Diagnosis of Pumping Well Equipment Trouble By The Use of A Dynamometer

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The proper and economical operation of pumping wells may be simulated to a good safety program. The problem is always changing, inasmuch as reservoir conditions immediately around the well bore change from month to month.

Formations that carry no water have available for pumping smaller and smaller volumes of oil. Bottom hole pressures decline, and gas ratios may either increase or decrease. When bottom hole pressures decline below the saturation pressure, gas comes out of solution to present further problems in pumping. By using the dynamometer, these conditions will be found as soon as they develop so that proper changes in pump size, speed, and stroke length may be made to maintain good operation.

In a water drive field, change in the oil water percentage results in increased pumping loads due to heavier fluid, lower bottom hole pressures; increased pump sizes, and faster operation speeds. This affects the sucker rods, gears, belts, and engine. If the counterbalance is not adjusted to take care of this increased load, unnecessary equipment failures result. The only practical way to keep up these changes is constant use of the dynamometer.

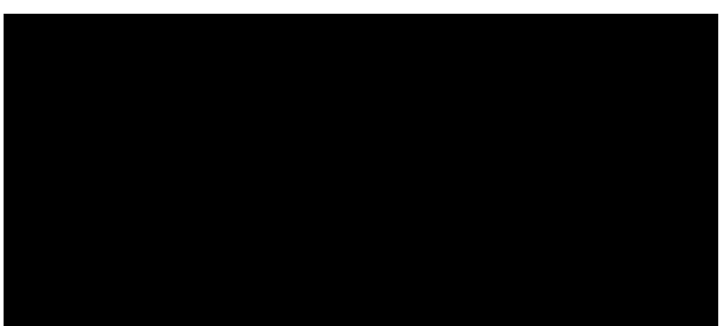
By broad definition, a dynamometer is a device to measure force. The dynamometer we are concerned with measures and records the load of a pumping well. It is based on the principal of the United States Bureau of Standards Proving Ring. The ring type dynamometer employs a proving ring with a strut type take-off in conjunction with flexures and levers for mechanical magnification of the deflection of the ring.

The dynamometer card as taken at the polished rod of a pumping well measures and records the resultant of all longitudinal forces acting on the polished rod at any particular instant of time throughout the pumping stroke. The various components of this resultant force or load curve provide the facts necessary for analysis of the operation of the entire system from the pump to the engine. Detailed steps in the analysis and interpretation of the dynamometer card may be found under "Dynamometer Card Interpretation" in the Sucker Rod Handbook, published by Bethlehem Steel Company.

We are concerned here primarily with the practical aspect of the use of the dynamometer for analyzing equipment failures. We shall start with the engine and proceed through the major parts of the pumping system.

Engine

The first consideration in proper operation of an engine is to understand the nature of its load. The load on a pumping engine varies from zero at each end of the stroke and reaches a maximum near the center of the upstroke and near the center of the downstroke. This is assuming that the well is properly counterbalanced. A detailed analysis illustrating these facts is found in the paper "Counterbalancing of Beam Pumping Units" by Douglas O. Johnson.



A look at the horsepower vs. time curves, (Figure 6), particularly curve B, shows that the instantaneous horsepower is continuously changing. The peak horsepower is approximately 63 while the average is only 15 This means that the engine must have enough fly wheel effect and reserve capacity above average to meet the high peak demands. Most pumping engines are loaded in such a manner that they cannot maintain a constant speed throughout the pumping stroke. As the load increases, the speed of the engine decreases (especially is this true of multicylinder engines). In most pumping wells therefore, we find a speed fluctuation of the engine from 5 to 35 percent.

Belts

When considering belt life, it is easily seen that the variation in torque, which is a function of horsepower, is the main factor. Torque, like horsepower, fluctuates from maximum to zero throughout each pumping stroke. Belts should therefore be of sufficient size and number to take care of the peak torque rather than the average torque.

Gears—Speed Reducers

The peak load on the gears is expressed as peak torque. In analyzing gear trouble, it is essential to understand the importance of proper counterbalancing. For example, a gear box might have to be twice as large as necessary if the load were not counterbalanced properly. Also, improper counter balancing results in additional load on the belts and engine.

The method for properly counterbalancing a well using a dynamometer is as follows:

First: Dynamometer cards are taken at the normal speed of operation at 15 minute intervals and covering a long enough period of time so that stabilized pumping conditions have been reached.

Second: Stop the pumping unit at the position where the counter balance effect is the greatest. That is the point at which the crank is horizontal on the upstroke.

Third: Place a polished rod clamp a few inches above the stuffing box or above the polished rod liner if there happens to be one installed.

Fourth: Place a chain above the clamp just installed and wrap around the polished rod one turn, then run the chain under the casing head vent or under the lead line and hook the chain together as closely as possible.

Fifth: Release the brake and check to see that the clutch is free. Release stylii and pull the cord. This records the counterbalance effect as measured at the polished rod.

If the well is considerably underbalanced, the rods will go down when the brake is released. In this case, the clamp should be put directly over the stuffing box to prevent the rods from going down. No chain is necessary for this condition.

For correct counterbalancing, the measured counterbalance effect line should pass through the approximate center of the dynamometer cards.

The above procedure taken from the paper "Dynamometer Charts and Well Weighing" by L. W. Fagg.

Structure & Beam

The load on the pumping unit structure is taken directly from the dynamometer card. It is the maximum load.

Sucker Rods

The load on the sucker rods is also taken directly from the dynamometer card and is represented by the maximum load, minimum load, and range of load. Not only the maximum load and range of load but also the character of the load curve must be taken into consideration.

All sucker rod failures are the result of load. Where corrosion is a factor, the allowable maximum load is less than it would be otherwise. In order to analyze sucker rod failures and take steps to prevent or to decrease them, it is necessary that the load be measured. In most cases sucker rods are stressed up to and exceeding the maximum allowable load. This means that any reduction in load due to changes in operating speeds or pump size are highly desirable.

The Bottom Hole Pump

One of the most beneficial uses of the dynamometer is that of checking the operation and condition of the pump. This is described and illustrated in detail in the bulletin "Use of the J-F Dynamometer for Checking Pumps," Bulletin No. 25.

Summary

In summary, the dynamometer is used in the following ways for operational control: to select the pumping speed that results in the lowest peak load and elimination of fluid pounds; to properly counterbalance pumping units as well conditions change; to check pumps to avoid unnecessary pulling jobs, also to find pumps that should be pulled; to check unusual situations such as accumulation of paraffin in tubing, or excessive friction due to improper setting of packer or tubing anchor.

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