TOPIC 2

Equation of state

In physics and thermodynamics, an equation of state is a thermodynamic equation relating state variables which describe the state of matter under a given set of physical conditions, such as pressure, volume, temperature (PVT), or internal energy. Equations of state are useful in describing the properties of fluids, mixtures of fluids, solids, and the interior of stars.

At present, there is no single equation of state that accurately predicts the properties of all substances under all conditions. An example of an equation of state correlates densities of gases and liquids to temperatures and pressures, known as the ideal gas law, which is roughly accurate for weakly polar gases at low pressures and moderate temperatures. This equation becomes increasingly inaccurate at higher pressures and lower temperatures, and fails to predict condensation from a gas to a liquid.

Another common use is in modeling the interior of stars, including neutron stars, dense matter (quark–gluon plasmas) and radiation fields. A related concept is the perfect fluid equation of state used in cosmology.

Equations of state can also describe solids, including the transition of solids from one crystalline state to another.

In a practical context, equations of state are instrumental for PVT calculations in process engineering problems, such as petroleum gas/liquid equilibrium calculations. A successful PVT model based on a fitted equation of state can be helpful to determine the state of the flow regime, the parameters for handling the reservoir fluids, and pipe sizing.

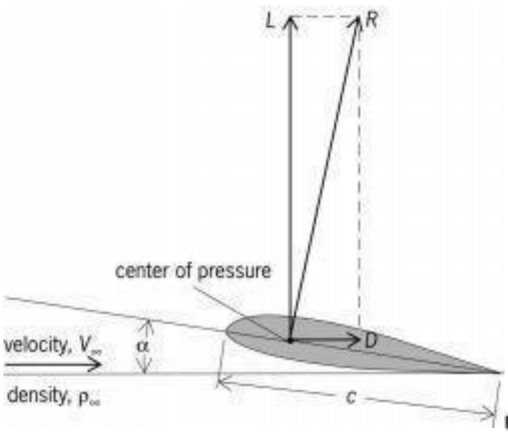
Measurements of equation-of-state parameters, especially at high pressures, can be made using lasers.

Aerodynamic force

The force exerted on a body whenever there is a relative velocity between the body and th e air. There

are only two basic sources of aerodynamic force: the pressure distribution and the fri ctional shear stress distribution exerted by the airflow on the body surface. The pressure exerted by the air at a point on the surface acts perpendicular to the surface at that point; and the shear str ess, which is due to the frictional action of the air rubbing against the surface, acts tangentially to the surface at that point. The distribution of pressure and shear stress represent a distributed load over the surface. The net aerodynamic force on the body is due to the net imbalance between the se distributed loads as they are summed (integrated) over the entire surface.

For purposes of discussion, it is convenient to consider the aerodynamic force on an airfo il (see illustration). The net resultant aerodynamic force *R* acting through the center of pressure o n the airfoil represents mechanically the same effect as that due to the actual pressure and shear s tress loads distributed over the body surface. The velocity of the airflow V_∞ is called the freestream velocity or the freestream relative wind. By definition, the component of *R* perpendicular to the relative wind is the l ift, *L*, and the component of *R* parallel to the relative wind is the drag *D*. The orientation of the b ody with respect to the direction of the free stream is given by the angle of attack, α. The magnit ude of the aerodynamic force *R* is governed by the density &rgr;$_\infty$ and velocity of the free stream, the size of the body, and the angle of attack.



Resultant aerodynamic force (*R*), and its resolution into lift (*L*) and drag (*D*) components

An important measure of aerodynamic efficiency is the ratio of lift to drag, *L*/*D*. The high er the value of *L*/*D*, the more efficient is the lifting action of the body. The value of *L*/*D* reaches a maximum, denoted by $(L/D)_{max}$, at a relatively low angle of attack. Beyond a certain angle the l ift decreases with increasing α. In this region, the wing is said to be stalled. In the stall region the flow has separated from the top surface of the wing, creating a type of slowly recirculating deadair region, which decreases the lift and substantially increases the drag.

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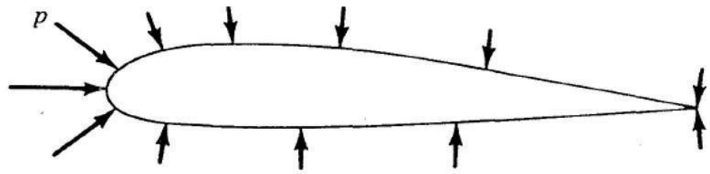

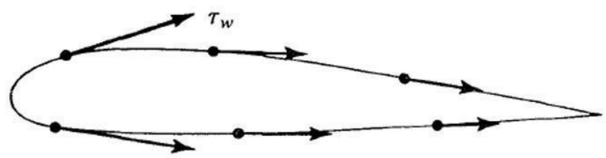

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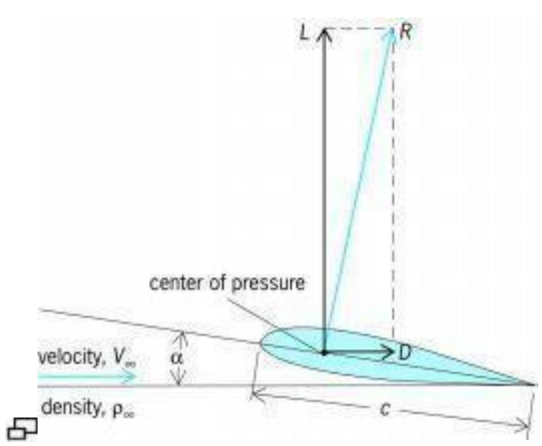

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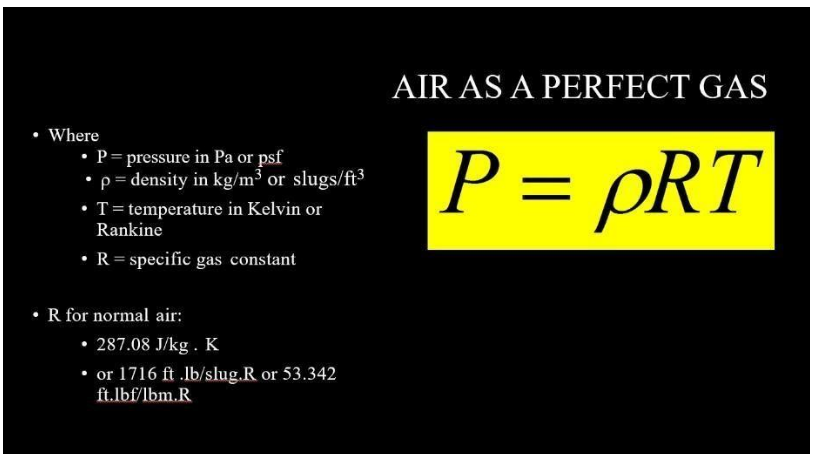

SUMMARY OF EQUATION OF STATE

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