BEI
3HY E&P

MODELING OF OXIDATION DITCHES IN WASTEWATER TREATMENT

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Plan

- Industrial context
- Presentation
- Objectives
- Equations
  - Modeling of liquid flow only
  - Modeling of spiral flow in cross section
  - Modeling of the oxygen transfer
- Results
- Conclusion
- Opening

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Industrial context(1/2)

Project O2Star

D. Legendre

A. Cockx

Industrial context (2/2)

Project O2Star

- Development of software for the conception, sizing and optimization of aeration system in wastewater treatment plant
- For water treatment industries
- From experiments and numerical tools
- To predict precisely the oxygenation capacity of oxidation ditch

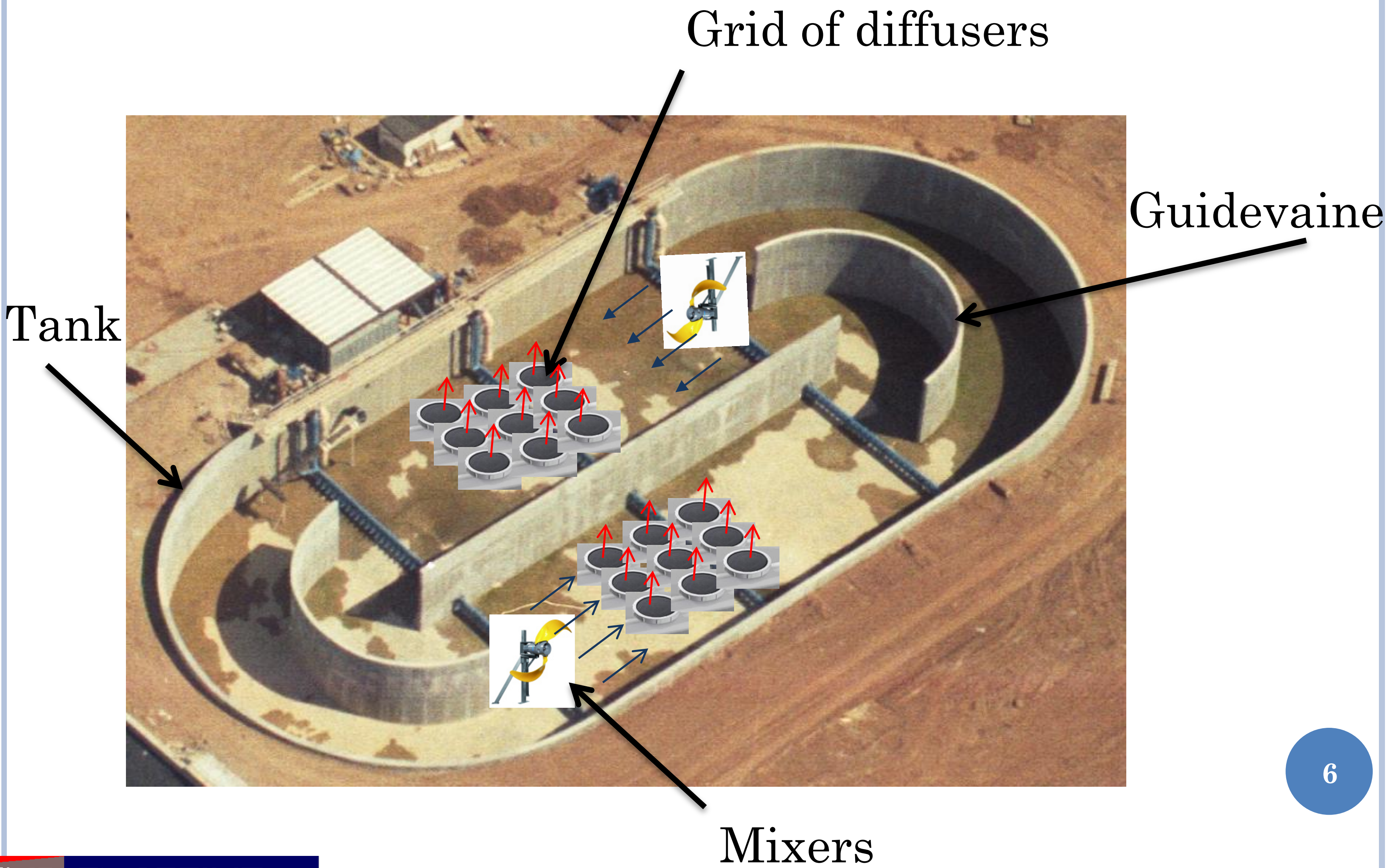
PRESENTATION (1/3)

- Wastewater Treatment Plant (WWTP) :biological reactor
  - **Aeration** : creates a bacteria activity

    => consumption of oxygen

  - **Mixers** : creates stir

PRESENTATION (2/3)



PRESENTATION (3/3)

- Calculating the oxygen transfer

  → Creation of a simple tool

- Matlab program
  - Adaptation for all the reactors
  - Variation of several parameters
  - Functional tool
  - For industrials

EQUATIONS (1/6)
MODELING OF LIQUID FLOW ONLY

- Mixers => flow inside the tank
- Losses :
  - friction

$$\Delta P = \frac{S_w \tau_w}{A}$$

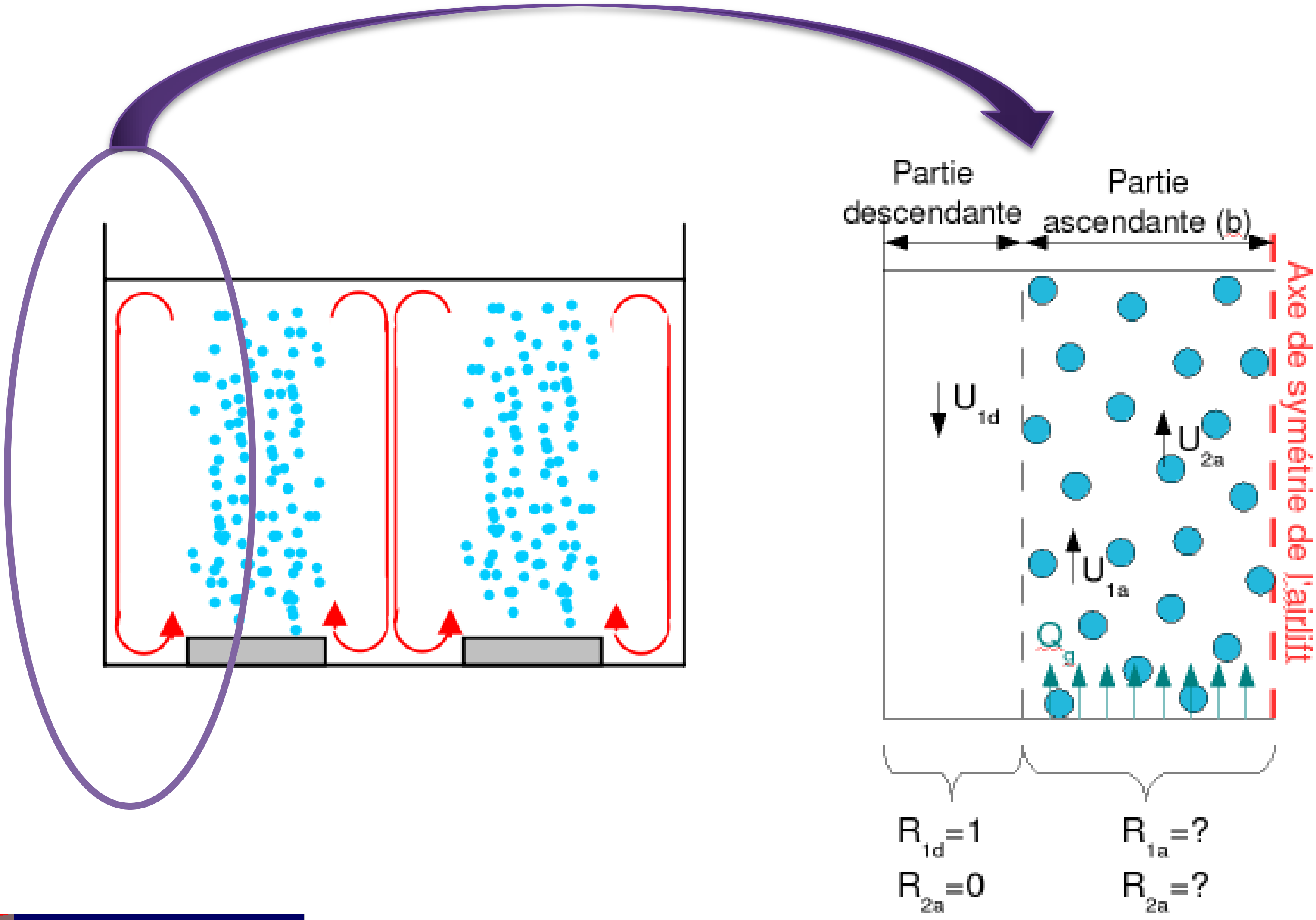
  - bend

$$\Delta P_{sing} = \frac{1}{2} \rho_L \xi_{coude} U^2$$

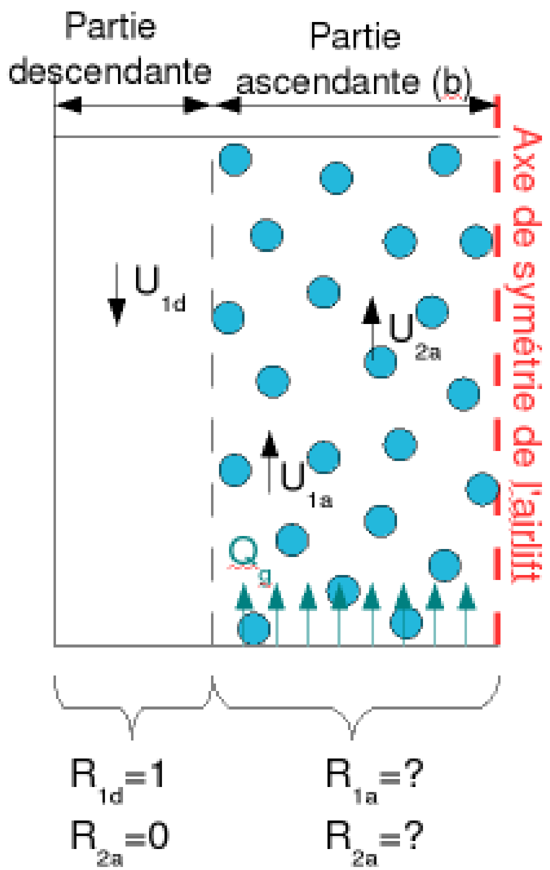
  - roughness

- Sum of $\Delta P = 0$ inside the tank => U

Equations (2/6)
Modeling of spiral flow in cross section



Equations (3/6)
Modeling of spiral flow in cross section



- Geometry

$$R_{2a}+R_{1a}=1$$

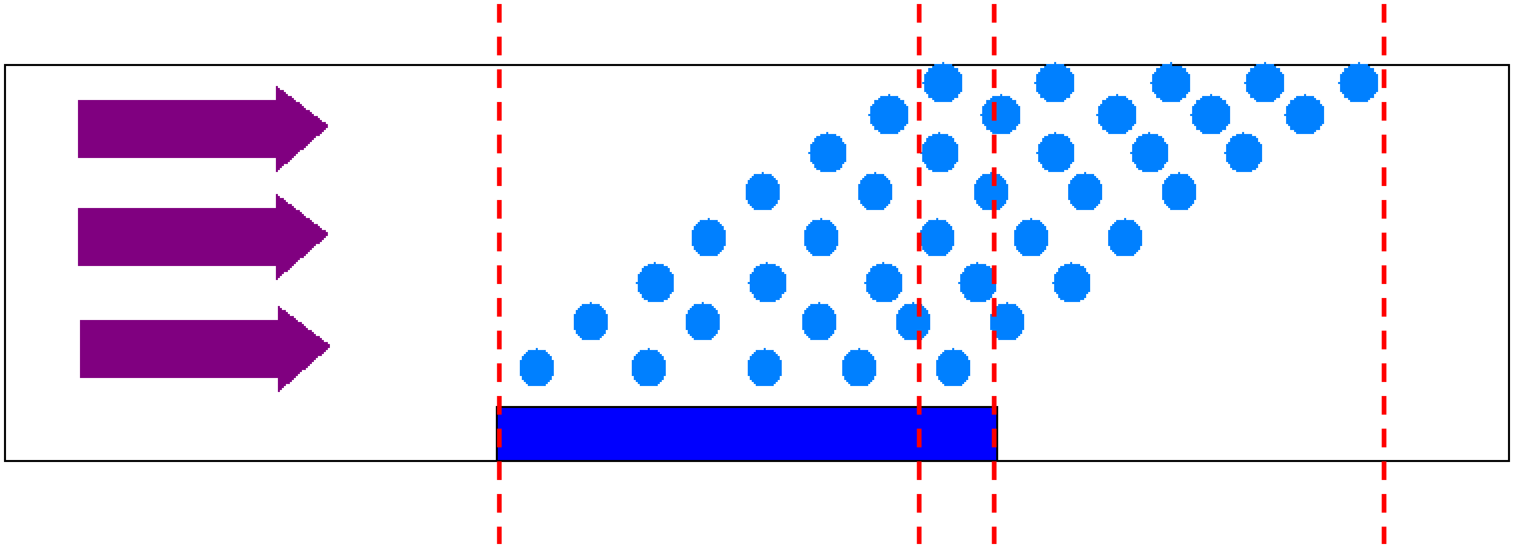
- Mass conservation

$$R_{2a}*\rho_2*U_{2a}=\frac{Q_g}{A}$$

- Momentum conservation

$$\Delta P_a-\Delta P_d=\rho_1*R_{1a}*g*h-\rho_1*g*h=PdC$$

Equations (4/6)
Modeling of spiral flow in cross section



Three zones :

- Entering : increasing of gas rate
- Permanent : maximum gas rate
- Exit : decreasing of gas rate

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Equations (5/6)
Modeling of the oxygen transfer

- Spring terms :
  - Transfer of oxygen from air bubbles to water

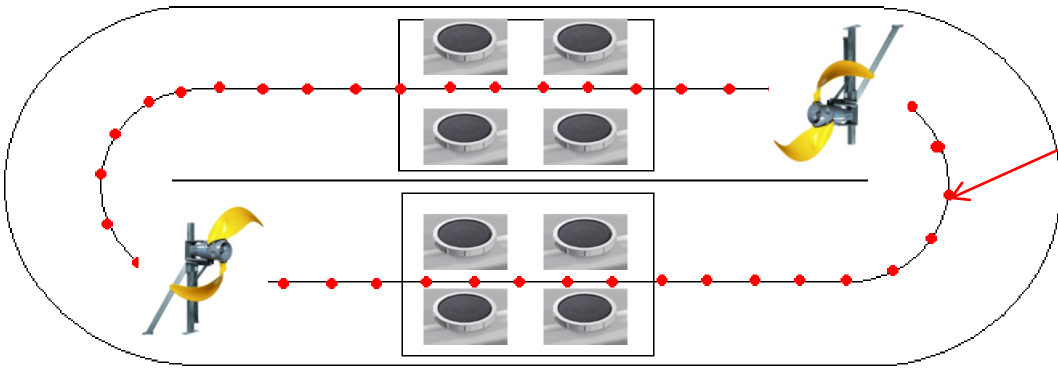
- Well terms :
  - Bacteria consumption of oxygen
  - Disappearing of bubbles at the tank surface

Free tank surface << Total bubbles surface

Simulation in clean water => no bacteria

Neglecting of well terms

Equations(5/6)
Modeling of oxygen transfer



x-discretization

$$C(x)=C_s-(C_s-C(x-1))\,e^{\left(\frac{-Kl.a.x}{Umoy}\right)}$$

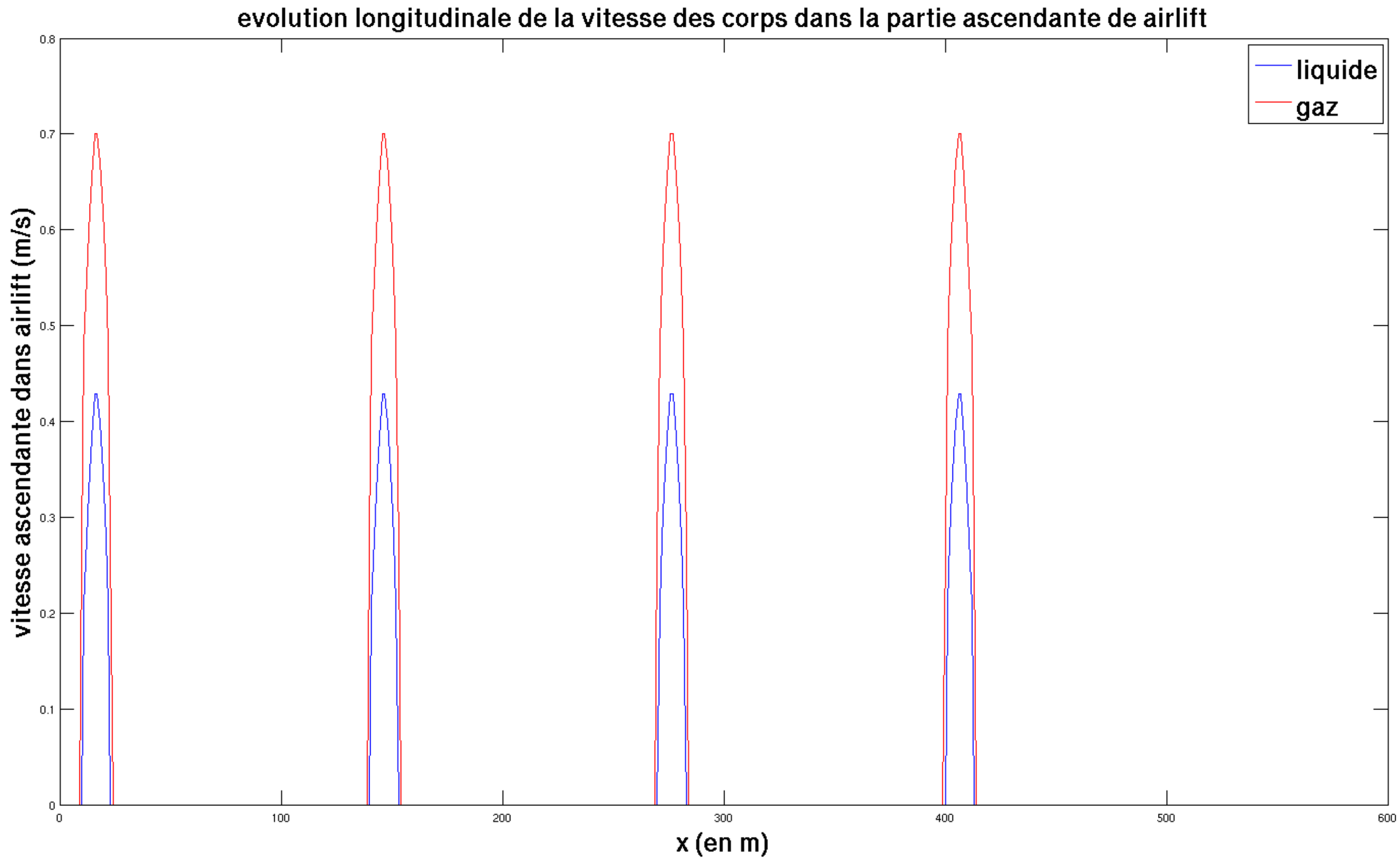
Kl : transfer coefficient

a : interfacial area

Umoy : average liquid velocity

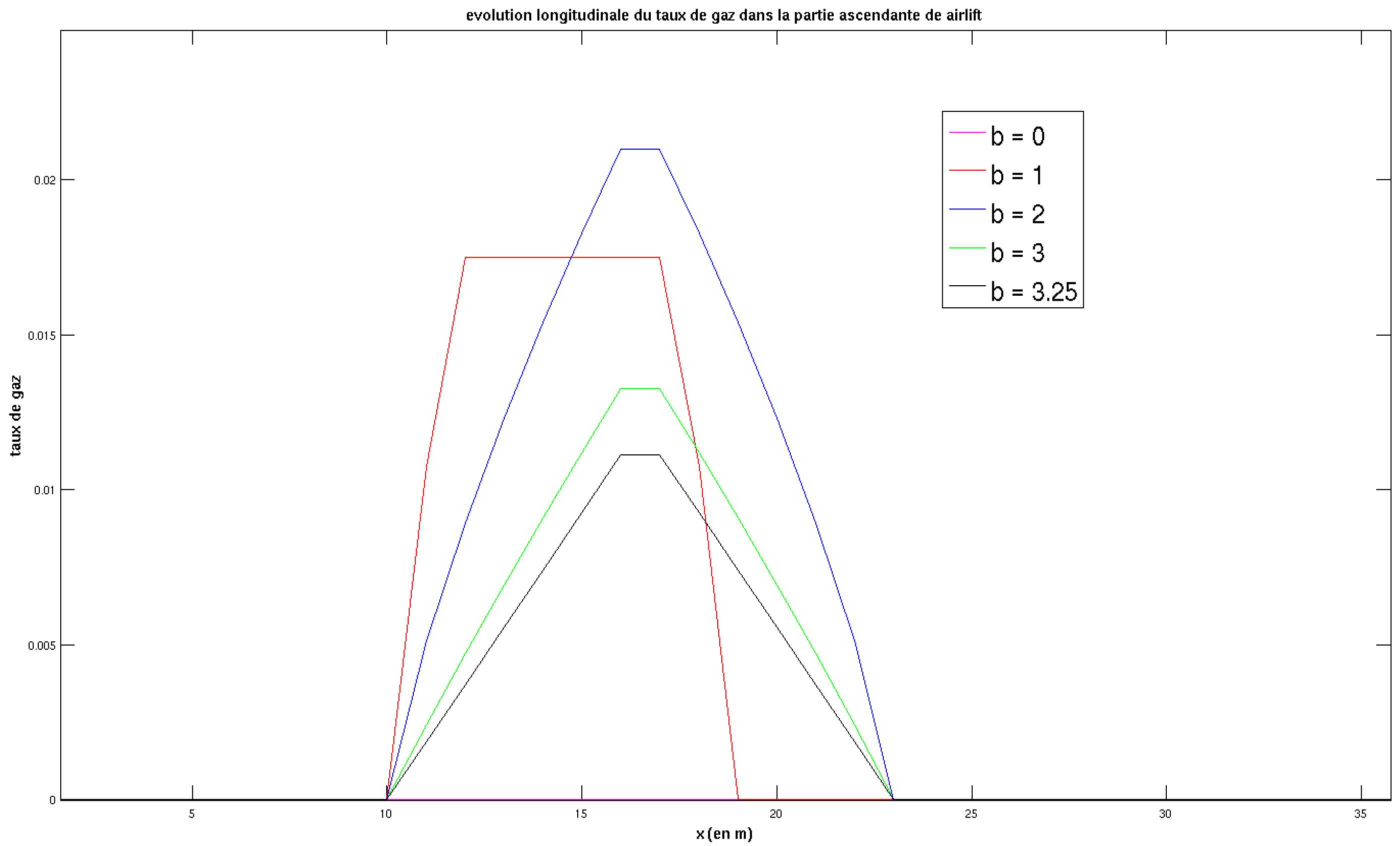
Cs : gas concentration at saturation

RESULTS (1/4)



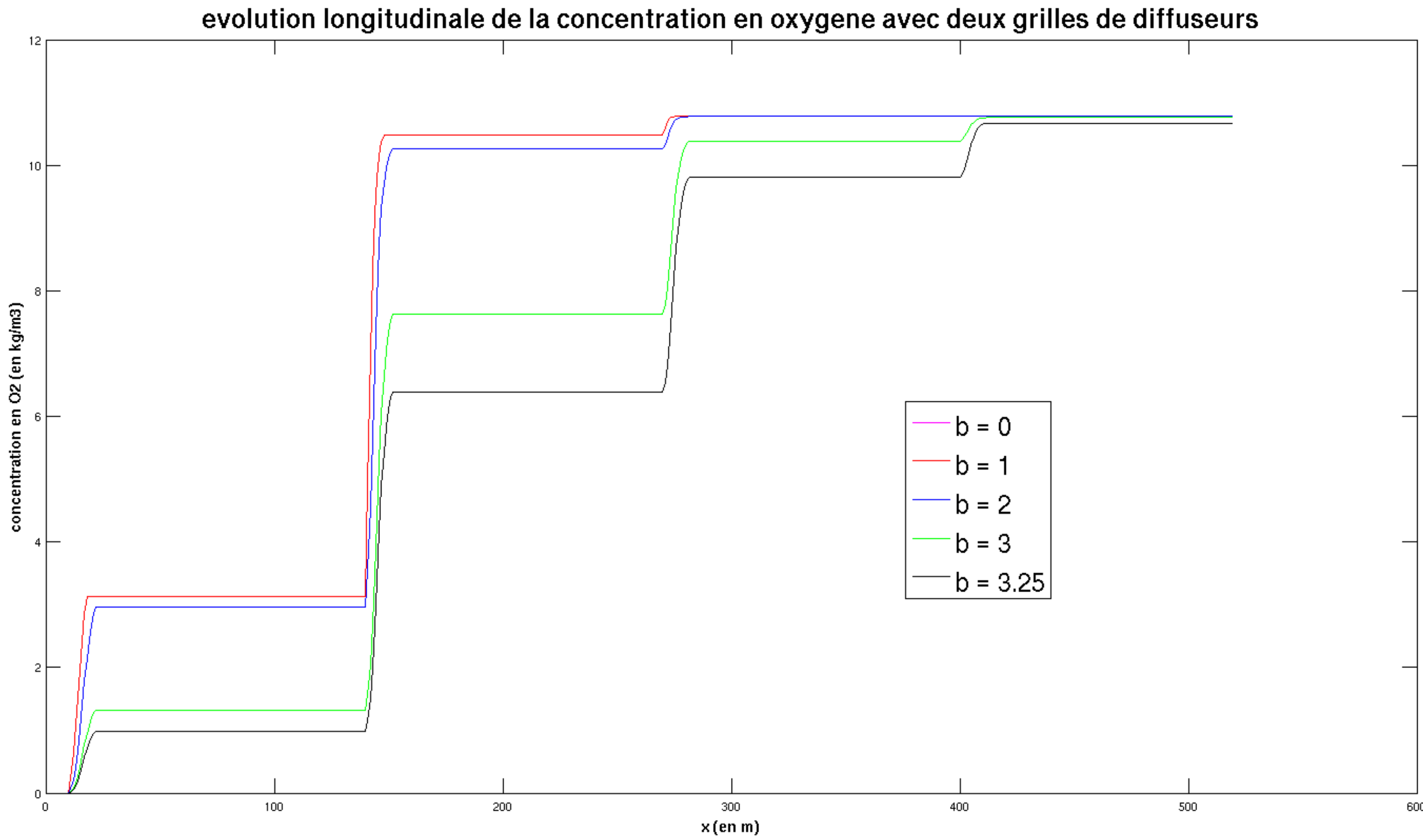
Gas and liquid velocities inside the rising part of the airlift

RESULTS (2/4)



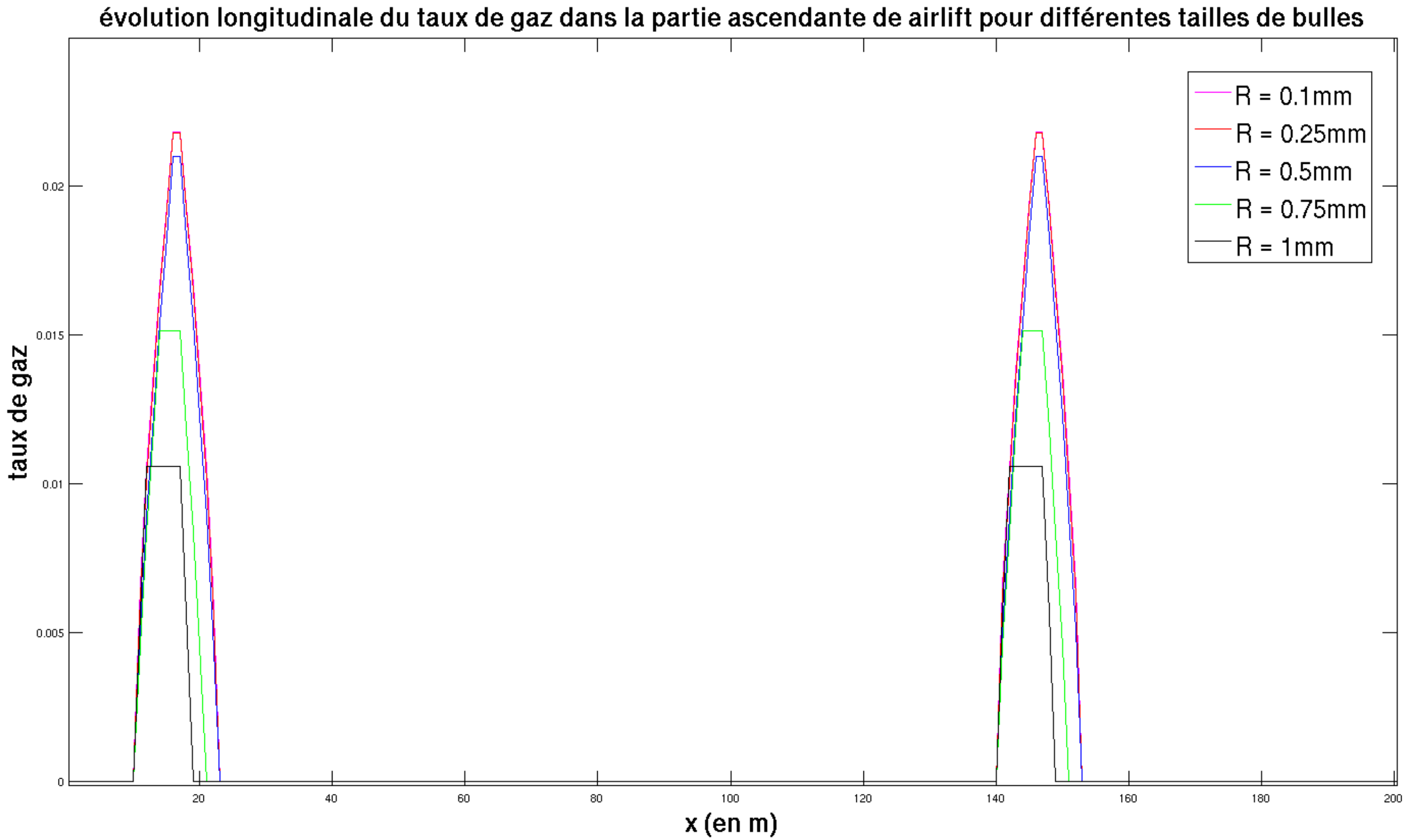
Gas rate for several airlift sizes

RESULTS (3/4)



Oxygen concentration for several airlift sizes

Results (4/4)



Gas rate for several bubble sizes

Conclusion

- Project entirely built
  - Hypothesis reflection
  - Establishing of the equations
  - Creation of Matlab program
  - Results analysis

- Scientific and personal enrichment
  - Using and improving of our two-phase flow skills
  - Autonomy
  - Contact with industrial world

Opening

- To drag along bubbles inside the descendant part of the airlift
- To add a longitudinal airlift modeling
- To improve the precision of the calculations
- To consider the mixers influence upon the flow