VARIABLE SPEED DRIVES CAN REDUCE BEAM WELL FAILURE FREQUENCY

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ABSTRACT

Variable Speed Drives (VSDs) have numerous advantages over wells that operate using pump-off control (POC); however, the capital cost to purchase, install, and maintain VSDs often discourages operators from increasing their use. A study of 81 wells with VSDs producing from the San Andres formation in the Permian Basin shows they can substantially decrease failure frequency compared with wells operating under POC, with negligible impact on production volume or operating cost. These VSDs were installed on Permian Basin wells at a depth of approximately 5,000 ft.

VSD FUNCTION AND USES

VSDs, sometimes referred to as VFDs (variable frequency drives), function by measuring pump fillage in the downhole dynamometer card and varying the strokes per minute (SPM) accordingly. As pump fillage decreases, the VSD will slow the unit's SPM; conversely, it will increase SPM as pump fillage increases. Unlike normal pump-off control (POC), when the unit cycles off after incomplete pump fillage, the result of VSD operation is continuous pumping operation.

VSDs can be a useful application in complicated producing environments such as:

- Wells producing significant solids, when cycling off can result in solids falling on top of the plunger,
- Gassy wells dealing with incomplete fillage at the beginning of downstroke,
- Water-alternating-gas (WAG) flood environments, where total liquid production varies with injection cycles, and
- Avoiding significant rod string buckling at pump-off.

All these conditions can lead to increased failure rates (see Reference 1). VSDs provide a unique solution by varying SPM to match reservoir inflow while avoiding dangerous conditions at pump-off.

IMPACT ON FAILURE FREQUENCY

Failure frequency (FF) is defined as:

$$FF = \frac{\frac{\#\,Failures}{Well}}{Year}$$

Failure frequencies before and after VSD installation were measured for 64 of the 81 VSD wells in this study. The other 17 wells were omitted because there were insufficient data for the FF calculations. The VSDs were installed between 2007 and 2017.

The length of time that FF was measured was the same before and after installation.

$$\Delta t = t_{present} - t_{install}$$

$$t_{pre} = t_{install} - \Delta t$$

"Pre" and "Post" VSD failure frequencies are defined as:

$$FF_{pre} = \frac{\# \, Failures_{t_{install} - tpre}}{t_{install} - t_{pre}}$$

$$FF_{post} = \frac{\# \, Failures_{t_{present} - tinstall}}{t_{present} - t_{install}}$$

The average FF_{pre} of the population was 0.84 failures/well/year, and the average FF_{post} was 0.37 failures/well/year, or a 56% reduction in FF. Also noteworthy is the change in fluid production over those time durations. The average pre-install production for the population was 215 BPD + 96 Mcfd, whereas the average post-install production was 168 BPD + 148 Mcfd. The field was responding to CO_2 injection, which results in a total fluid decrease. One could argue that not only did the VSDs lower the failure frequency of the well population, but they also did this as the reservoir shifted towards a gassier, more operationally difficult environment due to maturing WAG floods.

PRODUCTION IMPACT

There are concerns that operating with VSDs could result in decreased oil production. To contextualize this issue, it is important to examine the productivity index formula (see Reference 2):

$$Q = J * \left(P_e - P_{wf}\right)$$

$$Q = Surface\ flowrate\ at\ standard\ conditions, STB/D$$
$$J = Productivity\ Index, \frac{\frac{STB}{day}}{psi}$$
$$P_e = External\ boundary\ radius\ presure, psi$$
$$P_{wf} = Well\ sandface\ midperf\ pressure, psi$$

As long as there is significant reservoir pressure, P_e will be great enough to minimize any impact on Q as a result of a small hydrostatic increase in P_{wf}*.* For wells with a low oil cut, only a fraction of the Q reduction will represent any oil loss. Most importantly, proper surveillance of VSD wells to ensure that fluid levels do not get too high will help mitigate the production loss. If programmed correctly, VSDs might lower the average P_{wf} because they operate at various percentages of incomplete fillage, whereas the POC shuts down at incomplete fillage and allows the pressure to build.

For the 64 wells in this study, the three-month average production shows a median of -1% change and a mean of +5.6% change in total reservoir barrels produced after VSD installation. There was a median of -4.7% (-0.4 BOPD) and a mean of +7.6% (+0.6 BOPD) change in oil production after VSD installation. The change in production is negligible, if not within the degree of measurement error; the reduction in FF easily offsets this production loss for wells in this study.

SURFACE MAINTENANCE AND DOWNTIME

To study the surface maintenance impact of VSDs, all 81 wells with VSDs and all 1540 wells running with POCs were examined. When considering only motor- or POC-related issues, VSD wells had 2.35 issues/well/year for a cost of $894/year, whereas POC wells had 2.07 issues/well/year for a cost of $489/year. The small increase in maintenance cost is marginal compared with the reduced operating costs due to lower failure frequency.

Over the course of a calendar year, the VSD wells averaged only 2 hours/well/year more downtime related to electrical or automation issues than the POC wells.

CONCLUSION

Operators should pay special attention to any electrical impact that VSDs may have due to harmonic disturbance. VSDs offer a unique solution to difficult pumping environments. While well candidate selection is key, they offer the opportunity to reduce failure frequency significantly. The reduction in failure frequency outweighed any production and surface maintenance costs that came with VSD operation in this study. Using average failure costs and ignoring the negligible production variances, the VSD wells paid off the capital expenditure in ~1.5 years with an ROI of ≥100%.

REFERENCES

1) Beam Well Manual, Occidental Petroleum in-house report, Revised 2017-11-23, Pages 36-37.
2) https://petrowiki.org/Productivity_index_(J), retrieved 2019-02-20.

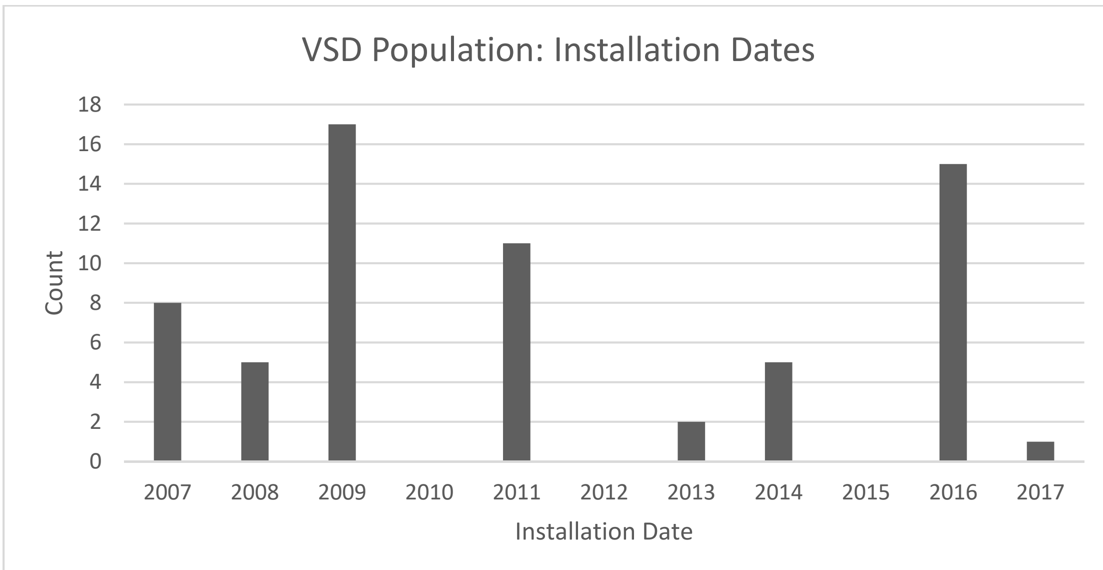

Figure 1: VSD Installations by Year in This Study

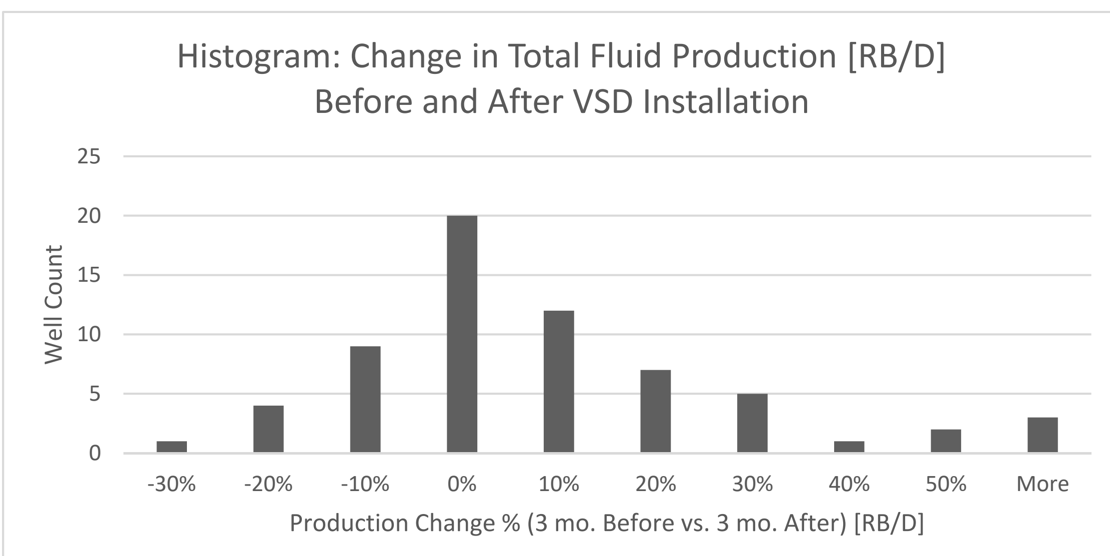

Figure 2: Change in Total Fluid Production Pre- and Post-VSD Installation

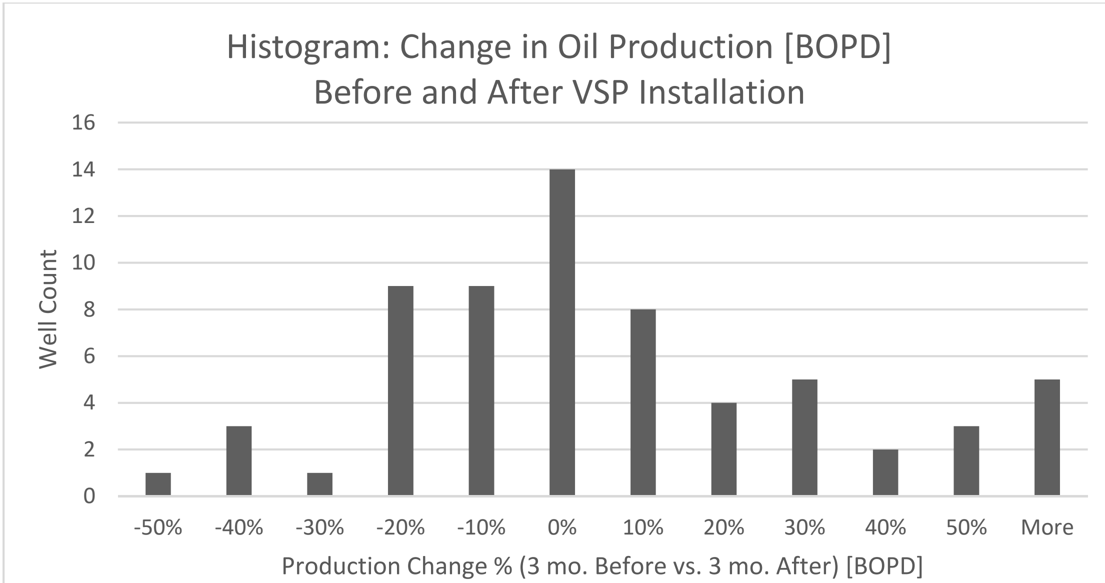

Figure 3: Change in Oil Production Pre- and Post-VSD Installation