Real-time Sucker Rod System Design

Louis Ray
Trainer / Consultant
eProduction Solutions
Background

- 27.5 years with Shell Oil –
  - In the “gang”, relief lease operator
  - Rod pumping analysis / optimization
    - On-site dynamometer analysis
    - Stand-alone RPC systems
    - RPC systems with host surveillance, analysis, and design software

- 10 years with eP –
  - Sales / Trainer / Consultant
    - Remote analysis / Optimization
“de-sign”

- To formulate a plan for; devise
- To plan out in systematic, usually graphic form
- To create or contrive for a particular purpose or effect
Design What?
The Total Rod Pumping System – Which Includes

- SPM
- Stroke length
- Downhole pump size
- Rod string design
- Pumping unit size
- Pumping unit counterbalance
- Prime mover size
- Minimum operating cost
- Minimum operating fluid level
- Etc.
Sucker Rod Design

- Once there is the recognition for the need to change or re-design one or more of the operating parameters of a rod pumped system, wave equation based design programs provide today’s “state-of-the-art” methodology of how best to optimize the system.

- There are three types of sucker rod system design programs available today:

  1) “Stand-alone” design programs with no well configuration data or real-time analysis data available to be used to “model” or teach the design engine about the operating conditions of a producing well before predictive work is done. In other words, a well must be manually added to the design program, configured to current operating specs, and predictive work accomplished without access to knowledge relative to actual operating conditions.
2) Design programs that allow a user to add a well, configure the well to current operating specs, and then “import” data from a real-time system capable of gathering dynamometer information to be used as a model for “what-if” predictions. In general, these programs are limited in the number of cases or combinations of operating parameters that can be handled in a single “run”.

3) Integrated host systems that have all wells and their current operating specs for a particular producing field already available in their database and real-time dyno analysis data available “on-line” at all times for design engine “modeling”. Generally, these programs are capable of handling as many cases or combinations of operating parameters as the user desires.

Let’s look at how one “State-of-the-Art” design system works …
Real-time Sucker Rod Design

Real-time dyno cards are available from the selected well in the design program.
Real-time Sucker Rod Design

The selected well can be fully analyzed in the design program.
The first opportunity to see the effects of "change" to a rod pumping system involve SPM and the degree of pump fillage.
Real-time Sucker Rod Design

Establish what the design program calculates using base configuration with no change.
Real-time Sucker Rod Design

See what happens to the load span and downhole pump stroke when SPM is increased.

This functionality can also be used as a great teaching tool.
Real-time Sucker Rod Design

See what happens to the load span and downhole pump stroke when SPM is decreased.
Real-time Sucker Rod Design

Change the degree of liquid pump fillage
The key to successful sucker rod design is the ability to "model" or "calibrate" the design program to the actual operating conditions of the selected well before beginning the design process.
Real-time Sucker Rod Design

There are approximately 120 input parameters that a user can adjust to see how the design program reacts to change. The next several slides display examples of such changes and how they might effect the design “modeling” process.
Real-time Sucker Rod Design

The effect of fluid level in the casing annulus
Real-time Sucker Rod Design

Change the "gradient" in the tubing
Real-time Sucker Rod Design

Change the “damping factors” or the “friction factor” to make adjustments to the calculated downhole card and the load span of the surface card.
After preparing the design program to closely match the actual operating conditions of a selected well, the real “nuts and bolts” of the design process can begin.
Real-time Sucker Rod Design

Design options are available to be used based on the optimization need.
Real-time Sucker Rod Design

To understand how a rod pumped system will respond to a pump size / SPM / stroke length change or a combination of these parameters, users may choose a “What-If” design process. This process can be used when a well is over or under displaced to increase / decrease any combination of available pump size, entered SPM, and available stroke lengths to obtain a “optimized” production rate.

This process can be used when a well is over or under displaced to increase / decrease any combination of available pump size, entered SPM, and available stroke lengths to obtain a “optimized” production rate.

Note that the number of input combinations can be controlled by the user’s choice of “Minimum/Maximum Range” – pump size, SPM, stroke length, and even pumping unit rotation direction.
Real-time Sucker Rod Design

Other "Criteria" may be entered based on the user’s knowledge of the well or field.
A wave equation solution of each set of design parameters is performed and the results displayed for user examination.
One of these parameters is usually the “driving force” behind the “What-If” design process. The grid can be sorted in ascending or descending order to facilitate easy recognition of key data, i.e. a certain displacement rate, peak torque, electrical usage, required counterbalance or rod stress. Users can select the “case” that provides the best solution to the design requirement.
State-of-the-Art Rod Pumping Optimization

If the rod string needs optimization – that is, a change to the number of rods in specific taper or even a complete new string design – either to the existing rod string or based on a proposed pumping system change, the “Design Rods” feature will calculate a new rod string design based on near equalized stress on the top rod of each taper.
Real-time Sucker Rod Design

A report is available for each design case that displays the calculated number of rods in each taper based on equal stress on the top rod of each taper.
A third design option is “Design Production”. Users select this method when designing a complete rod pumping system for a new well or when well production is expected to change – new perfs, acid, a frac job, etc.

The design program will calculate every combination of the user entered range of parameters that will result in the desired “Production Rate” range in increments of 25 B/D.
Users choose the best “case” scenario based on a key design parameter - pump displacement, pumping unit size / availability, rod stress, etc. or change the “range” of input parameters to change the output data if needed.
Real-time Sucker Rod Design

Whether using “What-If”, “Design Rods”, or “Design Production”, the design program makes both the predicted surface and DH cards available for each set of parameter ranges – as well as a report of key calculated data.
Summary

“State-of-the-Art” rod pumping design requires:

- Well trained personnel
- Rod Pumped Controllers on each well for control and analysis
- Communication of wellsite data to a host analysis software program
- An integrated “real-time” design program
- A focused effort to use the analysis and design “tools”

Why analyze and optimize rod pumped wells?

There is a payoff ----

😊 Watch energy consumption and repair costs decline - and production decline curves level off