CIRCULATING TREATING (CT) SKIDS FOR IMPROVED TREATING PROCESSES

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ABSTRACT

Alternatives need to be considered for delivering chemical treatments to rod pump wells. This paper reviews the problems with the current treating methods and proposes an alternative that mitigates the problems with the current procedures. This alternative uses a circulating treating skid to displace chemical treatments through a filtering system. Operational criteria for the CT skid are discussed as well as its cost effectiveness compared with current practices.

BACKGROUND

Chemical treatments for scale and corrosion inhibition are generally pumped periodically or continuously down the production tubing by production casing annulus. These treatments are flushed to the bottom with a volume of water from a truck or with a slip stream from the tubing. Corrosion inhibitors deposit as films on steel surfaces. To be effective, these films may only need to be several molecules thick to separate corrosive fluids from the steel. These films degrade over time with the flushing action of the production or the mechanical erosion of the artificial lift equipment. The residuals of the chemical program are monitored at the surface. The amount of chemical and the frequency of the treatments are adjusted based on the residual profiles over time.

Effective treating programs create tough films/barriers and maintain or heal these films to avoid or minimize corrosion-wear cycles. Historically, oil in higher oil cut wells supplemented the chemical treating programs and failure frequencies were modest. As water cuts increase and the supplemental filming tendencies diminish, reliance on chemical treating has become increasingly important. Although these programs are substantially better than not treating wells at all, there are still serious limitations.

Perhaps the greatest limitation is so called “rod cutting” commonly found in the bottom section of tubing strings when wells are pulled for repairs. There is now so little experience in the industry with pumping high oil cut wells that rod cutting is now considered a wear mechanism rather than a serious corrosion- wear mechanism. This misdiagnosis is so pervasive that “splits” are often times only characterized as a wear problem. Proper analysis of many splits that are cut open often times show intense corrosion pitting under the “cut” channel-like area. Metal to metal galling should not be considered a true wear mechanism in many circumstances. For example, severely over pumped high oil cut wells that should be expected to show wear often times show very little wear. Conversely, there is considerable industry experience with relatively soft rod guides creating “rod cuts” where galling mechanisms are entirely improbable. Complex corrosion-wear mechanisms are generally the more accurate diagnosis. In effect, rod wear actually scrapes or grinds off the products of corrosion that are repeatedly formed from the fluid attack on the steel. This process is far more consistent with the data and historical experience than true metal to metal galling.

The lack of adequate failure analysis often leads operators to use wear reduction strategies rather than work on improving their filming programs. Toughening up the wear resistance at the bottom of the well is now a common practice in industry. Plastic lined tubing and various hardening techniques are examples of these toughening efforts. While these efforts are effective, improving the chemical treating programs will dramatically supplement these efforts.

FILMING SOURCES

There are several sources of filming material to protect steel. Most crude oils have filming tendencies. However, as the percentage of oil production decreases and water cuts increase, effective filming diminishes. Corrosion inhibitors pumped from the surface are another source of protective films. As these films are degraded, the filming material reattaches repeatedly up the hole until the material is finally produced out of the well. In effect, filming agents deeper in the hole become sources of filming material for components up the hole. This concept is critical to understanding the corrosion in the bottom section of the hole. If there is insufficient oil cut and there is no replenishment from below, chemical inhibitor films become single pass treatments. Once the films in the bottom of hole are damaged, intense cycling of corrosion-wear mechanisms can develop.

FILM DESTRUCTION MECHANISMS0

Mechanical wear from the rod string is the primary mechanism that damages corrosion inhibitor films. When a rod string buckles from tagging or from pounding fluid, the rods and rod boxes bow outward and impact the tubing string. The amount of side loading stress that is created at each areas of contact at the couplings is extremely difficult to model and predict. Films in shallow wells may withstand the side impact. However, there are very few in industry that believe films that are a few molecules thick can withstand the impact in deeper wells where the side loading is far greater with heavier rod weights and longer pump lengths.

Wells that pump off shortly after truck treating are the most vulnerable to failed corrosion treating. Since there are no trailing residuals to replenish the film, pumped off conditions buckle and damage the film at the bottom of the well. The residuals that are monitored at the surface do not reflect the lack of availability of the filming agent at the bottom of the well. Although residuals may be present at the surface, the bottom of the well may be effectively treated for less than 10% of an entire weekly treating cycle.

While the side loading can be dramatic without aggravating circumstances, any grit or trash in the well can create stress risers that amplify the loading. In effect, the grit becomes an abrasive “sand paper” like material. The presence of the stress riser material is well documented in industry. The top 6-12” of plungers often exhibit the patterns of wear associated with sand or grit in the well. In addition, the channel areas of corrosion wear failure quite often show similar striation patterns. This abrasion becomes a dramatic mechanism for inhibitor film destruction. Once destroyed, intense corrosion wear cycles develop.

SOURCES OF GRIT

Grit or trash comes from a variety of sources in producing wells and can generally be broken down into two broad categories.

The first category is grit that comes from the formation. Some formations are so friable that gravel packing is required. Wells that were fractured with sand may dribble back proppant for years after they are put on production.

The second category of grit is introduced by operations at the surface through the casing by tubing annulus. Solids from hot oil trucks, solids from chemical trucks, and solids from circulating slip streams are all events that can introduce grit into the well. Grit coming into the pump from above can cause severe problems like stuck tubing anchors.

In some wells, one of the worst sources of grit is from produced fluid slip stream that is used for continuous treating processes. These solids are often believed to be less harmful because they “have already made through the pump.” Unfortunately, mechanically worked scale and corrosion by-products are a serious source of grit formed above the pump. The problem can be very bad in wells with sour, high water cut production. This source of grit was measured in a number of wells and the results are shown in Table I.

TRUCK TREATING-OTHER FILMING ISSUES

Although the grit and lack of film replenishment are the key issues associated with truck treating, there are several other issues that affect the consistency of the film effectiveness. First among these other issues is the quality control related to personnel problems. Treating companies and operating companies alike have spent millions of dollars over years with audit procedures, GPS tracking, real time satellite truck volume measurement etc. to either prove the integrity of their service or to catch the “bad apple” in the field or in the blending shop. The second problem with truck treating is the grit in the displacement water. If the water is incompatible or “trashy”, the down hole risks are increased.

CONTINUOUS TREATING ISSUES

Although continuous treating addresses the critical process shortcoming of truck treating, the contamination problem is potentially much worse. As noted above, the slip stream can be a dramatic source of grit back down the well. In addition to the grit, the test also found the solids were coalescing around and with globules of paraffin. There is considerable industry experience with plugging problems in the slip stream line to the casing. In addition, paraffin is introduced into the annulus. When a well that is continuously treated is hot oiled, some of the problems with hot oiling are from displacing the buildup from the continuous treating slip stream and not from the hot oil truck. There is a strange paradox about conventional continuous treating. This technique is often times used on the worst wells that need more treating. However, although they have more severe problems with being treated, they typically have more grit material being generated above the pump. The increased effectiveness of the continuous treating process is undermined by the type of fluid being used to displace the treatment.

PARAFFIN TREATING ISSUES

Hot oiling has some of the same inherent treating problems as chemical treating. In particular, the process is a well known source of solids being introduced into wells.

CIRCULATING TREATING ("CT") DESCRIPTION

A circulating treating (CT) skid is comprised of a circulating pump, control panel, and filtering system. In addition, the skid is outfitted with electrical connections to allow chemical pumps to inject into the suction line of the skid. The purpose of the CT skid is to pump a filtered slip stream of fluid down the well, preferably weathered crude oil. In addition to being a clean displacement fluid for the chemical treatment, a slip stream of crude oil will generally provide a supplemental filming agent with additional lubricity. There are a number of other benefits of the CT skid. Unlike most water sources, stock tank crude oil will generally have little or no oxygen and the bacteria levels will be lower than typical open top water tanks. Entrained sour gasses are drastically less in stock tank crude compared with pressurized produced well fluids. Since the CT skid pump is designed for most wellhead pressures, smaller and more economical chemical pumps can be used to inject into the suction line of the skids

Using a CT skid will reduce the cost of labor and improve the control of the chemical program. The inventory of chemical totes or drums can be gauged by both the chemical company and the lease operator. Sampling of the chemicals is more easily accommodated compared with a chemical truck driver being on location for only a few minutes.

There are number of artificial lift issues with using a CT skid. First, there will be a slightly higher electrical bill associated with lifting the additional load back continuously. Second, many operators are concerned about the "loss" of production. Last, pumping down the annulus where there is a high fluid level can cause some problems. For example, if a well a well has been down for an extended period of time, the apparent "loss" of production may seem significant until the pump catches up.

The most serious concern with CT skids is the labor cost with keeping the filter section of the skid clean. Mesh strainers are notorious in the industry for being by-passed or removed because of plugging. The CT skid has a number of features that extend and simplify the filtering operations. First, the filter is comprised of stages that distribute the filter loading. Second, these stages can be changed out to match the profile of the fluids being used. Third, the entire filter system is designed to be quick-connected so the filter does not need to be cleaned in the field. In many cases, the filter life has been extended to more than 90 days with the final filter stage being approximately the pump clearance of the down hole pump.

Using a CT skid can be used to make solvent treating for paraffin more economical. Solvent treating has significant advantages over hot oiling to treat for paraffin. However, bulk suppliers of solvent will typically not allow their drivers to hook up to wells because of training and liability issues. Hot oilers or kill trucks can pump solvents but can generally not haul solvents over the road because of licensing requirements. Retail solvent treating with chemical companies is costly because of the mobilization of pumping equipment and personnel. Using a CT skid to pump solvents from storage tote allows bulk delivery of solvents to pump more economically.

ECONOMICS, SUSTAINABILITY, AND THE ENVIRONMENT

From the operator's perspective, having an onsite pump delivery system that can deliver filtered fluids into the well has a range of benefits, including:

- The most fundamental benefit of chemical treating with a CT skid is the potential to reduce failure frequencies by improving the corrosion protection. Reducing grit, improving lubricity, and more effectively maintaining protective films all contribute to reducing failures. Avoiding just a single failure in a 5 year period would more than pay for the installation.
- Beyond lowering the failure frequency, the CT skid reduces the likelihood of higher cost failures. Intuitively, using filtered fluids reduces the chances of stuck anchors and higher cost stripping jobs.
- CT skids allow for more cost effect solvent treating for paraffin. Compared with hot oiling, solvents allow for deeper treatments and avoid serious safety issues.
- In a broader sense, a CT skid allows the use of bulk treatments and reduces the frequency of deployment of pumping operations to the field. Reduced heavy trucking and reduced road repairs contribute to an overall lower environmental footprint for both the operator and the chemical providers.

Improving the delivery process not only improves the down hole protection of the well but improves the sustainability of the long term operations.

Table I
Entrained solids sieve size distribution
Mesh size recovery, oz

Well	Approx BFPD	30	40	60	80	Total grit/5gal bucket	Total grit scaled to production (lbs/day)	Total grit Scaled to 10 b/d (lbs/day)
A	667	0.2	0.3	0.1	0.1	0.7	245.1	3.7
B	69	0.2	0.3	0.2	0.2	0.9	32.6	4.7
C	139	0.3	0.1	0.1	0.1	0.6	43.8	3.2
D	236	0.3	0.2	0.1	0	0.6	74.3	3.2
E	237	0.2	0.1	0.3	0.1	0.7	87.1	3.7