SEFPRO
BRIGHTER SOLUTIONS TOGETHER

GS GROUP OF COMPANIES

GS GLASS SERVICE

FLAMMATEC Combustion Technologies

F.I.C. (UK) LIMITED

Industry 4.0+

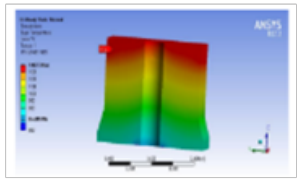
Decarbonisation Through AI-Powered Batch Monitoring and Model-Based Predictive Control *(ESIII)* for Electric and Gas-Fired Furnaces

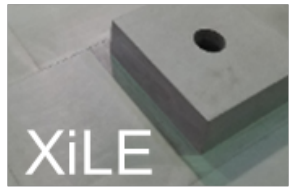
Glassman 14.5.2025

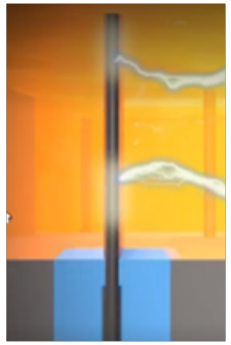
SEFPRO – GLASS SERVICE: TECHNICAL SYNERGIES

REFRACTORY SOLUTIONS

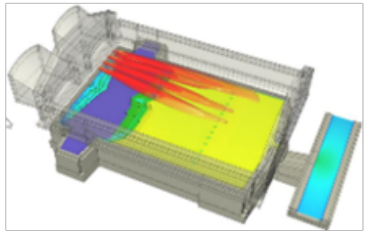
Electrode Holder + Block = Electric heating solution

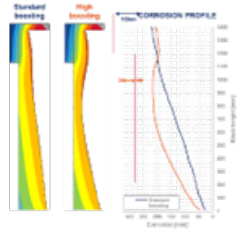




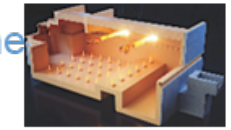


CORROSION FEATURES IN MODELLING





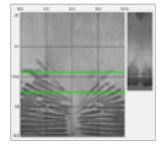
Unique software **solution** to handle all the constraints of new furnace design

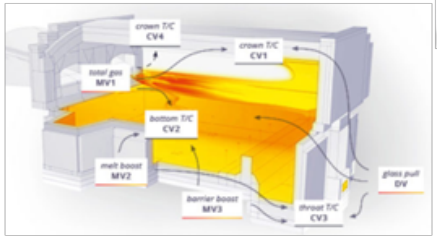


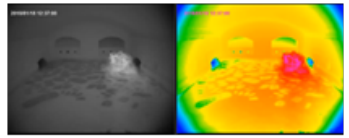
SEFPRO GUARD & EXPERT SYSTEM

Process control solution with real-time **corrosion** assessment

DIGITAL FACTORY / A.I. / SENSORS





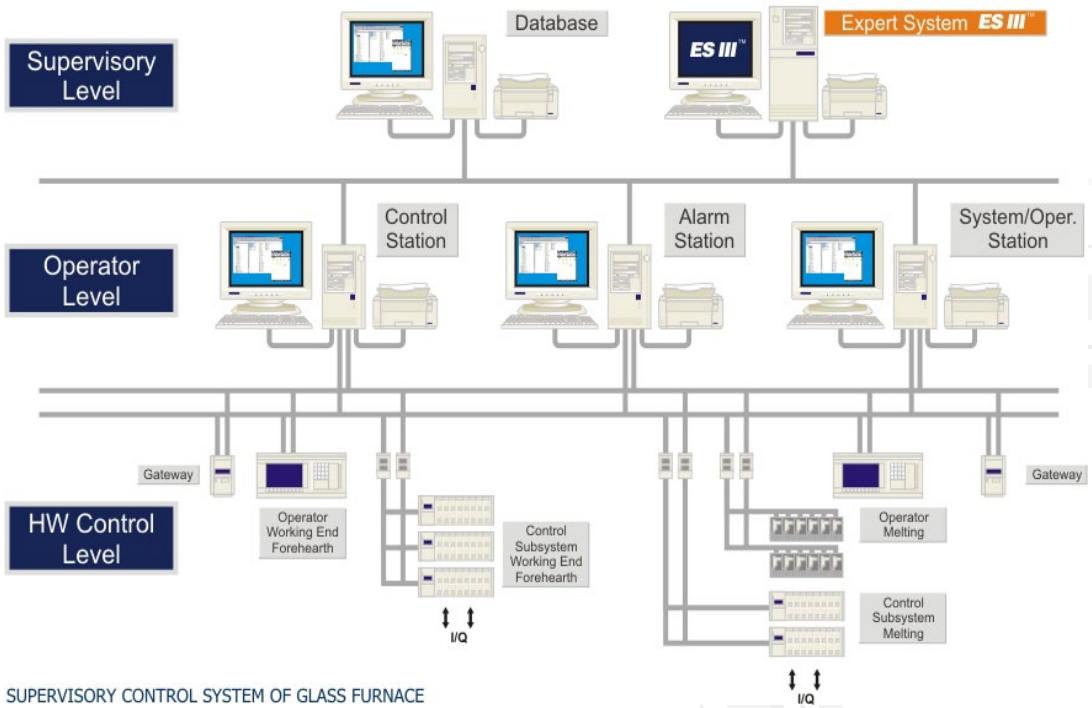


New digital solutions for Smart furnace

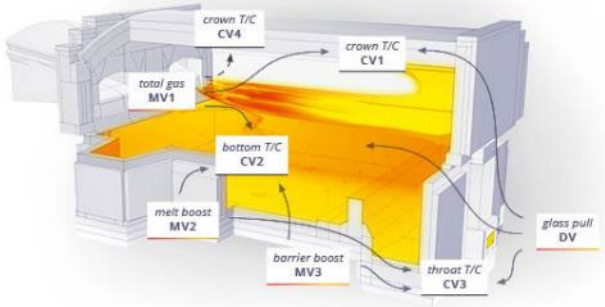
Expert System *ESIII*

Introduction

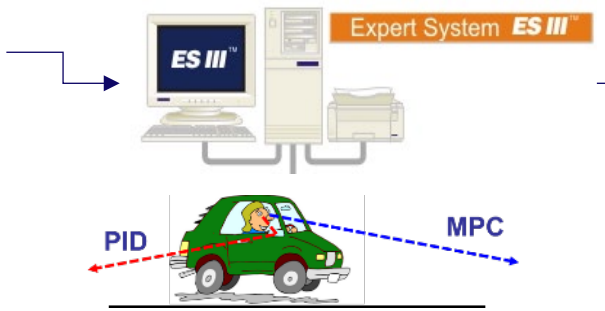
- ***ESIII*: state-of-the-art furnace control software introduced at supervisory level**
- **More than 410 installations worldwide**
- **Model-based predictive control (MPC): correlations between input parameters and resulting process control / target variables**
- **Can be installed in different zones of the furnace**
  - **Melting area ➔ combustion parameters, boosting level, batch feeding**
  - **Forehearth & feeders ➔ heating / cooling intensity and distribution**
- **Specific energy cost calculation & carbon reduction in real-time and online**
- **Reduced risk of human mistakes (>95% control time)**

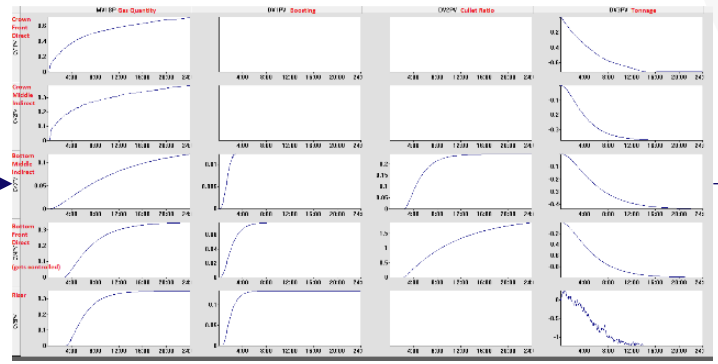


SUPERVISORY CONTROL SYSTEM OF GLASS FURNACE



Current and historical data



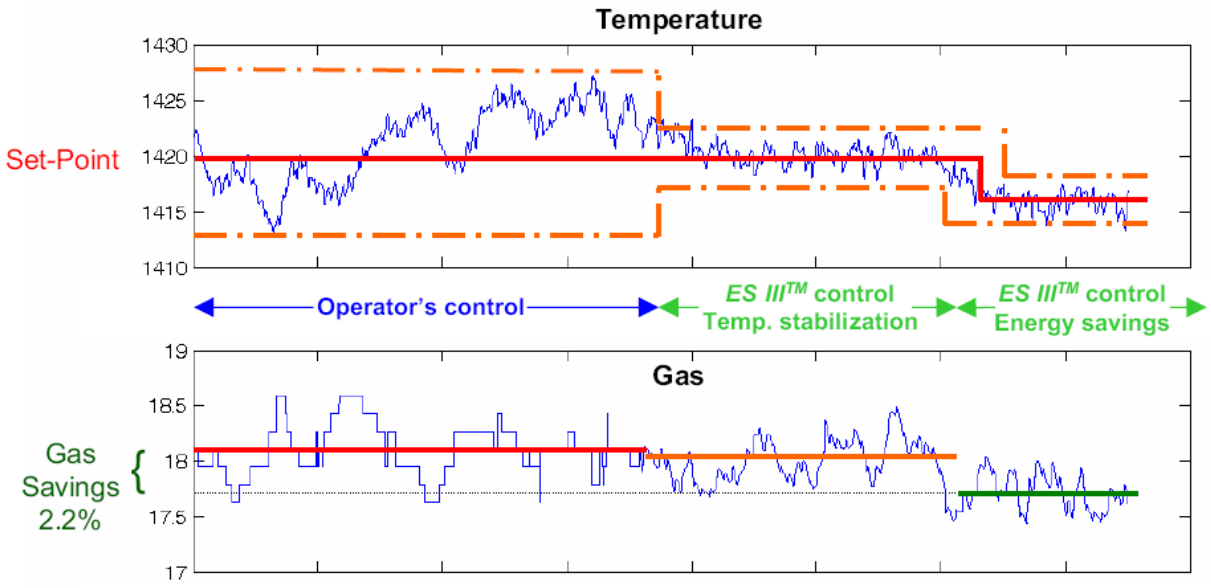

MPC functions

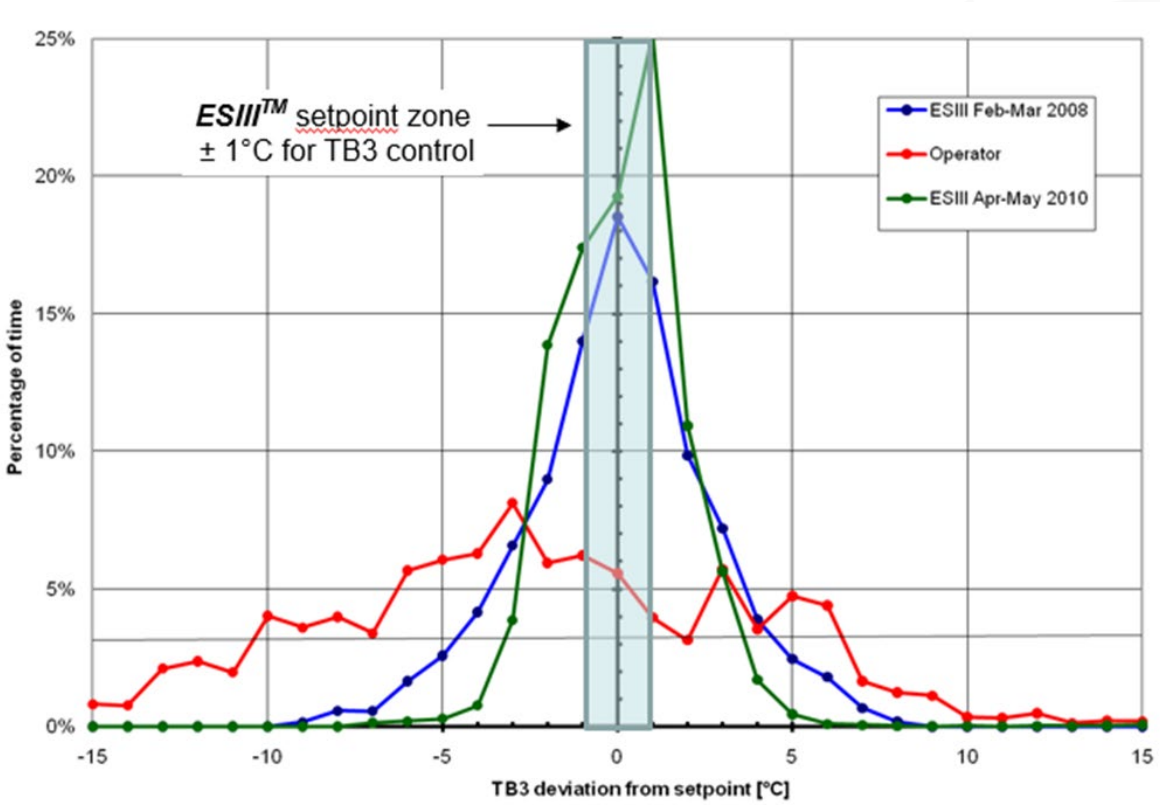
Glass quality

Expert System *ESIII*

Glass melting

- Preserves energy and temperature profiles
- Better process stability
- Rapid and optimal adjustment to change in glass pull
- Gas / E-boost cost minimize controller
- Energy savings: 2-4%





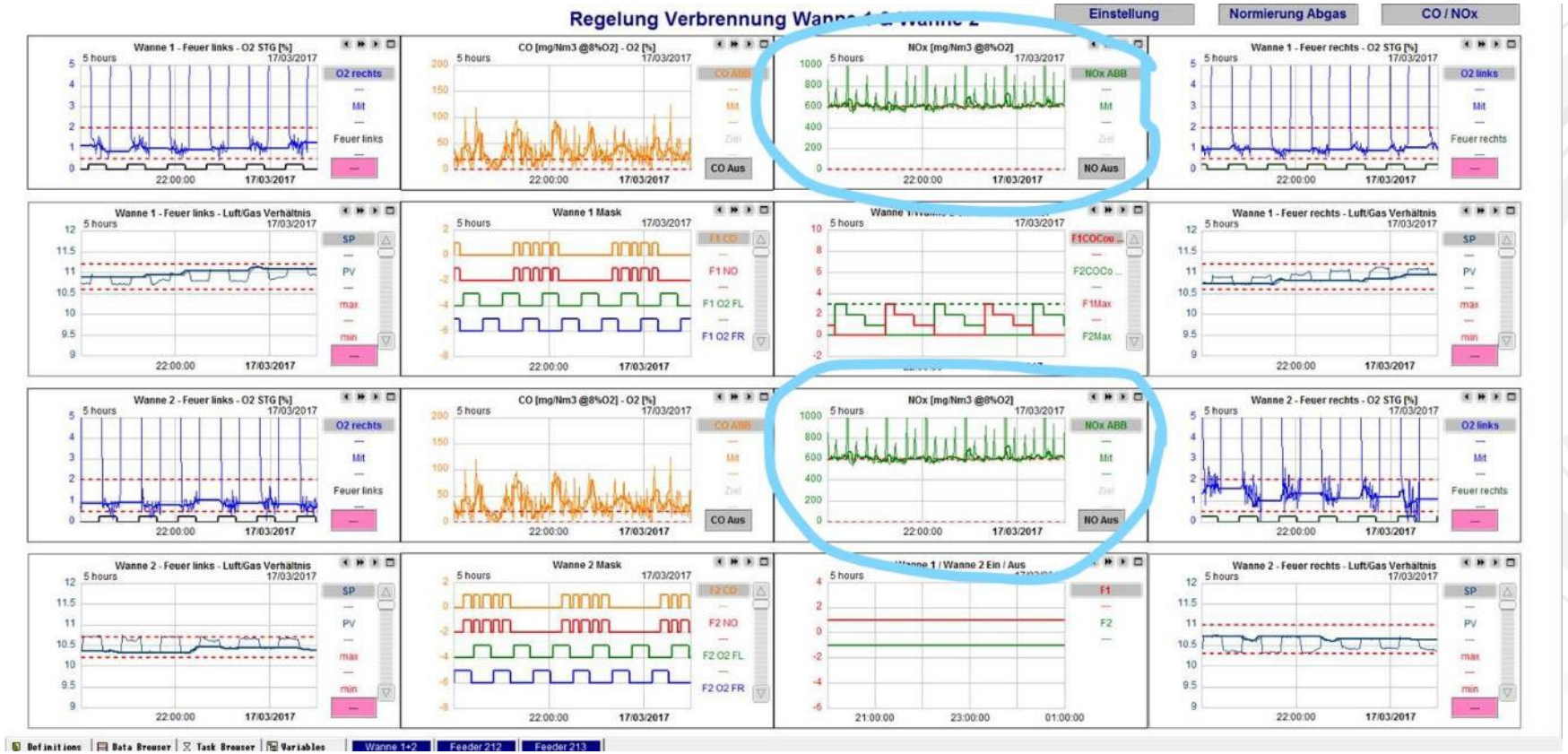
TB3 tolerance	Operator	ESIII™ (old furnace)	ESIII™ (new furnace)
± 2 °C	19.6%	64.8%	74.4%
± 4 °C	44.5%	91.6%	97.4%

Expert System *ESIII*

Glass melting – Extended combustion & emission control design

- Requires O_2, CO and NO_x on-line sensors at port neck, regenerator or stack
- Minimization of NO_x emissions
- Reduction of residual CO

NOx reduced and maintained at 600 mg/Nm3



Expert System *ESIII*

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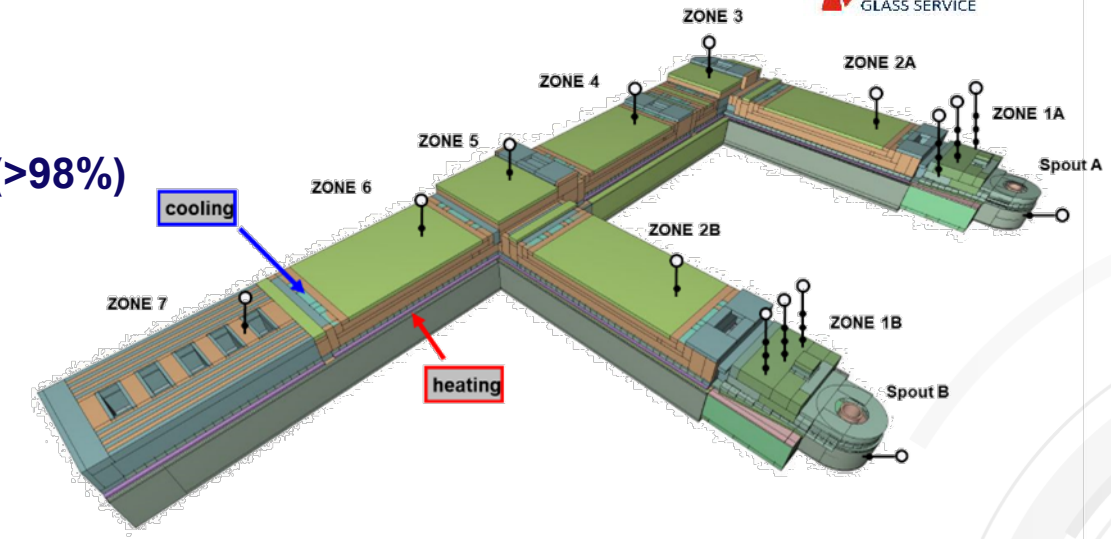
Expert System *ESIII*

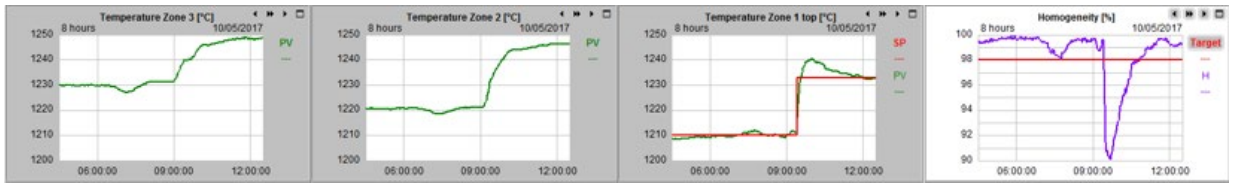
Forehearth & feeders

- Improved glass temperature stability and homogeneity (>98%)
- Significant gains in production yield
- Reduction of energy consumption
- Attenuation of job change impact
  - Minimize downtime by feeder preconditioning
  - Faster temperature stabilization

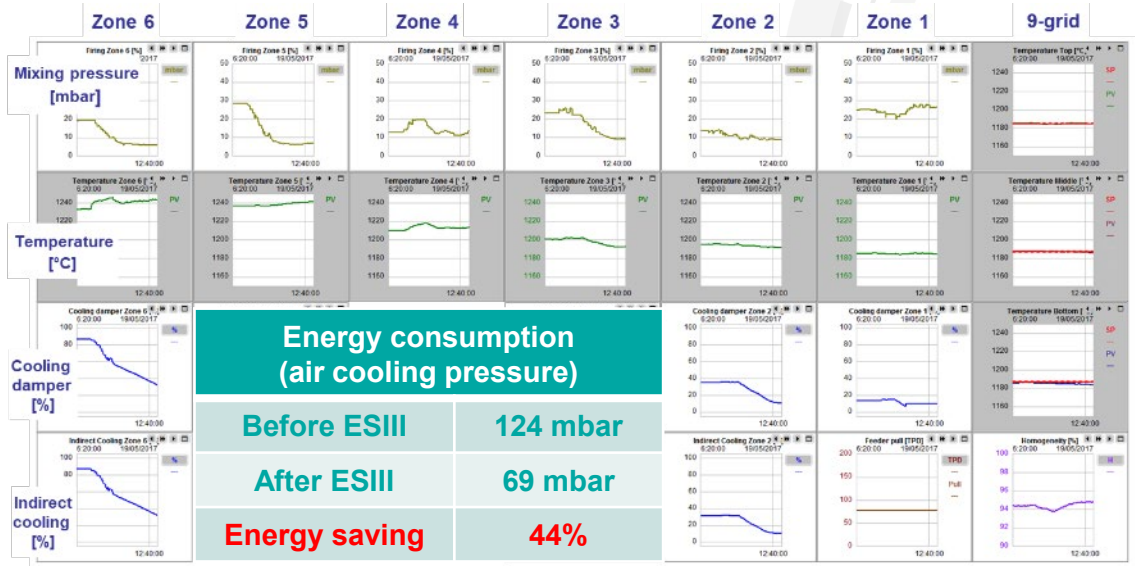


ESIII	Feeder 1	Feeder 2	Feeder 3	Feeder 4
	ESIII ON	ESIII ON	ESIII ON	ESIII ON
Article nummer	1264	3259	6358	2534
Feeder Pull	80.6 t/d	43.5 t/d	60.3 t/d	52.8 t/d
Production Setpoint	1200 °C	1190 °C	1194 °C	1210 °C
Temperature	1200.1 °C	1189.8 °C	1194.2 °C	1210.0 °C
New Feeder Pull	70.5 t/d	51.6 t/d	84.6 t/d	58.9 t/d
New Production Setpoint	1187 °C	1238 °C	1220 °C	1174 °C
Job Change	25.05.2017 07:00	25.05.2017 09:30	24.05.2017 06:00	26.05.2017 08:45
	Start	Start	Start	Start
Preconditioning	30 min.	56 min.	45 min.	51 min.

Operator input



Cooling minimization – Energy savings



Energy consumption (air cooling pressure)	
Before ESIII	124 mbar
After ESIII	69 mbar
Energy saving	44%

Expert System *ESIII*

Forehearth & feeders

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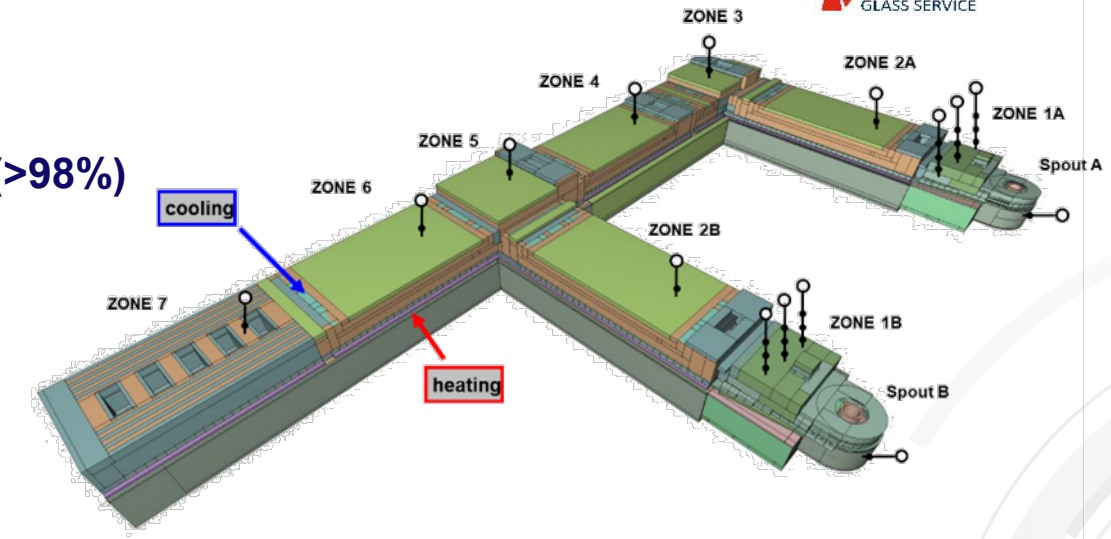

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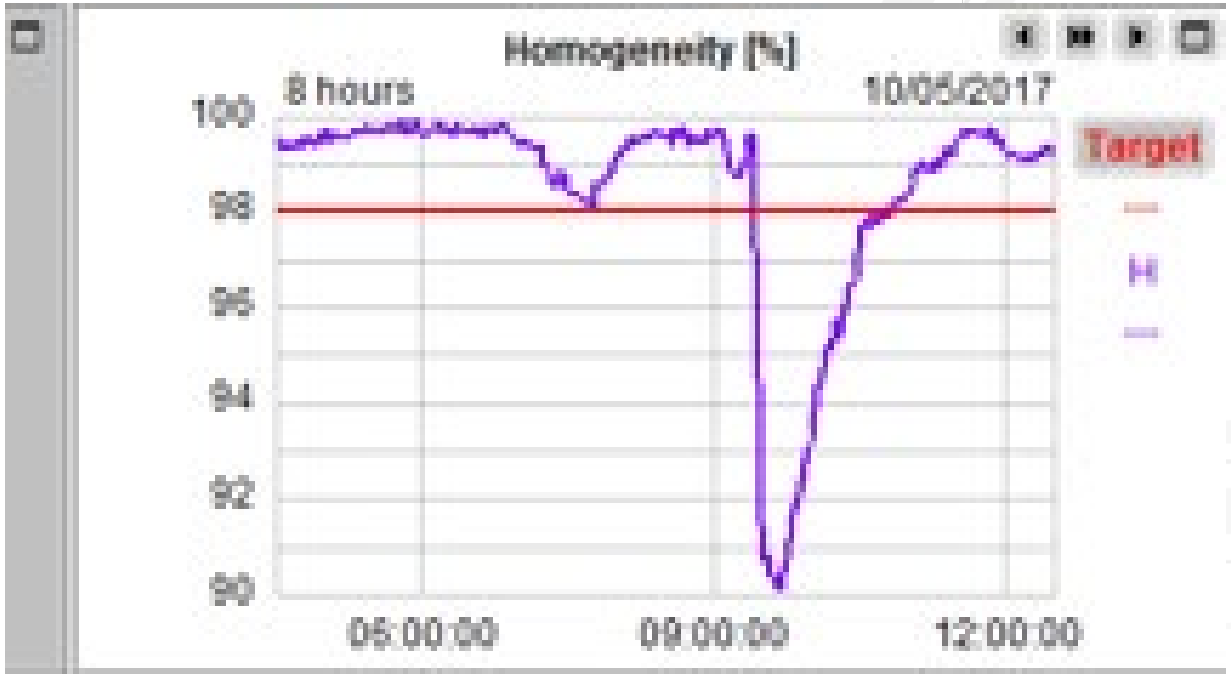


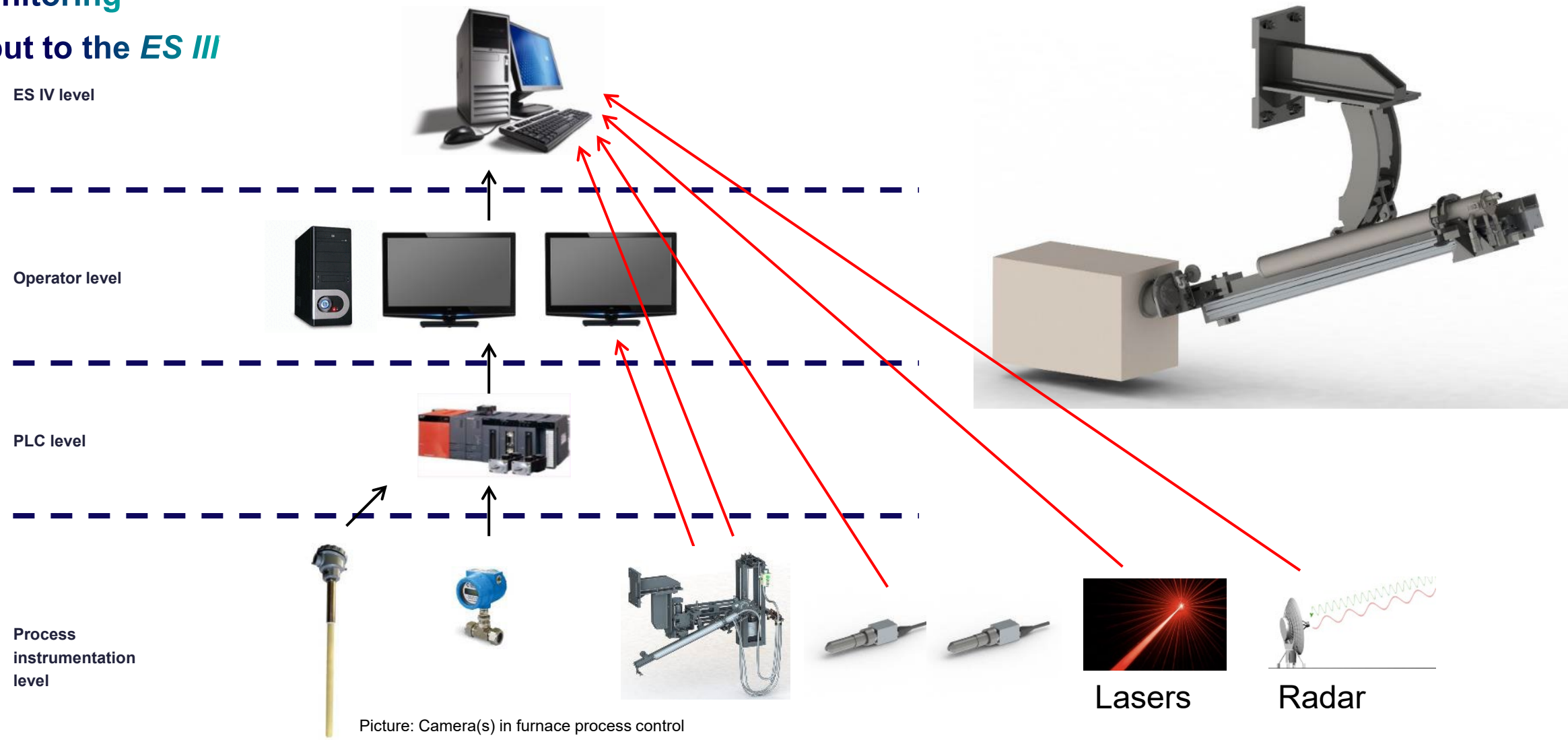
Camera & Sensor info is forwarded into *ESIII*

Computer for digital NN image analysis

The camera is like 5 Million AI T sensors
The AI checks and validates Temp values

Monitoring

Input to the *ES III*

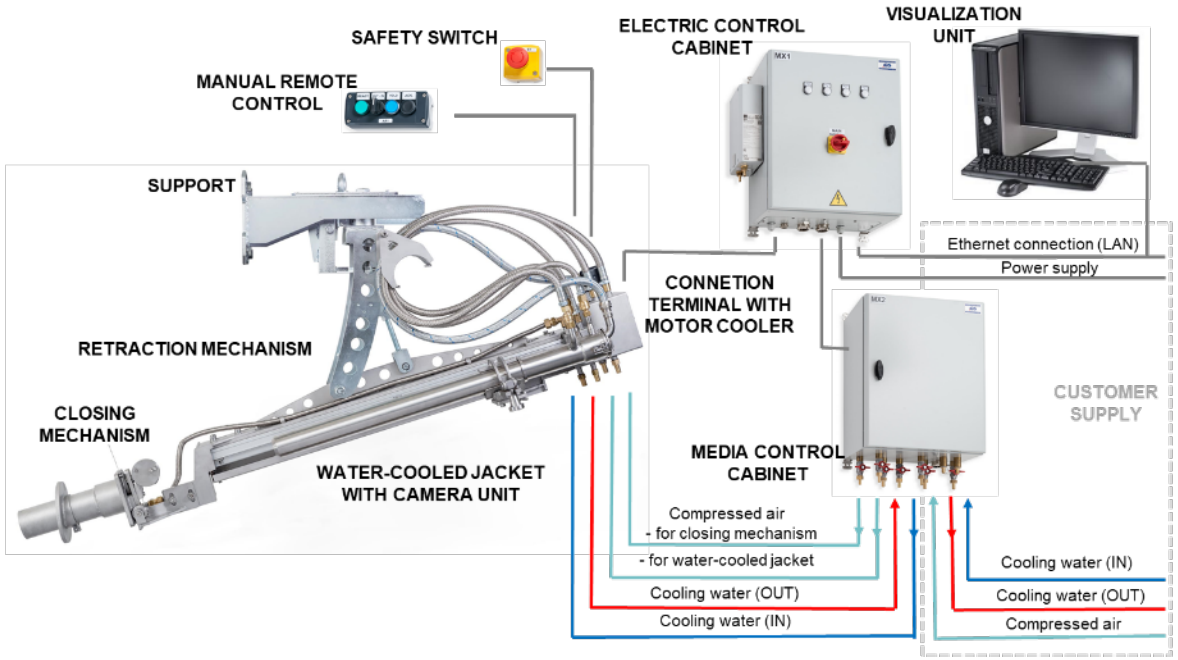


Picture: Camera(s) in furnace process control

Near infrared camera (NIR)

Introduction

- Highest resolution (5 mega pixel) camera for batch monitoring
- Possible to connect to furnace control (PLC / SCADA, *ESIII*)
- High-quality stainless steel jacket construction (1600°C max)
- Lens cleaning by air nozzles at the front of the jacket
- AI (Neural network) Image Software

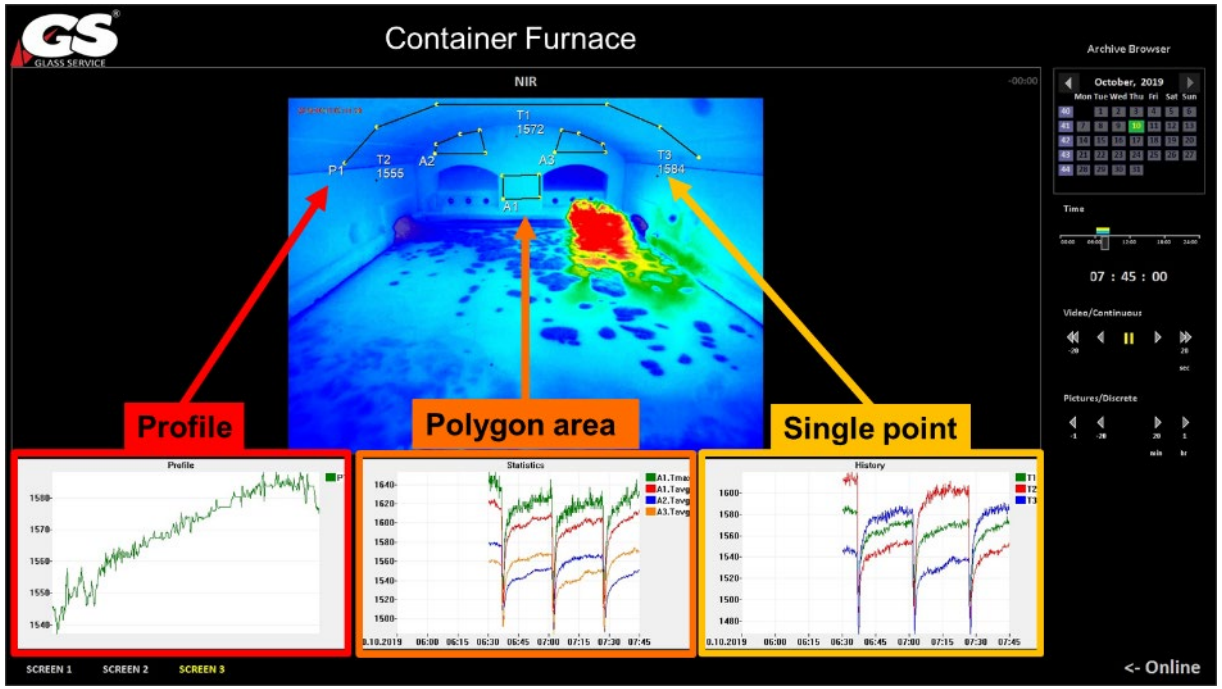


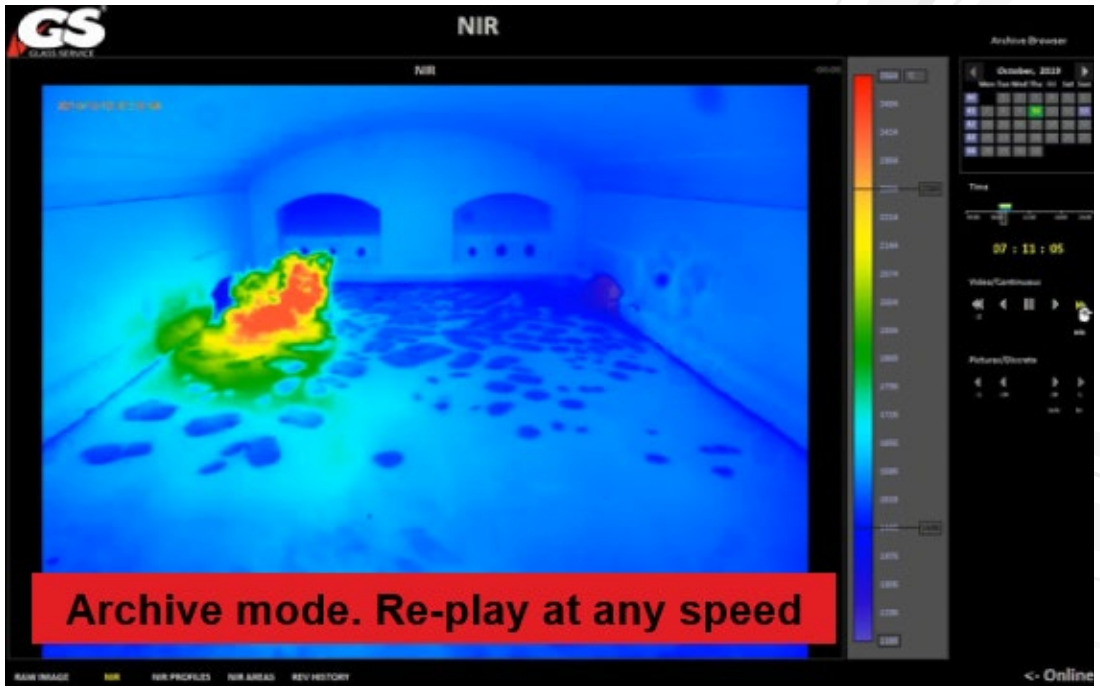
Near infrared camera (NIR)

Furnace Vision Suite software – Primary module

- IR temperature measurements (point, area, profile)
- Color scale (including grey scale)
- Image brightness/contrast adjustment
- Zoom

- Delayed view
- Archive (synchronized fast forward/backward replay)
- Multiple displays
- Export of measurements and pictures to file
- TCP/IP server-client architecture (multiple Browsers)





Near infrared camera (NIR)

Furnace Vision Suite software – AI batch monitoring module

- Includes all Primary and AI Temperature module features
- Batch line position measurement
- Batch distribution for every single user defined region
- Batch distribution behind predefined check-lines
- Critical batch isles positions measurement
- Glass surface bird's eye view transformation
- Batch movement pattern
- Bubbler monitoring – size and functionality (if utilized)

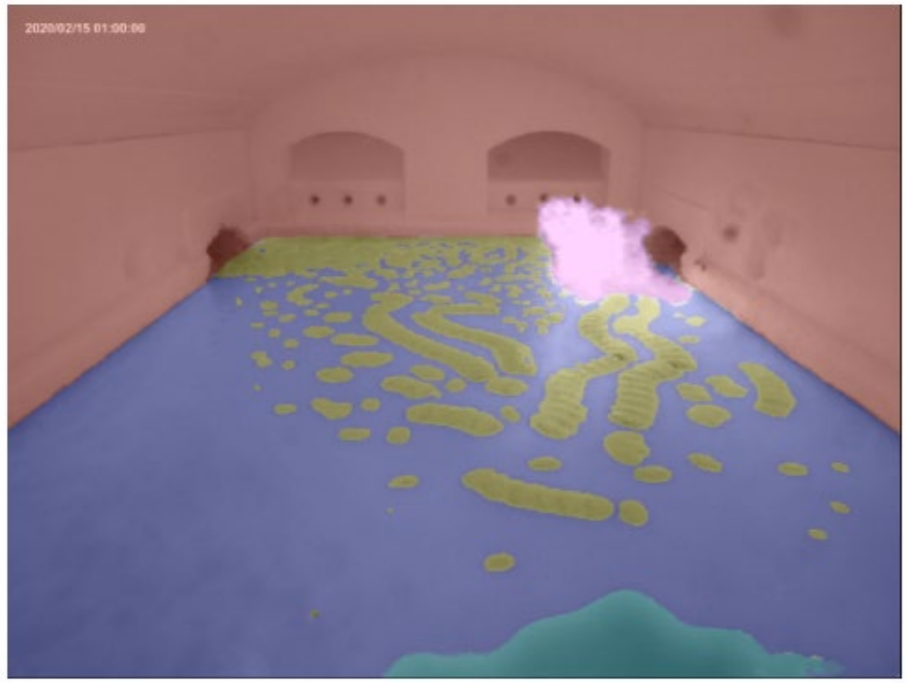
Batch Islands are Identified in yellow

Flame is identified dynamically

Glass Surface is shown as blue

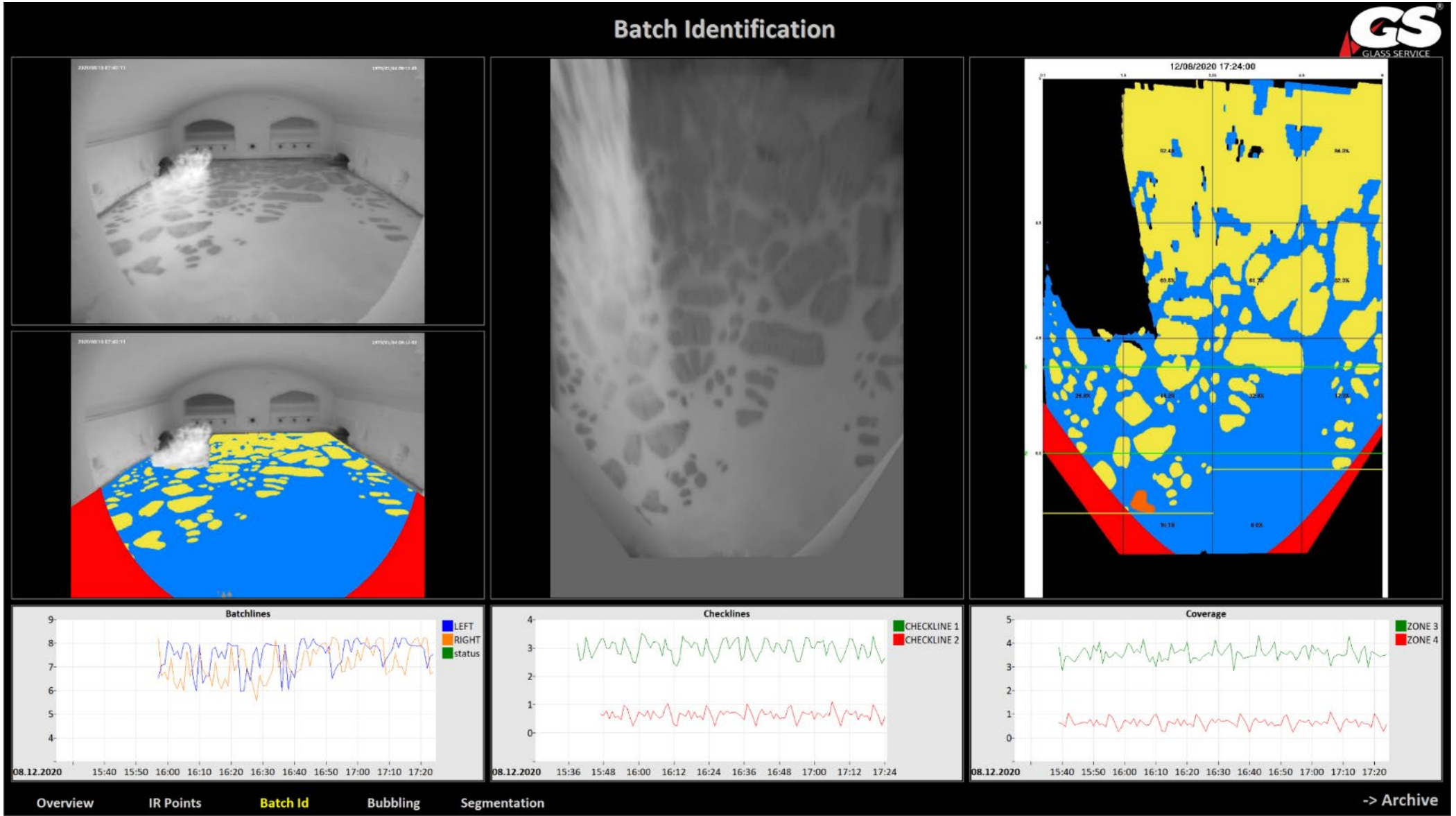
Refractory shown as orange pink

Camera buildup shown in green

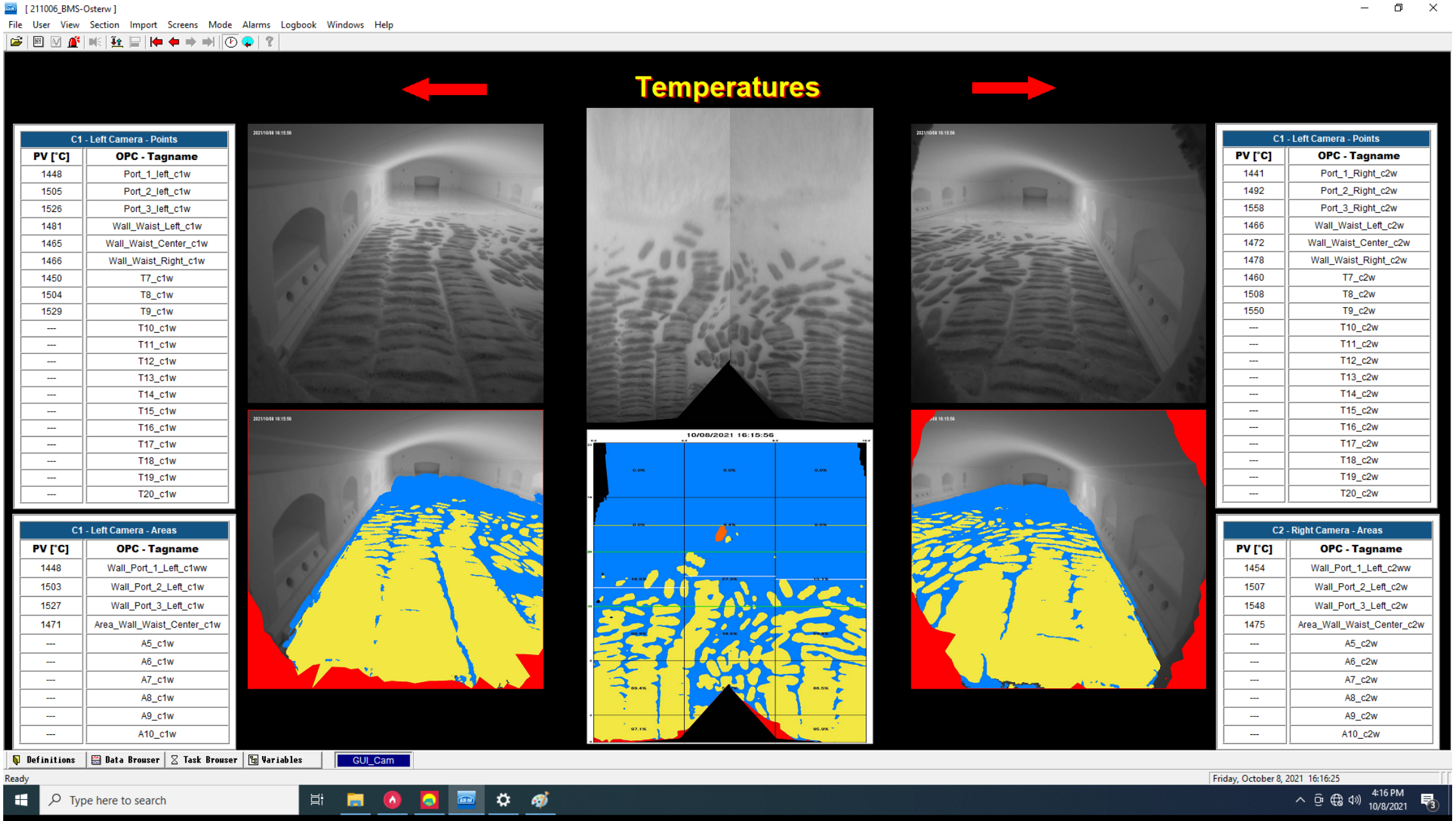


AI Batch Monitoring Module container glass

Glass/Batch Coverage with Historical Trends



Digital Batch Observation on Float furnace batch and Temp



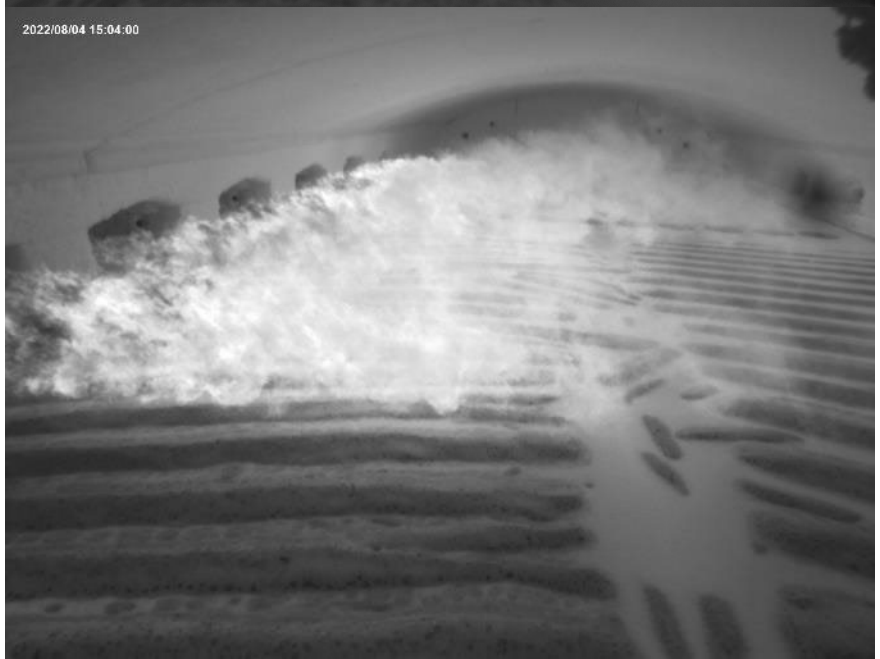
C1 - Left Camera - Points	
PV [°C]	OPC - Tagname
1448	Port_1_left_c1w
1505	Port_2_left_c1w
1526	Port_3_left_c1w
1481	Wall_Waist_Left_c1w
1465	Wall_Waist_Center_c1w
1466	Wall_Waist_Right_c1w
1450	T7_c1w
1504	T8_c1w
1529	T9_c1w
---	T10_c1w
---	T11_c1w
---	T12_c1w
---	T13_c1w
---	T14_c1w
---	T15_c1w
---	T16_c1w
---	T17_c1w
---	T18_c1w
---	T19_c1w
---	T20_c1w

C1 - Left Camera - Areas	
PV [°C]	OPC - Tagname
1448	Wall_Port_1_Left_c1ww
1503	Wall_Port_2_Left_c1w
1527	Wall_Port_3_Left_c1w
1471	Area_Wall_Waist_Center_c1w
---	A5_c1w
---	A6_c1w
---	A7_c1w
---	A8_c1w
---	A9_c1w
---	A10_c1w

C1 - Left Camera - Points	
PV [°C]	OPC - Tagname
1441	Port_1_Right_c2w
1492	Port_2_Right_c2w
1558	Port_3_Right_c2w
1466	Wall_Waist_Left_c2w
1472	Wall_Waist_Center_c2w
1478	Wall_Waist_Right_c2w
1460	T7_c2w
1508	T8_c2w
1550	T9_c2w
---	T10_c2w
---	T11_c2w
---	T12_c2w
---	T13_c2w
---	T14_c2w
---	T15_c2w
---	T16_c2w
---	T17_c2w
---	T18_c2w
---	T19_c2w
---	T20_c2w

C2 - Right Camera - Areas	
PV [°C]	OPC - Tagname
1454	Wall_Port_1_Left_c2ww
1507	Wall_Port_2_Left_c2w
1548	Wall_Port_3_Left_c2w
1475	Area_Wall_Waist_Center_c2w
---	A5_c2w
---	A6_c2w
---	A7_c2w
---	A8_c2w
---	A9_c2w
---	A10_c2w

Digital Batch Observation on Float furnace batch and Temp



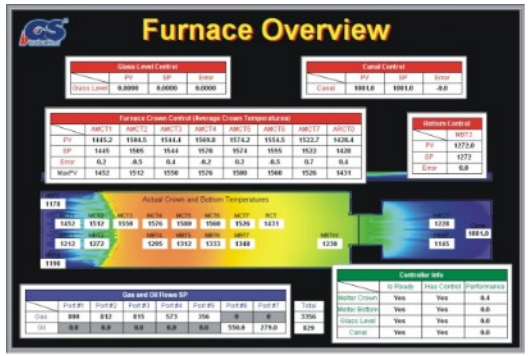
Digital Batch Observation on Float furnace batch and Temp

At the end of pretests there is matrix of significant relations between process inputs and outputs

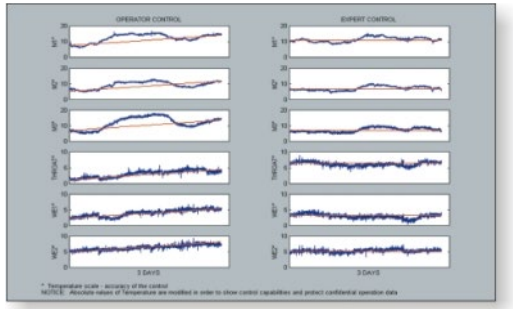
	Gas1SP	Gas2SP	Gas3SP	Gas4SP	Gas5SP	Gas6SP	GLCO	BTU
AMCT1	Dead time: 480 Time const.: 4080 Gain: 0.236	Dead time: 1920 Time const.: 5520 Gain: 0.149					Dead time: 240 Time const.: 1440 Gain: -1.03	Dead time: 240 Time const.: 1200 Gain: 0.396
AMCT2	Dead time: 1920 Time const.: 5520 Gain: 0.159	Dead time: 240 Time const.: 4320 Gain: 0.246	Dead time: 1920 Time const.: 5520 Gain: 0.131				Dead time: 240 Time const.: 1440 Gain: -1.03	Dead time: 240 Time const.: 1200 Gain: 0.396
AMCT3		Dead time: 1920 Time const.: 5520 Gain: 0.159	Dead time: 240 Time const.: 4320 Gain: 0.226	Dead time: 1920 Time const.: 5520 Gain: 0.14			Dead time: 240 Time const.: 1440 Gain: -1.05	Dead time: 240 Time const.: 1200 Gain: 0.495
AMCT4			Dead time: 1920 Time const.: 5520 Gain: 0.159	Dead time: 240 Time const.: 4320 Gain: 0.258	Dead time: 1920 Time const.: 5520 Gain: 0.158	Dead time: 1920 Time const.: 5520 Gain: 0.13	Dead time: 240 Time const.: 1440 Gain: -3.07	Dead time: 240 Time const.: 1200 Gain: 0.99
AMCT5				Dead time: 1920 Time const.: 5520 Gain: 0.159	Dead time: 240 Time const.: 4320 Gain: 0.246	Dead time: 1920 Time const.: 5520 Gain: 0.158	Dead time: 0 Time const.: 2640 Gain: -0.134	Dead time: 240 Time const.: 1200 Gain: 0.297
AMCT6				Dead time: 1920 Time const.: 5520 Gain: 0.131	Dead time: 1920 Time const.: 5520 Gain: 0.167	Dead time: 240 Time const.: 4080 Gain: 0.24	Dead time: 240 Time const.: 1440 Gain: -0.108	Dead time: 240 Time const.: 1200 Gain: 0.099
AMCT7					Dead time: 1920 Time const.: 5520 Gain: 0.13	Dead time: 480 Time const.: 6480 Gain: 0.185	Dead time: 240 Time const.: 1440 Gain: -0.105	Dead time: 240 Time const.: 1200 Gain: 0.0495
AMCT8					Dead time: 2880 Time const.: 5760 Gain: 0.121	Dead time: 480 Time const.: 6480 Gain: 0.175	Dead time: 240 Time const.: 1440 Gain: -0.105	Dead time: 240 Time const.: 1200 Gain: 0.0495
AMCT9					Dead time: 2880 Time const.: 5760 Gain: 0.111	Dead time: 480 Time const.: 7440 Gain: 0.157	Dead time: 240 Time const.: 1440 Gain: -0.105	Dead time: 240 Time const.: 1200 Gain: 0.0495

Digital Batch Observation on Float furnace batch and Temp

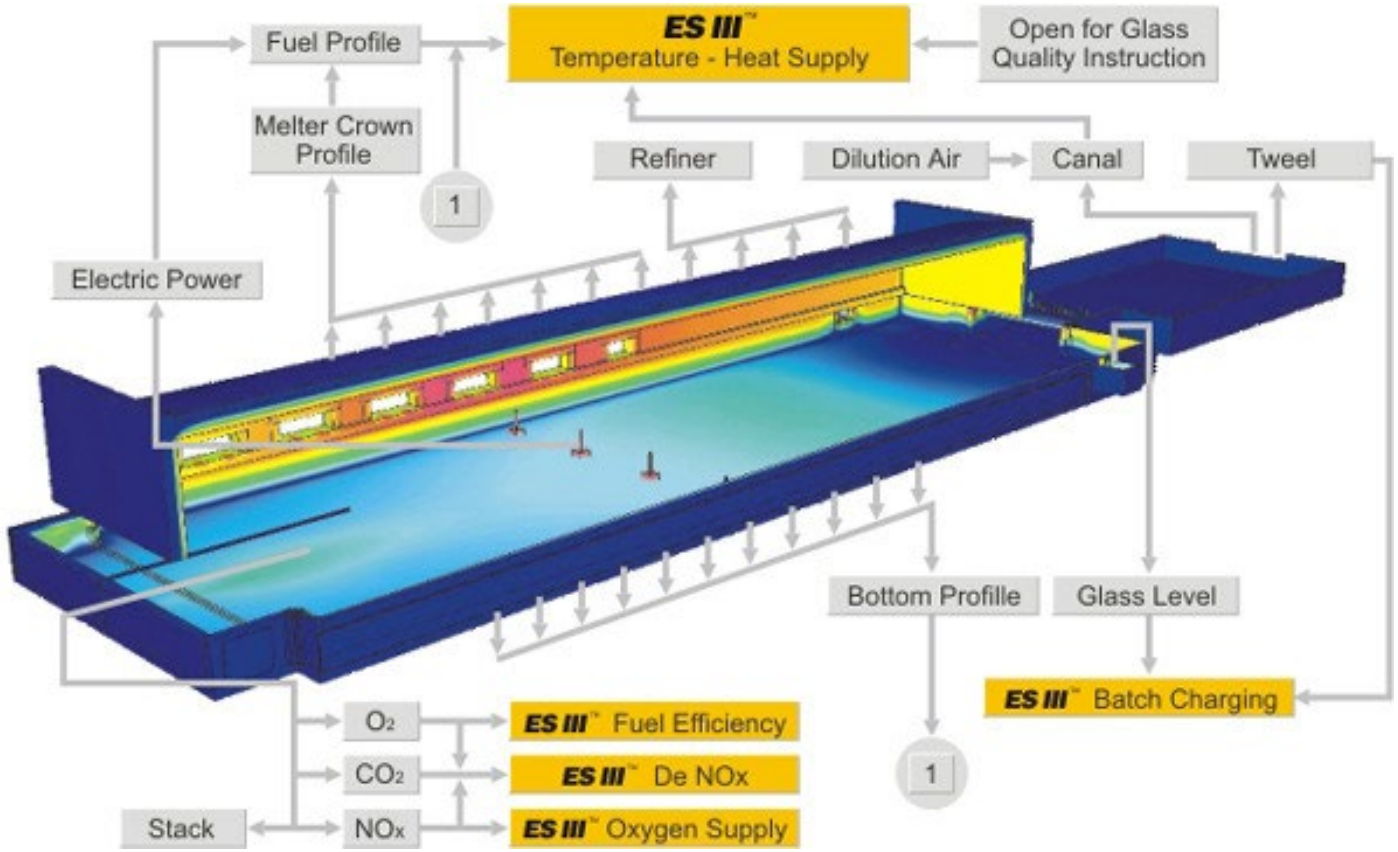
- Supervisory Advanced Control System
- Advanced control
- Improved Furnace Operation
- Stabilization of Process
- Optimization of Energy Consumption



FLOAT FURNACE

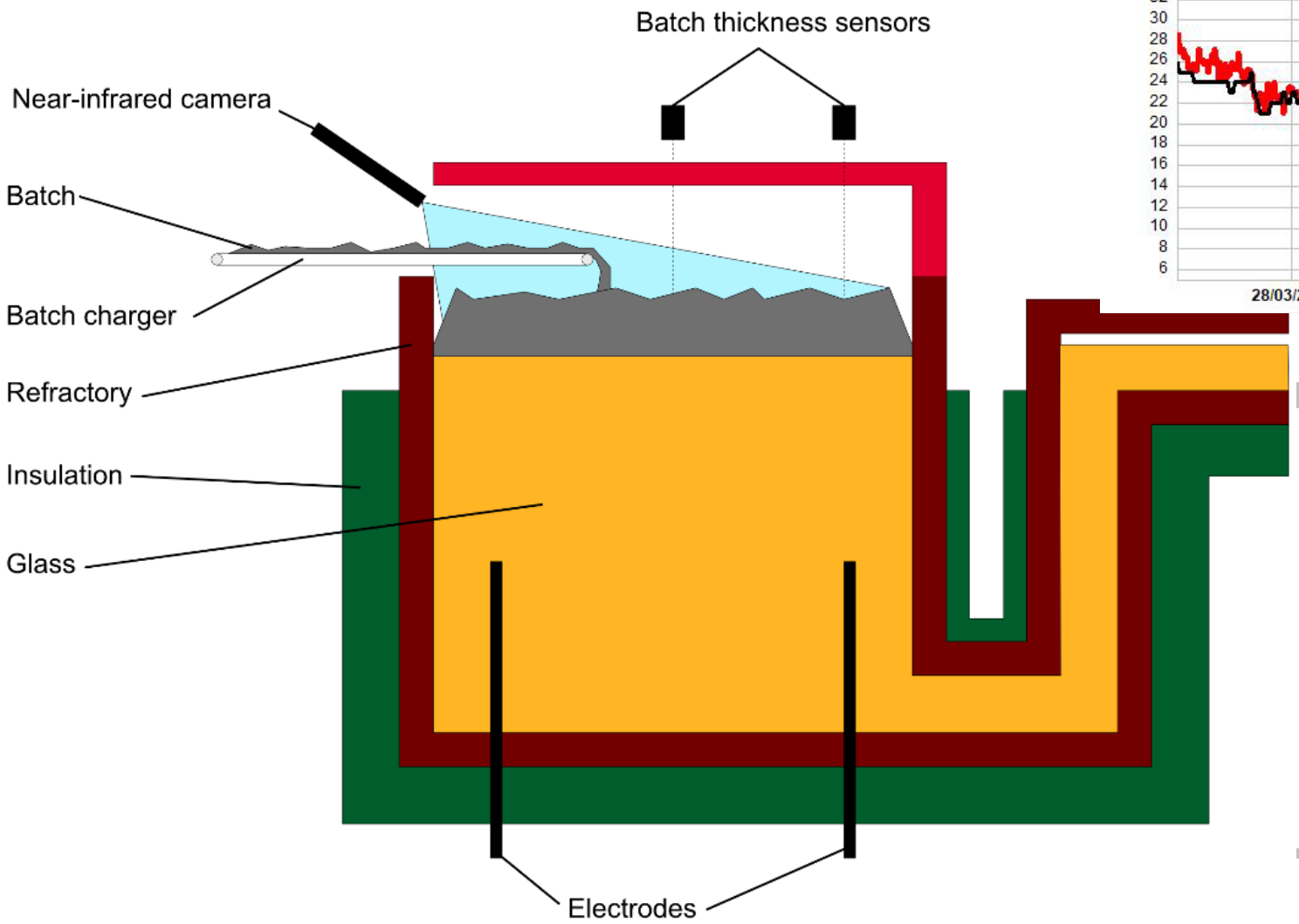


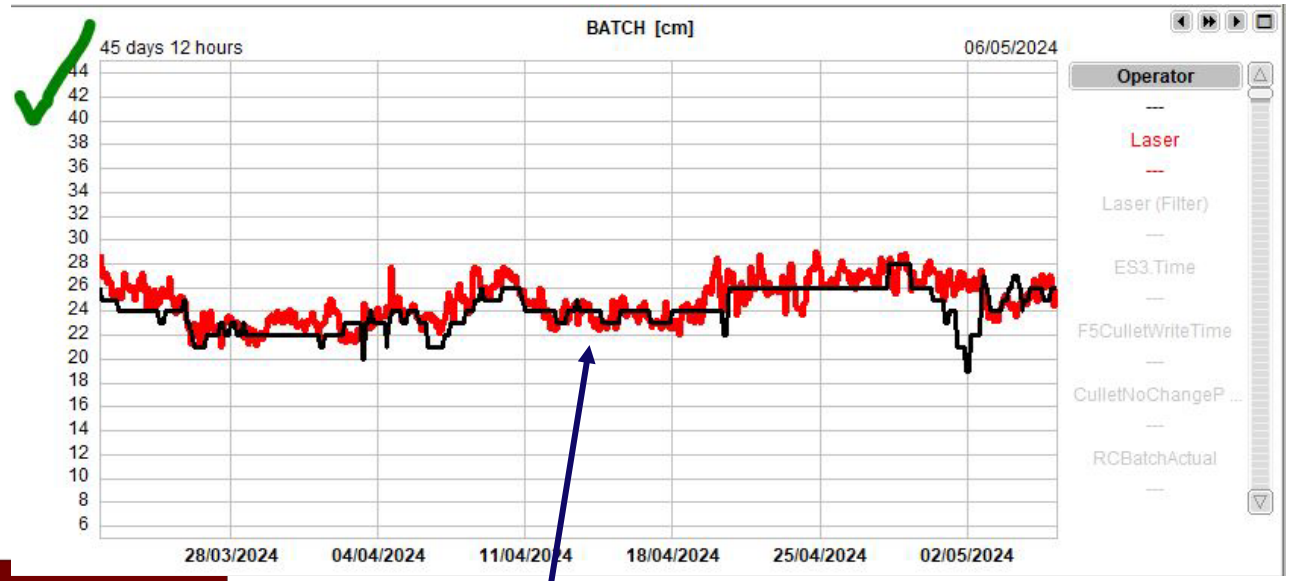
ES III™ BOTTOM TEMPERATURE CONTROL
MELTER (M) AND WORKING END (WE)



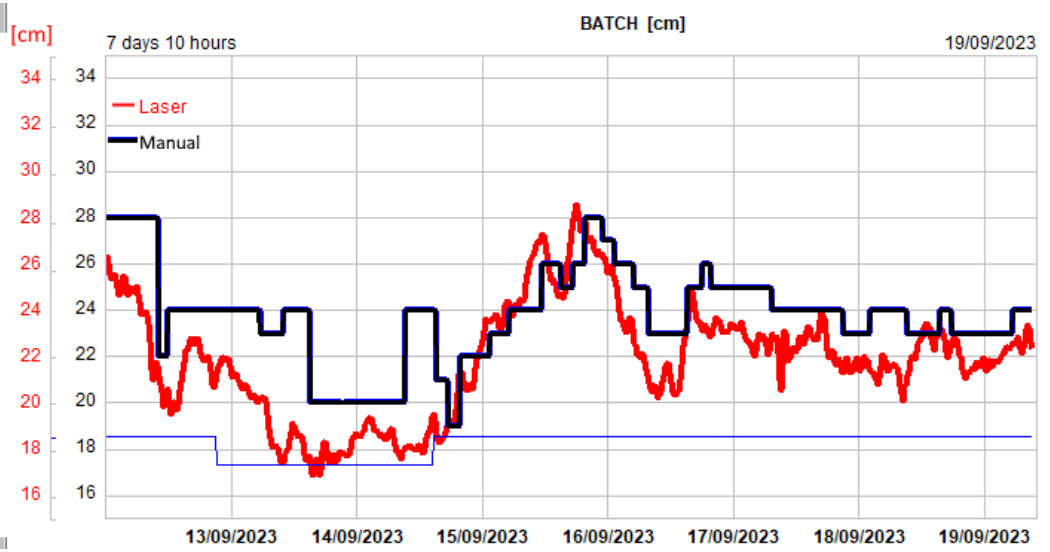
Laser & camera batch crust thickness measurement system

For all electric cold top melters





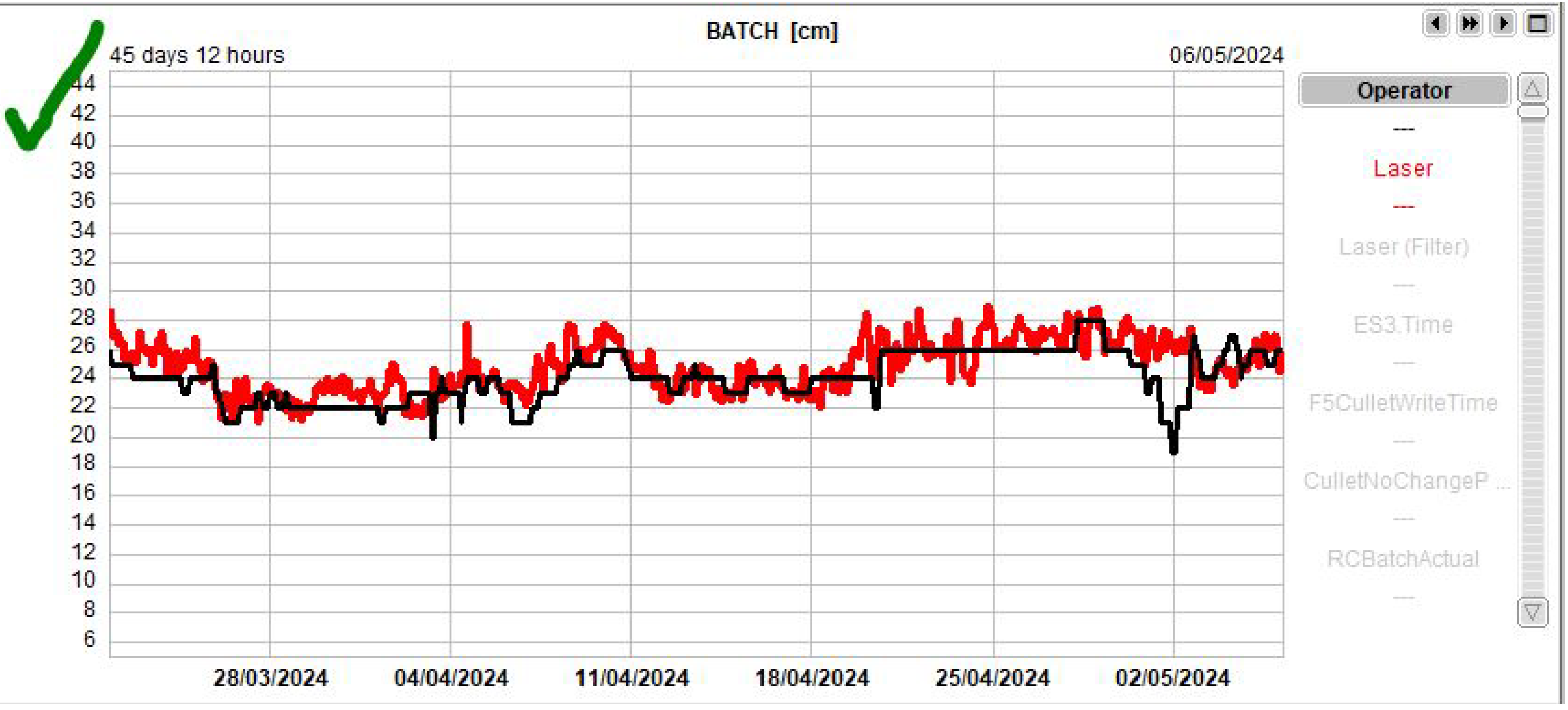
After BBMS and ESIII Control



BEFORE

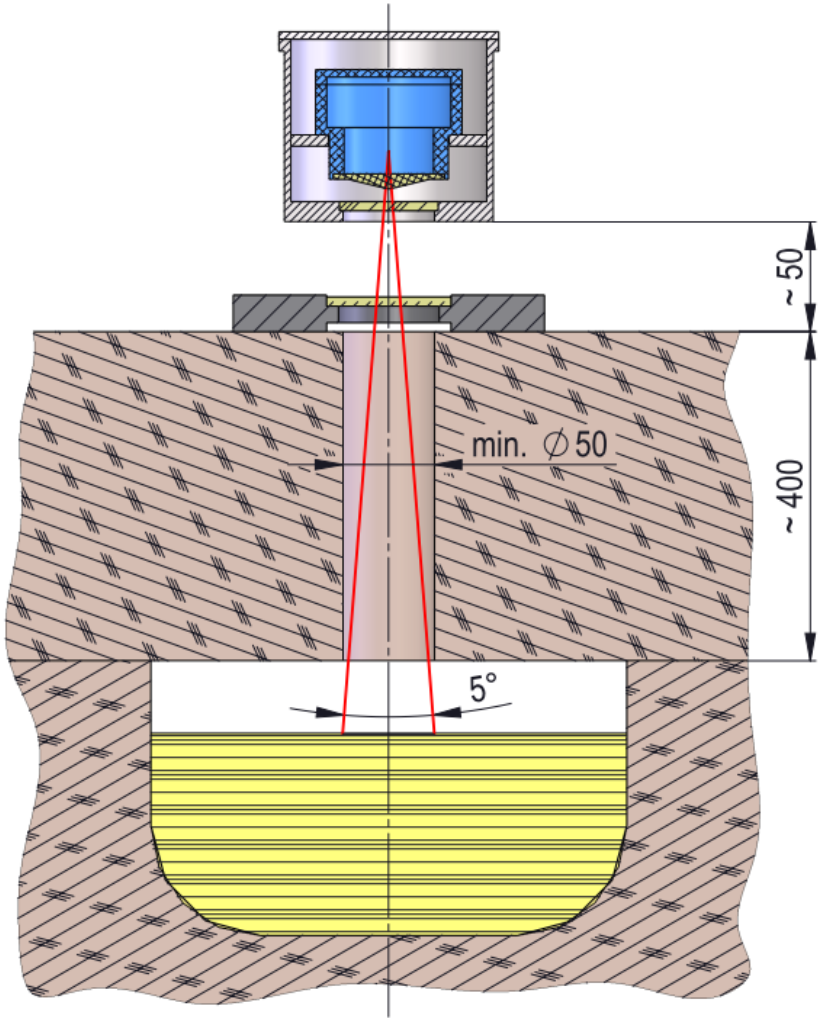
Laser & camera batch crust thickness measurement system

For all electric cold top melters



BASIC DATA SHEET OF GLASS LEVEL RADAR SENSOR

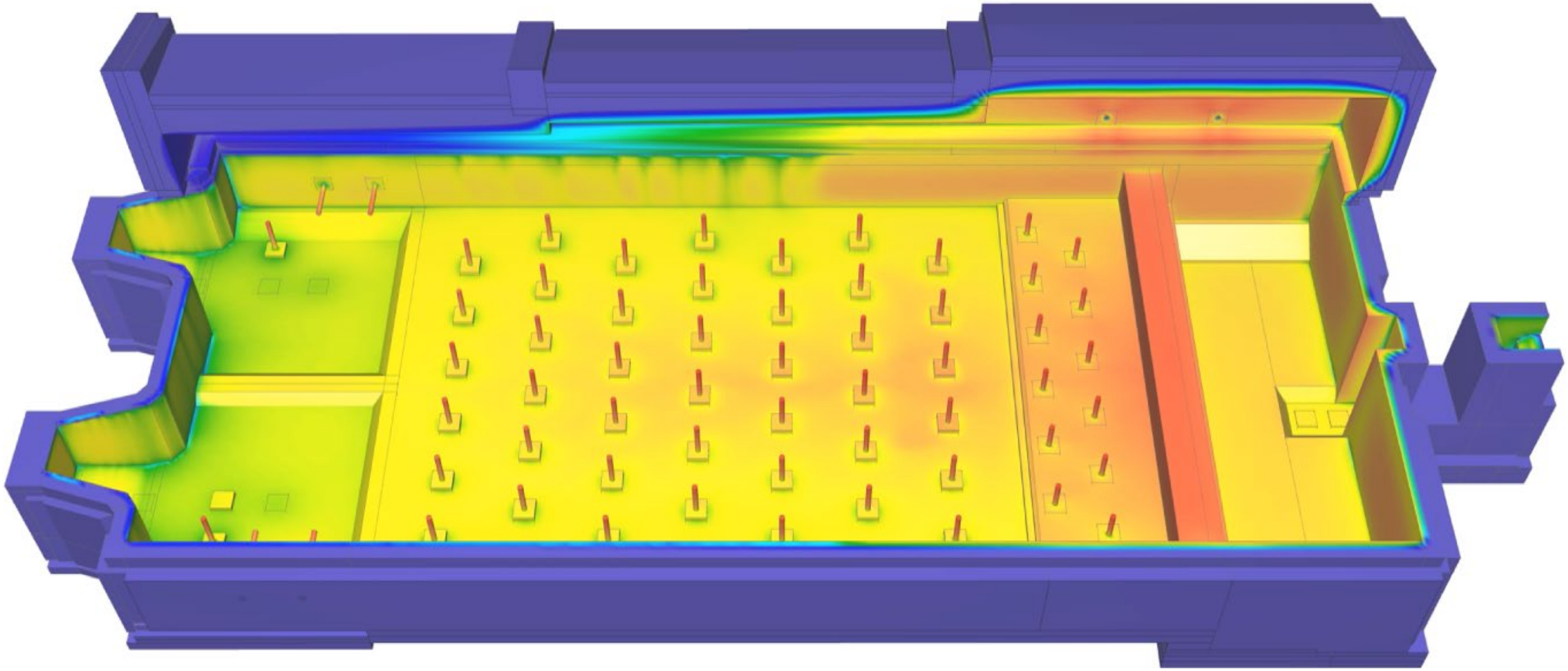
- Contactless radar sensor
- Operating frequency: Around 80 GHz
- Beam angle: 5°
- Detection distance: Up to 8 m
- Resolution: 0.03 mm or better
- Accuracy: +/- 0.2 mm or better
- Sampling frequency: 10 Hz



Radar sensor location proposal

Ideal to make cost optimization of gas versus FIC super boost

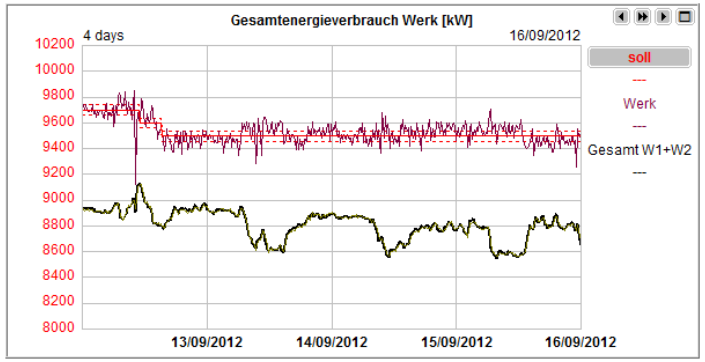
Example on a Hybrid melter

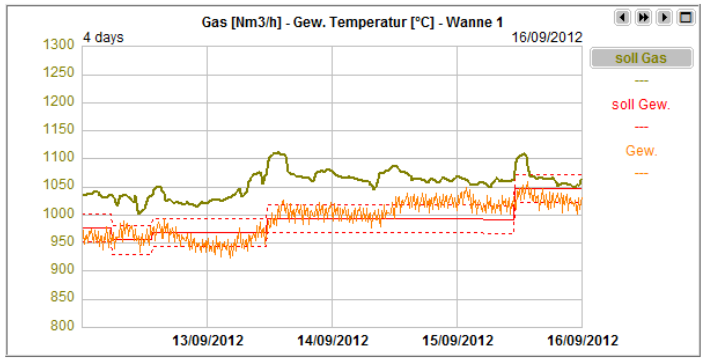


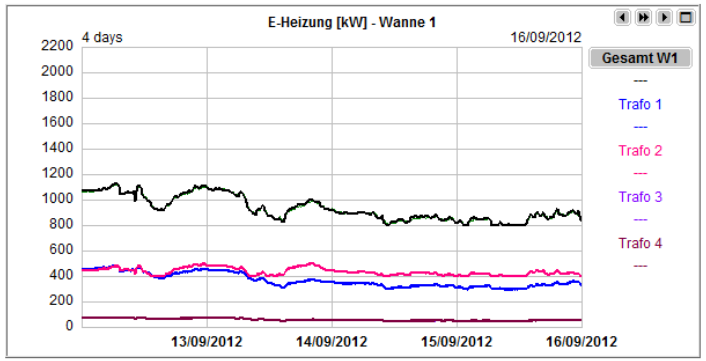
ESIII™ ENERGY MANAGEMENT SYSTEM

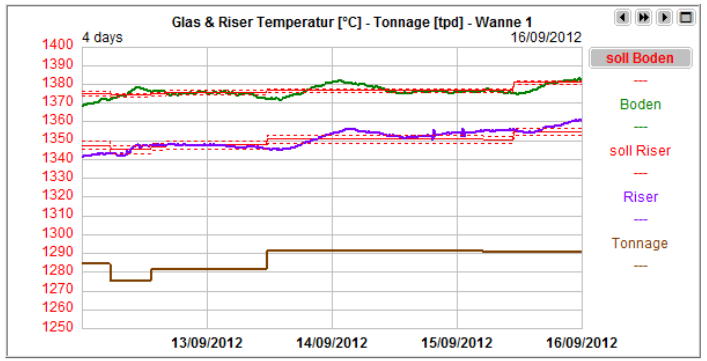
Use more boost when Electricity costs are low and less when costs are up

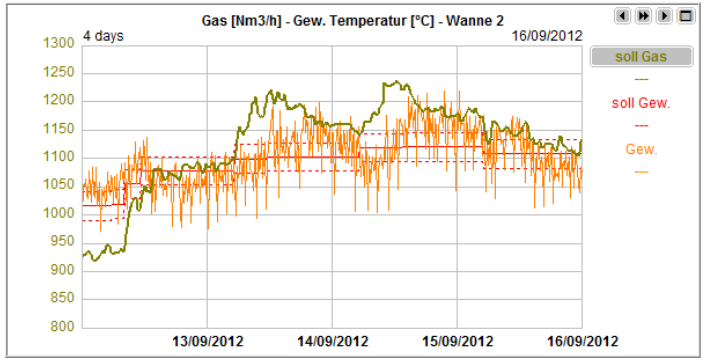
Example 2 large E boost furnaces at one location optimized by *ESIII*

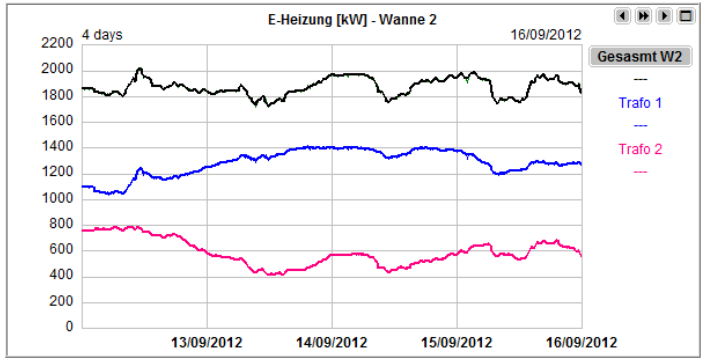


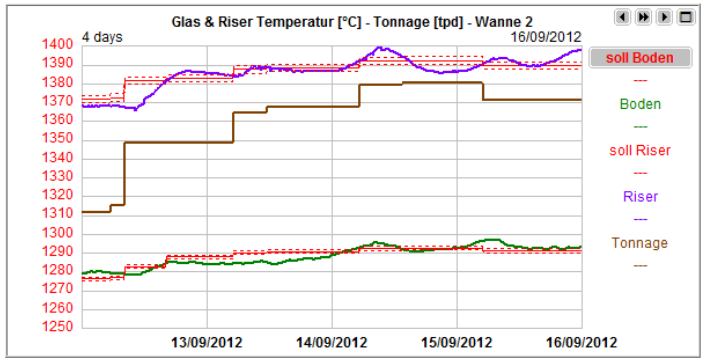






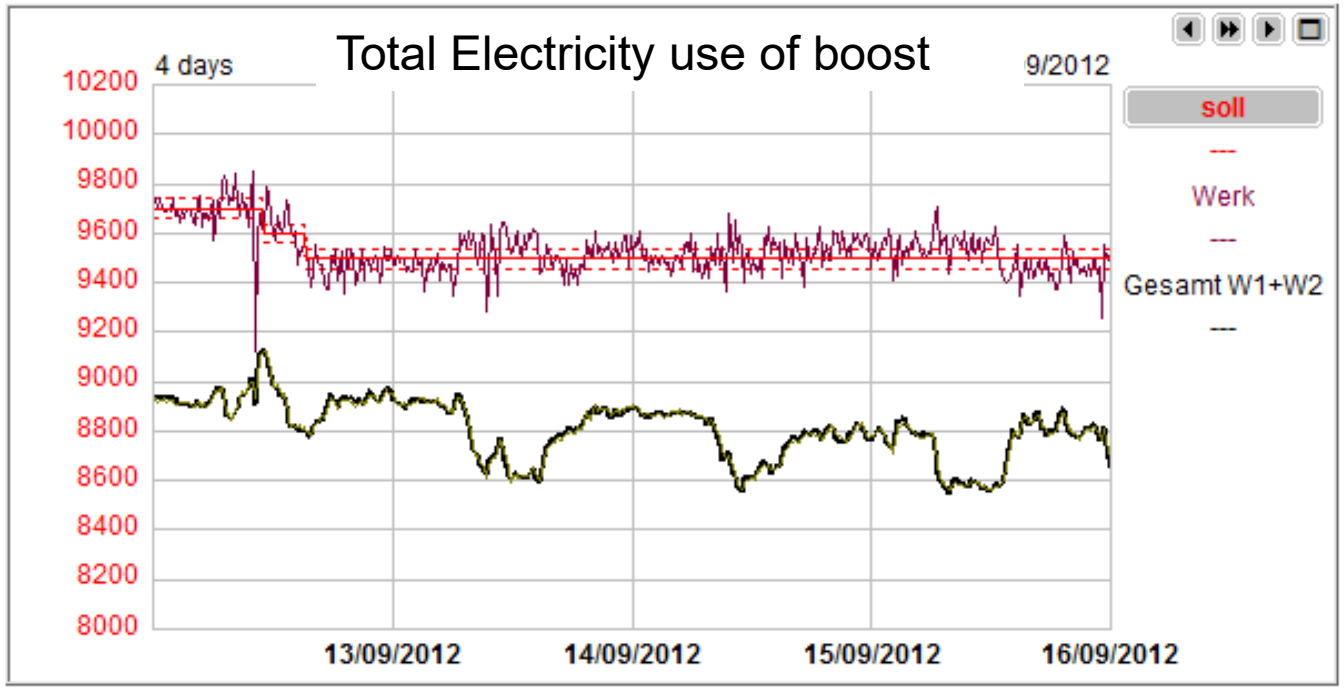


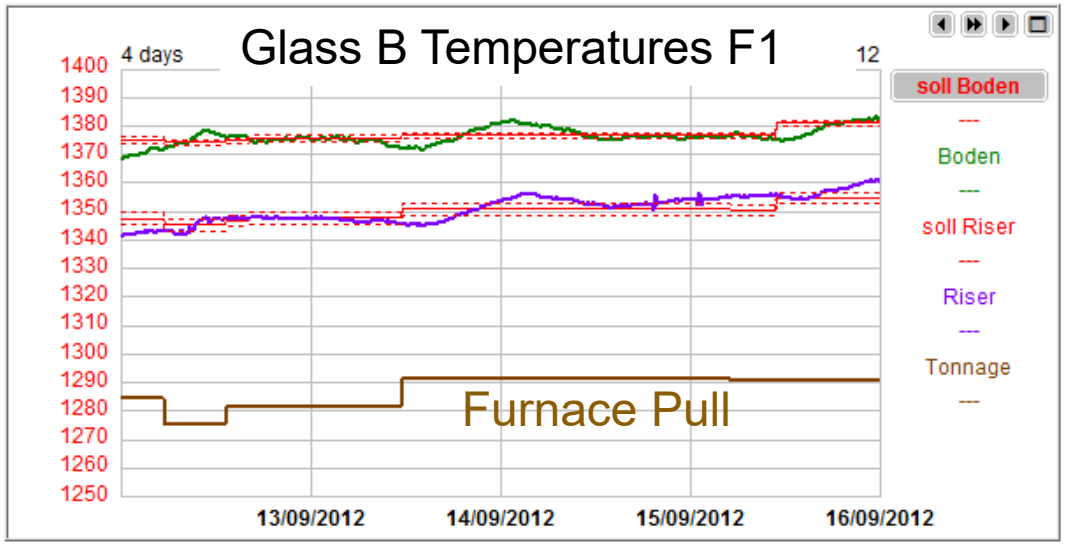


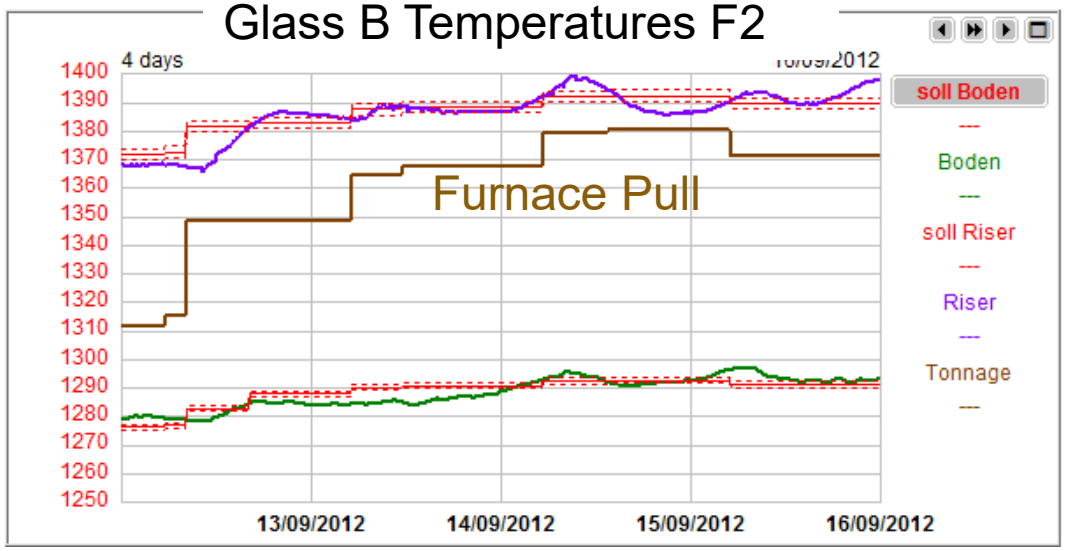


ESIII™ ENERGY MANAGEMENT SYSTEM

Use more boost when Electricity costs are low and less when costs are up







ESIII™ Online Energy cost and carbon reduction analysis
Energy cost savings in range of 100-300 k€ p.y.

Specific Energy

Sample 1 - Base sample. Historic period of manual furnace control (From - To)
Sample 2 - Historic period of ESIII furnace control (From - To)
Sample 3 - Recent period of ESIII furnace control (Last x days)

Select time samples		
Sample 1	16.09.2018	15.11.2018
Sample 2	15.11.2018	24.12.2018
Sample 3	100	

Aging compesation	Nominal Date	Aging Coef.
On	01.03.2018	1.00%

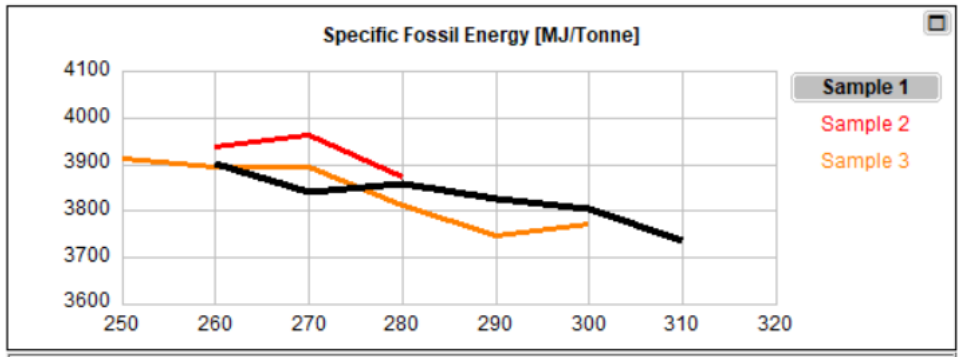
Cullet compensation	Nominal Cullet	Cullet Coef.
On	50%	0.25%

Energy Prices [EUR/ ...	
Electricity	0.09120
Gas	0.02681

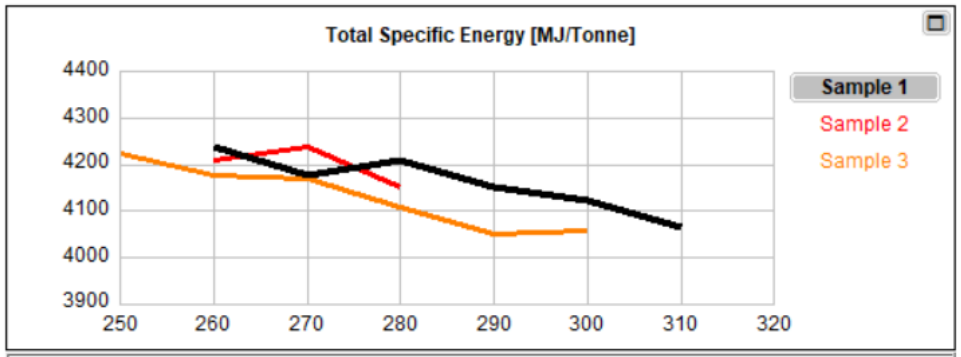
Update now.

-3.8%

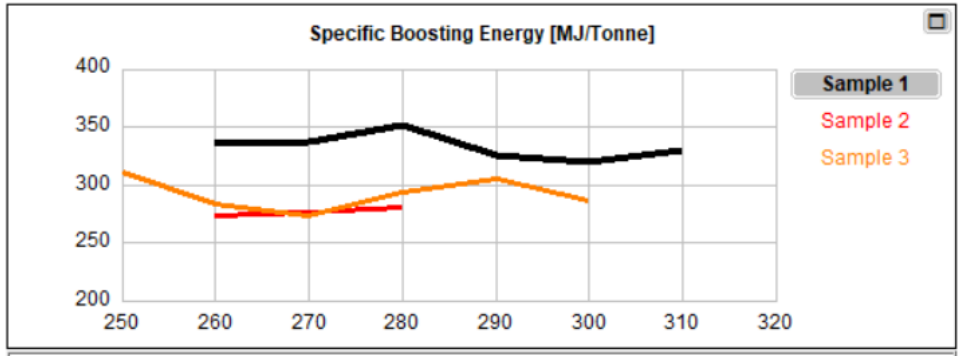
Approximate cost savings for comparable tonnages
Calculated from comparison of Sample 3 to Sample 1



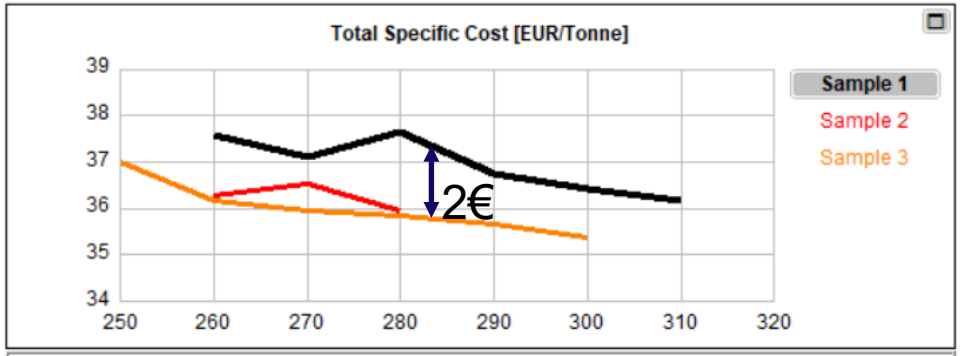
Specific Fuel Energy in comparison to Sample 1 [%]								
Pull group	250	260	270	280	290	300	310	320
Sample 2	---	0.8	3.2	0.3	---	---	---	---
Sample 3	---	-0.2	1.5	-1.2	-2.1	-0.9	---	---



Total Specific Energy in comparison to Sample 1 [%]								
Pull group	250	260	270	280	290	300	310	320
Sample 2	---	-0.7	1.5	-1.4	---	---	---	---
Sample 3	---	-1.5	-0.2	-2.5	-2.4	-1.6	---	---



Specific Boosting Energy in comparison to Sample 1 [%]								
Pull Group	250	260	270	280	290	300	310	320
Sample 2	---	-18.4	-17.6	-20.2	---	---	---	---
Sample 3	---	-15.6	-18.8	-16.6	-6.1	-10.3	---	---



Total Specific Cost per Ton in comparison to Sample 1 [%]								
Pull group	250	260	270	280	290	300	310	320
Sample 2	---	-3.5	-1.6	-4.5	---	---	---	---
Sample 3	---	-3.7	-3.2	-4.9	-3.0	-3.0	---	---

2 € savings per ton at 300 tpd per day is **220.000 € per year**, plus carbon reductio

Thank you for your attention

Supervisory automatic control will help us to decarbonize

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Add into your agenda
Furnace Design Conference
18-19 June 2025 Czechia