"TOTAL ROD" SYSTEM DESIGN AND MANAGEMENT ON LOTUS 123

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INTRODUCTION

Given the dynamic nature of production for an oil well and the magnitude of the lifting cost, there are few opportunities with a better payoff than reviewing the total rod system design[1,2]. However, with the current trend of increased well count and responsibility for the engineer and field personnel, it is often one of the things for which there is never enough time. Even with a shelf full of technical manuals, books, forms, and programs to calculate everything from pumping unit and rod loads to sheave and belt sizing, designing all of the components of the rod system is a very time-consuming operation.

"TOTAL ROD" system design is a LOTUS 123 ® based template for efficient rod system design and management. It allows numerous combinations of all operating conditions to be considered simultaneously in one program. Calculations are performed for: API RP 11L loads [3] for Conventional, Mark II, Air Balance, and C M I units based on conventional RP11L tables (or based on tables generated by the wave equation model [4] of Shell Oil Company), sinker bars, producing and static bottom hole pressures based on fluid levels [5] corrected for gas in fluid or foam, production capacity based on producing and static pressures and reservoir drive, belt and sheave sizes, daily pump time, electrical cost, mud anchor and gas anchor sizes and placement, and total system efficiency.

"TOTAL ROD" allows multiple runs to be considered in detail and in a fraction of the time. The spreadsheet format of LOTUS 123 presents the runs side by side and provides graphics and data management capabilities.

INDUSTRY TRENDS

Several major trends in the oil industry have led to the need and development of "TOTAL ROD" on Lotus 123.

1. The major downturn in oil prices.
2. The increased work load for the engineer and field personnel.
3. The significant restructuring of personnel due to mergers, acquisitions, and budget constraints. Few people in the industry are working in the same capacity with the same wells and the same employees.
4. The need to operate producing properties with increasing efficiency, both in terms of cost and manpower.

Five years ago, a design program such as "TOTAL ROD" would not have been feasible with the slower personal computers with limited memory and with the limited use of LOTUS 123. The major reduction in cost for both computers and computer memory, resulting in the current availability of computers with 640 kilobytes conventional RAM and ever increasing speed, has opened the door to programs such as LOTUS 123 to such an extent that there are over 7,000,000 users of LOTUS 123. These changes open the door to design programs such as "TOTAL ROD".

ROD SYSTEM DESIGN AND MANAGEMENT

There are three major goals in designing the total rod system. The first and most common goal is the reduction of work-related lifting cost. The second, and often unexpected in the majority of wells, is the production of additional oil that is currently available. The third major goal is the creation of an efficient record system or data base.

Reducing Work-Related Lifting Cost

Work-related lifting cost such as fuel, engine and motor repairs, pumping unit repairs, replacement materials, and pulling unit cost for repairs caused by failing rods, pump, and tubing represent the largest expense on most Lease Operating Expense reports. Add to this the cost of supervision and lost production, and the value of detailed review of lifting methods becomes readily apparent.

The first step in efficiently designing the total rod system is no different than the first step in making almost any decision or solving any problem. All pertinent data concerning current lifting methods and options available must be gathered from well records and from the field. With this information in hand, thorough and complete design may be obtained and changes may be implemented. This means that data on production, producing and static fluid levels, gas interference in producing fluid levels, formation drive and depth, plug back total depth, rods, sinker bars, pump, gas anchor, mud anchor, tubing, tubing anchor, pumping unit, and prime mover needs to be gathered prior to beginning rod system design. The temptation (and often the nature of the work load) is to skip this step and begin design work with the limited data available. The problem with this approach is the resulting design is based on incomplete data which can result in an inefficient rod system design.

Work-related lifting costs are affected by the design of each component in the rod system. The design of each component of the rod system is affected by the design of the other components in the rod system. A rod system design that overlooks one part of the system may be inefficient and it may not produce the oil the well is capable of producing.

Major Goals And Key Factors In Rod System Design

1. Improve down hole gas separation.
   A. Pump intake in relation to perforations.
   B. Mud anchor diameter.
   C. Gas anchor diameter, length, and intake area.
   D. Pump capacity versus production capacity.
   E. Perforated nipple intake area.
   F. Turbulence of well fluids at pump intake.
   G. Pump intake pressure.

2. Reduce rod failures.
   A. Pump size.
   B. Rod taper.
   C. Pump setting depth.
   D. Placement of chemicals.
   E. Slim hole couplings.
   F. Rods in compression.
   G. Fluid pound.
   H. Peak rod stress and range of rod stress.

3. Reduce rod on tubing wear.
   A. Amount of sinker bars or stiff rods.
   B. Compression in rod string.
   C. Impact point and force of fluid pound.
   D. Gas entry into pump and gas lock condition in pump.
   E. Tubing buckling.
   F. The point of rod coupling on tubing contact.

4. Reduce pump failures.
   A. Pump size.
   B. Gas entry into pump.
   C. Tagging bottom.
   D. Traveling valve spacing and dead area in pump.
   E. Friction into pump.
   F. Heat buildup in pump.
   G. Placement of chemicals.

5. Reduce pumping unit loads.
   A. Peak polish rod load and range of load.
   B. Counterbalance.
   C. Pump capacity versus production capacity.
   D. Tagging bottom.
   E. Pounding fluid.
   F. Stroke length.

6. Reduce fuel consumption and fuel cost.
   A. Total work or horsepower requirements.
   B. Counterbalance.
   C. Transfer of energy from prime mover to rod string.
   d. High slip motors.

The greatest oportunity for reducing work-related lifting cost is found in wells with lift capacity that greatly exceeds production capacity of the well. These are also often the simplest and the easiest to redesign. This situation is typically found in wells with a relatively high initial rate, a high initial decline rate, and little or no change in lift capacity. This situation may also be found in wells in which the initial production was considerably less than the designed lift capacity, either initially or after a short period of flush production.

Wells with production capacity in a pumped-off condition that greatly exceeds lift capacity offer lifting cost savings primarily by designing the pump setting depth to match the production capacity at that depth. This may result in decreased loads or increased production or both.

The third area of opportunity for reducing work-related lifting cost is found in wells with proper lift capacity but one or more components of the system has become inefficient or has been overlooked at some point, resulting in increased lifting cost. Finding improvements in this area requires detailed comparison between current operating conditions and desired design.

Producing Additional Oil

Finding additional oil available for production, without additional stimulation, is the exception. However, it is out there and it is there for a number of reasons. Reviewing lift design has the side benefit of identifying wells with this potential. Reviewing the total rod system design requires reviewing producing and static fluid levels, determining the gas interference in annular fluid columns, and calculating producing and static bottom hole pressures. With this information and a knowledge of the formation drive, production capacities at various producing bottom hole pressures may be calculated. This level of review places a significance, in terms of barrels of oil, on a fluid level that may have been previously discounted due to an incompleteness of data, foam or gas interference, or a general feeling that the well is pumped off.

Efficient Rod System Data Base

Designing the rod system efficiently requires a large amount of data from the well file, from the well, and from the surface equipment. This requires an initial investment of time and effort. This expenditure of time and effort gathering pertinent data and designing the rod system can serve other purposes and possibly other users if managed properly. With the advent of powerful data base and spreadsheet programs such as LOTUS 123, data gathered and analysised for rod system design can be managed to meet future needs.

ROD SYSTEM DESIGN USING "TOTAL ROD"

"TOTAL ROD" can be looked at as a tool to help you perform your rod system design and management more efficiently and perhaps more thoroughly. Combining all data, calculations, look-up tables, and reference tables into one program in a format as flexible as LOTUS 123 provides the following advantages:

1. Eliminates running multiple programs.
2. Eliminates numerous support calculations when running only one present program.
3. Eliminates need for all look-up tables for API RP 11L.
4. Eliminates need for reference books for tubing drift, casing drift, sheave sizes, V belt sizes, annular fluid gradient correction for gas, and maximum O D fish (for rod box and mud anchor).
5. Provides updated design for each component of the rod system with each individual change in design.
6. Allows multiple runs to be considered simultaneously on the same screen or printout. This enhances the decision-making and presentation or filing.
7. LOTUS 123 format provides powerful data management capabilities.

"TOTAL ROD" calculations

1. Pumping unit loads for Conventional, Mark II, Air Balance and C M I units.
2. Rod loads, including maximum permissable loads for grades "K", "C", "D", "E" and for slim hole boxes.
3. Loads may be calculated on the standard API RP 11L or on the wave equation model presented by Joe Clegg (Shell Oil Co.) in 1988.
4. Sinker bars.
5. Mud anchor and gas anchor size, length, and placement in relation to perforations to achieve maximum pump efficiency.
6. Placement and K B depth of tubing string components to achieve minimum producing bottom hole pressure.

7. Static and producing bottom hole pressures based on fluid levels and gas interference in fluid above the seat nipple.

8. Production capacity of the well based on static and producing bottom hole pressures and the formation drive.

9. Prime mover horsepower.

10. Sheaves and belts required for design strokes per minute.

11. Total system efficiency including fuel cost projection.

DATA MANAGEMENT USING "ROD FILE"

Data from "TOTAL ROD" may also be stored on a LOTUS 123 file named "ROD FILE" for multiple well management. This file is a side benefit gained from reviewing individual lifting methods. Data from over a hundred wells may be stored in a common file. An additional twenty columns are available for user specified data such as monthly fuel cost, lifting cost, failure rates, etc.

User may then use "ROD FILE" just as he would his current well file. Access to key data would be almost instantaneous. Comparing lifting methods of similar wells would be quick and clear. Sorting data by user's criteria to arrange any field of data could be accomplished in a matter of minutes.

Identifying and locating oversized equipment (primarily pumping units and motors or engines) needed for another installation can save a company thousands of dollars. Design work on "TOTAL ROD" will identify oversized equipment. User can quickly sort data on "ROD FILE" and locate the equipment that meets his criteria.

SUMMARY

1. Properties must be operated with increasing efficiency.

2. Reviewing rod system design pays off in reduced lifting cost.

3. Additional oil production is the exception, but it is there.

4. Data must be managed to be readily available.

5. "TOTAL ROD" is a tool to add efficiency and thoroughness to the rod system design.

6. "ROD FILE" gives the user instant access to data from over one hundred wells analysised using "TOTAL ROD".

* LOTUS 123 is the registered trademark of Lotus Development Corp.

REFERENCES

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5. McCoy, J. N., Podio, A. L., and Huddleston, K. L., "Acoustic Producing Bottom Pressures", Society of Petroleum Engineers paper 14254, 1985.