SAND FLUSH PLUNGER PERFORMANCE IN THE HWY 80 FIELD, CASE STUDY UPDATE

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ABSTRACT

The performance of Harbison-Fischer's patented Sand Flush Plunger (SFP) was assessed relative to the average runtime for standard API plungers in the HWY 80 field, operated by Pioneer Natural Resources (PNR). The field case study captured information from Harbison-Fischer's pump-tracker for 5,283 wells and 32,804 workover records dating back to 1989. As of the record date, 1,934 different wells had used an SFP 3,473 times. The analysis focused on 194 wells, for each of whom the data showed at least one failure originated by the pump for each of the two plunger types. The average runtime for the SFP and the API plungers were found to be 1,178 days and 579 days respectively.

The present study constitutes an update on the continuous monitoring of the performance of the SFP that has been carried out in HWY 80 field since 2015 [1]. The number of wells considered for calculating the average runtimes has gone up by 37 wells from 157 reported in 2015. Similarly, the number of qualifying pump changes has increased by 102 from 486 reported back in 2015. The data processing has been carried out using Tableau, and slightly different criteria for cleaning the records have been implemented.

SAND-DRIVEN ABRASION

The volumetric efficiency of a sucker-rod pump is determined by the design of the mechanical seal provided by the precision fit between the highly-polished surfaces on the plunger outside diameter (OD) and the barrel inside diameter (ID). The fit and the length of the plunger are sized to regulate the slippage flow for specific well conditions, such as the pump setting-depth and the oil viscosity, among other factors and preferences of the operator. The differential pressure across the plunger causes the slippage flow, and in a conventional API standing-barrel pump configuration it is only present during the upstroke stage of the pump stroke. The slippage flow is needed for cooling and lubricating the seal of the pump, but ideally, it should not exceed approximately 5%-10% of the produced fluids, so the overall efficiency of the system is not compromised [2,3].

The volumetric efficiency of the pump degrades over time due to the deterioration of the sealing surfaces on the barrel and the plunger, being sand-driven abrasion one of the most common causes. When the slippage flow drags sand particles into the clearance formed by the barrel ID and the plunger OD, the sand particle being typically harder than the spray-metal coated surface of the plunger and larger than the barrel-plunger clearance, will cause grooves on the plunger surface starting on the top and extending downwards. The barrel is also subject to abrasion, but it usually degrades at a slower rate than the plunger because of the case hardening, the Chrome plating, or the Nickel-Carbide plating applied to the ID surface, which are usually preferred over a non-plated steel or brass barrel when operating under extremely harsh conditions. The barrel being usually much longer than the plunger distributes the wear over a larger surface area, which also contributes the comparatively longer life of the former compared to the later. The lower-than-expected production resulting from the poor efficiency of the pump may be compensated with an increase in the SPM of the pumping unit, although this approach is often limited to wells with some automation built-in. The timing for replacing a pump operating at a low efficiency depends ultimately on the economics of the well as assessed by the operator.

Frequently the fit of the plunger will be chosen so that particles up to a certain diameter will be allowed to travel freely through the clearance, causing minimum damage to the sealing surfaces of the pump on their way. This approach, however, is reserved for dealing with very fine sand, and it is somewhat counterproductive for dealing with coarse sand because the extremely loose fit required will result in a prohibitively high slippage flow rate. Multiple approaches for extending the life of the mechanical seal in sucker-rod pumps working in sand-laden fluids have been discussed in the literature and among these proposed solutions is the SandFlush plunger [3].

THE SANDFLUSH PLUNGER

The SFP is a patented plunger design (patent # 8,535,024) manufactured by Harbison-Fischer (HF) that has been in the market since 2009. The SFP was designed to improve the runtime of pumps working with sand-laden fluids by washing out the sand particles away from the plunger top leading edge, reducing the amount of sand that will be dragged by the slippage flow into the barrel-plunger clearance; hence, extending the life of the metal seal of the pump [4].

The SFP design aims at reducing the amount of sand particles accumulating near the plunger's top leading edge through the combined action of the distinctive nozzle ports and the scrapper, both located on the top of the plunger. The nozzle ports accelerate and direct the production flow during the downstroke forming 6 jet-flows that will impinge on the internal surface of the barrel, washing out material that may have settled and inducing substantial turbulence that keeps the sand particles in suspension. On the other hand, the distinctive scraper profile mechanically removes particles away from the barrel-plunger clearance during the upstroke.

Besides the nozzle ports and the scrapper, which were engineered to actively fight the accumulation of sand during the downstroke and the upstroke respectively, the SFP also incorporates a passive feature that helps to mitigate the amount of sand that will ultimately be dragged by the slippage flow. Unlike API plungers, the SFP connects directly to the valve-rod eliminating the need for a top-bushing, thus, eliminating the void space between the plunger top connection and the bushing. This void space is critically located next to the plunger leading edge, and it serves as a repository for sand particles, which from there can be easily dragged into the barrel-plunger clearance either by the slippage flow or by the relative movement of the plunger with respect to the barrel.

The SFP is offered in all the API sizes but 1-1/4" is by far the most commonly used. The SFP can operate in corrosive environments thanks to its top stainless-steel connector and bottom Monel pin. The current SFP design is not recommended for environments with high H_2S concentration; however, an H_2S tolerant design will begin testing during Q1 2019.

HIGHWAY 80 FIELD STUDY

Highway 80 field is operated by Pioneer Natural Resources (PNR) using HF pumps assembled by Tommy White Supply (TWS). The SFP was formally introduced to the field in 2009, and as of July of 2018, 1,482 different wells had used it a total of 2,489 times. The performance of the SFP in Highway 80 field has been closely monitored since 2015 when TWS shared with HF their pump-tracker data containing pump repair records dating back to 1989. The present publication is a continuation of the study that was presented at this same conference in 2015, which has been updated to reflect pump repairs performed between July of 2015 and July of 2018.

The pump-tracker data, as received in 2018, was cleaned and merged with the data that had been previously processed in 2015. Special attention was put into the merging of the two databases, as the data was formatted differently due to the transition to a new pump-tracker software that took place in 2015. For instance, different spellings of the same well name were found in 185 wells, which were algorithmically detected and manually consolidated using Tableau. In the present study, all the records not reporting a run time, or the run-time being less than 15 days or more than 10,000 days were excluded. Moreover, following the methodology of the study presented in 2015, each record was assigned one of the following pull reasons: *pump, tubing, rod,* or *unknown.*

The workover activity in HWY 80 field has varied drastically over the past 10 years following the trends of the industry, as it is illustrated in Figure [2]. A record high in the number of pump changes for the last ten years was reached in 2013, with nearly 1,400 WO for the calendar year, while a record low for the same period took place in 2016 with only 600 pump changes. The apparent decline in the number of pump changes during 2018 is explained by the fact that the data only reflects the first 6 months of the year. In 2012, the number of pump changes on pumps using an SFP surpassed for the first time the number of pump changes using API plungers, only 3 years after SFP was formally introduced to the field. Moreover, for the past 3 years, the utilization of the SFP has continuously exceeded the utilization of API plungers. Wells with high concentrations of H_2S still require the utilization of standard API or Monel-pin plunger.

Since 1989, 5,283 different wells have had at least 1 pump of any type installed, for a total of 31,804 pumps changes. Out of the total number of wells, 3,349 wells have only run API plungers, and 732 have just run SFP; thus, their run times are not suitable for direct comparison. The total number of wells that have run both types of plungers was found to be 1,202. See Figure 3.

After careful processing and analysis of the data for the 31,804 records, and for the purpose of providing a fair performance comparison between the two plunger types while isolating as many external factors as possible; it was decided to concentrate only on 5,930 records for which the pump was the reason for the pulling, thus, excluding from the analysis all the records with pull reasons such as *tubing, rod,* and *unknown*.

Figure 4 and Figure 5 show the number of pump changes grouped by the reason that originated the intervention to the well. Figure 5 shows information only from the 1,202 wells that have used both plungers, whereas Figure 4 shows data from all the 5,283 wells in the database. A quick look at Figure 5 shows that approximately 25% of the pump changes are due to a rod failure, 50% are due to a tubing failure, 8% are attributed to miscellaneous or unknown factors, and only about 17% are due to a failure of the pump itself. To the best of our knowledge the 1,202 wells under consideration have not received any special treatment that may have selectively affected the runtime of the pump; moreover, the similarity between Figures 4 and 5 proves this subset of wells statistically aligns with the behavior observed from the entire population of wells in HWY 80 field.

The present study implicitly assumes that every pump failure is due to a plunger failure, that is because the pump-tracker data does not allow for a more specific diagnostic of the condition of the plunger to be done at a massive scale. The *comments* section on some records does contain information on the condition of the plunger, but the interpretation of such comments becomes extremely challenging given the number of records and the qualitative and open-ended nature of this data field. As it can be observed in Figure 3, at most a quarter of all the pump changes are motivated by a failure of the pump, which means that all other factors set aside, and in the absence of data to massively evaluating the condition of the plunger alone, investigating the runtimes for the workovers motivated by pump failures provides the best estimation possible for the durability of each plunger type.

In that vein, the 31,804 records and 5,283 wells were filtered to include only those records meeting the following two conditions, 1) records from wells that have run both types of plungers, and 2) records originated by pump failures. The number of wells suitable for a direct comparison between the average runtime for each type of plunger further dropped to 194, that is, when considering only those wells with at least 1 failure due to the pump reported for each type of plunger. All the records meeting these conditions were used for calculating the average runtime for each plunger type.

For the 194 wells previously identified, the total number of pump changes was found to be 1,897, but only 588 (31%) of these were attributed to pump failures. This number of pump changes breaks downs as follows: 215 pump failures using the SFP, and 373 using API plungers. The average runtime for the 215 pumps using an SFP was 1,178 days, and for the 373 pumps using an API plunger was 579 days.

The number of wells useful for comparison in the present study is up by 37 from the 157 reported in 2015. Similarly, the number of useful workovers for the SFP and the API plunger are up by 45 and 57 respectively.

The average runtime for the API plunger is up by 36 days whereas the average runtime for the SFP is down by 119 days. The trend established in the 2015 study has maintained despite these minor changes in the runtimes for both plunger types, with the SFP still doubling the runtime of API plungers.

Looking into the 194 wells that have run both types of plungers, the SFP provided an increased runtime in 127 of these wells (65%), whereas the API plunger provided a longer runtime in 67 of them (34%). Extrapolating from the trend that has been established from wells that have run both types of plungers, it is expected that for installations that have never used an SFP plunger before, the odds of attaining a longer runtime would double when an SFP is chosen over an API plunger. HF, TWS, and PNR will continue to track the performance of the SFP and the API plunger in the HWY 80 field. An update on this study should be provided within a couple of years of this publication.

SUMMARY

The average runtime for pumps using SFP and API plungers was calculated from 194 wells that have run both types of plungers as of July 2018, using only the records reporting the pump as the reason for pulling the well. The average runtime for the SFP was found to be 1,178 days out of 215 pump changes. On the other hand, the average runtime for the API plungers was found to be 579 days out of 373 pump changes. The average runtime of the SFP doubles the average runtime of the API plungers in the HWY 80 field.

ACKNOWLEDGMENTS

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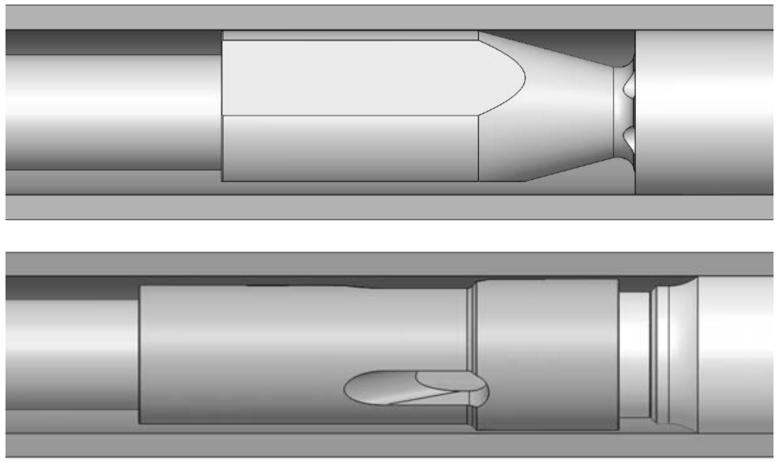

Figure 1. Top: Front view of the top end of the SandFush Plunger.

Bottom: Front view of the top end of an API plunger.

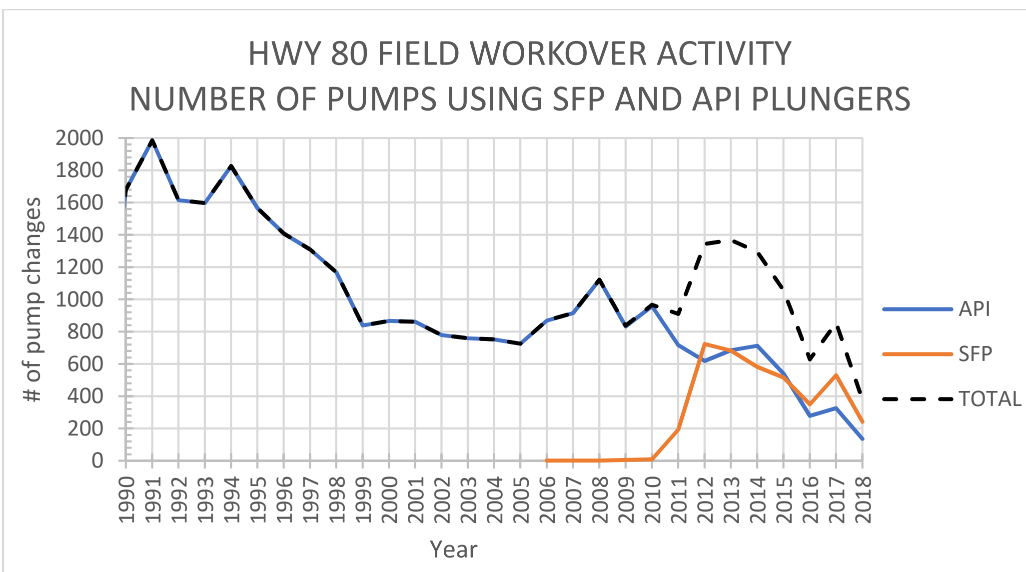

Figure 2. Overview of workover activity of HWY 80 field from 1990 till 2018.

Total number of pump changes for API and SFP are shown for each year.

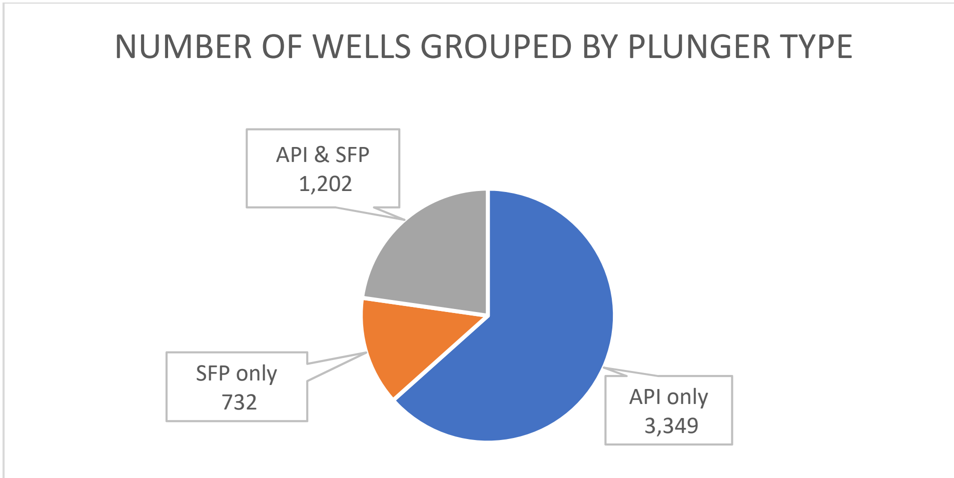

Figure 3. Distribution of the wells from HWY 80 field according to the plunger type(s) ever used.

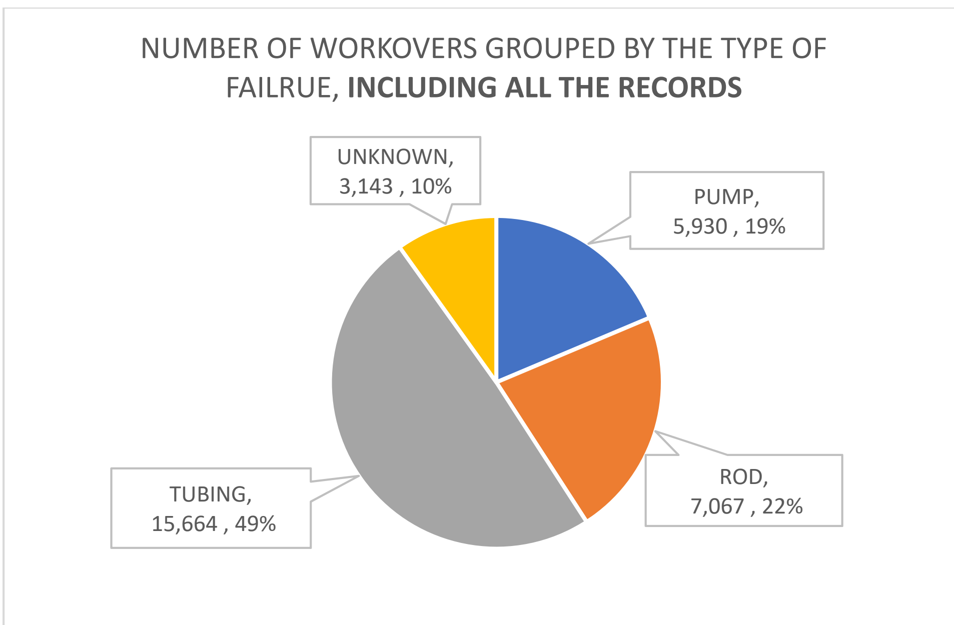

Figure 4. Pull reason distribution including all the records since 1989.

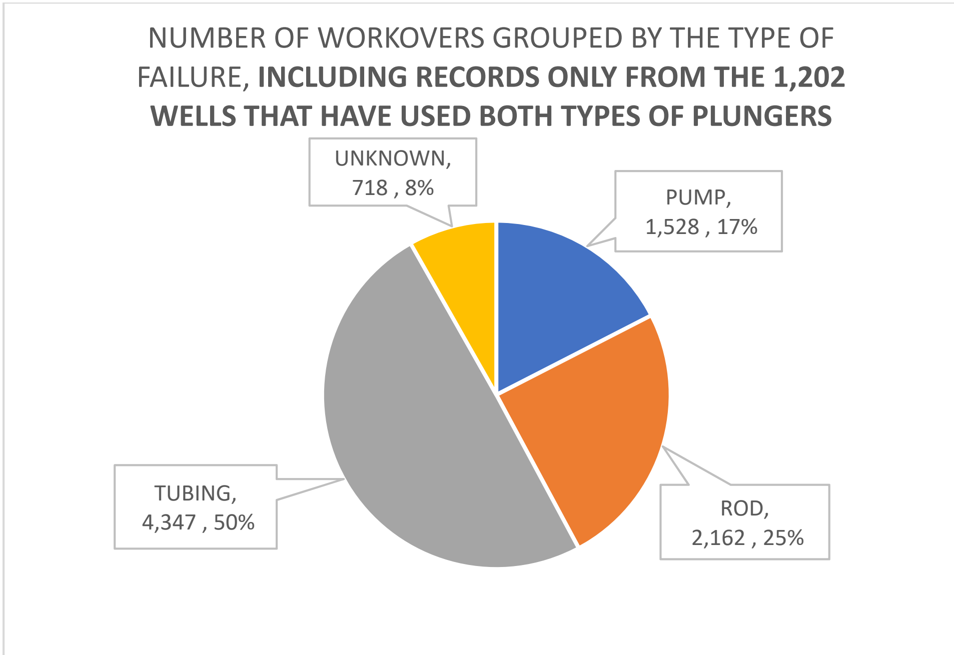

Figure 5. Pull reason distribution including only the records from wells that have used both the SFP and the API plunger.