ROTARY DRILLING

Rotary, Kelly, Swivel, Tongs, and Top Drive

First Edition

UNIT I • LESSON 4

ROTARY DRILLING SERIES

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English-Units-to-SI-Units Conversion Factors

Quantity or Property	English Units	Multiply English Units By	To Obtain These SI Units
Length, depth, or height	inches (in.)	25.4	millimetres (mm)
		2.54	centimetres (cm)
	feet (ft)	0.3048	metres (m)
	yards (yd)	0.9144	metres (m)
	miles (mi)	1609.344	metres (m)
		1.61	kilometres (km)
Hole and pipe diameters, bit size	inches (in.)	25.4	millimetres (mm)
Drilling rate	feet per hour (ft/h)	0.3048	metres per hour (m/h)
Weight on bit	pounds (lb)	0.445	decanewtons (dN)
Nozzle size	32nds of an inch	0.8	millimetres (mm)
Volume	barrels (bbl)	0.159	cubic metres (m^3)
		159	litres (L)
	gallons per stroke (gal/stroke)	0.00379	cubic metres per stroke (m^3/stroke)
	ounces (oz)	29.57	millilitres (mL)
	cubic inches ($in.^3$)	16.387	cubic centimetres (cm^3)
	cubic feet (ft^3)	28.3169	litres (L)
		0.0283	cubic metres (m^3)
	quarts (qt)	0.9464	litres (L)
	gallons (gal)	3.7854	litres (L)
	gallons (gal)	0.00379	cubic metres (m^3)
	pounds per barrel (lb/bbl)	2.895	kilograms per cubic metre (kg/m^3)
	barrels per ton (bbl/tn)	0.175	cubic metres per tonne (m^3/t)
Pump output and flow rate	gallons per minute (gpm)	0.00379	cubic metres per minute (m^3/min)
	gallons per hour (gph)	0.00379	cubic metres per hour (m^3/h)
	barrels per stroke (bbl/stroke)	0.159	cubic metres per stroke (m^3/stroke)
	barrels per minute (bbl/min)	0.159	cubic metres per minute (m^3/min)
Pressure	pounds per square inch (psi)	6.895	kilopascals (kPa)
		0.006895	megapascals (MPa)
Temperature	degrees Fahrenheit (°F)	$\frac{°F - 32}{1.8}$	degrees Celsius (°C)
Thermal gradient	1°F per 60 feet	—	1°C per 33 metres
Mass (weight)	ounces (oz)	28.35	grams (g)
	pounds (lb)	453.59	grams (g)
		0.4536	kilograms (kg)
	tons (tn)	0.9072	tonnes (t)
	pounds per foot (lb/ft)	1.488	kilograms per metre (kg/m)
Mud weight	pounds per gallon (ppg)	119.82	kilograms per cubic metre (kg/m^3)
	pounds per cubic foot (lb/ft^3)	16.0	kilograms per cubic metre (kg/m^3)
Pressure gradient	pounds per square inch per foot (psi/ft)	22.621	kilopascals per metre (kPa/m)
Funnel viscosity	seconds per quart (s/qt)	1.057	seconds per litre (s/L)
Yield point	pounds per 100 square feet ($lb/100\ ft^2$)	0.48	pascals (Pa)
Gel strength	pounds per 100 square feet ($lb/100\ ft^2$)	0.48	pascals (Pa)
Filter cake thickness	32nds of an inch	0.8	millimetres (mm)
Power	horsepower (hp)	0.75	kilowatts (kW)
Area	square inches ($in.^2$)	6.45	square centimetres (cm^2)
	square feet (ft^2)	0.0929	square metres (m^2)
	square yards (yd^2)	0.8361	square metres (m^2)
	square miles (mi^2)	2.59	square kilometres (km^2)
	acre (ac)	0.40	hectare (ha)
Drilling line wear	ton-miles (tn•mi)	14.317	megajoules (MJ)
		1.459	tonne-kilometres (t•km)
Torque	foot-pounds (ft•lb)	1.3558	newton metres (N•m)

Introduction

Drillers ready to drill ahead sometimes say, "Let's put the bit on bottom and turn it to the right." This oil patch expression is a nod to a special technology called rotary drilling. Rotary drilling bores through underground formations by rotating (turning) the drill stem and the bit.

Today, rotary drilling is the industry standard, but it was not always so. Before rotary drilling started to flourish in Texas in the 1900s, oil people drilled most wells with cable drilling tools. With this method, rig crewmembers attach a sharp tool—a bit—to a cable. The cable, along with other rig equipment, repeatedly picks up and drops the heavily weighted bit, which punches a hole into the ground.

Cable tool drilling has two big drawbacks. Chips of rock (cuttings) that the bit gouges from the formation stay in the hole. The cable-tool system has no way of getting them out of the way as the bit drills. Eventually, the cuttings build up to the point that the bit starts punching into old cuttings instead of into fresh, uncut rock. At this point, the bit no longer deepens the hole. Crewmembers therefore have to stop the operation and bail (remove) the cuttings. Even worse, however, is that some soft formations cave in around the bit and keep it from drilling at all.

Rotary drilling solves the problems of having to stop drilling to bail, and of cave-ins in soft formations. The beauty of the rotary method is that it not only rotates the bit to drill ahead (make hole), it also removes cuttings from the hole at the same time. Removing cuttings at the same time the bit drills keeps the hole clean, regardless of how soft the formations are. Unlike cable-tool drilling, rotary drilling uses hollow pipe (the drill stem) to put the bit on the bottom of the hole. The diameter of the bit is larger than the diameter of the drill stem, so it drills a hole whose diameter is larger than the drill stem's. Thus, there is space between the drill stem and the wall of the hole. This space is the annular space, or the annulus.

Conventional Rotating System

Figure 1 shows a conventional rotary system. From top to bottom, it consists of a hook, a swivel, and a rotary (kelly) hose. It also has an upper kelly cock (valve), a kelly, and a lower kelly cock (valve), which is screwed into the bottom of the kelly and cannot be seen on the figure. Not shown in the figure, but an important part (you will see why later), is a kelly saver sub.

The conventional rotating system also has a kelly bushing, a master bushing, and a rotary table assembly. The rotating system allows part of the drill stem's weight to press down on the bit to make it drill. The system also provides the rotating force to turn the bit. Finally, it provides a passageway for the pump to send drilling fluid downhole to lift cuttings.

Let's take a closer look at how a conventional rotary rig accomplishes these three jobs (fig. 2). The drilling crew attaches a drill bit studded with metal or diamond cutters to the bottom of the drill stem. Crewmembers then lower the drill stem into the hole until the bit is very near the bottom. At this point, the driller engages the rotary table assembly on the rig floor to turn the drill stem and bit. The mud pump is also started to circulate drilling fluid. The driller then lowers the rotating bit the rest of the way to bottom and allows part of the drill stem's weight to push down on the bit. Weight causes the bit's cutters to bite into the formation and drill ahead.

Top-Drive System

Some rigs, especially those offshore, do not use a rotary table, a kelly, and a swivel to rotate the drill stem. Instead, they use a top drive, which replaces the rotary table, the kelly, and the swivel. The top drive does the work of all three and works much like a motorized swivel (fig. 3). Because of its design, the top drive can speed up the rotary drilling process. Like the swivel, it hangs from the hook on the traveling block. Unlike the swivel, it has a heavy-duty motor (or motors) that provides power to rotate the drill stem.

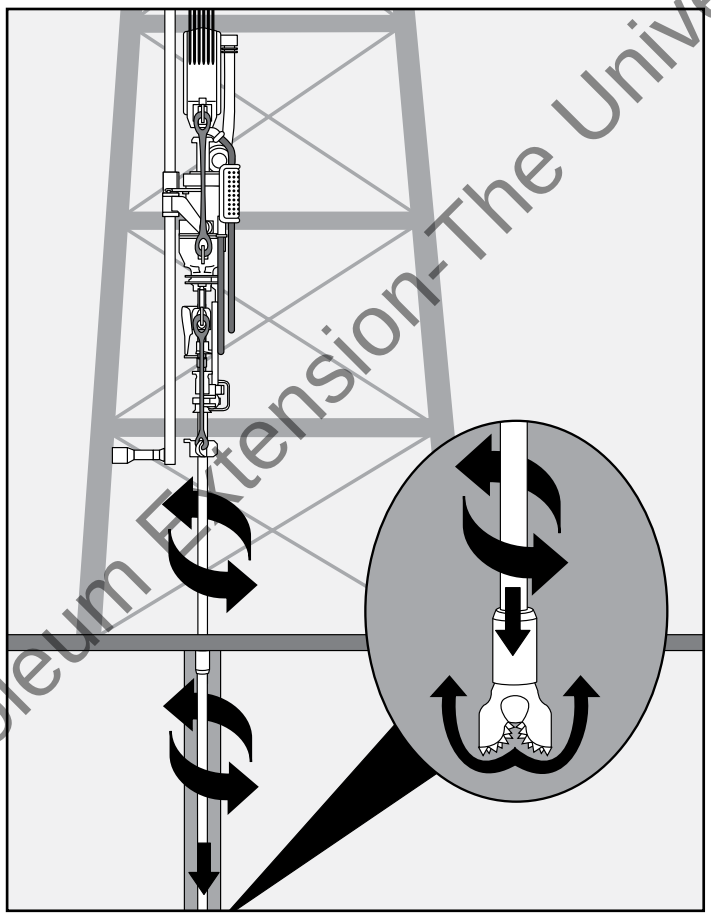

Figure 3. A top-drive system does not use the rotary table to turn the drill stem.

Rotary Table Assembly

Definition

A conventional rotary rig uses a conventional rotary table assembly (fig. 4). This assembly is a rotating machine housed inside a rectangular steel box. The assembly has an opening in the middle for the kelly and drill pipe. The main parts of the rotary table assembly include the base, the turntable (also called the rotary table), and the master bushing. It also has a drive-shaft assembly, a drawworks sprocket and a drive-shaft sprocket, and a chain.

Righands often call the steel box and the equipment it houses the rotary, or the rotary table. Strictly speaking, however, a rotary table is a collection of many components. One of its main parts is a turning component called the rotary table, or the turntable. This manual will refer to the entire rotary machine as the rotary table assembly and refer to the turning device in the assembly as the rotary table.

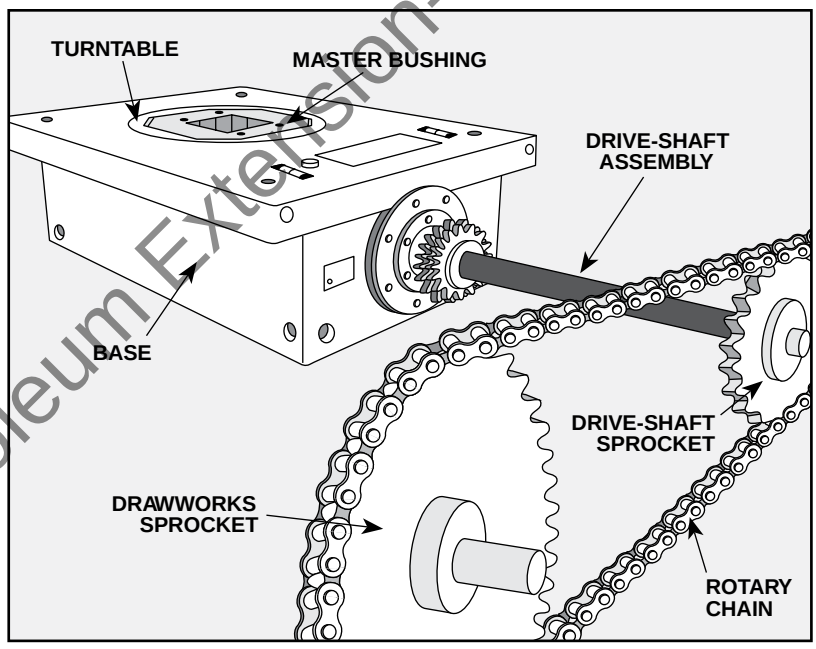

Figure 4. A conventional rotary table assembly

Master Bushing, Kelly Bushing, and Slips

On a conventional rotary rig (one without a top drive), three important devices fit inside the rotary table: (1) the master bushing, (2) the kelly (or drive) bushing, and (3) the slips. The rig uses the master bushing and the kelly bushing during drilling. The rotary table assembly cannot turn the kelly directly. Instead, the master bushing and the kelly bushing transfer the rotary table's motion to the kelly.

Crewmembers use the slips when drilling stops. The slips hang (suspend) the drill stem in the rotary table assembly when righands make a connection, or when they trip the drill stem in and out of the hole.

Master Bushing

Definition

The master bushing is a rugged steel cylinder. It sits inside the turntable, which turns it (see fig. 5). The master bushing then turns the kelly bushing during normal drilling. The master bushing has a tapered surface for the slips. This surface is either part of the bushing itself, or it is a removable inner bowl that is separate from the master bushing (fig. 18). Manufacturers also provide the master bushing with a way to drive the kelly bushing. The two ways to drive the kelly bushing are the four-pin drive and the square drive.

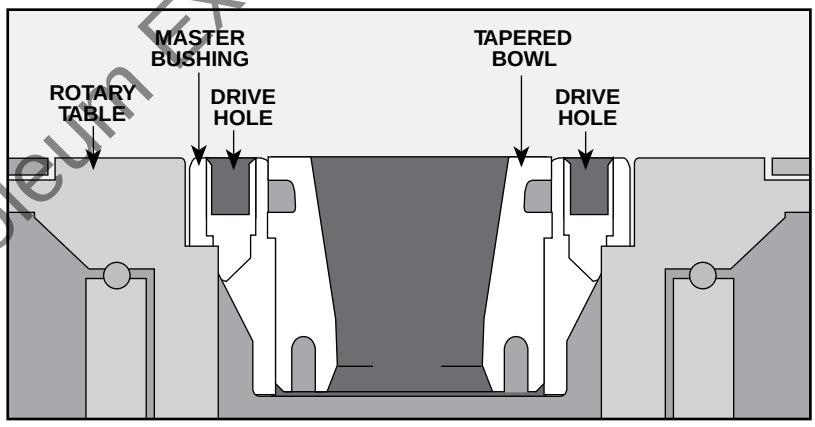

Figure 18. Tapered bowl that fits inside the master bushing

Kelly

Definition

The kelly is a flat-sided, heavy steel pipe that crewmembers attach to the bottom of the swivel. They attach the other end of the kelly to the drill stem. The kelly bushing and the master bushing transfer the rotary table assembly's rotation to the kelly. The kelly, since crewmembers make it up on the drill stem, turns the drill stem and bit.

The kelly is usually 40 feet (12 metres) long and has either four or six flattened (not round) sides. Crewmembers make up several attachments to the kelly. These attachments include the upper kelly cock, the lower kelly cock (drill pipe safety valve), and the kelly saver sub (fig. 58).

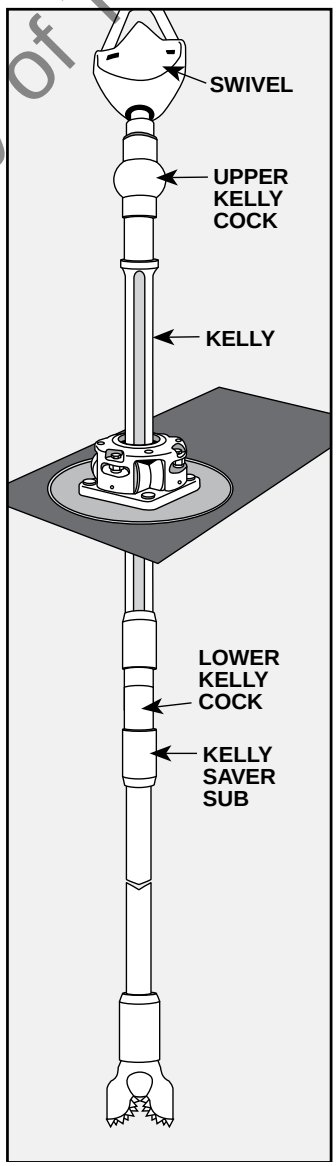

Figure 58. Kelly and attachments

Swivel

Definition

Standard dictionaries define a swivel as a device joining two parts so that one or both can pivot freely. The rotary drilling swivel does precisely that. On conventional rotary drilling rigs, the swivel hangs from the traveling block and hook. Crew members attach one end of a strong, steel-reinforced flexible hose—the rotary, or kelly, hose—to the standpipe. (The standpipe is a steel pipe that runs from the mud pump's discharge line and up one leg of the derrick.) They attach the other end of the rotary hose to a short, curved steel pipe, called the gooseneck, which is on the swivel. A passageway inside the swivel conducts drilling mud from the gooseneck to the kelly and drill string. At the same time, the swivel allows the drill stem to turn, or rotate, freely (fig. 64).

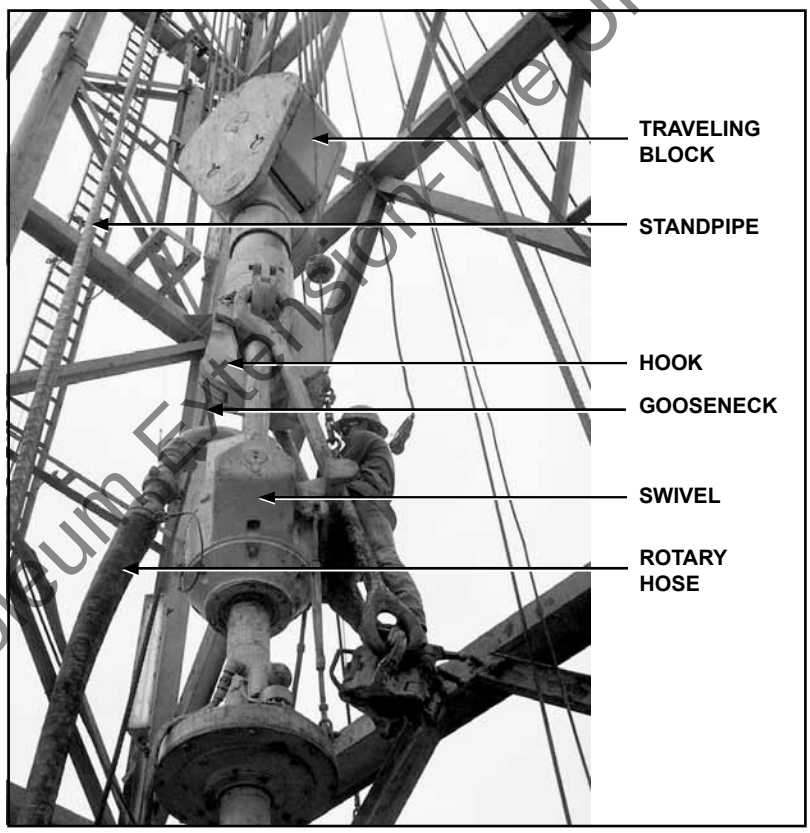

Figure 64. Traveling block, hook, and swivel

Spinning and Torquing Devices

Spinning and torquing devices on a conventional rotary rig include large manual wrenches (fig. 69), power wrenches, chains, and other equipment that turn drill pipe. Crew members use this equipment to connect or disconnect the pipe. They frequently remove the drill stem from the hole and disassemble it. Crew members also often join lengths of drill pipe together. For example, they may need to add a length of drill pipe to drill ahead. Or, they may need to trip out the entire drill string to change bits.

When connecting pipe, floorhands use spinning tools first, and then powerful torque wrenches to finish the job. The spinning equip-ment rapidly rotates, or spins, the joint together. Crew members then use torquing tools to make the joint up to final tightness. Spinning equipment also spins out the joint after the floorhands break the two members of the joint apart with torquing equipment. Examples of spinning tools are the spinning chain, the kelly spinner, and the spinning wrench.

Figure 69. Using manual tongs to tighten a joint

Top Drives

Definition

A top drive is a system suspended in the derrick that works as a kind of power swivel (fig. 79). Modern units combine the elevators, the tongs, the swivel, and the hook.

A top drive performs several rotary drilling jobs at one time:

- it rotates the drill stem;
- it serves as a passageway for drilling mud; and
- it supports the drill stem in the hole.

The rig uses a top drive in place of the regular swivel, the kelly, the kelly bushing, and the rotating function of the rotary table. Even on rigs with a top drive, however, the rig owner retains the rotary table and master bushing as a place for the floorhands to set the slips to suspend the drill stem in the hole.

Figure 79. Top drive in derrick

Conclusion

The early days of rotary drilling overlapped the fading era of cable tool drilling. For a time, the rival technologies waged a battle across the oilfields of the United States. Rotary workers called cable tool crew members rope chokers, jar heads, and mail pouchers (after a brand of chewing tobacco). Cable tool workers branded rotary hands auger men, chain breakers, clutch stompers, twisters, and swivel necks. Feelings were so fierce in Electra, Texas, for example, that boardinghouses segregated the workers to keep fights from breaking out. One house was for swivel necks only; the other was reserved for mail pouchers.

Nearly a century later, the oilfield remains just as colorful, and drilling methods are still advancing. Rotary drilling eventually took its place as the industry standard. Now, top-drive technology is changing rotary drilling itself. The old debate over drilling gear continues as top-drive equipment improves and challenges the conventional rotary method. But the news media have not reported any instances of separate boardinghouses for top-drive hands and for rotary table hands—at least, not yet.

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