AL-MAMON UNIVERSITY COLLAGE

DEPARTMENT OF ELECTRICAL POWER
ENGINEERING TECHNIQUES

Part 3

Lecture notes ١ & 2

FLUID MECHANICS

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Basic Concepts of Thermodynamic

This lecture notes consist the following topics:

- Introduction.
- Fluid Mechanics.
- Dimensions and Units.
- Properties of Fluid.
- Pressure.
- Temperature.
- Density.
- Viscosity.
- Specific weight.
- Specific gravity.
- Specific gravity.
- Sound Speed.
- Reynolds number.

FLUID MECHANICS

Fluid properties, Fluid static's

1.1 Introduction

A fluid is defined as a substance that deforms continuously when acted on by a shearing stress of any magnitude. A shearing stress (force per unit area) is created whenever a tangential force acts on a surface.

In another words, it is a material in which the application of any shear stress (no matter how small) will cause motion.

المائع أي مادة قابلة للانسياب تحت تأثير إجهاد القص وتأخذ شكل الإناء الحاوي لها.الموائع اسم شامل للسوائل والغازات وأحيانا الأصلاب اللدنة.

1.2 Fluid Mechanics

Fluid Mechanics is the science that deals with behavior of fluids at rest (fluid statics) or in motion (fluid dynamics) and the interaction of fluids with solids or other fluids at the boundaries.

ميكانيكا الموائع هو العلم الذي يتعامل مع سلوك السوائل أثناء السكون (إستاتيكية الموائع) أو أثناء الحركة (ديناميك الموائع) وتفاعل السوائل مع المواد الصلبة أو السوائل الأخرى عند الحدود الفاصلة بينهم.

1.3 Dimension and Unit

A dimension is the measure by which a physical variable is expressed quantitatively and the unit is a particular way of attaching a number to the quantities of dimension. All the properties of fluid are assigned with certain unit and dimension. Some basic dimensions such as mass (M), length (L), time (T) and temperature (θ) are selected as Primary/Fundamental dimensions/unit. While others such as velocity, volume is expressed in

terms of primary dimensions and is called as secondary/derived dimensions/unit. In this particular course, SI (Standard International) system of units and dimension will be followed to express the properties of fluid.

1.5 Properties of Fluid

Any characteristic of a system is called property. The state of a system is described by its properties. The number of properties required to fix the state of the system is given by state postulates.

أي خاصية مميزة للنظام بحيث يمكن وصف حالته حسب خصائصه.

Most common properties of the fluid are:

1. Pressure (p):

It is the normal force exerted by a fluid per unit area. In **SI** system the unit and dimension of pressure can be written as, N/m^2.

إنها القوةوزن السائل لكل وحدة مساحة.

2. Temperature (T):

It is the measure of hotness and coldness of a system. In thermodynamic sense, it is the measure of internal energy of a system. Many a times, the temperature is expressed in centigrade scale (**°C**) where the freezing and boiling point of water is taken as **0°C** and **100°C**, respectively. In **SI** system, the temperature is expressed in terms of absolute value in Kelvin scale (**K = °C+ 273**).

درجة الحرارة يمكن تعريفها انها مقياس سخونة وبرودة النظام. بالمعنى الديناميكي الحراري ، هو مقياس الطاقة الداخلية للنظام.

3. Density (ρ):

The density of a substance is the quantity of matter contained in unit volume of the substance. It is expressed as

كثافة المادة هي كمية المادة الموجودة في وحدة حجم المادة.

mass density $\rho = \frac{\text{mass}}{\text{volume}}$

$$\rho = \frac{m}{V} = \frac{Kg}{m^3}$$

4. Viscosity (μ):

Is a measure of a fluid's resistance to flow. It describes the internal friction of a moving fluid. Gases also have viscosity, although it is a little harder to notice it in ordinary circumstances.

اللزوجة هو مقياس لمقاومة المائع للتدفق. وتصف اللزوجة الاحتكاك الداخلي للمائع المتحرك. تتميز الغازات أيضًا بلزوجة ، على الرغم من صعوبة ملاحظتها في الظروف العادية.

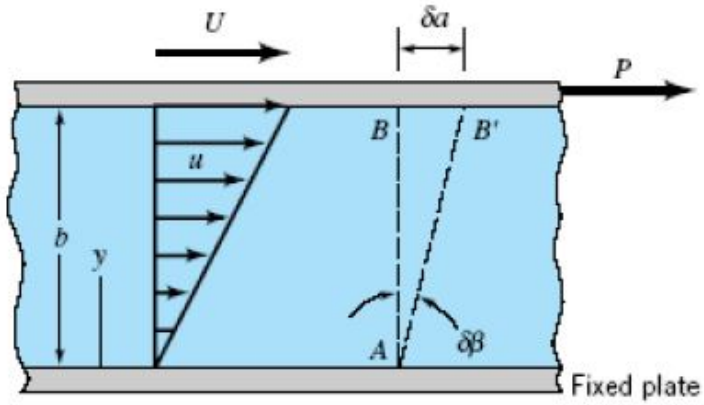

figure 1-1 Flow between two fix plates

$$\tau = \mu \frac{du}{dy}$$

τ = shear force

μ = viscosity of the fluid

$\frac{du}{dy}$ = rate of shear deformation

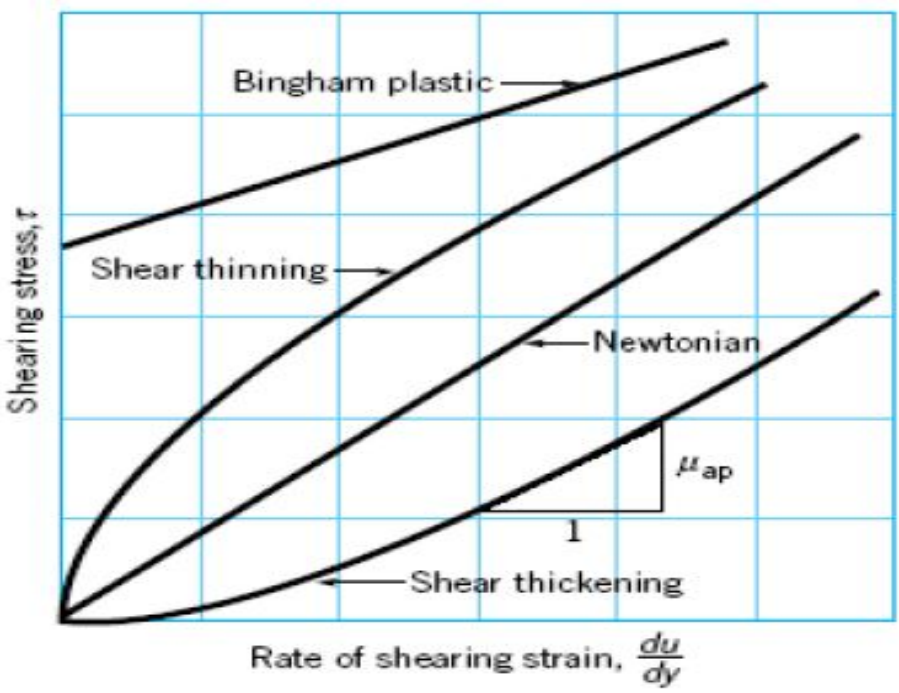

Figure 1-2 Variation of shearing stress rate for several types of fluids

Kinematic viscosity ν is the ratio of - absolute (or dynamic) viscosity to density - a quantity in which no force is involved.

اللزوجة الحركية هي نسبة - اللزوجة المطلقة (أو الديناميكية) إلى الكثافة - وهي كمية لا تدخل القوة فيها.

$$\nu = \frac{\mu}{\rho}$$

ν = Kinematic viscosity

μ = viscosity of the fluid

ρ = densitv

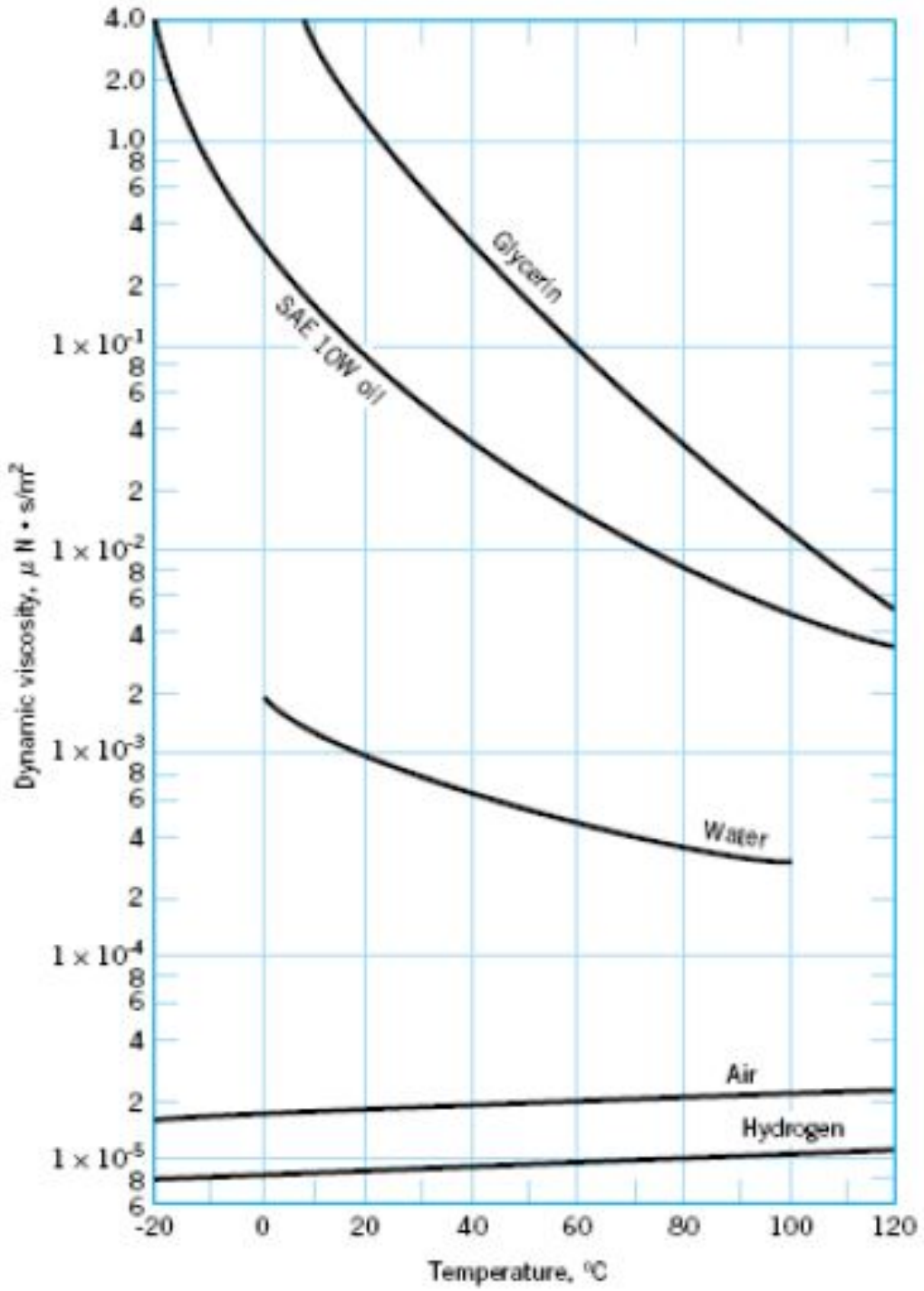

Figure 1-3 Variation of viscosity with temperature

5- Specific weight (γ *or* k):

The specific weight of a fluid is its weight, per unit volume. Density and specific weight are related by gravity:

الوزن النوعي للمائع هو وزنه لكل وحدة حجم. ترتبط الكثافة والوزن النوعي بالجاذبية:

$$\boxed{\gamma = \rho g} \quad units \ (\frac{N}{m^3})$$

6- Specific gravity (SG):

Specific gravity is the ratio of a fluid density to a standard reference fluid, typically water at 4˚C (for liquids) and air (for gases):

الثقل النوعي(الجاذبية النوعية) هو نسبة كثافة المائع إلى مائع مرجعي قياسي ، عادةً الماء عند ٤ درجات مئوية (للسوائل) والهواء (للغازات):

$$SG_{gas} = \frac{\rho_{gas}}{\rho_{air}} = \frac{\rho_{gas}}{1.205(kg/m^3)}$$
$$SG_{liquid} = \frac{\rho_{liquid}}{\rho_{water}} = \frac{\rho_{liquid}}{1000(kg/m^3)}$$

For example, the specific gravity of mercury is SG_{Hg} = 13,580/1000 ≈13.6

7- Speed of sound (c):

An important consequence of compressibility of the fluid is that the disturbances introduced at some point in the fluid propagate at finite velocity. The velocity at which these disturbances propagate is known as “acoustic velocity/speed of sound”. Mathematically, it is represented as below:

(For an ideal gas medium) $c = \sqrt{kRT}$ In isentropic process

where **R** is the gas universal constant, the constant **R** is different for each gas; for air, (R_{air} = 0.287 **kJ/kg.K**).

8- Reynolds number

It gives the nature of the flow or the transition from laminar to turbulent flow.

رقم رينولدز يعطي طبيعة الجريان أن كان جريان طبقي او جريان مضطرب.

$$\boldsymbol{R}_e = \rho VD/\mu = \boldsymbol{VD}/v$$

$\boldsymbol{R_e}$ = Reynolds number

$\boldsymbol{\rho}$ = density of the fluid

$\boldsymbol{V}$ = flow speed

$\boldsymbol{D}$ = pipe diameter

$\boldsymbol{\mu}$ = dynamic viscosity of the fluid

$\boldsymbol{v}$ = Kinematic viscosity