OSLO AND AKERSHUS
UNIVERSITY COLLEGE
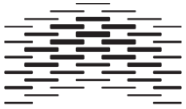OF APPLIED SCIENCES

On-line analyzer and control of a copper solvent extraction process

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Oslo Metropolitan University

Presentation for Hydrometallurgy-seminar in Oslo 07.03.2018

RESEARCH

- MSc and PhD in Chemical Engineering/ Process Control: monitoring, modeling and control of continuous chemical processes

- Asc Prof: Operator training simulators. Goal: Enhancement of simulator use with intelligent tutoring system

- Research groups in Automation, Robotics and Intelligent systems (ARIS) and Applied AI

INDUSTRIAL EXPERIENCE

- MSc: Neste Engineering, Kilpilahti Refinery Finland
- PhD: Outotec, Copper solvent extraction plant at Phelps Dodge Morenci USA,
- Kongsberg: dynamic large scale oil & gas process simulation
- HiOA: collaboration with simulator companies, Statoil, ABB, Fortum.
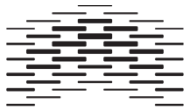
About Copper Solvent Extraction Process

- L: Copper is leached with mild H_2SO_4 solution from crushed ore piled in large heaps
- SX: Aqueous copper solution is concentrated (3g/L$\rightarrow$40g/L) and purified in solvent extraction
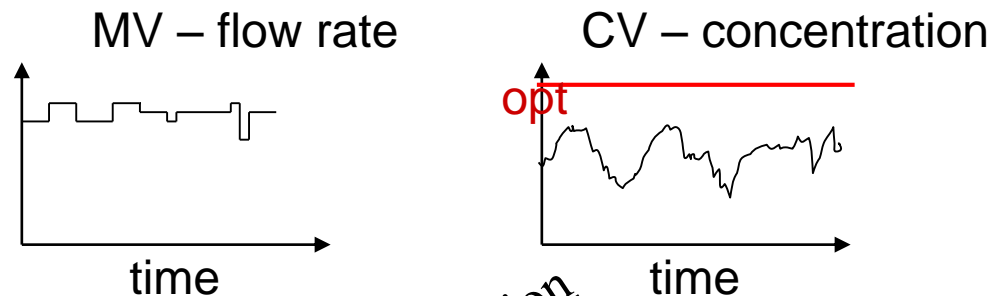- EW: 99,999% pure copper cathodes are produced in electrowinning

Leach solution

Electrolyte solution

Organic solution

Leaching

Extraction

Stripping

Electro winning

Cu
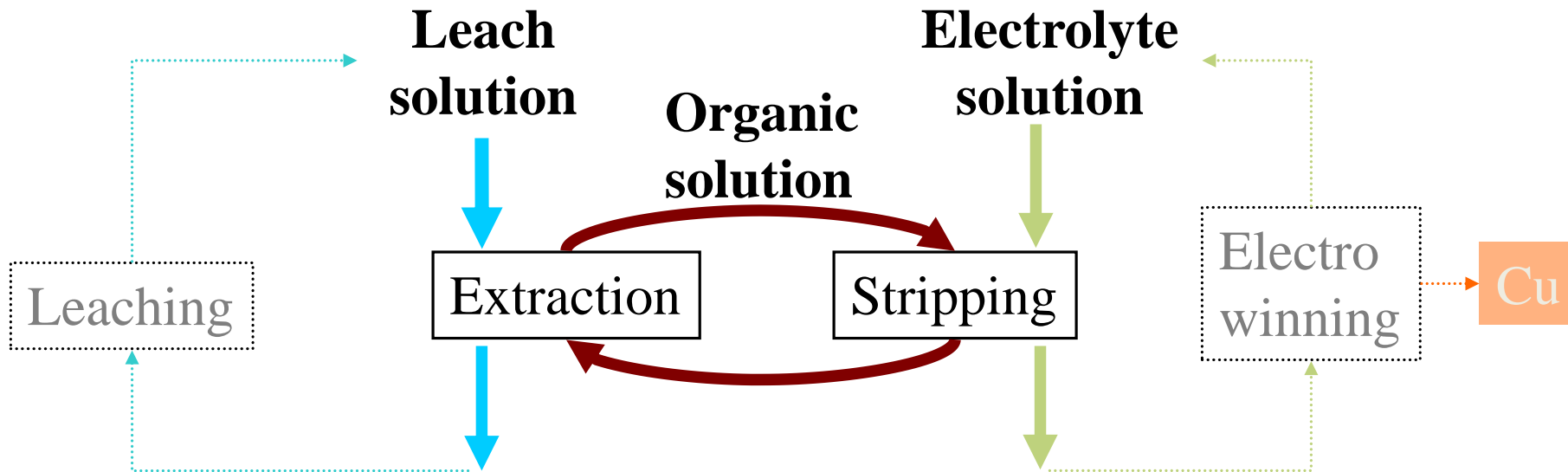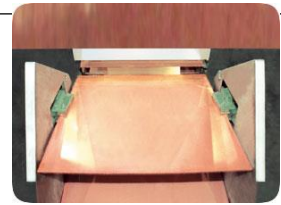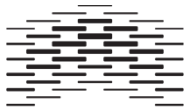
Why advanced control for copper solvent extraction process?
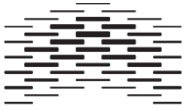
- Relatively stable process, research focused on process equipment & chemicals
→ no advanced control by 2006
- Long time delays (hours) and complex interactions, slow process variations
→ difficult to interpret cause - effect relationships
→ conservative manual operation
- Optimal production not reached
→ Advanced control to improve the process performance

MV – flow rate   CV – concentration

MANUAL CONTROL

opt

time   time

MV – flow rate   CV – concentration

Move variation

ADVANCED CONTROL

opt
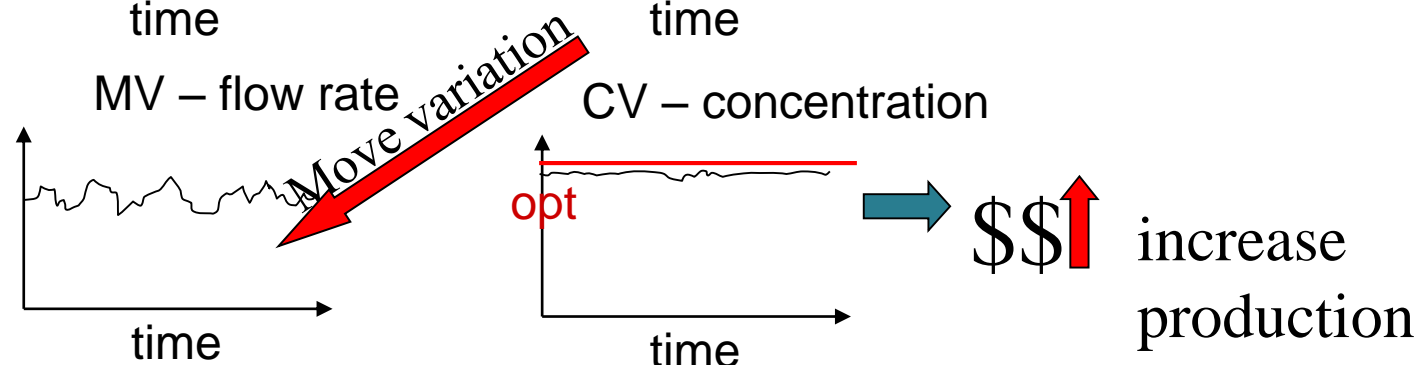
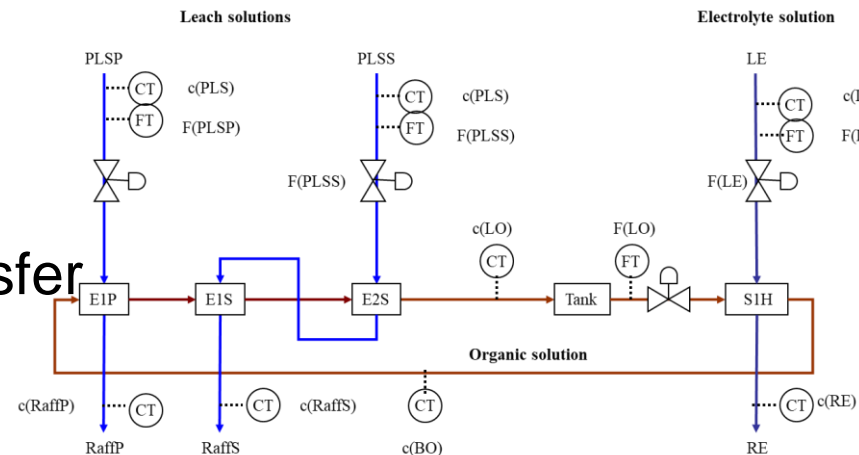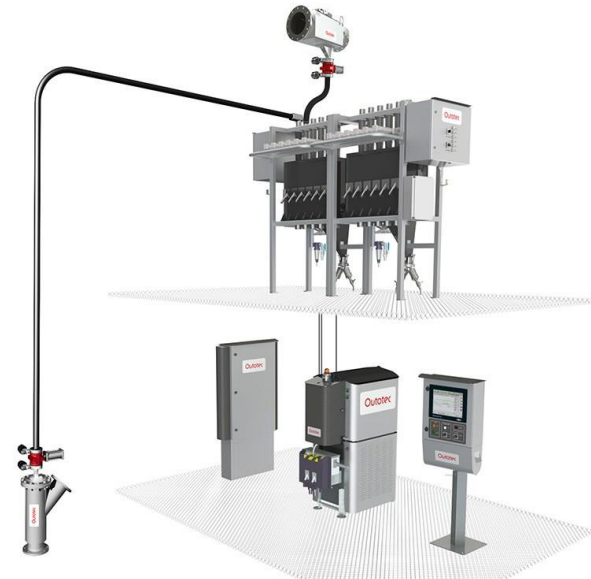$$ increase production

time   time

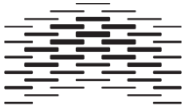# How? Necessary measurements for Copper Solvent Extraction Process

Online measurements enabling advanced control

– Copper concentration [g/L] in aqueous and organic solutions

  – Outotec Courier® X-ray fluorescence method

– Flow rates [L/min]

– (Temperature and level)

Offline/ diagnostic measurements

– pH, acidity, maximum loading, equilibrium isotherms →Mass transfer speed K, extraction efficiency α
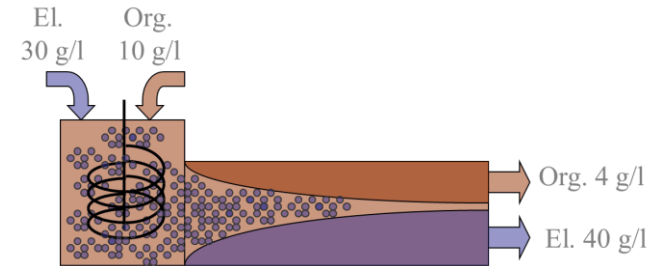
How? Modeling and control of Copper Solvent Extraction Process

– Development of dynamic mass-transfer models for a copper solvent extraction process, set together according to plant flow sheet
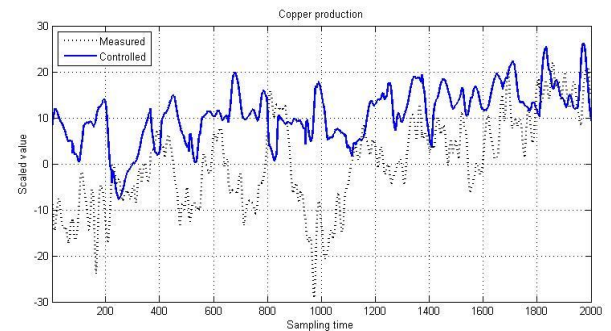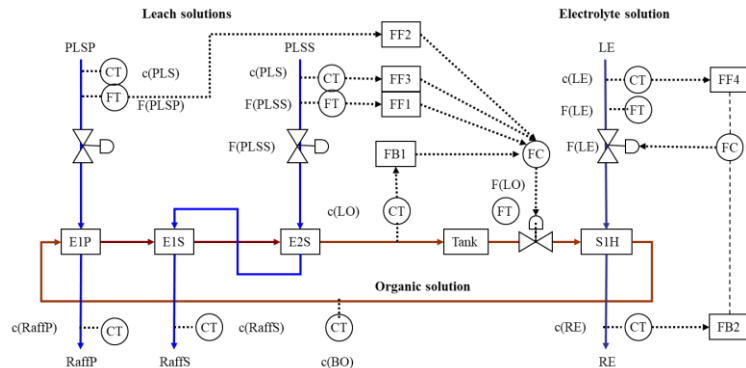
$$\frac{dc_1^{el}(t)}{dt} = \frac{F_1^{el}(t)}{V_{mix4}(t)} \cdot \left[c_0^{el}(t - t_4) - c_1^{el}(t) \right]$$

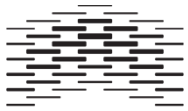$$+ K_4 \left[c_1^{el}(t) - c_1^{el*}(t) \right] \qquad (6)$$

$$c_1^{el*}(t) = h(c_3^{org}(t - t_3), c_0^{el}(t),$$

$$F_4^{org}(t), F_1^{el}(t), \alpha_4, isotherm_S)$$

$$cRE(t) = c_1^{el}(t - t_4). \qquad (8) \qquad (7)$$

– Development of control strategies for a copper solvent extraction plant

– Copper concentrations stabilized, variation decreased 70-90%

– Production increased 3-5%

Suggestion for research collaboration for hydrometallurgical plants

Oslo and Akershus University College of Applied Sciences

Operator support system giving
- Early indication of drift towards «less optimal operating point»
- State estimation for more reliable measurements
- Predictive performance-based maintenance
- Improved control of the product quality

Using Artificial Intelligence based methods in combination with traditional modeling, monitoring and control methods

OsloMET research groups
ARIS http://www.hioa.no/eng/Research-and-Development/Our-research/R-D-at-the-Faculty-of-Technology-Art-and-Design/node_73129/ARIS-Automation-Robotics-and-Intelligent-Systems
Applied AI www.hioa.no/eng/Research-and-Development/Our-research/R-D-at-the-Faculty-of-Technology-Art-and-Design/node_73129/Applied-Artificial-Intelligence
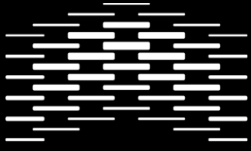
Questions?

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- T. M. Komulainen, P. Pekkala, A. Rantala, and S.-L. Jämsä-Jounela, *Dynamic modelling of an industrial copper solvent extraction process*, Hydrometallurgy, 81(1):52-61, 2006. doi: http://doi.org/10.1016/j.hydromet.2005.11.001

- T. M. Komulainen, F. J. I. Doyle, A. Rantala, and S.-L. Jämsä-Jounela, *Control of an industrial copper solvent extraction process*, *Journal of Process Control,* 19(1):2-15, 2009. doi: http://doi.org/10.1016/j.jprocont.2008.04.019