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Numerical Simulation and Experiments of Hydrogen Diffusion Behavior for Fuel Cell Electric Vehicle

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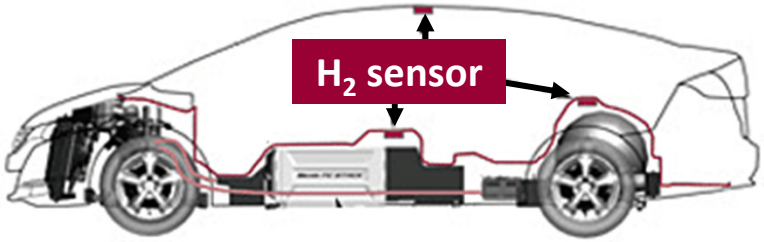
Background

Honda's hydrogen technology

Hydrogen safety system



Requirement

Efficient detection using few H_2 sensors

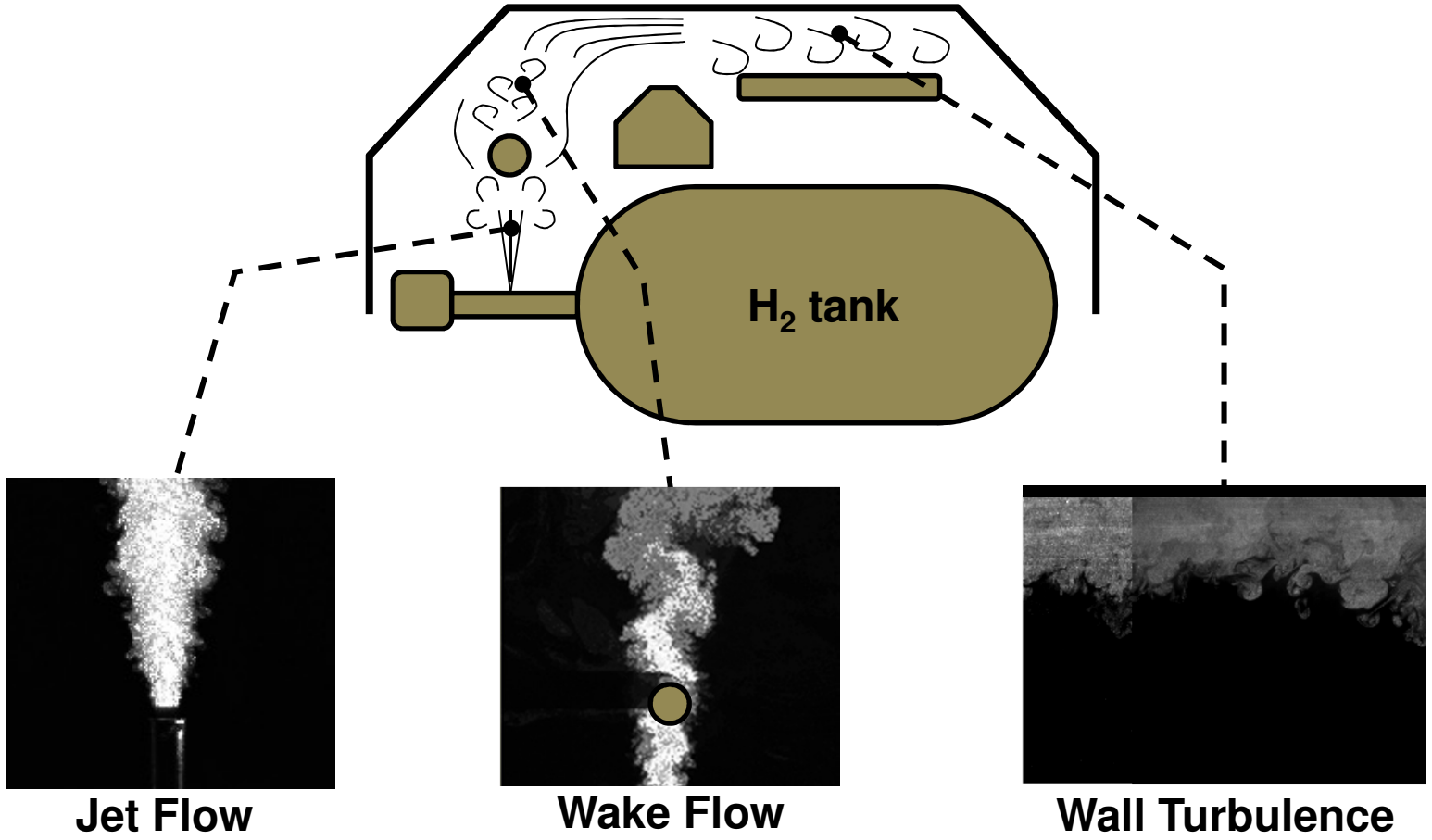
How does leaked hydrogen diffuse into complexly shaped spaces?

Significant need for hydrogen diffusion simulations

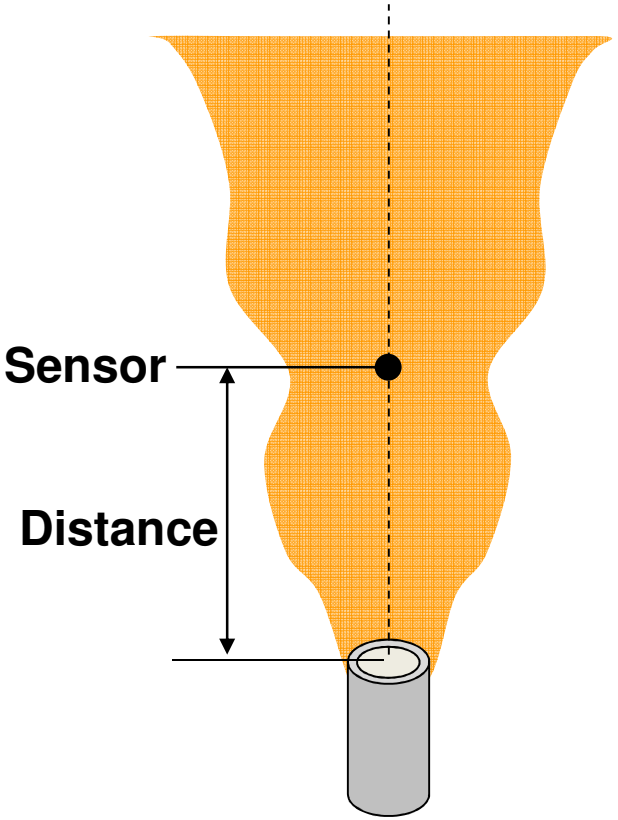
Objective & Approach

Objective — To develop a simulation method for hydrogen leaks into **complexly shaped spaces.**

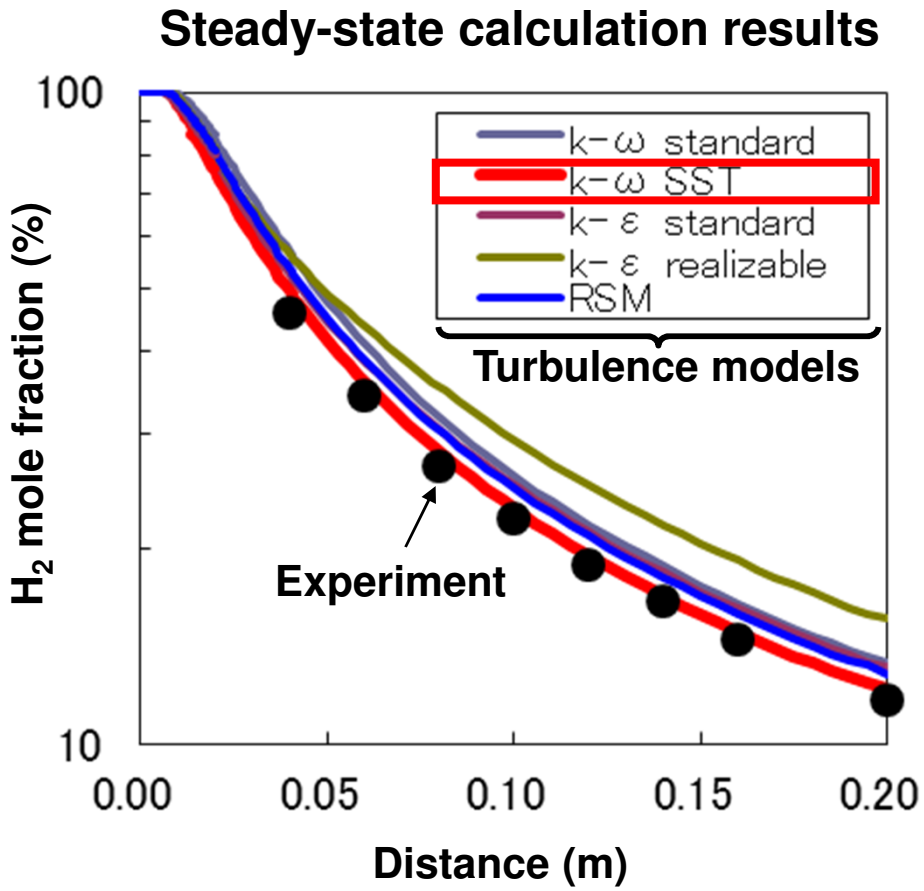
Approach — Turbulence elements in FCEVs were classified into three types. Appropriate calculation methods were established to each.



Modeling of Turbulence - Jet Flow

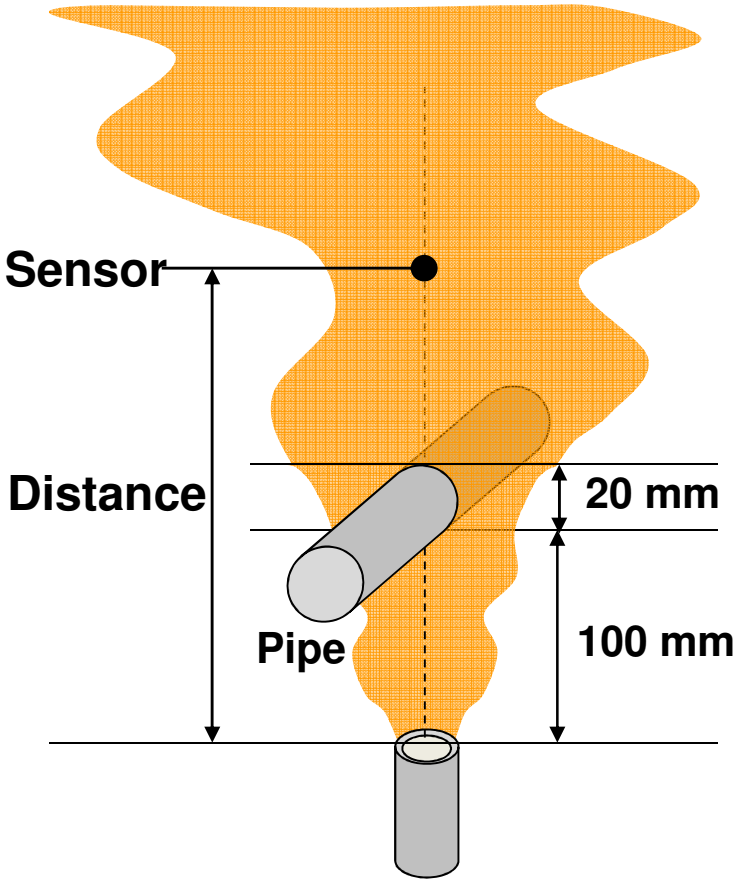


Spout diameter : 1.4 mm
Flow rate : 120 L/min

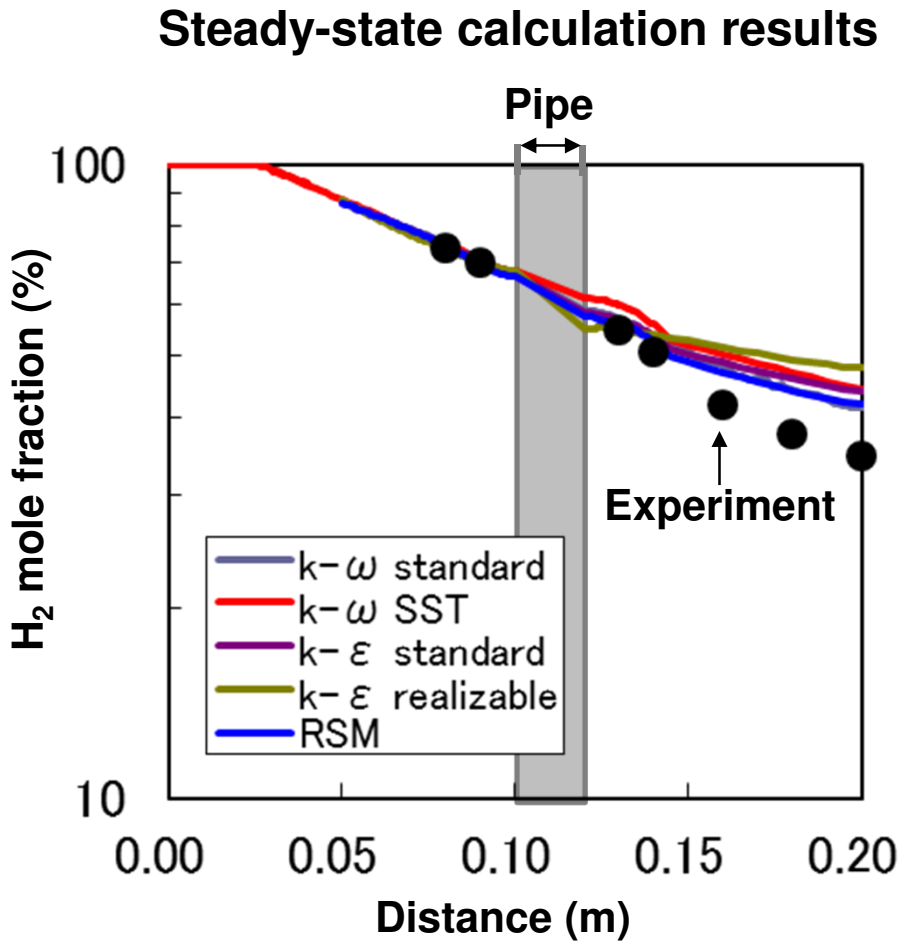


k-ω SST model is most accurate for jet flow.

Modeling of Turbulence - Wake Flow

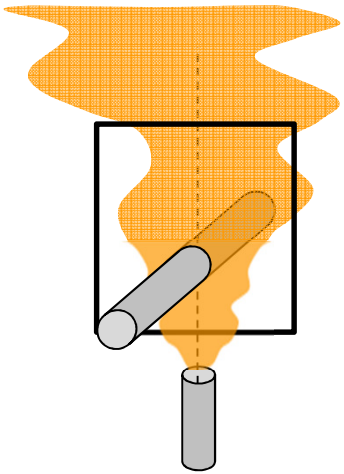


Spout diameter : 7 mm
Flow rate : 212 L/min

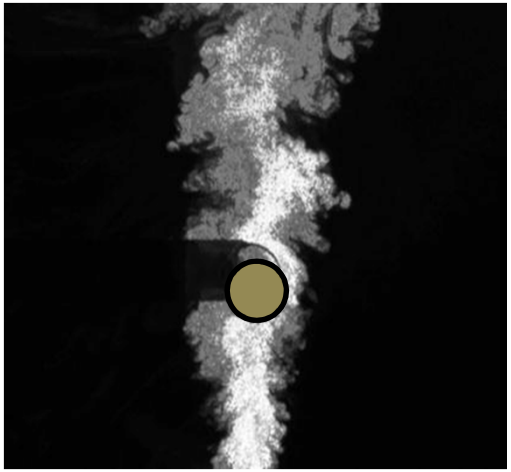


Steady-state calculations using the candidate models could not express wake flow.

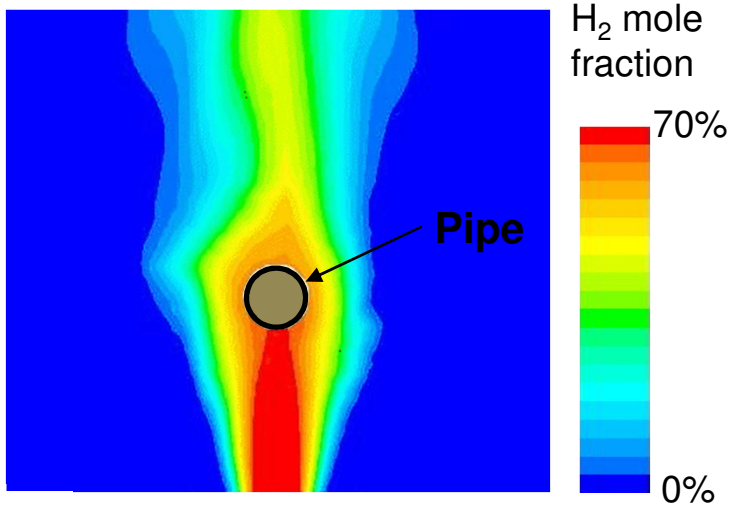
Modeling of Turbulence - Wake Flow

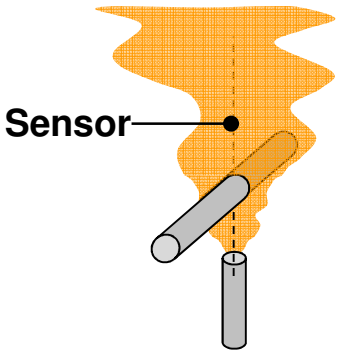


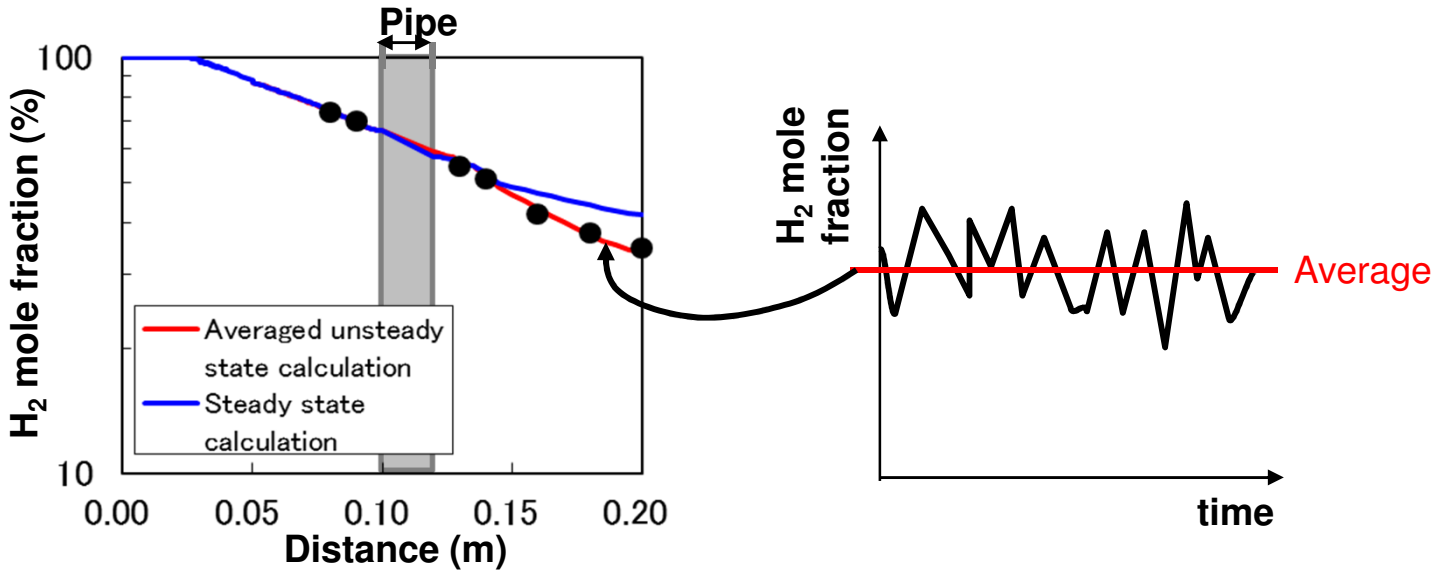
Visualized flow image
(Helium with oil mist)



Contours of unsteady-state calculations

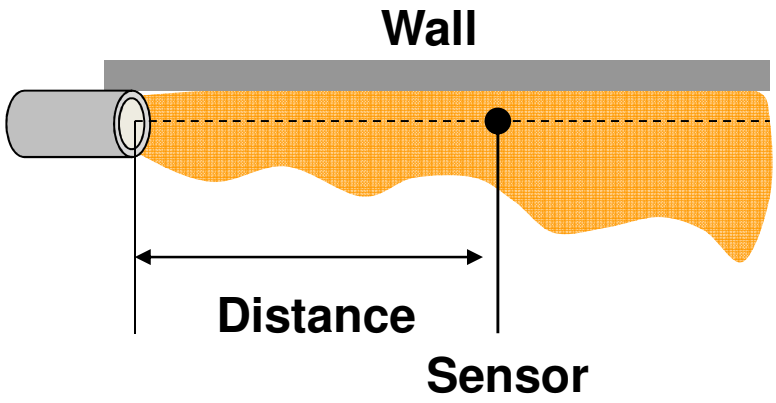




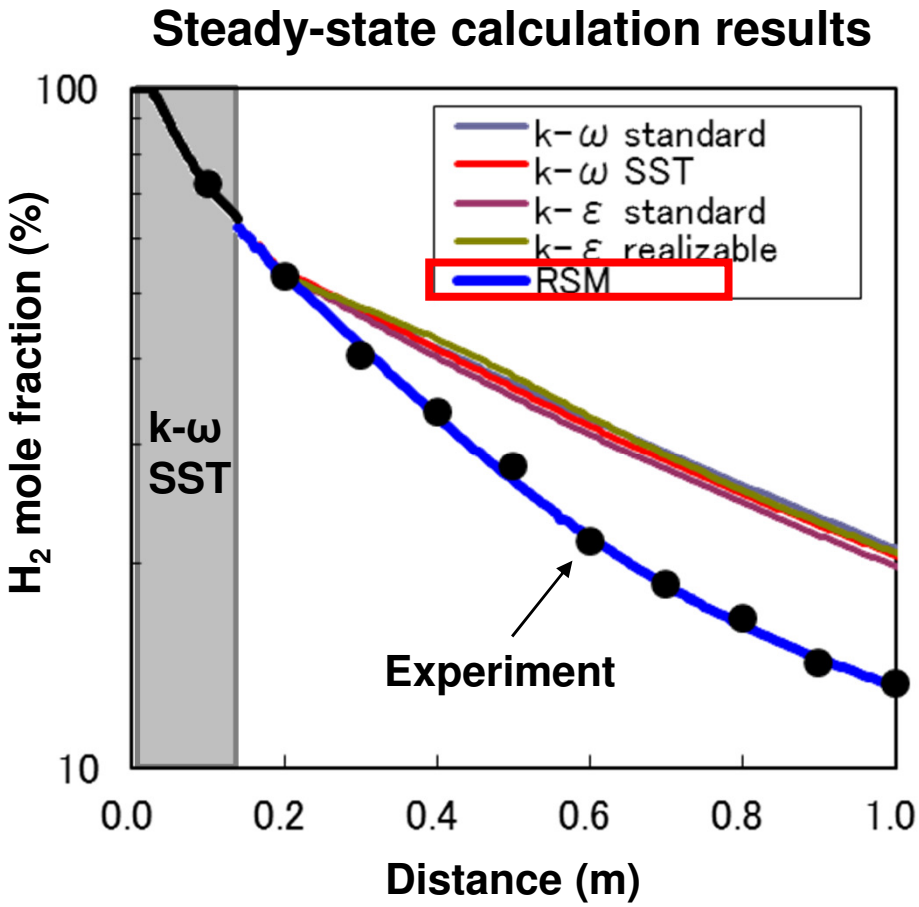


Time-averaged unsteady-state calculations are necessary to express the powerful fluctuations of wake flow.

Modeling of Turbulence - Wall Turbulence

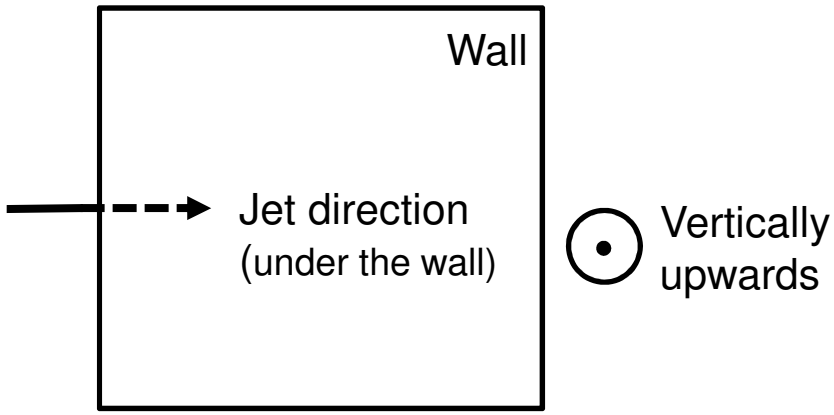


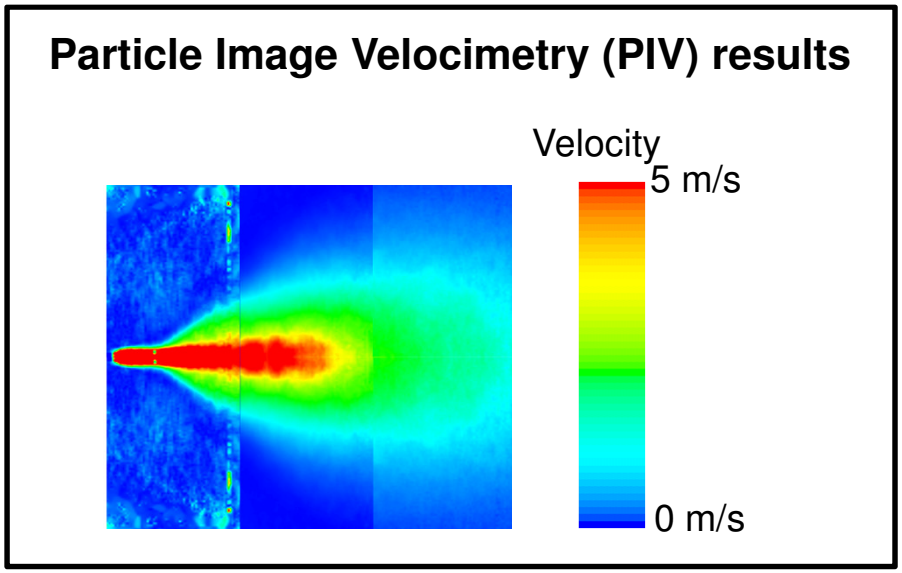
Spout diameter : 7 mm
Flow rate : 212 L/min



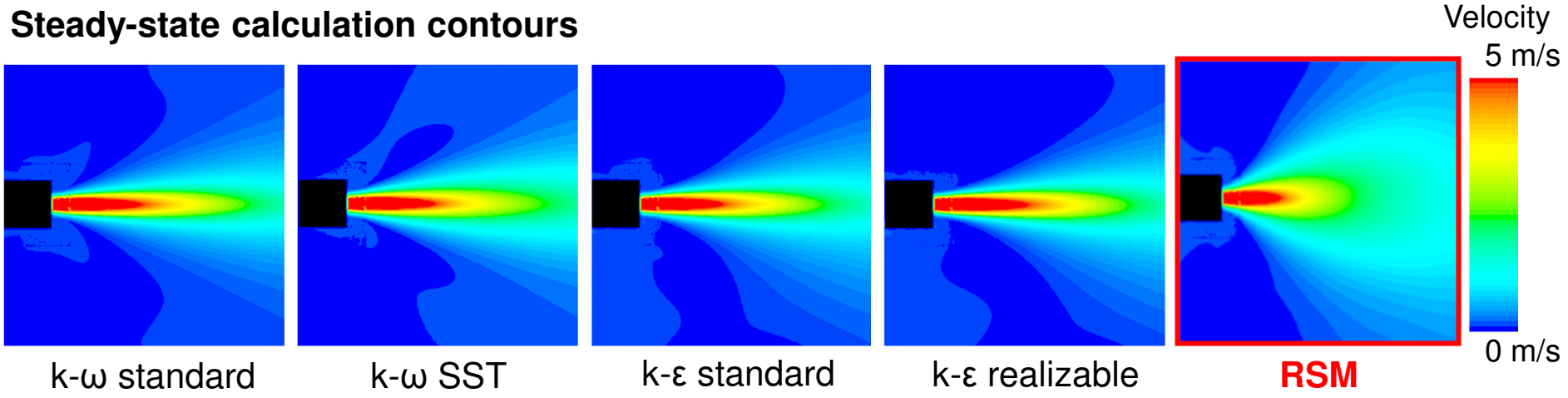
RSM model is most accurate for wall turbulence.

Modeling of Turbulence - Wall Turbulence





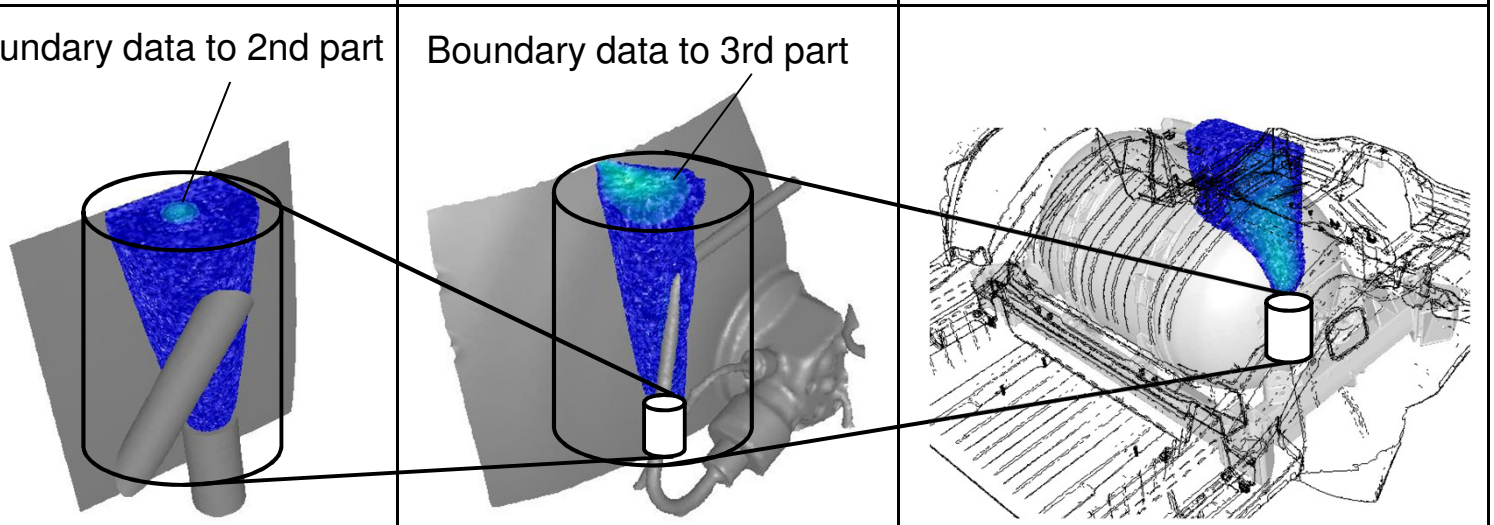
Steady-state calculation contours



RSM model can express the behavior of the hydrogen in spreading along the wall surface.

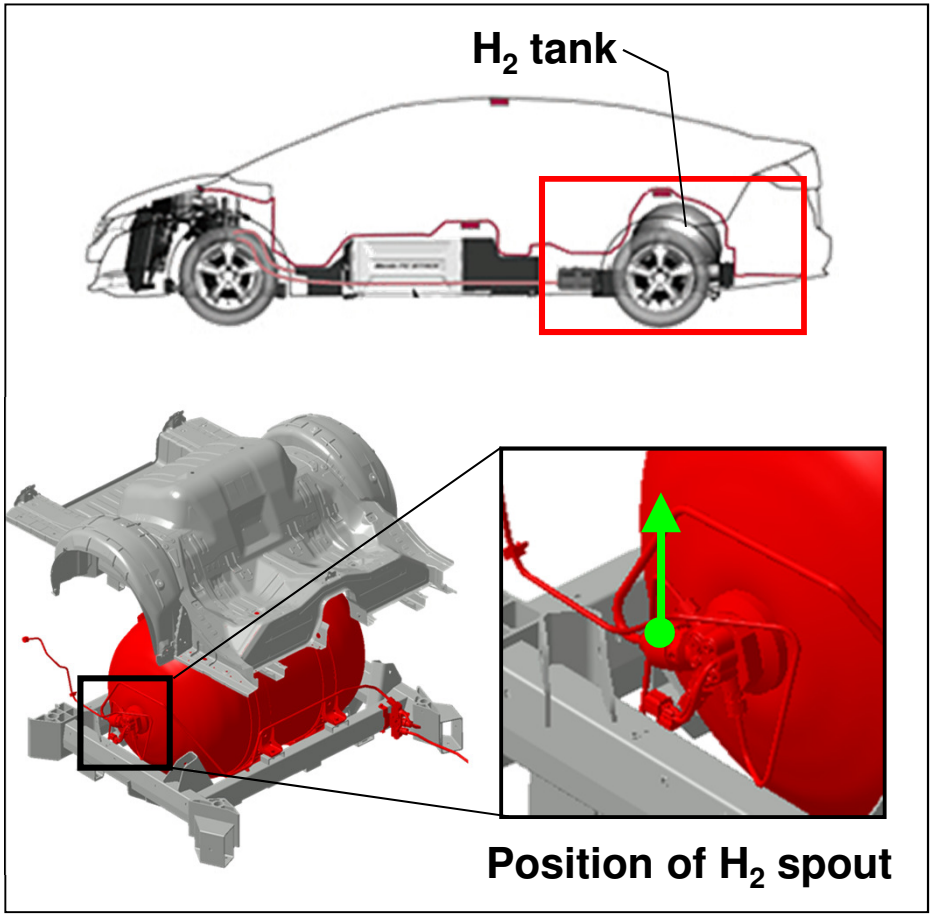
Application to FCEV – Method

Three parts partitioning method

	1st part	2nd part	3rd part
Image			
Steady or unsteady	**Steady-state**	**Time-averaged unsteady-state**	**Unsteady-state**
Compressibility	**Compressible**	**Incompressible**	**Incompressible**
Dominant turbulence elements	**Jet flow**	**Wake flow**	**Wall turbulence**
Turbulence model	**k-ω SST**	**RSM**	**RSM**

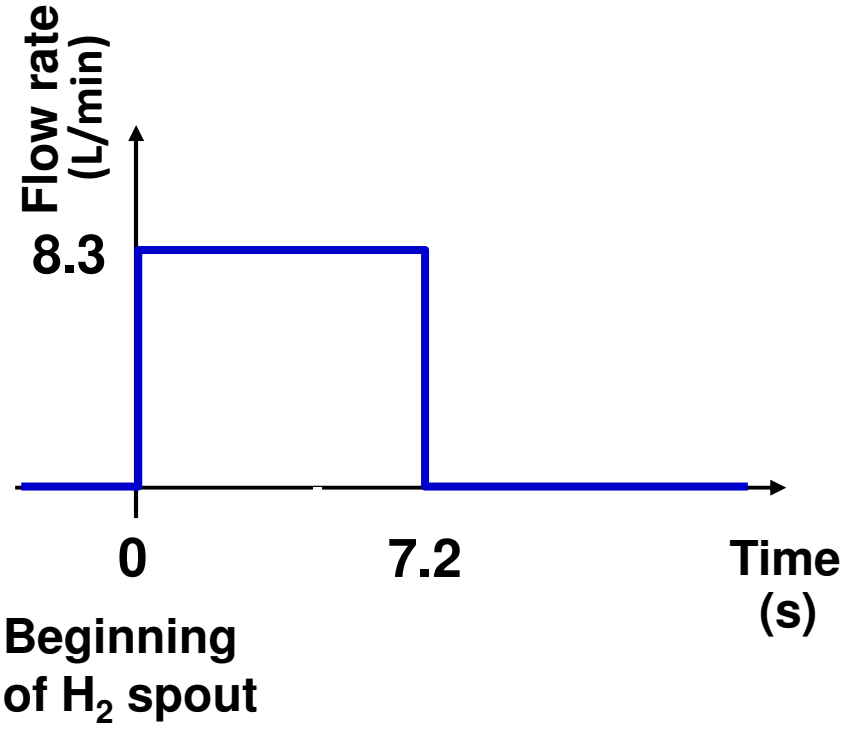
Application to FCEV – Conditions

Object : Around the H_2 tank



Spout condition

Spout diameter : 1.4 mm
Direction : Upward

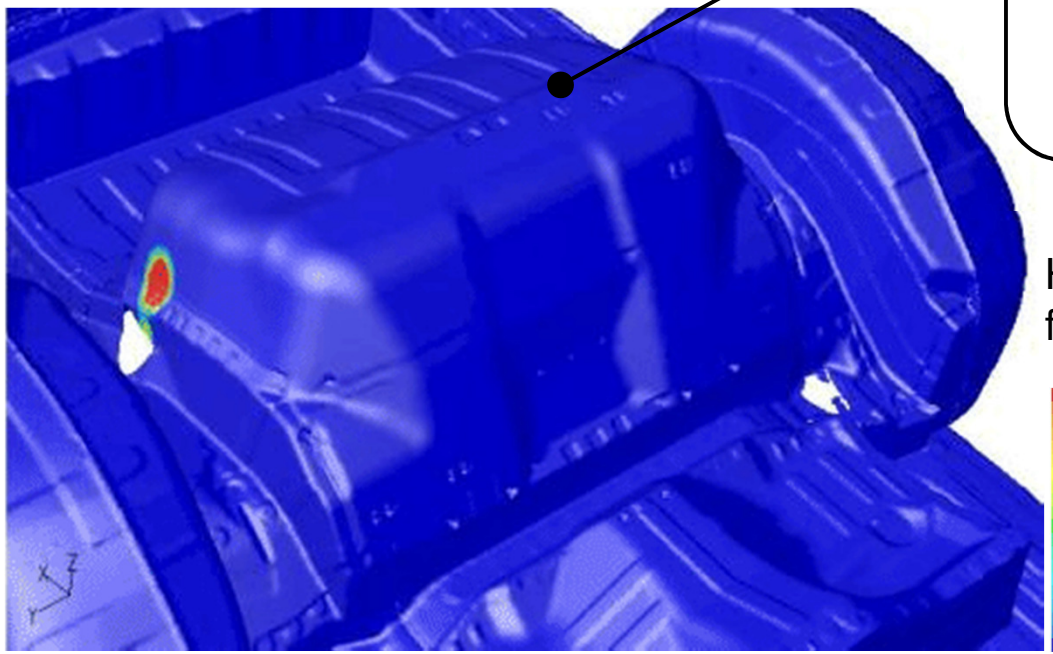


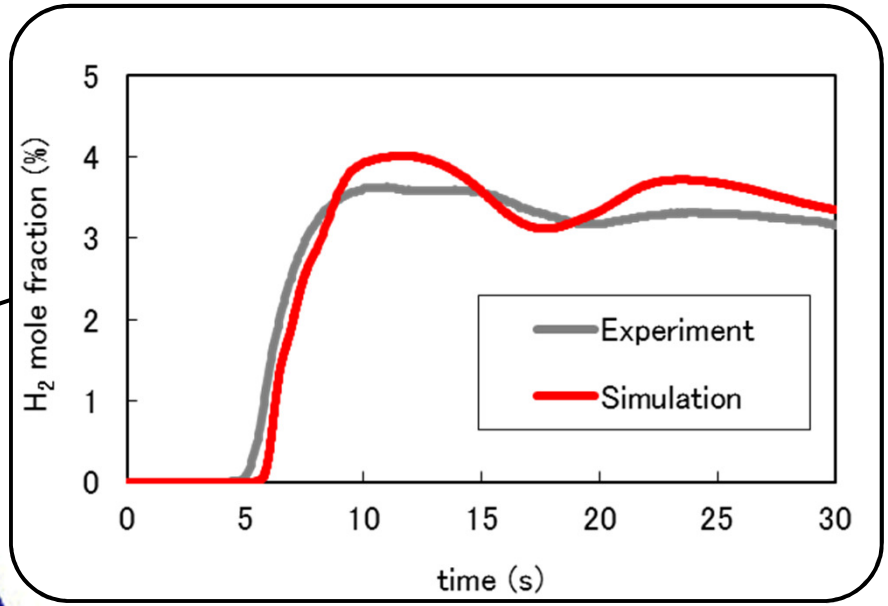
Application to FCEV – Results

Calculation results for 3rd part

Time from beginning of H_2 spout

00.2 sec



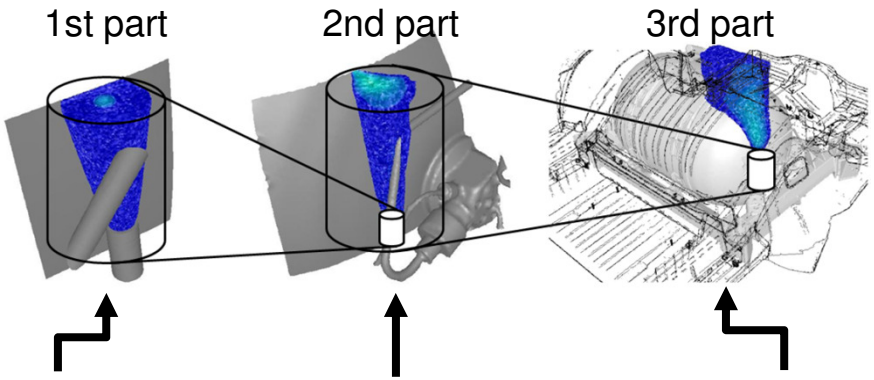


Simulation and experiment results correspond well, even in complexly shaped underfloor spaces.

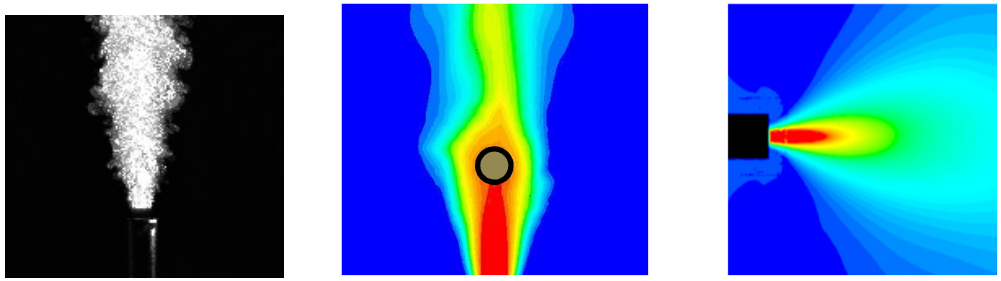
Summary & Conclusion

Simulation methods

Three parts partitioning method



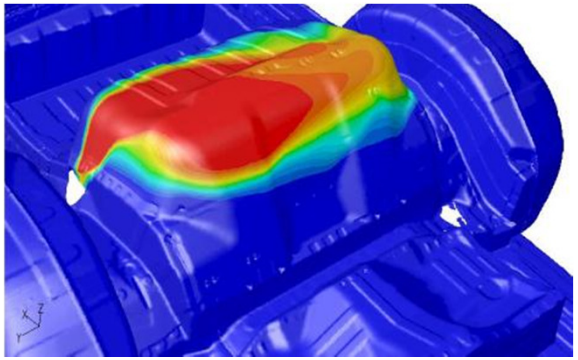
Jet Flow | **Wake Flow** | **Wall Turbulence**



k-ω SST | **Time-averaged Unsteady-state** | **RSM**

Application to FCEV

FCEV underfloor spaces



Simulation results matched closely with experimental data.

Conclusion :

These methods can be used to accurately simulate the hydrogen leaks in complexly shaped spaces.


Our dream is the realization of a hydrogen society
with high-level hydrogen safety
and to keep
Blue Skies for our Children