Smart Tomographic Sensors for Advanced Industrial Process Control - TOMOCON

HZDR

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Medical Tomography

Non-destructive Testing Tomography

Process Tomography

TOMOCON
Smart Tomographic Sensors for Process Control

📖 Wang (2015)

1972   1995   2020

Industrial Process Control

TOMOCON VISION

Tomographic Sensors
Smart & Soft-field, ERT, ECT, UST, WMS, MWT, MIT, CIFT

Process Control
Model Predictive Control, Fuzzy Control, Neural Networks

Process Modelling
CFD, Electromagnetics Modelling Reduced Order Modelling

Human-Machine Interaction
Process Visualisation, Augmented Reality

TOMOCON VISION

- 1D sensor signal input
- Feedback control loop drives actuator
- Lumped parameter process models

- 2D/3D tomography sensor input
- Rapid data processing and parameter extraction
- Advanced feedback control drives actuator

- 4D process models accounting for parameter fields
- Adapted human-machine interaction and augmented reality

TOMOCON Demonstrations

Batch Crystallization
Controlled anti-solvent injection and sonication using UST & ERT

Continuous Casting
Controlled filling of mold in continuous casting using CIFT & ECT/MIT

Microwave Drying
Optimal microwave drying of porous materials using ECT & MWT

Inline Fluid Separation
Optimal separation of fluids in an inline fluid separator using ERT & WMS

Advanced Inline Fluid Separation

How does an inline fluid separator work?
- Fluids with different densities entering a pipe
- High centrifugal forces with much higher gravitational acceleration separates the phases.
- Less density phases are extracted by a pick up tube

📖 Slot (2013)

gas outlet
liquid carry over
gas carry under
pressure regulator
gas/liquid two-phase flow
swirl element
liquid outlet

Objective: Substitute **"static inline fluid separation system"** with **"dynamic tomography-controlled inline separation system"** to cope with instabilities and flexible throughputs to reduce gas carry under and liquid carry over

Flow Design using Computational Fluid Dynamics

Swirl element
CAD model
Velocity magnitude

- Streamlines of single phase flow through the separator.
- Velocity decreases with distance.

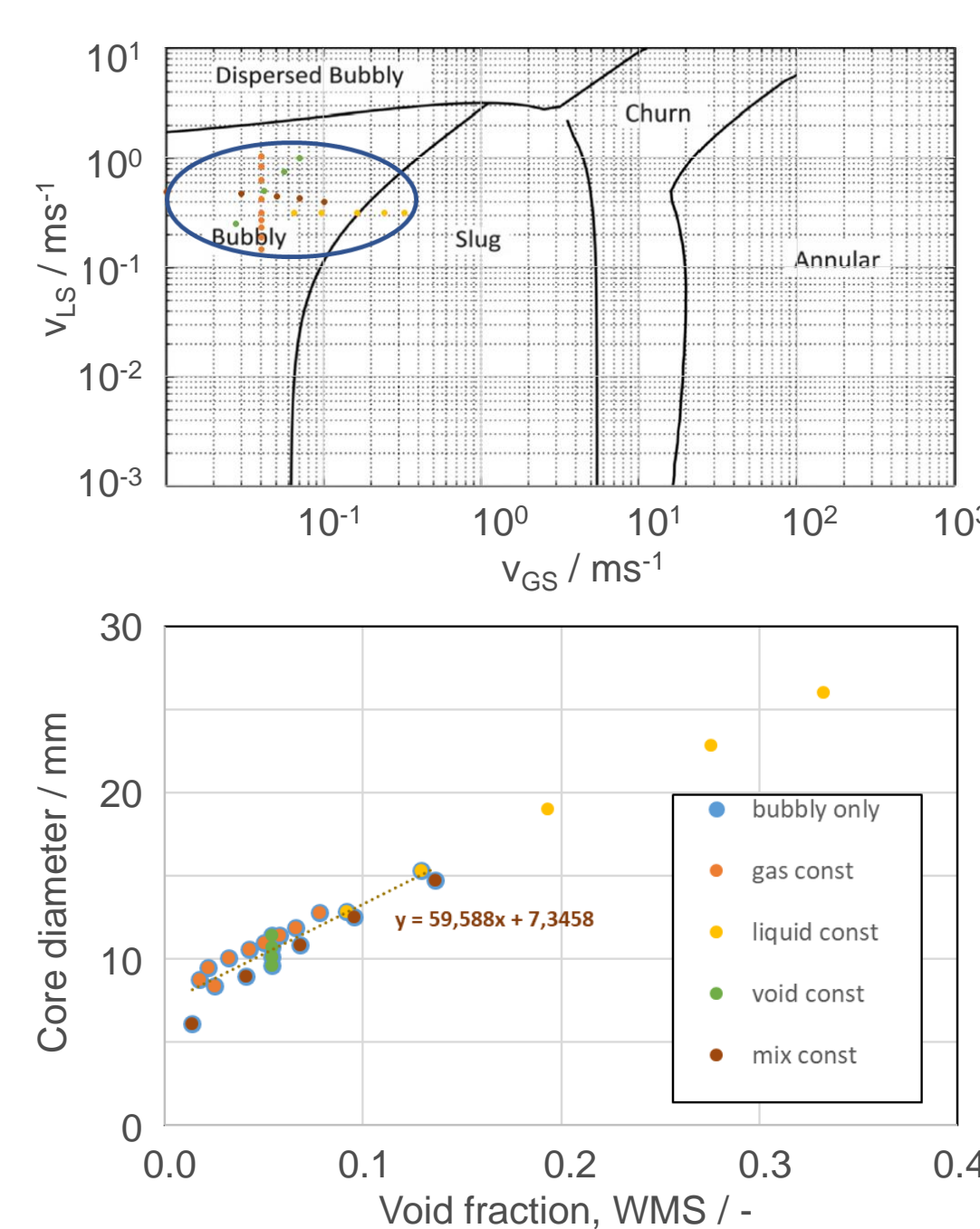### Flow Characterization via Wire-Mesh Sensor and High-Speed Imaging
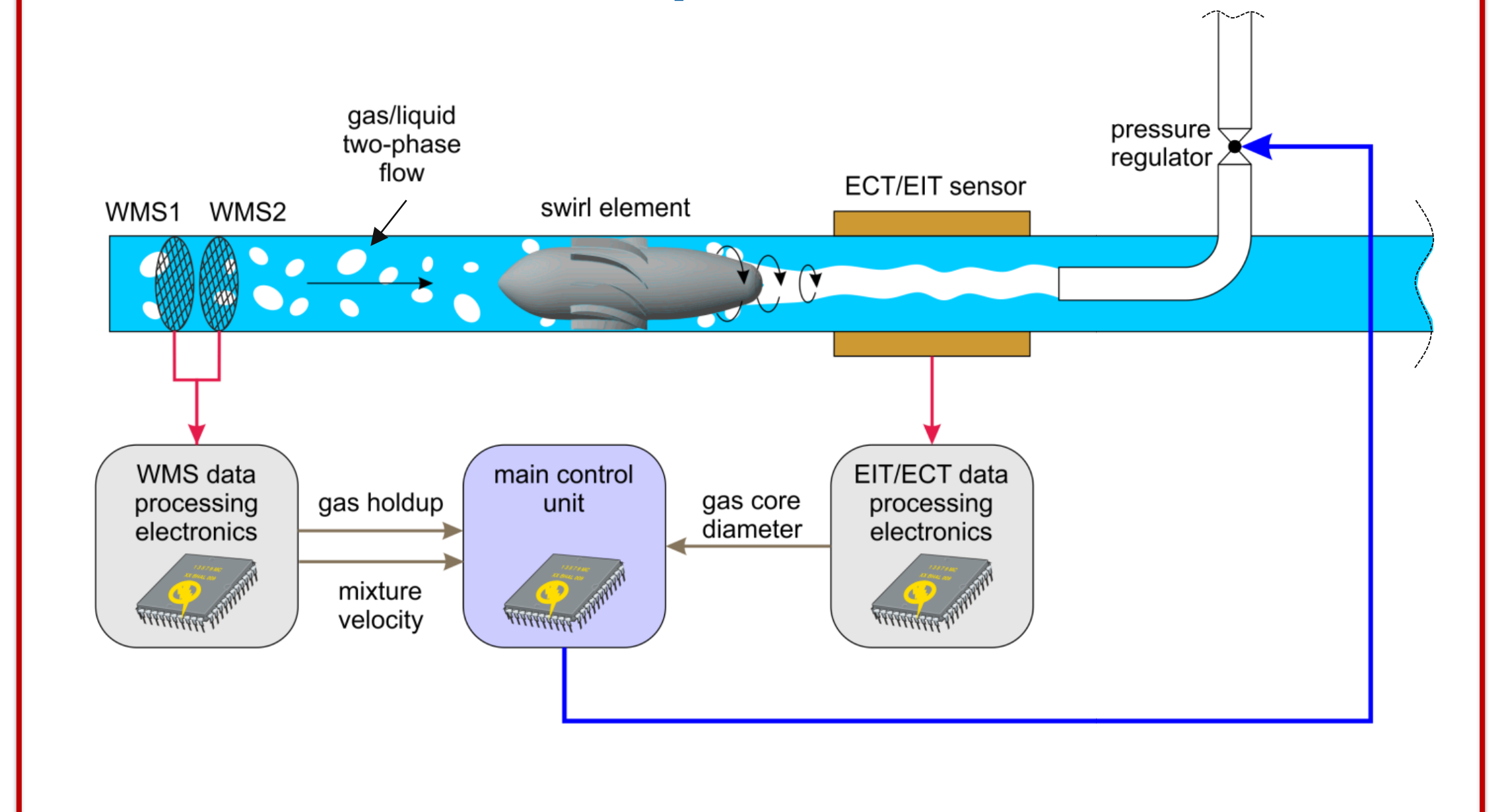
WMS

📖 Prasser et al. (1998)

WMS flow visualization

High-speed imaging

$$SD = \sqrt{\frac{\sum_{i=1}^{N}|D-\mu|}{N}}$$

Region of Operation and Core Diameter

Dispersed Bubbly
Churn
Bubbly
Slug
Annular

v_{GS} / ms⁻¹
v_{GS} / ms⁻¹

Core diameter / mm
$y = 59,588x + 7,3458$
Void fraction, WMS / -

bubbly only
gas const
liquid const
void const
mix const

Conceptual Demonstrator Design for Dynamic Tomography-Controlled Inline Separation

gas/liquid two-phase flow
WMS1 WMS2
swirl element
ECT/EIT sensor
pressure regulator

WMS data processing electronics
gas holdup
main control unit
gas core diameter
EIT/ECT data processing electronics
mixture velocity

References

1. Wang (2015). Industrial tomography: Systems and applications. Woodhead Publishing.
2. Slot (2013). Development of a centrifugal inline separator for oil-water flows. Ph.D. Thesis, Twente.
3. Prasser et al. (1998). Flow Measurement and Instrumentation. 9, 2, 111-119.

DRESDEN concept