FIELD PROVEN METHOD SIMPLIFIES ANALYSIS OF ROD PUMPING PROBLEMS

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INTRODUCTION

Numerous articles have been published on field application of dynamometers. However, dynamometers are not widely used. Use of dynamometers has been limited by the difficulty of interpreting dynamometer cards.

This paper deals with recognizing rod-pumping problems through field analysis of qualitative dynamometer cards.

BACKGROUND

In 1954, Midwest Research Institute established that the behavior of a sucker rod pumping system could be predicted through use of a mathematical model. An analog computer was used to generate over 1100 dynamometer cards which are presented in API Bulletin 11L2 (Catalog of Analog Dynamometer Cards).

Comparison of field-dynamometer cards with the analog-computer cards is the basis of this paper. Over 3000 field cards were observed. Figure 1 shows how well the field card compares with the analog-computer card.

FIG. 1—COMPARISON OF DYNAMOMETER CARDS

APPROACH

Field dynamometer cards which compare to the simulated analog cards indicate that downhole conditions are normal; the following conditions are present.

I. The pump is filling.
   A. There is no fluid pound.
   B. There is no gas interference.
II. The tubing is anchored.
III. There is no abnormal friction.

A qualitative comparison allows abnormal pumping conditions to be recognized.

THEORY

The qualitative method requires an understanding of the forces which affect pumping behavior, such as the following.

I. Fluid load (pounds)
II. Stroke length (inches)
III. Pumping speed (strokes per minute)
IV. Physical characteristics of the rod string

These known pumping variables have the dimensions of force, distance, and time, and API Bulletin RP11L has equated them to two non-dimensional parameters which can be used to express a normal pumping condition. These parameters are as follows.

I. Fo/Skr - non-dimensional rod stretch
II. N/No' - non-dimensional pumping speed

API Bulletin RP11L provides an explanation of the parameters and how they are derived. In addition, calculating Fo/Skr and N/No' and locating the corresponding computer cards are topics discussed in a paper entitled "Qualitiative

Load Analysis—A New Approach to Beam Pump Monitoring and Control," which was presented at the 1973 Southwestern Petroleum Short Course.

The loading and unloading of the subsurface pump and the corresponding effect on the surface dynamometer card should be understood to recognize and diagnose pumping conditions. Figures 2 and 3 show upstroke and downstroke representations on dynamometer cards.

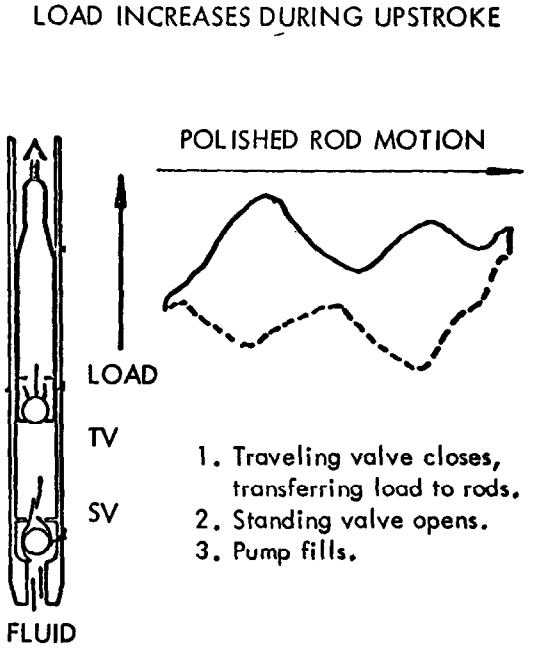


FIG. 2—SURFACE DYNAMOMETER CARD (UPSTROKE)

Causes of abnormal loads can be outlined as follows (See Figures 4, 5, and 6 for examples of abnormal loading.)

I. Upstroke (Fig. 4)
   - A. Traveling Valve
     1. Leaking
     2. Delayed Seating
     3. Not Seating
   - B. Hole in Pump Barrel
   - C. Pump Sticking

II. Downstroke (Fig. 5)
   - A. Leaking Standing Valve

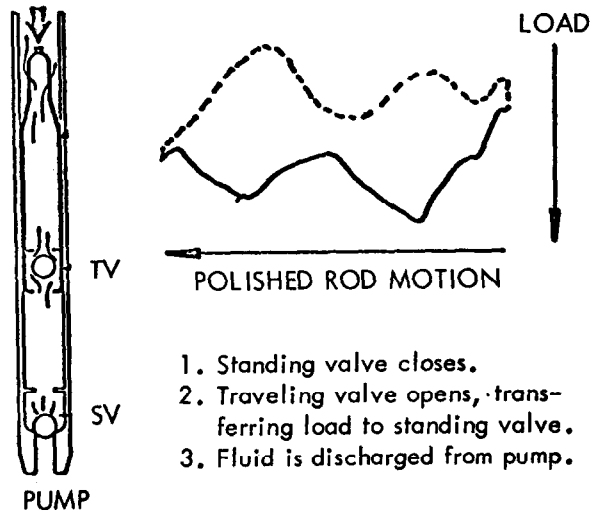
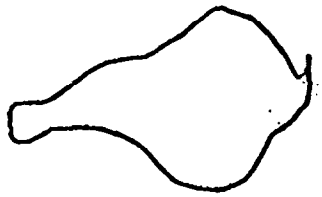


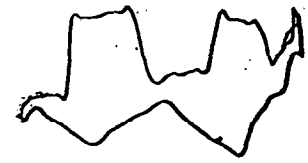
FIG. 3—SURFACE DYNAMOMETER CARD (DOWNSTROKE)

   - B. Delayed Unseating of Traveling Valve
     1. Fluid Pound
     2. Gas Lock
     3. Gas Interference
     4. Restricted Intake
        - a) Pump
        - b) Reservoir
   - C. Sticking Pump

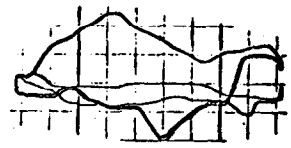
III. Both Upstroke and Downstroke (Fig. 6)
   - A. High Fluid Level
   - B. Flowing Well
   - C. Friction
     1. Crooked Hole
     2. Buckled Tubing
     3. Paraffin
   - D. Parted Tubing
   - E. Rod Part
   - F. Surface Equipment
     1. Bearings
     2. Gear Box



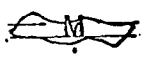
LEAKING TRAVELING VALVE



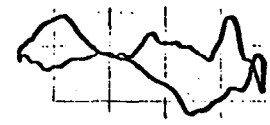
DELAYED SEATING OF TRAVELING VALVE



TRAVELING VALVE NOT SEATING

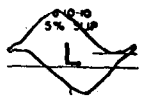


HOLE IN PUMP BARREL

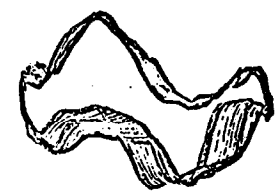


STICKING PUMP

FIG. 4—ABNORMAL LOADING (UPSTROKE)

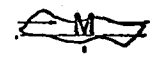


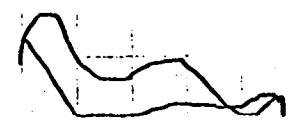
LEAKING STANDING VALVE



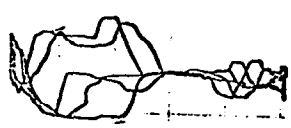
FLUID POUND

GAS LOCK

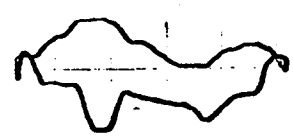




GAS INTERFERENCE



RESTRICTED INTAKE



STICKING PUMP

FIG. 5—ABNORMAL LOADING (DOWNSTROKE)

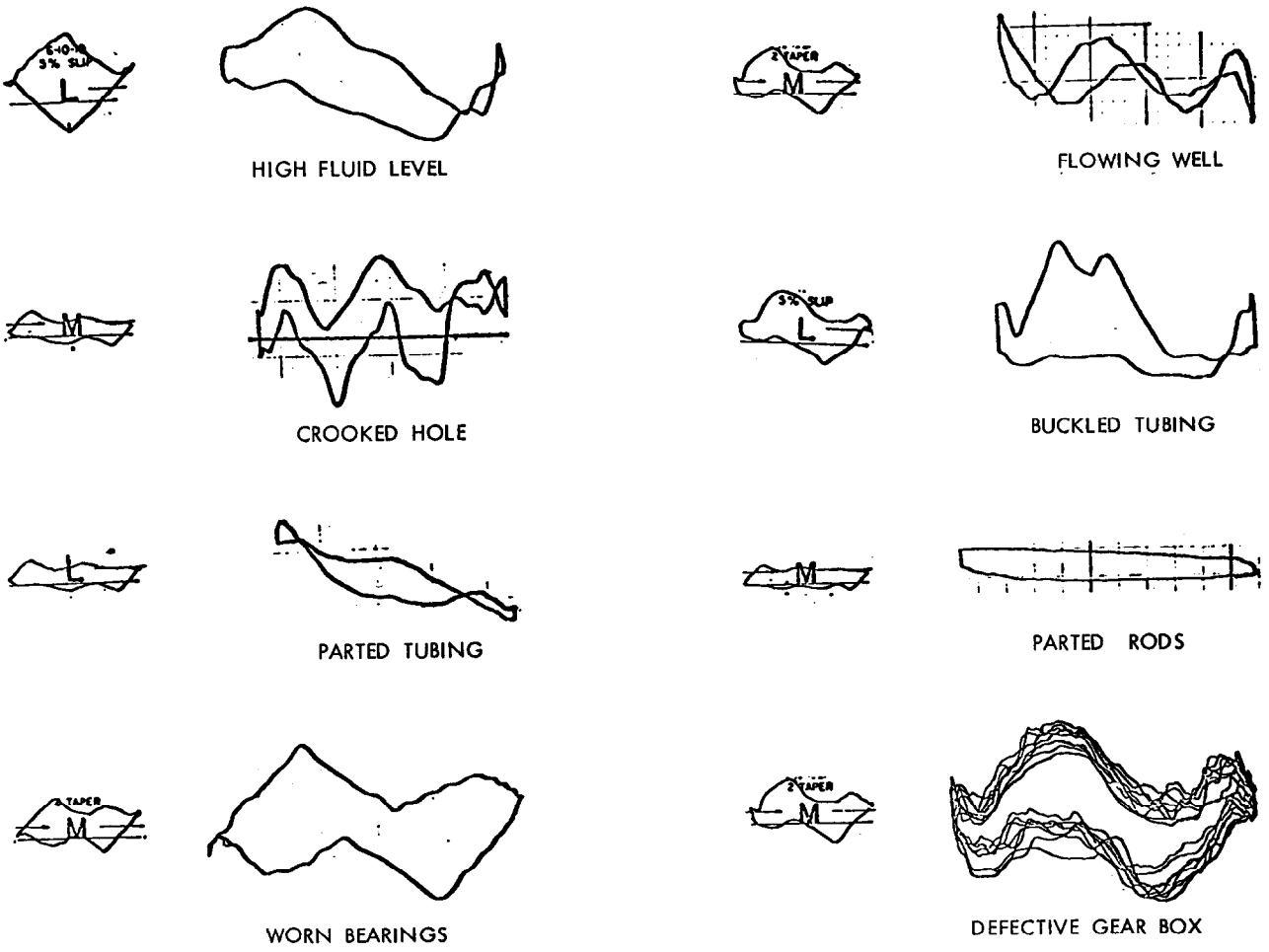


FIG. 6—ABNORMAL LOADING (UPSTROKE AND DOWNSTROKE)

CONCLUSION

Use of the dynamometer as a production tool can be very effective.

The authors wish to expand this presentation into a publication which will include numerous field cards of abnormal pumping conditions. Your participation in furnishing us with abnormal examples in your files or ones you may encounter is solicited.

REFERENCES

API RP11L, Recommended Practice for Design Calculations for Sucker Rod Pumping Systems (Conventional Units), Second Edition March, 1972.

API Bulletin 11L2, Catalog of Analog Computer Dynamometer Cards, First Edition, December, 1969.

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