



UNIVERSITÉ DE STRASBOURG

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INSTITUT DE MÉCANIQUE DES FLUIDES ET DES SOLIDES DE STRASBOURG

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# Optimization of a hydrodynamic separator using a multiscale CFD approach

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**Intro**

Objectives

Methods

Results

Conclusion

# 1. Introduction

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✘ Stormwater pollution :

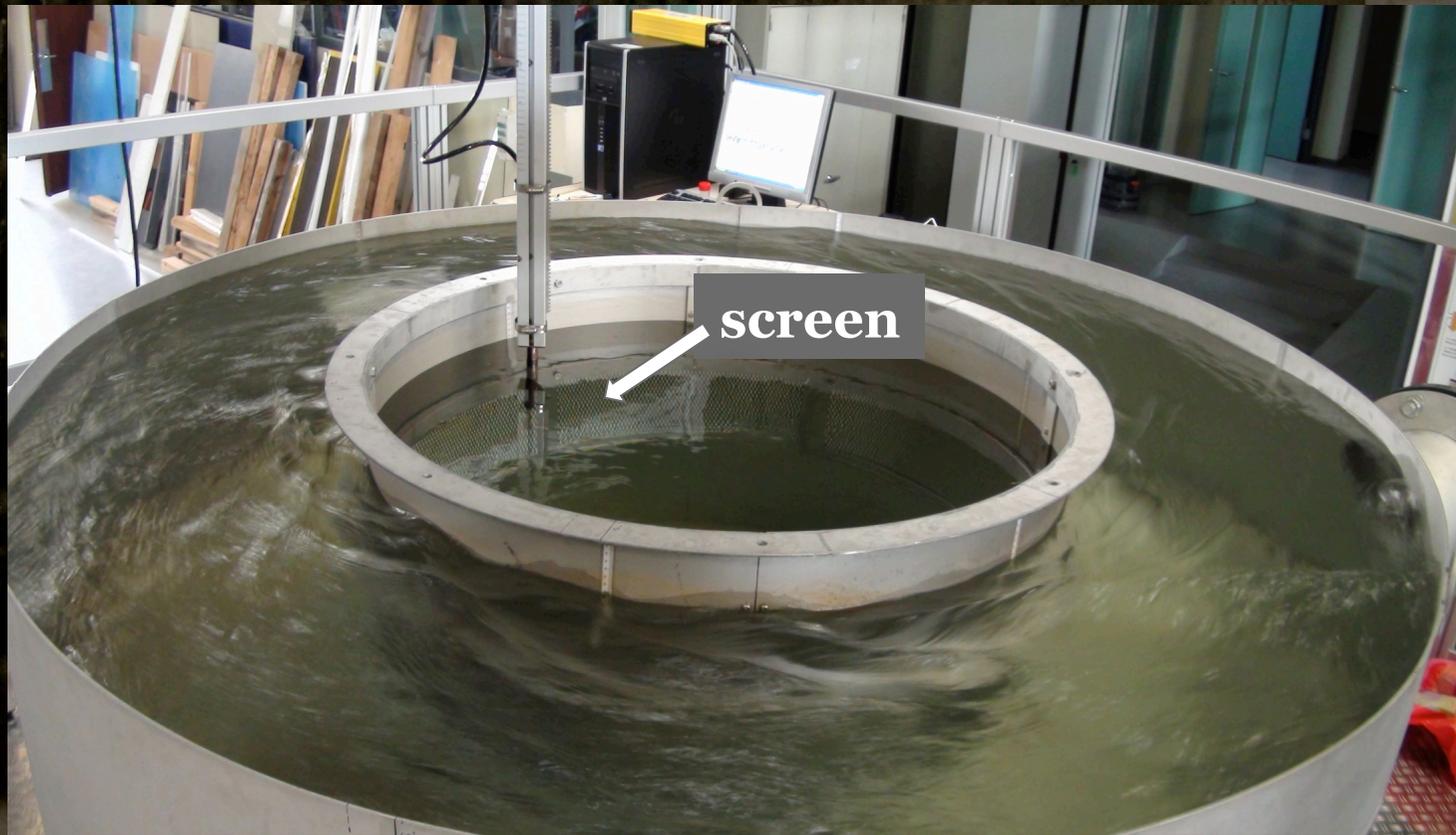
- plastic debris
- coarse sediments
- large particles



✘ Hydrodynamic separator :

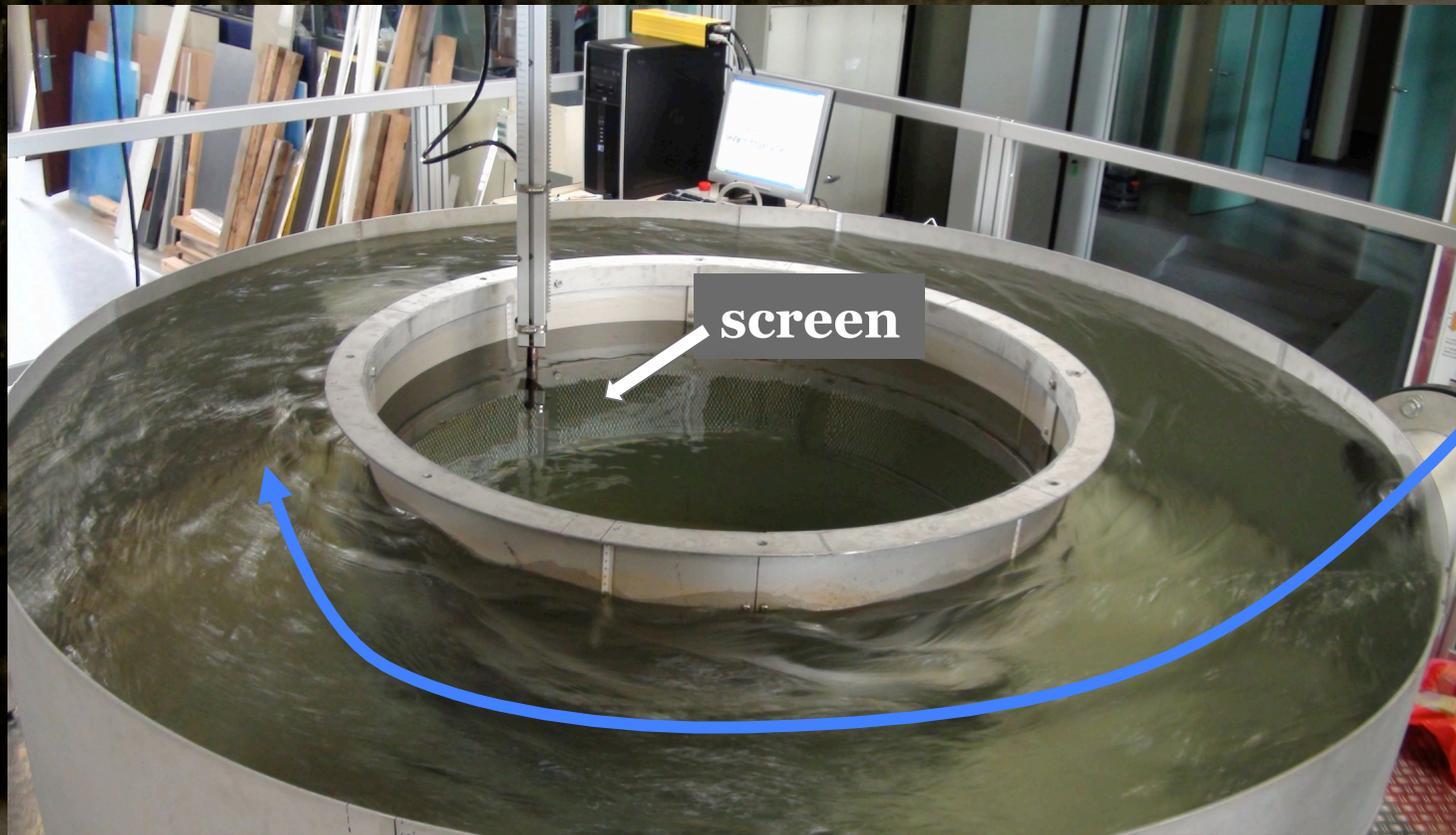
- structure used to remove gross pollutants from water

✘ The CycloneSep<sup>®</sup>: the pilot of IMFS lab



$$h = 1 \text{ m} ; D_{\text{screen}} = 1 \text{ m} ; D_{\text{ext}} = 2 \text{ m}$$

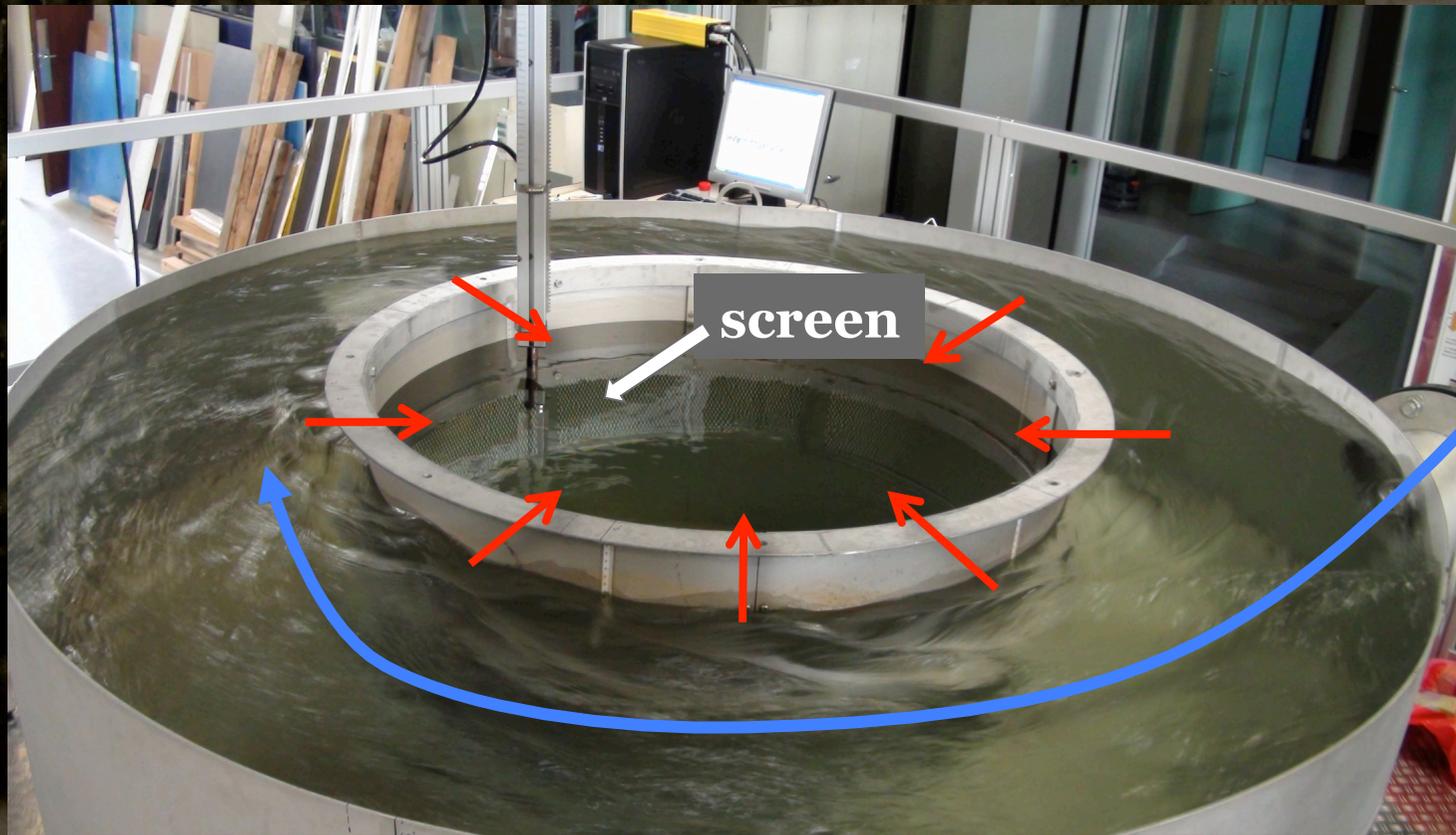
✘ The CycloneSep<sup>®</sup>: the pilot of IMFS lab



inlet pipe

$h = 1 \text{ m} ; D_{\text{screen}} = 1 \text{ m} ; D_{\text{ext}} = 2 \text{ m}$

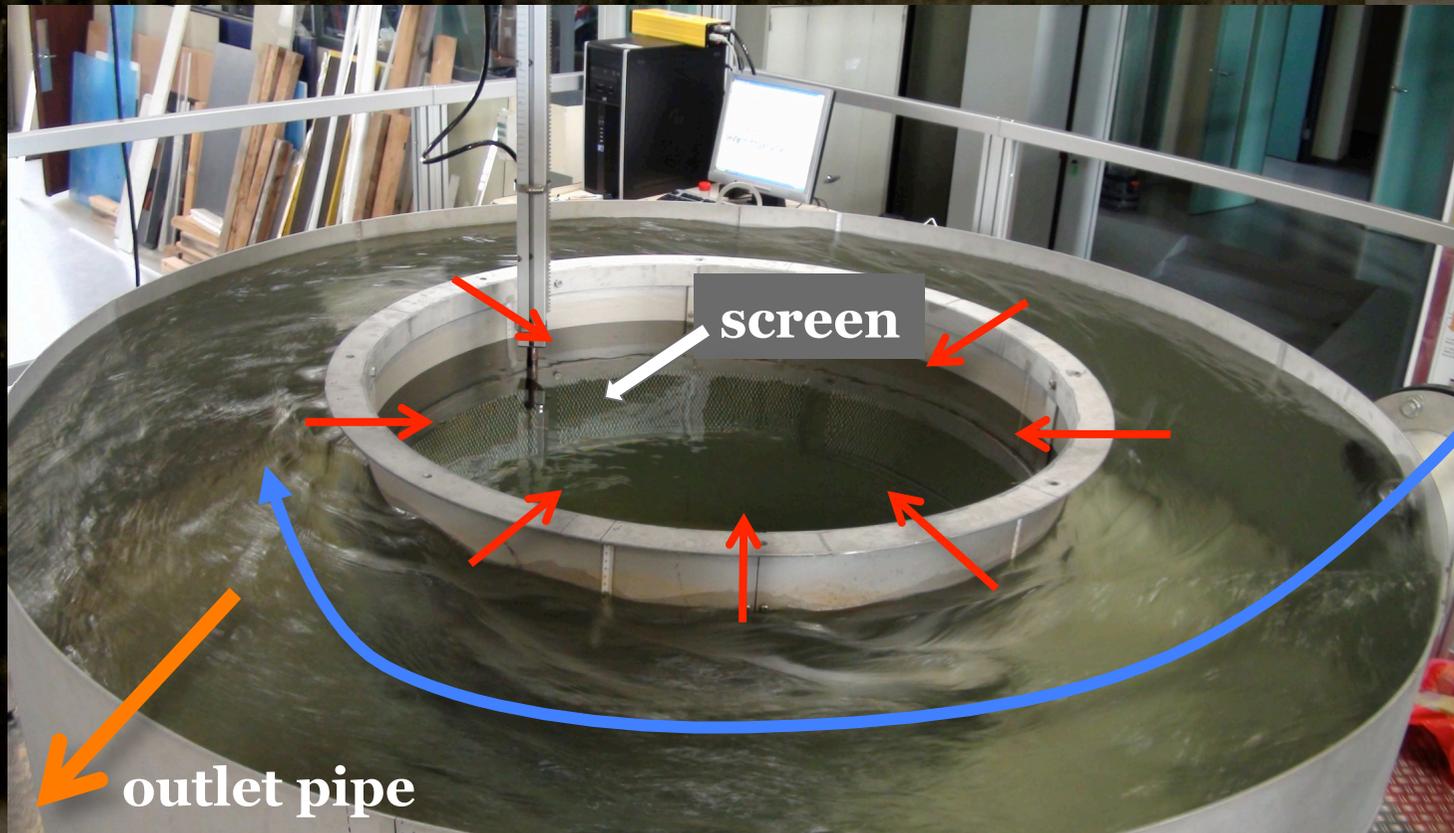
✘ The CycloneSep<sup>®</sup>: the pilot of IMFS lab



inlet pipe

$h = 1 \text{ m} ; D_{\text{screen}} = 1 \text{ m} ; D_{\text{ext}} = 2 \text{ m}$

✘ The CycloneSep<sup>®</sup>: the pilot of IMFS lab



$h = 1 \text{ m} ; D_{\text{screen}} = 1 \text{ m} ; D_{\text{ext}} = 2 \text{ m}$

✘ The CycloneSep: large waste in rotation



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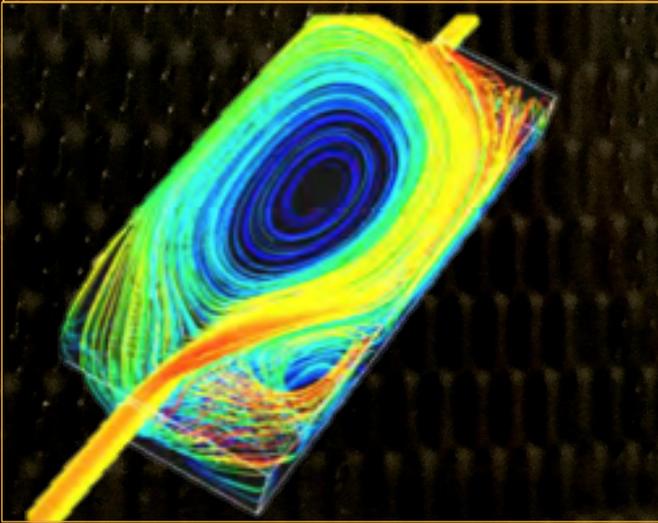
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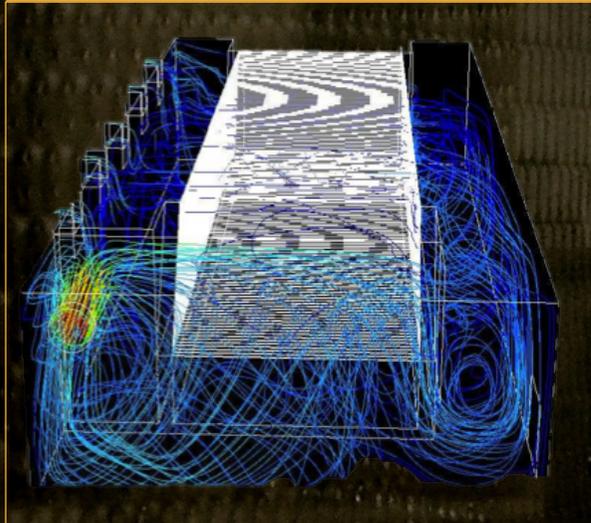
✘ Computational Fluid Dynamics : hydrodynamic visualization

Storage tank



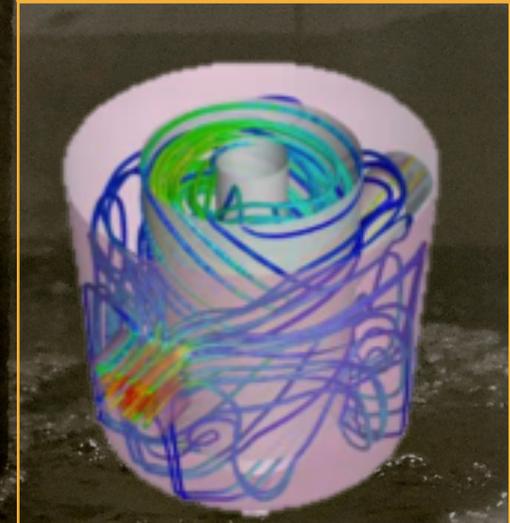
*Dufresne et al. 2008*

Lamella settlers



*Vazquez et al. 2008*

Hydrocyclone



*Lee et al. 2010*

Intro

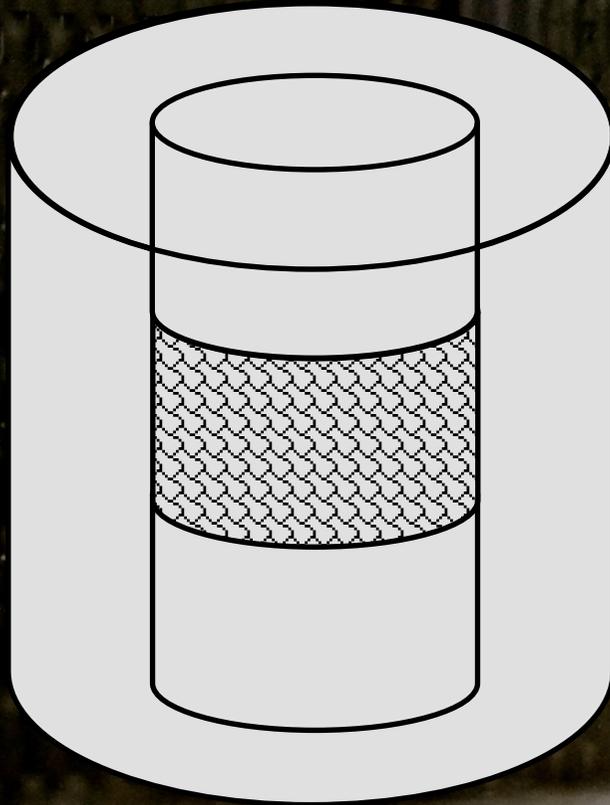
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Discretization of the domain



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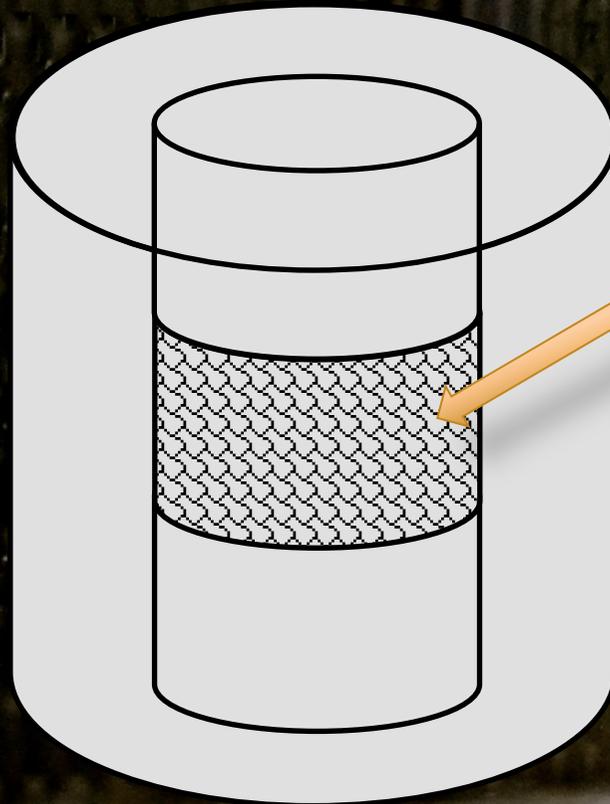
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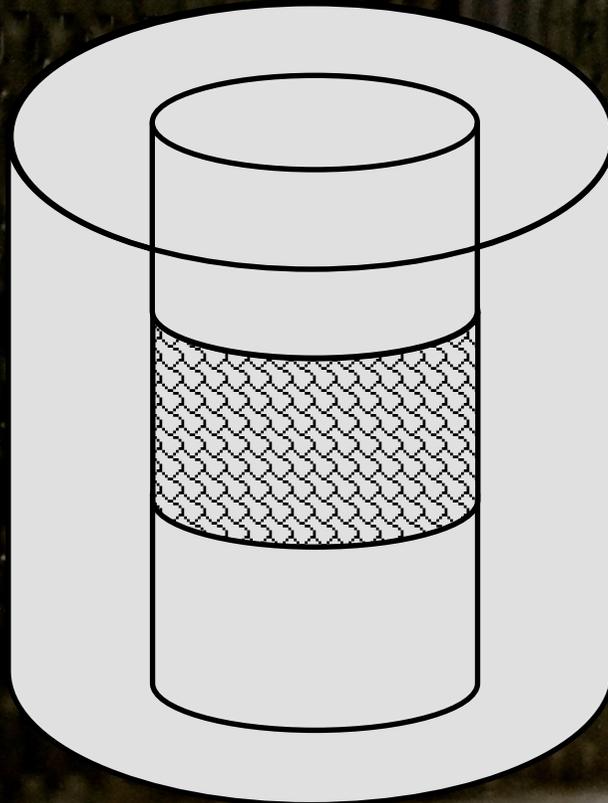
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Discretization of the domain



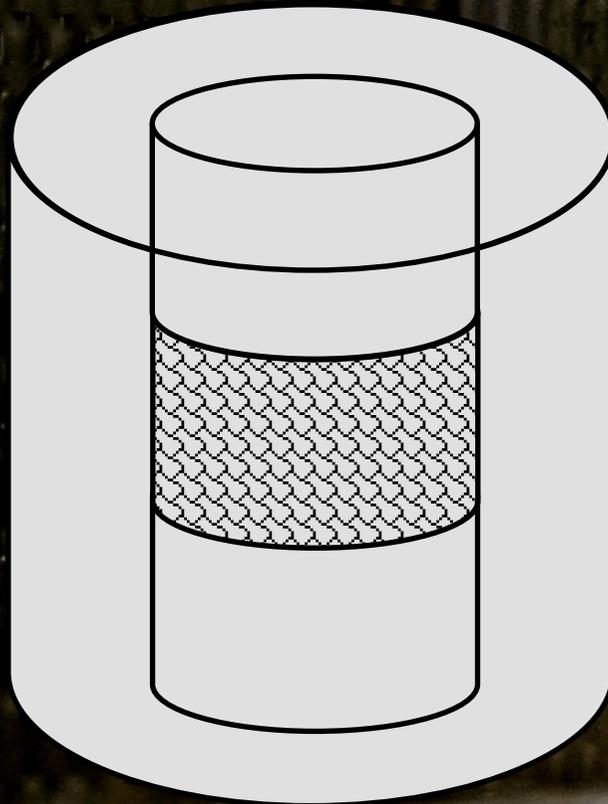
fine mesh nearby the screen

Discretization of the domain:



discretization of the volume

## Discretization of the domain



fine mesh nearby the screen



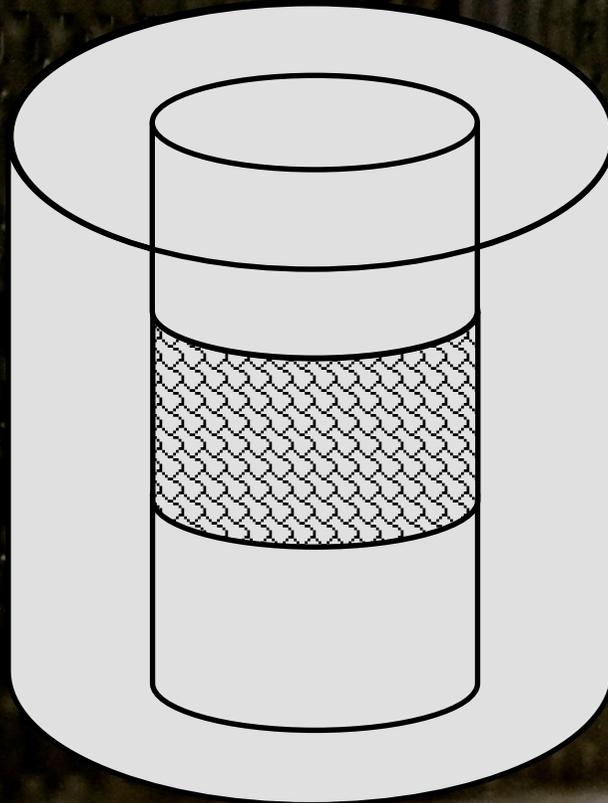
discretization of the volume



➔ Difficulties in mesh generation

➔ Too long computational time

## Discretization of the domain



fine mesh nearby the screen



discretization of the volume



→ Difficulties in mesh generation

→ Too long computational time

**Multiscale approach**

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**2 Objectives**



Intro

**Objectives**

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**2 Objectives**



Engineering



*Optimization*

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Engineering

*Optimization*



Research

*Multiscale method*

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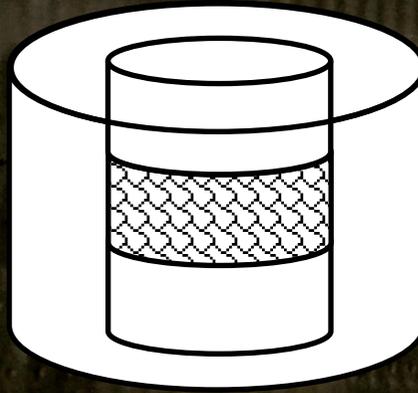
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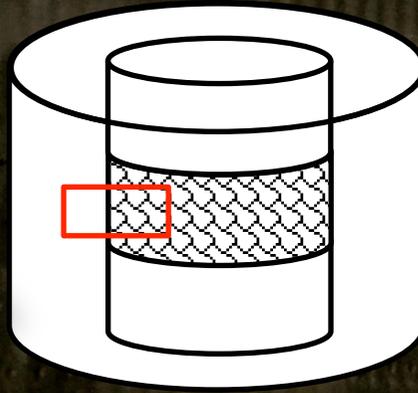
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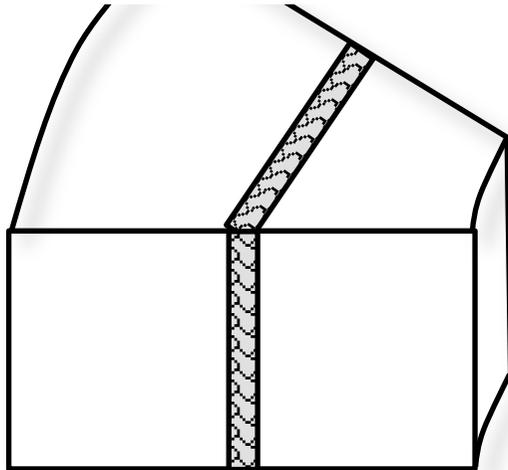
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Portion of the actual screen

**Local phenomena**



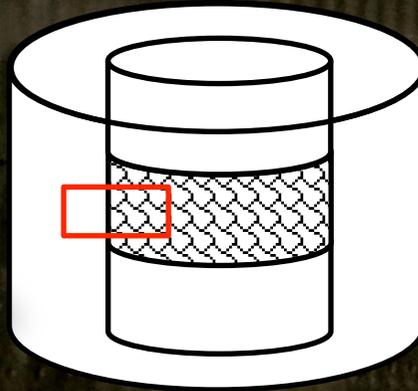
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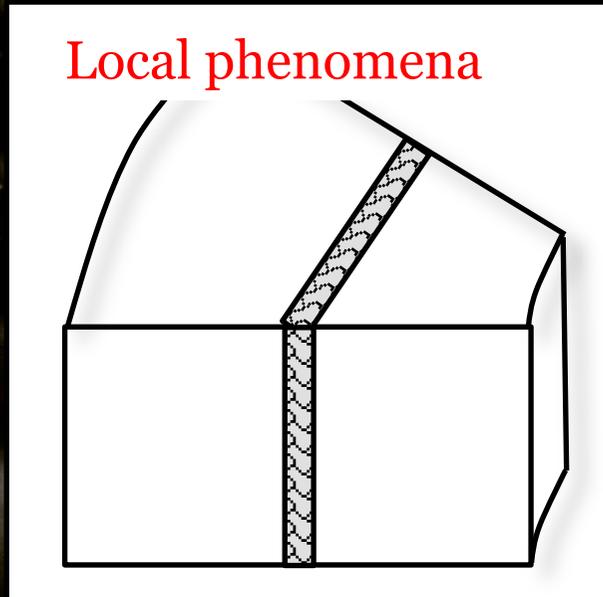
**Methods**

Results

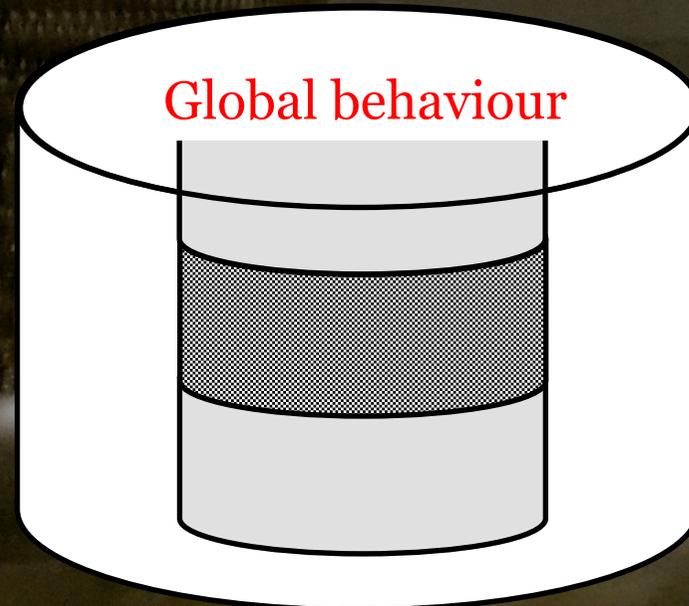
Conclusion

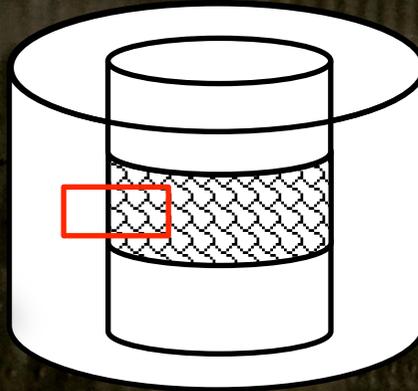


Portion of the actual screen



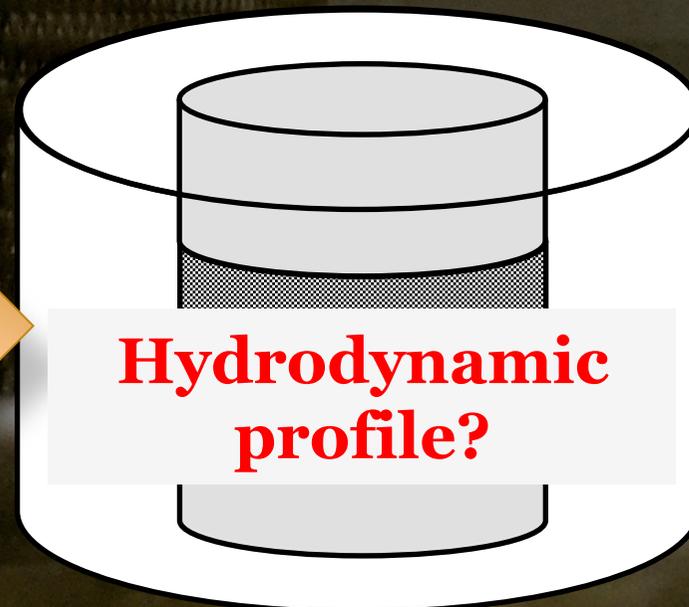
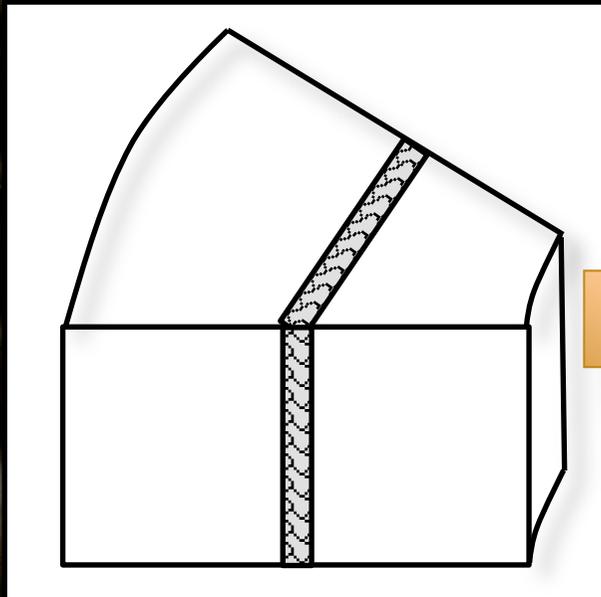
Porous screen





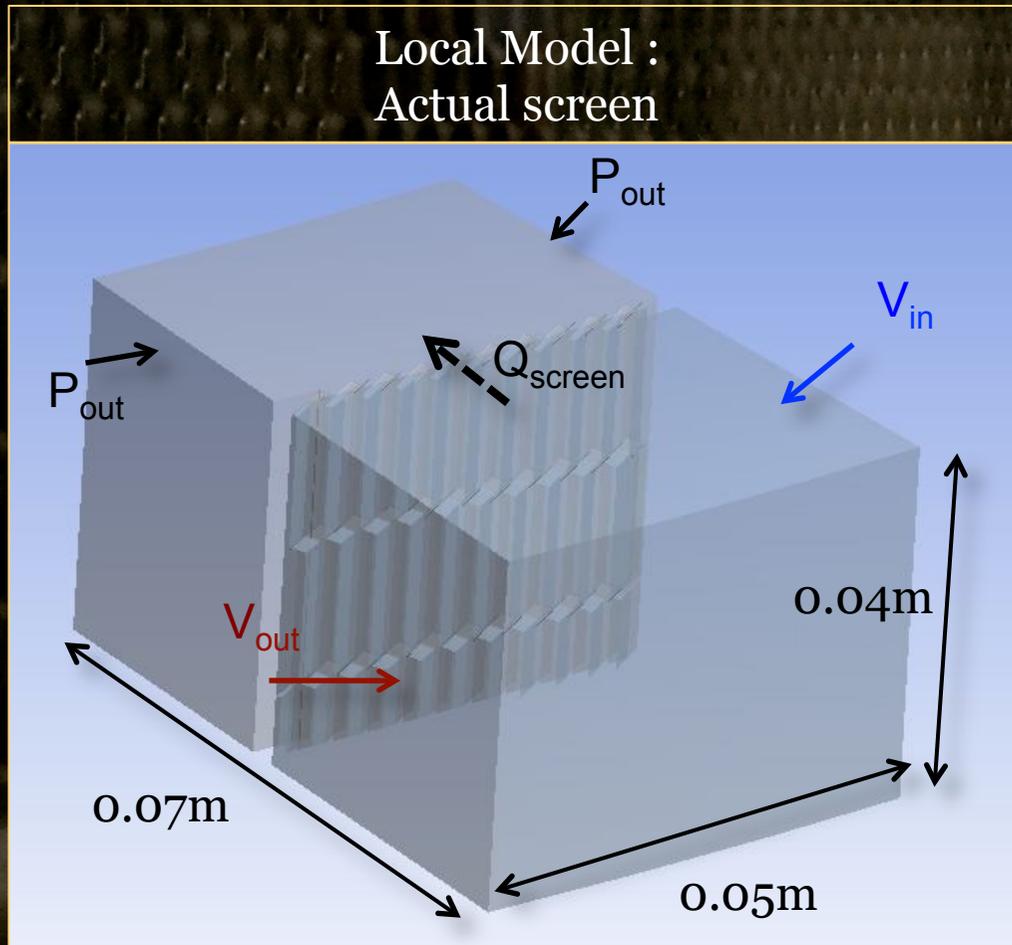
Portion of the actual screen

Porous screen



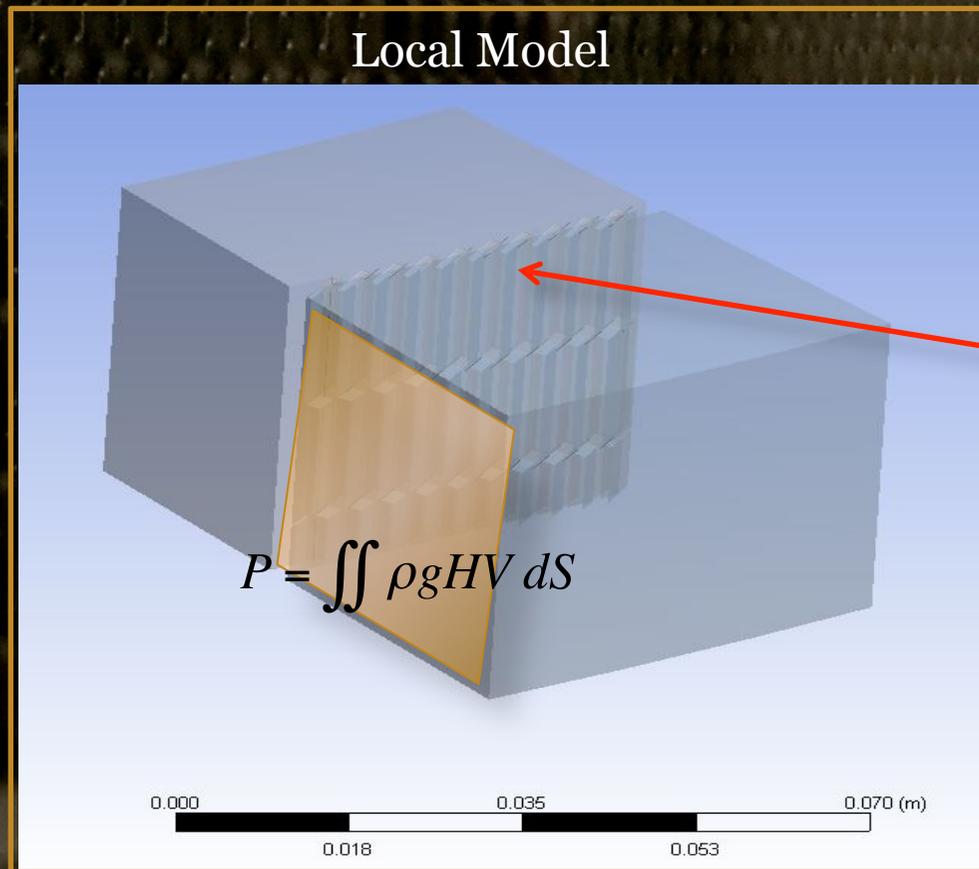
## ✘ Boundary conditions

Local Model :  
Actual screen



- $V_{out} - V_{in} \rightarrow Q_{screen}$

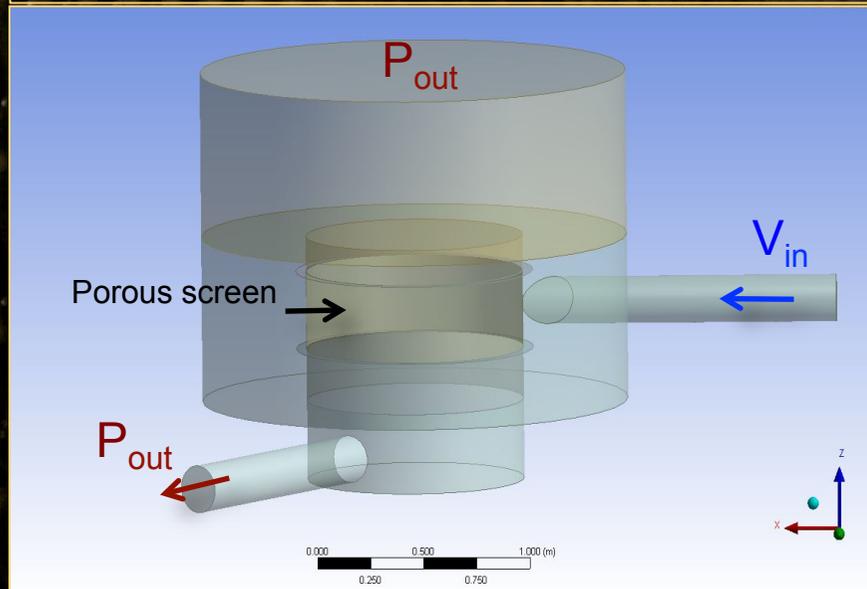
✘ Estimation of the energy loss caused by the screen



$$\Delta H = K \frac{\left( \frac{Q^2}{S^2} \right)}{2g}$$

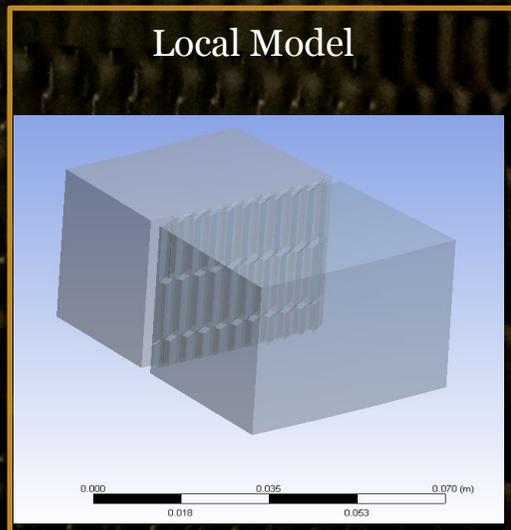
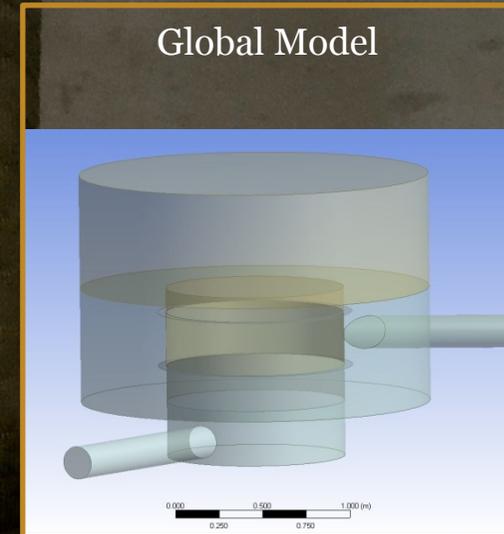
## ✘ Boundary conditions

Global Model :  
Porous screen



- $V_{in}$  impose the discharge
- $P_{out}$  impose the downstream water level

## ✘ Reproduction of the Energy loss in the global model

 $K$ 

- Source term in the CFD code:

$$S_i = - \left( \frac{K}{\Delta m} \frac{1}{2} \rho v_{mag} v_i \right)$$

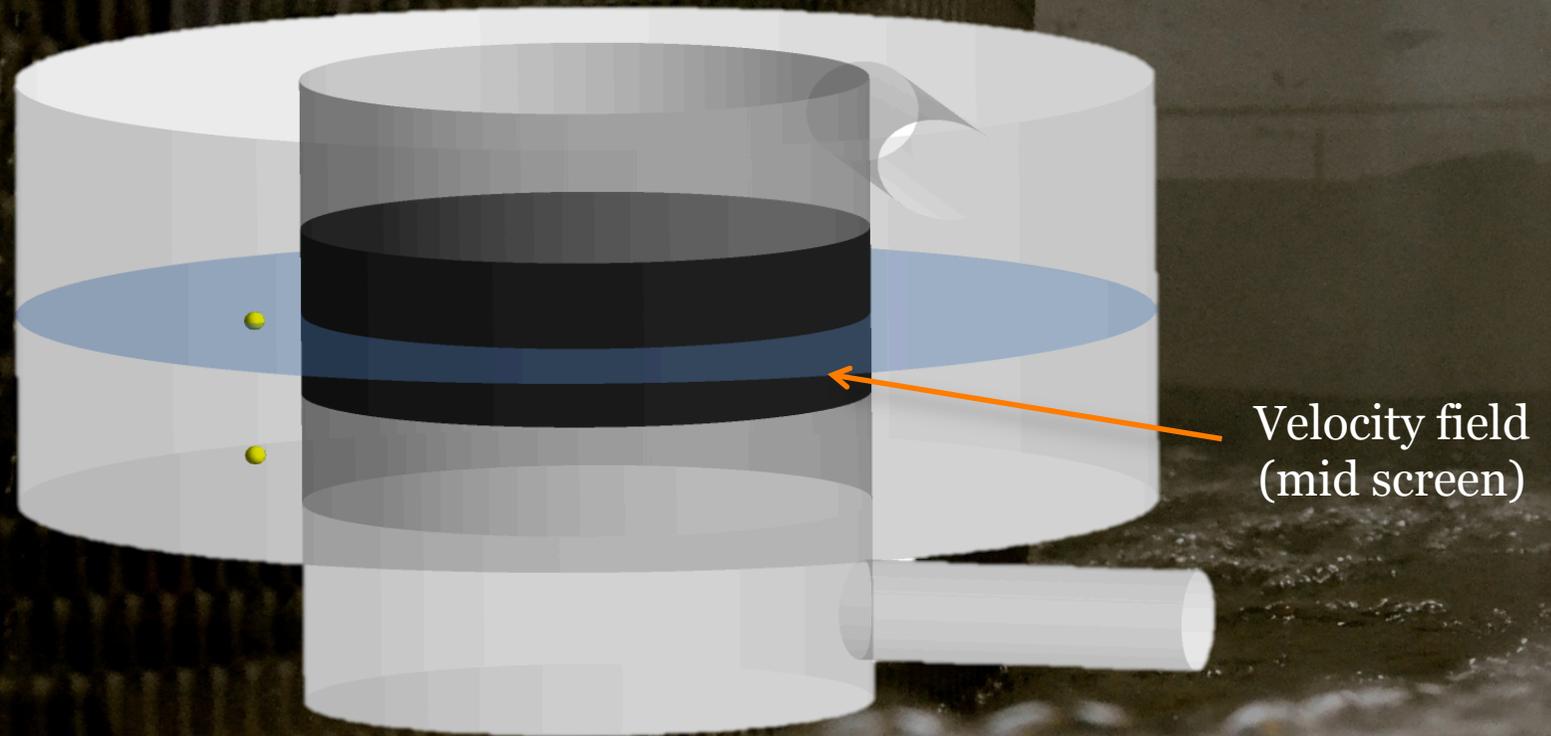
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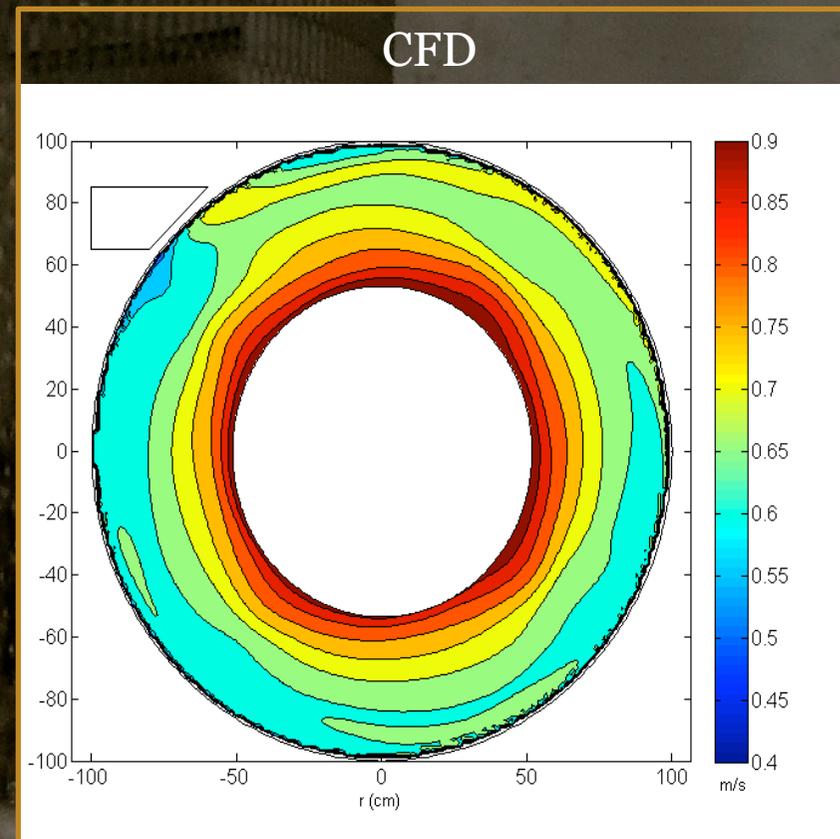
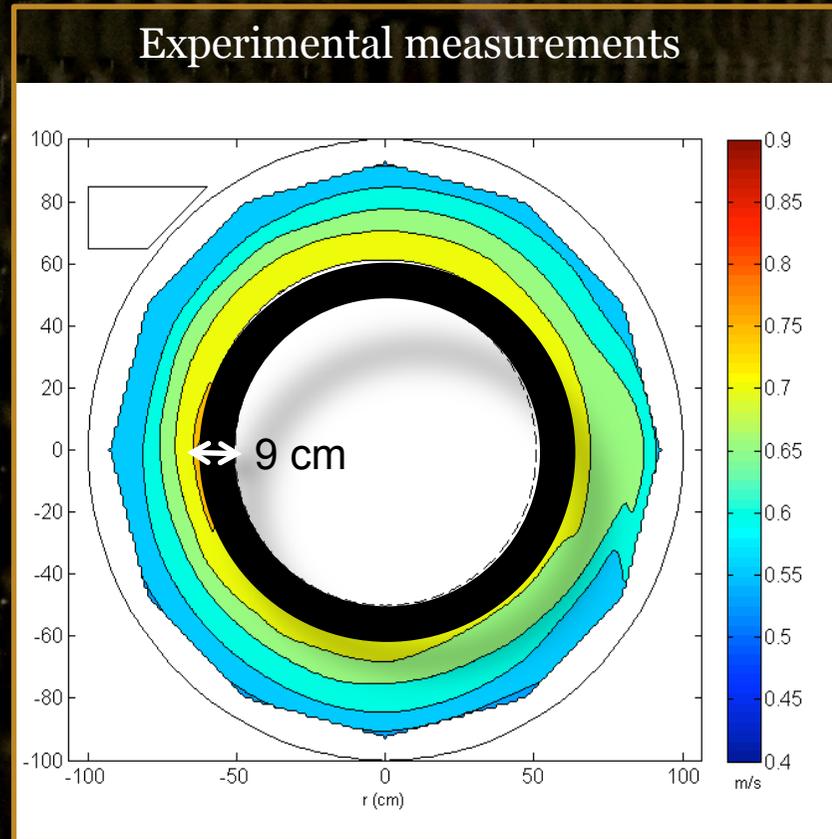
- *Validation of the method*
- *Optimization*

5. Conclusion

✘ Comparison: CFD/ Measurements



## ✘ Velocity fields



*Comparison of the velocity field for a flow rate equal to 25 L/s at  $z = 38$  cm*

## ✘ Comparison: CFD/ Measurements



## ✘ Global/local values:

	<b>Discharge ratio</b> $Q_{\text{circulation}}/Q_{\text{inlet}}$	$V_{\text{grid}}$ (m/s)	$V_{\text{under\_grid}}$ (m/s)
<b>Measurements</b>	10,1	0,73	0,76
<b>CFD</b>	10,1	0,84	0,82
<b>Error</b>	0,1%	15%	8%

*Comparison for a flow rate equal to 25 L/s*

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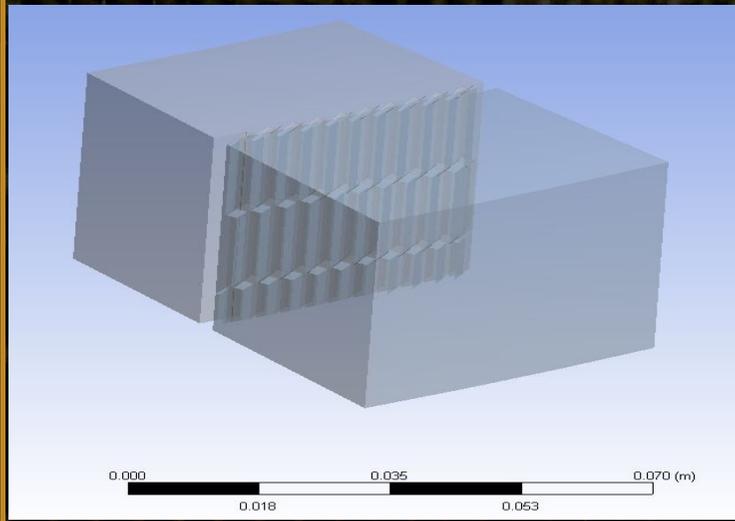
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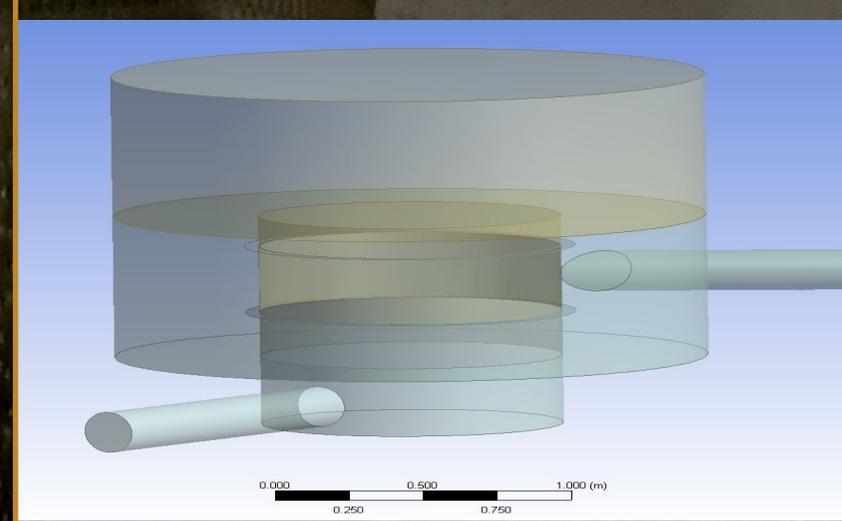
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Local Model



Local phenomena

Global Model



Global behaviour

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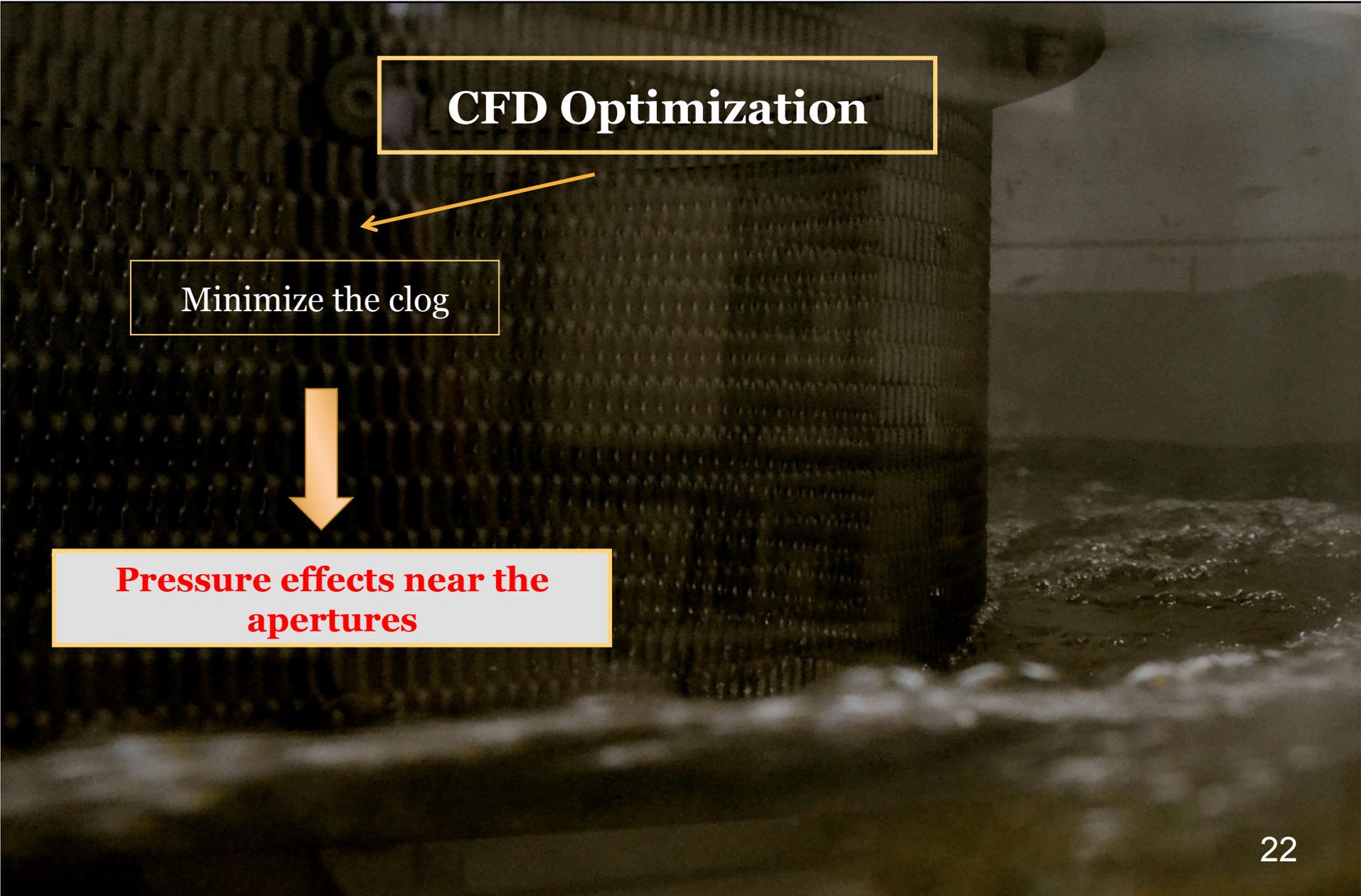
Conclusion



**CFD Optimization**

The image shows a 3D visualization of a pipe with a fine mesh overlay, representing a CFD simulation. The pipe is partially submerged in water, with a turbulent flow field visible around it. The mesh is denser in the regions of high flow velocity and turbulence. The background is a dark, textured surface, possibly a wall or another part of the pipe.

←  
Minimize the clog

A photograph of a large, dark, cylindrical structure with a grid-like surface, possibly a filter or a part of a machine, partially submerged in water. The structure is the central focus of the image. Overlaid on the image are several text boxes and arrows. At the top, a box contains the text 'CFD Optimization'. An arrow points from this box to a second box containing 'Minimize the clog'. A large downward-pointing arrow connects this second box to a third box at the bottom containing 'Pressure effects near the apertures'. The background is a dark, textured surface, and the foreground shows some water splashing.

**CFD Optimization**

Minimize the clog

**Pressure effects near the apertures**

**CFD Optimization**

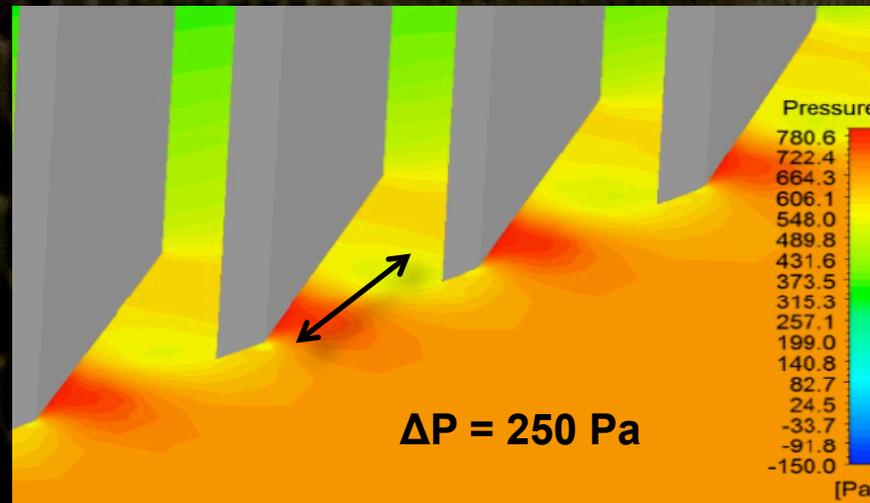
Minimize the clog

**Pressure effects near the apertures**

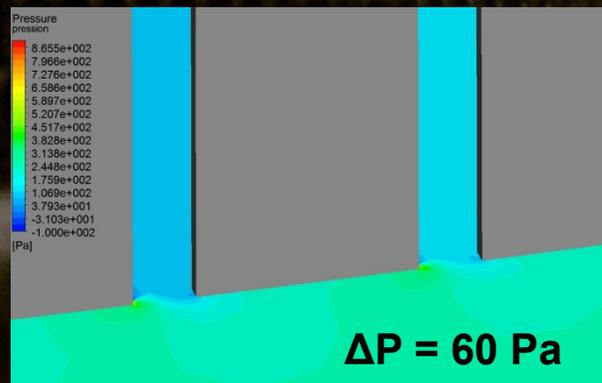
Testing different parameters

## ✘ Shape comparison : expanded metal VS perforated screen

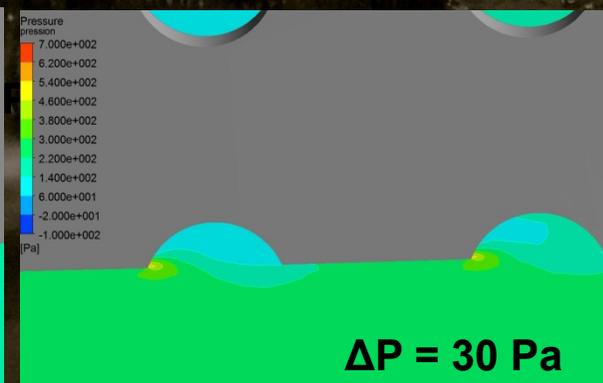
*CycloneSep screen*



Hexagonal holes

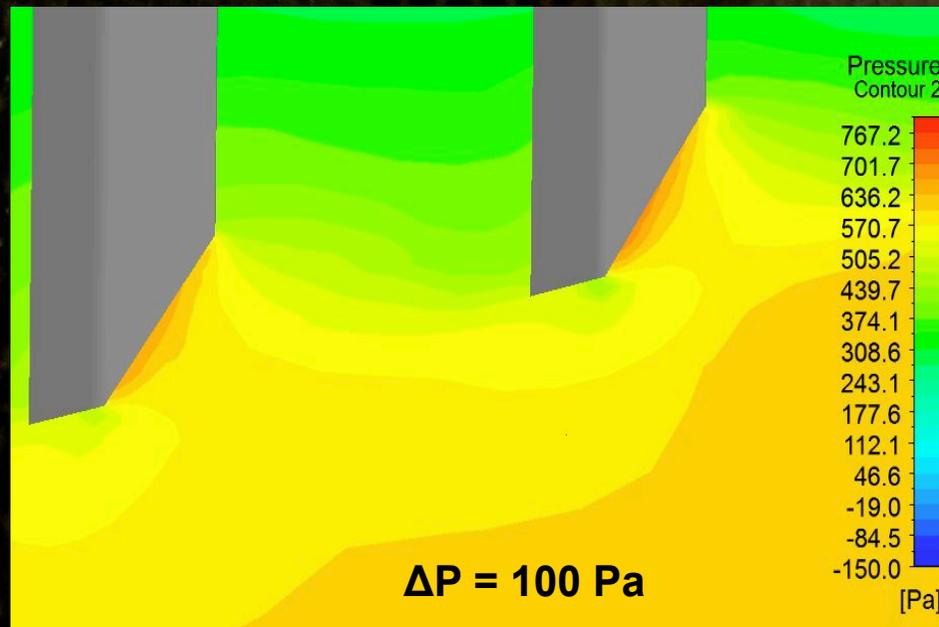


Circular holes

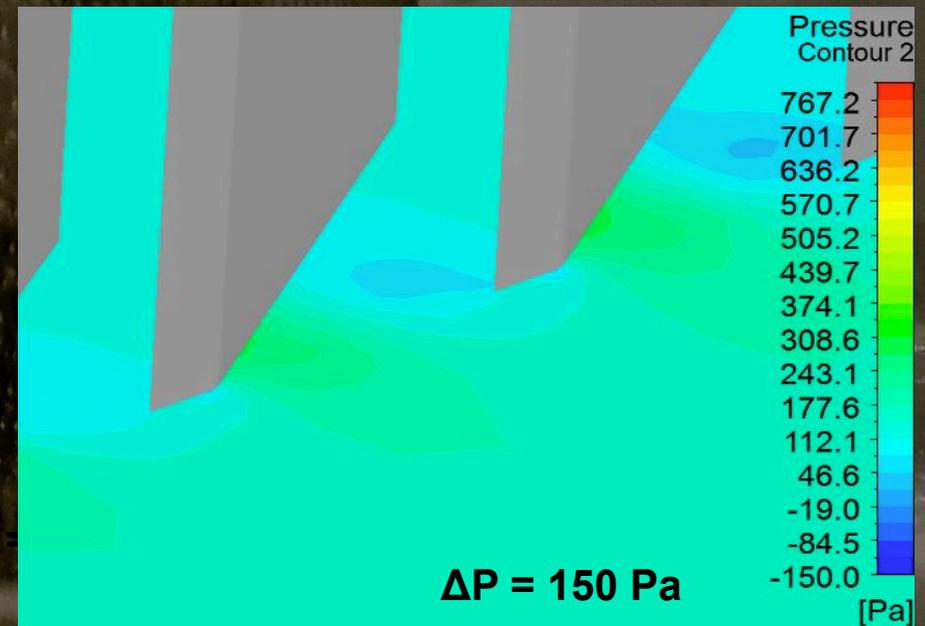


## ✘ Shape comparison : influence of hole size

45° 25mm x 5,2mm

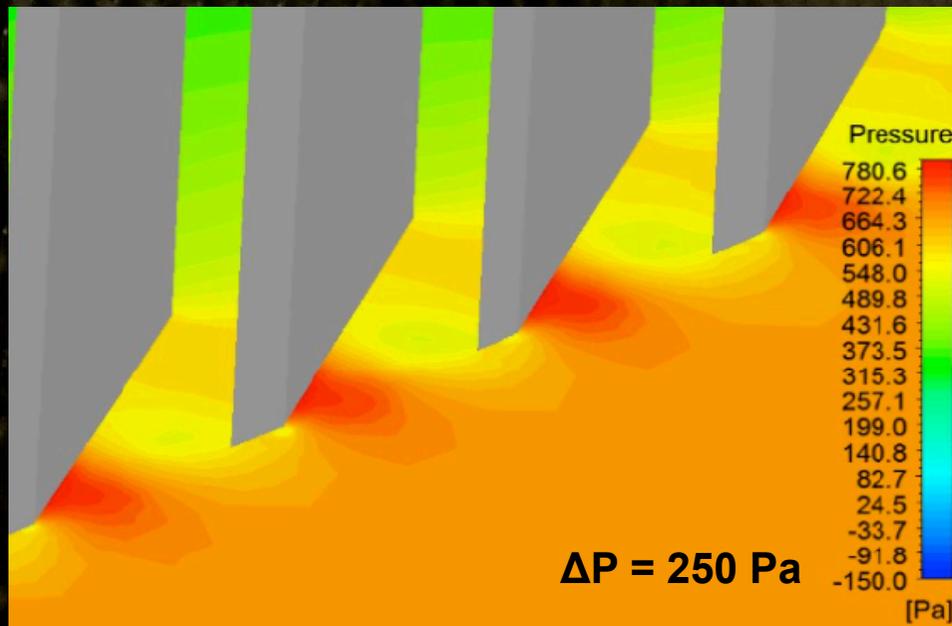


45° 17mm x 1,65mm

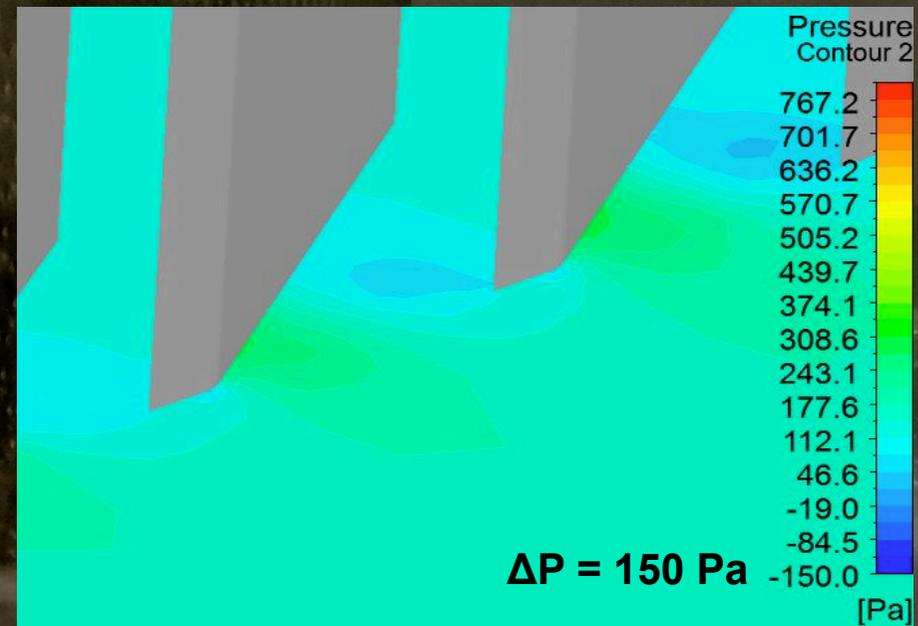


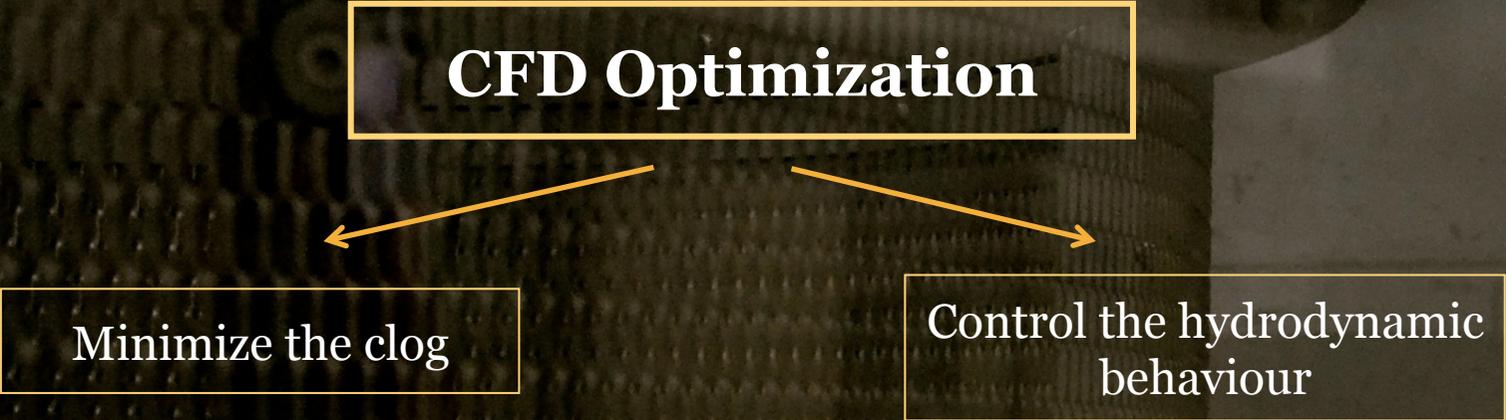
## ✘ Shape comparison : influence of metal inclination

60° 17mm x 1,65mm



45° 17mm x 1,65mm





CFD Optimization

The diagram shows a central box labeled 'CFD Optimization' with two arrows pointing downwards to two separate boxes: 'Minimize the clog' on the left and 'Control the hydrodynamic behaviour' on the right. The background is a photograph of a large, dark, cylindrical structure with a textured surface, possibly a filter or a part of a water treatment plant, partially submerged in water.

Minimize the clog

Control the hydrodynamic  
behaviour

**CFD Optimization**

Minimize the clog

Control the hydrodynamic behaviour

**Maximize velocity near the screen**  
**Minimize velocity under the screen**

## CFD Optimization

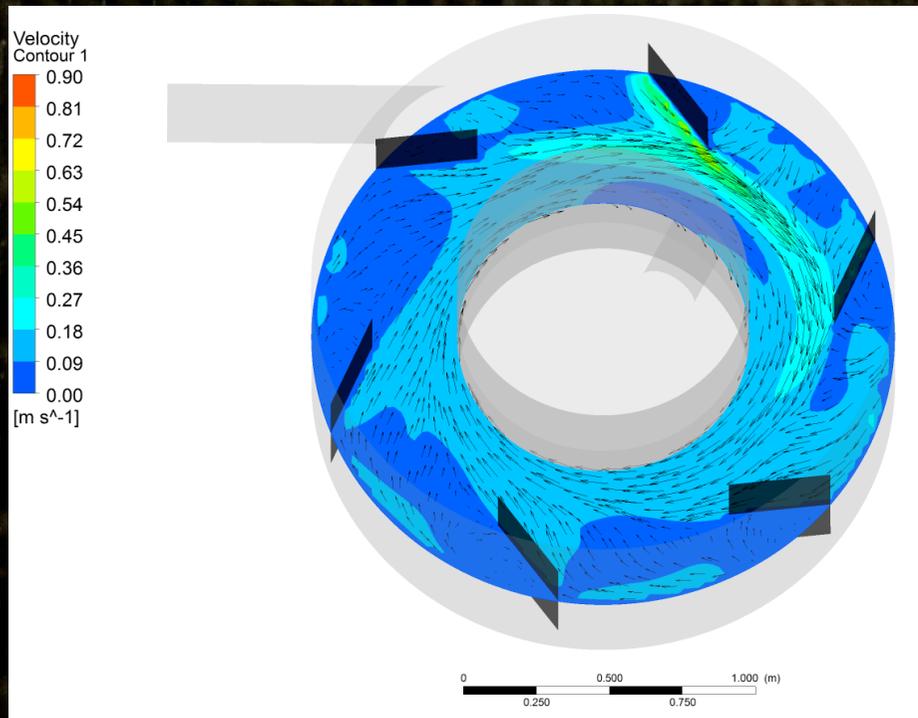
Minimize the clog

Control the hydrodynamic  
behaviour

**Maximize velocity near the screen**  
**Minimize velocity under the screen**

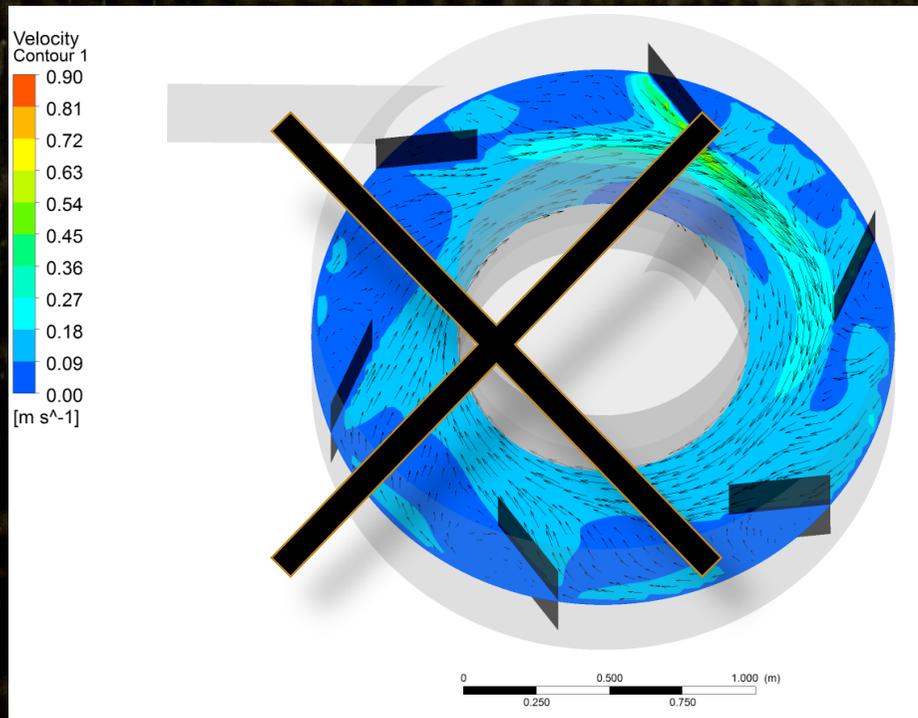
Installation of singularities

✘ Optimization of the device : ( $Q=25\text{L/s}$ )

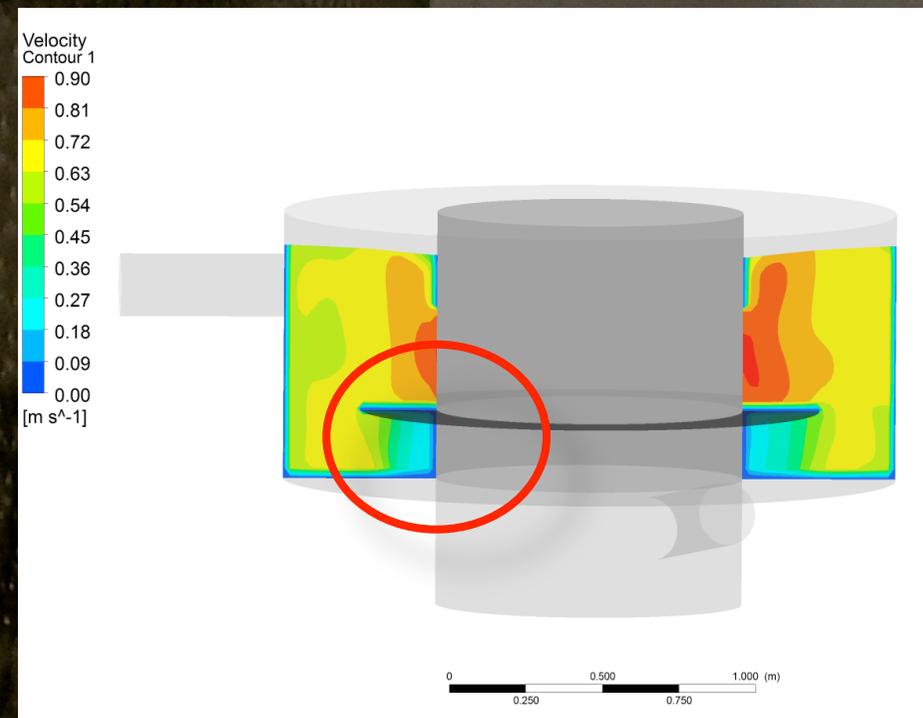


6 deflectors

✗ Optimization of the device : ( $Q=25\text{L/s}$ )



6 deflectors



Disk plate

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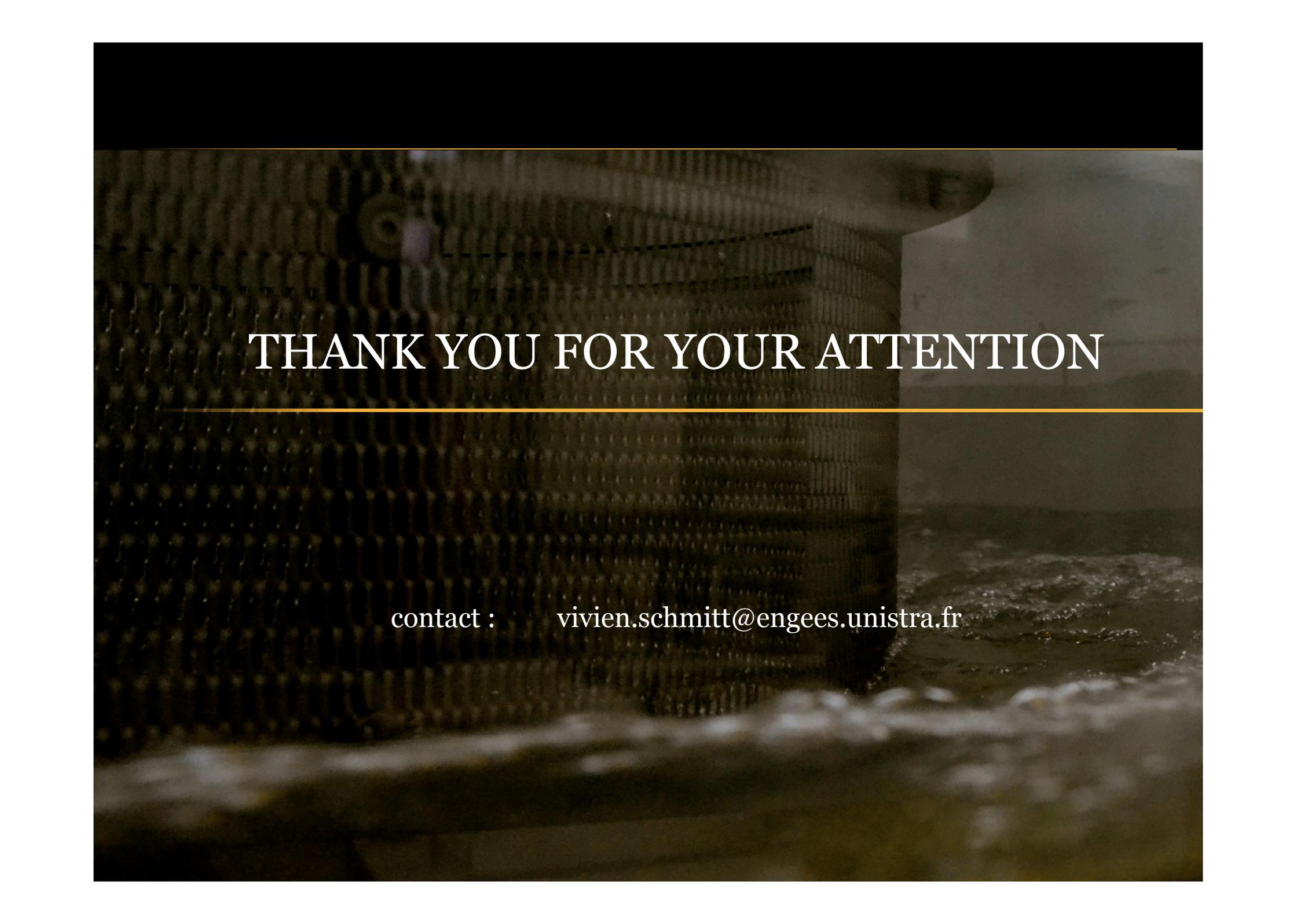
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- ✘ CFD multiscale approach is a good alternative to optimize a device at different scale





THANK YOU FOR YOUR ATTENTION

contact : [vivien.schmitt@engees.unistra.fr](mailto:vivien.schmitt@engees.unistra.fr)



✘ CFD simulations:

- 2 500 000 cells for the local model
- 1 200 000 cells for the global model
- Turbulence model: RSM
- Discretization scheme: 2<sup>nd</sup> order

✘ Validation of the local model

- $K_{\text{exp}} = 1700$
- $K_{\text{cfd}} = 1900$

Q (L/s)	$H_{\text{exp}}$ (m)	$H_{\text{cfd}}$ (m)
15	0.028	0.017
25	0.054	0.55
50	0.203	0.225

✘ CycloneSep Trouville/Mer (France)

