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高压氢气瓶快充过程温升变化及充装率影响研究

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Thermal behaviors and SoC of the high pressure hydrogen cylinder during the fast fill process

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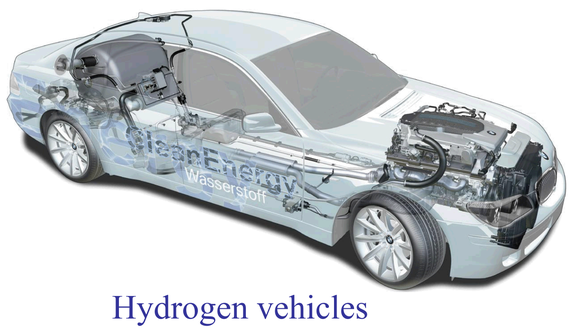
1 Introduction

High pressure storage



Hydrogen vehicles

Fast fill safety → **Temperature limitation ≤ 85℃**

Driving range → **State of Charge (SoC)**

2 Numerical model

2.1 Governing equations

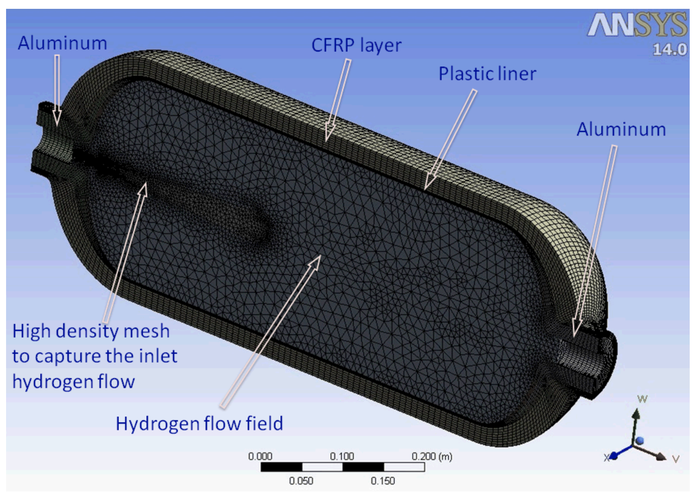
$$\frac{\partial p}{\partial t}+\frac{\partial}{\partial x_i}(\rho u_i)=0$$

$$\frac{\partial}{\partial t}(\rho u_i)+\frac{\partial}{\partial x_j}(\rho u_i u_j)=-\frac{\partial p}{\partial x_i}+\frac{\partial}{\partial x_j}\left[\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}-\frac{2}{3}\delta_{ij}\frac{\partial u_k}{\partial x_k}\right)\right]+\frac{\partial\left(-\rho\overline{u_i'u_j'}\right)}{\partial x_j}+F_Y$$

$$\frac{\partial}{\partial t}(\rho E)+\frac{\partial}{\partial x_i}(u_i(\rho E+p))=\frac{\partial}{\partial x_j}\left(k_{eff}\frac{\partial T}{\partial x_j}+u_i(\tau_{ij})_{eff}\right)$$

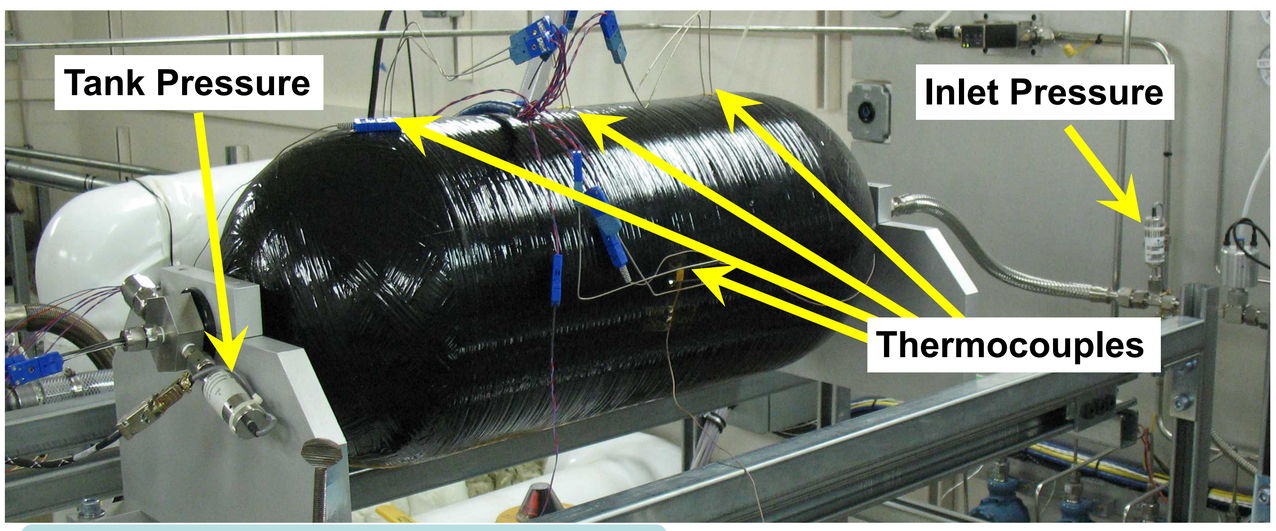
2.2 3D simulation model

- ANSYS Fluent V14.0
- K-epsilon model
- Buoyancy effects
- NIST real gas model
- Structured-Unstructured grid
- Coupled fluid dynamics & heat transfer

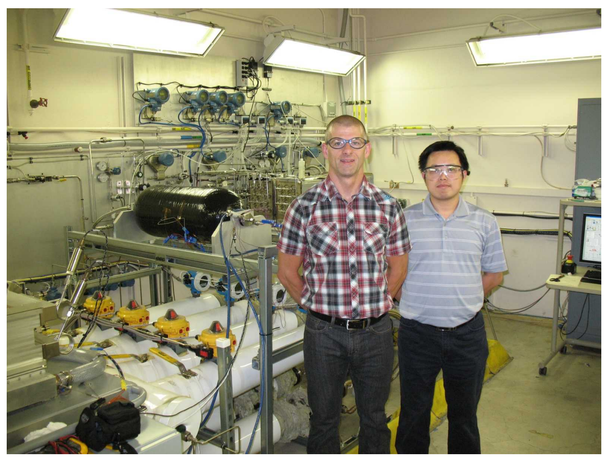


A 3D model of type IV tank

3 Fast fill experiment



- **22 Thermocouples**
  - 5 Gas Temperatures
    Five TCs spaced along the tank length
  - 16 Tank Temperatures
    Four TCs at each of 4 locations.
  - 1 Inlet Gas Temperature
- **2 Gas pressure**
  - One at the gas inlet
  - One at the closed end
- **Mass flowrate measurement**
- **360 rotatable**

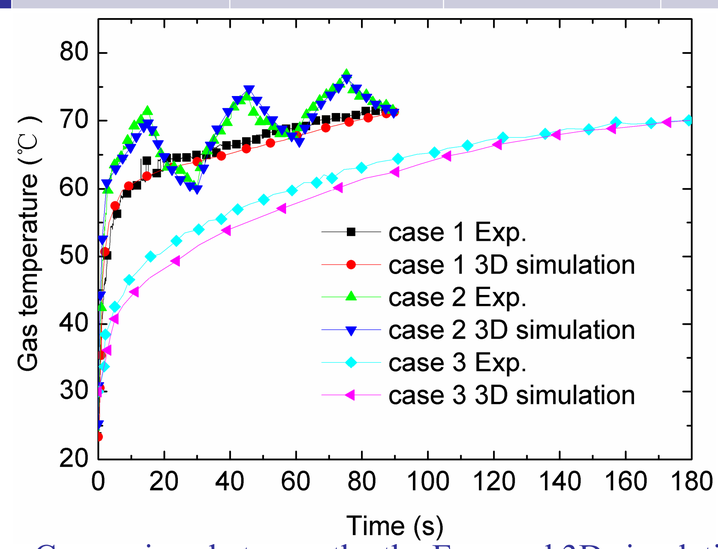


High pressure hydrogen fast fill system

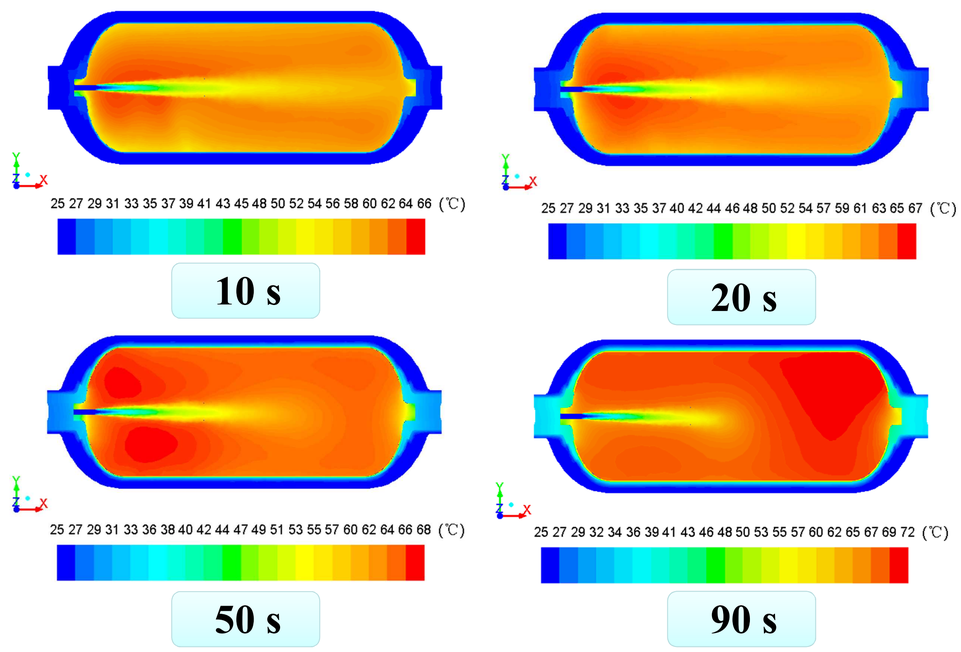
4 Results and discussions

4.1 Validation and temperature rise

Case	Initial pressure (psi)	Final pressure (psi)	Fill time (sec)	Tank type
1	20	2000	90 (linear)	IV, 37L
2	20	2000	90 (steps)	IV, 37L
3	350	5000	180	III, 74L

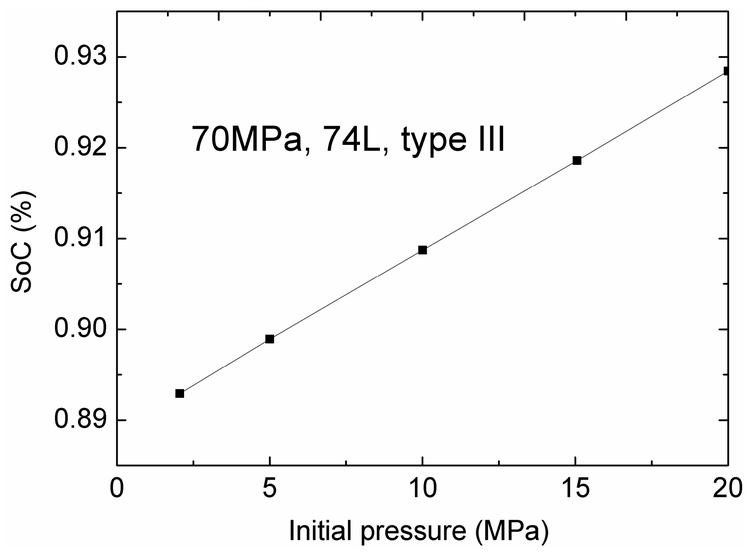


Comparison between the the Exp. and 3D simulation



Temperature distribution of case 1 at different time

4.2 State of charge (SoC)



Effect of initial pressure on SoC

5 Conclusions

(1) 3D model is valuable for temperature prediction;

(2) Linear pressure fill mode produces lowest temperature;

(3) Highest temperature is at the end & top region;

(4) SoC is higher when the initial pressure is higher.

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