The importance of thermodynamics for business intelligence tools

Dr. Sander Arnout (InsPyro) – ProOpt International

InsPyro – inspiring metallurgy

- KU Leuven spin-off, est. 2009
- High-temperature processes
  - Slag, refractory, off-gas
  - Furnace modelling and steering
  - Classical and novel technology
- Consultancy in metallurgy
- Research projects in waste
- Software for metallurgical calculations on site

Lead

Zinc

Steel

Foundry

Various

ProOpt International SA

& InsPyro & bee.solutions

have pooled their knowhow and systems to offer

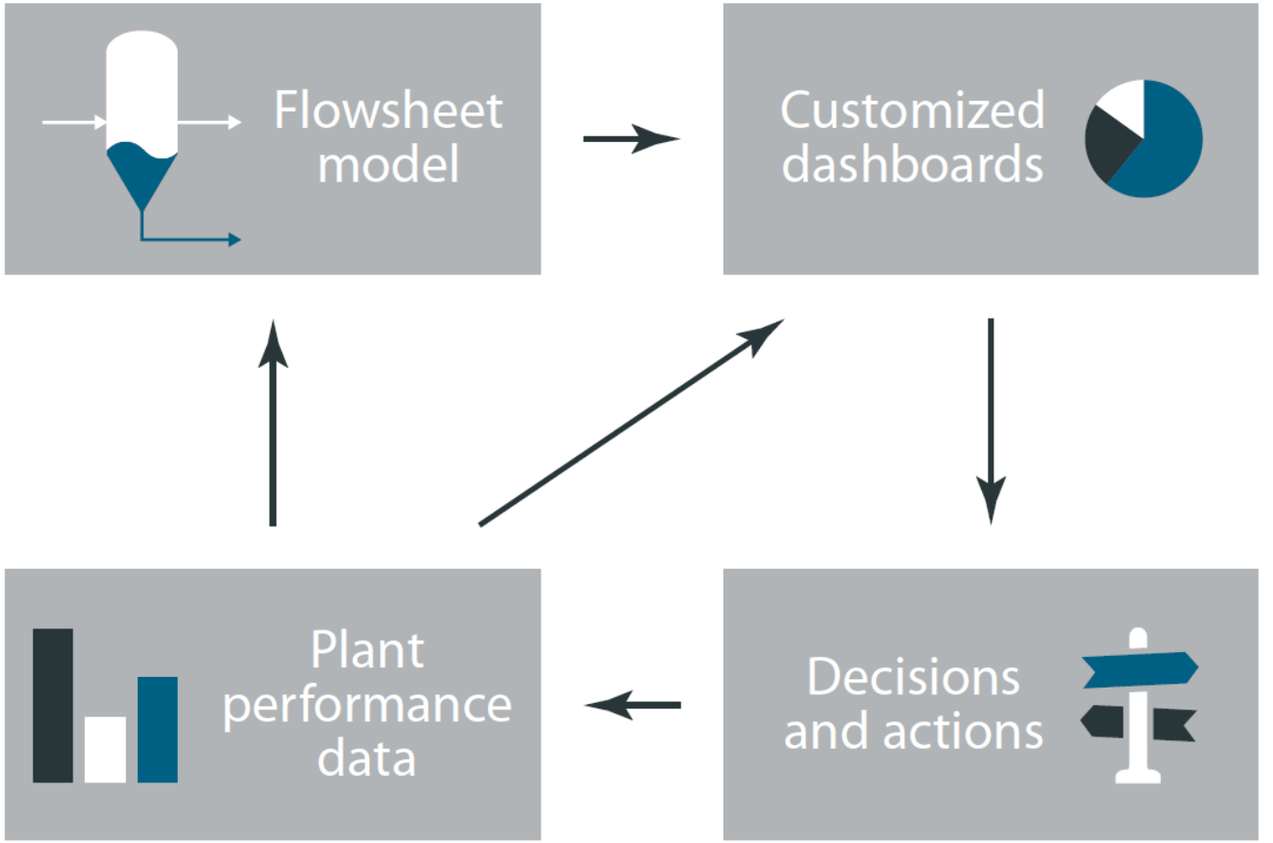
- ProOpt Optimisation
  - Data integration
  - Process modelling
  - KPI Reporting
  - Process optimisation
  - Value optimisation
  - Knowledge sharing
- Experts available in
  - Metal industry
  - Mining industry
  - Data management
  - Engineering
  - Process management
  - Market & Finance

Founding companies of ProOpt

- InsPyro
  - University spin-off company, founded 2009
  - Technical consultancy in steel and non-ferrous industry
  - Spark software for predefined models and thermodynamic calculations
- Proval Partners
  - Experience in trading, market, finance
  - Acquired ErasMetal in 2011 and turned it around
  - Reliable data and modelling proved key in turning the plant around
- bee.solutions
  - Data management experts
  - Experience in oil industry, financial institutions, telecom…

Metallurgy & Business Intelligence

- ProOpt combines metallurgical insight with data management

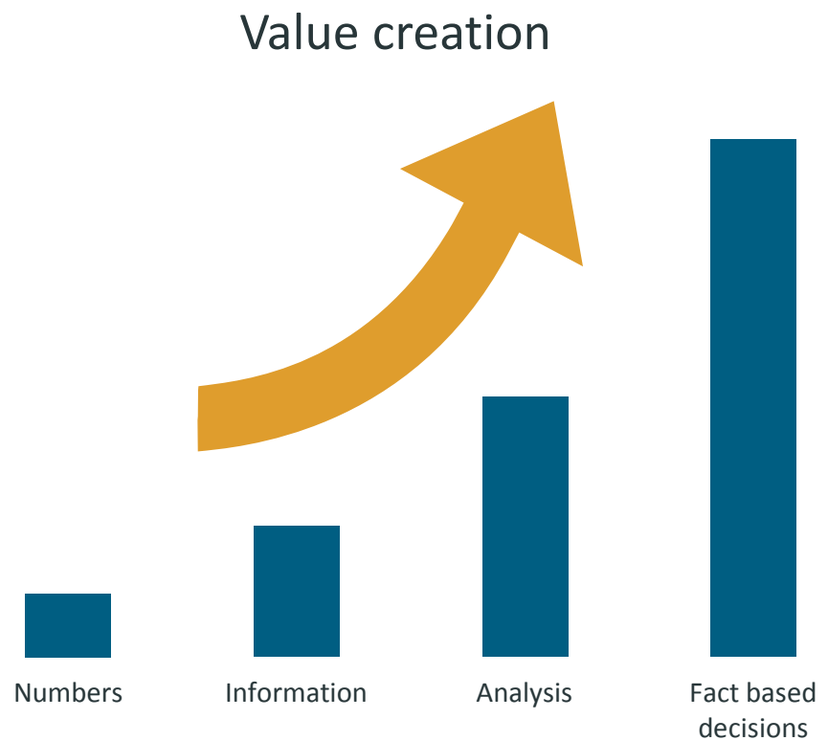


4 steps to optimize metallurgical process and profitability

1. You trust your numbers
2. Numbers becomes information
3. Information becomes analysis
4. Analysis leads to fact based decisions

Moving up the ladder increases returns

- Better process understanding
- Less deviations/unexpected events
- More efficient operations
- Lower cost structure
- Reduction of operational risks



ProOpt goal: increase value creation

World Class optimisation and control system for the process, melting and mining industry

- **Info.base**: data information system
  - secure availability and quality of data when you need it
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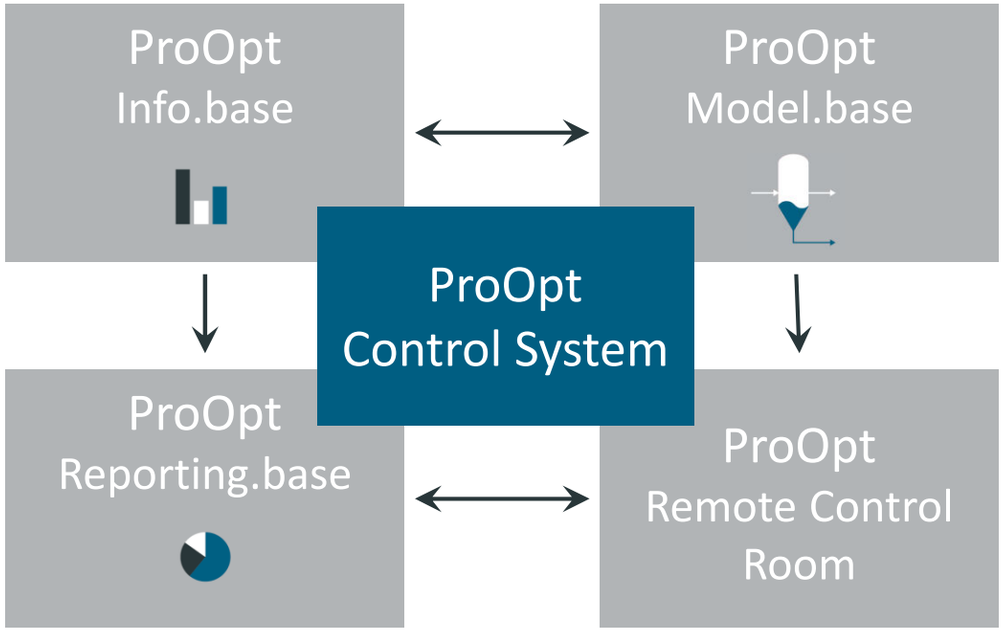
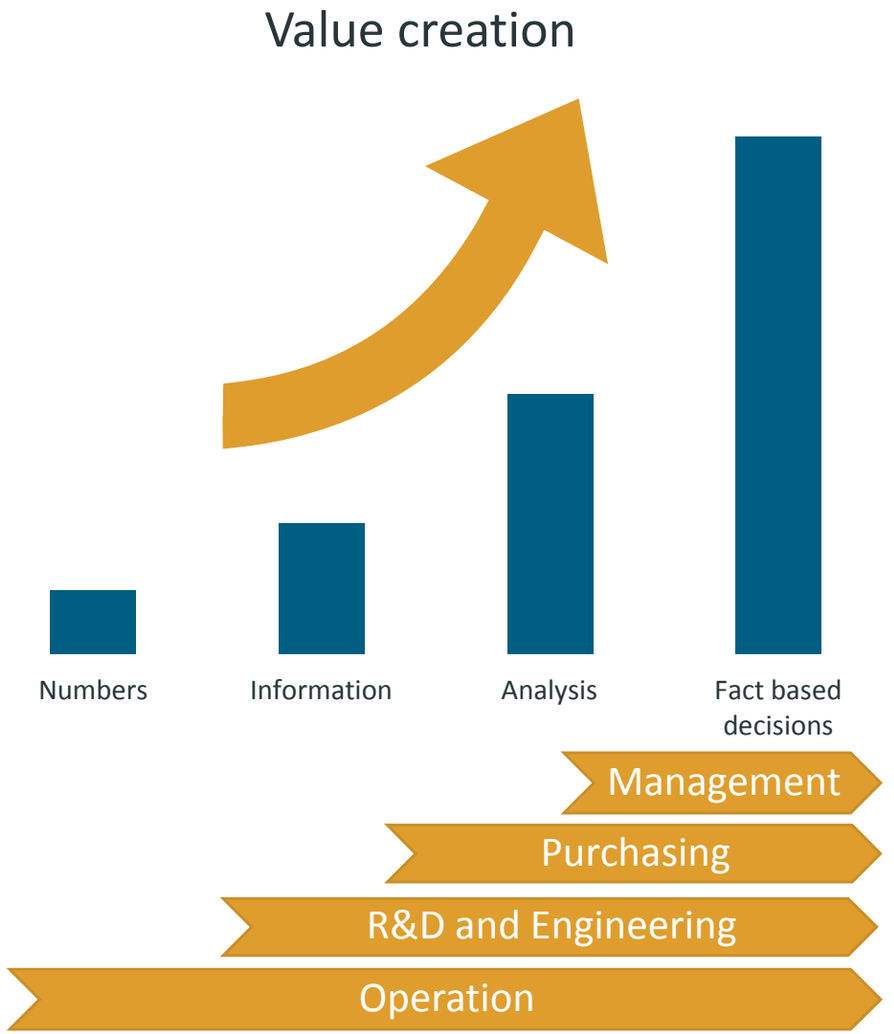


Expected impact of ProOpt system

- Engineers spend time on doing the work – not finding and checking the data
- Optimize feed mix to reduce fluctuation in process and cost per produced unit
- Better understanding of process reduces mistakes – makes complex plants manageable
- Wide insight in critical factors – also by operators, management, purchasing
- Feed forward function reduces critical happenings

- **Go beyond insight and optimise value**

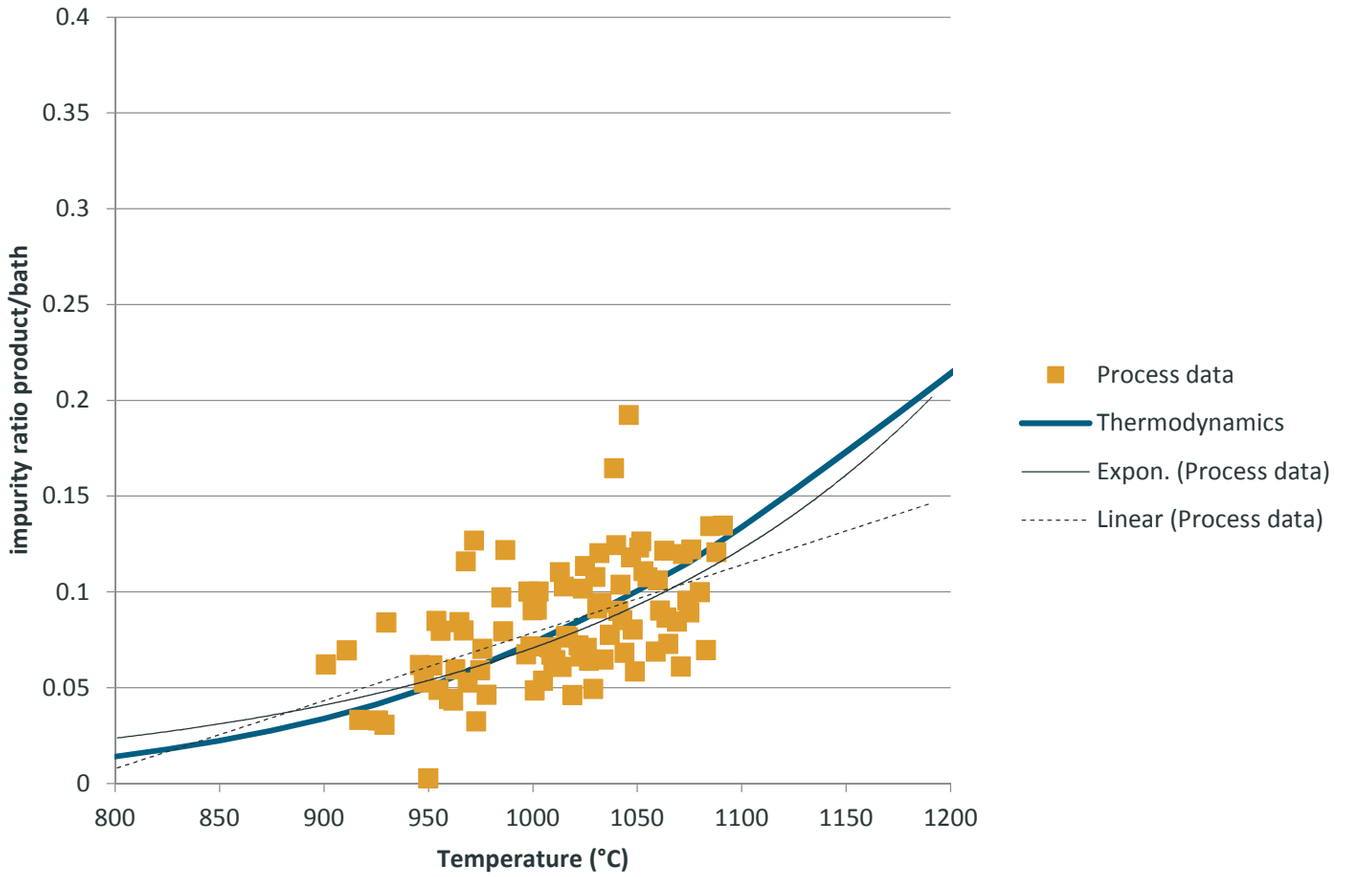


What is the role of thermodynamics?

- Thermodynamics as a framework
- Base assumption for unknown processes
- Non-linear effects based on reaction equilibrium, liquidus,...
- Allowing extrapolation
- Allowing determination of deviation from equilibrium and empirics

Example: impurity volatilization

- Fitting process data: always noisy, which shape to take?
- Not simple linear behavior:
  - 2 element's vapor pressures
  - Metallic and oxidic forms in the gas phase
- Thermodynamics enables more reliable extrapolation
- Not just one variable but the whole process



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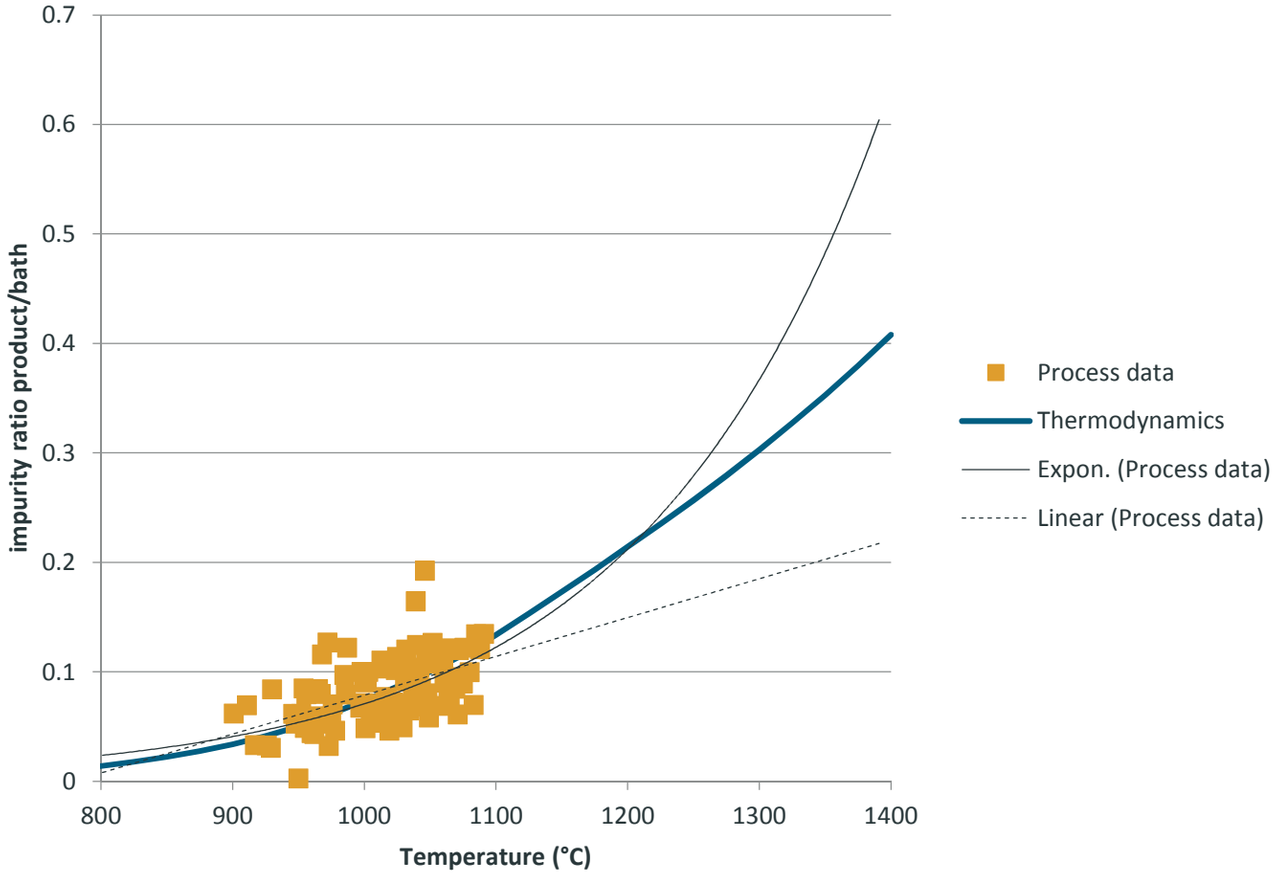
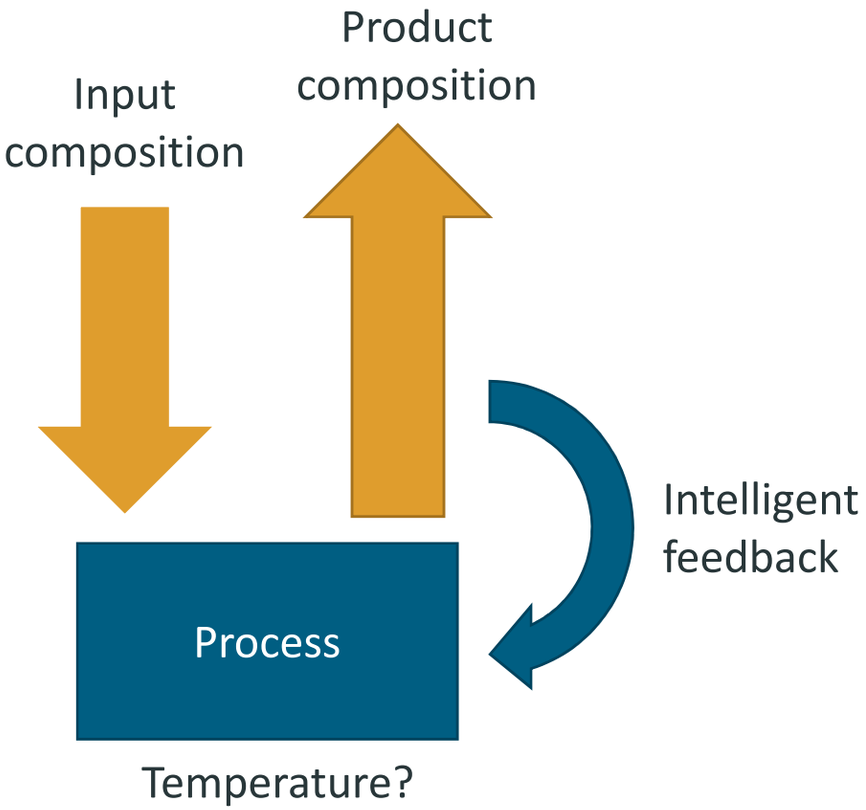


Example: impurity volatilization

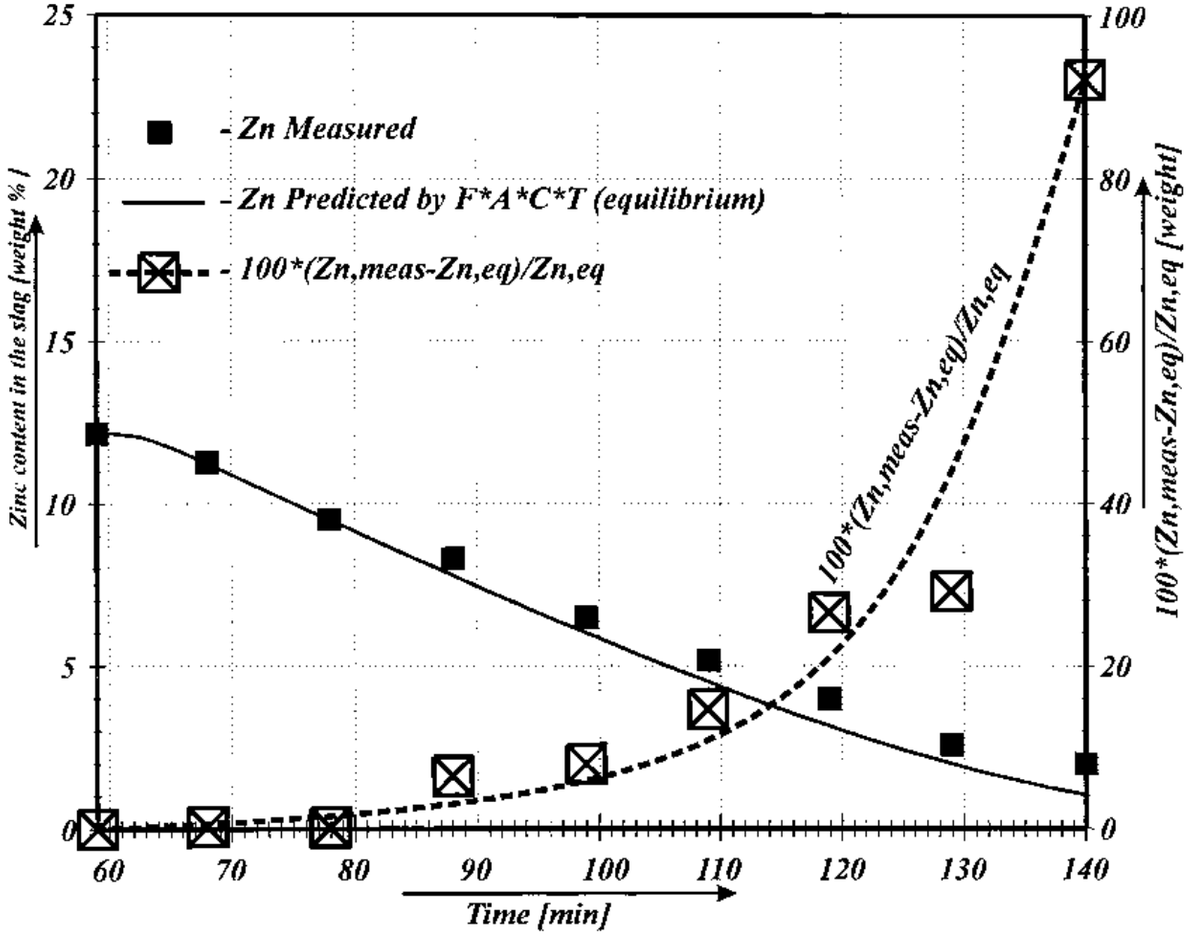
Now if we have these relations for several impurities, we can:

- Select parameters for the existing process
- Determine if we should invest in different temperature process
- Create a “virtual instrument” for the bath temperature:
  - From measured impurities, calculate best fit temperature
  - Decide on steering to meet specifications (e.g. decrease 50°C)



Example: Zinc fuming

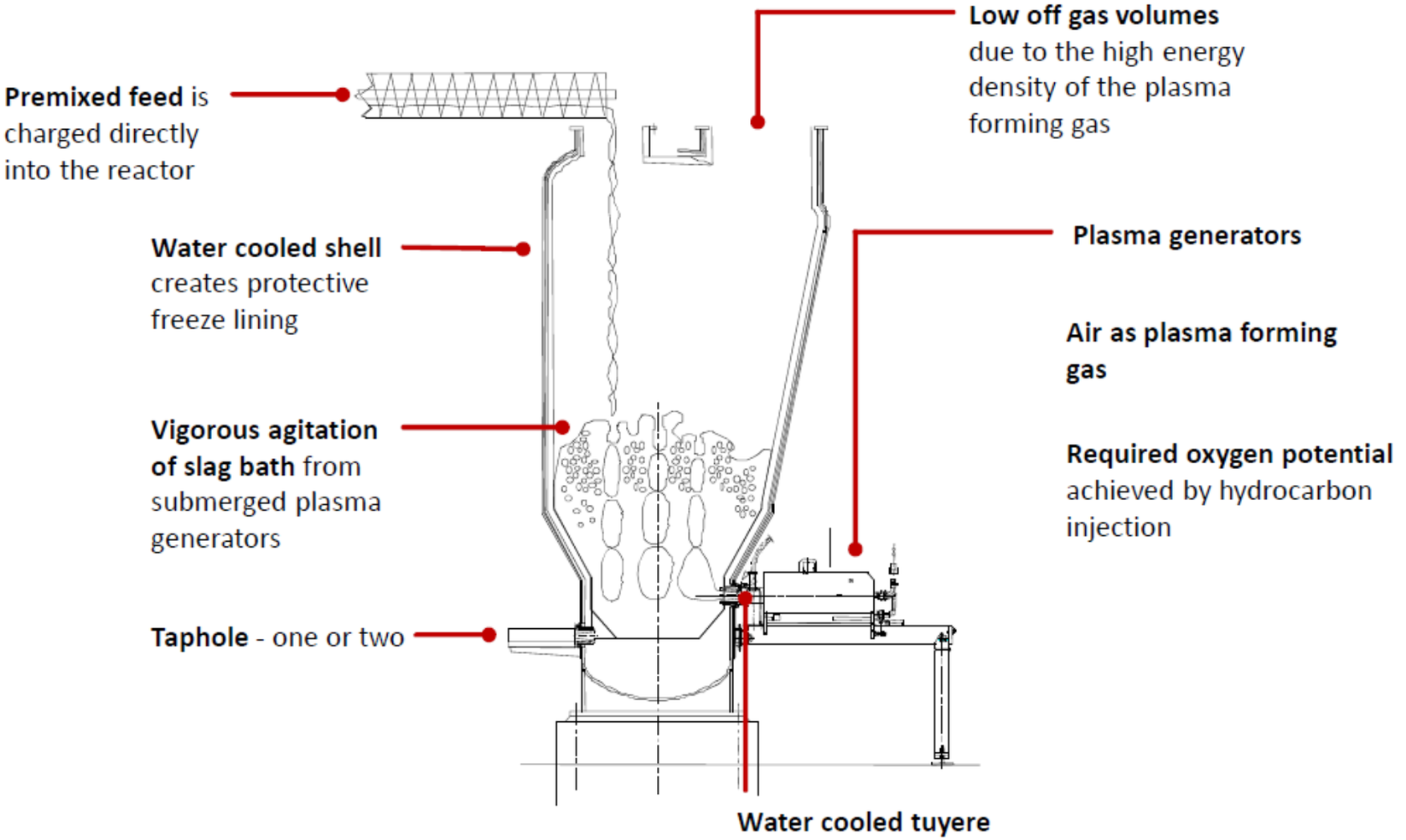
- Classical example of thermodynamics vs. kinetics discussion
- Thermodynamics as “best case”
- Reaction can be incomplete, but cannot go further than equilibrium
- If deviation from equilibrium is relevant, add kinetic or empiric model
- To design a better reactor, need more detailed type of model



E. Jak et al., 2002

Eras plant layout

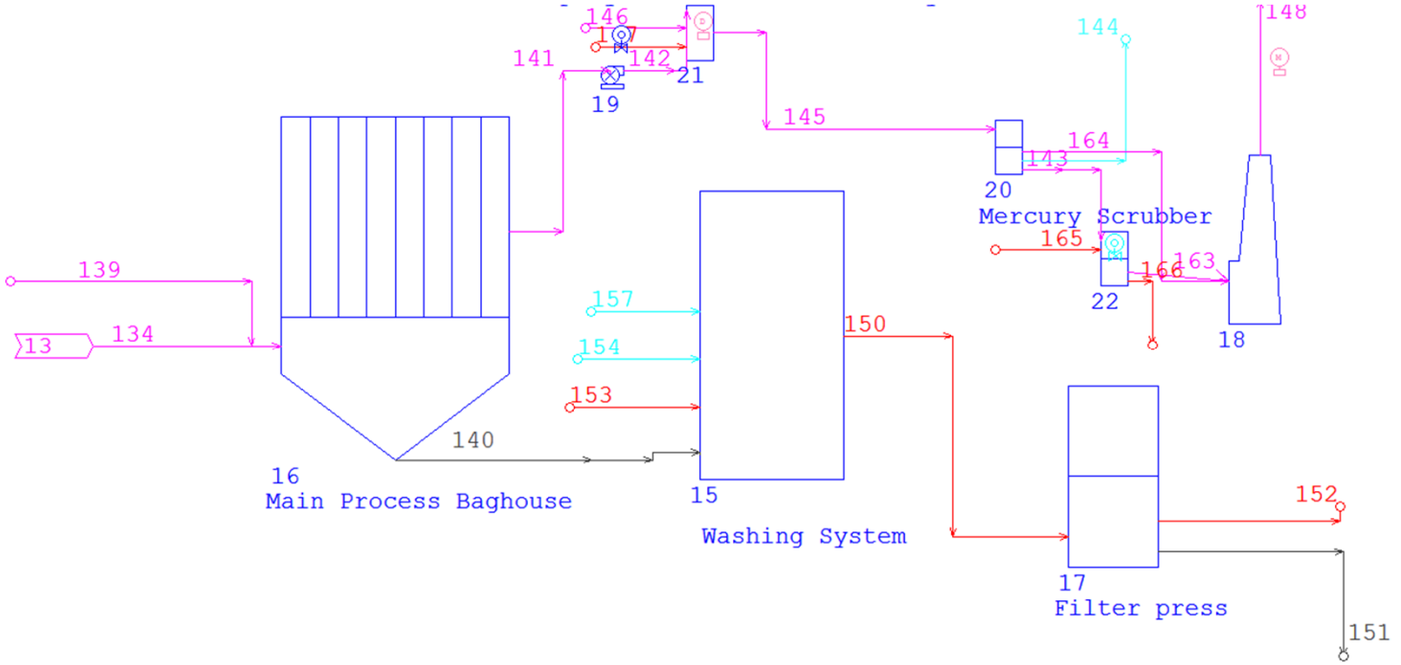
- ScanArc ArcFume technology
- Built in 2005 with unique set-up
- 50 ktpa EAF dust capacity
- Acquired by Proval Partners in 2011
- Sold to Nyrstar in 2014



ArcFume Technology for Reprocessing Residues from Industry, Imris M. Swartling M. Heegaard B. M., EMC 2013

Eras plant model

- In 2011, clear need to stabilize and optimize the process
  - Reduce standstills = improve throughput
  - Start to build systematic mass and energy balance
  - Mark W. Kennedy, an authority on slag furnaces, was attracted by Proval
  - Full flowsheet model containing charge mixer, furnace, plasma generators, filter,...
- Use of a formal model rather than control by “feeling”



Advantage of models to learn from data

- Example: explanation of furnace temperature and energy need, depending on the mix
- Correlation statistics: will only give you noise
- AI: may find a link between high temperatures and certain raw materials
- Mass balance & thermodynamics:
  - Expected slag composition
  - Expected slag melting point – virtual instrument
  - Correlation furnace temperature and melting point found
  - Unravel mechanism step by step
  - Next step: expected furnace temperature from model
- More relevant correlations (=understanding) using known relations

Eras business development

- Assessment to be made with every offer:
  - What is the production cost to treat this material?
  - How much zinc oxide will we produce, and with what quality?
  - So, in the end, what is the margin, and...
  - Will we take this material or not?

- Cooperation between technical and commercial side crucial to detect opportunities
  - E.g. batteries or battery fractions
  - When compensated correctly, the flexibility of the process was shown to be much larger than previously assumed

The new life of Eras

- Successful turnaround of the plant:
  - Process stable, standstills decreased
  - Profitability increased
  - Slag useable in building products

- Sold to Nyrstar, to become part of their strategic investments
- The plant will be modified to treat primary zinc byproducts

- Fact-based and model-driven plant management (including thermodynamics) had shown to pay off

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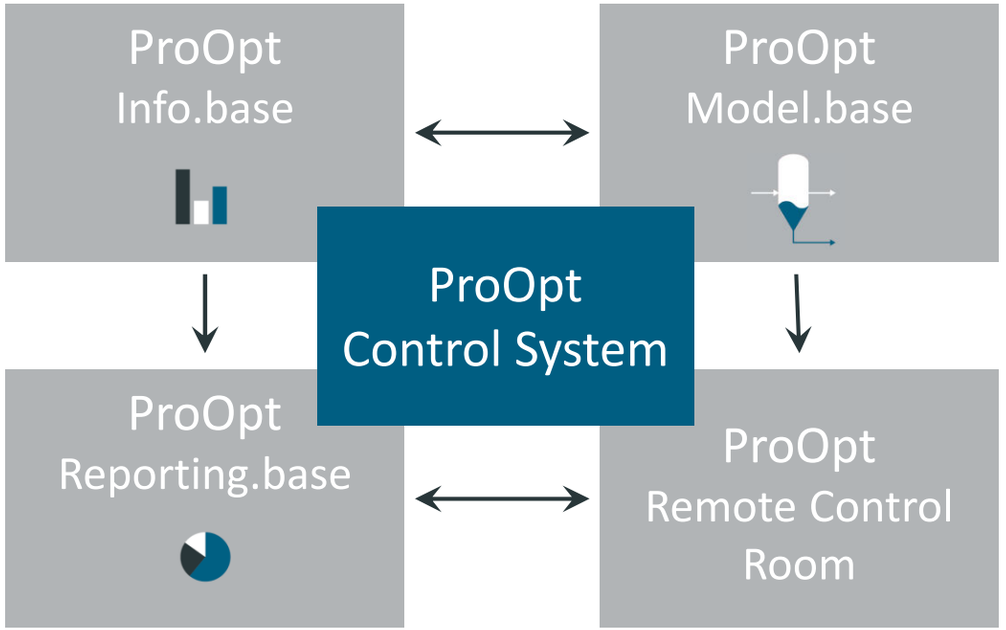

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