Rayleigh–Plesset equation

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Rayleigh–Plesset equation

- Governs dynamics of spherical air bubbles in a infinitely large volume of incompressible fluid as a function of time
- In regards to its pressure volume based on the surrounding fluid
- The equations also puts into regards different gases in different types of fluids

Origin

- Created by William H. Basant in his book in 1859
  - British Mathematician - Only published accomplishment
  - Purpose: *An infinite mass of homogeneous incompressible fluid acted upon by no forces is at rest, and a spherical portion of the fluid is suddenly annihilated; it is required to find the instantaneous alteration of pressure at any point of the mass, and the time in which the cavity will be filled up, the pressure at an infinite distance being supposed to remain constant*
- Derived from both the Raleigh and Plesset equation of fluid mechanics
- It was derived with help from Raleigh's equation, Boyle's Law and Milton Plesset -
  - Boyle's - Pressure increase as volume of container decrease
  - Rayleigh's Equation - Was another equation regards to incompressible liquid

Applications

- Study of Cavitation
  - Physics behind formation of vapor cavities in liquid caused by movement
  - Elimination of cavitation is large field in fluid dynamics
- Machinery
  - Very often involved in creation of propellers, rotors and turbines
    - Cavitations and air bubbles are able to significantly hurt moving parts and causes damage to metal blades
  - Cyclic stress
- Chemistry
  - Mixtures of paint, milk
    - Break down suspended bubbles

Rayleigh–Plesset equation

$$R\frac{d^2R}{dt^2} + \frac{3}{2}\left(\frac{dR}{dt}\right)^2 + \frac{4\nu_L}{R}\frac{dR}{dt} + \frac{2\gamma}{\rho_L R} + \frac{\Delta P(t)}{\rho_L} = 0$$

- Second Order Equation
- The DE is solved for R(t) which is the radius of the bubble as a function of time
- vL is the kinematic viscosity of the fluid
  - Considered to be constant and unique to the fluid
- PL is the density of the liquid
- **τ** is the surface tension

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- △P(t) = Pf(t)-Pb(t) : usually given based on the given fluid
  - Pf is pressure the pressure outside of the bubble for an infinite distance
  - Pb is the internal pressure of the bubble

Sources

- https://en.wikipedia.org/wiki/Rayleigh%E2%80%93Plesset_equation