

INTEGRATED MODELLING OF A SMELTER OFF-GAS CLEANING SYSTEM

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Overview

- ♦ Introduction
- ♦ Process description
- ♦ Furnace off-gas system modelling
- ♦ Dynamic simulations
- ♦ Conclusions



Introduction

smelter	}	roaster	- sulfur elimination
		furnace	- smelting hot calcine
		converter	- further removal of metal impurities

Introduction

- ◆ Smelters
 - ◆ Include roaster, furnace and converters
 - ◆ Key operation in obtaining metals
 - ◆ Generate a large amount of off-gases: SO₂ and CO₂
 - ◆ SO₂ abatement programs

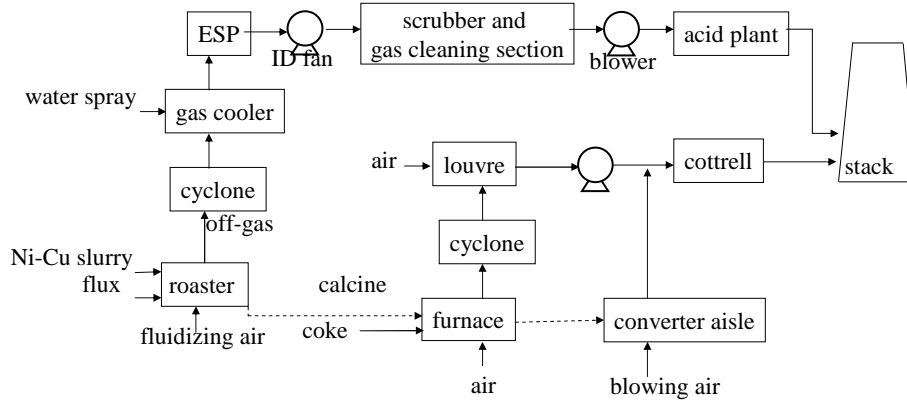
Introduction

- ♦ Research on smelter operations
 - ♦ Active research on modelling of furnace
 - ♦ Off-gas treatment emphasized in industrial presentations
 - ♦ Limited research on off-gas systems

Introduction

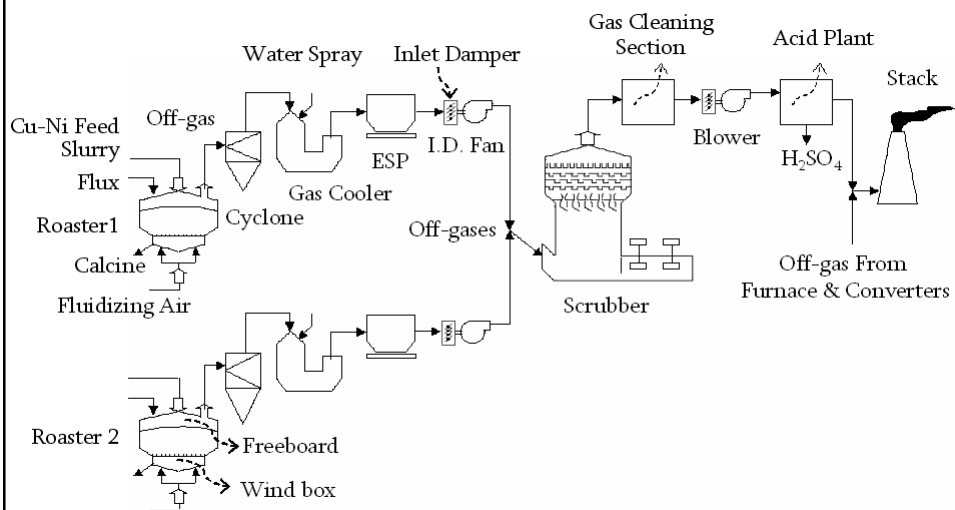
- ♦ Extensive studies for off-gas systems are needed
 - ♦ Environmental importance
 - ♦ Equipment protection
 - ♦ Plant hygiene

Process description: smelter off-gas system



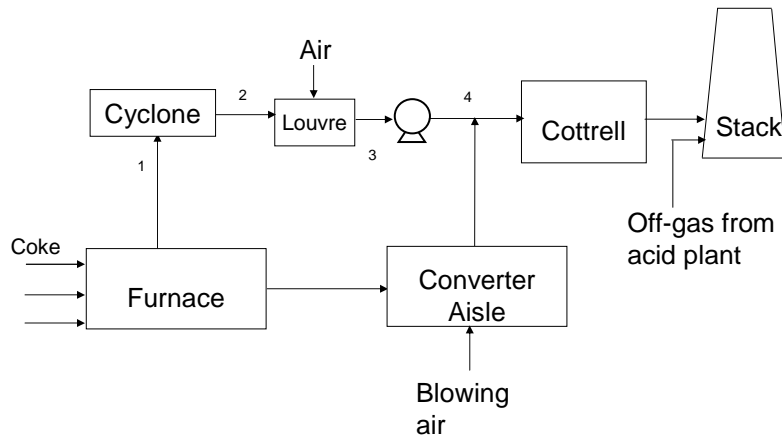
Schematic plot of a smelter off-gas system

Process description: roaster off-gas system



Schematic plot of a smelter off-gas system

Process description: furnace and converter off-gas system



Schematic plot of a smelter furnace off-gas system

Control objectives

- ◆ Pressure:
 - negative enough to keep all process gases in the process
 - 0.1 to 0.15 inches water column
 - maximum limit to avoid entraining too much calcine
- ◆ Fan inlet temperature:
 - ◆ equipment protection
- ◆ Other temperatures:
 - equipment life, efficiency, environmental performance

Dynamic modelling

- ♦ Modelling principles:
 - ♦ Mass continuity
 - ♦ First Law of Thermodynamics
 - ♦ Gas state equation
 - ♦ Momentum conservation
- ♦ State variables:
 - ♦ Mass flow-rate, temperature, pressure

Dynamic models of a smelter off-gas system

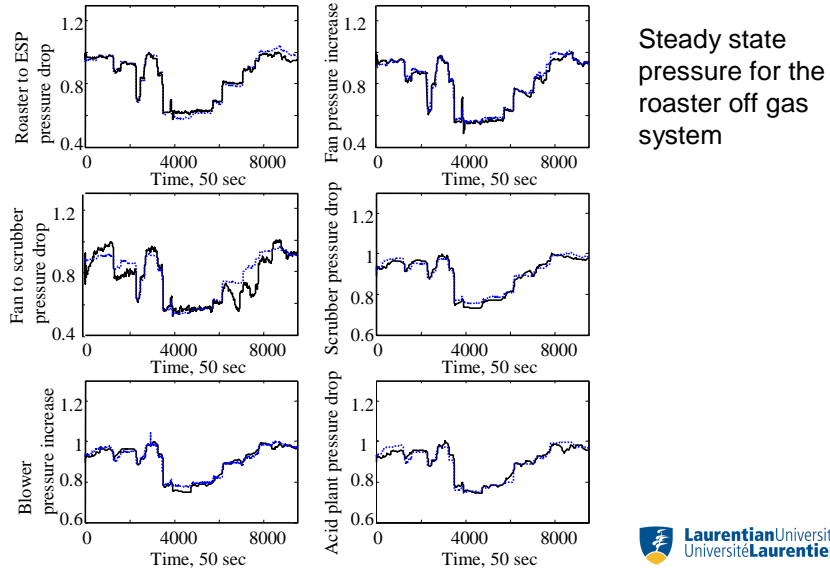
- ♦ Modelling equations:

$$\frac{d\mathbf{x}_i}{dt} = f(\mathbf{x}, \mathbf{p})$$

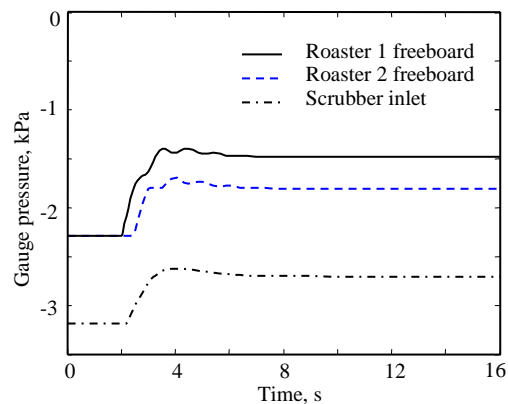
where \mathbf{x}_i are state variables including pressure, flow rate and temperature

- ♦ For details on modelling equations, please refer to the paper in the proceedings.

Steady state parameter identification and model validation

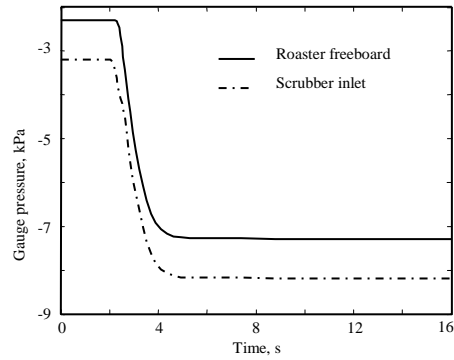


Process dynamics (roaster off-gas)



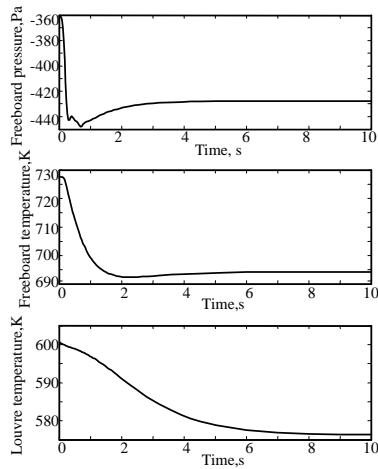
Step response of gas pressures to roaster 1 feed flowrate increase

Process dynamics (roaster off-gas)



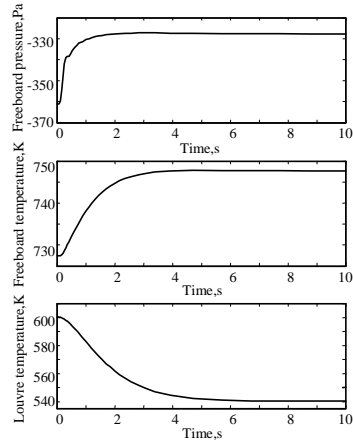
Step response of gas pressures to a blower vane position increase

Process dynamics (furnace off-gas)



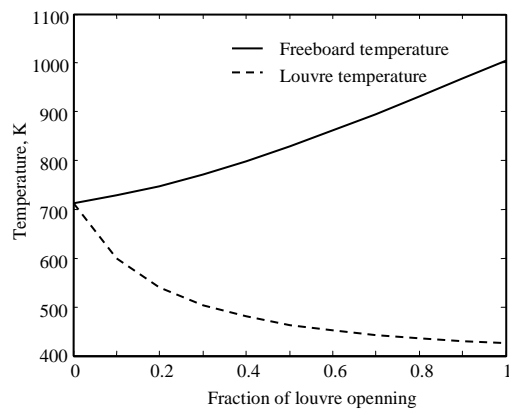
Step response to a step increase in the fan speed

Process dynamics (furnace off-gas)



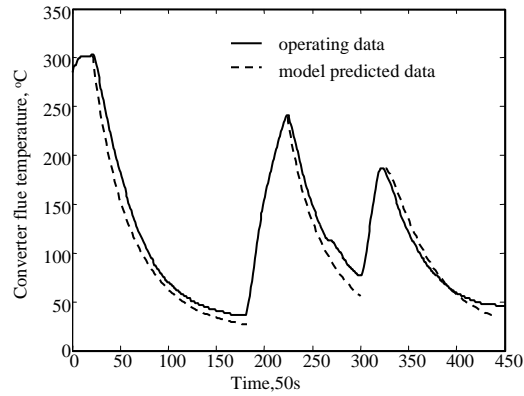
Step response to a step increase in the louver opening

Process dynamics (furnace off-gas)



Step response to a step increase in the louver opening

Process dynamics (converter off-gas)



Converter flue temperature

Conclusions

- ♦ A detailed dynamic model is developed for a furnace off-gas system
- ♦ Very fast dynamics for pressure
- ♦ The fan speed is effective
 - ♦ reducing the off-gas pressure and temperature
 - ♦ increase the energy use
- ♦ Louver opening, the manipulated variable
 - ♦ control the louver off-gas temperature efficiently when the opening is small

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