RESEARCH PAPER | Engineering | Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

Modeling of Sucker rod pump in CBM wells using QRod Simulator

KEYWORDS: Sucker rod pump, production optimization, QRod simulator and dynamometer

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ABSTRACT *Sucker-rod pumping (SRP) is a very popular means of artificial lift all over the world; roughly two-thirds of the producing oil wells are on this type of lift. De-watering of CBM/CSG (coal bed methane / coal seam gas) wells has been challenge to different operators around the world and is a technique that is evolving through the selection of innovatively designed lift systems that match the fluid conditions, liquid volumes and tubing and casing head requirements. There are mainly three types of artificial lift technologies in the de-watering of CBM wells, namely ESP, PCP and SRP systems. To maximize profits from these wells in the ever-changing economic situation with rising costs of electric power, installation designs must ensure optimum conditions. QRod is the most widely used program for the design and prediction of the performance of Sucker Rod Beam Pumping Installations. The program uses a wave equation solution to accurately predict the surface dynamometer loads, gearbox torque and pump capacity, with a minimum amount of input. The effect of changing a parameter such as tubing anchor, stroke length, stroke rate, and pump diameter can be immediately seen in the dynamically updated plots. After a review of the surface and downhole energy losses in sucker-rod pumped wells, some key considerations on the ways to improve system efficiency are given. The most important task is the proper selection of the pumping mode, i.e. the combination of plunger size, pumping speed, stroke length, and rod taper design for lifting the prescribed amount of liquid to the surface. The paper gives aspects and details of modeling of Sucker rod pump in CBM wells using QRod Simulator by using QRod simulator along with CBM well case study.*

1. Introduction

De-watering of CBM/CSG wells has been challenge to different operators around the world and is a technique that is evolving through the selection of innovatively designed lift systems that match the fluid conditions, liquid volumes and tubing and casing head requirements. There are mainly three types of artificial lift technologies in the de-watering of CBM wells, namely ESP, PCP and SRP systems. Of these, most popular methods used in low volume shallow CBM wells are the surface driven PCP systems and Sucker Rod Pumping systems. It is indeed true that Theoretically, PC Pumping systems are the best value solution for the de-watering of CBM wells due to the presence of coal fines and the low operating temperature, but this only holds good for wells that are shallow (200-300 meters) and truly vertical.

Reciprocating oil pumps consist of surface equipment, such as a pump jack with a prime mover, and downhole components, including the sucker rod and the downhole pump that operate inside tubing inserted into a well. The pump jack converts the rotation of the motor to an oscillating linear movement of the polished rod which is attached to a sucker rod. The sucker rod, made of steel or fiberglass, is usually of substantial length (over 5,000ft) and its function is to transfer the polished rod movement to the plunger of the downhole pump. Due to the considerable elasticity of the sucker rod the plunger doesn't exactly follow the movement of the polished rod, which depends on the dynamics of the rod string and the surrounding fluid.

1.1. Principle of SRP operation

A belt driven prime mover rotates and transfers the power to the connecting rod through gear mechanism. The connecting rod moves in a circular motion causing up-down movement of the reciprocating rod. This reciprocating movement of the rod results in pumping action at the bottom hole. A motion sensor senses the reciprocating motion and the output of the sensor are fed to iRTU digital input. The intelligent device counts the number of strokes and calculates total stroke counts to estimate production rate. The intelligent Remote Terminal Unit stores all the configuration data and well data locally in a non-volatile memory. The configuration allows defining limits of various parameters and can diagnose / report the following:

1.2. Common Problems Associated with SRP installations

Fluid Pound

As the rod pump continues to produce, the bottom hole characteristics remains dynamic and the pump filling percentage changes due to change in reservoir behavior, or sand etc. Matching pump displacement to oil inflow remains one of the biggest challenges.

As the oil inflow rate decreases due to sand, fluid pressure, gas locking etc. the pump fills partially. During the upstroke it creates a void inside the tube. As soon as the down stroke starts the liquid column and the rod string experience a free fall and the plunger hits the fluid level in the pump barrel. The sudden transfer of load from the rod string to the tubing causes a shock wave which is transmitted throughout the pump. This is called fluid pound.

Fluid pound affects performance of a SRP in the following way:

- Uncontrolled fluid pound increase energy cost
- Increases wear & tear of tube, rod and plunger
- Decreases gear box life
- Decreases life of the pumping system
- Demand more maintenance & down time.

2. How SRP automation (QRod)

Problems can be avoided by closer monitoring & control of the downhole characteristics through Dynacard.

3. Benefits of SRP automation & optimization by (QRod)

Improved data integrity for analysis of trend

- Improved production accounting
- Improved safety due to facility of remote operation
- Reduction of operating cost

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

- Enables early detection of problem to avoid expensive repairs
- Extends pump life
- Can alert the operator by alarm messages on designated mobile phones
- Increases manpower availability for analysis
- Better system efficiency due to availability of pump run data

4. Production optimization -:

Wells and fields have different characteristics that affect the type of solution best suited for automation/optimization. These characteristics involve more than just the volume of fluids that are being produced. Wells in shallow production, typically heavy oil producers, require different features than deep wells. Producing sand wells require different features than producing clean fluid wells. By integrating rod pump controllers (RPCs), variable speed motor drives, remote diagnostic software, and communication systems, Weatherford enables operators to properly optimize rod-pumped wells.

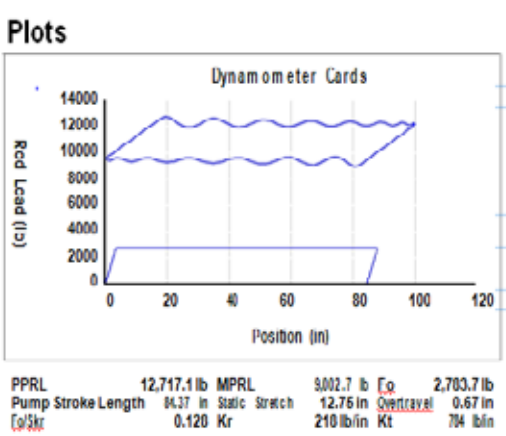
The solution includes intelligence at the wellhead and in the remote software. The RPC and the motor controller alter the operation of the pumping system in real time, based on real-time data. The software provides remote configuration of the well site hardware and the diagnostic analysis to make informed decisions about individual well and total field operation.

5. Case study:-

Problem no:-1

Results: - Table 1.

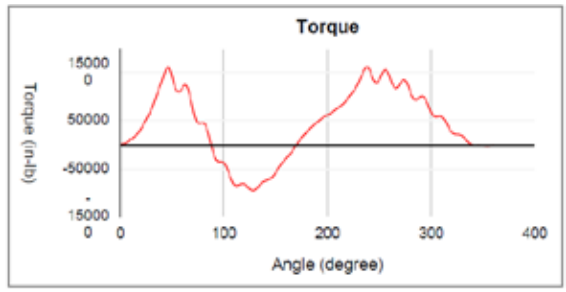
Rate (100% pump volumetric efficiency)	49.3 BBL/D
Rate (95% pump volumetric efficiency)	46.9 BBL/D
Rod Taper	34.0%, 66.0%
Top steel rod loading	56.9%
Minimum API unit rating	228-133-100
Minimum MEMA D motor size	2.79 HP
Polished rod power	1.35 HP
TVL Load	12,228 lb
SVL Load	9,444 lb



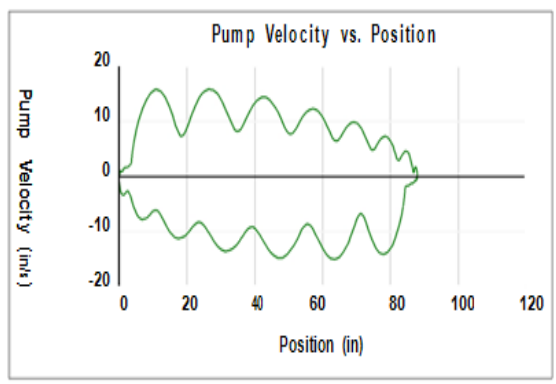
Graph 1.

Design Input: - Table 2.

Unit	CCWConv
Pump Depth	5,700 ft
Target Rate	46.87 bbl/day
Stroke Rate (SPM)	2.23 SPM
Surface Stroke Length	100.00 in
Pump Diameter (D)	1.500 in
Tubing Size	2.875" (6.40 lb/ft) 2.441" ID
Anchored Tubing	NO
Rod Type	Steel Rods
API Rod Number	76
API Rod Grade	D



Peak GearBox Torque 162 Kin-lb
Counter Balance Moment 658 Kin-lb
Counter Balance Effect 10,919.2 lb



Graph 2

Default Settings: - Table 3

Total Sinker Bar Weight	0.0 lb
Fluid Specific Gravity	0.83Sp.Gr.H2O
Tubing Pressure	66.00 psi
Casing Pressure	0.00 psi
Damping Factor	0.02
Surface Unit Efficiency	95 %
Pump Volumetric Efficiency	95.00 %
Pump Intake Pressure	532.00 psi

Graph 3

6. Conclusion & Recommendation-:

1. A comparative study can be easily done for volumetric efficiency and production obtained.

E.g. Rate (100% pump volumetric efficiency) 115.9 BBL/D and Rate (19% pump volumetric efficiency) 22.0 BBL/D. thus, making convenient for optimizing production for a given well on SRP.

Minimum motor size can be selected giving a specified load of production to the simulator. There is no need to select or find out appropriate polished rod power, TVL Load, SVL Load.

2. Output of simulator is in for of generating dynamometer cards which gives a clear indication of operating of downhole pumps.
3. QRod can give other output as pump velocity vs. position this is very important to study the positioning with respect to velocity which can be easily controlled.
4. Last very important output by QRod is Torque which is important in terms of motor and power requirement thus overall optimization of Sucker rod pump can be achieved in terms of operation.
5. Production optimization can be done using QRod simulator for many wells at same time by obtaining precise output.

Acknowledgement:

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

We would like to express our gratitude to Dr. L.K Kshirsagar and Dr. P.B.Jadhav for giving an opportunity to work on this project. We are obliged to Mr. Anand Gupta, DGM- ONGC, for giving in depth knowledge and sufficient data on this topic to work hard and prove our self by presenting this paper.

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