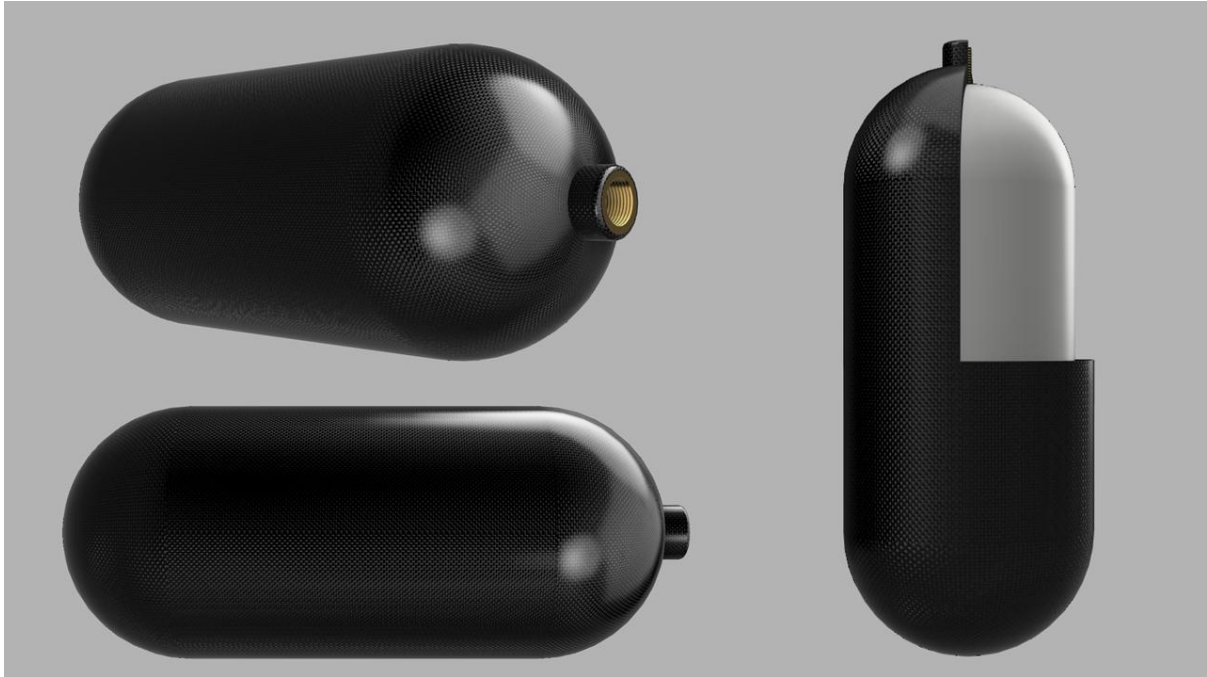


Hydrogen Gas Cylinder

Type 4

Calculate the Wall Thickness for a Hydrogen Gas Cylinder with an internal pressure of 70Mpa. Calculate the Volume in litres, also calculate the mass of Hydrogen for pressures of 35Mpa & 70Mpa at 20° respectively.



Parameters

Length = 1200mm

Internal Diameter = 450mm

Safety Factor = 2.5

Two Hemispheres

Cylinder Volume

Cylinder with two hemispherical domes, total height 1200 mm, diameter 450 mm.

$$r = \frac{450}{2} = 225\text{mm}$$

The two hemispherical ends together make **one full sphere** of radius r , whose axial length is $2r = 450$ mm.

Straight Cylindrical Length

$$1200 - 450 = 750\text{mm}$$

$$v_{cyl} = \pi r^2 l_{cyl}$$

$$r^2 = 50625$$

$$v_{cyl} = 50625 \times 750 = 37968750\text{mm}^3$$

Two hemispheres

$$v_{domes} = \frac{4}{3} \pi r^3$$

$$r^3 = 225^3 = 11390625$$

$$v_{domes} = \frac{4}{3} \times 11390625 = 15187500\text{mm}^3$$

$$v_{total} = v_{cyl} + v_{domes} = 37968750\text{mm}^3 + 15187500\text{mm}^3 = 53156250\text{mm}^3$$

$$v_{total} = 53156250 \times \pi = 1.6 \times 10^8$$

Covert to Litres

$$v_{total} = \frac{1.6 \times 10^8}{1 \times 10^6} = 167 \text{ Litres}$$

Maximum Hydrogen Stored under 35Mpa

Room Temperature $20^\circ = 293$ kelvin

$$\rho = 24.6\text{kg/m}^3$$

$$24.6 \times 0.167 = 4.1\text{kg/m}^3$$

Maximum Hydrogen Stored under 70Mpa

Room Temperature $20^\circ = 293$ kelvin

$$\rho = 40\text{kg/m}^3$$

$$40 \times 0.167 = 6.68\text{kg/m}^3$$

Determine Wall Thickness

Materials

Polyamide 6 (PA6): Higher strength (~80–90 MPa), lower permeability.

Carbon Fibre, High strength (1200 GPa).

Polymer Liner

The Polymer Wall thickness has not been calculated due to Carbon Fibre absorbing 90% of the internal pressure, however, the wall thickness in this example is to be 9mm.

Carbon Fibre

$$t_{\text{comp}} = \frac{p_{\text{burst}} \times r_i \times sf}{\sigma_{\text{allow}}}$$

$$t_{\text{comp}} = \frac{70 \times 10^6 \times 0.225 \times 2.5}{1.2 \times 10^9} = 0.033$$

$$t_{\text{comp}} = 33\text{mm}$$

The above calculation is for standard operation, refuelling requires the cylinder to withstand even more pressure, approximately 90Mpa.

$$t_{\text{comp}} = \frac{p_{\text{burst}} \times r_i \times sf}{\sigma_{\text{allow}}}$$

$$t_{\text{comp}} = \frac{90 \times 10^6 \times 0.225 \times 2.5}{1.2 \times 10^9} = 0.042$$

$$t_{\text{comp}} = 42\text{mm}$$

The Wall Thickness is 51mm using a Safety Factor of a 2.5. The Hydrogen Gas Cylinder can hold 167 Litres whilst the mass of Hydrogen was determined to be $4.1\text{kg}/\text{m}^3$ at 35Mpa, and $6.68\text{kg}/\text{m}^3$ at 70Mpa at 20°.