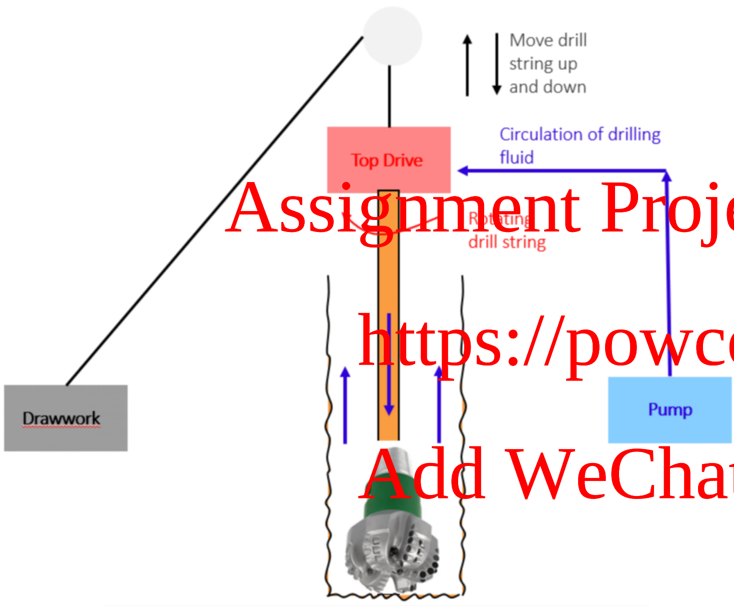
PRRE1003 Resources, Processes & Materials

Workshop P2: Drilling Engineering

LEARNING OUTCOMES

- Material and energy requirements of a drilling operation
- Density of a drilling fluid and its role in well bore stability

ACTIVITY 1: Energy requirements of a drilling operation: fuel consumption (40 minutes)



Lecture recap:

Figure 1: The drawwork to lift/lower drill string, top drive to rotate the drill string and mud pump to circulate drilling fluid.

The drawwork is used to move the drill string (like a crane). The pumps are used to circulate the drilling fluid and the top drive is to rotate the drill string (see Figure 1).

As mentioned in the lecture material, while drilling, the top drive and mud pumps are used. The top drive rotates the drill string and the pump circulates the mud. During drilling, the drill string is lowered in a controlled way using the brake system of drawwork, therefore, the fuel consumption of drawwork can be ignored.

During tripping, only drawwork is consuming power, as the circulation is almost stopped, and the rotation of drill string is at very low speed with minimum energy consumption. Therefore, while drilling, mud pumps and top drive are active, and while tripping only drawwork is active.

Background: Drilling operation consumes significant energy and is a 24hr operation, usually conducted in remote areas, where access to energy can be only provided only using diesel generators.

In this question, an onshore drilling rig is located 500 km away from the nearest fuel source. The rig is mobilised to drill a deep hole for petroleum exploration. The total drilling operation is expected to take 30 days, and due to distance from the nearest fuel supplier, the engineers are considering storing the fuel for the entire operation. The power requirements for the top drive are 1200 kW; for the mud pump are 1000 kW; and for the drawwork (hoisting system) are 1600 kW.

(a) Calculate the energy requirements for the operating systems in each mode (kW)

	Drilling Mode	Tripping Mode	Idle Mode
Mud Pump	Yes/No	Yes/No	Yes/No
Top Drive	Yes/No	Yes/No	Yes/No
Draw work	Yes/No	Yes/No	Yes/No
Energy required (kW)	1000kW+1200kW=2200kW	1600kW	0kW

The power is provided by a diesel-generator system with efficiency of 28%. The heating value of diesel is 40 MJ/litre. During the operation, 55% of the time is spent drilling, and 25% tripping, and 20% on idle. On idle mode, the rig only uses a negligible amount of power.

(a) Calculate the total fuel consumption (m^3) by the generator for the 30-day operation

	Drilling	Tripping	Idle
Energy input to generator (kW)	$N = \frac{P}{Q} = \frac{2200}{0.28} = 7857.1kW$	output = 1600kW $input = \frac{1600}{0.28} = 5714.3kW$	output = 0kW $input = \frac{0}{0.2} = 0kW$
Fuel consumption (litres/s)	$Q = m(H)$ $7857.1 \times 10^3 J/s = m(40 \times 10^6) J/l$ $m = \frac{7857.1 \times 10^3 Js^{-1}}{40 \times 10^6 Jl^{-1}} = 0.19643$ $= 0.196 l/s$	$Q = m(H)$ $5714.3 \times 10^3 J/s =$ $m(40 \times 10^6) J/l$ $m = \frac{5714.3 \times 10^3 Js^{-1}}{40 \times 10^6 Jl^{-1}} = 0.143 ls^{-1}$	$Q = m(H)$ $0 \times 10^3 J/s = m(40 \times 10^6) J/l$ $m = \frac{0 \times 10^3 Js^{-1}}{40 \times 10^6 Jl^{-1}} = 0 ls^{-1}$
Time spent in each mode (days)	30days × 24 hours × 60mins × 60s = $2.593 \times 10^6 s$		
	$55\% = (2.593 \times 10^6 s) \times (0.55)$ $= 1.426 \times 10^6 s$	$25\% = (2.593 \times 10^6 s) \times (0.25) =$ $6.483 \times 10^6 s$	$20\% = (2.593 \times 10^6 s) \times 0.2$ $= 5.186 \times 10^6 s$
Fuel required for each mode (m^3)	fuel consumption × time $0.196 ls^{-1} \times (1.426 \times 10^6 s)$ $= 279496 l = 279.5m^3$	fuel consumption × time $0.143 ls^{-1} \times (6.483 \times 10^6 s)$ $= 927001 = 92.7m^3$	fuel consumption × time $0 ls^{-1} \times (5.186 \times 10^6 s)$ $= 0 l = 0m^3$
Total fuel consumption (m^3)	$279.5m^3 + 92.7m^3 + 0m^3 = 372.2m^3$		

ACTIVITY 2: Material requirements for a drilling operation: mud selection (20 minutes)

The second Activity is related to mud selection and the minimum flow rate of mud required to transport cuttings.

Lecture recap:

During drilling, it is required to transport the cuttings to surface. The drilling fluid is pumped using the mud pumps sending the drilling fluid through inside the drill string to the bit, and then from the bit nozzles to the annulus. In the annulus, the drilling fluid carries the cuttings to surface (see Figure 2).

There are different parameters controlling the transportation of the cuttings. The main parameters discussed here are *cuttings size*, *flow rate* (or fluid velocity which is flow rate divided by cross section area), and *fluid viscosity*.

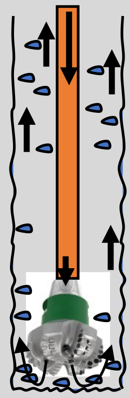


Figure 2: Schematic of circulation system to carry the cuttings to surface.

(a) Using Figure 3, estimate the minimum velocity required to transport a 1.25 mm cuttings size, for each fluid? Label the Figure to show how you obtained your estimate.

	Fluid 1	Fluid 2
Minimum velocity (m/s)	0.75	1.5

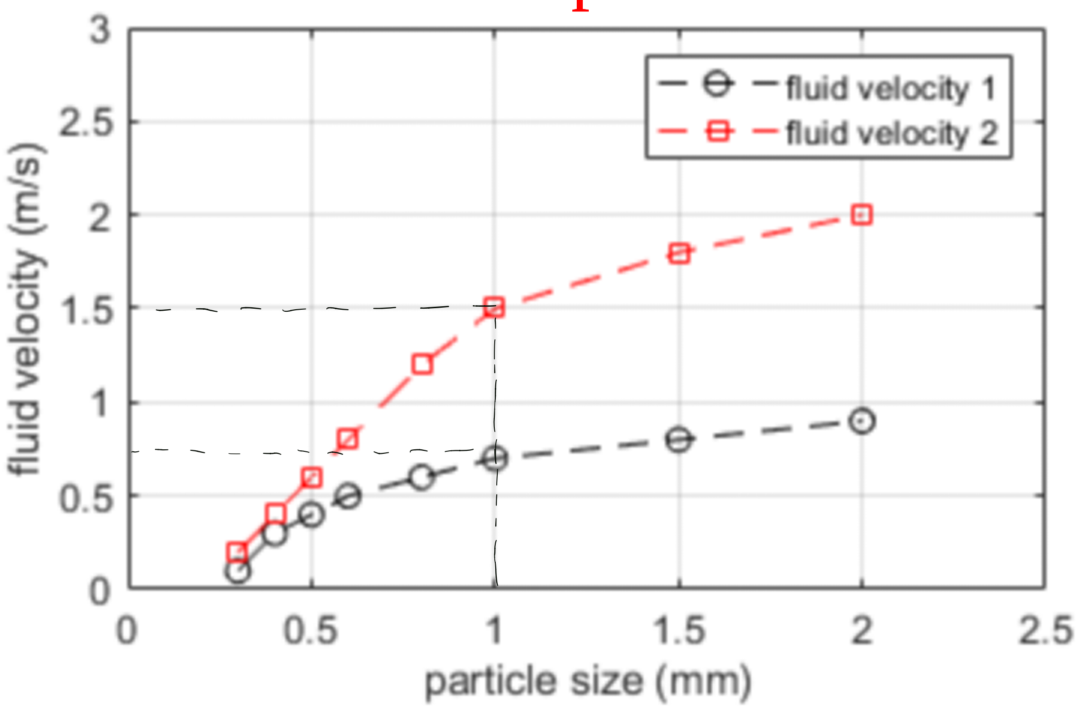


Figure 3: the variation of minimum fluid transportation velocity and cutting size.

The inner (D_i) and outer diameter (D_o) of the pipe is 80mm and 130 mm, respectively, and the diameter of the hole is 1000 mm. Please note that the cutting transportation is only important in the annulus, where the cuttings are transported.

(b) Calculate the minimum flow rate in the annulus, for each fluid.

	Fluid 1	Fluid 2
Minimum flow rate (L/min)	3.47×10^5	7.64×10^4
Sample calculation for Fluid 2	Annulus area = outer circle area − outer pipe area $= pi \times (0.5)^2 - pi\,[(\frac{0.13}{2})^2]$ $= 0.772\,m^2$ flow rate = area × velocity $= 0.772\,m^2 \times 0.75\,m/s$ $= 0.5790937\,m^3/s$ $= 0.5790937 \times 1000 \times 60$ $= 34745.622\,L/min$ $= 3.47 \times 10^5\,L/min$ Fluid 2: Annulus area = outer circle area − outer pipe area $= pi\,(0.5)^2 - pi\,[(\frac{0.13}{2})^2]$ $= 0.772\,m^2$ flow rate = area × velocity $= 0.772\,m^2 \times 1.65\,m/s$ $= 1.2738\,m^3/s$ $= 1.2738 \times 1000 \times 60$ $= 76428\,L/min$ $= 7.64 \times 10^4\,L/min$	

(c) Fluids 1 and 2 are made of barite, polymer and water. What is the role of polymer, and of barite, in the composition of this mud in cuttings transportation and wellbore stability?

The primary role of the polymer in the composition of the mud with regard to wellbore activity and cutting transportion is to enhance wellbore stability by improving core recovery, increasing penetration rates, retain near gauge-hole as well as to help in minimizing the formation damage. This is because the polymer normally acts as both a friction reducer and viscosifier while at the same time enhancing fluid loss control. On the other hand, the role of the barite is to improve the quality of the drilling fluid and reduce the formation damage by increasing the mud filtrate. This is due to the ability of barite to barite can effectively bridge the rock formation and the filter paper

ACTIVITY 3: Density of a drilling fluid and its role in well bore stability (30 minutes)

Lecture recap:

The density of mud (commonly referred to as mud weight) is the parameter that can keep the borehole open. Insufficient mud density (weight) can cause borehole instability and borehole collapse. The mud density provides sufficient hydrostatic pressure which can result in stability of borehole.

The required bottom-hole pressure at this depth to keep the wellbore stable is 62 MPa. The mud is made up of water, 2 kg of polymer per m^3 of water, and barite. The barite will be suspended by the mud. Densities: Barite - 4200 kg/m^3, Polymer - 2000 kg/m^3 and Water - 1000 kg/m^3

The drilling depth (km) can be found from inserting your initials into the Excel worksheet below (*double-click to open Excel*):

Initial #1	Initial #2	depth (km)
D	Q	4.71

(a) Calculate the required mud weight (density, kg/m^3) to ensure wellbore stability, showing your working.

$P = \rho(mud) \times h \times g$

65×10^5 = required mud weight $\times 5 \times 10^3$

required mud weight = 1322.7 kg/m^3

(b) Calculate the mass of barite (tonnes) required to make up the mud, if the available water is 1000 m^3.

Show your working to calculate mass of barite	Mw = mass of water / total weight = 2000 $2000 + 4200 + 106 \times \frac{1}{3}$ $V_b = 26.81\ m^3$ weight of Barite = 4200×26.81 = 112602 kg
Mass of barite needed (tonnes)	1 Tonne = 1000 kgs 112602 kg = $\left(\frac{112602}{1000}\right)$ tonness = 112.602

Assignment Project Exam Help

https://powcoder.com

Add WeChat powcoder