Thermodynamic Analysis: Hydrogen Fuel Tank

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a place of mind
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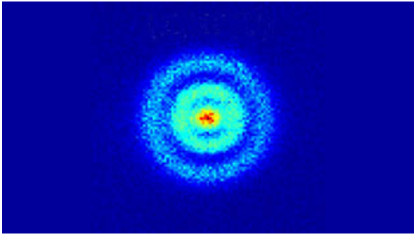
CERC

Overview

Why Hydrogen Fuel?

- High specific energy content
- Relatively Abundant
- Low Emissions

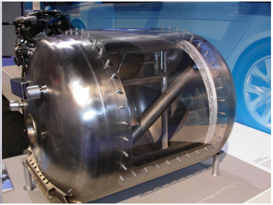


- Infrastructure Integration
- Simple Production
- Relatively Renewable

Hydrogen Storage

Can be stored in Liquid or Gaseous States

- Liquid Hydrogen Has very high Energy Density
- Gaseous Hydrogen uses cheap and simple storage

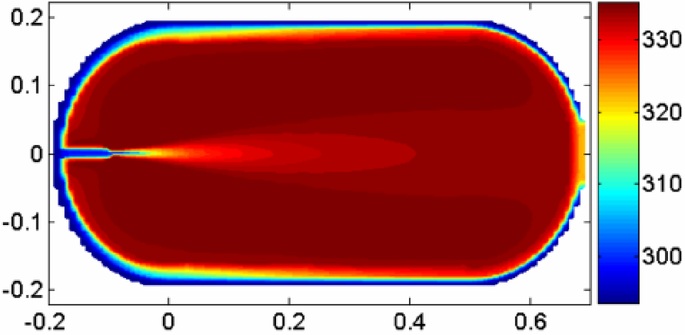


- Liquid Requires Complex Cryogenic Systems
- Gaseous Hydrogen Has to be Compressed to match acceptable energy density

Problem and Constraints

- Hydrogen Heats during throttling
- Hydrogen Heats during compression
- Fills times need to match current standards
- Needs to be compressed $\geq$ 350 Bar

Modelling Temperature Distribution

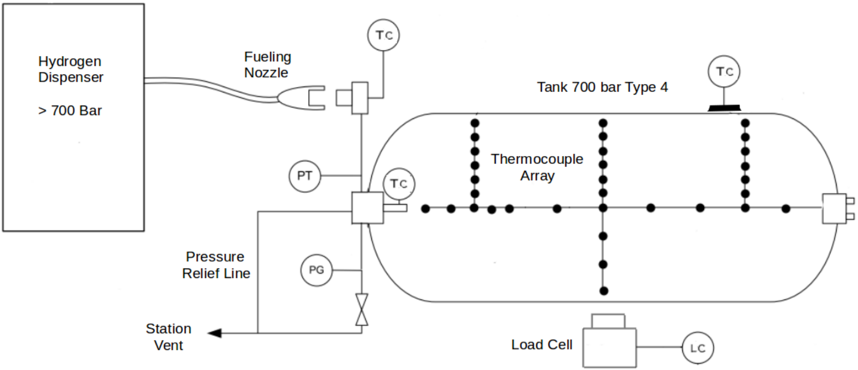


Temperature Distribution for 35MPa Tank during fast filling [Dicken, 2006]

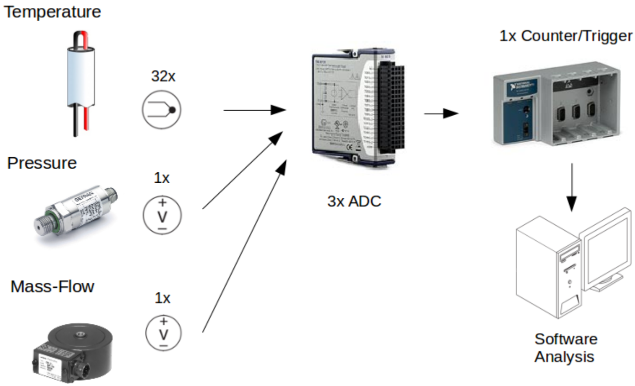
Problem and Constraints

- Map 2D temperature distribution inside tank
- Determine mass transfer during a fast fill.
- Determine Pressure during fast fill
- Semi-portable system
- No modifications to tank
- Adhere to SAEJ2601 standards

Experimental Setup



Data Acquisition System



Temperature

Thermocouple:

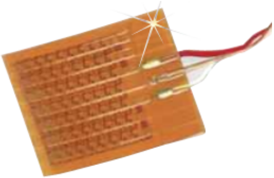
- Type T Special Grade
- 0.008mm Diameter $\tau = 0.15$ s
- $\pm 0.5^{\circ}$C accuracy

ADC 2x NI 9213

- 16ch 24 bit ADC
- ± 78.125mV input range @ 78 S/s
- accuracy with type T $\pm 0.02^{\circ}$C

Temperature

Thin-Film Heat Flux Sensor:



- Type K Standard Grade
- $\tau = 1.5$ s
- $\pm 1.1^{\circ}$C accuracy

ADC 2x NI 9213

- 16ch 24 bit ADC
- $\pm$78.125mV input range @ 78 S/s
- accuracy with type T $\pm 0.02^{\circ}$C

Pressure

GEFRAN Diaphragm Transducer:

- 0-1000 Bar for 0-10V
- Response Time $\leq$ 1msec
- $\pm$0.5% accuracy FS

ADC 1x NI 9215

- 4ch 16 bit ADC
- $\pm$10V input range @ 100 kS/s
- $\leq$ 0.2% error (calibrated)

Mass Flow

Honeywell 3397 Load cell:

- 2mV/V ±0.25%
- 0-200lb range
- Universal Inline Amplifier ±10Vdc

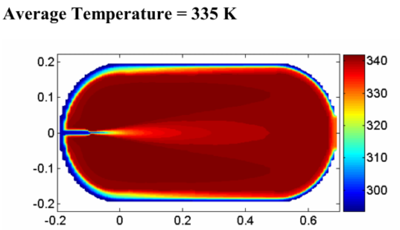
ADC 1x NI 9215

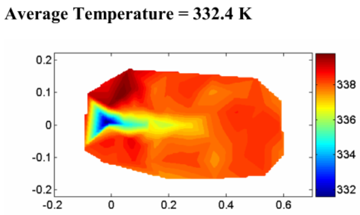
- 4ch 16 bit ADC
- ±10V input range @ 100 kS/s
- ≤ 0.2% error (calibrated)

Procedure

- Purge Tank and Set Pressure to 50 Bar
- Allow Temperature/Pressure to Stabilize
- Record Initial Conditions
- Apply Required Ramp Rate
- Measure P, T @ 10S/s HF, m @ 1S/s during Fast fill
- Measure P, T @ 10S/s HF, m @ 1S/s during cool down
- Record Final Conditions
- Repeat for different array configurations

Summary





- Temperature: T $\pm 0.16\%$
- Pressure: P $\pm 0.22\%$
- Heat Flux: HF $\pm 0.4\%$
- Mass: m $\pm 0.45\%$

References

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Thank-you