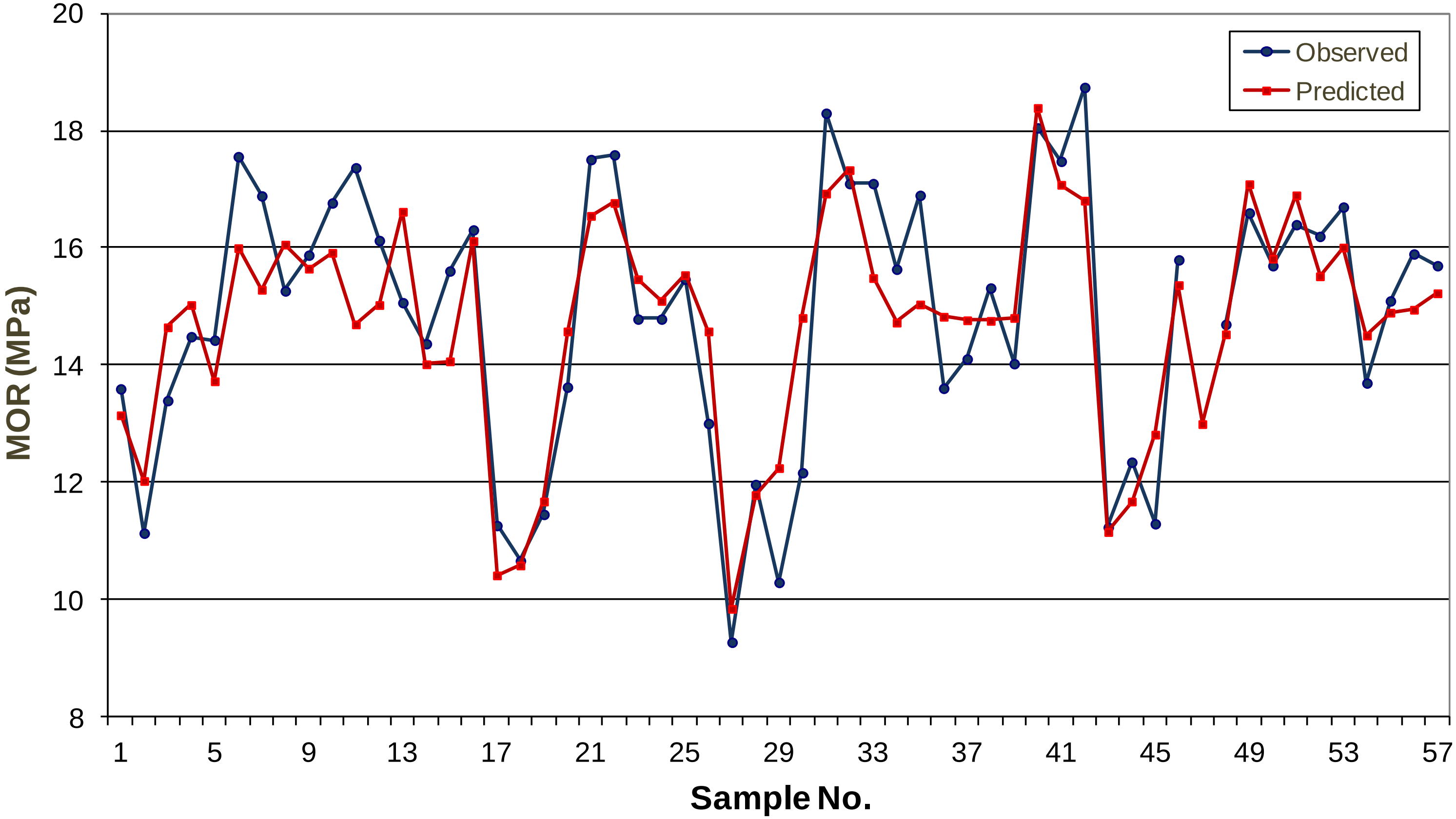
Std error for MOR in duplicates ~ 0,5 MPa

Modulus of rupture

Source of error	Lab	PLS	Inpendent/Additive
Sample preparation	X		Yes
Precision in lab measurement	X		Yes
Sample homogeneity	X	X	No
Std dev in process parameters		X	Yes
Time lag for process tags		X	Yes
Spectrometer stability		X	Yes
Calibration error		X	Yes

The BoardModel vision

Time series, MOR
external data set collected during 10 weeks



Implementation

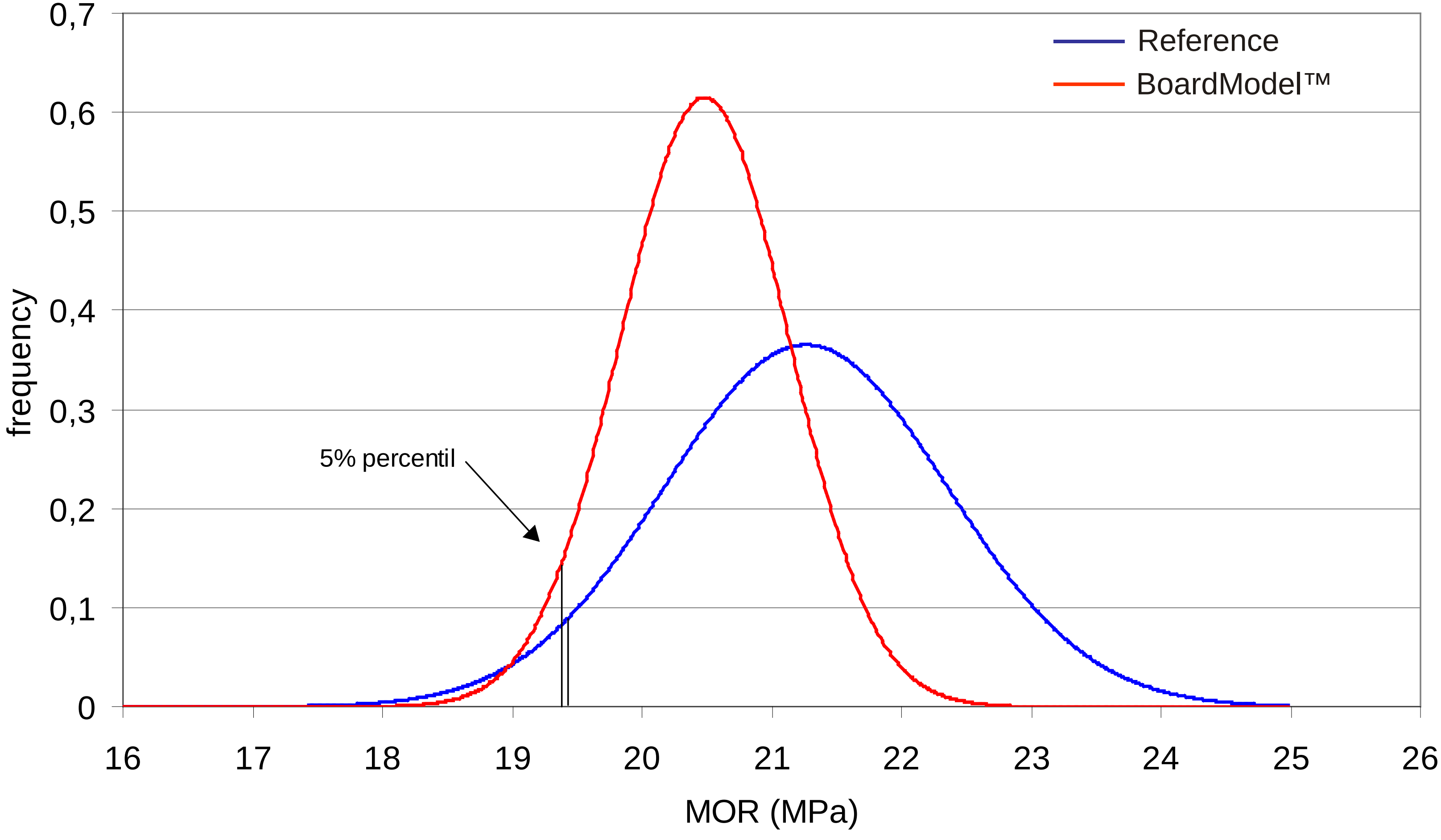
Drivers

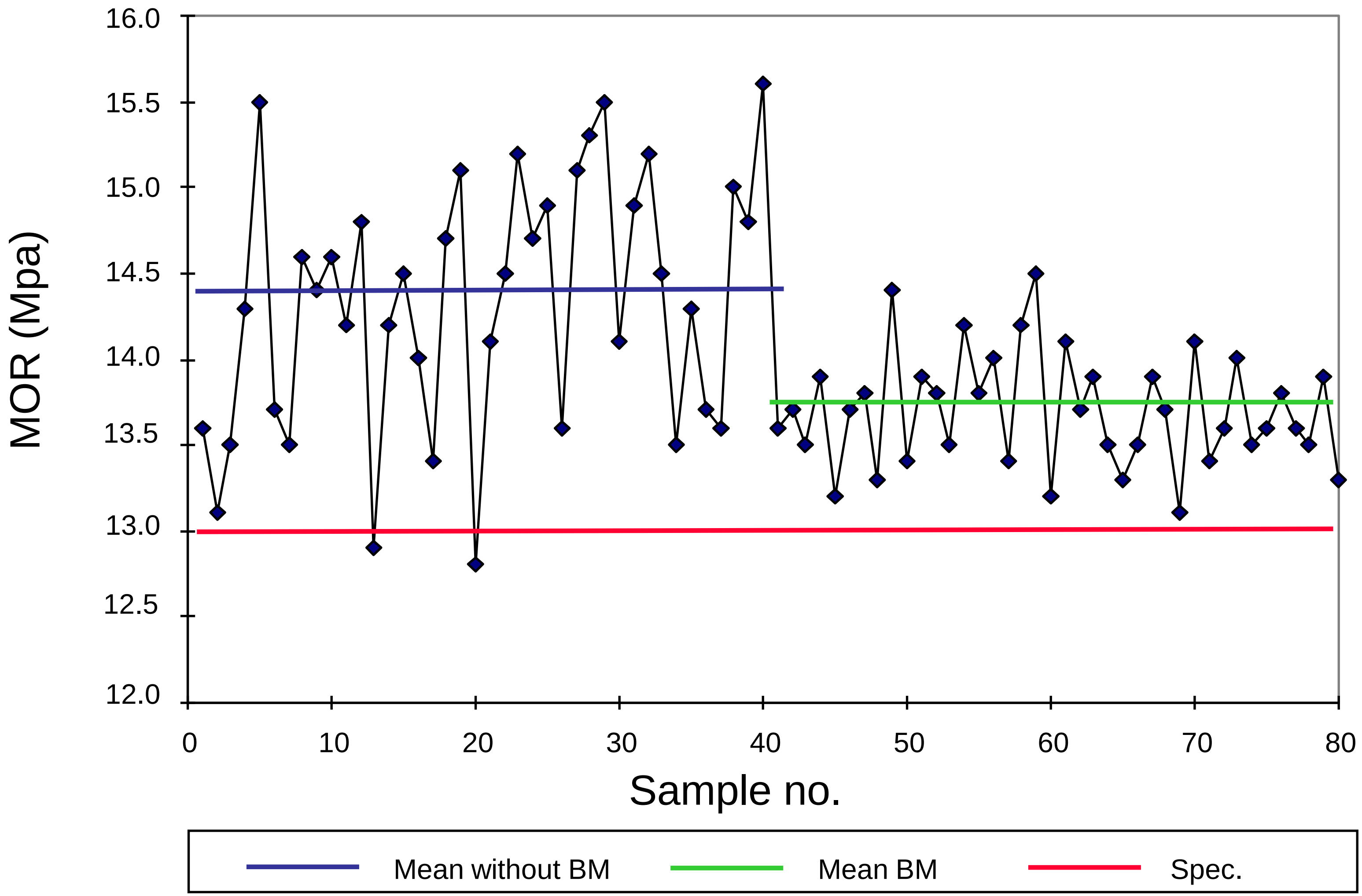
- Optimal quality
- Increase productivity
- Optimal raw material use
- Reduce rejects/claims

Challenges

- Technical performance
- Relevant parameters
- Certificates
- Will it be used in the control room at 1 a.m.?
  - Company culture
  - Incentive systems
  - Trust – resistance

Reduction of standard deviation





16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
MOR (Mpa)
0
10
20
30
40
50
60
70
80
Sample no.
Mean without BM
Mean BM
Spec.

Savings achieved

In €/m³ when optimizing a particleboard mill
with the BoardModel™ system

	Reference		BoardModel™	
	MOR (MPa)	IB (MPa)	MOR (MPa)	IB (MPa)
Average	21,263	0,674	20,483	0,664
Std. Deviation	1,092	0,044	0,649	0,034
Lower 5%	19,431	0,599	19,395	0,608
	n=60		n=53	
Reduced resin consumption:			7.07%	
Reduced dry wood consumption:			2.60%	
Savings:			2,82 €/m^3	

Optimization of Particleboard Production using NIR Spectroscopy and Multivariate Techniques
Erik Sjöblom, Bo Johnsson and Henrik Sundström*
FOREST PRODUCTS JOURNAL Vol. 54, No. 6

Moisture wood pellets

Perten DA7200

NIR method: 2 repacks, 2 repeats

The sample is packed two times and scanned twice per repack.

This gives in total 4 spectra that are averaged to give one measured value

Evaluation of 85 samples

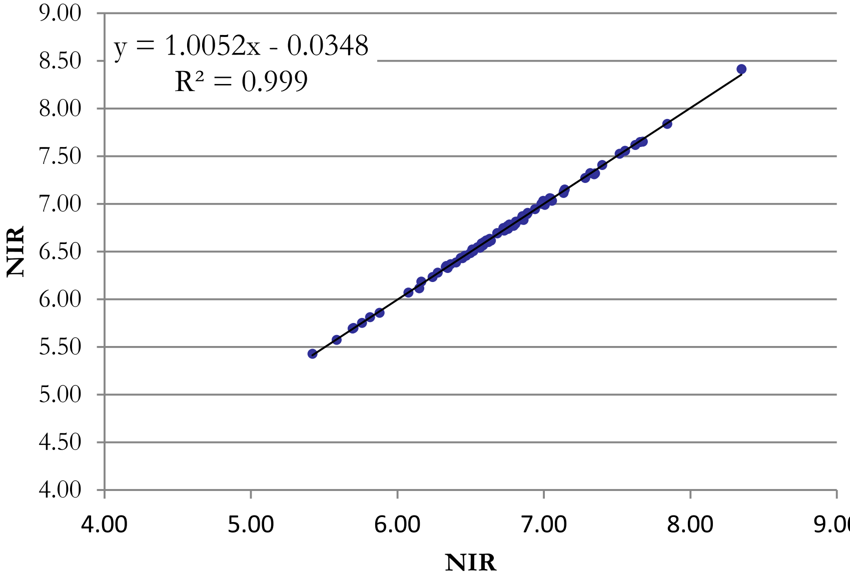
Method	r^2	Std dev/SEP	# Outliers
NIR Repeat	0,999	0,016	0
NIR Repack	0,972	0,099	4
NIR Repack	0,930	0,145	0
Owen moisture duplicate samples	0,953	0,145	0
NIR- Owen moisture	0,918	0,160	3
NIR- Owen moisture	0,905	0,203	0

Perten INSTRUMENTS

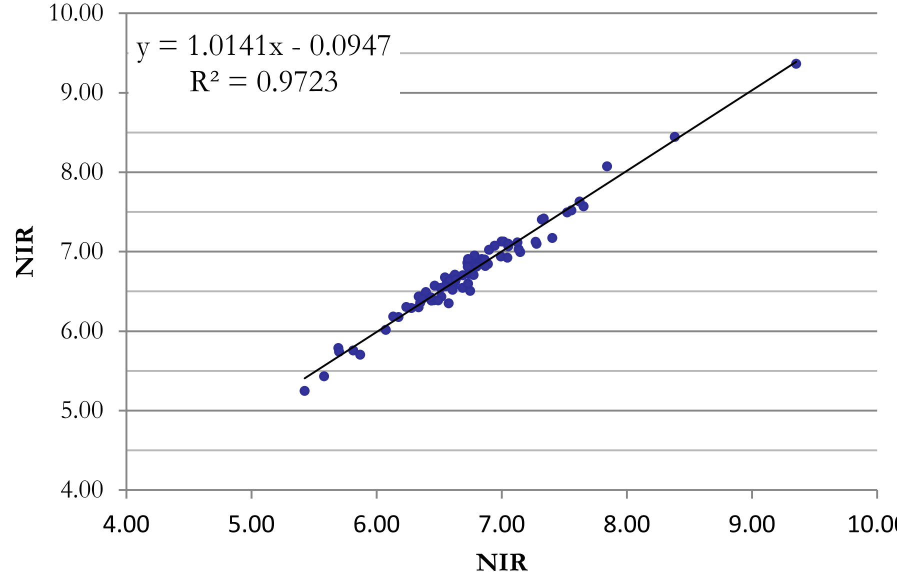
Moisture wood pellets

Source of error	Owen	NIR	Inpendent/Additive
Weighing sample twice	X		Yes
Owen temperature	X		Yes
Particle size and shape	X	X	No
Sample homogeneity	X	X	No
Spectrometer stability		X	Yes
Sample distance		X	Yes
Calibration error		X	Yes

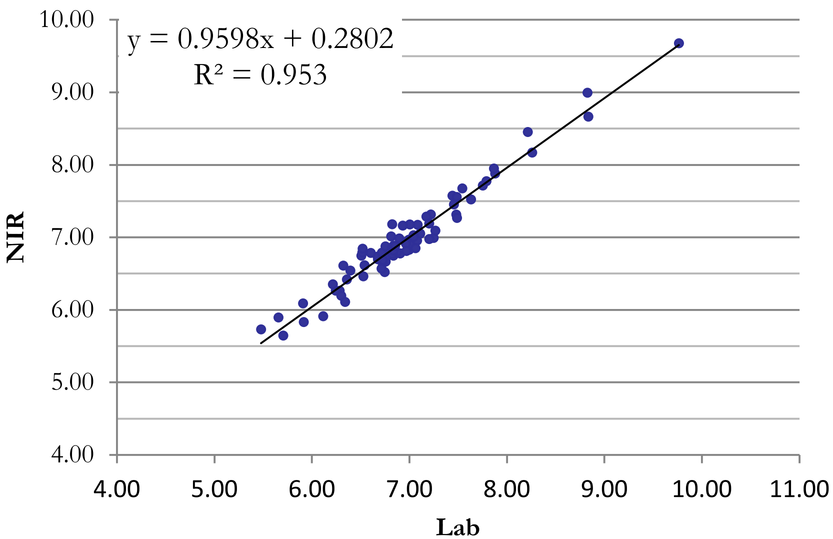
Repeats



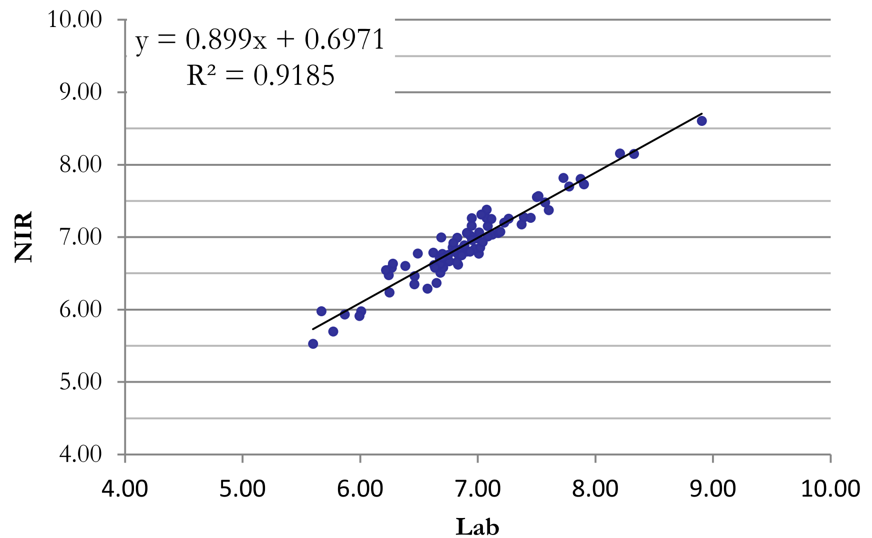
Repack



Owen duplicates

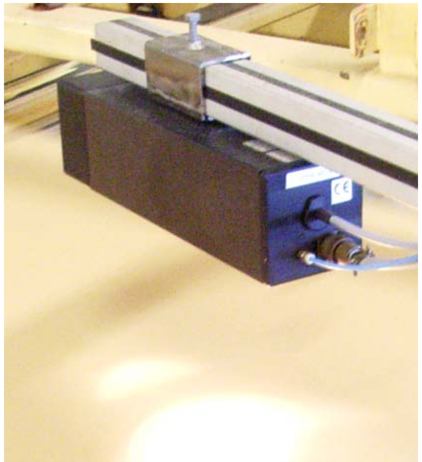


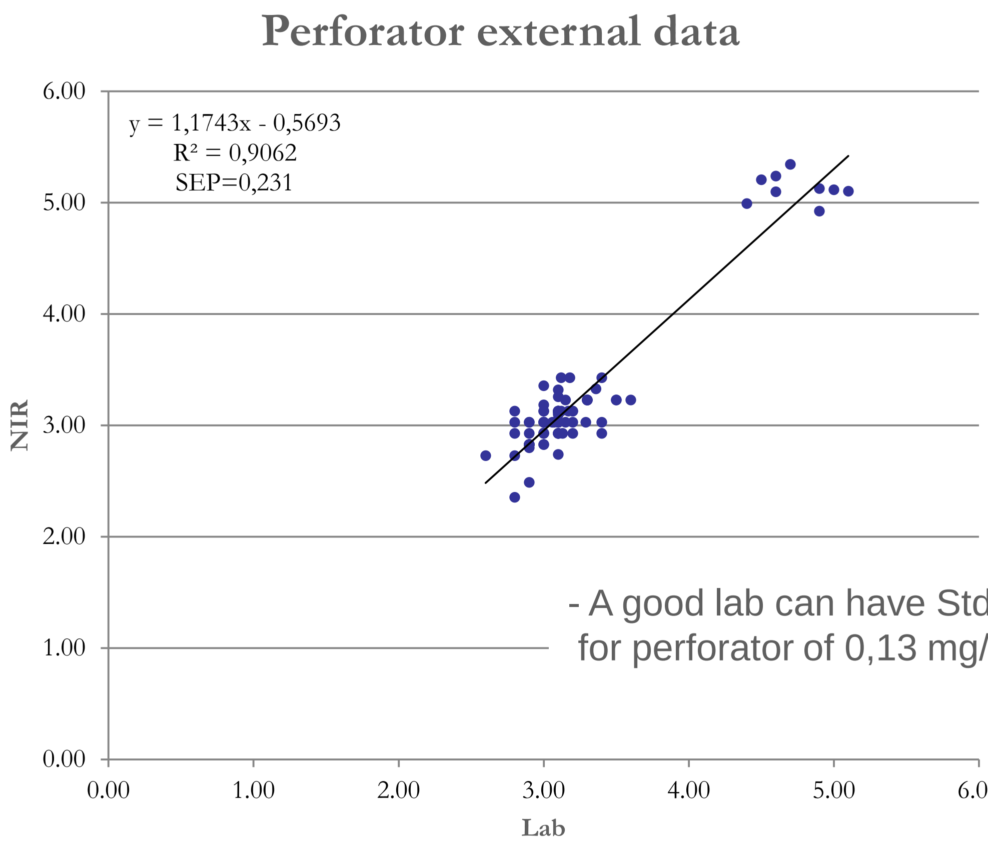
Owen - NIR



Formaldehyde

Perten DA7400

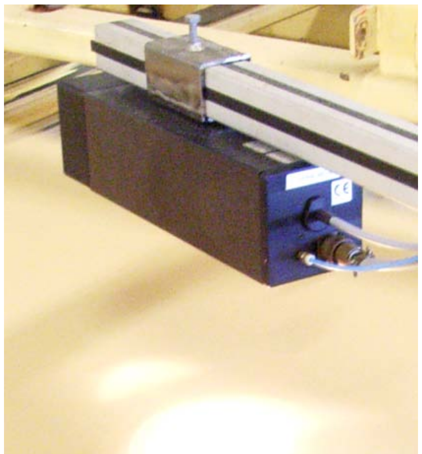


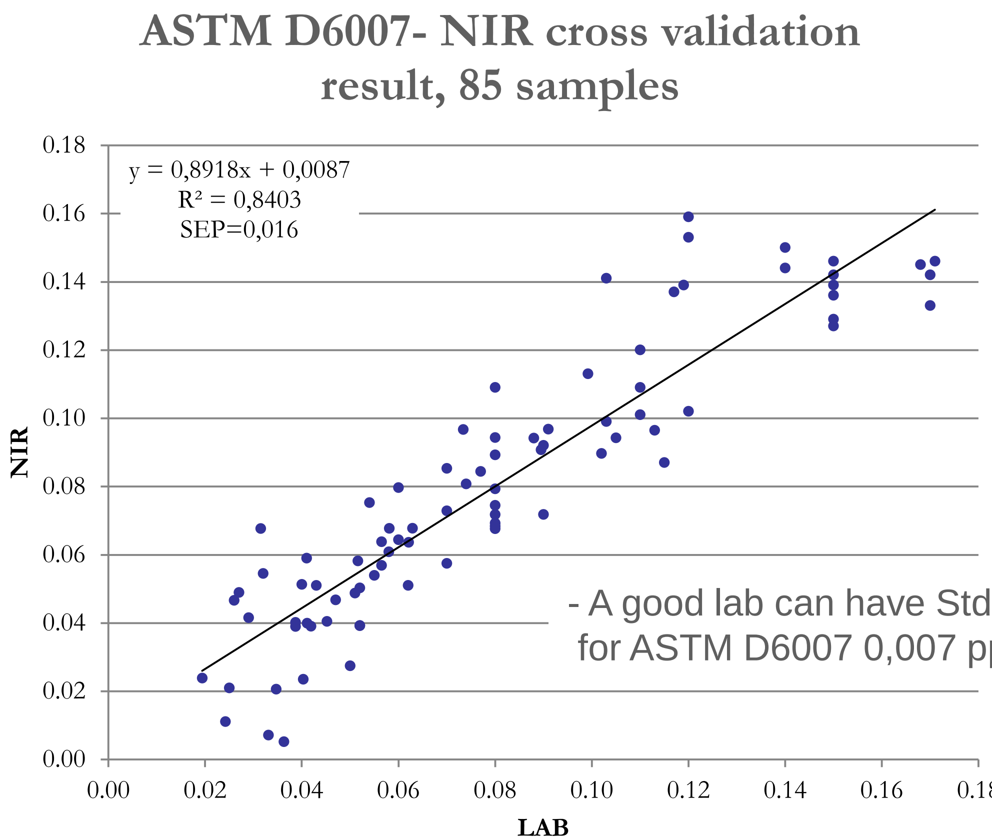


- A good lab can have Std error for perforator of 0,13 mg/100 g

Formaldehyde

Perten DA7400





- A good lab can have Std error for ASTM D6007 0,007 ppm

Formaldehyde

Source of error	ASTM D 6007	NIR	Inpendent/Additive
Sample age	X		Yes
Collection of formaldehyde	X		Yes
Determination of formaldehyde	X		Yes
Sample homogeneity	X	X	No
Spectrometer stability		X	Yes
Side of board scanned		X	Yes
Calibration error		X	Yes

Summary

- Process modelling with PLS is doable
  - Calibration works but is a challenge
  - Implementation – main challenge

- Comparing calibrated data with reference values
  - Sources of error are independent and additive

- Formaldehyde NIR calibrations
  - Calibrations with SEP compared Std error of reference method are now available

Thank you!