Introduction to Hydrogen systems

Padmini Mellacheruvu

Technology Specialist – Cryogenic and compressed gas fuels

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Introduction to Hydrogen systems

Agenda

1. Why use Hydrogen as marine fuel?
2. Hydrogen Properties
3. Design challenges
4. Design Considerations

Why use Hydrogen as marine fuel?

Hydrogen as marine fuel

- **IMO strategy –** To reduce GHG emissions from international shipping by at least 50% from 2008 levels by 2050
- **Decarbonization –** Alternative and zero carbon fuels offer a pathway to achieve this goal
- **Challenges –** Toxicity of Ammonia, limited availability of biofuels, large and heavy batteries for long distance shipping etc.,
- **Solution -** Hydrogen is a potential zero-emission fuel alternatives capable of meeting shipping industry’s energy needs

Hydrogen as marine fuel

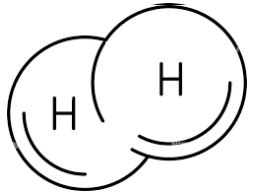
- **Early estimates –** UK DfT estimates 75-95 TWh of demand for hydrogen-based fuels in international shipping
- **Production –** Green hydrogen by electrolysis using renewable sources, blue hydrogen from captured carbons/hydrocarbons, grey hydrogen from hydrocarbons using non-renewable resources
- **Storage options –** Compressed gas, Liquified gas, metal hydrides, organic hydrides
- **Propulsion methods –** Combustion engines (e.g., ICE, GT), Fuel cells (e.g., Proton exchange membrane, Solid oxide etc.,)

Hydrogen Properties

Gaseous hydrogen properties

Highly Flammable

Can burn from 4% to 75% v/v in air when ignited



Small molecular size and low density

Extremely high potential for leaks and fast dispersion

Low minimum ignition energy

Can ignite by electrostatic discharge

Low volumetric Energy density

Need to be stored at high pressures

Colorless, odorless gas, with near invisible flame

Difficult to detect combustion

Asphyxiant, non-toxic, non-corrosive

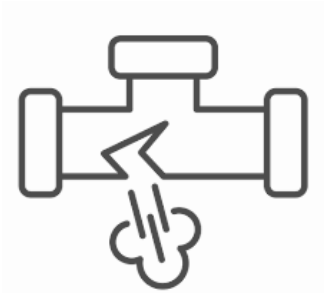
Liquid hydrogen properties

Low temperature

At -253^{0}C, nitrogen and oxygen will freeze

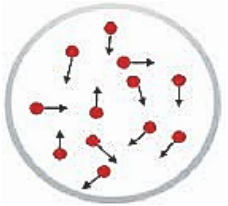
Low heat of vaporization

High vaporization rate if not well-insulated



High liquid to gas expansion

850x increase in pressure during evaporation

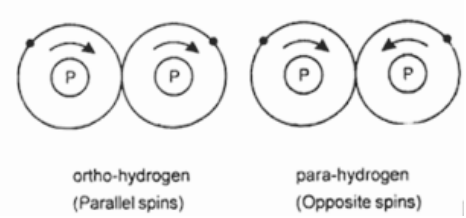


Low density

Difficult to pump; high pressures required for flow

Energy intensive liquification

Consumes more than 30% of hydrogen’s energy content



Ortho-Para conversion

Exothermic reaction, results in evaporation

Design Challenges

Challenges in Hydrogen systems design

- Embrittlement
- hydrogen attack at high temperatures
- Permeable through composites

Material compatibility

- 35-70 Mpa compressed hydrogen storage
- Pressure vessel and piping failures
- High energy explosions

Design for high pressure

Difficult to detect and extinguish hydrogen flames with conventional methods

Combustion and explosion hazards

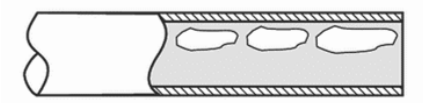
Challenges in Hydrogen systems design

Design for safety

- Inherently safe designs
- Safe venting of hydrogen
- Inerting and ventilation
- Hazardous zones

Low temperature design

- Strict material requirements
- Thermal fatigue
- Insulation and vacuum systems



Two phase flow

- Eliminating cavitation
- Sloshing
- Stratification
- Geysering effects

Design Considerations

Design considerations for Hydrogen systems

Risk elimination and Inherently safe design
Fail-safe designs, design for worst case scenarios, safety devices, control and emergency shut down, hazardous area classification

Consequence management
Control of handled hydrogen quantity, detection, fire fighting systems, limiting personnel, safety cases, explosion analysis

Commissioning and factory acceptance
Quality assurance plan, Workmanship, Survey procedures, traceability, review of commissioning trials

Inspection and Periodic maintenance
Preventive maintenance plan, replacement philosophy, maintaining logs, review of performance and functional tests

Operating procedures
Normal and emergency response manuals, trained personnel, periodic review of procedures

Thank you

Contact details:

Name: Padmini Mellacheruvu

Email : padmini.mellacheruvu@lr.org