PSA PEUGEOT CITROËN

Direction Recherche et Développement

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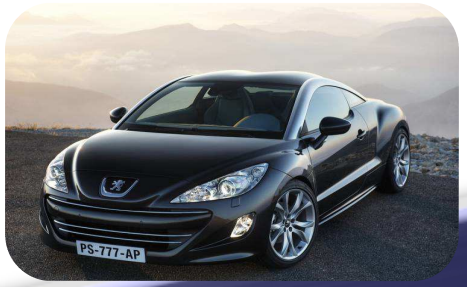

Automotive absorption cooling system with falling film.

PSA-DRD/DRIA/ACBI/INT/THQA

Date 07 février 2014

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- Technologies
- Propositions techniques
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- Résultats sur banc d’essais
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Context

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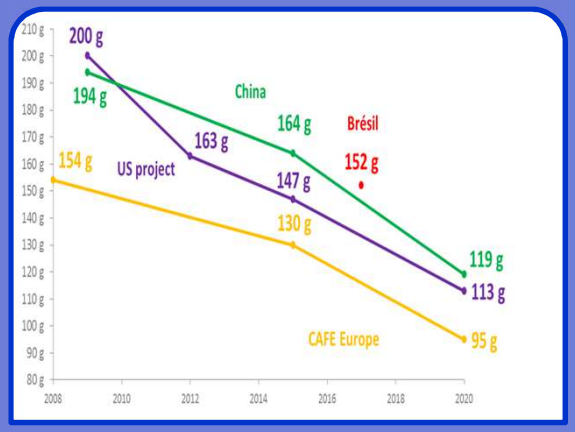
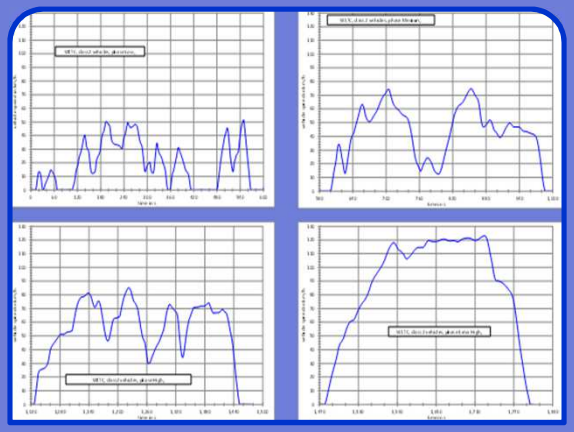
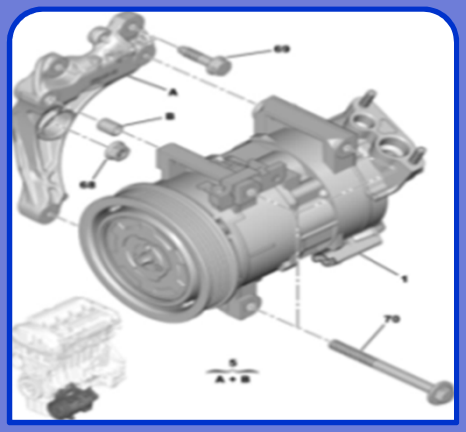
CONTEXT

Automotive CO_2 regulations:







Effort on CO_2 emissions:
regulations worldwide

Cylce WLTP:
Worldwide / more representative

Introduction of MAC regulation
Mobile **A**ir-conditionning **C**onsumption

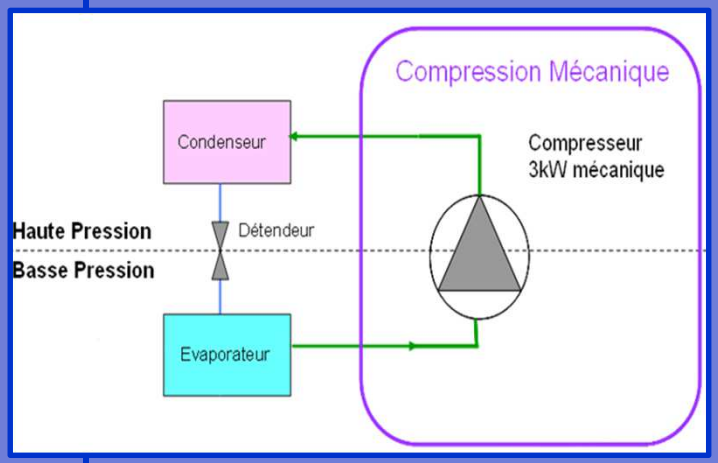
2020

2017

201x

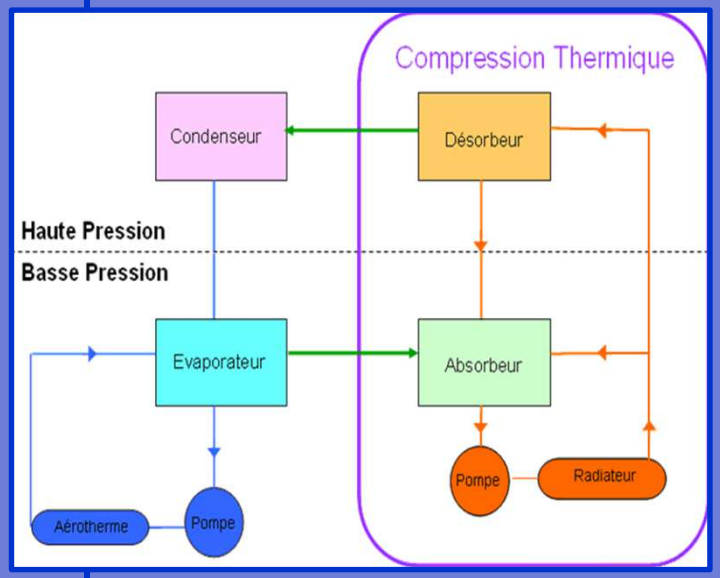
Automotive absorption cooling system: Expected benefits

Automotive A/C system



- Engine load:
- 70% compressor work (up to 5kW)

Absorption A/C system



- Engine thermal losses: (50 to 80% of combustion energy)
- 85% heat conversion
- 2 pumps (50W electrical power)

Automotive absorption cooling system
Constraints

Implementation volumes
Power

Heat sources temperatures

Mass

Reliability (>15years)

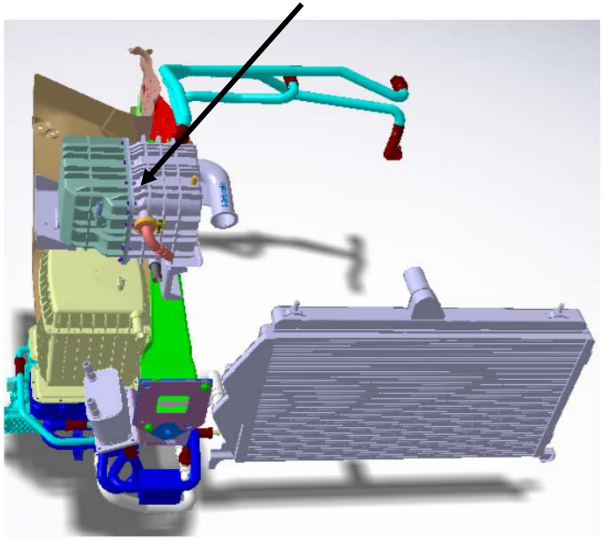
Raparability & end of life

Industrialization

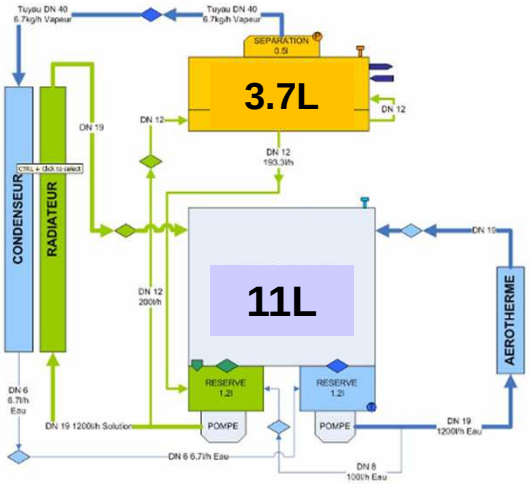
Cost…

Absorber: 23L

Desorber: 8L



Objectives



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TECHNOLOGIES

Falling film for absorption

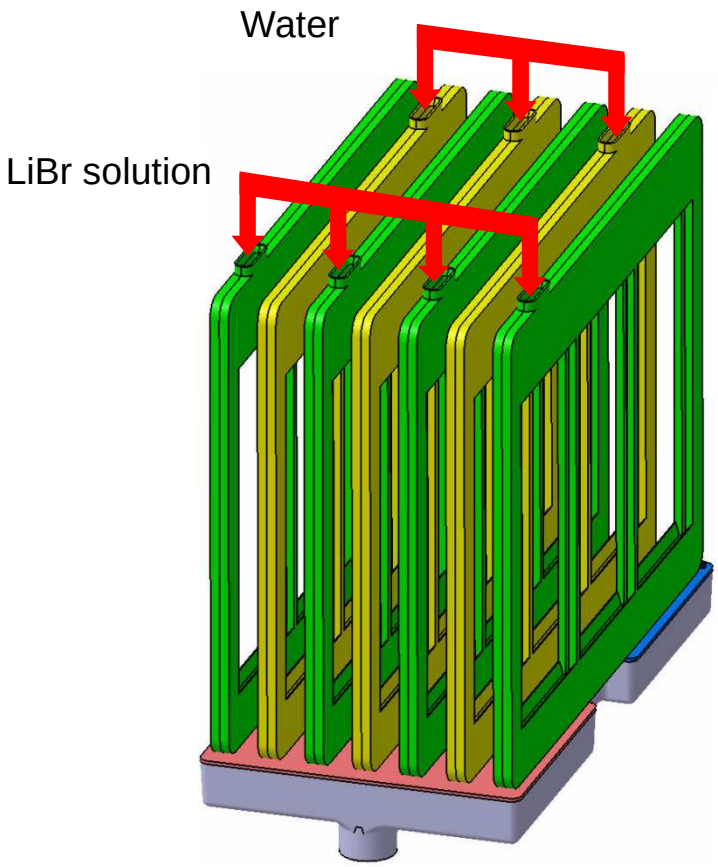
Benefits:

- Small packaging
- Vapour displacement with low pressure drop
- Reproduced plates
- Use of water as liquid calorific flow
- Use of solution as liquid calorific flow

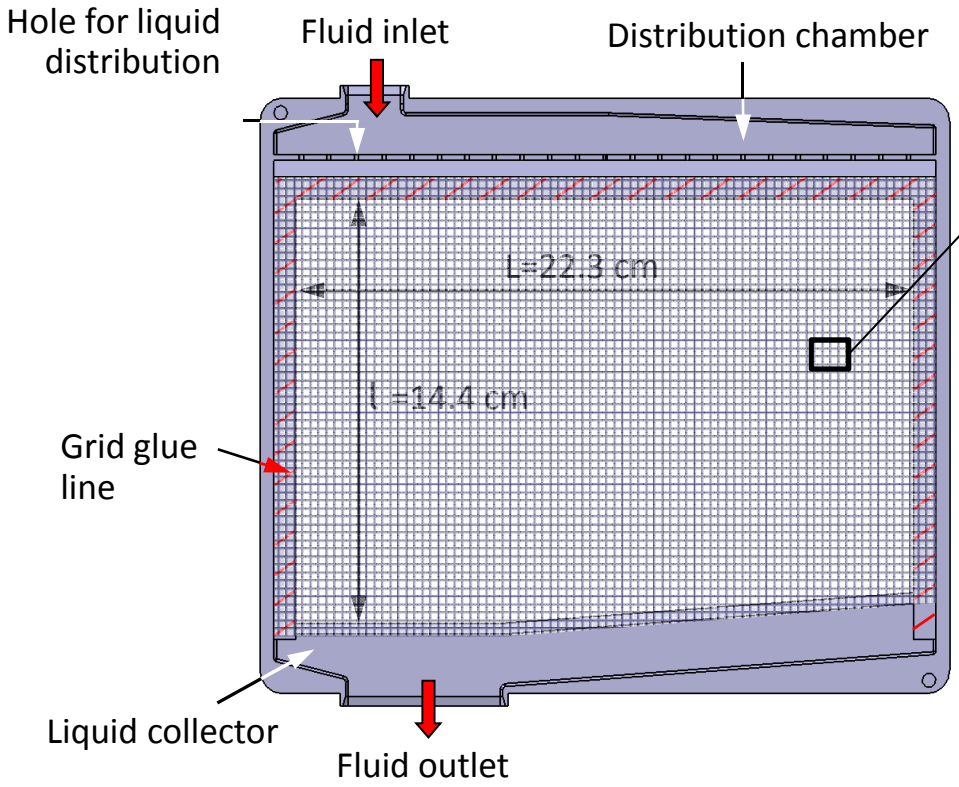
Capillarity is used for vibration response
Capillarity is used for inclination response

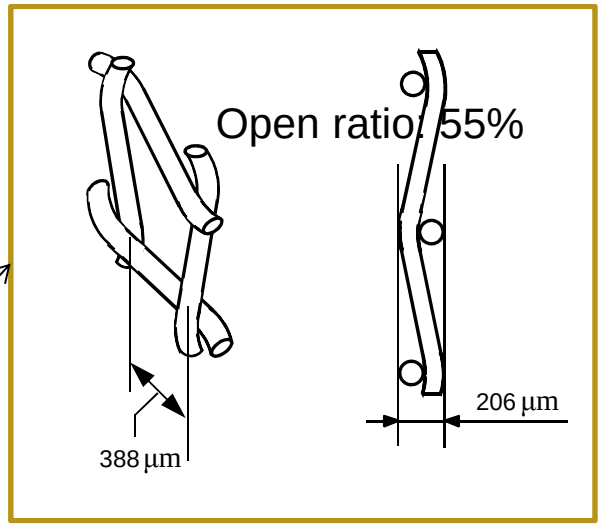
Constraints:

- Small
- Water dropplets
- Multi-physics



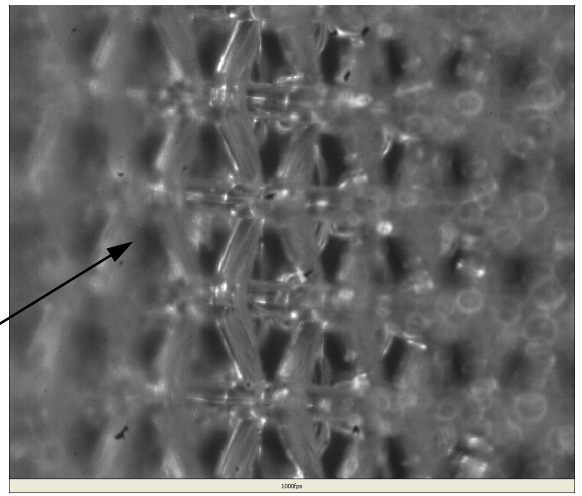
Grids as key point for automotive





LiBr flow 100 L/h

54 % salt mass fraction



Interest of capillarity for automotive

PSA requirement:

The capillarity effect between 2 grids spaced by 1.4mm permit to keep the fluids between the 2 grids for a flow rate of 120L/h:

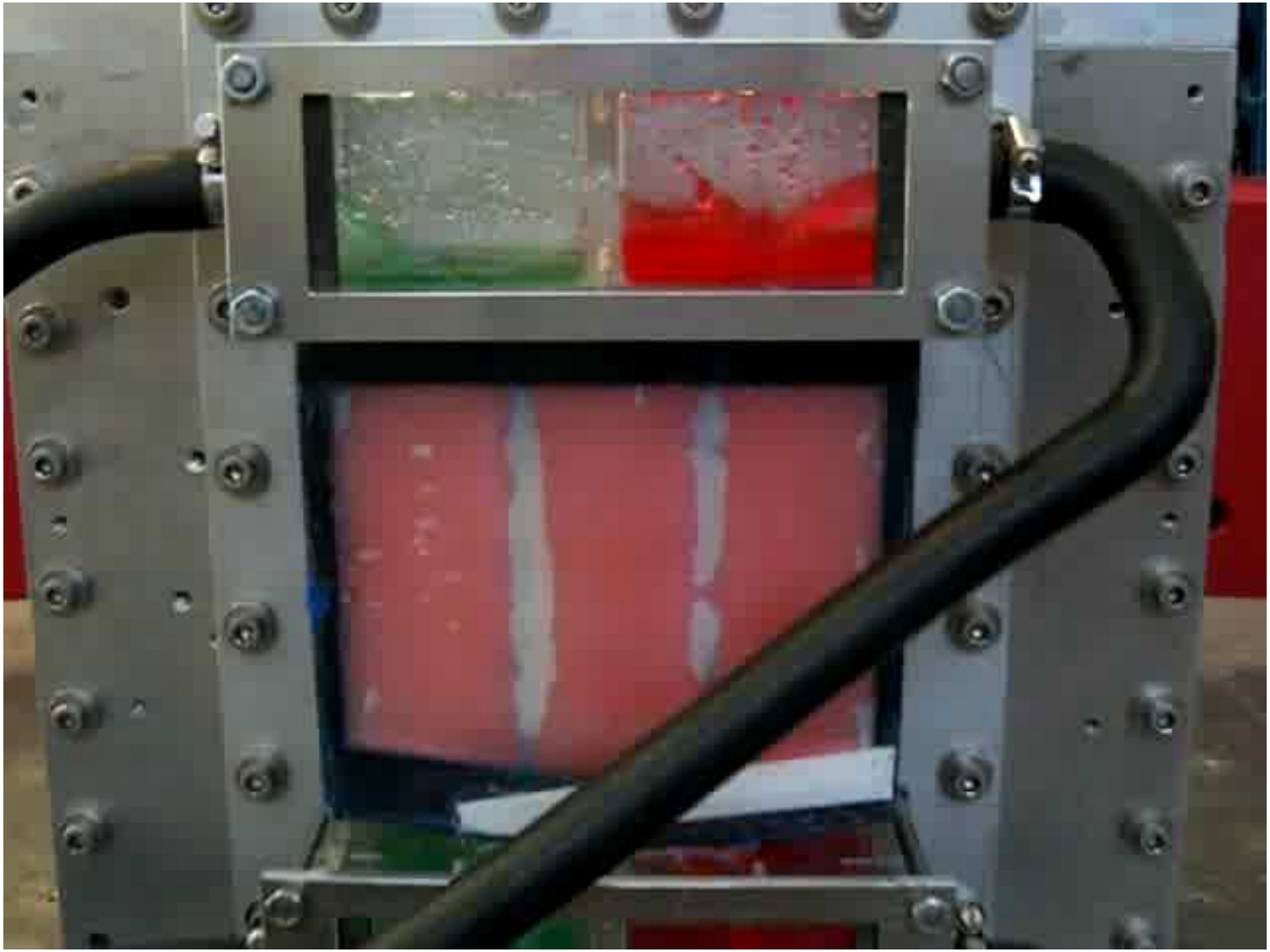
20 degrés
36%

33 degrés
65%

28 degrés
53%

40 degrés
85%

Interest of capillarity for automotive



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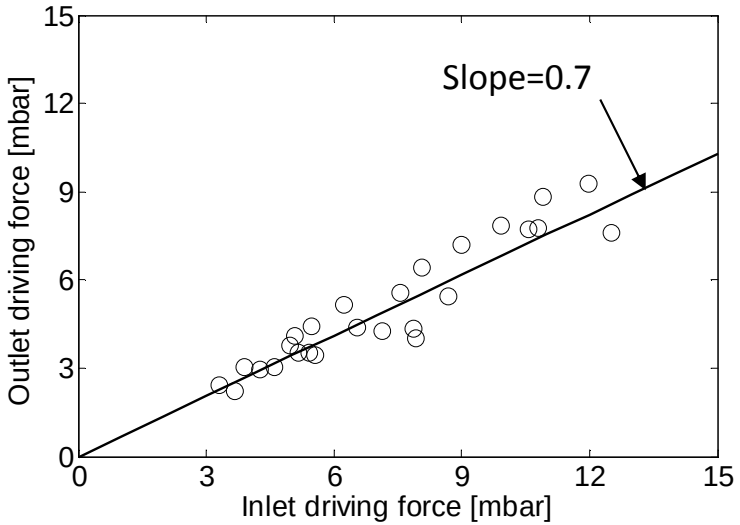
TECHNICAL PROPOSAL SCIENTIFIC VALIDATIONS

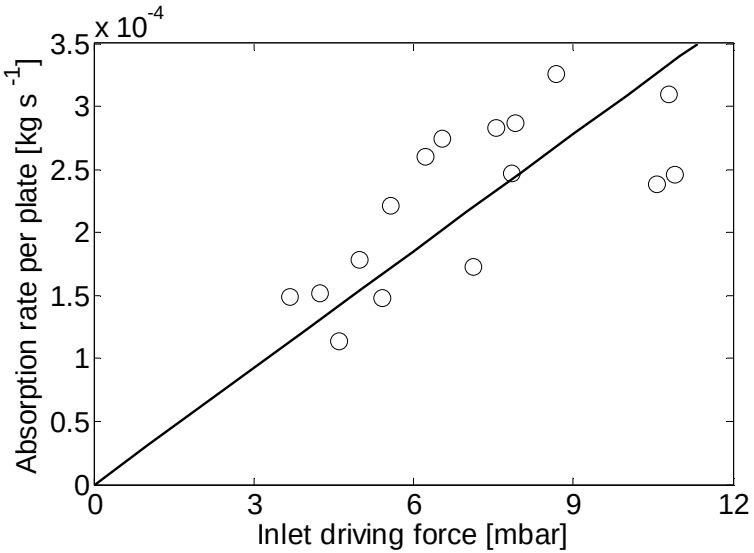
Grids limitation

The driving force for absorption or “distance to equilibrium” is defined as :

$$\Delta P = P - P_{eq}(\overline{T}, \overline{Y}_B)$$

ΔP decrease is mainly due to the temperature increase

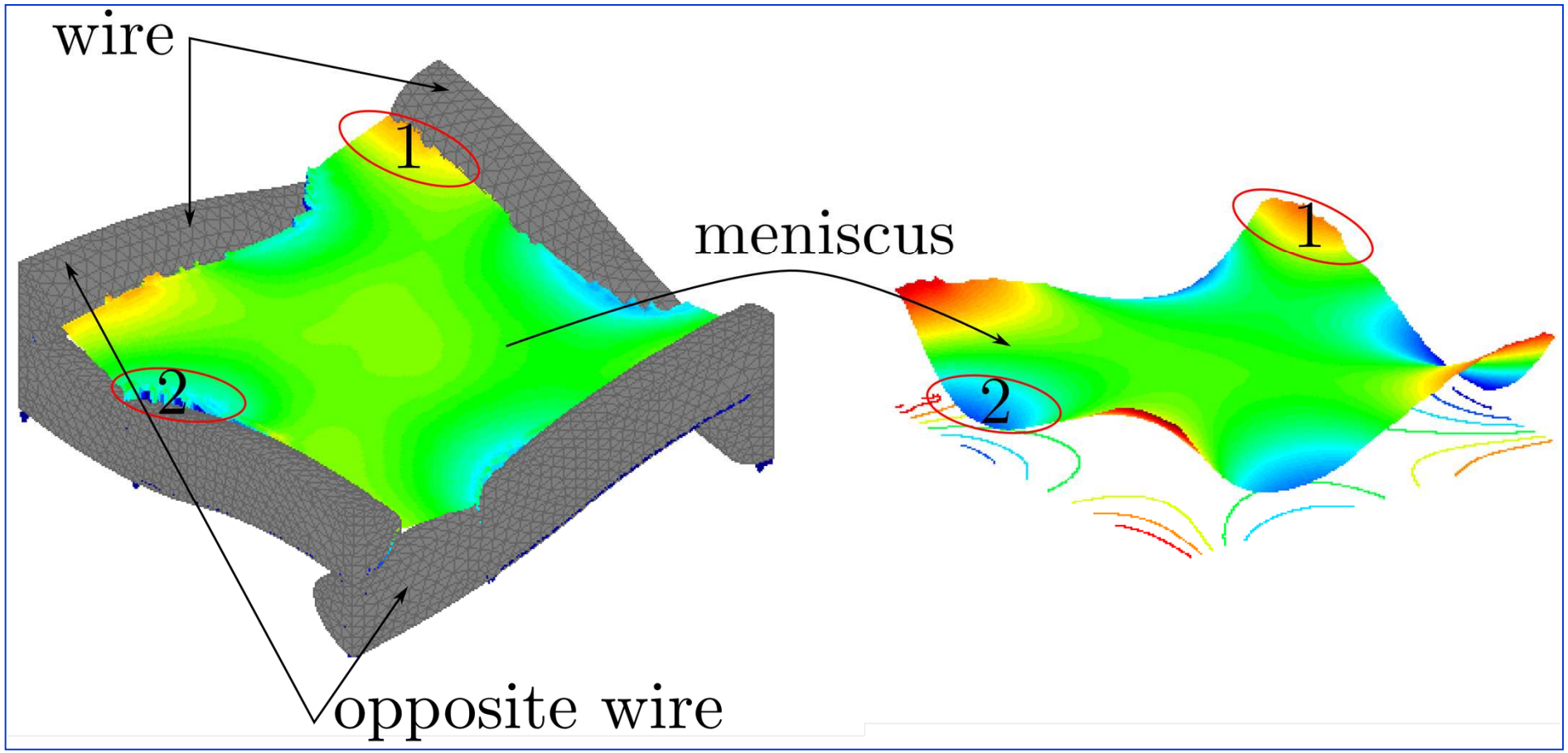




Absorption rate is roughly equal to one third of the maximal rate that could be achieved (only valid within the flow rate range of the tests)

R. Goulet. PHD 2011
Development and analysis of an innovative evaporator/absorber for automotive absorption-based air conditioning systems: investigation on the simultaneous heat and mass transfer
CETHIL, UMR5008 INSA de Lyon - CNRS - UCBL & PSA

Identification of absorption limitations: meniscus & grids porosity



H. Obame MVE. Ongoing PHD (2011-2014):
Intensification of heat and mass transfer in Lithium Bromide water solution flow confined in grids absorption

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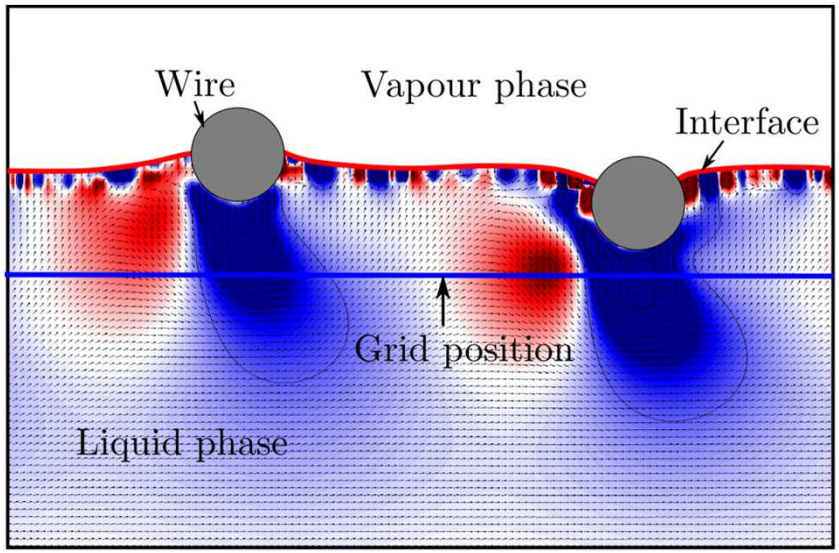
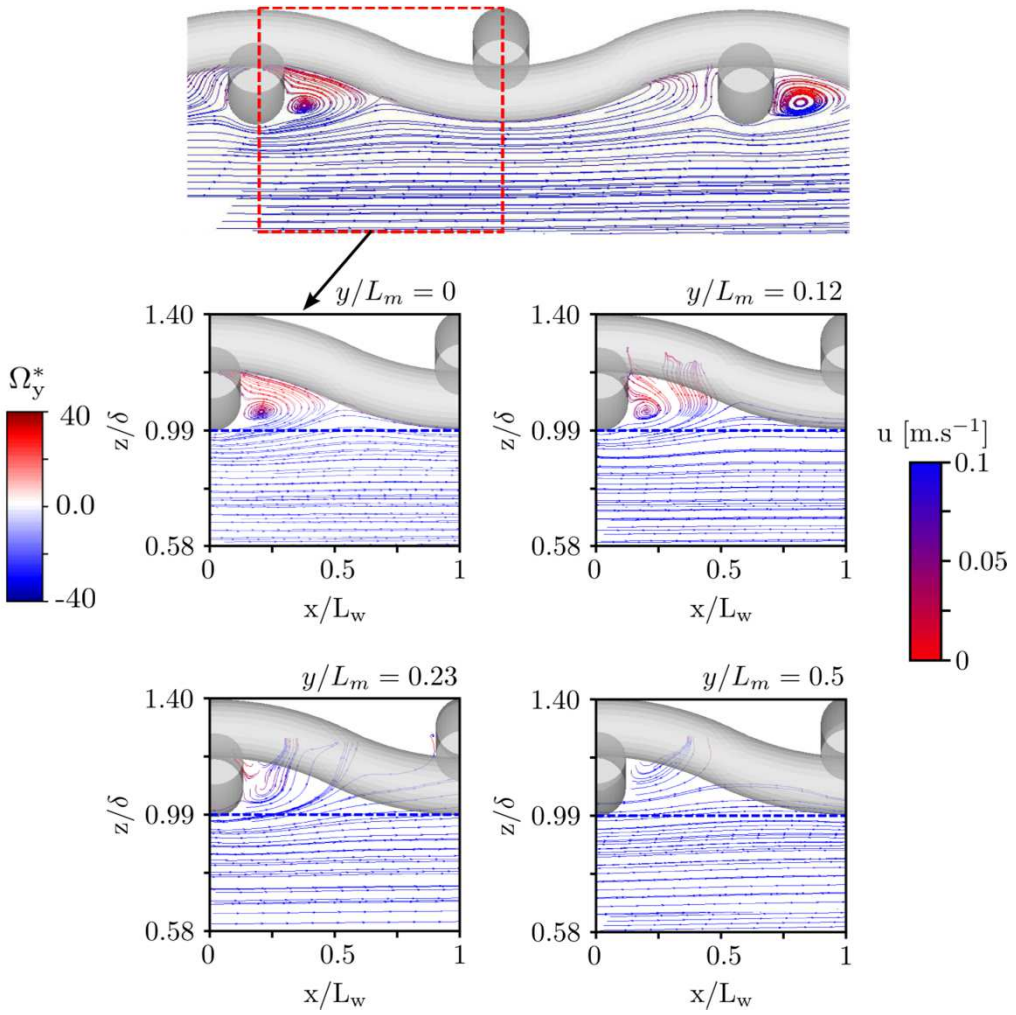
Identification of absorption limitations: Stabilization of interface & LiBr flow modification





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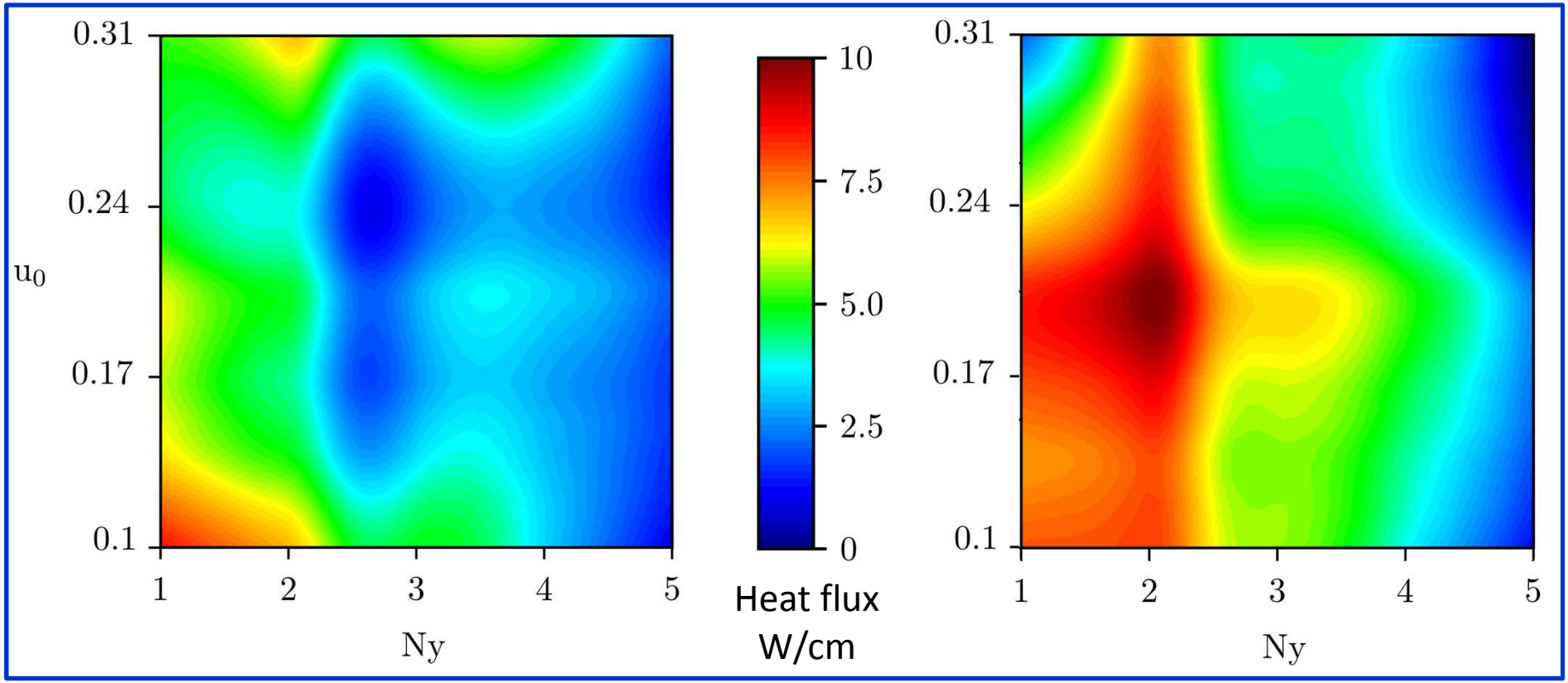
Identification of absorption limitations

Mass transfer & heat transfer intensification:

- Create more fluid mix in grid spaces
- Increase grids porosoty
- Conserve capillarity effects



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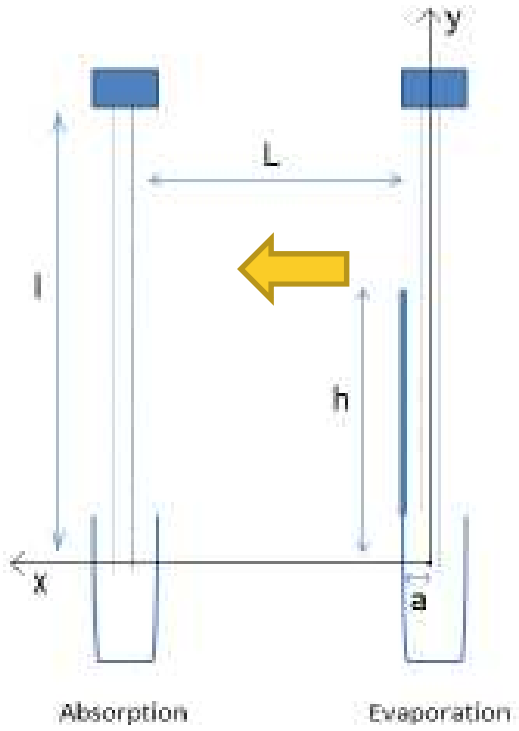
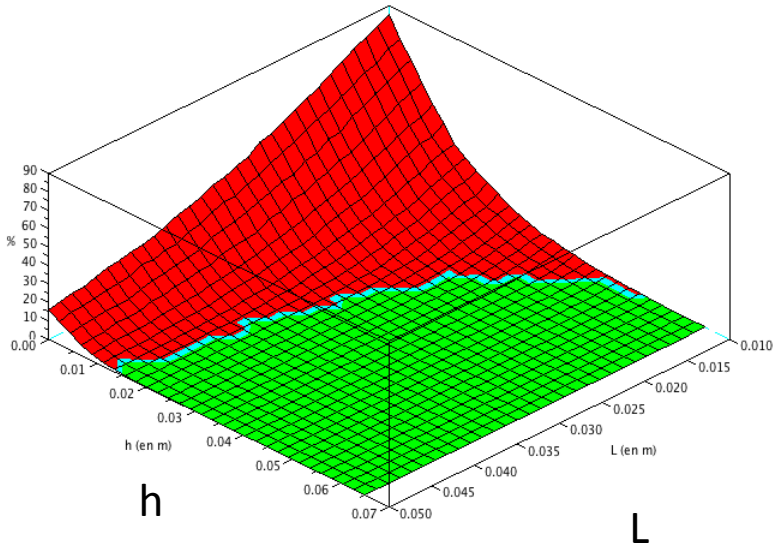
Identification of absorption limitations

Water dropplets elimination in a water vapor gas flow



Droplet %
Affecting absorption



Robin SCHUCKER, Benjamin BROCHE, Mohamed SABAH, Jonathan GRANDPERRIN, Shen DENG,Alexandre BUTTERLIN PSC 2013: Investigation on dropplets, Laboratoire d'Hydrodynamique (LadHyX), Ecole Polytechnique, PSA

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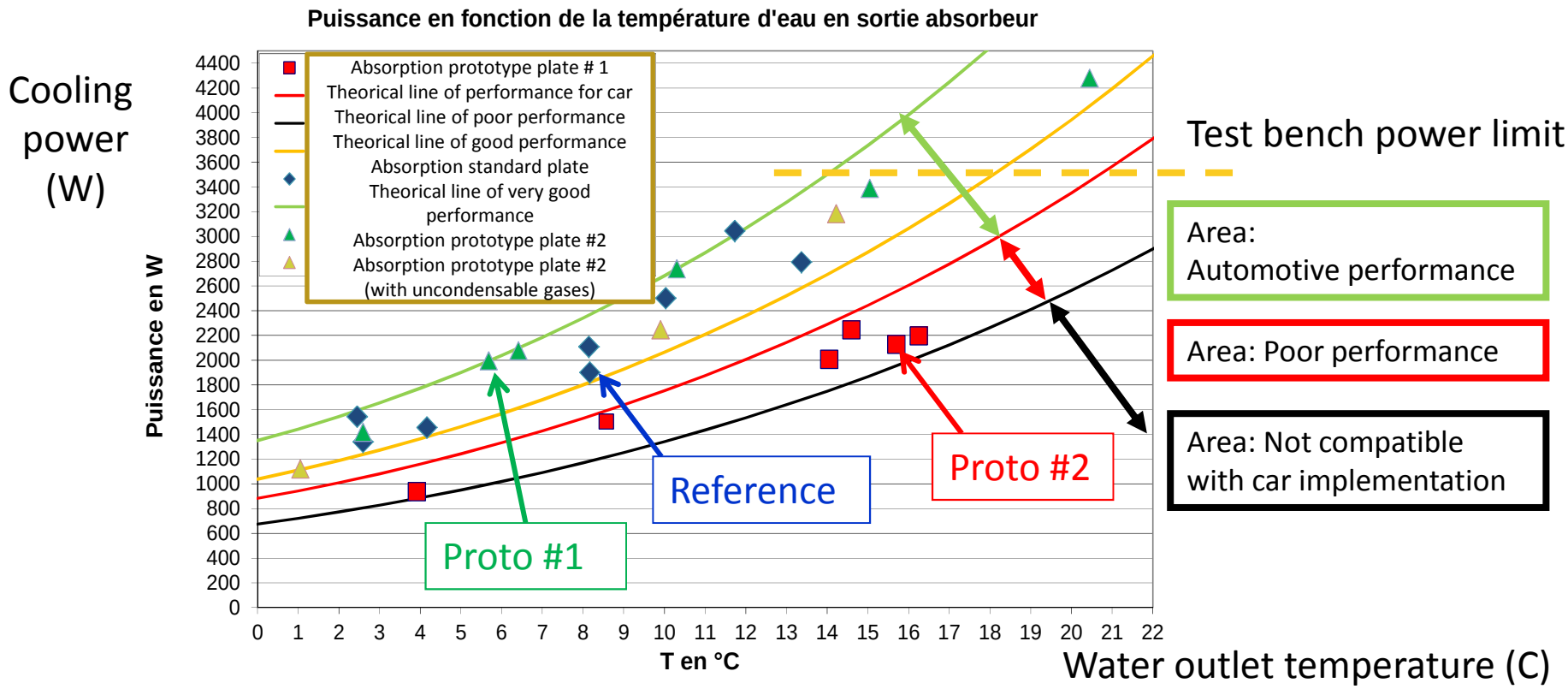
TEST BENCH RESULTS

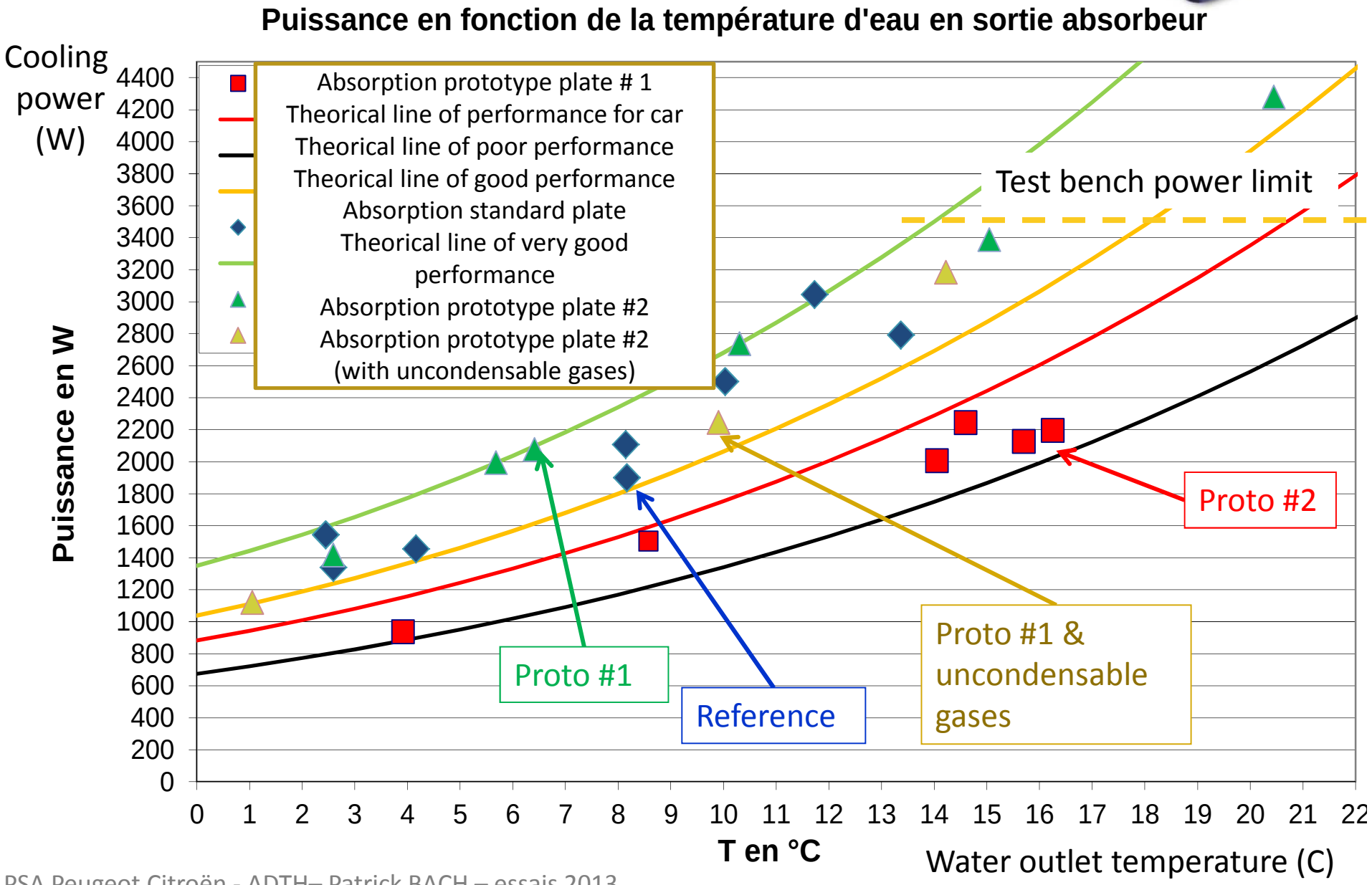
Absorbers: configurations & results

LiBr 3,5kW test bench for absorbers (2005 - Bertin Technologies – stainless steel)

- 8,8L evaporator /absorbers (painted aluminium+plastics – PU+PP distribution + PET grids)
- 5 plates (3 LiBr/2 Water) for 2400cm2 absorption surfaces
- Climatic conditions & heating systems representative in car conditions (+30C / +90C)
- Tests with different plates geometry and same grids



Absorbers: configurations & results



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CONCLUSION

Automotive falling film for absorption: Conclusion

Power on 1/3 on absorber is checked.
Improvements for the future are identified.

Still very difficult to make it work:
- Flow equilibrium between grids
- Flow distribution on grids
- Pressure equilibrium
- Uncondensable gases

The key points are known today but the optimised characteristics are still to identify.