Drilling, Rig Types, Drill String Components (2)

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Previous Lecture

- Drilling
- Drilling Rig Types
- Drilling Rig Systems
- Drilling Rig System Components
- Drill String Components

Lecture Learning Outcomes

By the end of this lecture, you will be able to:

- Define the drilling rotary and circulations systems.
- Outline the rotary and circulations system components and their functions.
- List the functions of the drilling mud.
- Describe the drilling process concept and procedure.

Contents

- Rotation System
- Circulation System
- Circulation (Solid Control System)
- Drilling Fluid (Mud) and its Functions
- Drilling Process

Rotating System

- The rotary system is used to rotate the drillstring, and therefore the drill bit, on the bottom of the borehole.

Generally, rigs can rotate the bit in one of three ways:

A. The traditional way, the method that still dominates drilling, especially on land sites, uses a rotary table and Kelly.

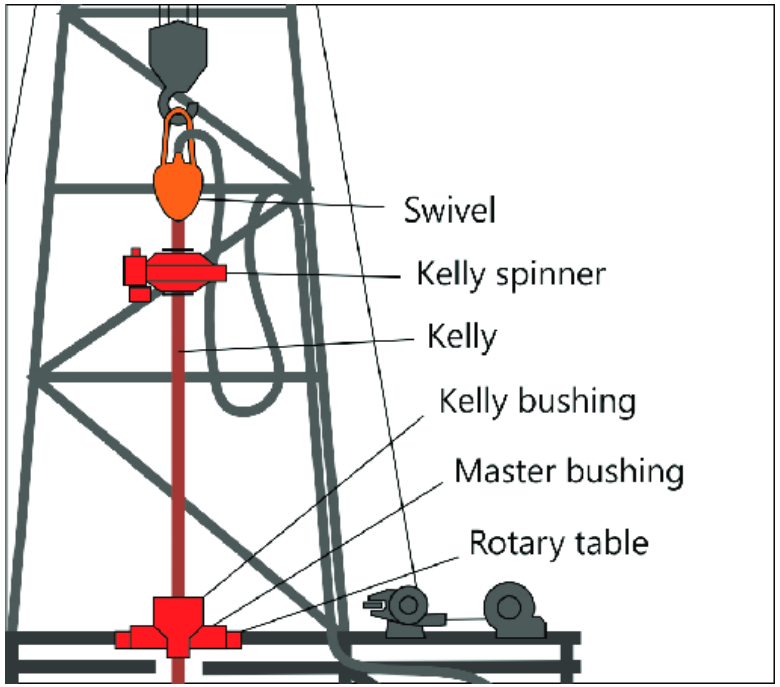
B. A second way uses a top drive system, which drilling contractors began to employ widely in the 1980s.

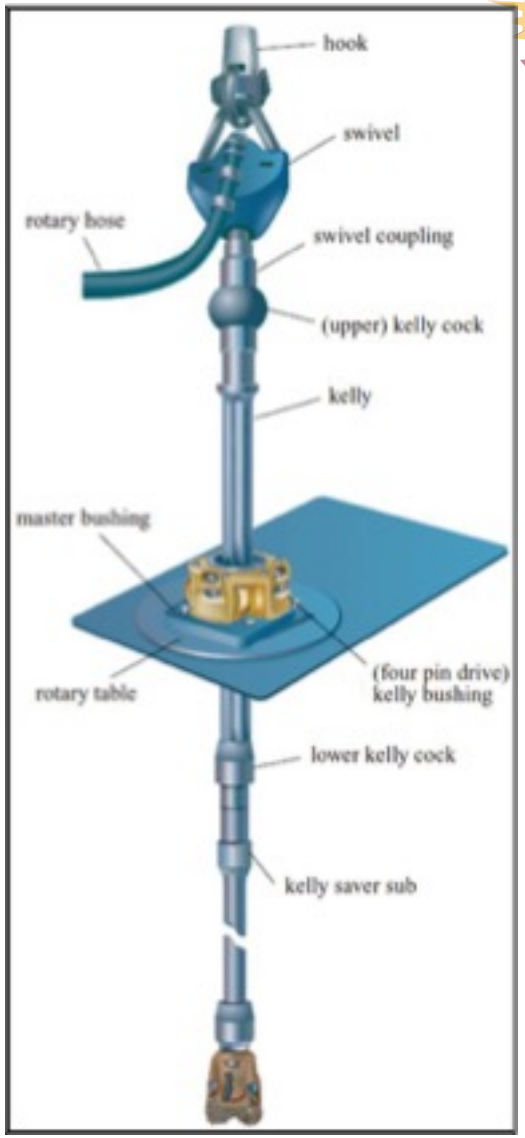
C. A third way uses a downhole motor, which contractors use in special cases such as directional drilling.

Rotating System

A. Traditional Method with rotary table and kelly.

The traditional method relies on the rotary table in generating the rotary motion and on the kelly to transmit the rotation to the drill string and bit.

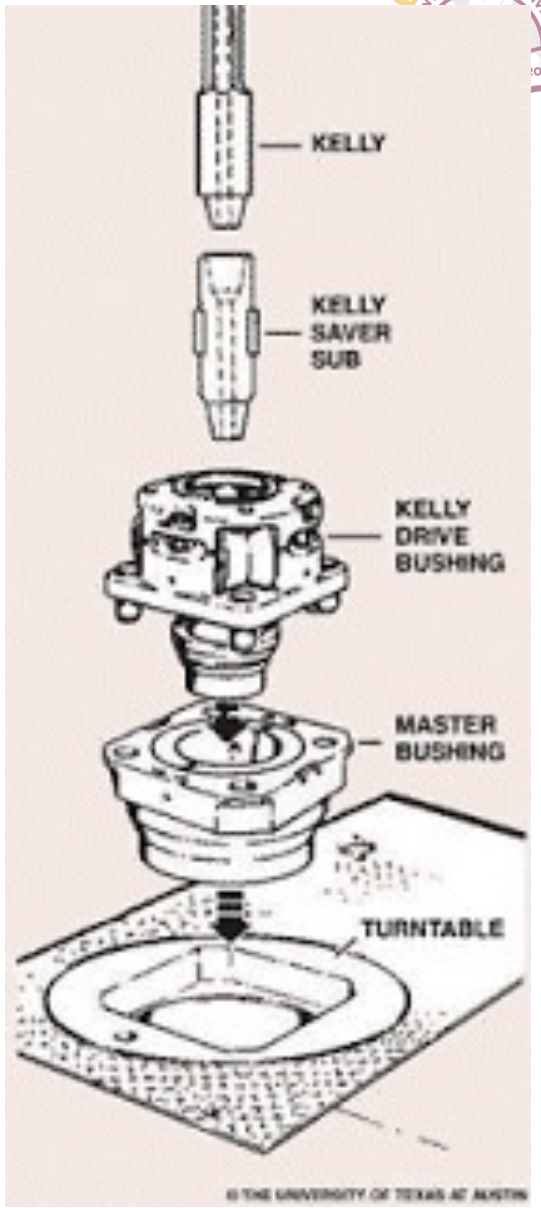




Rotating System

Rotary Table:

- Rotary table is the main component of rotating system which turns the drillstring.
- A stationary heavy-duty rectangular steel case houses the rotating turntable. The turntable is round in shape and is near the middle of the case.
- The turntable produces a turning motion that machinery transfers to the pipe and bit.
- An electric motor or gears and chains from the rig drawworks power the turntable. Additional equipment transfers the turntable's turning motion to the drill pipe and attached bit.



Rotating System

Master Bushing:

- A bushing is a fitting that goes inside an opening in a machine.
- A master bushing fits inside the turntable. The turntable rotates the master bushing.
- The master bushing transmit torque and rotation from the rotary table to the Kelly bushing.
- The master bushing has an opening through which crew members run pipe into the wellbore.

Rotating System

Kelly Drive Bushing

- The kelly drive bushing fits into the master bushing.
- Two types of master and kelly drive bushing are available.
- One master bushing has four drive holes. Strong steel pins on the bottom of a kelly drive bushing made for this type of master bushing fit into the holes.
- When the master bushing rotates, the pins engaged in the drive holes rotate the kelly drive bushing.

Rotating System

- Another type of master bushing has a square opening and no drive holes.
- The opening corresponds to a squares shape on the bottom of a kelly drive bushing made for this kind of master bushing.
- The square bottom of the Kelly drive bushing fits into the corresponding square opening in the master bushing.
- With the square drive bushing in place, the rotating master bushing turns it.

Rotating System

Types of Master and Kelly Drive Bushings

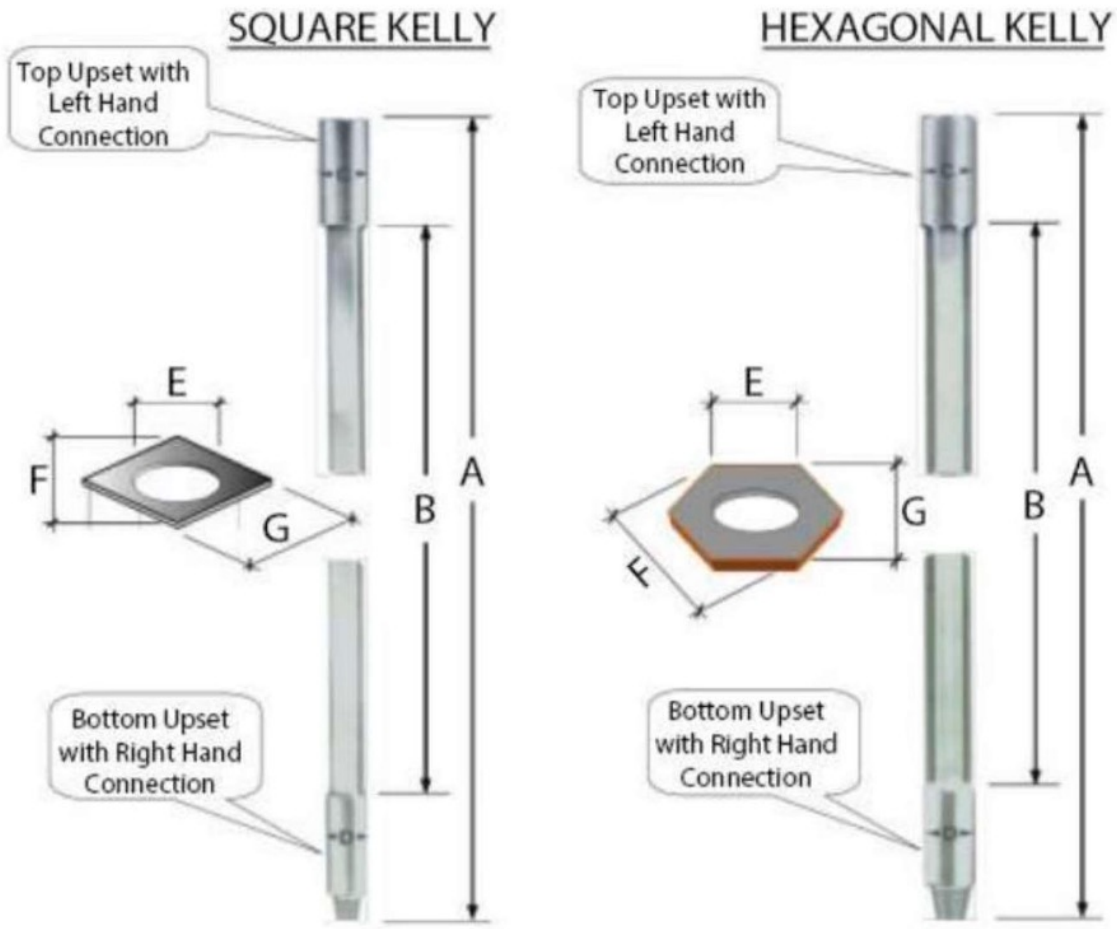
Rotating System

Kelly:

- A kelly drive bushing transfers the master bushing's rotation to a special length of pipe called the "kelly".
- A kelly is a special section of pipe that is attached to the bottom of the swivel by threading.
- It is not round. It has a hexagonal (6 sides) or square shape (4 sides) of pipe.
- It is attached to the swivel and fitx in a matching slot in the kelly drive bushing and in turn in the master bushing and rotary table.
- Functions:

✓ Transmit roation and weight to the drill string and bit.

✓ To carry the weight of the drill string.



Rotating System

Swivel

- The swivel interfaces the rotary system with the hoisting system.
- Swivel is a mechanical device that suspends the weight of the drill straing.
- A heavy-duty bail, similar to the bail, or handle, on a water bucket but much larger, fits into a big hook on the bottom of the traveling block.
- The kelly screws onto a threaded fitting (the stem), that comes out of the swivel.
- It is designed to allow the rotation of the drillstring.
- Near the top and on one side of the swivel is a gooseneck.
- The gooseneck is a curved, erosion-resistant piece of pipe. It conducts drilling mud under high pressure into the swivel stem.

Rotating System

B. Top Drive

- Newer rig systems use a top drive to rotate the drill string
- The top drive can be hydraulically or electrically powered.
- The top drive in rotary drilling eliminates the need for a kelly and rotary table.
- The top drive reduces the amount of manual labor during trips and the accociated hazards of working on the derric floor.
- Top drive rigs are designed to work with a smaller footprint than other drilling rigs, which reduces its environmetnal impact, especially in urban environments where the space available for well sites is limited.

Rotating System

C. Downhole Motors (Mud Motors)

- In special situations, the rig may use a downhole motor to rotate the bit.
- Unlike a rotary table or a top drive system, a downhole motor does not rotate the drill string. Instead, it rotates only the bit. Drilling mud powers most downhole motors.
- Normally, crew members install the motor in the drill string just above the bit.
- To make a mud motor rotate the bit, the driller pumps drilling mud down the drill string as usual. The mud enters the motor and strikes a spiral shaft and rotates it which in turn rotates the drill but which is attached to it
- Rigs often use downhole motors to drill directional holes.
- Because it is easier to get the bit to drill in the desired direction if the drill string does not rotate, rigs employ downhole motors.

https://www.youtube.com/watch?v=Ba-arRTGDsI&t=55s

Circulation System

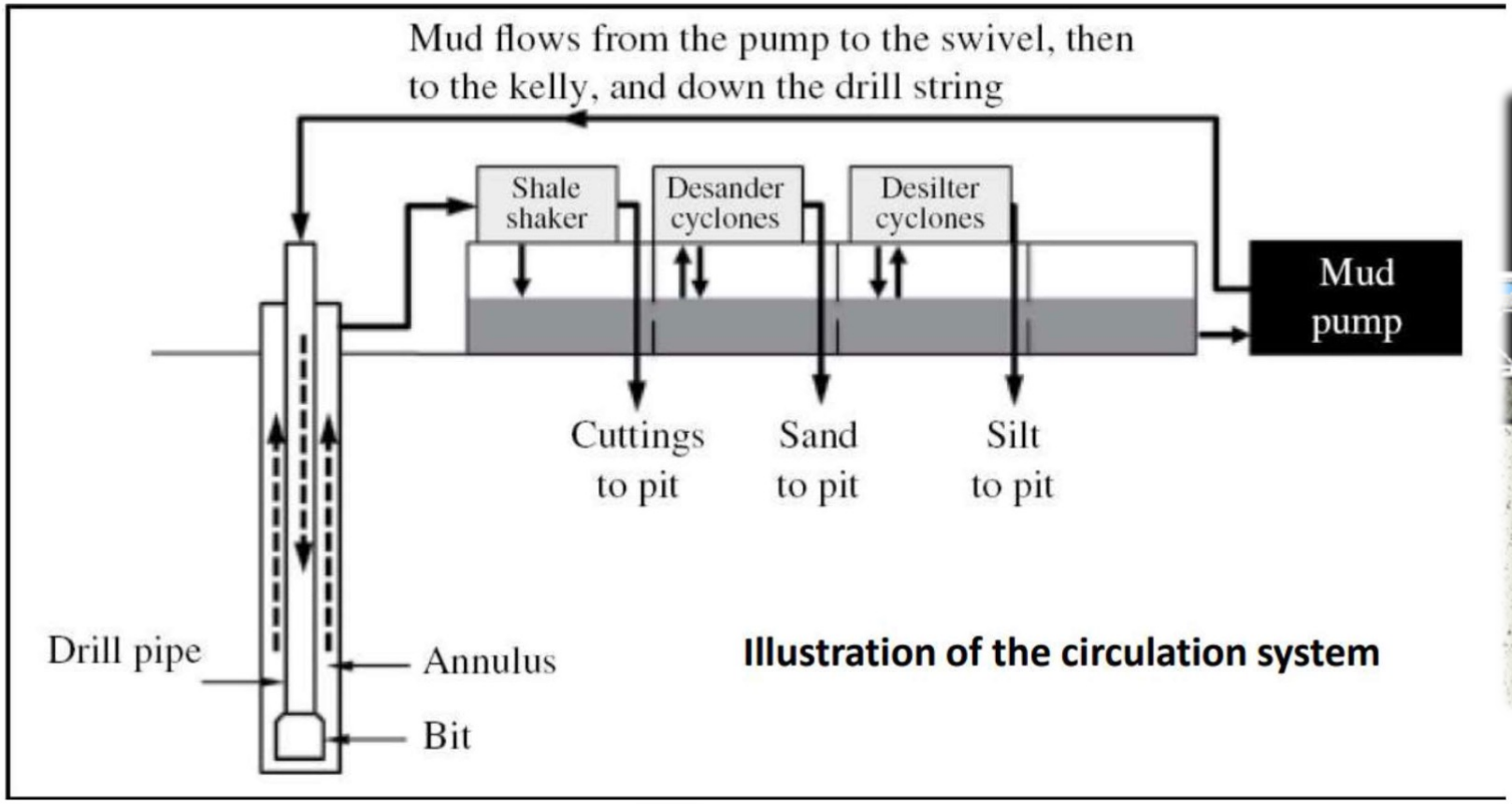
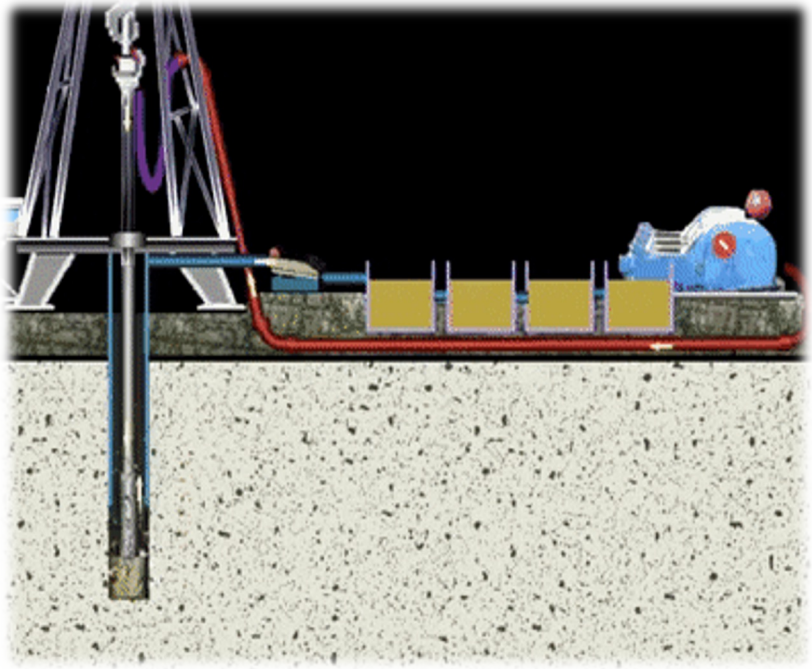


Illustration of the circulation system



Circulation System

Mud Pump:

A mud pump is used to circulate drilling mud (also refereed to as drilling fluid) downhole during drilling operations.

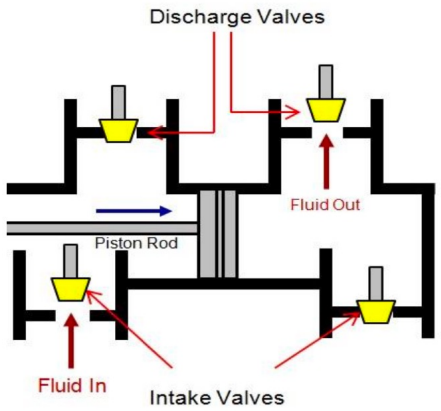
There are two types of pumps used in the oil industry: Duplex (Two cylinders) and Triplex (Three cylinders).

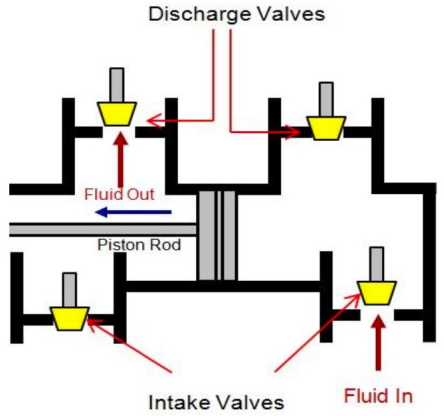
- The duplex pumps generally are double-acting pumps that pump on both forward and backward piston strokes.
- The triplex pumps generally are single-acting pumps that pump only on forward piston strokes.

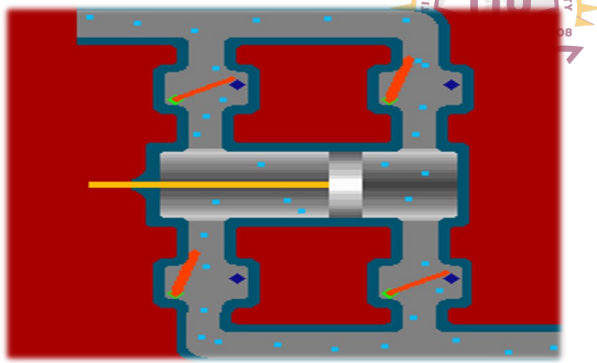
Circulation System

Mud Pumps, cont.

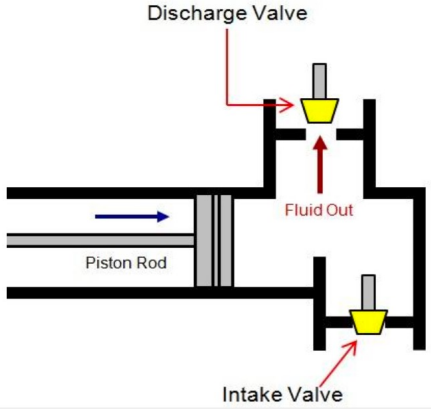
- **Duplex**

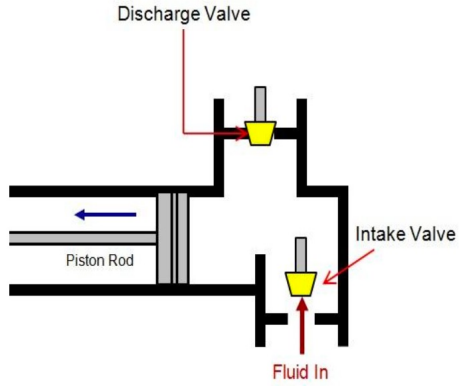


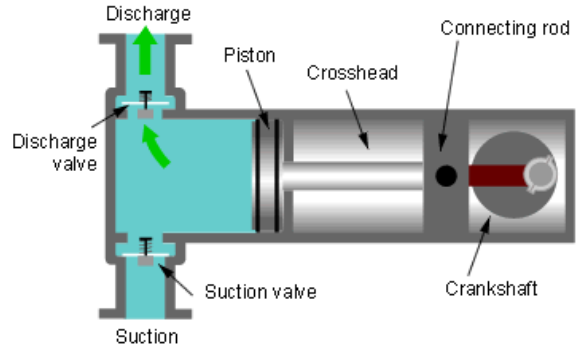


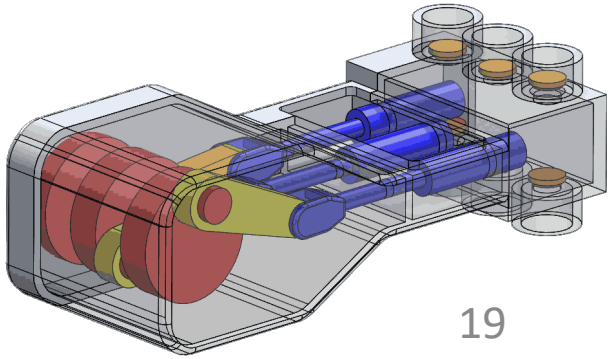


- **Triplex**







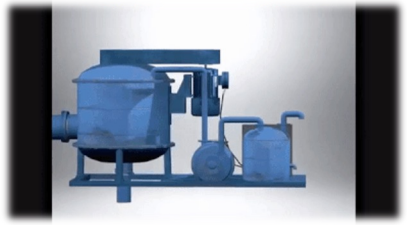


Circulation (Solid Control) System

Circulation System: Solid Control

Shake Shaker

Vacuum Degasser



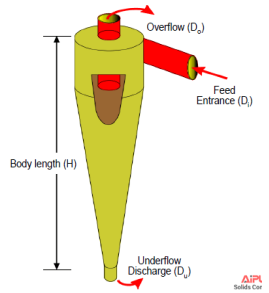
Decanter Centerfuge

Desander

Desilter

Mud tank

Hydrocyclones



Circulation (Solid Control) System

Shale Shaker:

- A device on the rig for removing drilled solids from the mud.
- This vibrating sieve is simple in concept, but a bit more complicated to used efficiently
- A wire-cloth screen vibrates while drilling fluid flows on top of it.
- The liquid phase of the mud and solids smaller than the wire mesh pass through the screen, while larger solids are retained on the screen and eventually fall off the back of the device and are discarded.

Circulation (Solid Control) System

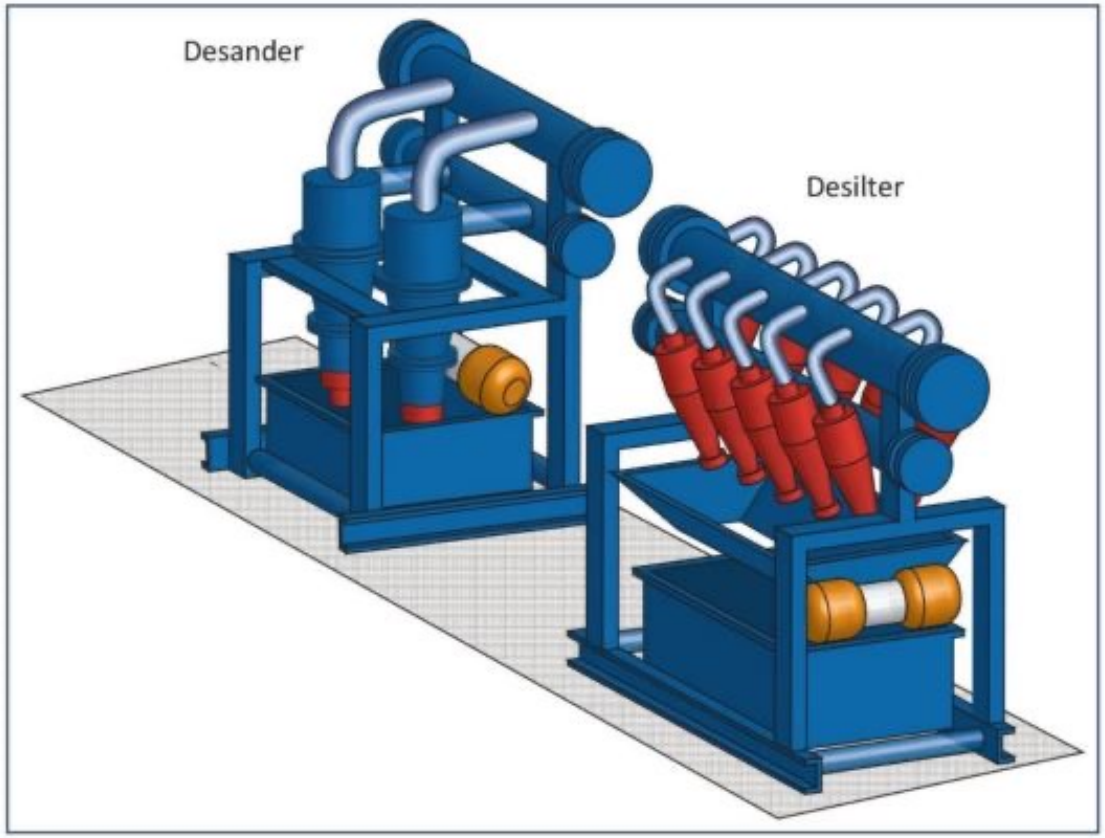
Desander:

- A hydrocyclone device that removes drill solids from the mud system.
- The desander should be located downstream of the shakers but before desilters or mud cleaners

Circulation (Solid Control) System

Desilter:

- A hydrocyclone much like a desander except that its design incorporates a greater number of smaller cones.
- As with the desander, its purpose is to remove unwanted solids from the mud system.
- The smaller cones allow the desilter to efficiently remove smaller diameter drill solids than a desander does.
- For that reason the desilter is located downstream from the desander in the surface mud system.



Drilling Fluid (Mud)

Drilling Fluid "Mud" is any fluid which is circulated in the borehole to help in carrying out a cost-effective and efficient drilling operation resulting in stable and gauged borehole to targeted depth with minimum possible damage to prospective formations.

- In its most basic form, a drilling fluid is composed of a liquid (either water or oil) and some sort of viscosifying agent. A typical mud consists of the following:

1. A continuous phase (liquid phase).
2. A dispersed phase such as colloidal solids and/or emulsified liquids.

Water

+

Bentonite Clay

=

Drilling Mud

Functions of Drilling Mud

Drilling mud has several functions, including:

- Lifts cuttings and contents of drilled formations to the surface.
- Controls formation pressure.
- Lubricates the drill string and bit.
- Cools the bit.
- Mechanically supports the wellbore.
- Transmits hydraulic power (e.g. mud motor)
- The mud can also prevent movement of fluids from one formation to another.

Drilling Process

Three basic functions are carried out during rotary drilling operations:

1. Torque is transmitted from a power source at the surface through a drill string to the drill bit.
2. A drilling fluid is pumped from a storage unit down the drill string and up through the annulus. This fluid will bring the cuttings created by the bit action to the surface, hence clean the hole, cool the bit and lubricate the drill string.
3. The subsurface pressures above and within the hydrocarbon bearing strata are controlled by the weight of the drilling fluid and by large valve assemblies at the surface.

Drilling Process

- The process of drilling begins months, and often years, before a drilling rig arrives on location. The following five stages of the process will be considered.
- Planning
- Site preparation
- Drilling
- Open hole logging
- Setting production casing
- Planning is the longest of these (five) stages, and open-hole logging and setting of casing are the shortest, oftern just 1-3 days for each.

Next Lecture

Next lecture on Monday November 20th, 2023. at 09:00 in class L.104 we will discuss:

- Types of reservoir rocks
- Reservoir fluid properties