REPLACING BRIDGE PLUGS CAN LEAD TO COST SAVINGS WITHOUT SACRIFICING PRODUCTION

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ABSTRACT

The most common completion method in horizontal shale wells is plug-and-perforate. The proper use of plugs can result in an effective well stimulation with high reservoir contact. However, the use of plugs has many drawbacks, such as the potential of premature setting, difficult and costly drill-out in extended-reach laterals, and plug costs. Perf PODs were used to replace all 55 frac plugs in one of 11 wells on a pad. The frac design was the same on all wells on the pad to allow a comparison of the two methods. Pressure responses were observed after POD deployment throughout the job, indicating that isolation of the previously stimulated stages was maintained. Production from the Perf POD well was among the best of the pad, demonstrating the effectiveness of plug replacement with Perf PODs.

INTRODUCTION

The plug-and-perforate completion method is an industry standard that uses a single wireline run to set a bridge plug for isolation and perforate the next interval/stage prior to fracture stimulation. The wireline assembly, when used in horizontal applications, is pumped downhole to reach the desired depth and then pulled to surface after perforations are made. Plug spacing has been a major industry topic; most trends over time show reduced spacing with more plugs per completion. This tighter spacing is primarily due to the evolution of fracturing-treatment design, with the goal of maximum reservoir contact resulting in optimized production.

Horizontal completions have allowed the operator to penetrate a greater length of the reservoir, offering a significant production improvement over a vertical well. Due to the extended lateral lengths of some completion designs, the intervention portion of the completion is reaching its limits. Coiled tubing's maximum reach constraints require the use of vibratory tools to alleviate pipe friction, along with the addition of chemicals to aid in debris removal and friction reduction. Drilling out with a workover rig can overcome the lateral reach limitation of coiled tubing, but at a significant cost in time. The additional costs associated with extended-reach laterals has many operators looking for a more innovative and cost-effective solution.

Increasing the stage count across a lateral delivers additional reservoir contact, allowing operators to optimize design parameters for higher production. The use of high numbers of bridge plugs to isolate between each stage, and the concomitant difficulty and expense of extended-reach, post-frac intervention; now has operators looking to dissolvable technology.

The use of dissolvable plugs provides an alternative to completion designs based on composite plugs. Dissolvable plugs are intended to degrade in a certain amount of time to eliminate the need to drill out the plugs post frac. Dissolvable plug degradation relies on exposure time either at an increased bottom hole temperature or in an electrolyte solution (e.g., salt water), or both.[1] If the temperature is higher than expected, plugs that contain degradable plastic may degrade too rapidly. Similarly, magnesium plug parts will corrode faster than expected if the salt concentration is too high.[2] As an isolation tool, dissolvable plugs are required to maintain integrity for the duration of the fracturing treatment stage. Failure of a dissolvable plug that results in part of the treatment entering a previously treated zone has been reported.[3] Well conditions that result in delayed or incomplete dissolution of the plugs may require the use of a bottom-hole assembly to clean out remaining plug components. The added expense for a dissolvable plug in addition to the unplanned cleanout operation increase overall costs to complete the well.

Utilizing Perf PODs to plug or isolate individual perforations allows operators to not only eliminate bridge plugs, but also divert the frac stimulation from the dominant clusters into under- or unstimulated perforations. Eliminating the need for bridge plugs while maintaining the advantages of closer stage spacing (e.g., contacting more of the productive formation) ensures the most cost-effective use of the wellbore design. The risk of a prematurely set plug while performing a wireline pump-down can be drastically reduced or eliminated; along with routine costs associated with plugs, including pump down time, completion costs, and resources associated for the corresponding wireline runs and subsequent cleanout operations. Replacing bridge plugs also addresses the limitations of the intervention process and the extended-reach constraints of coiled-tubing cleanouts.

CASE STUDY

With wellbore diameter restrictions (e.g., casing patch, partial collapse), modifications to the standard completion design are often required, including the use of specialty tools and equipment. The diameter limitations restrict the use of a standard sized bridge plug, due to clearance needed while pumping the wireline BHA into the wellbore. The use of a reduced OD bridge plug often allows the operator to maintain stage spacing, cluster design and stimulation volumes as per their original well design. However, the cost associated with the specialty bridge plugs, as well as the additional limitations for removal post frac, make this option difficult to justify.

An operator replaced all bridge plugs with Perf PODs, deployed between each frac stage to isolate and divert the flow to the next interval of perforations. By isolating each perforation individually, the entire wellbore was efficiently stimulated, attaining more reservoir contact with an improved cluster efficiency. The Perf PODs were deployed to divert the flow from the dominant perforations and provide breakdown of the less-dominant or under-stimulated perf clusters within each interval.

The original well design of 55 stages was maintained, with 200-foot stage spacing and 50 feet between clusters. The operator was able to maintain the designed pump schedule ensuring each interval was stimulated with the same volumes as neighboring wells in the field. Following each frac interval, the wireline guns were pumped downhole, without a bridge plug, to shoot the next interval of perforations. Degradable Perf PODs were deployed from surface as a preface, during the pad phase of the subsequent frac stimulation. By modifying the initial pump rate during pad, the pressure remained below the calculated frac gradient, thus ensuring all Perf PODs were circulated down past the new perforations to the lower interval previously fractured. Perf PODs seating inside the dominant perforations contributed to an increase of pressure, indicating the flow had been stopped and redirected to other perforations. Once treating pressure increased above the calculated frac gradient additional perforations were opened up to be stimulated for the next interval.

With bottom-hole temperature as the leading contributor to degradation of the Perf POD material, choosing the correct degradation range is critical in maintaining isolation for the duration of the frac stimulation, as well as ensuring adequate degradation quickly after the conclusion of the frac. The Bio-Rez® Hi material was selected for this operation, based on the BHST of 220 °F. The Perf PODs maintained complete isolation to the toe of the well for the entirety of the 10-day operation. Post frac, the operator elected to perform a coiled tubing cleanout to ensure all sand had been cleared out of the wellbore and bring the well onto production. No residual Perf POD material was seen on surface or in the production equipment, confirming the degradation timeline of the Perf PODs at corresponding bottom-hole temperature.

The remaining 10 wells on this pad were completed following the standard plug-and-perforate method, isolating with a composite bridge plug between intervals. Perf PODs allowed the operator to effectively stimulate the entire wellbore as designed, while reducing overall completion costs and eliminating the risks associated with setting and removing reduced OD bridge plugs. Monthly oil and gas production was available for the 11 wells on the pad and are shown in Figures 1 and 2, respectively.[4] Where Perf PODs were used to replace bridge plugs on one well, production compared favorably to other wells on the pad. These results demonstrate the effectiveness of Perf PODs in bridge-plug replacement.

CONCLUSION

Replacing bridge plugs provides an initial cost savings, as well as risk reduction, to the standard completion plug-and-perforate method. By eliminating the requirement of a bridge plug as an isolation tool between intervals, Perf PODs can contribute to an increase in reservoir contact and cluster efficiency. Perf PODs provided effective isolation between frac intervals without the use of plugs, resulting in achieving the expected production rates when compared to the other wells in the field having the same well design. Even in extended-reach laterals when total plug replacement is not planned, Perf PODS can still provide substantial benefits. Simply using Perf PODs to replace plugs from the toe back to the depth where coiled-tubing intervention is practical (and from that point using either plugs or Perf PODs as desired) reduces risk and yields substantial savings in both time and expense.

REFERENCES

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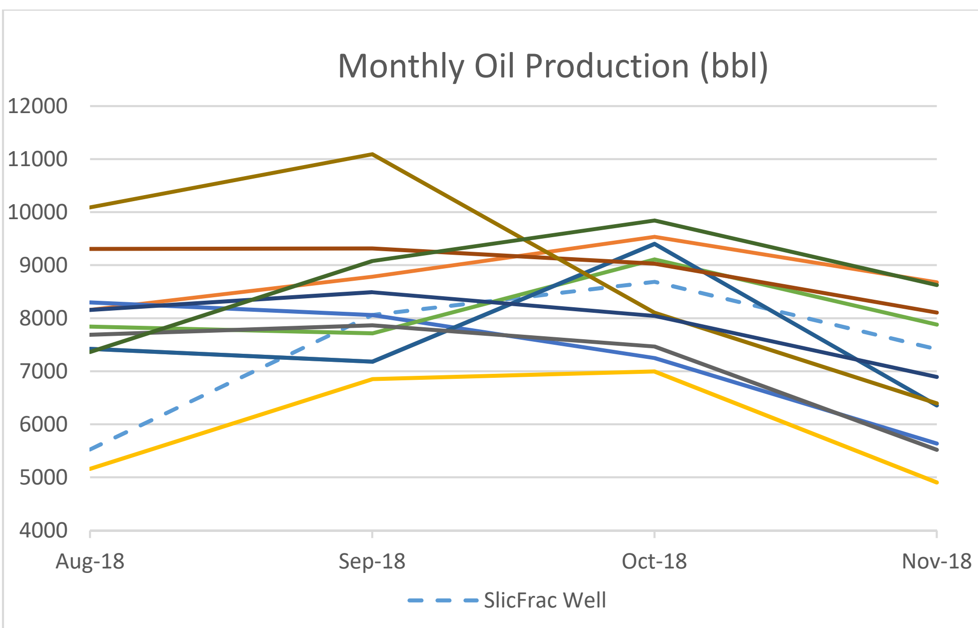

Figure 1 – Monthly Oil Production (bbl)

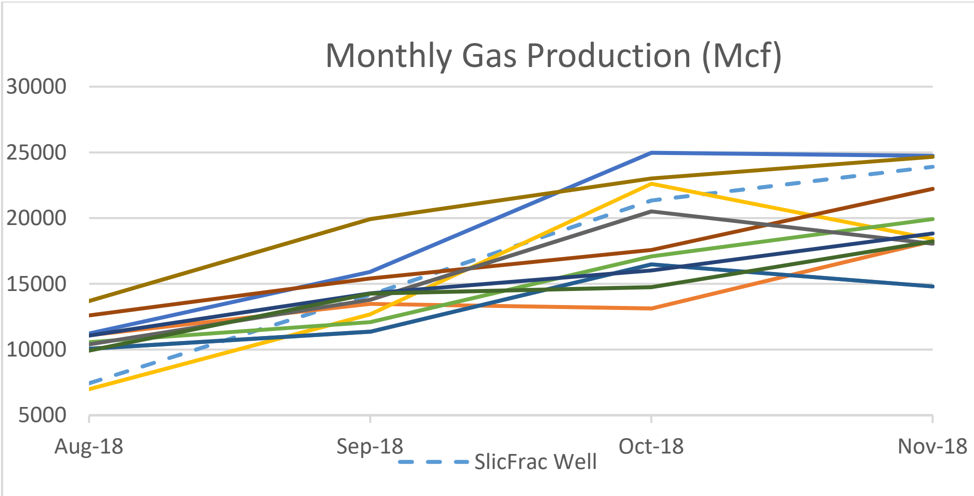

Figure 2 – Monthly Gas Production (Mcf)