PE 8601 / Well drilling equipment and Operation

Unit - IV

1. **Explain briefly about Bingham plastic model and newtonian fluid model :-**

Bingham plastic model :-

→ A Bingham plastic is a viscoplastic material that behaves as a rigid body at low stresses but flows as a viscous fluid at high stress.

→ It is named after Eugene C. Bingham who proposed its mathematical form.

→ It is used as a common mathematical model of mud flow in drilling Engineering, and in the handling of slurries.

Definition :-

→ For fluids that are described by the bingham fluid model it is more difficult to predict the flow pattern (laminar - turbulant).

→ Therefore the so called "hedstron number" N_{He} was introduced general, the hedstron number can be correlated with the critical Reynolds number by :

$$N_{He} = (N_{Re})_c^{25}$$

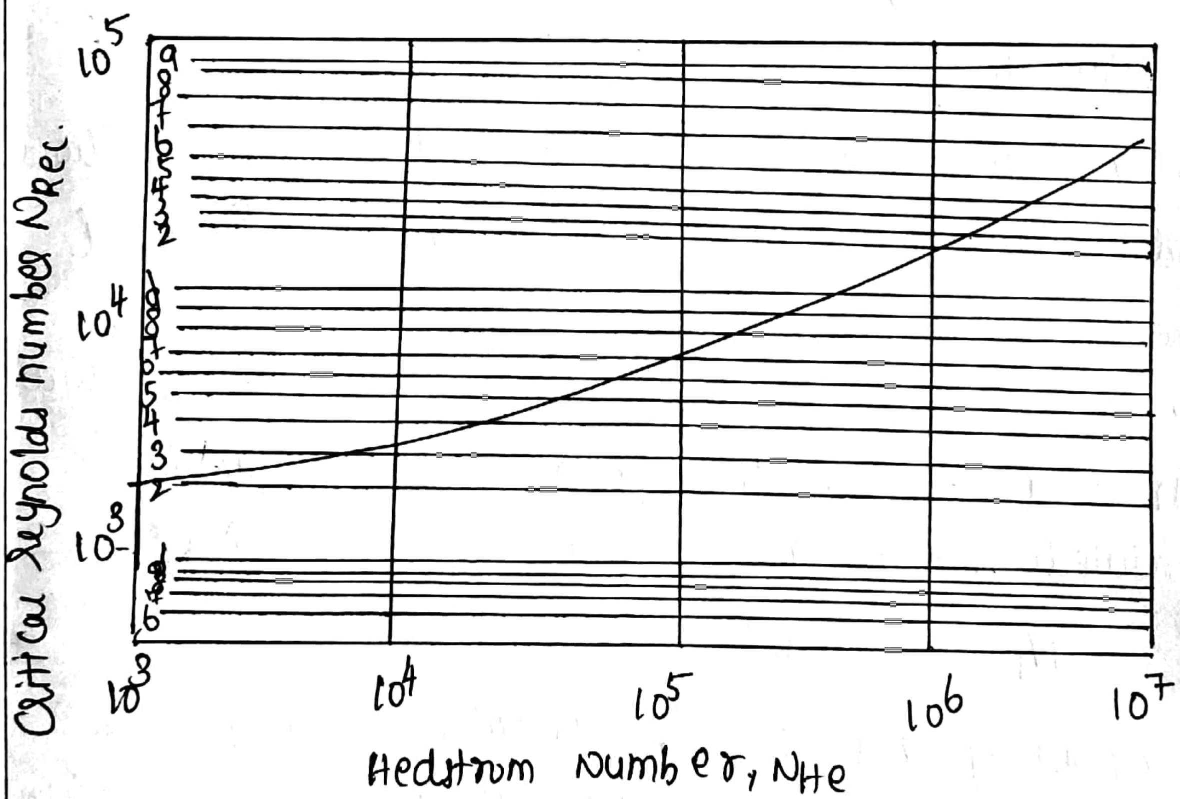
Applying this theory, a turbulant flow pattern exist when $N_{Re} > (N_{Re})_c$ when the newtonian viscosity μ is replaced by the plastic viscosity μ_p.

→ The correlation b/w the hedstrom number and the critical reynolds number, shown in fig, is based on solving simultaneously, equation given below,

$$\frac{N_{He}}{16,800} = \frac{\left(\frac{\tau_y}{\tau_w}\right)}{\left(1-\frac{\tau_y}{\tau_w}\right)^3}$$

$$(N_{Re})_c = \frac{1-\frac{4}{3}\cdot\left(\frac{\tau_y}{\tau_w}\right)+\frac{1}{3}\left(\frac{\tau_y}{\tau_w}\right)^4}{8\cdot\left(\frac{\tau_y}{\tau_w}\right)}$$

$$N_{He} = \frac{37400 \cdot \rho_m \cdot \tau_y \cdot d_i^2}{\mu_p^2}$$



Newtonian fluid model:-

→ Newtonian fluids, like water, gases and thin oils (high API gravity) show a directional proportional relationship b/w shear stress τ and shear rate $\dot{\gamma}$.

→ Assuming pressure and temperature are kept constant. They are mathematically defined by

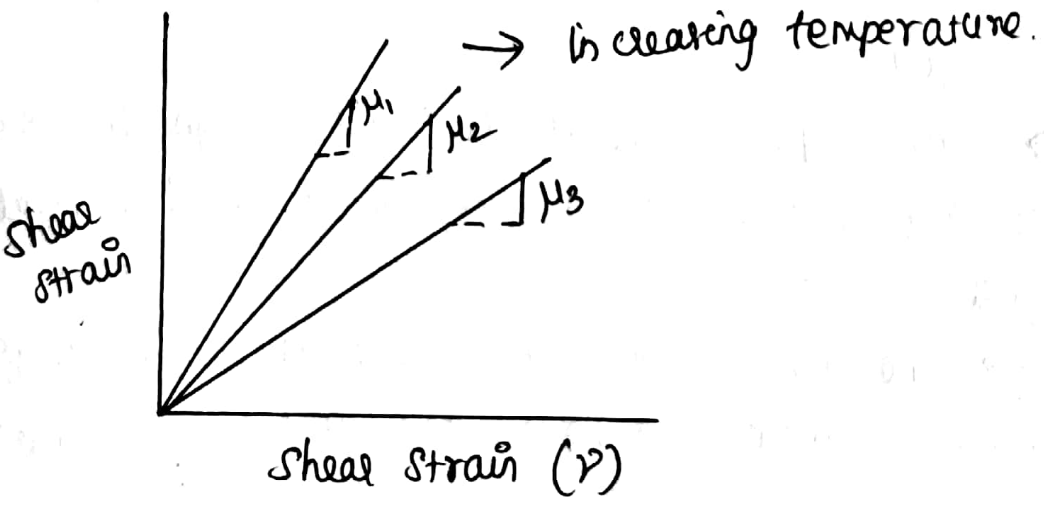
$$\tau = \mu\left(\frac{-dV_r}{dr}\right) = \mu . \dot{\gamma}$$

where,

$\tau\,[dyne/cm^2]$ ⇒ shear stress

$\dot{\gamma}\,[1/sec]$ ⇒ shear rate for laminar flow within circular pipe

$\mu\,[p]$ ⇒ absolute viscosity.



$$\mu_a = \frac{300}{N} . \theta_N$$

$$\dot{\gamma} = \frac{5.066}{r^2} . N$$

2. write an essay on annular velocity and its importance to drilling hydraulic:-

Definition :-

→ Annular velocity is the speed of fluid moving up the annulus and it must be high to transport cuttings generated while drilling from the well bore.

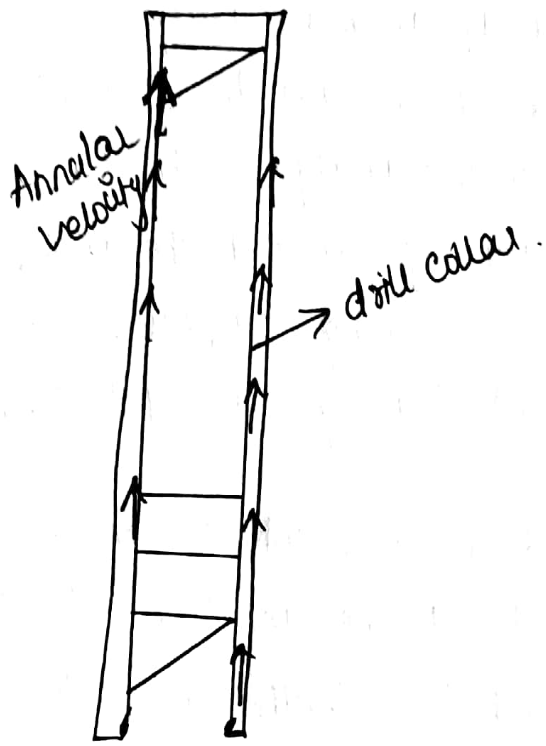
→ However if the annular velocity is too high, it can create hole wash out and excessive equivalent circulating density.

Process :-

→ when the drilling mud is circulated through a system, the moving speed is lower at location where the moving speed is lower at location where the cross section area is bigger.

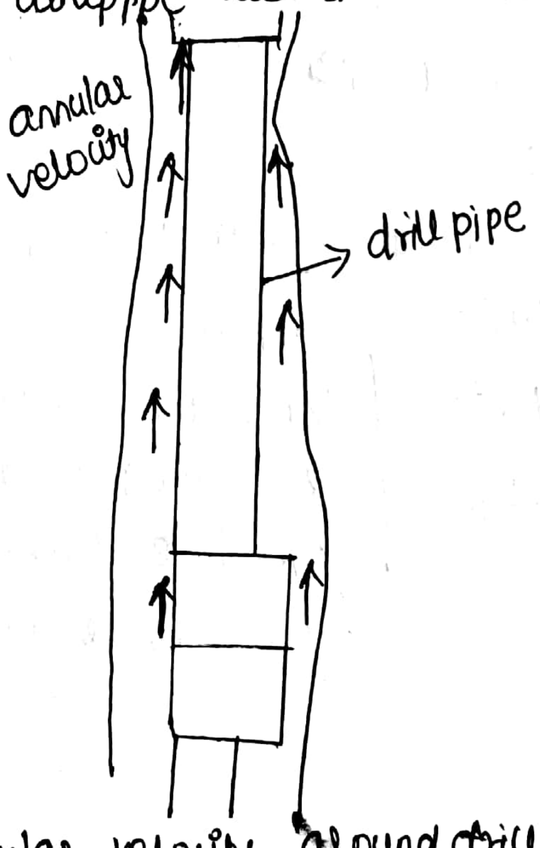
→ conversely, when the fluid flows through the small cross section area, the annular velocity at that point is higher.

→ The cross section area around drill collar and BHA has the smallest area so the annular velocity is the highest.



(Annular velocity around drill collar and BHA)

→ on the other hand the area around drill pipe has the biggest cross sectional area, hence the speed of fluid around the drillpipe area is smallest



Annular velocity around drillpipe

→ The annular velocity around drillpipe must be used to determine if it is good enough for hole cleaning because it is the lowest velocity in the wellbore.

→ If the annular velocity around the drill pipe is good enough for hole cleaning purpose, it will definitely be sufficient for hole cleaning around drill collars, BHA and tool Joints.

→ If you have formations which can be easily washed out you need to look at the annular velocity around drill collars, BHA and tool Joints the size of drill collars and BHA should be reduced if the flow rate can cause excessive wellbore erosion.

→ To adequately transport the cuttings from the wellbore the annular velocity is affected by mud properties rate of penetration, mud types, formation types, hole angle size of cuttings, etc.,

→ A formula for the annular velocity in an oil field unit is shown below;-

$$Va = \frac{24.51 \times Q}{D_h^2 - D_p^2}$$

where,

Va = annular velocity, ft/min

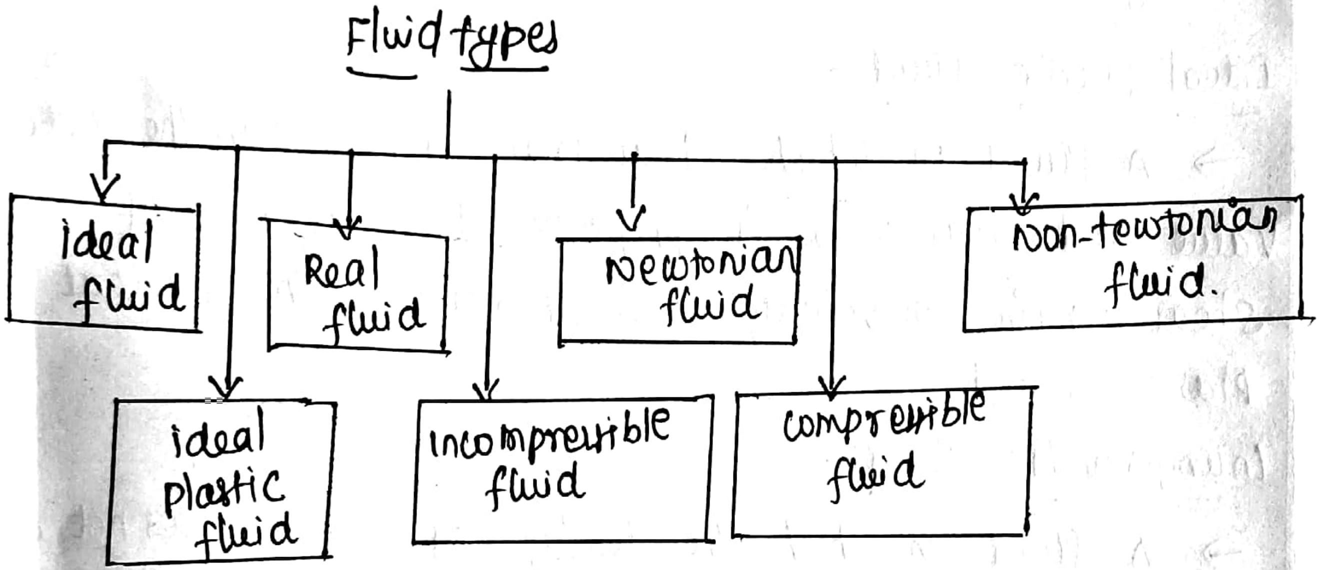
Q = flow rate, gallon per minute

D_h = hole diameter, inch

D_p = Outside diameter of drill pipe, inch

3. Give an account on the classification of fluids:-

→ All fluids encountered in drilling and production Operations can be characterized as either New-tonian fluids or non-newtonian fluids.



Ideal fluid :-

→ A fluid which is incompressible and having no viscosity is known as an ideal fluid, ideal fluid is only an imaginary fluid as all the fluids, which exist, have some viscosity.

Real fluid:

→ A fluid, which possesses viscosity, is known as real fluid. All the fluids, In actual practice are real fluids.

Example:- water air.

Newtonian fluid :-

→ A real fluid, in which shear stress is directly proportional to the rate of shear strain or velocity gradient, is known as a Newtonian fluid.

→ Example :- water, Benzene, etc.,

Non newtonian fluid:-

→ A real fluid, in which shear stress is not directly proportional to the rate of shear strain or velocity gradient, is known as non newtonian fluid.

Eg:- plaster, slurries etc.,

Ideal plastic fluid:-

→ A fluid in which shear stress is more than the yield value and shear stress is proportional to the rate of shear strain or velocity gradient, is known as ideal plastic fluid.

Incompressible fluid:-

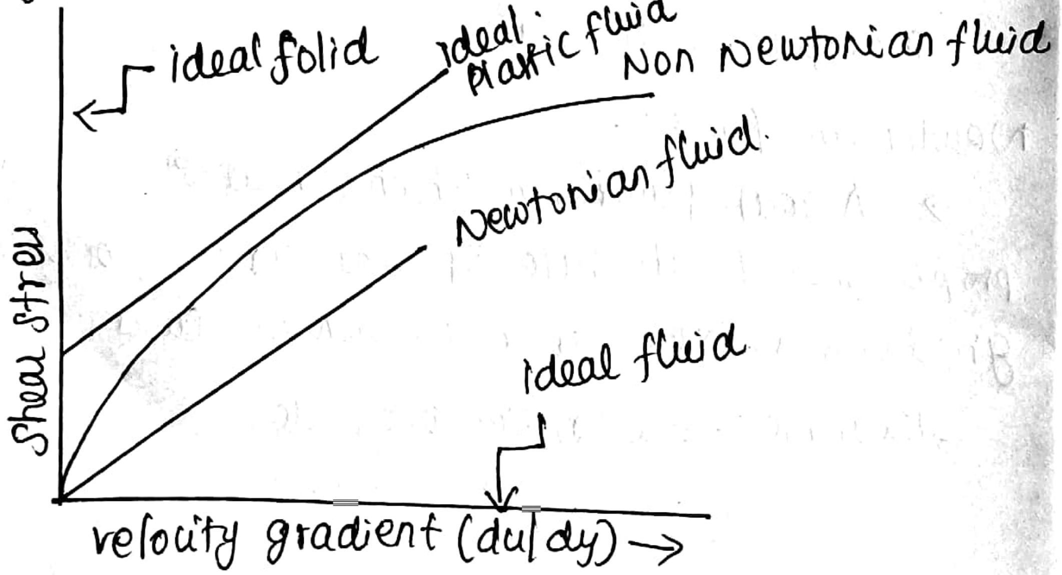
→ A fluid in which the density of fluid does not change which change in external force or pressure, is known as incompressible fluid.

→ All liquid are considered in this category.

Compressible fluid:-

→ A fluid in which the density of fluid changes while change in external force or pressure, is known as compressible fluid.

→ All gases are considered in this category.



Types of fluid	Density	viscosity
ideal fluid	constant	zero
Real fluid	variable	Non-zero
Newtonian fluid	constant / variable	$\tau = \mu (du/dy)$
Non newtonian fluid	constant / variable	$\tau \neq \mu (du/dy)$
Incompressible fluid	constant	non zero / zero
compressible fluid	variable	non zero / zero.

4. Explain in detail about rotary drilling hydraulics:-

→ Proper utilization of mud pump horsepower is of considerable importance to rotary drilling operations, Analytical appraisal of the rig's circulating system requires an understanding of the components which consume power, so that the available energy may be used as advantageously as possible.

→ The standard hydraulics approach to such analyse is hindered by numerous factors, among which are,

* Mud flow property
* Irregularities of the circulating system.

→ Drilling mud leaves the pump discharge, passes through the surface lines, standpipe and mud hose, and finally

5. Explain in detail about vertical and deviated holes:-

Refer Unit-III.

· write note on drill bit, pills and slugs:-

drill bit:-

~~Ro~~· In the oil and gas industry, a drill bit is a tool designed to produce a generally cylindrical hole in the earth's crust by the rotary drilling method for the discovery and extraction of hydrocarbons such as crude oil and natural gas.

Roller cone bit

→ Roller cone bits comprise one, two or three cones having teeth sticking out of them.

→ When the bit is rotated at the bottom of the hole the teeth are pressed onto the formation below the bit and applies a force exceeding the compressive strength of the rock.

Advantages

* Can handle rough drilling conditions
* Less expensive than fixed cutter bits.

Offset drill bit

→ The bit cone's "offset" is defined as the horizontal distance between the axis of the bit and a vertical plane through the axis of the journal.

Polycrystalline Diamond bit:

PCD bits consists of industrially manufactured, temperature stable di-amonds that are mounted directly into the bit matrix.

	very soft formation:	very hard formation
Offset	big, high influence	no, low influence
Tooth height	high, high influence	low
hydraulics	low diameter nozzles, high impact force, high influence	low influence.
Bearings	function of applied WOB, low influence	high grades / qualities high influence.
Lubrication	low influence	high influence own lubricant reservoir

pills and slugs:-

Slug:-

→ A volume of mud that is more dense than the mud in the drillpipe and wellbore annulus.

pill:-

The pill is pumped into the top of the drillstring to push mud downward, out of the pipe, thus keeping the upper stands of pipe empty.

7. **Explain in detail about hole cleaning:-**

Definition:

→ Hole cleaning is the ability of a drilling fluid to transport and suspend drilled cuttings.

→ Inadequate hole cleaning can lead to costly drilling problems,

* Mechanical pipe sticking
* premature bit wear
* slow drilling
* Formation fracturing

→ hole angles b/w 30 and 60° creates the most difficult hole cleaning conditions.

→ Hole cleaning can be minimized by good management of

* Annular velocities
* Drilling-fluid viscosity
* pipe rotation speed
* pipe eccentricity.

Tools for hole cleaning optimization:

→ Using hydraulics-modeling software that is programmed specifically for oilfield applications, it is possible to accurately predict drilling-fluid properties under actual downhole conditions, including,

* static and dynamic temperature profiles
* Hydraulic pressures.

* ECD (equivalent circulating density).
* Annular pressure loss.

→ The Immediate feedback from the modeling process can allow the operator to optimize hole cleaning by several means,

* Adjustment of surface mud properties to meet changing downhole conditions.
* Adjustment of mechanical parameters such as penetration rate, flow rate, pipe rotation speed
* Design and Implementation of an effective sweep program.

→ A comprehensive modeling software package should accurately predict:

* cuttings loading in the annulus
* The cuttings-bed height
* effect of drillstring rotary speed and pipe eccentricity.

Drillstring rotation:-

→ The drillstring rotation has moderate to significant effects in enhancing hole cleaning.

→ The level of enhancement is a combined effect of

* pipe rotation
* mud rheology

* cutting size
* flow rate

Annular fluid velocity:

→ high flowrate can be increased may be limited by

* Maximum allowed ECD
* The susceptibility of the openhole section to hydraulic erosion
* The availability of rig hydraulic power.

Hole cleaning sweeps:

* The sweep is pumped at regular intervals at the normal circulating rate.
* The pipe rotation speed is ≥ 60 rev/min once the sweep has reached the bit
* The sweep is allowed to return to the surface with continuous circulation.

→ enters the drillstring at the top of the kelly joint. Here it begins the long downward travel through the drill pipe and drill collars, is expelled through the water courses or nozzles of the bit and returns up the annulus?

→ The annular area is relatively small around the drill collars and becomes larger in the portion containing drillpipe. Since the mud enters the drillstring and leaves the annulus at essentially the same elevation, the only pressure required is that necessary to overcome the frictional losses in the system.

→ The discharge pressure at the pump is defined by,

$$\Delta P_t = \Delta P_s + \Delta P_p + \Delta P_c + \Delta P_b + \Delta P_{ac} + \Delta P_{ap}$$

where ΔP_f → pump discharge pressure

ΔP_s → Pressure loss in surface piping, stand pipe and mud hose

ΔP_p → Pressure loss inside drill pipe

ΔP_c → pressure loss inside drill collars

ΔP_b → Pressure loss across bit water courses or nozzles.

ΔP_{ac} → pressure loss in annulus around drill collars.

ΔP_{ap} → pressure loss in annulus around drillpipe.
