REDUCING FLUID POUND EFFECTS WITH A DOWNHOLE CUSHIONING DEVICE

David Hobgood
Fiberflex, Inc.

Abstract

The downhole cushioning device can reduce fluid pound effects on sucker rod strings. The tool studied in this paper is compact and simple. It is placed in the rod string above the pump to absorb shock waves. This should help prolong equipment life and reduce operating expenses.

The cushioning device uses a piston and sleeve that fill with well fluid. Fluid enters the chamber creating a buffer to absorb and dampen shocks. Field data available at present indicate the device to be effective. Case histories show a reduction in rod failures after installation in problem wells.

Introduction

Fluid pound and gas pound are the result of incomplete liquid pump fillage. Ideally, artificial lift systems could be sized and maintained to match reservoir productivity. In most circumstances, sufficient reservoir information is not available to do this. Well conditions also change with time as fields deplete and undergo secondary and tertiary recovery adding to the complexity of the situation. Devices like pump-off controllers significantly decrease fluid pound problems but may not always eliminate it depending on how they are set. Gassy wells can also experience pounding problems as gas finds its way into the pump. A variety of situations can translate into partially liquid-filled pumps with a potential to pound fluid.

The cushioning device and shock absorber are not new inventions in the oilfield[1]. A variety of devices have been tried over the years. Most were installed at the surface between the carrier bar and clamp with a goal of decreasing maximum loads and increasing minimum loads by storing and releasing energy. The cushioning device studied in this paper is placed downhole in the rod string just above the pump. It protects the rods by interrupting the transmission of a shock wave.

Fluid Pound

Fluid pound is a hammering effect generated when the pump plunger collides with liquid in a partially liquid-filled pump. Several models have been developed to mathematically approximate fluid pound. The simplest model described by Juch and Watson[2] is:

$$F \sim 0.025VD^2(\gamma K)^{0.5}$$

where:

F = impact force (lb.)
V = plunger velocity (in/min)
D = plunger diameter (in.)
K = liquid bulk modulus (psi)
γ = liquid specific gravity.

Large diameter pumps and faster pumping speeds tend to worsen fluid pound as seen in the above equation. Juch and Watson[2] report impact forces of 1000 lb. and higher in some wells. This can significantly increase rod loading. Rod loads (measured in percent) are based on the difference between maximum and minimum stresses from a modified Goodman type diagram. The impact force reduces the minimum load thereby increasing the difference between maximum and minimum loads and raising the percent rod loading.

Fluid pound and gas pound are also associated with rod buckling. According to Craft, Holden and Graves[3], buckling and flexing considerably shortens sucker rod life. Buckled rods collide with tubing, rubbing thin places that develop into tubing leaks. Shock waves may also jar threaded connections loose causing additional repairs and expenses. Fiberglass rods, that can not withstand compression loads, may become cracked by fluid pound shock waves leading to premature failure.

Reducing Fluid Pound Problems

Solutions to fluid and gas pound problems include the following:

- Slow pumping speed to match artificial lift capacity and reservoir productivity.
- Install a pump-off controller with appropriate settings.
- Install a timer to reduce capacity.
- Pin pumping unit in shorter crank position to reduce displacement.
- Install a smaller diameter pump.

Resources and information may not always be available to solve fluid pound problems. A downhole cushioning device can offer supplemental protection in such cases.

Cushioning Device

The downhole cushioning device is a piston assembly that travels 1.5 inches as it pumps well fluid in and out of the chamber. There are a series of holes drilled into the sleeve allowing free movement of fluid.

There are three components that make up the device. The first is a top pin assembly that is threaded for a coupling on the upper side and threaded to screw into the sleeve on the lower side. The second component is the sleeve or barrel. It is threaded on the upper side but has a square pattern cut in the lower end. The center portion is hollow and serves as the piston barrel. The third component is the piston and lower pin assembly. The piston and pin are connected by a square section that matches the lower part of the sleeve. The entire device is about one foot long.

The cushioning device serves as a mechanical buffer but does not absorb the entire shock wave. It dampens the shock enough to offer some protection to the rods. Gearboxes, tubing and other artificial lift components should also benefit. It is run like a shear tool above or near the pump. Well spacing is unaffected by the cushioning device.

Results And Data

Data from 22 wells operating with the cushioning device was studied to determine its performance. Well histories "prior to" and "after" installation show dramatic results. All of the subject wells are located in the Permian basin of West Texas and are suspected to have a history of pounding or other problems.

The data was examined to see what if any effect the cushioning device had on rod part frequency. Wells with histories that invalidated their data were discarded. Examples of this included replacing rod strings and insufficient data. Ten of the 22 sample wells had usable data.

A significant improvement was noted in the ten wells "after" versus "before" installation of the cushioning device. Rod part frequency decreased in nine of the ten sample wells. Figure 1 shows rod part frequency before and after installation. The well conditions, pumping system configurations and rods remained essentially unchanged during the study period.

The overall results show a substantial improvement averaging 1300 days per part with the device versus 295 days per part without it. This represents a significant cost savings to the operator.

Future Work

Empirical results indicate that the cushioning device can be effective in protecting rod strings. Increased run time between rod parts should be attributable to the cushioning device since all other well parameters were held constant. Additional quantitative information from other wells should be the next logical step. A larger sample could increase confidence in these findings. Also, a dynamometer might be useful to verify loading before and after installation in a well suspected of fluid or gas pound.

Conclusions

The downhole cushioning device acts as a shock absorber to dampen shock waves from fluid or gas pound. A sample of ten problems wells indicates substantially fewer rod parts were realized by installing the device. A significant cost savings resulted from fewer pulling jobs. The tool is placed in the rod string above the pump like a shear tool. Benefits to other artificial lift components such as the gearbox and tubing should be expected but are harder to quantify.

References

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2. Juch, A. H., and Watson, R. J., "New Concepts in Sucker Rod Pump Design", Presented at the SPE Annual Fall Meeting in Houston, Texas, Sept. 29 - Oct. 2, 1968.

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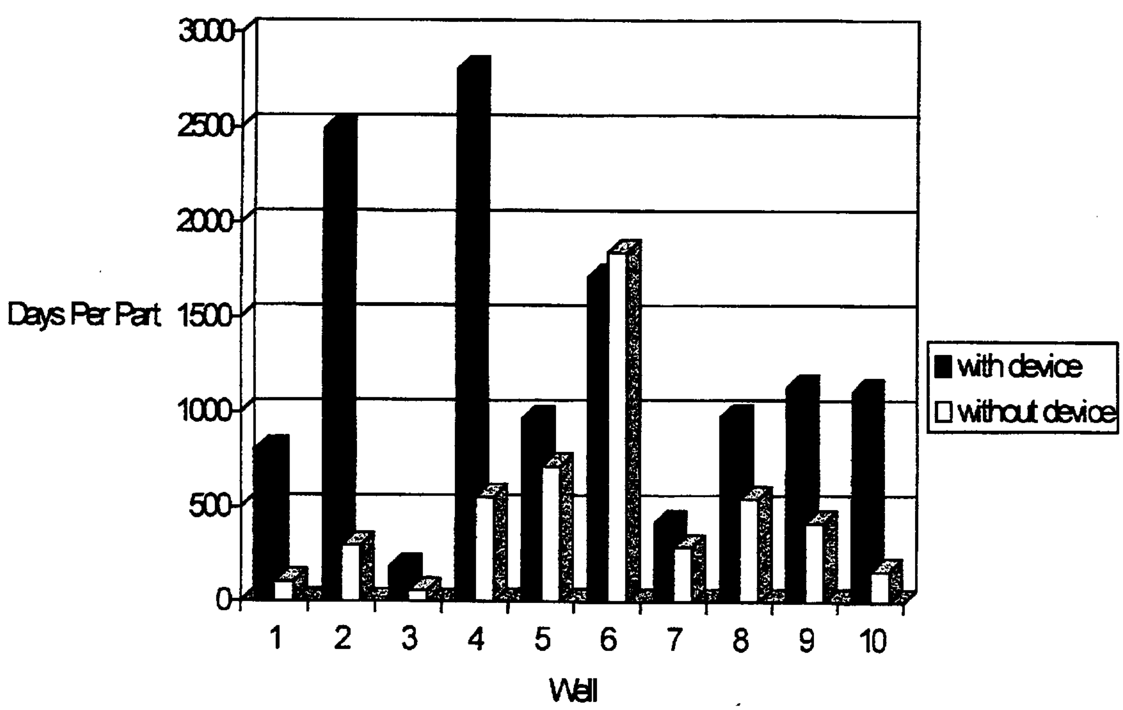

Figure 1 - Rod Failure Frequency