Short - Cycle Rod Pumping

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INTRODUCTION

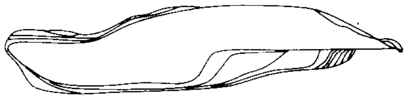
Maximum fluid production is achieved in pumping a well by keeping the fluid level as low as possible which keeps the minimum pressure on the formation face. The easiest way to accomplish this is to have a pump capable of lifting more fluid than is being produced and to operate it continuously. Although popular this technique isn't a very good answer since fluid "pounding" would result which is hard on equipment and lift efficiency is reduced. Another approach is to change either the pump size or stroke rate so that the lift capacity is equal to the inflow rate. This approach isn't very practical since this is a very delicate balance to maintain to keep from either losing production or pounding fluid again. The best answer, based on theory as well as field experience, is to short-cycle pump the well. Since the well is started many times a day this approach is limited inherently to pumping units with electric motor prime movers.

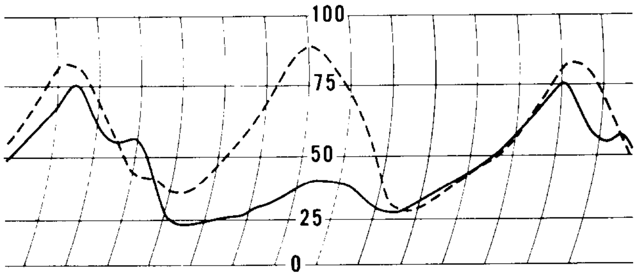
Short-cycle pumping is best explained by describing the percentage timer which may be used. The timer chosen operates on a 15-minute cycle and it is set to operate the well any portion of 15 minutes desired and shut down the remainder of the 15-minute cycle. For example, if the timer were set on 66 per cent, the well would be pumped for 10 minutes and would be down for five minutes. In this example a 15-minute cycle was chosen so that power would be consumed on the same basis that it is frequently purchased minimizing the kilowatt demand. An alternate and more flexible method of short-cycle pumping, is accomplished by use of a pump-off controller which is explained in more detail later.

PRINCIPLE OF OPERATION

The principle which makes it practical to short-cycle pump wells is illustrated in Fig. 1. The dotted current line corresponds to the pumping condition of the dynamometer card. In about five minutes, however, this well "pumped off", or more properly dropped from about 80 per cent to less than 40 per cent lift efficiency as seen on the card. The motor current also goes through a similar transient and changes to the solid line shown. This current change, as recorded here, is very easily detected with a clip-on ammeter by reading the peak value only on the downstroke and the pumping condition of the well may be monitored during each stroke by the current. This well, incidentally, is an excellent example of a unit that was counterbalanced under pumping conditions having sufficient lift capacity to keep the well pumped-down. The current change that occurs is explained as follows: First, the well is counterbalanced under pumping conditions so that the counterweights are equal to the rod weight plus half the fluid weight. On the upstroke the motor must then lift half the fluid load. At the top of the downstroke the fluid load is transferred from the rods to the tubing when the traveling valve opens, and the counterweight load that is now lifted is also equal to half the fluid load. When the well begins to pump off, this load transfer occurs lower and lower in the downstroke, and the fluid load is retained longer on the rods which in turn helps lift the counterweights and reduces the motor load. Thus, the time shuts the well in for a short time to allow fluid to collect in the wellbore; it is then turned on and pumped with very good efficiency and under design conditions, and then shut down after it pumps off. By short-cycle pumping, both the kilowatt demand and kilowatt-hours are minimized and the fluid level is kept near the seating nipple.

There are a variety of pump-off controllers now on the market. They employ several different principles of design which include sensing of the polished rod load, average motor current, and flow of the liquid component only of the production. The unit with which we have had the most





MOTOR CURRENT CHANGE
PRODUCED BY PUMPING OFF

FIGURE I

experience[1] senses the motor current at the same point in the downstroke of each revolution. The unit is calibrated for a given well by adjusting the current set-point knob to some intermediate value of current between pumping and pumped-off positions. When the downstroke current declines below this set point a timer is started which shuts the pumping unit down for a fixed 14 minutes. The well is then restarted and runs a minimum of one minute, which is generally adequate to get the well started pumping. The well then continues to operate as long as the current stays above the set point value.

WELL ANALYSIS

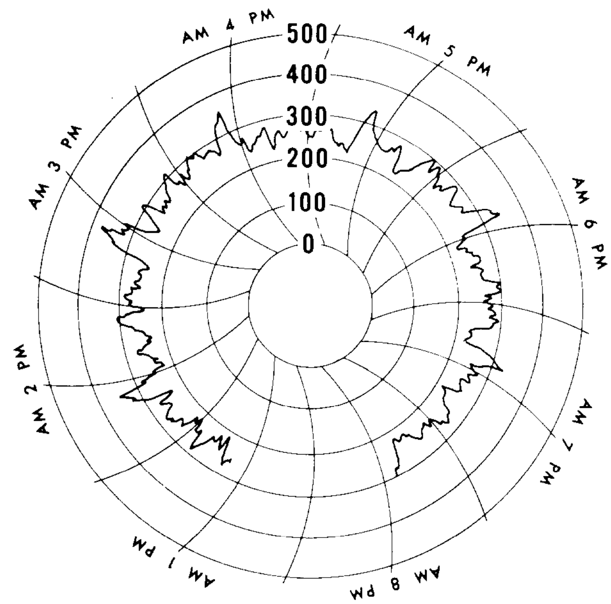
Some analysis is required of a well in order to be sure that it is pumping and pumps-off, that the pump is properly spaced and the unit counter-balanced under pumping conditions. It is preferable to take previous well test results and downhole equipment data to the field to check a well. Also before field testing it is desirable to start pumping the unit continuously the day before so that it can be assumed initially that the well is pumped down at arrival. The first data recorded at the well is both the up and downstroke peak currents. The well is then shut down for an arbitrary five minutes to allow fluid to collect in the borehole. Practically all wells, regardless of how little fluid is produced, will pump for a few strokes when started up. The pumping action is reflected by an increase in downstroke current if the well had been pumped-off initially as assumed. It should be noted that following the start-up of a well, it generally takes from one to three strokes for the increase in downstroke current to occur. If it is a typical pumped-off well, the current increase experienced will decline and the well will return to its pumped-off condition. It will become obvious during this procedure whether the well had been counterbalanced in the pumping condition.

If no current change occurs, further checking is necessary. It would be assumed at this point that either the well is not pumped-off or that there is gas interference. A comparison between the well test data and lift capacity should indicate whether the well should be pumped-off. The pump spacing should be checked next by lowering the rods until the pump taps bottom. There will probably be a change in current if the respacing of the pump eliminated the gas interference. Of course, the use of a fluid-level sounder and dynamometer would be very useful in determining the well condition or if more serious problems, such as a hole in the tubing or defective pump, exist. Finally the counterweights should be moved, if necessary, so that the well is counterbalanced while pumping.

BENEFITS OF SHORT-CYCLE PUMPING

Power savings possible are illustrated by data from well No. 62 near Monahans, Texas. This well produces about 100 bbl of fluid per day from 5000 ft with an 1-1/2-in. pump operating on a 74-in. stroke at 14 SPM. Pumping continuously, the lift efficiency of the pump is about 40 per cent. The measured demand is 7.1 KW and 170 KWH are consumed per day. After a pump-off controller was installed the unit would run about nine minutes following a fixed 14-minute down time. The demand dropped to 6.2 KW and the energy consumption to 100 KWH. Monthly power consumption, operating continuously, was a calculated $38 compared with $25 when the well was short-cycle pumped with a controller. Figure 2 shows power consumption on a daily basis at this lease. Many of the wells are time-clocked with a conventional program timer but are also programmed so that they will be operating when the lease operator makes his morning rounds. The monthly demand then is determined at about 9 A.M. when all of the wells are turned on. Eleven of the 42 wells in this field were changed to short-cycle pumping. As seen in Fig. 3, the power bill for the whole field, which is recorded through one central meter, increased an average of about $40 a month due to power requirements resulting from a combination of additional motors and increased water production from the wells. Beginning in January, power consumption, however, was stabilized by short-cycle pumping these 11 wells for about six months until increasing load finally started the up-trend again. During this period the power cost declined from 2.4 cents to 1.7 cents per bbl of fluid lifted.

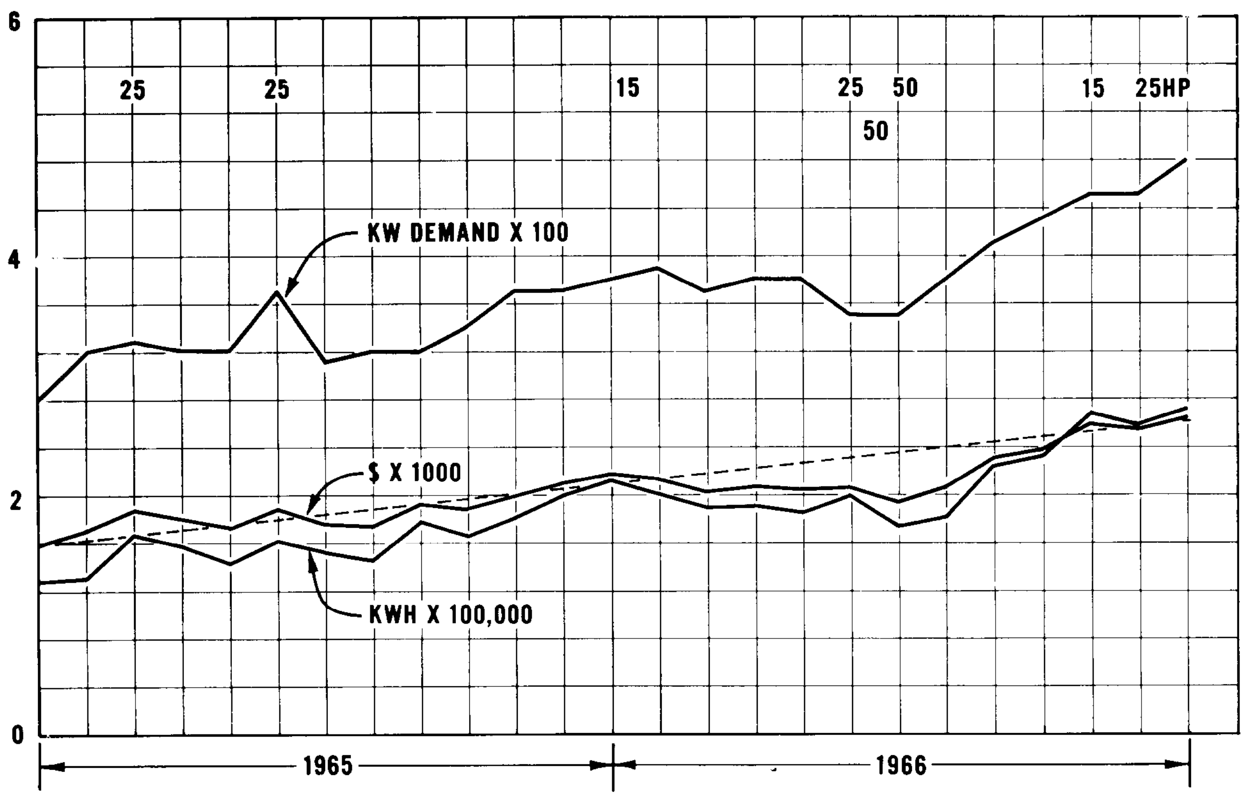
It is felt that the old problem of gas interference is also reduced by short-cycle pumping in the following way: In most wells the pumps are usually spaced by the pulling unit operator following a rod repair, pump repair, etc. If the well pumps, that is about all that can be done at that time. But at the time he leaves the well the tubing is usually not full, which affects tub-



LEASE KILOWATT CONSUMPTION

EIGHT DAY CHART

FIGURE 2



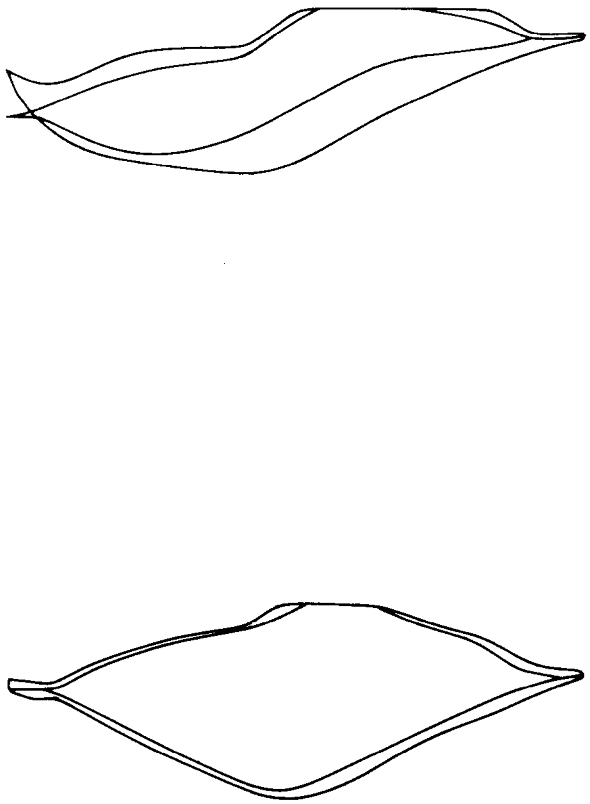
LEASE POWER CONSUMPTION

FIGURE 3

ing stretch, rod stretch and bouyancy, and the annulus has a higher than normal fluid level because of the downtime. It is felt that ideal pump spacing cannot be realized until the tubing has been filled. At that time then, the rods may be lowered until under pumping conditions, the pump taps the bottom. The pump should be raised slightly then to eliminate the tap. At this time the maximum compression ratio possible has been realized for a given pump. The higher this ratio the less gas interference will be realized in the typical single-zone well. E.g. short-cycle pumping combined with dynamic pump spacing on well No. 71 also raised pump efficiency by allowing gas separation by gravity during the downtime. This well produced as much fluid running 65 per cent of the time, after spacing, as it did running 24 hours a day with gas interference present before spacing. A dynamometer was used in the analysis of this well and Fig. 4 shows the benefit of proper spacing. This 2-1 2-in. tubing pump was lifting about 220 bbl of fluid and 11 MCF of gas were produced.

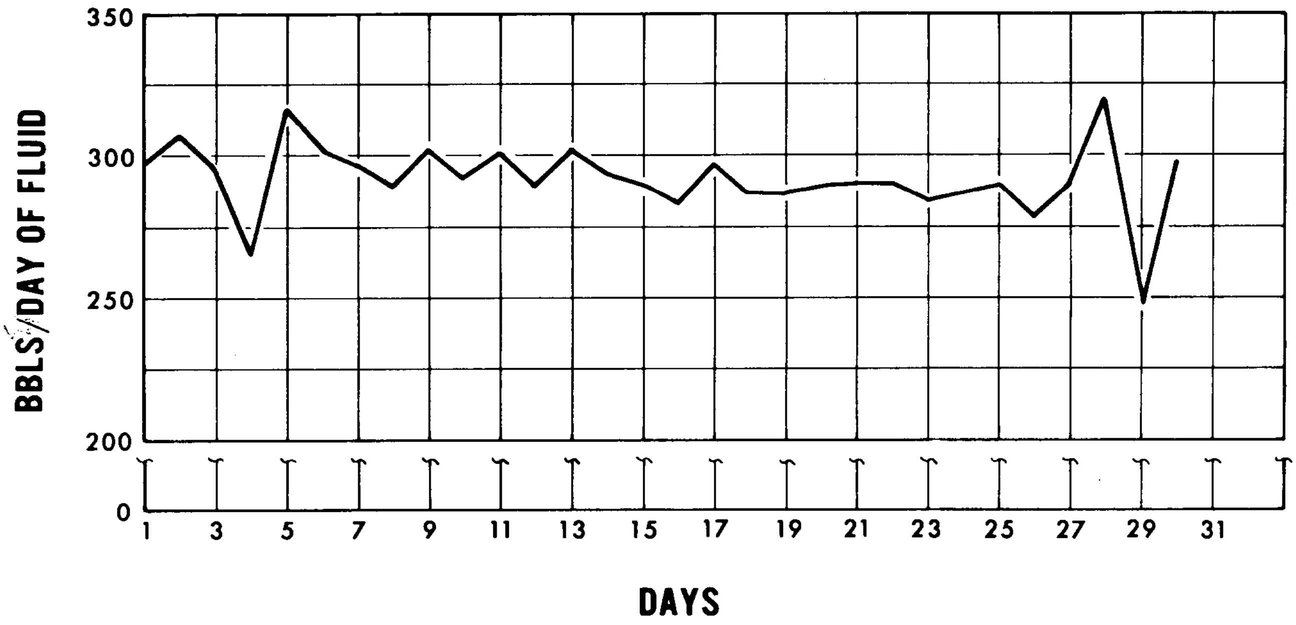
Inherently short-cycle pumping can be used to minimize both wear and stress on the equipment by operating it the minimum time required to lift the fluid under design conditions. One operator conducted extensive tests on a well which showed that a pump-off controller could be used to allow a fluid pound to develop only so far and then stop the unit. The controller would allow the lift efficiency to decline to 55 per cent and it would then stop the unit. Another operator was experiencing rod parting about every 45 days on a well. After six months' operation, following the installation of a pump-off controller, there had been no further rod parts.

Generally when wells are counterbalanced under pumping conditions they become rod heavy when they pump-off since the fluid load is retained by the rods. This is a happy coincidence in West Texas where the sand blows because the horsehead will generally stop in the down position when the unit is stopped. The life of the stutffing box packing is increased by the frequent cooling periods in short-cycle pumping and elimination of sand collecting on the polished rod during downtime. The only exceptions encountered to date which keeps the cranks from stopping straight up, have occurred when the wing weights were not symmetrical about the



EFFECT OF PUMP SPACING ON GAS INTERFERENCE

FIGURE 4



SATELLITE FLUID PRODUCTION

FIGURE 5

cranks. In these cases the cranks come to equilibrium near the top. Since they are off-center, however, the cranks fall as fast as slippage past the plunger will allow. The pumping unit cannot be properly counterbalanced and, while operating, the motor is made to generate as the cranks swing through either the bottom or top of the stroke, depending on the direction of rotation.

LEASE AUTOMATION

Field experience also shows that short-cycle pumping accomplished by either percentage timer, pump-off controller, or both, has a place in the current industry activity of operating with minimum lease attendance. Through short-cycle pumping a well will produce essentially the same amount of fluid during the running portion of each 15-minute interval. If all the wells on a lease are short-cycle pumped the production received at the battery, of course, should also be stabilized. The entire lease may then be monitored by the counter if equipped with an LACT unit. E.g., seven wells which produce into a satellite battery, were equipped with a combination of percentage timers and pump-off controllers. The battery itself consisted of a two-phase production separator, a surge tank, a transfer pump, and automatic well test equipment. A meter was installed in the pump discharge line and a level control was installed on the tank so that it was pumped to the same level at the same time each day. When there was no trouble with any of the wells the daily fluid production from the seven wells was consistent within two per cent as seen in Fig. 5. A daily, or preferably more often, meter reading will monitor the entire satellite operation until, in this case, the fluid leaves the satellite. Similarly an entire battery that is equipped with a LACT unit can be monitored by the LACT meter counter. It would only be necessary to bring this counter reading into the Production Foreman's office anticipating that the lease might be visited only weekly as long as production is being maintained. The lease operator would go to the lease immediately, however, whenever a loss in production is indicated.

Under this concept, automatic well testing now becomes justified since, with the production from each well stabilized, it is necessary to test the wells only for the length of time it takes the poorest well to make the test separator dump. In this way the wells are scanned at least daily on a *"go-no go"* basis and the test results recorded on a strip chart. This chart is then very useful in locating a well that is down when a decline in production occurs. Under this concept there is no necessity to transmit the well test data to the Foreman's office since it would be used primarily when on the lease and looking for trouble. Twenty-four hour tests would also be required periodically for filing State forms and engineering data. More experience is required to determine the best way of scheduling well tests.

The percentage timer is a very reliable and economical device to accomplish short-cycle pumping. E.g., this equipment has been in operation on six wells for about a year with a minimum of adjustment necessary during this time since these wells are very stable. They are set so that the unit is operated for an additional 30-60 seconds after the well pumps-off before shutting down. Incidentally, it is very easy to check to make sure that the well is pumping-off by merely listening to the sound of the motor. The eight per cent slip motors which are used for pumping applications have a very obvious change in sound on the down-stroke as they pump-off after they have been counterbalanced under pumping conditions. However, wells which have a change in production, as in a waterflood, may lose production when they respond if pumped on a fixed cycle. This situation is best handled by using a pump-off controller which will automatically adjust itself to the pumping cycle required.

CONCLUSION

Most of the ideas presented above, such as dynamic pump spacing and unit counterbalancing, are certainly not new but it is felt that combining them within the concept of short-cycle pumping offers definite advantages in rod pumping. Much additional work remains to be done to field test the additional equipment needed and train field personnel. Experience indicates, however, that power savings can be easily realized. A closer analysis is required of each well initially but it results in better spaced pumps and counterbalanced units; stress and wear will be minimized on all equipment; and better surveillance of production is realized which may be expanded into minimum attended lease operation by field personnel.

REFERENCE

1. Pump-off controller manufactured by Jaeger Controls, Dallas, Texas.