



Fluid and gas, Pressure, and Buoyancy in Aerospace Systems

Introduction

In aerospace engineering, fluids such as air and fuel play a critical role in aircraft performance. Understanding fluid behavior is essential for analyzing lift, drag, and pressure distribution over aircraft surfaces.

Fluids differ from solids in that they deform continuously under applied shear stress.

Definition of Fluid

A fluid is a substance that continuously deforms under shear stress.

Types of fluids:

- Liquids (water, fuel)
- Gases (air)

Fluid Properties

➤ **Density (ρ)**

Density is defined as mass per unit volume:

$$\rho = m / V$$

Unit: kg/m³



Example:

- Air $\approx 1.225 \text{ kg/m}^3$
- Water $\approx 1000 \text{ kg/m}^3$

➤ Specific Weight (γ)

$$\gamma = \rho \times g$$

Unit: N/m^3

3.3 Specific Gravity (SG)

$$\text{SG} = \rho / \rho_{\text{water}}$$

➤ Viscosity (μ)

Viscosity represents resistance to flow.

- High viscosity \rightarrow oil
- Low viscosity \rightarrow air

Pressure in Fluids

Pressure is defined as force per unit area:

$$P = F / A$$

Unit: Pascal (Pa)



Types of Pressure:

- Atmospheric Pressure
- Absolute Pressure
- Gauge Pressure

Pressure Variation with Depth

$$P = \rho g h$$

- Pressure increases with depth in liquids.

Buoyancy (Archimedes Principle)

A body immersed in fluid experiences an upward force equal to the weight of displaced fluid.

$$F_b = \rho g V$$

❖ Aerospace Application

- Balloons → buoyancy
- Fuel tanks → pressure variation
- Aircraft altitude → pressure change

Fluid Resistance (Drag)

Drag force acts opposite to motion.



Depends on:

- Velocity
- Density
- Shape

Solved Example 1

Problem:

Calculate the pressure at a depth of 5 m in water.

Solution:

$$P = 1000 \times 9.81 \times 5 = 49050 \text{ Pa} = 49.05 \text{ kPa}$$

Solved Example 2

Problem:

An object displaces 0.02 m³ of water. Find buoyant force.

Solution:

$$F_b = 1000 \times 9.81 \times 0.02 = 196.2 \text{ N}$$

Comprehensive Problem

Problem Statement

An aircraft fuel tank contains fuel with density 800 kg/m³ at a depth of 3 m.



Required:

1. Calculate pressure at bottom
2. Calculate force on area of 0.5 m²
3. Determine buoyant force on object (volume 0.01 m³)

Solution

Step 1:

$$P = \rho gh = 800 \times 9.81 \times 3 = 23544 \text{ Pa}$$

Step 2:

$$F = P \times A = 23544 \times 0.5 = 11772 \text{ N}$$

Step 3:

$$F_b = 800 \times 9.81 \times 0.01 = 78.48 \text{ N}$$

Engineering Judgment ✈

- Pressure values are moderate
- Design is safe for fuel tank
- Buoyancy effect is small

Conceptual Question

Why does pressure increase with depth?

Answer:



Because of the weight of the fluid above the point.

Homework

1. Calculate pressure at depth 10 m in oil ($\rho = 850 \text{ kg/m}^3$)
2. Find buoyant force for volume 0.05 m^3
3. Explain viscosity with real-life example

Conclusion

Understanding fluid properties and pressure is essential for aerospace applications such as lift generation, fuel storage, and aerodynamic analysis.

References

1. Serway & Jewett – Physics for Scientists and Engineers
2. Fox & McDonald – Fluid Mechanics
3. White – Fluid Mechanics