Tubing Anchors Offer Various Benefits

By Mike Bair

SIGNAL HILL, CA.–Tubing anchors have been deployed successfully in the oil industry for many decades to secure tubing to the casing. Anchoring the tubing in tension has many benefits. First and foremost, it reduces wear on tubing, sucker rods and the casing. By reducing wear throughout the tubing string, a tubing anchor helps minimize the frequency and number of tubing string leaks. The cost of adding an anchor to a well is negligible, compared with the high costs associated with pulling the well for repair.

A tubing anchor also increases bottom-hole plunger travel, relative to the tubing, resulting in increased production. The amount of production loss in unanchored tubing can be a very substantial, but often overlooked, loss of revenue. For example, consider a deep well producing 350 barrels of oil a day. Assume the well’s pump has a 2¾-inch plunger with 2½-inch tubing, a pump depth of 7,780 feet, 26.6 inches of tubing stretch, and a 240-inch stroke length.

The pump’s efficiency loss is calculated by dividing the amount of tubing stretch by the stroke length. In this case, the pump efficiency loss is 11 percent. Multiplying the 350 barrels of daily oil production by the 11 percent pump efficiency loss indicates this well loses $3,465 in revenue each day, at an average price of $90 a barrel.

In this example, using a tubing anchor basically would pay for itself in only one day of increased production!

Mechanical Anchors

There are two types of tubing anchors: mechanical and hydraulic. Each has specific benefits for different applications.

The mechanical tubing anchor (sometimes called the catcher) uses pure mechanical operation. It consists of two sets of gripping teeth—one set facing up and one set facing down—on each slip. This double gripping action allows the anchor to be set for both anchoring and catching. The mechanical anchor is activated by rotating the tubing string, typically about six turns.

Mechanical anchors are available with both left- and right-hand turn settings. It is customary to pull on the tubing string to make sure the anchor has seated against the casing. To release the gripping action, the tubing string must be rotated in the opposite direction to that used to set the anchor until the anchor moves freely.

If the anchor/catcher cannot be retrieved normally, the anchor may be released by an emergency straight upward pull. The mechanical anchor can be set above or below the pump. Setting below the pump eliminates the chance of rod cut. It is not advisable to set mechanical anchors in horizontal wells because the anchor can easily bind in the deviation.

Another type of mechanical anchor is the tension or compression style. These units are set by running the anchor to the desired depth, making the last movement down before attempting the actual set. The anchor is set by rotating the tubing (left or right, depending on anchor) one-quarter turn at the tool and picking up the tubing string. These units are operated by a J-slot mechanism that is actuated by the surface rotation and has an emergency shear ring release as well as the ability to be unscrewed by rotating the tubing approximately 20 more turns.

Mechanical anchors are very cost effective tools priced in the $1,500-$4,000 range.

Hydraulic Anchor

The hydraulic tubing anchor is a completely automatic tool that utilizes the
weight of the fluid column in the tubing string to power the piston in the anchor. Load reversal from the pump is the force that moves the hydraulic tubing anchor into tension. When the differential pressure in the tubing string is greater than the pressure in the casing annulus, the anchor piston will be activated hydraulically and press the live slip against the casing. Only 70 psi of differential pressure is needed to activate the piston.

The anchor’s holding power is designed to resist upward movement against the normal forces encountered in the pumping operation, but will yield to forces beyond normal that would overstress the tubing string. Fixed slips are designed to span recesses, and are built with a 43-degree top tooth angle and 15-degree bottom tooth angle, which allows the anchor to move down the hole into proper tension position, but restricts upward movement.

Because they are simple to install and extract, the ease of operation is a strong advantage of hydraulic tubing anchors. Unlike a mechanical anchor, there is no need for surface manipulation to set a hydraulic anchor. The hydraulic anchor is activated when the insert or tubing pump is set and the pressure in the tubing string is greater than the pressure in the casing annulus. To retrieve the anchor, simply unseat the pump. The pressure will equalize and the anchor will no longer be in tension.

Blow drains are commonly used in conjunction with hydraulic anchors as a way to empty the tubing string of fluid in the case of a stuck pump. Because the hydraulic anchor is set by the differential pressure in the tubing string, it must be placed above the pump.

Hydraulic tubing anchors generally are more expensive than mechanical anchors, and have costs in the $2,500-$5,000 range. But they are much simpler to use and have more applications.

Choosing The Anchor

The information needed to select the correct mechanical anchor includes tubing size, anchor depth, flowline temperature, and fluid level depth when the anchor is set. With this data, tables listing the operating fluid level gradient (fluid level after pumping down annulus), temperature increase factor, and the fluid gradient of the initial well-fluid-level factor (fluid level when anchor is set) are needed to calculate the amount of tubing stretch needed to set the mechanical anchor in tension.

Mechanical anchors are deployed often in shallow wells, where it is easier to manipulate the tubing at surface. They also can be more advantageous in wells with extreme heat or high concentrations of chemicals, since the anchor is affected less by these conditions.

It is less advantageous to employ mechanical anchors in deep and/or deviated wells because they can be very difficult to set in tension in these conditions. Also, the operator needs to be cognizant that the same left-hand turn needed to set these anchors also can unscrew the tubing, if over-rotated (over-rotating on a right-hand-setting mechanical anchor can snap and lose the tubing).

If the decision is made to run a hydraulic tubing anchor, the information needed for the selection process includes approximate fluid level, casing size, casing weight, tubing size, pump bore size, pump depth, anchor depth, and well temperature. The casing size, casing weight and tubing size are the measurements needed for correctly sizing the hydraulic anchor, and the pump bore size, pump depth and anchor depth are needed to run the load/thrust calculation to determine whether the anchor selected has the necessary holding power to prevent tubing movement.

If a single “R” anchor doesn’t have the needed holding power, a “DR” anchor (two anchors) can be employed. When using a DR anchor, the individual anchors are placed one joint or one stand apart on the tubing string.

Load/Thrust Calculation

In order to ensure the proper tubing anchor application, a pump load/thrust calculation should be performed for each anchor prior to installation. The weight of water (0.433 pounds per foot) is a constant figure and always should be used in the formula (hydrostatic head).

The thrust from the anchor needs to be greater than the load of the pump (plus 30 percent).

Consider the example of a well with the following conditions:

- Pump plunger size—two inches (3.14 square inches);
- Pump depth—9,010 feet;
- Anchor depth—7,240 feet; and
- Anchor piston—three inches (7.06 square inches).

The pump load is calculated by multiplying the 0.433 weight of water by the 9,010-foot pump depth (equals 3,901.33), and by the 3.14 square inches of the pump plunger (equals 12,250.18), then adding 30 percent of the total (3,675.05) for a total pump load of 15,925.23.

Thrust is calculated by multiplying the 0.433 weight of water by the 7,240-foot anchor depth (equals 3,134.92), and by the 7.06 square inches of anchor piston for a total thrust of anchor of 22,132.54.

In this instance, the thrust of a single hydraulic R anchor has sufficient holding power, since the thrust (22,132.54) is greater than the load plus 30 percent (15,925.23).

Usage Considerations

Considering the ease of setting hydraulic anchors, they are often the best selection in deeper, more deviated wells where surface manipulation is a challenge. Also, the sizeable bypass areas of the hydraulic anchor are conducive to running capillary tubing or other service tools through the tubing string. These large bypass areas also make the anchor less likely to get stuck on an accumulation of solids in the casing or at a casing deviation.

If a hydraulic anchor is stuck and cannot be extracted by normal means, the anchor often can be removed by first moving downward (since slip teeth only
face upward) and then pulling back up in order to dislodge it. Also, water can be pumped down the backside of the casing annulus in order to equalize the pressure differential, thereby releasing the hydraulic anchor from tension.

Using hydraulic anchors with Viton® seals is discouraged in wells with temperatures exceeding 400 degrees, and usage should be monitored in environments that have very high concentrations of chemicals because the seal cup and O-rings can be damaged by excessive heat and high chemical concentrations. Viton is a strong elastomer for this application, and other materials may be preferable in the case of excessive heat or high chemical concentrations. In extreme circumstances, the damage caused by these elements can result in an anchor leak.

Hydraulic tubing anchors can be repaired by replacing the seals, pistons, sleeves, O-rings or slips. Unless the mandrel experiences rod cut, anchors generally can be run back into a well multiple times.

It is strongly recommended to set all anchors above the well perforations. Anchor slips can get caught in the perforations and the chance of severe sand accumulation is increased. Both of these circumstances can result in a stuck anchor, making anchor extraction much more difficult.

Choosing the correct type of tubing anchor is essential in limiting rig costs, prolonging run times, and minimizing tubing/casing wear. An educated decision in selecting the right tubing anchor for each well is a great asset for maximizing production and profits.

Mike Bair was one of the founders of Black Gold Pump and Supply Inc. in 1982 in Signal Hill Ca. He began his career in 1975 at Oilwell Supply, and left in 1981 to join Page Oil Tool as a sales manager, where he helped design components still in use today. Bair led Page’s sales department until the company was sold in 1982 to Trico Industries. Under his leadership, Black Gold has a thriving pump repair shop, custom machine shop, electric submersible pump design and test center, Pro Rod rigs for deploying continuous rod strings, product manufacturing, and a professional sales and service organization. Bair has served as a guest lecturer at the University of Southern California, and holds seminars at customers’ sites and Black Gold’s seminar room.