COMPARATIVE SOAPING TECHNIQUES, HORIZONTAL VS. VERTICAL COMPLETIONS

Dan Casey
Pro-Seal Lift Systems, Inc.

ABSTRACT

Gas well de-watering techniques using soap sticks vary and are dependant on the completion profile. Vertical completions require a soaping routine significantly different than deviated completions. The factors that make some deviated profiles difficult to de-water with plunger lift can be overcome with an optimum application of soap sticks and well control. This paper includes case histories, water/hydrocarbon percentages and automation options.

BACKGROUND

Soapsticks have been a very effective de-watering technique for vertical completions for years. Many deviated completions have been drilled in the last two decades. The success of launching soapsticks on a time controlled basis has revealed preferred methods of soaping horizontal wells as compared with vertical completions. The cost of soapsticks and the skill requirements are very favorable for large and small Operators alike. Traditional manual dosing varies from 1 to 4 sticks per application. Some operators will shut-in the well before and after hand soaping. The determinate for this technique is the length of time between dosing. Longer periods between applications of surfactant require a shut-in period. This common technique can be improved upon.

QUANTITIES

Generally, the top of the water column is a cauldron of low density bubbling activity. As a soapstick enters this zone, dilution begins occurring from mechanical, chemical, and thermal action. One soapstick will effectively dilute one barrel of water in the *top* of the water column. This surfactant treatment changes the surface tension of the water molecule. A reduction in the surface tension allows the water drops to break up into ever smaller particles. Down-hole, smaller particles of water will 'float' in a column of gas just as fog will 'float' in the night air. The bubbling cauldron present at the top of the water column is the perfect environment for supplying the energy required to mechanically break up larger water drops. Thereafter, the surfactant reduces the 'cling' that would cause the droplets to regroup into larger, heavier drops. Surfactant deposition at perf depth requires increases in surfactant volume to achieve the same ratio of effectiveness. As the first barrel of fluid is unloaded, the concomitant reduction in column weight allows the bottom-hole pressure to lift an additional 3 or 4 barrels of untreated water to the surface. The operator will hear this as slugs unloading at the surface. The chloride percentage in the treated water and the presence of hydrocarbons reduce the effectiveness of the surfactant in the water column.

VERTICAL COMPLETIONS

Vertically completed well bores are predominant in the oilfield. The height of the liquid column in these flowing gas wells varies significantly from well to well. Nonetheless, a soapstick will find the top of the column of liquid. When the operator drops more than one soapstick into the well bore, the ratio of surfactant to produced water is increased in the short term meaning that the extra surfactant was not utilized fully. Extra surfactant, beyond that required to separate the water droplets, is not beneficial from a CAPEX position. Additional contra-indications against extra surfactants are; surfactant concentrations at the separator or, in the extreme, surfactant at the compressor.

When an operator drops multiple sticks into a well bore, it is generally because of a time and mileage constraint as opposed to a genuine de-watering technique. Knowing that he cannot return to the well with more soap in a timely fashion, the operator loads the tubing with extra soap, all at once. Our observations of applied soaping with solid surfactants indicate that a single soapstick launched into the tubing string is the better choice for de-watering flowing gas wells when the well bore is generally vertical. This technique, to be effective, should be repeated on a schedule determined by the well itself. A review of the flow chart (see Figure 1) will reveal the length of time that the flow rate has remained comfortably above critical from the launching of a single soapstick. Without further intervention, the flow rate will continue to fall to a point below critical. This lower flow rate occurs as the water level in the tubing builds beyond that which can be supported by bottom-hole pressure and in-flow rates. The goal of the soaping routine is to maintain the flow rate at a level above this critical rate. While the operator's desire is to maintain a flow rate at the maximum levels, the highest instantaneous rates are not realistic. The highest instantaneous rates exceed the IPR of the well. These momentary higher rates are a result of gas that is stacked in the tubing below a slug of liquid. A dense column of liquid droplets will show the same compressive effect on a column of gas until the heavy mist of liquid passes the tree. A review of the chart will reveal the point at which the flow rate falls consistently below the high instantaneous rate. This is the optimum point at which an additional soapstick should be introduced into the tubing of a vertical well bore. This repeat action will enable the well to lift the recently accumulated water while the flow rate is comfortably above critical. If the next soapstick is launched in a timely manner, it will encounter the water column at a lower level. Less liquid in the tubing should increase the in-flow across the perfs.

FLOW CONTROL OF VERTICAL WELL BORES

Some wells are shut-in during the soaping process either because the operator thinks that the soapstick will not fall against flow or because the flow rate has fallen below critical velocity. The rule of thumb for dropping a soapstick against flow is a 400 MCF rate for 2-3/8" tubing and a 600 MCF rate for 2-7/8" tubing. Below these conservative rates, a soap stick will fall and eventually reach the liquid surface. Additionally, the point at which the stick is dropped is generally the lowest instantaneous rate in the cycle. Therefore, a shut-in requirement for stick-fall is the exception, not the rule. The other reason to shut-in a flowing gas well (vertical) is if the well cannot generate a flow rate above critical. Shutting-in the well will stack gas in the tubing above the liquid column and it will also entrain gas in the liquid column as well as the near well-bore formation. When the flow control wing valve is opened, the rapid release of gas carries some of the liquid load to the surface. Surfactant in the top of the column is a great aid in flowing this liquid, in droplet form, to the surface. For maximum benefit with minimum surfactant, the soapstick should be launched into the tubing just minutes before the flow control valve is opened. There are really no other *routine* reasons to shut-in a flowing gas well. Non-routine shut-ins occur when the operator drops multiple Salt Crystal Modifier sticks (SCM) into the tubing to release a salt block. Daily, preventative use of an SCM stick does not require a shut-in. As such, less than 20% of gas wells should be shut-in when they are soaped on a routine basis.

HORIZONTALLY COMPLETED WELL BORES

Soaping routines for horizontal wells differ considerably from vertical completions. Only 20% of vertical wells are shut-in, whereas, 80% of horizontal wells should be shut-in while soaping. In those vertical wells that are shut-in, the soapstick is dropped in the last few minutes of the shut-in period, whereas with a horizontal well, the sticks should be dropped at the beginning of the shut-in cycle. Only a single stick should be used at each soaping cycle on a vertical completion, whereas multiple sticks, dropped at once, are preferred for de-watering a horizontal gas well (see Table 1). It is understood that the horizontal section of a wet gas well is full of liquid. A cross-sectional view of the perforated liner would be filled with water on the lower side and any disassociated gas movement would occupy a limited upper area of the cross section (see Figure 3). As such, gas moving toward the kick-off point would transport very little water with it. This is the same phenomenon that requires the periodic pigging of gathering lines and pipelines. A portion of the liquid in a *vertical* tubing string would slug to the surface, giving enough gas pressure and volume. This is not entirely true of liquid in a horizontal section where the gas can squeeze past (above) the quiescent liquid. The solution to de-watering a horizontal well, to the extent possible, is to combine a shut-in period with a generous application of surfactant.

If the horizontal section of a gas well is liquid loaded, the lower third of the vertical section is at least thoroughly saturated. The operator should drop 3 or 4 soapsticks into the tubing just as the well is being shut-in (Figure 2). The cross sectional area of soapsticks allows them to fall rapidly down the tubing string where they will encounter a low density water column. This gas cut liquid will not support the weight of the soapsticks which will sink quickly. A well that has just been shut-in has an accumulation of liquid clinging to the walls of the upper half of the tubing length. During the extended shut-in period, this strung-out water will fall downward and add to the liquid column. During the extended shut-in period (recommended), the weight of this liquid column will cause it to exchange position with the free gas in the horizontal section of the well bore. As a result, the heavy dose of soapsticks will migrate, first by gravity and then by carryover, to a lower position in the well bore. The distance of travel is dependant on the nature of the completion itself. A smaller diameter liner will promote distance travel, whereas an open section will not. At some point in the shut-in period, the soapsticks will dissolve, not from agitation, but from temperature and extended exposure to water. As the shut-in period endures and pressure builds at the surface and down-hole, the water column conforms and packs in the vertical tubing but, more importantly, in the horizontal section (Figure 4). At the end of the pressure build period, the well is re-opened at the surface. As in plunger lift, the head gas is discharged and the water column begins to move toward the surface begrudgingly. A plunger would prevent gas break out up through the water column but, without a plunger, a 'solid' column of water is the next best barrier to gas break out. As near well bore gas enters the perfs, the water slug in the horizontal section is moved into the lower vertical section. At this point, gas break out will occur in earnest and only a small portion of this liquid will make it to the surface. However, the accomplishment here is that at least some of the fluid in the horizontal section has moved upwardly. The confirmations are witnessed in the water reports and gas sales.

OTHER DEVIATED WELL PROFILES

This paper has described the preferred soaping technique using solid surfactants in vertical and horizontal well bores. A well bore that is deviated 45° would exhibit characteristics similar to either the vertical or horizontal depending on the gas to liquid ratio. Production with a greater gas to liquid ratio should be soaped similar to a vertical well bore. This is always the first choice decision because it will move the most water per MCF at the least cost in surfactant and down time. Heavier liquid loads will demand a soaping and flow control regime that discourage gas channeling in the lower portion of the tubing. Gas channeling, as describe in the section on horizontals, will not move liquid to the surface as preferred.

OTHER FACTORS

Surfactants react with chloride concentrated water effectively. Soapsticks will foam produced water with a maximum oil cut of 50% on a repeat basis. Soapsticks are less effective when the concentration of *condensate* exceeds 35%, although they can be used sporadically in concentrations as high as 90% hydrocarbon liquids. The operator should be aware of the oil cut limitations when using an automatic soapstick launcher to deliver surfactant into the well bore. Frequently, an automatic launcher is required to keep the well bore unloaded. Other factors not addressed in this paper are; depth variations, surfactant chemistries, and low bottom-hole pressure limitations.

CASE HISTORIES

In 2004, an automatic soapstick launcher was installed on the Brown #1, Bastrop County, Texas. The operator has been a plunger lift specialist for years, but because of the well profile, he had difficulty plunger lifting the volume of liquids produce by the Brown. Soapsticks had shown some promise, but the tech could not stay ahead of the scheduling demands. Over a four year period, a pattern of operation has emerged. Soon after the initial installation of the automatic launcher, the well was placed on a 20 hour cycle. At the top of the cycle, the well was shut-in and 3 soapsticks were dropped. The duration of the shut-in was 12 hours after which the well was opened and allowed to flow for 8 hours. Under those conditions, the Brown produced 20 BWPD, 10 BOPD and 700 MCFD, a considerable increase. The production over the years has been consistent within the natural decline. At present, the cycle time is 16 hours, i.e. 3 sticks dropped, 11 hours off time and 5 hours flowtime.

Figures 5, 6 and 7 are Austin Chalk installations in Grimes County, Texas from 2006. Each chart shows an up-tick in the rate of gas over time. Figure 5 shows the beginning of hand soaping on well #2. The failure to improve production thereafter was due to either incorrect timing or operator time constraints or both. After the initial installation on well #3 and #4 (Figures 6 and 7), an error in communication occurred between the well management software and the SoapLauncher Controller. Soap sticks were not being deployed at the appropriate point in the management cycle. Although the quantity of soap launched was correct and the duration of the shut-in period was adequate, the timing of the fall in conjunction with the timing of the shut-in was in error. Corrections were not made until February, as seen on the chart. After that point, the real benefit of the automated soaping and flow control regime became apparent.

CONCLUSIONS

Despite advances in production technologies, the use of solid surfactants in horizontal and vertical completions remains a viable solution to de-watering gas wells. Advances in oil foamers promise to expand the options for soapstick use. The economics of soapsticks, even those deployed by automation, are unmatched by any other technology in the operator's toolbox.

Table 1 - Flow Control & Soaping Schedule Guidelines

Quantities / Profile	# of Soapsticks per Launch Cycle	Time Between Launch Cycles	Flow Control Shut-in Time	Open Flow Time	Ratio of Flow Time to Off Time
Vertical Completions	1 on average	4 to 24 hours	None on average	24/7 on average	100% on average
Horizontal Completions	3 or 4 on average	18 to 48 hours	8 to 24 hours	5 to 18 hours	35% on average

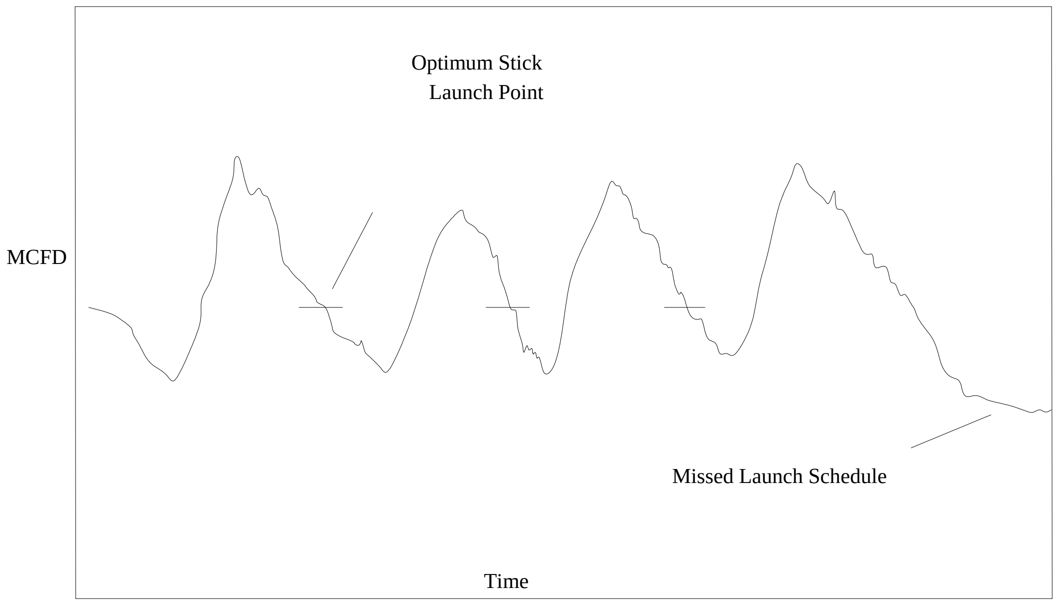

Figure 1 - Soaping Schedule, Continuous Flow in Vertical Well Bores

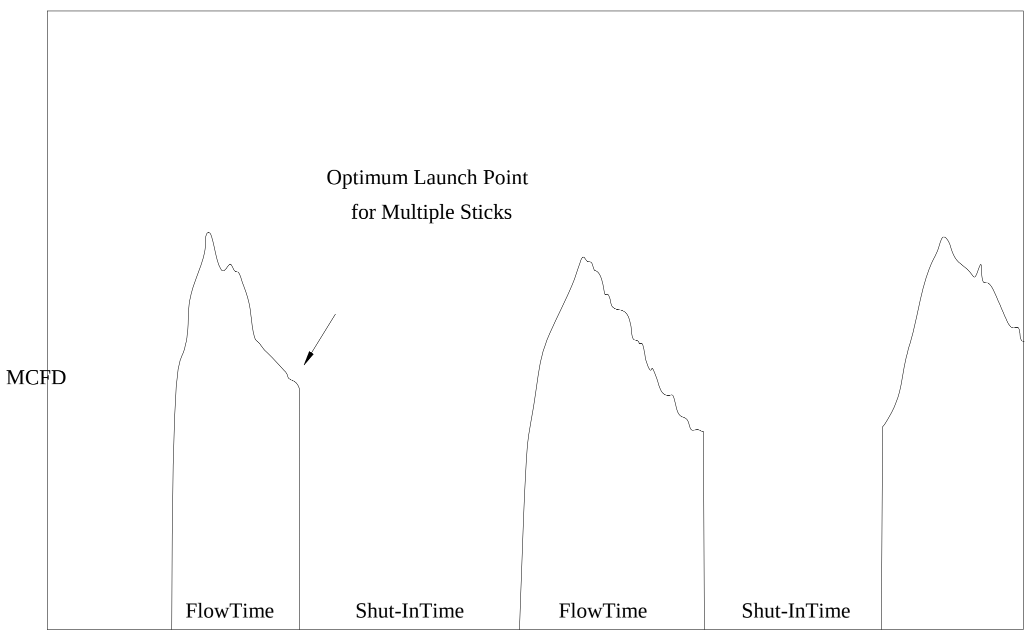

Figure 2 - Soaping Schedule, Intermittent Flow in Horizontal Well Bores

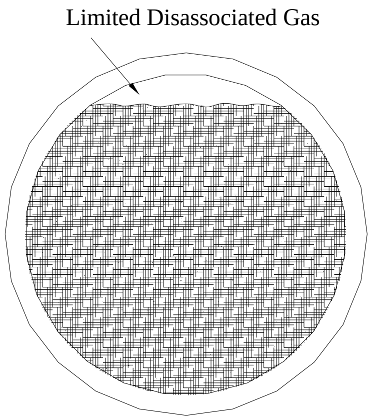

Figure 3 - Cross Section of Horizontal Bore in Flow Regime

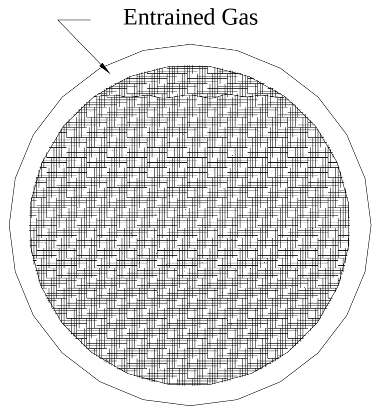

Figure 4 - Cross Section of Horizontal Bore, Extended Shut-In

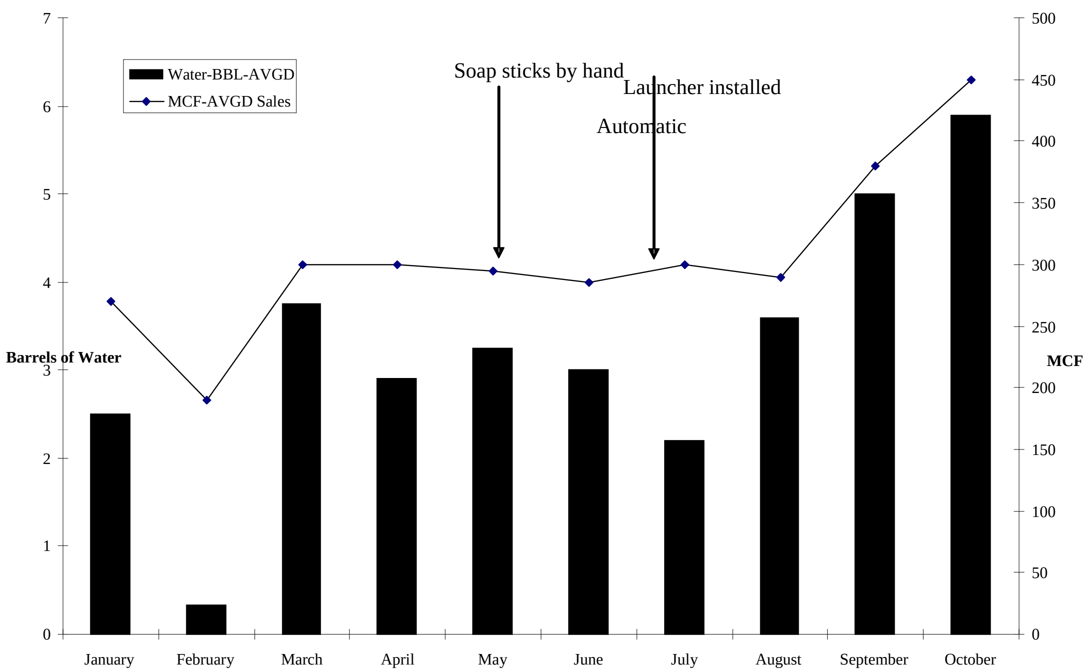

Figure 5 - Well #2 - Monthly Average Production

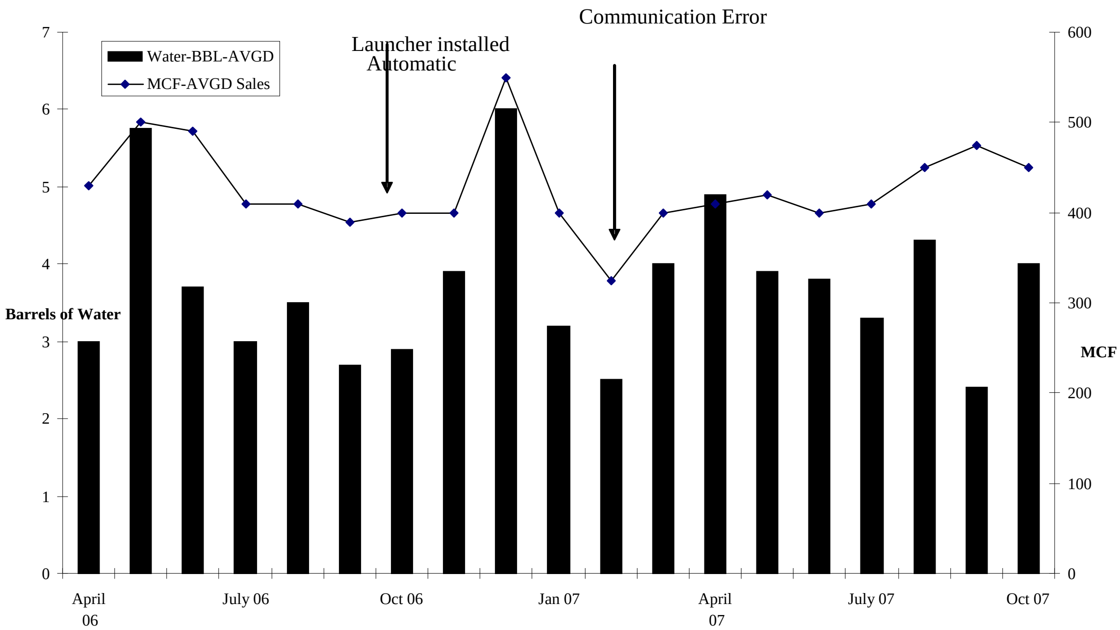

Figure 6 - Well # 3 - Monthly Average Production

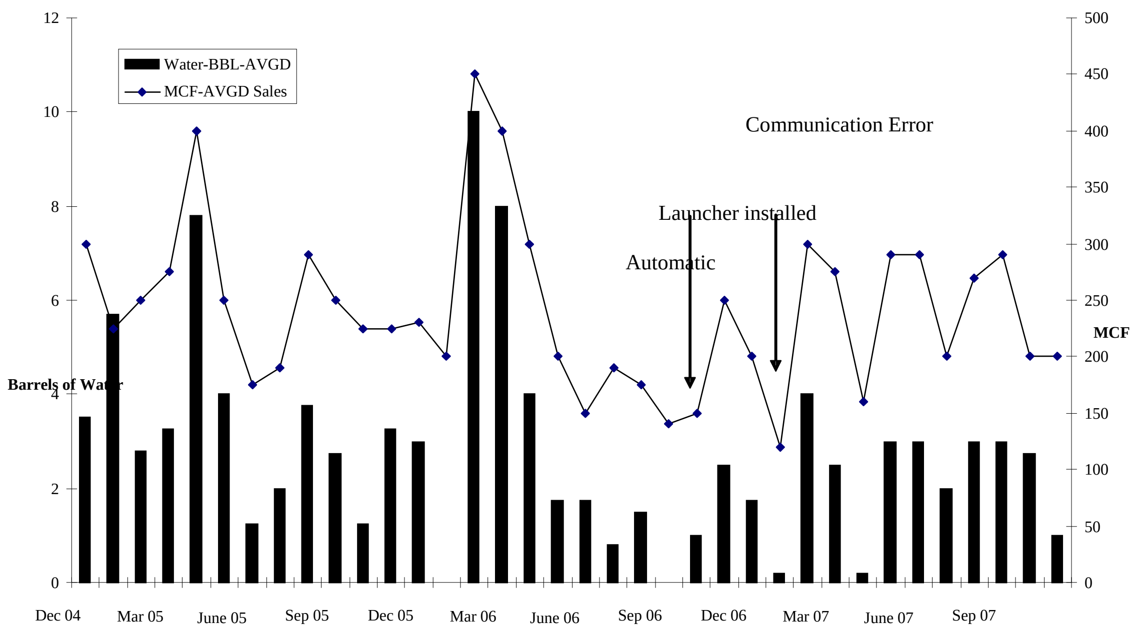

Figure 7 - Well #4 - Monthly Average Production