Pump Stroke Optimization: Results of Four Well Bakken Pilot

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History of Pump Stroke Optimization

• Concept and data from two pilot wells first presented to industry at 11th Annual Sucker Rod Pumping Workshop in September 2015

• Case Study of 20 Well Pilot presented at Southwestern Petroleum Short Course in April 2016

• Those presentations based on Eagle Ford wells

• Four well Bakken test begun in January 2016
In vertical wells, small pump speed changes can quickly match pump capacity to production.

Horizontal wells have fluctuating flow regimes. Short-term events (waves, slugs) can “mislead” a rod pump controller into making unwanted speed changes, rapidly cycling between maximum and minimum pump speeds.

The result: Poor pump fillage
How do operators handle poor pump fillage today?

- By manually setting pumping speed
  - Limiting maximum pumping speed
  - Reducing the minimum pumping speed

- Described by Malone at the 2016 Southwestern Petroleum Shortcourse in “Case Study – Gas Interference, Manage or Mitigate”
  - Type 1 Well - Moderate gas interference
  - Type 2 Well - Severe gas interference

- Requires regular observation and adjustment
How Pump Stroke Optimization Works

- PSO device continuously “learns” how to run a pumping unit at its optimum speed for the well
- Learns RPC equipment setpoints on Minimum and Maximum Working Speeds
- Determines when the pumping unit is on the upstroke or downstroke
- Calculates average pumping speeds
- Counts frequency of “pumpoff” or low fillage events
How Pump Stroke Optimization Works

• Delivers an alternate speed signal to the VFD
  • Keeps the maximum speed more in line with the recent average pumping speed
  • Does not over-react to artificially or temporarily high pump fillage

• Frees up skilled personnel from manually performing this repetitive task for the life of the well
  • The primary reason that PSO was developed
How Pump Stroke Optimization Works

- PSO algorithms automatically change pumping speeds as wells
  - Deplete
  - Recover from a temporary downtime event
  - Recover from a chemical treatment/flush
  - Are enhanced (by offset fracs)
  - Lose pump efficiency from worn pumping systems
Additional Benefits of PSO

- For wells pumping between 2 and 5 SPM, PSO will provide additional substantial benefits:
  - Increased pump fillage
  - Decreased pump slippage
  - Reduced daily stroke count
  - Reduced power consumption
  - Better loading for the rod string

- How? PSO utilizes the full capabilities of the VFD
PSO decreases slippage, increases pump fillage, and is better for the rods

- For RPCs that permit a downstroke speed that is slower than the upstroke speed, the PSO preferentially reduces the downstroke speed
  - This can result in substantially less pump slippage
  - Less pump slippage translates into high efficiency and less strokes per day for same amount of production

- Other benefits of slow downstroke speed
  - More time for evolving gas to exit gas anchor
  - Higher minimum rod loads reduce buckling tendencies and allow for higher maximum rod loads
Example: Conventional unit setup to run 10 SPM, but only needs to run at 3 SPM

- On VFD, 3 SPM would be 30% of 60 Hz, or 18 Hz
  - Total stroke duration is 20 seconds
  - Upstroke duration is 10 seconds (50% upstroke duration)
- By increasing the upstroke speed in relation to the downstroke speed, less of the stroke duration is spent on upstroke
  - 6 SPM (36 Hz) on upstroke, a 5 second duration
  - 2 SPM (12 Hz) on downstroke, a 15 second duration
  - Total stroke duration is still 20 seconds with 3 SPM but the upstroke duration is now only 25% of each cycle, not 50% (5/20 instead of 10/20)
Example Results

- Upstroke duration drops from 50% to 25%, resulting in deleterious pump slippage reduction of 50%

- Downstroke duration increases from 50% to 75%, giving more time for evolving gas to exit the gas separator, increasing pump fillage

- Desirable downstroke pump slippage is increased by 50%, and will hasten the opening of the travelling valve, increasing pump fillage
Four Well Bakken PSO Trial

- PSO Devices installed on January 26, 2016
- Three wells pumping continuously
- One well pumping intermittently (Well C)
- PSO devices tied in to operators existing internet
  - Allowed monitoring algorithm performance over webpage (IoT – Internet of Things)
- 4 weeks pre-PSO data, 8 weeks post-PSO
- Before and after power consumption only measured for Well B
XSPOC Data – Well A

- SPM drop by 20%
- Fillage up 5%
- Decreased Low Fillage Events
Load and Stroke Data: Well A

Max load up 800 pounds

Min load up 1200 pounds

Down 1600 Strokes per day
5 Months Post PSO Data: Steady Performance by Well A

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2016 Sucker Rod Pumping Workshop
XSPOC Data - Well B, erratic producer due to undulating toe up lateral

- SPM drop by 20%
- Avg Fillage up 10%
- Low fillage events far less severe
Load and Stroke Data: Well B

Max Load Unchanged

Min Load Up Slightly

Well operator reported a 15% drop in power consumption at this well

Down 1000 strokes per day, 20%
XSPOC Data – Well C, erratic producer due to undulating toe up lateral (intermittent pumping pre-PSO)

Production up an average of 10 BOPD

MSE Algorithm divergence issues, swapped to alternate algorithm 3/10
Additional Data for Well C

Note fluctuating average SPM, sustained production increase, steady fillage of 95%, and few low fillage events following algorithm change.
Load and Stroke Data: Well C

Max load unchanged

Min load up 1500 pounds

Stroke count increase due to increased production
XSPOC Data – Well D

SPM drop by 20%
Avg Fillage up by 13%
Less sub-70 fillage events
Load and Stroke Data: Well D

Max load up 1000 pounds

Min load up 1200 pounds

Down 1200+ strokes per day, 18%
Conclusions

- Wells A, B, and D experienced 18 to 20% reductions in stroke count.
- Well C did not experience a reduction in stroke count as more strokes were required to pump the 10 BOPD production increase.
- All wells experienced average pump fillage increases ranging from 5 to 13%.
- Pump fillage now rarely below 70%.
- All wells had higher minimum rod loads.
Discussion

• The primary purpose of PSO was to free up the operators staff from the mundane task of frequently adjusting maximum and minimum working speeds.

• Secondary benefits of PSO is that aggressive slowing of the downstroke provides:
  – Less pump slippage (less strokes for the same production)
  – Greater pump fillage (less strokes for the same production)
  – Power reductions approximating stroke reduction %
  – Better rod loading with potentially less rod buckling
Discussion

• Please see last year’s Sucker Rod Workshop presentation “New Method to Reduce Pump Slippage” and “Pump Stroke Optimization: A Better Way to Operate a Rod Pumped Well”

• Industry still does not recognize that a much slower downstroke in relation to the upstroke yields the benefits listed in the previous slide
Discussion

• Current industry RPC products do not provide the primary purpose of PSO, freeing up the operators' staff from monotonous, repetitive data observation required to set working speeds.

• The PSO device does a better job than a human simply by performing this task 24/7.

• Isn’t that what automation is all about?
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Additional Well D XSPOC Data
Additional Well D Load and Stroke Data