CHAPTER I

INTRODUCTION

I.1. Non-Newtonian Fluids.

It is well known that there are fluids which do not obey a simple relationship between shear stress and shear strain rate. If the stress components are linear functions of the rate of strain components, the fluid is called a Newtonian fluid. When the relations between stress components and the rate of strain components are invariant where they remain unchanged to all orientations of the coordinate axes, including also any interchange of the axes, the fluid is called "ISOTROPIC". Fluids which do not obey the above rule are called Non-Newtonian Fluids. Where the stress components are not linear functions of the rate of strain components.

Characteristics and classification of Non-Newtonian Fluids:

Consider the motion of a fluid between two very long parallel plates, one of which is at rest, the other is moving with a constant velocity parallel to itself, as shown in Fig. (1). We shall take the x-axis along the wall parallel to the flow while the y-axis perpendicular to it. The shearing stress τ for a Newtonian fluid is linearly related to the shearing rate $\dot{\gamma}$ which is the rate of change of the velocity.

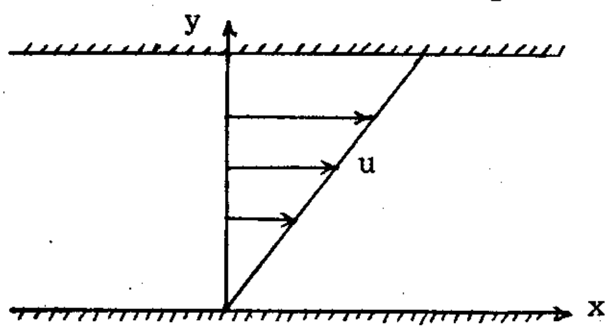

Fig. (1): Velocity distribution in a viscous fluid between two parallel flat walls.

$$\tau = \mu \dot{\gamma} = \mu \frac{du}{dy} \qquad (I.1)$$

where μ is the viscosity, $\dot{\gamma}$ is the rate of shear strain γ and u is the velocity. In what follows, non -Newtonian fluids which do not obey the linear relationship (I.1) will be classified and discussed as follows:-

(1) Time independent fluids.

(2) Time dependent fluids.

(3) Viscoelastic fluids.

(1) <u>Time independent fluids:</u>

The time independent non-Newtonian fluids are those in which the shear rate is unique but non-linear function of the shear stress and commonly represented by four distinct types which are:-

(i) Power-law (Ostwalde-Dewaele):

This is often represented by the following formulae.

$$\tau = k\,(\dot{\gamma})^{n}$$

or

$$\tau = k\,|\dot{\gamma}|^{n-1}\,\dot{\gamma} \qquad (I.2)$$

Where τ is the shear stress and $\dot{\gamma}$ is the corresponding shear rate. The negative sign of the modulus brackets is to be avoided because of it means that the motion is a simple steady one. While, there are different problems in the mathematical manipulation of the positive sign, for example:

$$\frac{d\tau}{d\dot{\gamma}} = nk\,|\dot{\gamma}|^{n-1} \qquad (I.3)$$

Here the value of the derivative $d\tau/d\dot{\gamma}$ does not depend upon the sign of $\dot{\gamma}$, as it is dersirable. The application of formulae of the type, Eq. (I.2) to any problem different from the simple steady shearing requires care.

(ii) Pseudoplastic fluids.

While it does not have a yield stress, the pseudoplastic fluid is also characterized by a decreasing slope of shear stress versus shear rate. This slope has been defined as the apparent viscosity which is