Master's Thesis Opportunities in Pisa

The STEEL Group of DICMaPI offers a great opportunity for our chemical engineering students to prepare their Master's thesis in the laboratories of the University of Pisa (Italy) on different topics of Chemical Engineering.

We have direct contact with Prof.ssa Elisabetta Brunazzi and her assistants from the University of Pisa, who will supervise you during the thesis period.

The available projects are:

- Cleaning operations for industrial effluents;
- Modelling of gas-liquid contactors;
- From batch to continuous;
- Numerical simulation and digital twins;
- AI applied to chemical engineering.

These activities can also be carried out as part of the program: **Erasmus Italiano**

Interested students can contact Prof. Domenico Flagiello by e-mail or Teams to discuss about thesis projects and arrange a call-meeting with Elisabetta Brunazzi, who is the direct contact for these activities at University of Pisa, and also to ask about further information for the facilities and organization of your accommodation in Pisa.

Contact:
Prof. Domenico Flagiello
domenico.flagiello@unina.it

UniPI Chemical Plant Lab Activities

University of Pisa, Department of Civil and Industrial Engineering

Activities

Members

Elisabetta BRUNAZZI	Associate professor
Marco VACCARI	Research assistant
Sara TOMASI MASONI	PhD student
Pietro GIUSTACORI	PhD student

and synergies

Chiara GALLETTI	Full professor
Maria Vittoria SALVETTI	Full professor
Alessandro MARIOTTI	Associate professor
Riccardo BACCI DI CAPACI	Research assistant

Main Focus

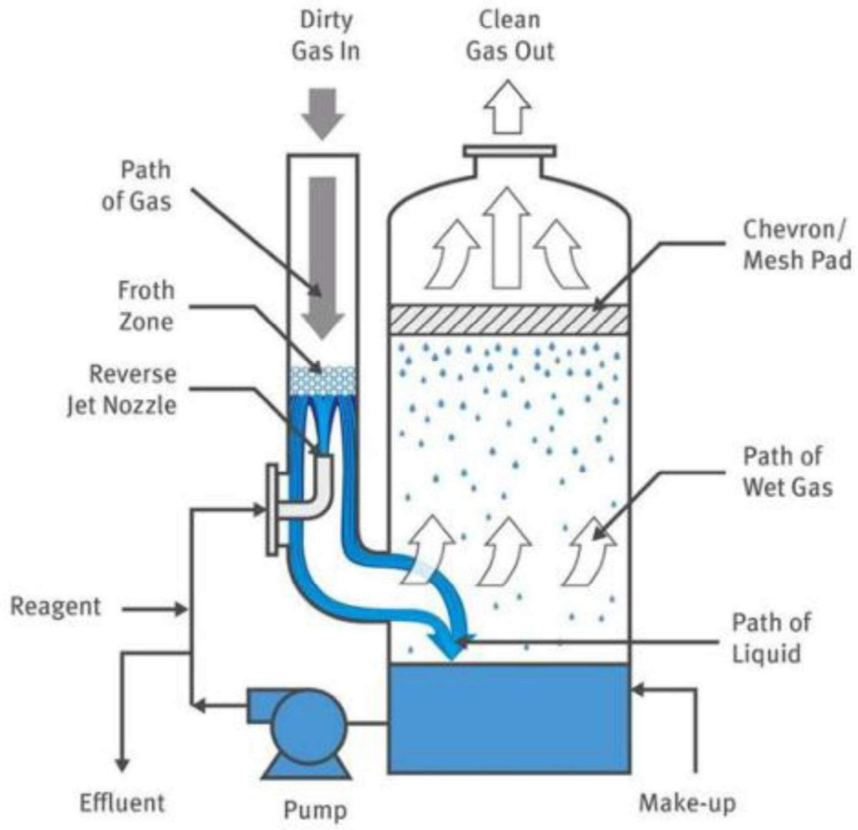
Process-Intensifying Equipment & Methods

Topics & activities

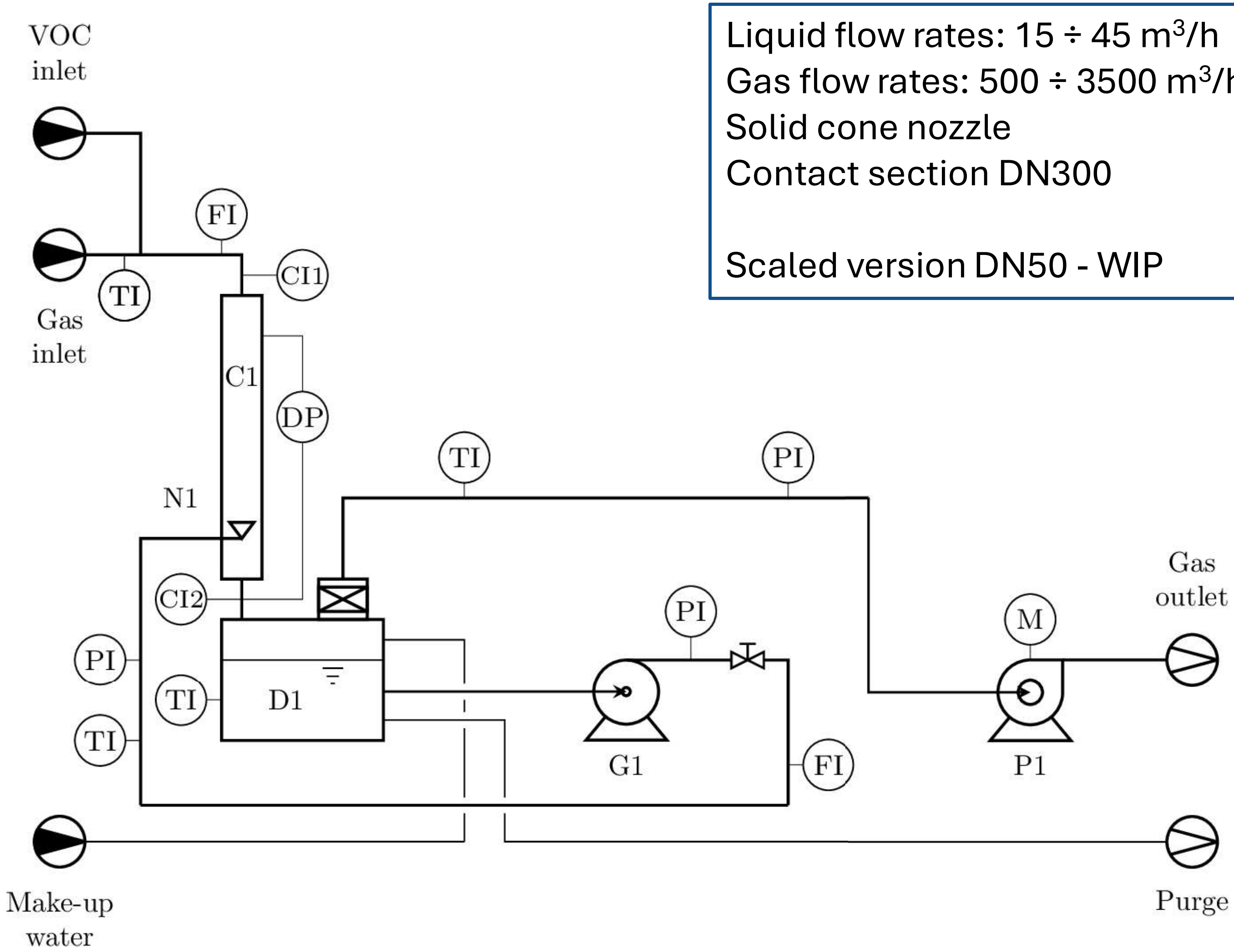
- Cleaning operations for industrial effluents
- Modelling of gas-liquid contactors
- From batch to continuous
- Numerical simulation and digital twins
- AI applied to chemical engineering

The Reverse Jet Scrubber (RJS) technology

- Scrubbing liquid is injected countercurrent to the gas stream
- High turbulence zone promotes particles removal and pollutant absorption
- Potentially capable to handle varying gas flow rates and pollutant concentrations
- Control emissions containing acid gases and particulates, gas quenching
- Simple design with fewer moving parts compared to other scrubber



RJS experimental test rig



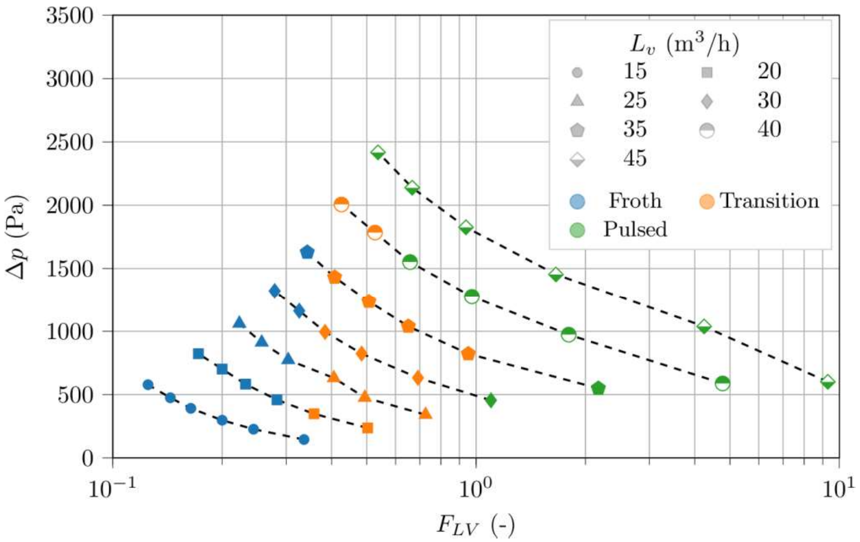
Liquid flow rates: 15 ÷ 45 m^3/h
Gas flow rates: 500 ÷ 3500 m^3/h
Solid cone nozzle
Contact section DN300

Scaled version DN50 - WIP

RJS experimental tests

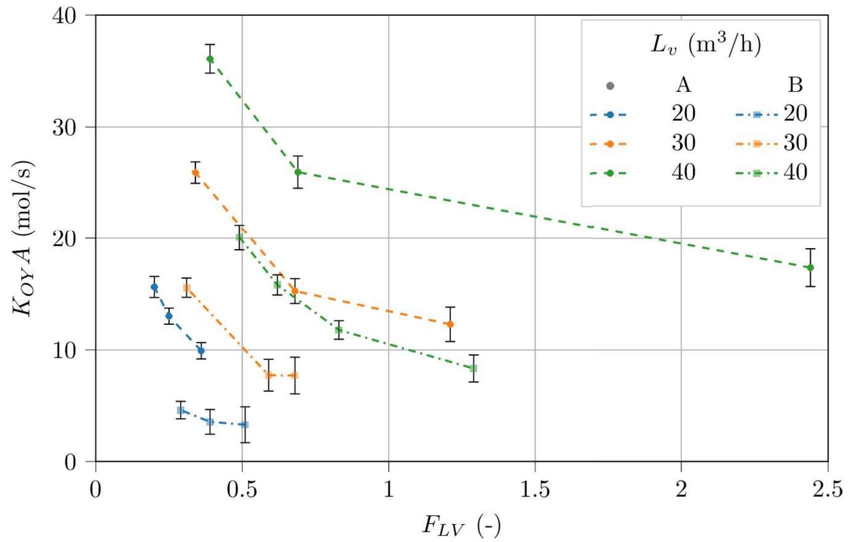
Fluid dynamic

- visual inspection of the jet
- jet height
- gas pressure drops across the jet



Mass transfer

- two test system with different water solubility (A, B)
- amount of absorbed VOCs across the jet
- modelling purpose



DN400 packed columns test rigs

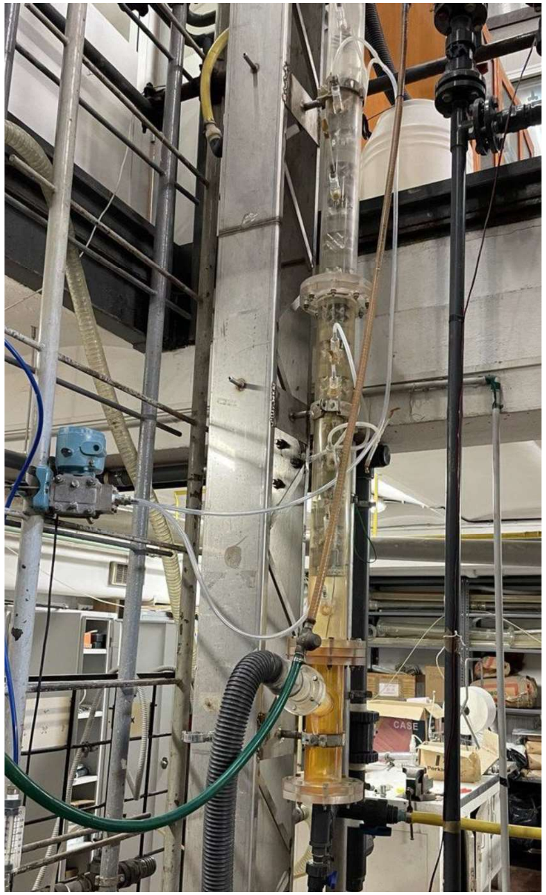
Two DN400 packed columns:

- fiberglass
- AISI316L

- 3 m bed height
- Concentration and pressure drops sampling points
- Inspection windows

- Pressure drops and mass transfer characterization of structured packings
  - Probes development
  - Physical and Chemical absorption
- Entrainment analysis

DN100 – DN50 gas-liquid experimental test rigs



DN100:

- Fluid dynamic and mass transfer performance evaluation
- Commercial structured packing (e.g., Mellapak 252Y, Katapak)
- Unconventional packing elements: sandwich, novel geometries

DN50 (vertical):

- Fluid dynamic and mass transfer performance evaluation
- Co- current compact scrubber

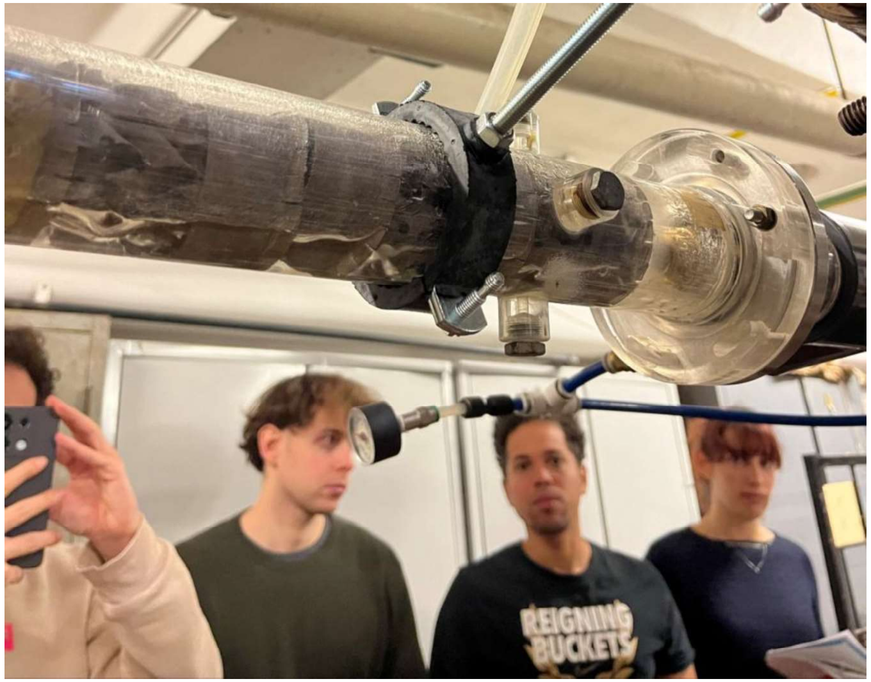
Applications:

- Gas effluent washing
- VOC scrubbing

DN100 – DN50 gas-liquid experimental test rigs

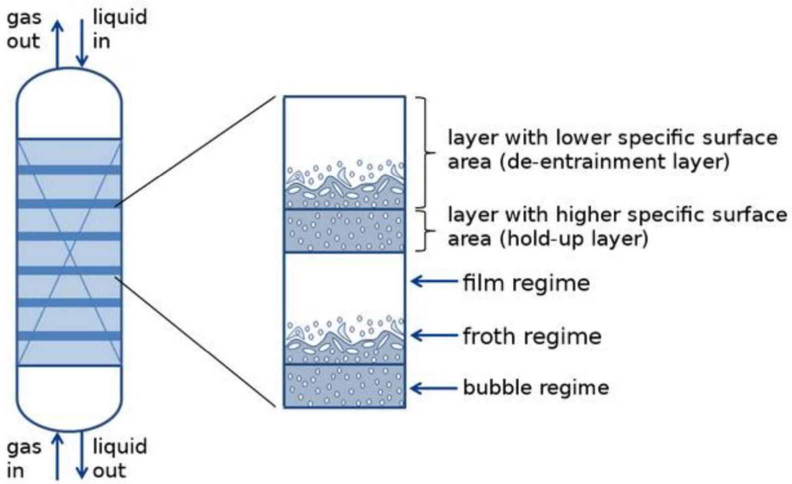
DN50 (horizontal):

- Fluid dynamic and mass transfer performance evaluation
- Co- current compact scrubber



Partially flooded packed bed (sandwich packing)

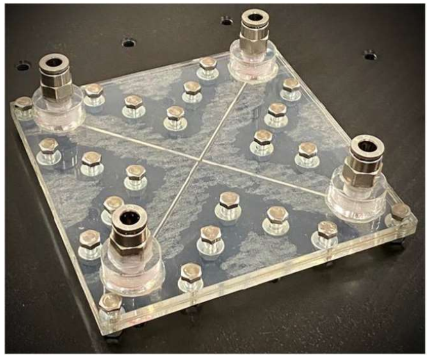
- Combination of low and high specific surface area packings (holdup and de-entrainment layer)
- Advantages in managing flooding and controlling stage residence times
- Narrow optimum operating range close to the flooding point of the high area element
- Experimental campaign to measure pressure drops at different locations along the packed bed
- Characterization of loading, flooding and incipient flooding phases
- Fourier (FFT) and wavelet transform

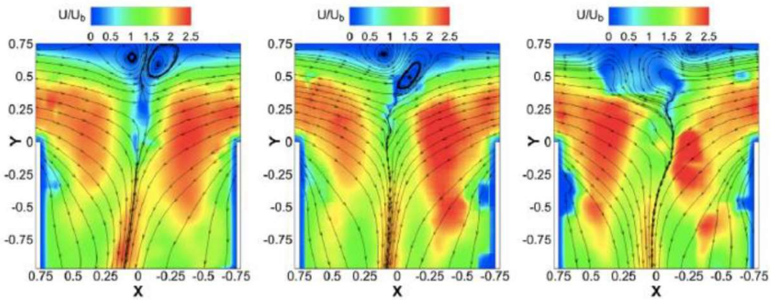


From batch to continuous

- **Microreactors**

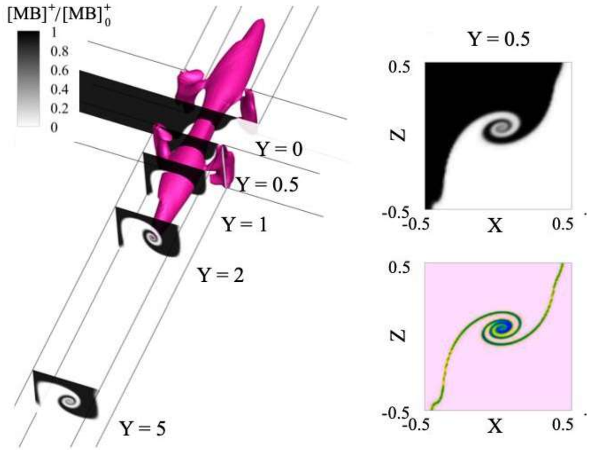
Experiments





Micro PIV

Numerical simulations

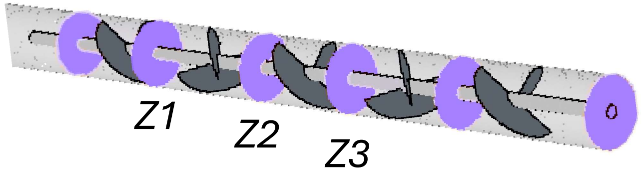


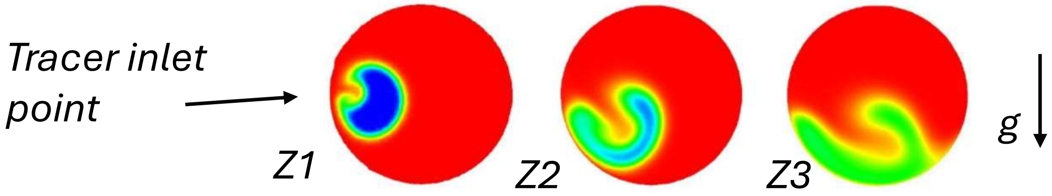
- Pharma application
- Micro-mixing
- Micro-encapsulation
- Emulsification
- Particles production

From batch to continuous

Tubular Flow Reactor: plant prototype for the flexible production of different chemical formulates

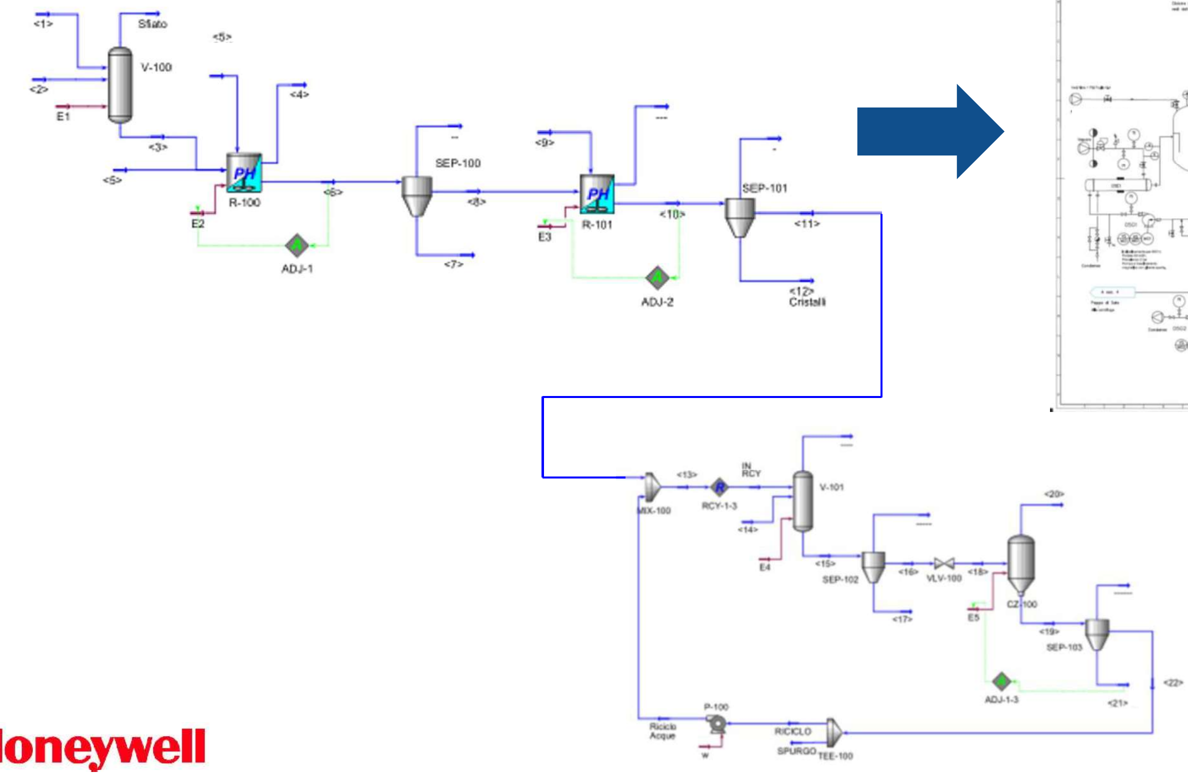
Numerical simulations aided design &
Digital Twin oriented to the development of the control system

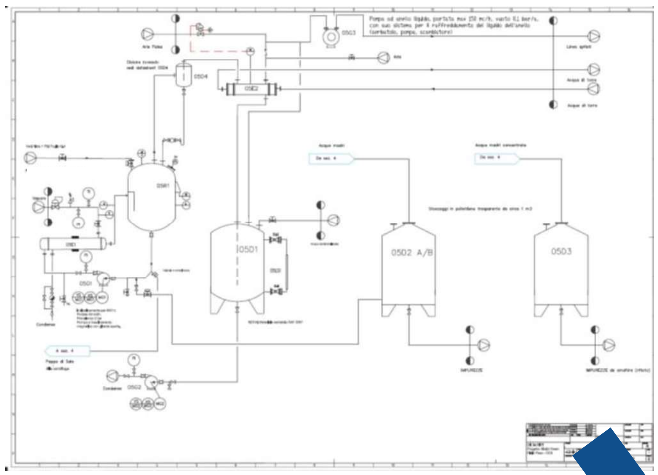


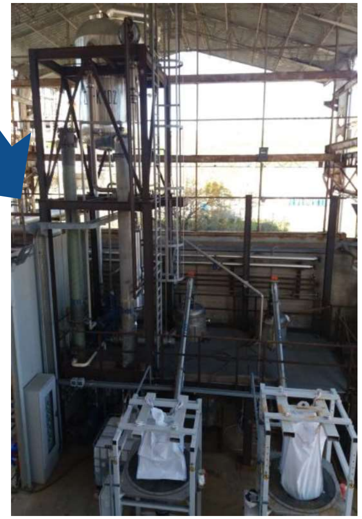


Numerical simulation and digital twins

- **Process development and pilot plant design**







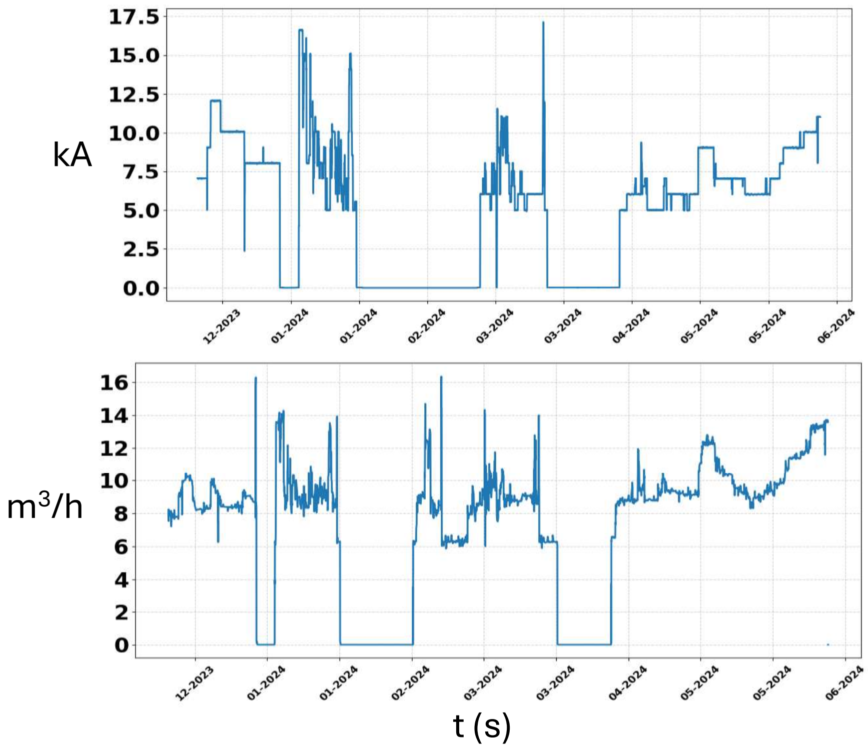
Honeywell
UniSim® Design

Numerical simulation and digital twins

- **Digital twin**

Application example: Chloro-alkali electrolyzer

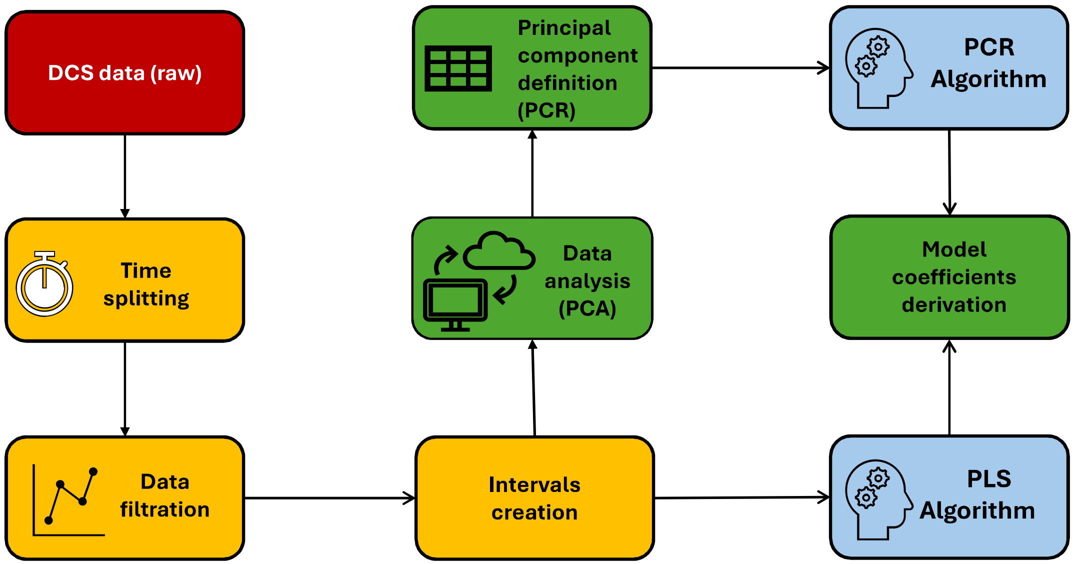
Data from DCS



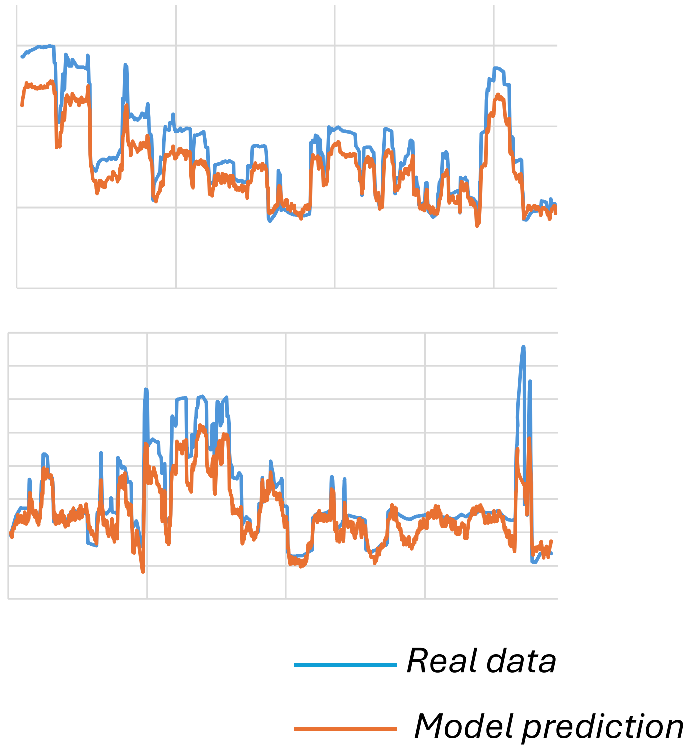
Numerical simulation and digital twins

- **Digital twin**

Model development



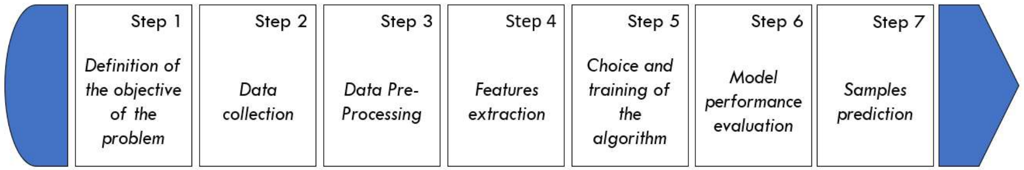
Model results

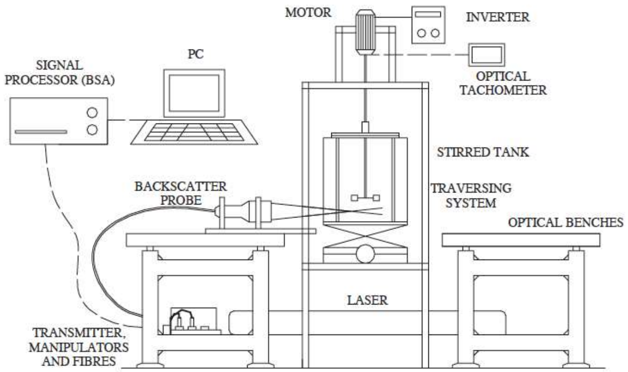


Maintenance management and optimization, reduction of downtime

AI applied to chemical engineering

- **Machine learning regimes identification:** Flow patterns in a stirred vessel

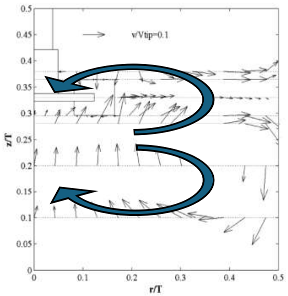




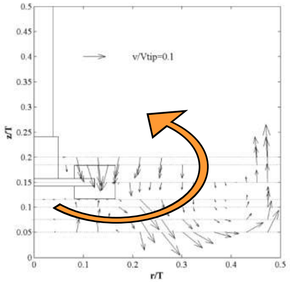
Transitional state
C = 0.175 · T

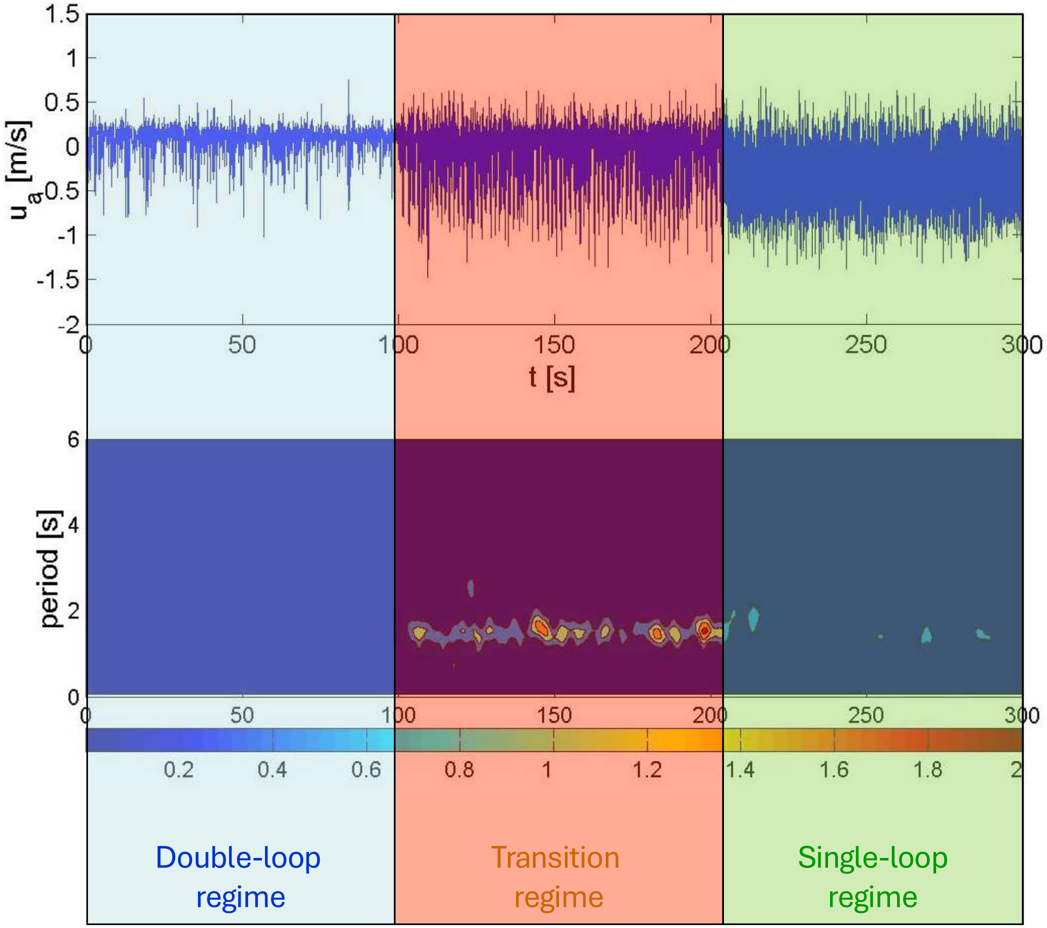
Velocity measurement technique: LASER DOPPLER ANEMOMETRY

Double Loop
C > 0.2 · T



Single Loop
C < 0.15 · T





AI applied to chemical engineering

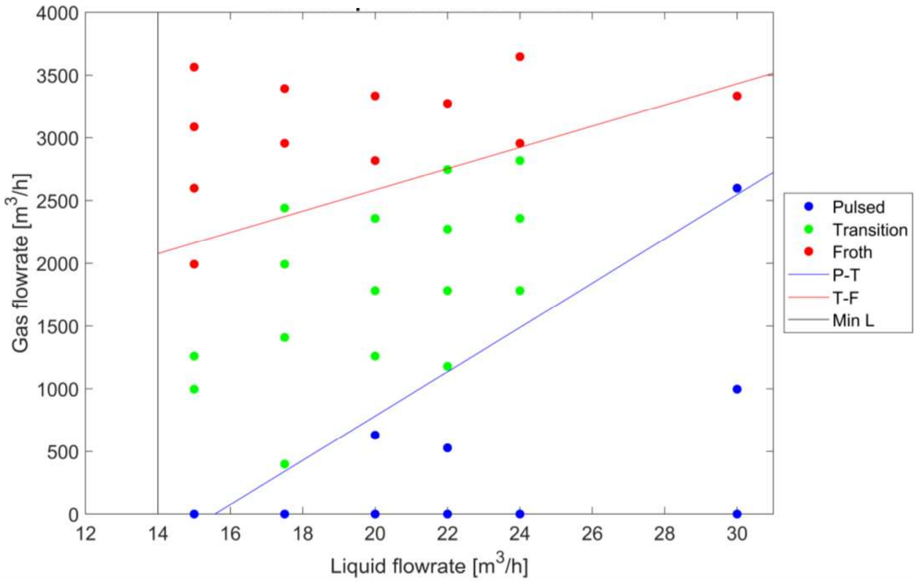
- **Machine learning regimes identification:** Reverse Jet Scrubber

Pulsed regime

L = cost
↑ G

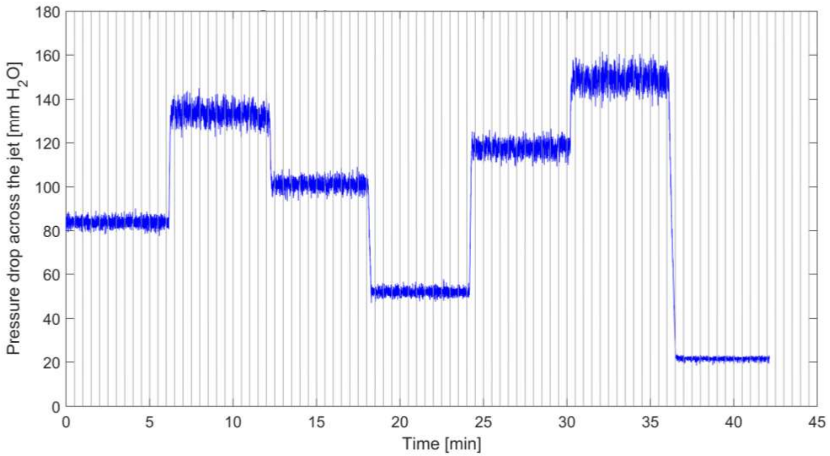
Froth regime

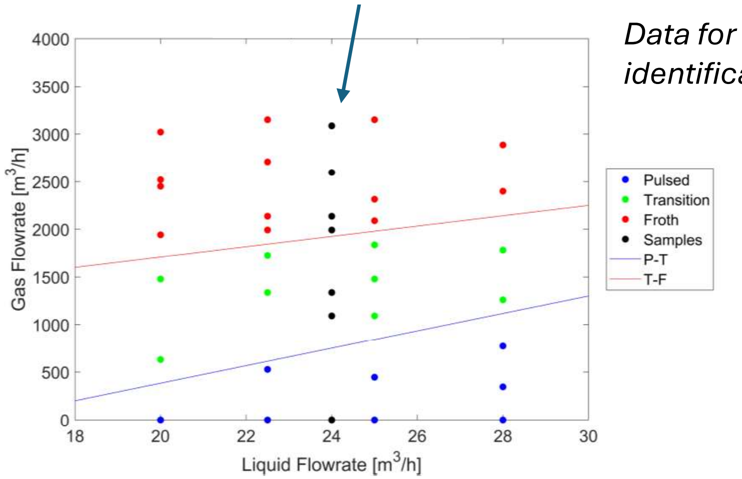
Flow map by jet visual inspection



AI applied to chemical engineering

- **Machine learning regimes identification:** Reverse Jet Scrubber





Data for regimes identification

Model prediction

FAN FREQ [Hz]	FLOW MAP	LINEAR DISCRIMINANT
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
20	TRANSITION	TRANSITION
35	FROTH	CHANGE
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
35	FROTH	FROTH
25	FROTH	CHANGE
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
25	FROTH	FROTH
12	TRANSITION	CHANGE
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION

FAN FREQ [Hz]	FLOW MAP	LINEAR DISCRIMINANT
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
12	TRANSITION	TRANSITION
30	FROTH	CHANGE
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
30	FROTH	FROTH
40	FROTH	CHANGE
40	FROTH	FROTH
40	FROTH	FROTH
40	FROTH	FROTH
40	FROTH	FROTH
40	FROTH	FROTH
40	FROTH	FROTH
40	FROTH	FROTH
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40	FROTH	FROTH