README: Pressure Vessel Weight Calculation Software

Introduction

This document provides an overview of the pressure vessel weight calculation software. The software is designed to estimate the weight of a cylindrical mild-steel pressure vessel with torispherical heads based on user-provided dimensions. It employs standard geometric assumptions and approximations for efficient computation.

Assumptions

The following assumptions have been made in deriving the formula used in the software:

1. **Geometry of the Pressure Vessel**
   - The vessel consists of a cylindrical shell with two torispherical (flanged and dished) heads.
   - Each head follows standard torispherical proportions:
     - **Overall head depth**: $d = 0.5D$
     - **Crown (spherical) radius**: $R_c = 0.9D$
     - **Knuckle radius**: $R_k = 0.1D$
2. **Material Properties**
   - The vessel is made of mild steel with a density of **7860 kg/m³**.
3. **Thicknesses**
   - Shell thickness = **10 mm**
   - Head thickness = **12 mm**
4. **Approximations**
   - The torispherical head surface area is estimated by summing the crown and knuckle surface areas separately.
   - Knuckle area is approximated using the average radius method.

Derivation of the Weight Formula

1. Shell Volume Calculation

The shell is a **cylinder** with:

- **External height** $L_{shell} = H - D$ (since each head contributes 0.5D to the overall height).
- **Lateral surface area**: $A_{shell} = \pi D(H - D)$
- **Steel volume of the shell**: $V_{shell} = \pi D(H - D) \times 10(\text{in mm}^3)$

2. Torispherical Head Volume Calculation

Each torispherical head consists of:

(a) Crown Area

- **Crown height**: $h_{crown} = d - R_k = 0.5D - 0.1D = 0.4D$
- **Crown area**: $A_{crown} = 2\pi R_c h_{crown} = 2\pi(0.9D)(0.4D) = 0.72\pi D^2$

(b) Knuckle Area Approximation

- **Knuckle arc length**: $s_{knuckle} = \pi R_k = 0.1\pi D$
- **Average radius**: $R_m \approx \frac{r_1+r_2}{2} \approx \frac{0.748D+0.5D}{2} = 0.624D$
- **Knuckle surface area**: $A_{knuckle} \approx 2\pi R_m s_{knuckle} = 2\pi(0.624D)(0.1\pi D) = 1.232D^2$

(c) Total Head Area

- **Total area per head**: $A_{head} \approx A_{crown} + A_{knuckle} = (2.26 + 1.232)D^2 = 3.49D^2$
- **Total volume for two heads**: $V_{heads} \approx 2 \times 3.49D^2 \times 12 = 83.8D^2$(in mm³)

3. Total Steel Volume

Adding the shell and heads:

$V_{total} \approx 10\pi D(H - D) + 83.8D^2$(in mm³)

4. Weight Calculation

Using the steel density $\rho = 7860$ kg/m³ and converting mm³ to m³:

$W = \frac{7860\times\left(10\pi D(H-D)+83.8D^2\right)}{10^9}$(kg)

Final Formula

W (kg) $= \frac{7860\times\left(10\pi D(H-D)+83.8D^2\right)}{10^9}$

where **D and H are in millimeters**.

How to Use the Software

1. **Input Parameters**
   - Enter the external diameter D (in mm).
   - Enter the overall vessel height H (in mm).
2. **Computation**
   - The software calculates the steel volume and weight using the above formula.
3. **Output**
   - The estimated vessel weight (in kg) is displayed.

Limitations

- This method assumes standard torispherical head proportions and uniform thicknesses.
- The formula is an approximation; actual vessel weight may vary based on fabrication tolerances and reinforcement structures.
- The software does not account for additional components like nozzles, supports, or insulation.

Conclusion

This software provides a quick estimation of a mild-steel pressure vessel's weight based on standard geometric assumptions. The derived formula ensures efficient and reasonably accurate calculations for engineering applications.