JET LIFT BRIDGES GAPS BETWEEN VARIOUS FORMS OF ARTIFICIAL LIFT IN HORIZONTAL WELL LIFECYCLE

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BACKGROUND

This paper aims to share insights from a case history of jet lift applications in the Permian Yeso play. Apache Corporation was among the first operators to deploy horizontal drilling and multistage fracturing in the Yeso formation in Eddy County, N.M., targeting dolostone/limestone/sandstone reservoirs interbedded with shale and anhydrite. The Yeso yields oil and liquids-rich gas at depths averaging 5,000-6,000 feet.

Apache's initial strategy was to commence post-flowback production from fractured wells with electrical submersible pumps and then transition to rod lift as rates declined over time. However, as the wells approached the transition window between ESPs and rod pumps, high sand content, wellbore deviation and gas-to-liquids ratios caused frequent downtime for both types of lift, negatively impacting well performance.

SOLUTION

The operator installed a concentric string jet lift to counter these problems and accommodate the solids and GORs. This solution effectively bridged the application gap between high-rate ESPs in early well life and lower-rate rod pumps later in the lifecycle. One of the main advantages of this system, is the intake being positioned at the base of the curve, where the other alternatives would have required the intake to be located in the upper portion of the the curve.

Jet lift systems need isolation between power fluid and the return fluid, which is comingled production, and exhausted power fluid. A standard jet lift system utilizes a packer beneath the bottom hole assembly (BHA) to isolate the tubing and casing (see Figure 1). In a concentric string design, a seating nipple is run on the bottom of a larger production tubing (in this case 2.875") and a concentric string of a smaller O.D. is run inside, which lands on the seating nipple (in this case 1.66"). This seating nipple seal provides the isolation of injection down the smaller tubing string and return up the tubing/tubing annulus (see Figure 2).

The concentric string jet lift installation keeps many of the same benefits of a conventional jet lift system,with no moving parts downhole which givess the jet pump ability to handle the changing GORs and solids production. In the event of a downhole failure or design change, hydraulic retrieval of the jet pump allows for quick repairs and nozzle/throat combination adjustments. The advantage of the concentric string jet lift system over the standard in this field is the ability to set the BHA deeper into the lateral of the well and allows for gas ventilation up the tubing/casing annulus, similar to a rod lift completion.

The disadvantages of concentric string jet lift systems are the high frictional losses between the tubing/tubing annulus and the small size of the 1.25” jet pump. The combination of these constraints limits the maximum production of the system to approximately 500 barrels per day of production. In addition, the frictional losses and limited nozzle/throat sizes, depths are also limited with the 1.25” jet pump.

RESULTS

By setting the jet pump at a 70 degree angle we were able to produce from a deeper location than previous forms of lift. This also allowed the jet lift system to maintain the same bottom hole pressure draw down as the previous ESP system. The transition window between ESP and rod lift was 200-300 BPD of production and about 450PSI production bottom hole pressure (see Figure 3 for jet design example).

The 1.25” concentric jet pump utilizes smaller than normal nozzle sizes. Because of this, injection rates per well are significantly reduced compared to a standard jet lift system allowing for multiple wells to be operated from one central surface pump. The subject project had 3 wells produced from a single surface system allowing rental rates/capital investment and maintenance costs to be spread across all the wells reducing individual lifting costs.

Once converted to concentric jet lift, the wells ran for 3 years without the need for workover intervention. There is still downtime related to surface maintenance and changing downhole jet components, but is significantly shorter in time and less costly compared to previous failures with other forms of list. The production also maintained expected decline rates over this period (see Figure 4 for example).

FIGURES

Figure 1

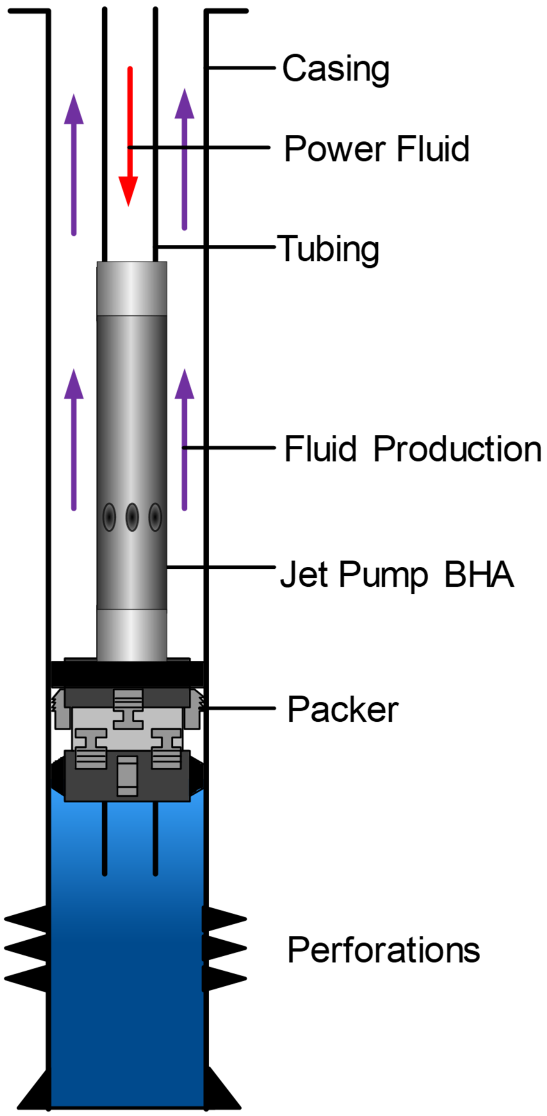

Figure 2

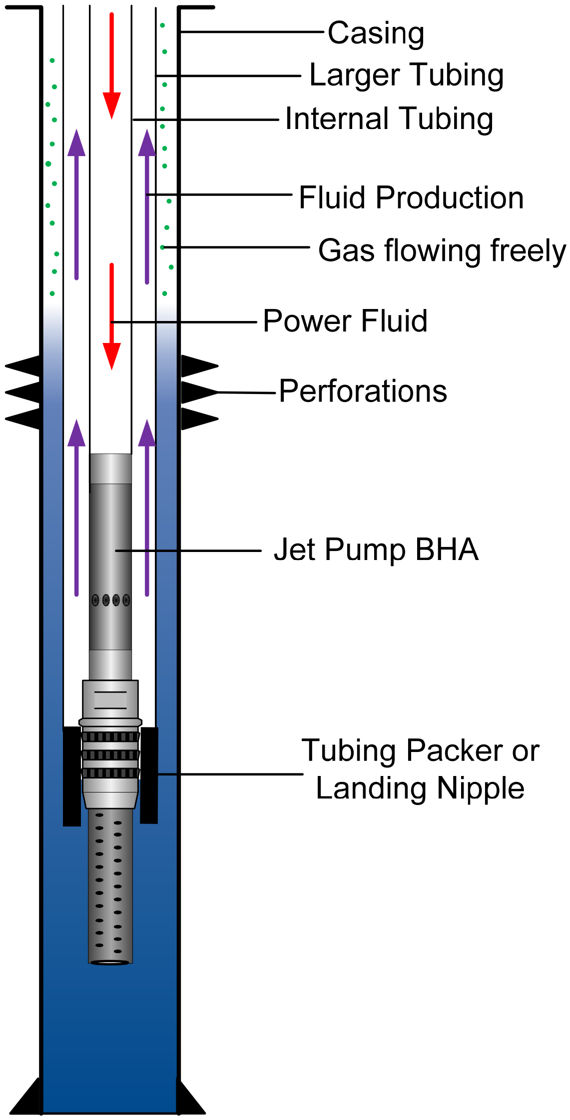
Casing
Larger Tubing
Internal Tubing
Fluid Production
Gas flowing freely
Power Fluid
Perforations
Jet Pump BHA
Tubing Packer or
Landing Nipple

Figure 3

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1) Perforation Depth        (ft) :   5282          13) Producing GOR  (scf/STB) :    323
 2) Pump Vertical Depth      (ft) :   5282          14) Gas Sp. Gravity (air=1.) :  0.800
 3) Pump Installation                               15) Separator Press    (psia) :   70.0
          Casing installation                       16) Well Static BHP    (psia) :  500.0
 4) Casing (production) ID  (in) :  2.441           17) Pump Intake Press (psia) :  382.0
 5) N/A                                             18) Well Test Flow Rate(bpd) :  159.0
 6) Power Tubing ID          (in) :  1.380          19) Well Head Temp    (deg F) :   95.0
 7) Power Tubing OD          (in) :  2.200          20) Bottom Hole Temp  (deg F) :  105.0
 8) Tubing Length            (ft) :   5441          21) Gas Vented                :    99%
 9) Pipe Roughness e/d    (in/in) : 0.0018          22) Power Fluid oil/water     :  Water
10) Oil Gravity             (API) : 34.000          23) Power Fluid Spec Gravity :  1.200
11) Produced Vol Water Cut (%)    :  75.00          24) Bubble Point Press(psia) :   1234
12) Water Specific Gravity        :  1.200          25) Well Head Press    (psia) :   70.0
=========================================================================================
  Kobe  6B  Pump Performance Summary
      Target Production Rate : 159 BLPD @pump intake pressure : 382 psia
      Predicted Surface Power Fluid Injection Pressure =   3323 psia
      Predicted Surface Power Fluid Injection Rate     =    744 bpf/d
      Predicted Pump Intake Pressure                   =    381 psi
      Predicted Pump Discharge Pressure                =   3099 psia
      Predicted Power Fluid Pressure at Pump depth     =   5857 psia
      Predicted Horsepower requirement                 =     43 HP
=========================================================================================
                        -----------------  -----------------  -----------------  -----------------
 Match Prod Rate (blpd)        Rate=    18        Rate=   110        Rate=   186        Rate=   252
 Match Pwr Fluid Press (psia)  PFP =  2500        PFP =  3000        PFP =  3500        PFP =  4000
 Match Pwr Fluid Rate (blpd)   QN  =   681        QN  =   720        QN  =   757        QN  =   792
 Match Pump Intake Pres(psia)  PIP =   488        PIP =   422        PIP =   359        PIP =   296
 Pump Discharge Prs(psia)       PD =  1238        PD  =  3051        PD  =  3126        PD  =  3212
 Match Pwr Fld prs @pmp (psia) PN =  5063        PN  =  5545        PN  =  6028        PN  =  6511
                        -----------------  -----------------  -----------------  -----------------
Max HP Requirement              HP =    29        HP =    38        HP =    46        HP =    55
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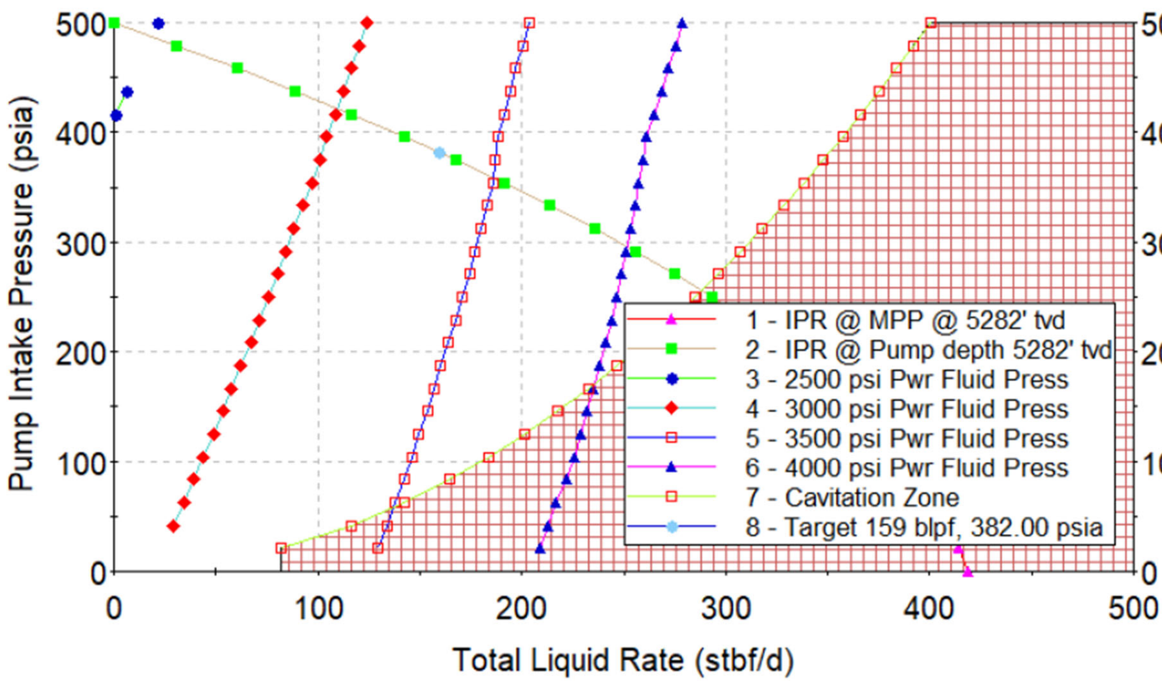
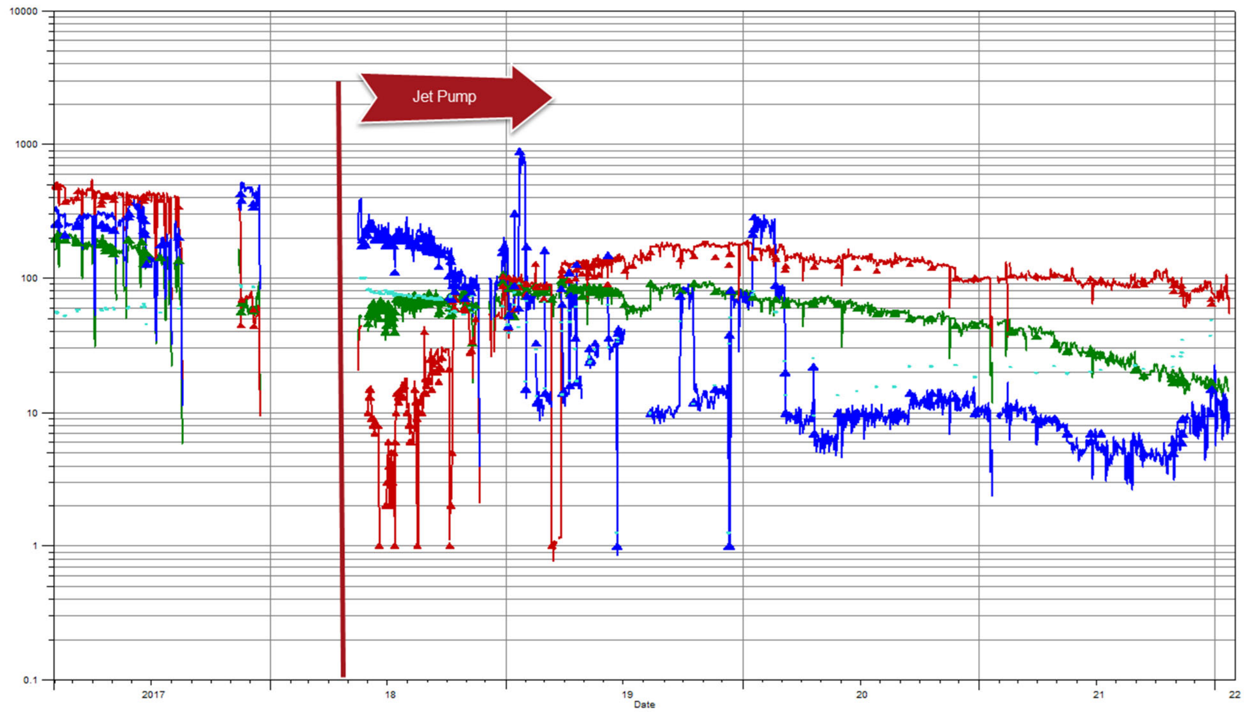


Figure 4



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Jet Pump
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