Kinetic Theory of Fluids

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Abstract

In this paper a kinetic theory of fluids has been presented. 

**Keyword**: Kinetic theory of fluids.

1 INTRODUCTION

The internal translational kinetic energy of a stable fluid can be obtained by local dynamic equilibrium hypothesis, i.e.,

\[
\langle v_x^2 \rangle = \langle v_y^2 \rangle = \langle v_z^2 \rangle = \frac{\langle v^2 \rangle}{3} = \frac{v_{rms}^2}{3}
\]

\[P_x = P_y = P_z = P = \frac{\rho v_{rms}^2}{3} \quad (i)\]

where

P = pressure of the fluid

\(\rho\) = density of the fluid

\(v_{rms}\) = root mean square speed of the fluid particles

2 INTERNAL TRANSLATIONAL KINETIC ENERGY

Let’s consider a container containing a fluid and is stationary with respect to an inertial frame of reference. Now for a static fluid, the pressure at a depth \(h\) from the top of the fluid is given by the Pascal’s law as

\[P_x = P_y = P_z = P = P_o + \rho gh \quad (ii)\]

where

\(P_o\) = pressure at the top of the fluid

\(\rho\) = uniform mass density of the fluid

\(g\) = uniform gravitational acceleration

From equations (i) and (ii), we obtain

\[\frac{\rho v_{rms}^2}{3} = P_o + \rho gh\]

\[\Rightarrow v_{rms}^2 = \frac{3P_o}{\rho} + 3gh\]

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Now the internal translational kinetic energy

\[ KE = \frac{1}{2} \int \rho v_{ms}^2 \, dV = \frac{1}{2} \int \frac{3}{2} P_o \, dV + \frac{1}{2} \int 3 \rho gh \, dV \]

\[ = \frac{3}{2} P_o \int dV + \frac{3}{2} \rho g \int h dV \]

\[ = \frac{3}{2} P_o V + \frac{3}{2} \rho g \, h_c \]

\[ \Rightarrow KE = \frac{3}{2} P_o V + \frac{3}{2} Mgh_c \]

where

\( V = \) volume of the fluid
\( M = \) mass of the fluid
\( h_c = \) depth of the centroid of the fluid volume from the top of the fluid

3 CONCLUSION

It should be noted that this theory is not compatible with the concept of temperature from the conventional kinetic theory wherein the temperature is assumed to be proportional to the internal kinetic energy per particle and per degree of freedom. Consequently, this theory differentiates between the concept of temperature from the zeroth law of thermodynamics and the concept of temperature from the conventional kinetic theory. Therefore, the concept of temperature needs to be revised in accordance with the zeroth law of thermodynamics.
References
