DE LA RECHERCHE À L'INDUSTRIE

EXPERIMENTAL INVESTIGATION OF GAS ENTRAINMENT THROUGH SURFACE SWIRLS

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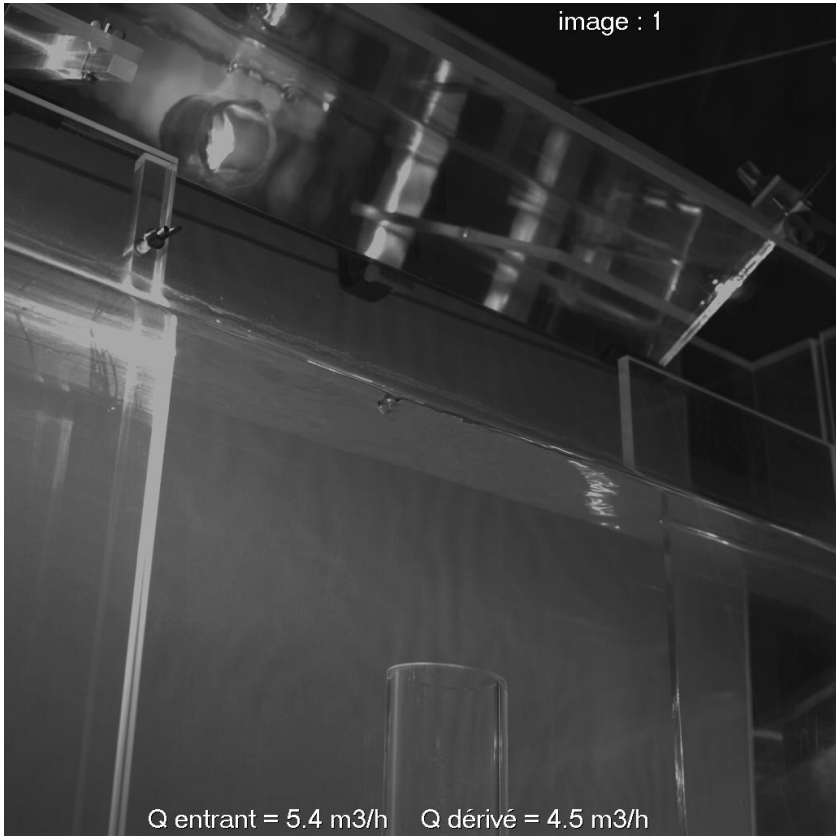
WHAT IS GAS ENTRAINMENT THROUGH SURFACE SWIRL?

Inlet flow

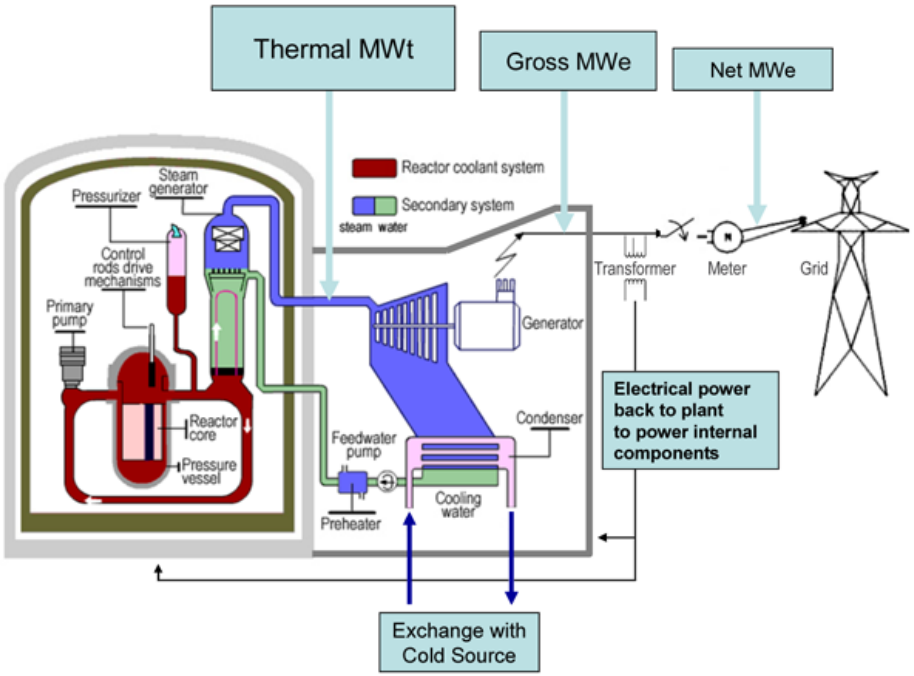


Outlet flow

Suction flow

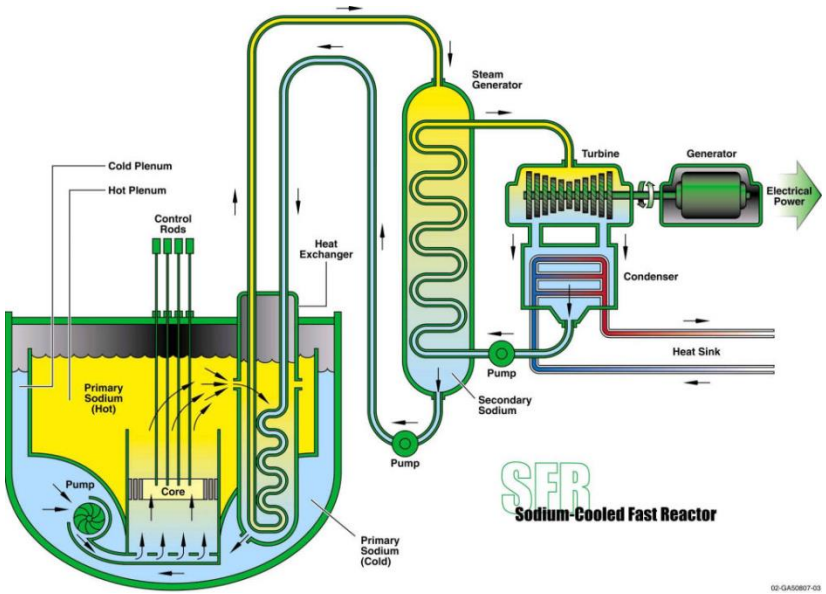
NUCLEAR REACTORS IN FRANCE

Nuclear **P**ressurized **W**ater **R**eactor (PWR)
Réacteur nucléaire à **E**au **P**ressurisée (REP)



Nuclear Reactor Generation III

Sodium Cooled **F**ast Nuclear **R**eactor (SFR)
Réacteur **N**ucléaire **R**apide refroidi au Sodium (RNR-Na)



Generation IV (ASTRID Project)
1 Experimental Nuclear Reactor
PHENIX (CEA) and SUPERPHENIX (CEA-EDF)

Why Generation IV ?

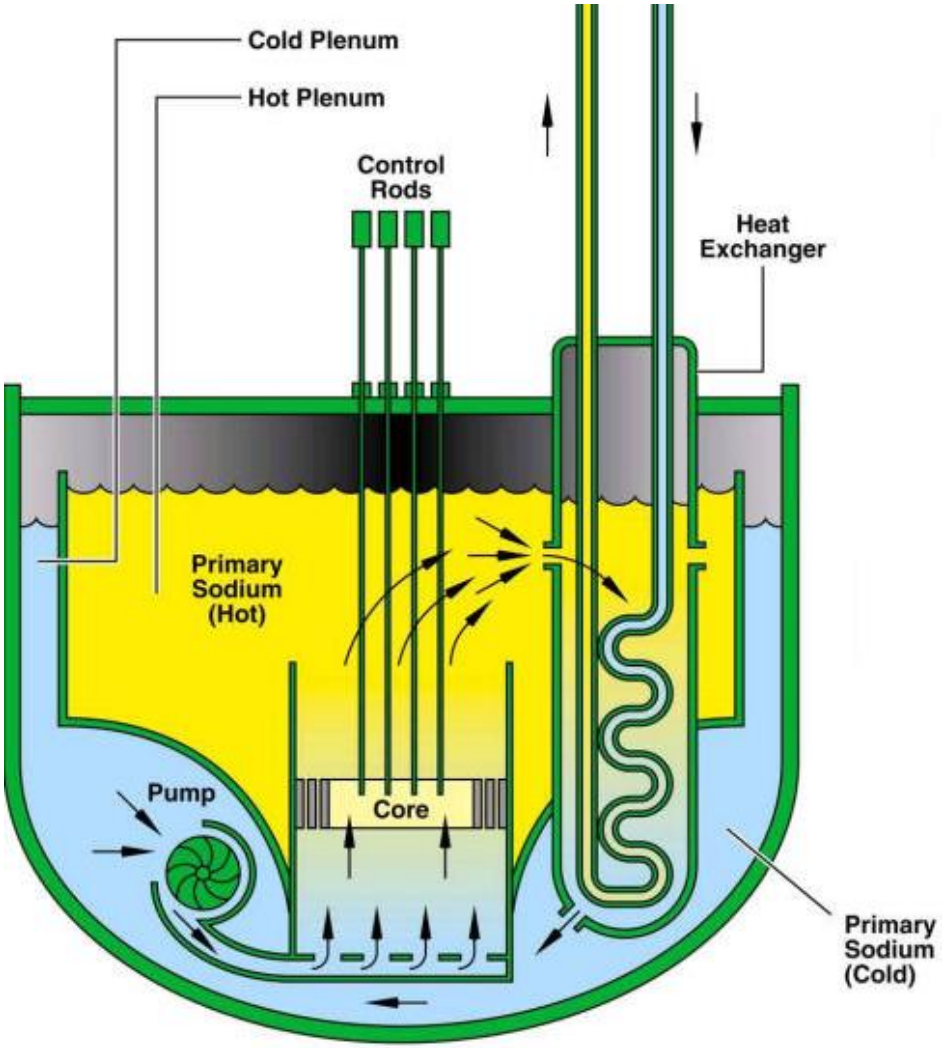
Decrease of nuclear waste (Volume & life time)
5000 years with storage of REP nuclear waste

GAS ENTRAINMENT ISSUE IN SODIUM COOLED FAST NUCLEAR REACTORS

Gas entrainment issue

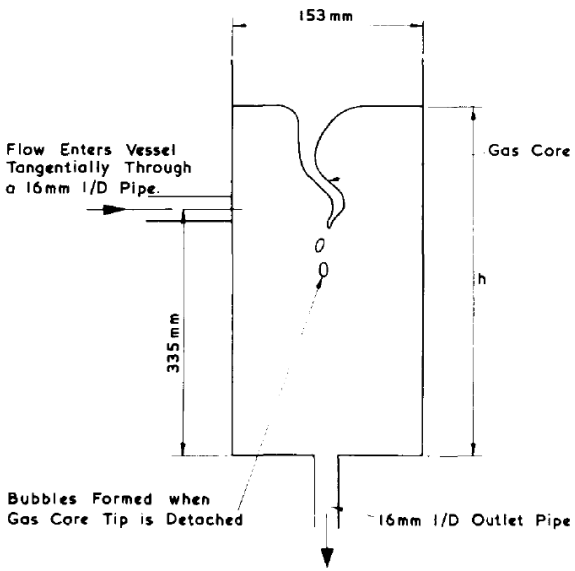
Surface Vortex flow
+ Heat exchanger downward flow
= gas entrainment

Safety issue: accumulation and transport of gas through the core
⇨ increase of nuclear reaction

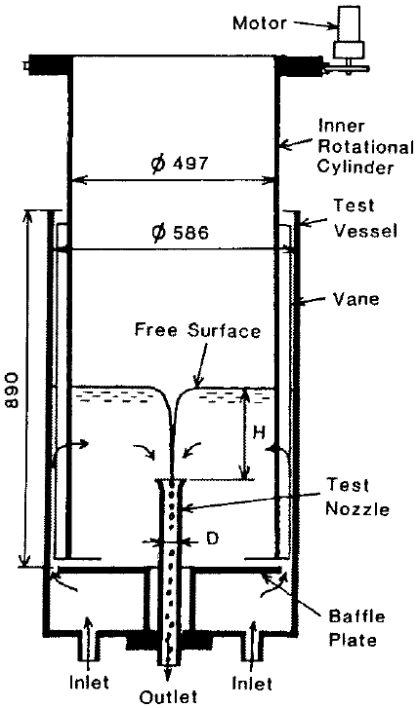


FORMER EXPERIMENTAL INVESTIGATIONS

Baum *et al*. (1975)[1]



Takahashi *et al*. (1988)[2]



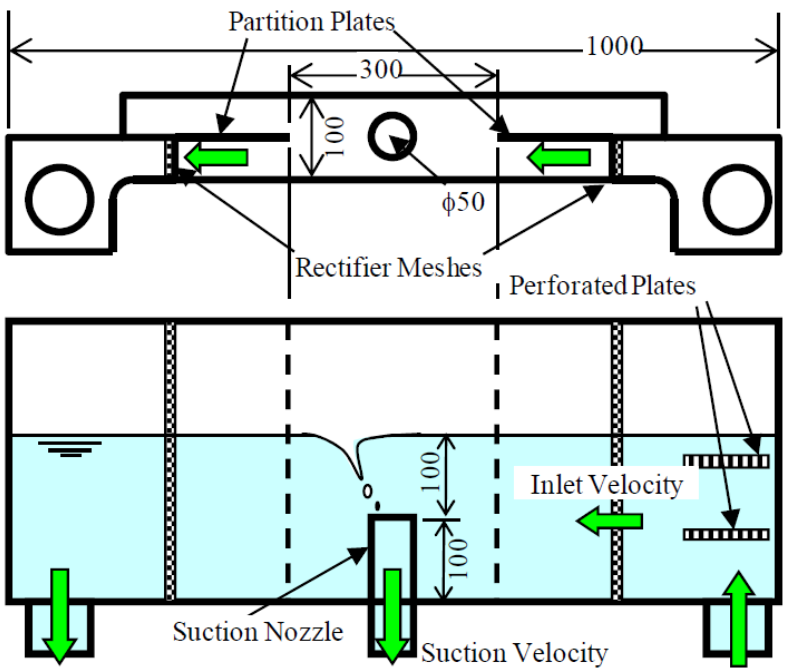
≠ Intermittent gas entrainment in RNR-Na

⇨ Maintained surface swirl and gas entrainment

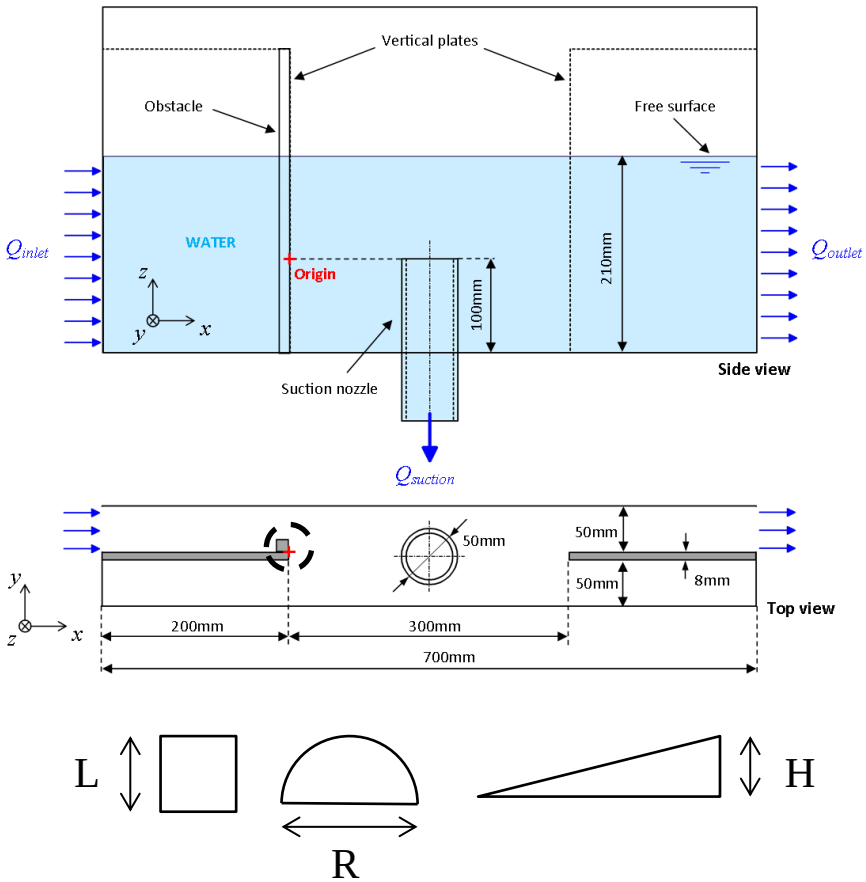
1. M. R. Baum and M. E. Cook, *Nucl. Eng. Des.*, **32** (2), 239-245 (1975).
2. M. Takahashi, A. Inoue, M. Aritomi, Y. Takenaka, and K. Suzuki, *J. Nucl. Sci. Technol.*, **25** (2), 131-142 (1988).

RECENT EXPERIMENTAL INVESTIGATIONS

Ezure *et al*. (2008)[1] & Kimura *et al*. (2009)[2]



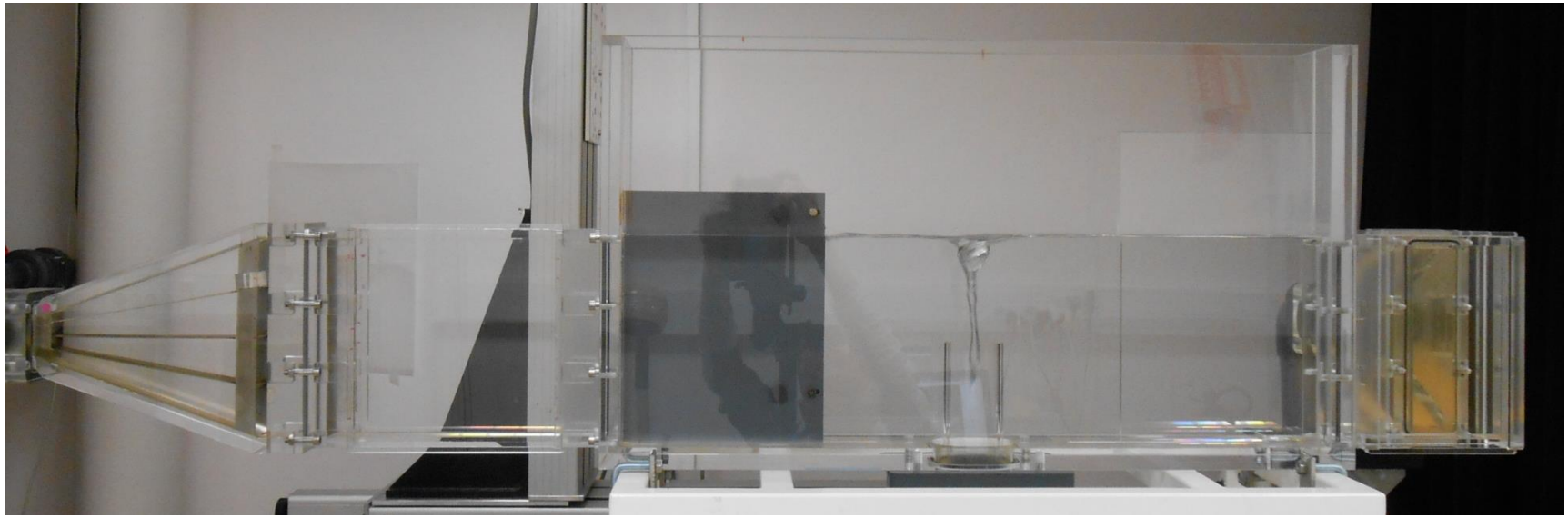
Present study



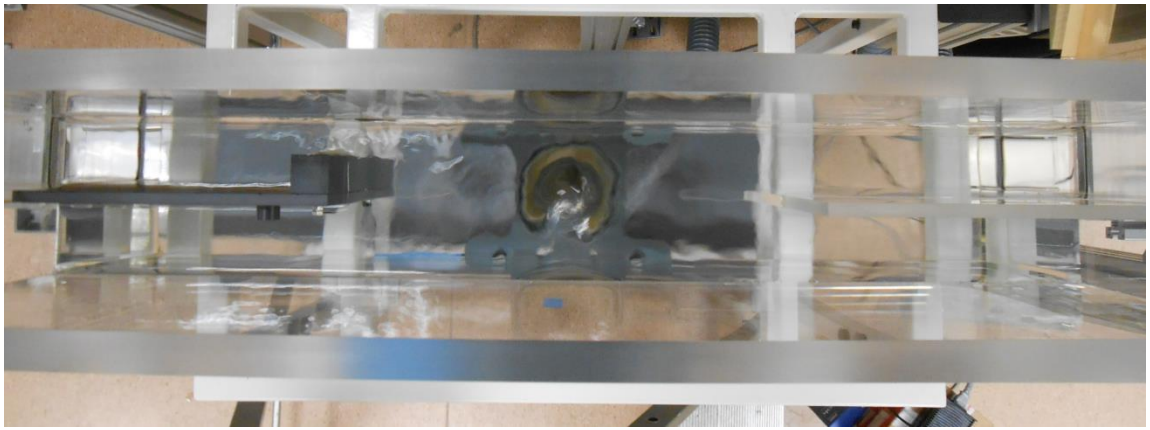
1. T. Ezure, N. Kimura, K. Hayashi, and H. Kamide, *Heat Transf. Eng.*, **29** (8), 659-666 (2008).
2. N. Kimura, T. Ezure, H. Miyakoshi, H. Kamide, and T. Fukuda, 17th International Conference on Nuclear Engineering, Brussels Belgium (2009).

EXPERIMENTAL SET-UP OF PRESENT STUDY

Side view



Top view

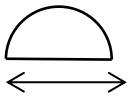


VIDEO OF GAS ENTRAINMENT BY SURFACE SWIRLS (1)

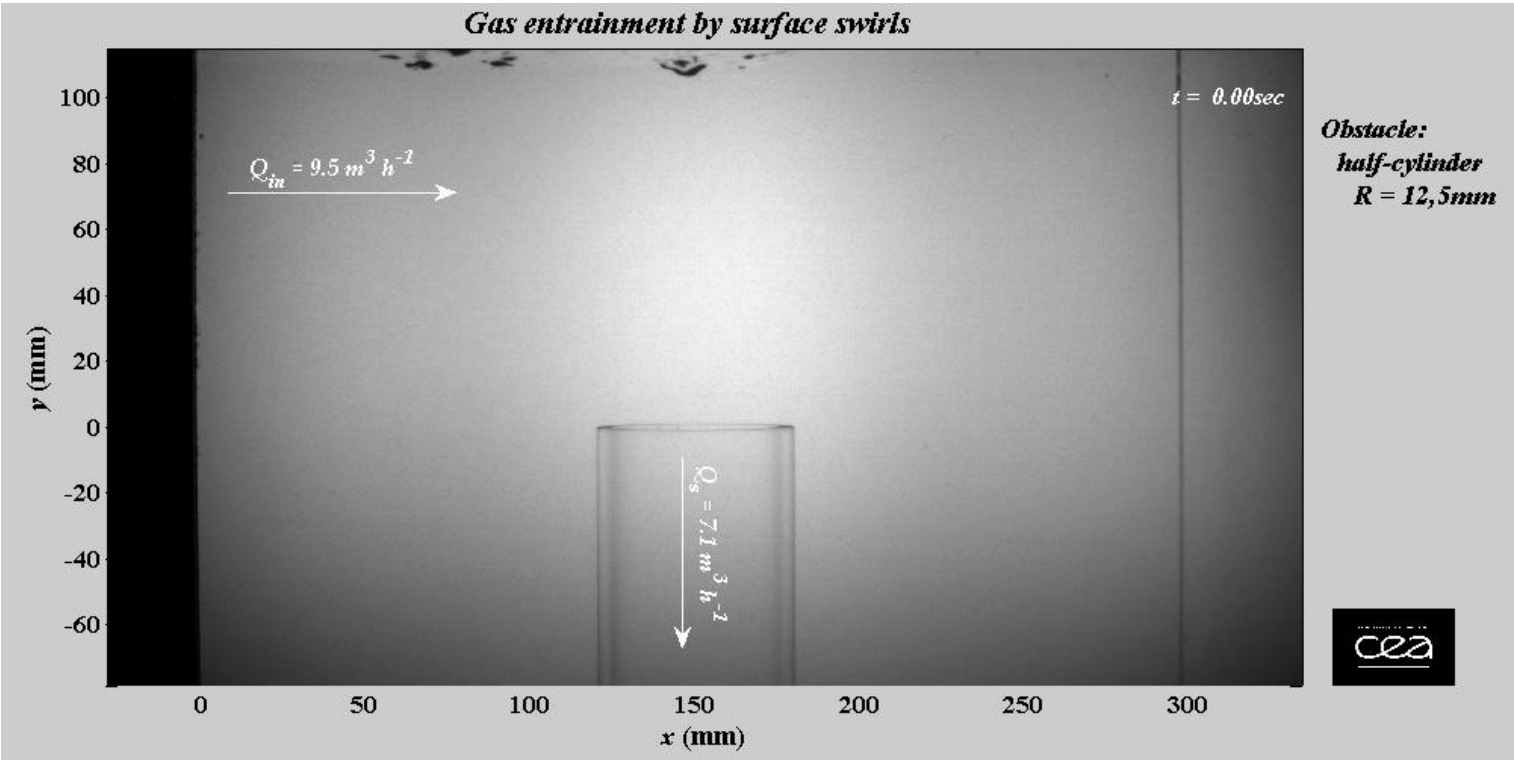
$$Re = \frac{V_{inlet} L}{\nu} = 12500$$

V_{inlet} , inlet velocity
L, width of inlet channel
ν, kinematic viscosity (ν_{water} = 10^6 m^2 s^{-1})

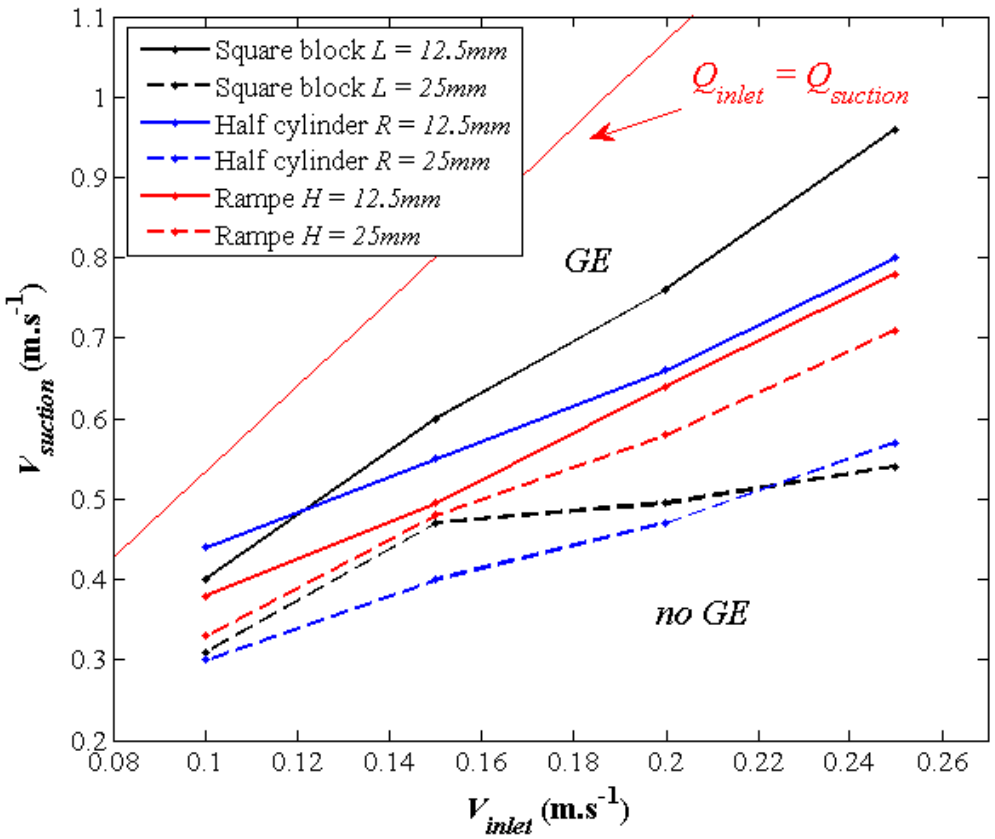
Half cylinder



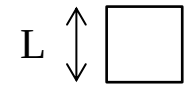
R = 12.5mm



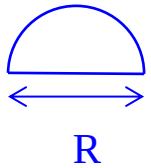
GAS ENTRAINMENT MAPPING



Square block



Half cylinder

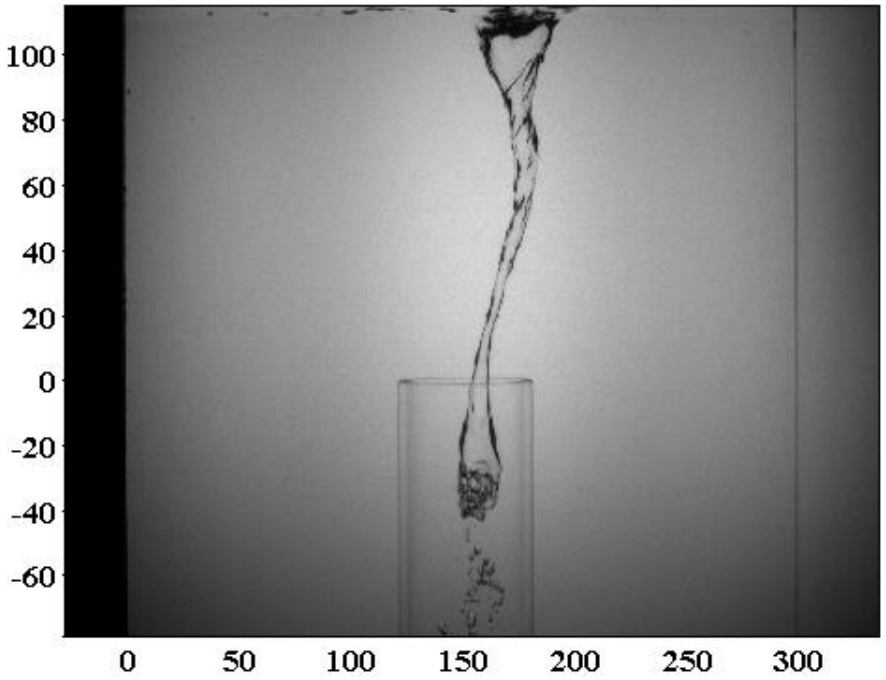


Ramp

AUTOMATIC DETECTION OF SURFACE SWIRLS AND GAS ENTRAINMENT

Obstacle: Half cylinder

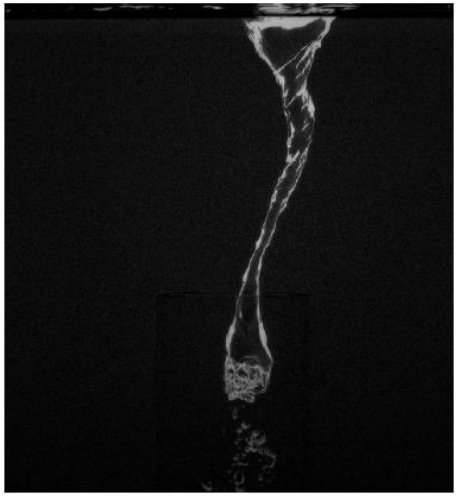
Q_{in} = 9,5 m^3 h^{-1} , Q_s = 7,1 m^3 h^{-1}



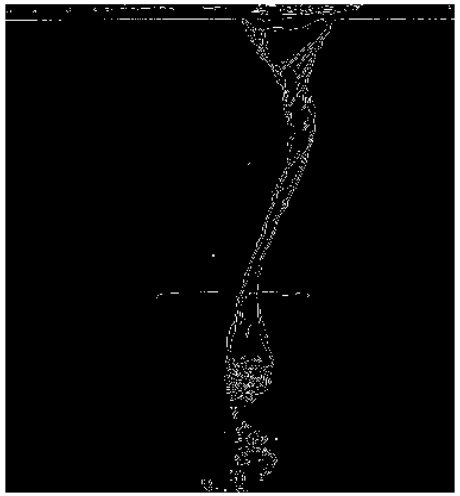
Frequencies of gas entrainment occurrence and surface swirl apparition ?

AUTOMATIC DETECTION OF SURFACE SWIRLS AND GAS ENTRAINMENT

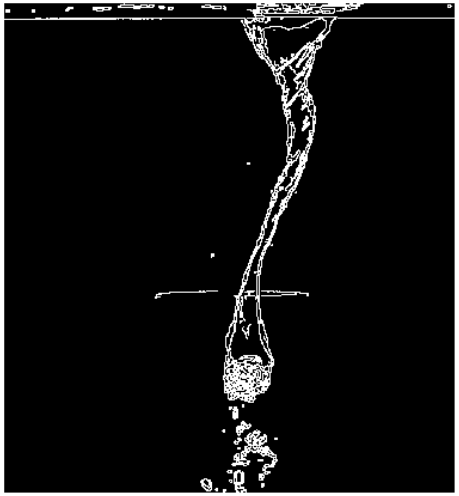
1. Delete noise



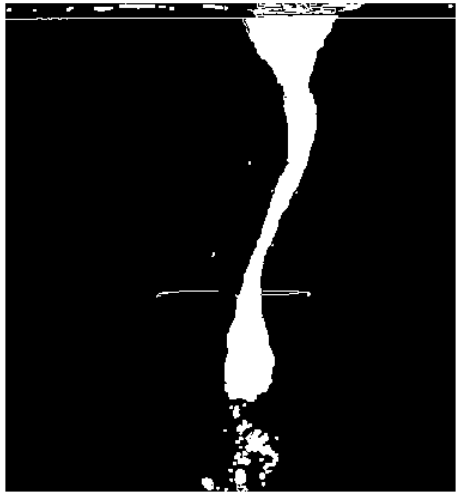
2. Detect edges



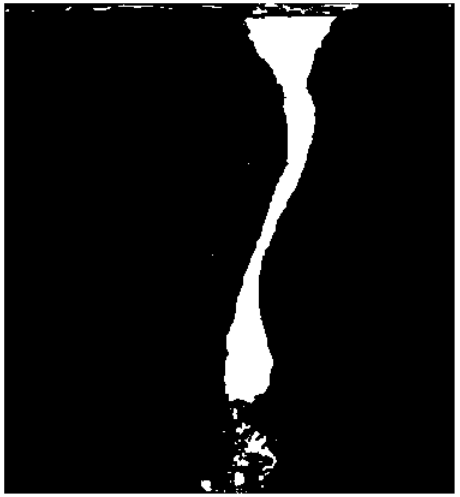
3. Dilate edges



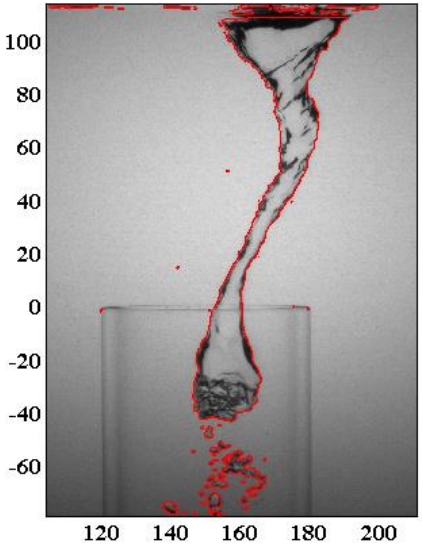
4. Fill close contour



5. Erode Shape

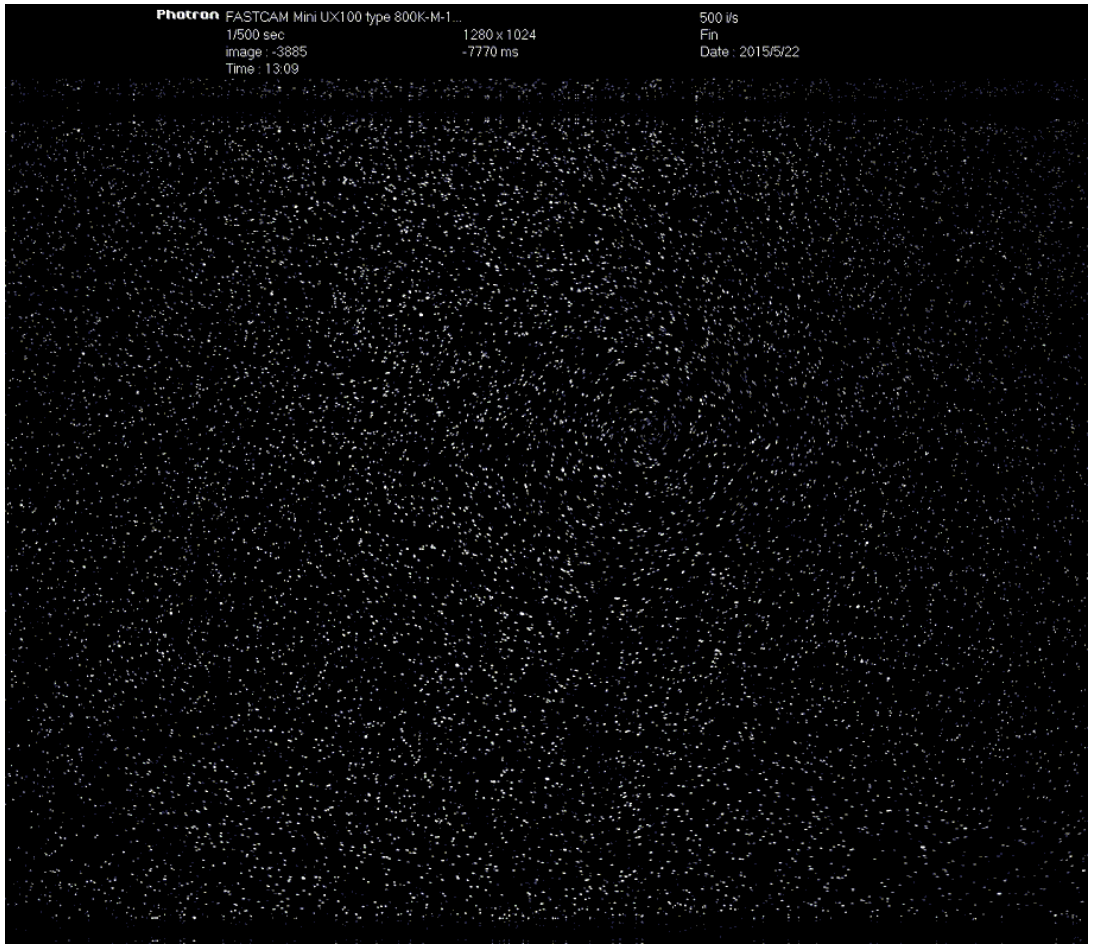


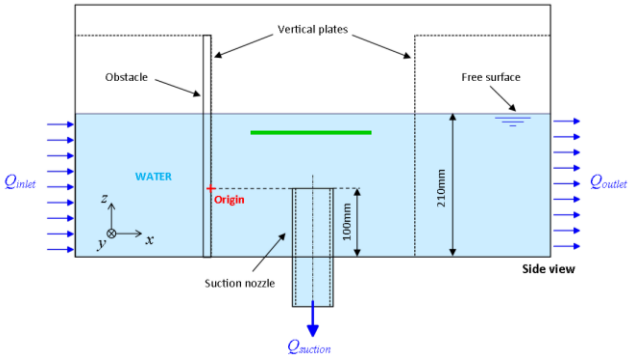
6. Create polygon



PROSPECTS AND CONCLUSIONS

PIV measurements





Thank you for your attention

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