Thermodynamics of Energy Conversion and Storage

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EXERCISES 14

1) Compare the size and weight of the energy storage in batteries and compressed air with the energy of a petrol tank (70 liters).

70 l * 10 kWh = 700 kWh
Batteries: 0.2 kWh/kg therefore 700kWh/0.2 kWh/kg = 3500 kg of batteries
Compressed air: 0.1 kWh/kg therefore 700kWh/0.1 kWh/kg =7000 kg of compressed air storage

2) How much hydrogen is in a 50 liter cylinder at 200 bar?

ideal gas equation: $p \cdot V = n \cdot R \cdot T$ therefore $p \cdot V \cdot M / R \cdot T = m$
$m = 0.05\ m^3 \cdot 1.013 \cdot 10^5\ Pa \cdot 200 \cdot 2g/mol / 8.314\ J/mol/K \cdot 298K = 0.817\ kg$

3) How thick is the wall of a 50 liter hydrogen steel cylinder storing at 200 bar.

$d_w/d_a = p/(2\sigma+p) = 200 \cdot 10^5/(2 \cdot 1.650 \cdot 10^9 + 200 \cdot 10^5) = 0.006$
$0.05/1.5/\pi = r^2$ therefore $r = 0.103$ and $d_a = 0.206$ m
$d_w = 0.206\ m \cdot 0.006 = 1.24$ mm

4) Calculate the density of hydrogen in a metal hydride.

1.4 mass% hydrogen in $LaNi_5$
1.4 kg in 100 kg/7000kg/m^3 = 0.0143 m^3 therefore 98 kg/m^3

5) Calculate the amount of hydrogen necessary to reach the flammability limit in a room of 5 x 10 x 2.8 m^3.

Flammability limit at 300 K is 4vol%. Volume of the room is 140 m^3. 4Vol.% of hydrogen is 5.6 m^3, which is 28 liter at 200 bar.