FLUID MECHANICS

This is a sub-discipline of applied mechanics which focuses on the behavious of liquids and gases at rest or in motion

TERMS USED

1. Shear Stress

2. Rate of deformation

3. Yield Value

AREAS OF STUDY IN FLUID MECHANICS

1. Fluid Statics: fluids at rest e.g. design of dams, water or fluid storage tanks

2. Fluid Dynamic: This deals with fluids in motion e.g. air-conditioning systems, gas turbines, water and oil pipelines

3. Fluid Kinematics: This also deals with fluids in motion. However, in fluid kinematics, the motion of fluid is studied without considering the forces causing such motion.

IMPORTANT PARAMETERS IN FLUID ANALYSIS

1. Physical size of the flow: Known as characteristic length e.g. pipe diameter for pipes in homes, blood flow in arteries and veins, air flow in lungs, oil pipelines etc.

2. Speed of the flow: E.g speed of a tornado, sound in air,

3. Pressure: E.g. pressure in automobile tyres

WHAT IS A FLUID

A fluid is defined as a substance that deforms continuously (flows) when acted by a shearing stress of any magnitude.

A shearing stress (for per unit area) is created whenever a tangential force (force that is parallel) acts on a surface.

A solid will initially deform when acted on by a tangential force but will not continuously deform.

SHEAR STRESS

Shear stress is defined as the force per unit area

RATE OF DEFORMATION

The rate of deformation (also called shear rate or velocity gradient)

CLASSIFICATION OF FLUIDS

There are some materials such as toothpaste, slurries, butter, corn starch (‘ogi’) etc. that are not easily classified as strictly solids or fluids.

They behave as solids when the shearing stress is small but if it exceeds a critical value, they flow like fluids

These classifications are based on the relationship between the shear stress (%tau) and the rate of deformation

For the classification of fluids, since all fluids, the general formula

1. Newtonian

2. Non-newtonian

3. Ideal Plastic

4. Ideal Fluids

NEWTONIAN FLUIDS

Fluid flow is highly dependent on the viscosity of fluids. Some fluids such as water, alcohol and most oils are said to be newtonian fluids as the rate of deformation is proportional to shear stress.

Fluids that have a linear relationship between shear stress and shear rate. This implies a constant dynamic viscosity and when there is no shear stress, the shear rate is zero

Examples are, water, sugar solutions, glycerin, silicone oils, light hydrocarbons, air, alcohol and glycerol.

For this class of fluids, the relationship between the shear stress and shear rate is called Newton’s law of viscosity, expressed as

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NON-NEWTONIAN FLUIDS

Most fluids are in fact non-newtonian. They are fluids that do not obey newton’s law of viscosity i.e. the relationship between the shear stress and shear rate is not linear.

SUB-CLASSIFICATIONS OF NON-NEWTONIAN FLUIDS

1. Pseudoplastic fluids: These are called shear-thinning fluids

2. Dilatant fluids: These are also known as shear-thickening fluids

3. Yield stress fluids: Have a critical stress below which they act like solids but flow like liquids. This means each of these liquids have their critical stress points, below this stress points, they act like solids but on reaching or passing that stress point, they act like liquids. e.g. toothpaste, cement, mud, mayonnaise etc.

4. Viscoelastic fluids: These have both viscous and elastic properties e.g. honey, some polymers, saliva, mucus etc.

CLASSIFICATION OF FLUIDS

Ideal Plastic Fluids

Are fluids that have their shear stress linearly proportional to the shear rate but the shear stress is greater than their yield value (resistance to deformation)

Ideal Fluids

They actually do not exist in physical/real life. This is a class of fluids that have no viscosity.

FLUID FLOW

CLASSIFICATION OF FLUID FLOWS

1. COMPRESSIBLE AND INCOMPRESSIBLE: In compressible flows, there is density change in the fluid during flow while in incompressible, there is no density change.

2. STEADY AND UNSTEADY: When conditions of the flow (e.g. velovity, pressure) don’t change with time, such flow is steady but if there are changes with time, it is an unsteady flow.

3. UNIFORM AND NON-UNIFORM: In uniform flow, velocity is constant at all points across a specific cross-section during fluid flow.

4. LAMINAR AND TURBULENT: Laminar flows are smooth and streamline, whereas turbulent flows are irregular and chaotic

IMPORTANT PROPERTIES IN FLUID ANALYSIS

1. Density: This is mass per unit volume and typically used to characterize the mass of a fluid system

For liquids, variation in pressure and temperature generally have a effect on density but for gases, density is strongly influenced by pressure and temperature. In thermodynamics, specific volume was considered; however, in fluid mechanics, we use density more often.

2. Specific Weight: This is defined as weight per unit volume

3. Specific Gravity: Is defined as the ration of density of the fluid to the density for water at some specified temperature.

**Relative** density is the ratio of the density of a substance to the density of a reference substance, usually water. It is a dimensionless quantity and is often expressed as a decimal or a percentage. On the other hand, specific gravity is the ratio of the density of a substance to the density of water at a specific temperature.

4. Dynamic Viscosity: Density and specific weight are not sufficient to uniquely characterize the behavior of fluids. For example, water and oil can have approximately the same value of density but they have different behaviours when flowing.

5. Kinematic Viscosity: Often in fluid flow problems, dynamic viscosity is combined with density. This ratio is called kinematic viscosity witht the unit {m^2}/s

LEARN THIS SHIT YOU MOFO KINGSLEY. BEHAVIOUR OF A FLUID BETWEEN TWO PARALLEL PLATES.

Imagine a fluid placed between two very wide plates where the bottom plate is fixed while the upper plate is free to move.

When a force P is applied to the upper plate, it will move continuously with a velocity U. The fluid in contact with the upper plate moves with the plate velocity while the fluid in contact with the bottom fixed plate will have zero velocity.

This implies that the velocity of the fluid between the plates will depend on their distance from the plate defined by the expression: