Installation and Care of Beam Pumping Units

By FRED GRIFFIN
Lufkin Foundry & Machine Company

INTRODUCTION

When it becomes necessary to put an oilwell on the pump, the operator is usually faced with an investment of several thousand dollars in some means of artificial lift. By far the most successful and most generally accepted type of artificial lift is the beam type pumping unit. Many years of research and testing have gone into the design of the modern pumping unit. Advancements in metallugry and the most up-to-date machine tools go into its manufacture. All these improvements in design and technique of manufacture are of little value if the equipment is not installed properly on the well or operated correctly. For the operator to get the most from his investment in a pumping unit, he should operate the unit as the manufacturer intended it to be used and within its nameplate rating.

INSTALLATION

Well Head

Even before the location for the pumping unit foundation is laid out, the precautionary measure of checking the well head is highly desirable. Very often the well head will lean one way or the other to the extent that the stuffing box on a high well head will be off 2 or 3 inches from the well center at the foundation level.

The well head should of course be straightened up before the foundation is located with respect to the centerline of the well. Otherwise, excessive polished rod wear and stuffing box leaks will result. Also, if the well head is not straightened up, it may be virtually impossible to install and operate the pumping unit properly. This precautionary measure of straightening a well head, if needed, is very important before locating a foundation for the pumping unit. It is also one that is nearly universally ignored.

Foundation

An adequate foundation is of course essential to the satisfactory operation of a pumping unit. Although there are circumstances under which substitutes may be acceptable, a reinforced concrete block is still recommended for trouble-free operation. The manufacturer's foundation print will show the location of the foundation bolts or holddowns, and a suggested outline of the foundation; however, the actual size and depth of the foundation will depend on local soil conditions.

To insure complete bearing of the base on the concrete block there is no substitute for grouting. Grout should be worked under all beams for their full width, not just the edges. Before grouting, however, make sure that the centerline of the base is in line with the well. Do this by aligning the center of the base with a chalk line extending from the center of the well along the center of the foundation.

After the unit is set and all components installed, the following points should be checked before the unit is started:

1. Levelness of the unit
2. Alignment of wireline hanger with well
3. Alignment of samson post with center of base
4. Beam alignment and alignment of pitmans
5. Tightness of all bolts and nuts
6. Correct alighment of V-belt drive
7. Correct V-belt tension
8. Correct oil level in gear box
9. Adjustment of brake
10. Lubrication of crankpin bearings and all bearings on the walking beam

On air balanced units, two additional points should be checked:

11. Lubrication of air counterbalance cylinder and compressor
12. Check for possible air leaks

The above list is intended as a general check list for any beam type unit. Depending on the manufacturer of the unit, additional check points may be necessary. Refer to the check list above for a more detailed discussion of each item.

1. (Levelness of the unit) One of the first items to check on any installation is to make sure that the unit is level. This may be done by putting a level across the main base members. Another more accurate method would be to place a level on a machined horizontal surface on the gear box.

2. (Alignment of wireline hanger with well) On crank balanced units the walking beam may be moved forward or backward approximately 3 inches each way to allow proper alignment with the stuffing box. On air balanced units the base must be skidded forward or backward to the correct position before the unit is grouted in. After beam is aligned, (as in (4) below) it may be necessary to re-align the horsehead by shimming.

3. (Alignment of samson post with center of base) After the base is in the correct position and level, drop a plumb bob from the center of the samson post at the center bearing connection to the base. The plumb bob should fall at the center of the main base members. If this is not the case, the base will usually be found to be out of level. Under these conditions, it may be necessary to shim under one or more legs of the samson post if the base has already been grouted in.

4. (Beam alignment and alignment of pitmans) To check beam alignment, measure the distance between the edge of one pitman and the face of the crank or counterweight nearest it and compare with the measurement taken on the other side. This gap should measure the same on both sides. If gaps are unequal, clamp off well, loosen both pitman connections at the crank pins, loosen all the bolts holding the beam to the samson post bearing and all bolts holding the samson post bearing to the post; then swing the walking beam to the correct position and retighten all bolts.

5. (Tightness of all bolts and nuts) It should be obvious

that all bolts, nuts, etc., should be thoroughly tightened before the operation of the unit is begun; yet this is one of the most common causes of structural failures on pumping units. A bolt that is properly sized for the job it is intended to do should never fail if it is properly tightened.

6. (Correct alignment of V-belt drive) If properly installed and cared for, modern V-belts are dependable and trouble-free. Sheaves should be aligned with a straight edge or a stretched string. If, for example, the engine sheave is offset just one groove with respect to the unit sheave, excessive wear will result as well as greatly increasing the possibility of one or more belts turning over.

7. (Correct V-belt tension) Belts should go on easily without prying of forcing. As the belts are tightened, it should be noted whether or not all belts are the same length. If one belt is still very loose when the others are tight, replace that belt with one to match the other. Tighten the belts until a few pounds finger pressure applied midway between the sheaves will depress a belt between one and two inches. Belts that are too tight will shorten the life of the reducer bearings and engine (or motor) bearings. Belts that are too loose may slip or turn over in the groove, causing belt damage. After a set of belts has run twenty-four hours recheck the tightness. Check again at the end of one week. Do not use any sort of belt dressing on V-belts.

8. (Correct oil level in gear box) Make sure that the oil level is somewhere between the high mark and the low mark on the oil level gauge. Too much oil will cause seal and gasket leaks. Too little oil, of course, will not do the job of adequately lubricating the gear teeth and bearings. There have been cases where the unit has been started without any oil in the gear box. For type of oil to use consult the manufacturer's recommendation.

9. (Adjustment of brake) The brake should be adjusted so that both shoes grip the drum tightly in the "on" position and are completely free in the "off" position. Proper brake adjustment is essential for the operating personnel's safety and also makes it possible to space the well and adjust counterweights.

10. (Lubrication of crankpin bearings and all bearings on the walking beam) Proper lubrication of bearings is absolutely essential for safety operation. Since different type bearings are often used by the different pumping unit manufacturers, always follow the manufacturer's recommendation as to type of lubricant to use. Don't assume that because one particular lubricant is used on a particular bearing on one manufacturer's unit that it is also satisfactory at this same bearing on another make. A recent development in the pumping unit industry has been the introduction of the factory packed bearing which does not require regular field lubrication. Although this development is relatively new in the oilfield and is still on an experimental basis, it appears to be the coming thing.

11. (Lubrication of air counterbalance cylinder and compressor) On air bananced units the air cylinder must be lubricated properly to prevent wear and maintain an adequate air seal. One type air balanced unit requires that a cylinder lubricator (McCord or Manzell type) be filled and properly operated. Another type maintains a pool of oil which "rides" the top of the piston and requires no lubricator. A quart of oil is added to this type every 30 days.

12. (Check for possible air leaks) Some operators complain that the compressor on an air balanced unit runs too often, yet never seem to consider what is causing the trouble. Even very small air leaks will cause the compressor to work excessively. Invariably, the operator will find that some connection is not made up tight or has been made up without a thread compound. Going over every conceivable source of air leak with a soap solution will always reveal even the smallest of air leaks.

COUNTERBALANCE

No phase of pumping unit operation is more important than correct counterbalancing. Since the early days of artificial lift of oil, much has been said and written about the importance of proper counterbalance of the loads involved. Unfortunately, little has been done in the oil industry toward systematic checking of pumping units to insure that the best counterbalance possible is being maintained. As a result, the oil industry loses heavily each year, this loss being in energy expended uselessly and in equipment damaged by overloading.

Counterbalancing may be defined as the means to offset the rod load and fluid load to the greatest extent possible, so as to minimize the net unbalanced load, thereby minimizing the load on the gear box and prime mover. Whether the unit is crank counterbalance, beam counterbalance, or air counterbalance, the importance of this phase of unit operation cannot be overemphasized.

The manufacturer gives each pumping unit gear reducer a peak torque rating. The torque the gearbox must exert is primarily dependent on the uncounterbalanced load; thus, it is the uncounterbalanced load that is of primary concern in counterbalancing a unit.

To properly understand the importance of counterbalance we must first analyse the changing loads imposed on the polished rod and pumping unit structure by the well. These changing loads, of course, apply a changing torque on the pumping unit gear box.

On the down stroke of the pumping unit the primary load exerted on the polished rod is simply the weight of the sucker rod string. Similarly, the load on the up stroke is the weight of the rod string plus the weight of the fluid column and plus the force necessary to accelerate the fluid column. (These are not the only loads imposed on a sucker rod string; however, they are by far the largest in magnitude and the only ones to be considered here.) Thus, the difference between the up and down load is the weight of the fluid column plus the load required to accelerate the fluid. If the operator is able to counterbalance one-half this difference as well as the weight of the rod string, then the load on the prime mover as well as the gear reducer will be equal on the up and down stroke.

If the operator counterbalanced the weight of the rod string only, there would be no load on the gear reducer on the down stroke. On the up stroke, however, there would be twice the normal expected load. If the unit were overcounterbalanced to the same extent, the same would be true on the down stroke. These abnormal loads on the gear teeth cause premature wear and pitting on the few teeth that are in contact at this maximum load point. Unfortunately, this maximum load point comes at the same place on the gear on every stroke of the unit, and it is at this point the gear will receive 90 per cent of the wear. If a unit is properly balanced, however, this abnormal loading will be distributed between to load points of equal magnitude, one on the up stroke and one on the down stroke.

We have established that for a gear to give a satisfactory service life it must be properly counterbalanced. Now let us explore some practical methods for determining if a unit is correctly counterbalanced.

Sound of Prime Mover

Perhaps the most widely practiced method of determining the correct counterbalance of a unit is merely by listening to the prime mover. If the unit is driven by an electric motor, this is an especially good method; the whine of the motor will vary in intensity on the up and down stroke if the torque peaks are not the same. This method is also good on gas engines where the flywheel effect is not too great and when the engine is 75 per cent or more loaded.

Ammeter Method

For units with electric motor drives, this is perhaps the best method for counterbalancing a pumping unit. This utilizes an ordinary ammeter to measure the motor current throughout the cycle and will clearly show the position and relative magnitude of the two torque peaks. This is a very accurate means of counterbalancing a unit.

Observation of V-belts

By observing the slack side of the V-belt drive and noting the amount of dip of the belts at the load points of the up and down stroke, the relative torques on the gear reducer are indicated. If the dip is the same on the up and down stroke, then the unit is fairly well counterbalanced.

Polished Rod Dynamometer

The polished rod dynamometer is an instrument that measures and records the well load at all points throughout the pumping cycle. The counterbalanced line on this dynamometer card can also be measured and plotted. While the other three methods mentioned above will all balance the gear reducer to varying degrees of accuracy, the polished rod dynamometer will not only reveal this same information but sill also reveal the magnitude of the unbalanced load from which the torque peaks can be calculated in inch pounds. For example, by the ammeter method an operator may balance the torque peaks perfectly, but he still doesn't know whether these two equal peaks represent 50 per cent of the rating of the gear reducer or whether it represents a 100 per cent overload. The dynamometer gives him this information as well as the actual polished rod loads and polished rod horsepower. Thus, the dynamometer is used principally to determine whether or not a unit is overloaded.

There are other methods that are used to determine if a unit is properly counterbalanced; however, the ones given above are the ones most commonly used.

Perhaps the single greatest mistake made in counterbalancing of team-type pumping units is that of attempting to counterbalance the unit under certain conditions as the operator finds them at the time. The well may be one of the type that tends to vary considerably throughout its pumping period each day. When a new unit is started, the counterbalance weights should be placed in such a position that the unit will operate satisfactorily without overloading the prime mover, yet no attempt should be made to achieve perfect counterbalance.

After the well has pumped long enough to settle down to fairly uniform conditions, accurate and close counterbalancing may be attempted. Even then, the well should be checked two or three times per day for the first thirty days of operation, in an attempt to determine whether or not the fluid level is dropping, or whether other conditions are present that would affect the counterbalance requirements. Many wells may be perfectly counterbalanced when started up, yet at the end of an eight-hour pumping period the unit may be so badly balanced that the prime mover is on the verge of stalling. Such a well cannot be counterbalanced throughout the pumping period, but must be overbalanced at the beginning, with the result that it will be perfectly balanced about midway through the pumping period and definitely underbalanced by the end of the period. There are thousands of such wells, and it is very probable that they cause the bulk of the equipment overload.

PREVENTIVE MAINTENANCE

An adequate preventive maintenance program on a pumping unit is primarily one of detailed observation at regular intervals. Since pumping units are not designed to "wear out" after a certain period of time, as are many products on the market, the program does not call for a periodic replacement of certain parts. Rather, it should call for observing the operation of the equipment; if a part shows signs of faltering, it can be replaced before further damage is done.

Any sort of preventive maintenance program must assume, of course, that the unit has been satisfactorily installed and adequately lubricated in the first place.

Monthly Inspection by Pumper

This inspection would be aimed at training the pumper to be observant of any abnormalities of pumping unit operation. In essence it would train the pumper to "Stop, Look, and Listen" and observe when he is around the unit. A list of things to look for would include the following:

1. Apparent looseness of bolts or capscrews at the bearing connections on the walking beam.
2. Possible oil seal or gasket leaks on walking beam bearings.
3. Abnormal squeaks or noises seeming to come from any of the bearings on the walking beam.
4. Observe if wire line "tracks" in center of horsehead or if it angles off at the bottom.
5. Note if base "breathes" on its foundation block indicating loose or broken foundation bolts.
6. Standing close to each crank pin bearing, note if there is any sort of abnormal noise in the bearing. If there is any doubt whether the noise is coming from the crank pin bearing or some other spot on the unit, place your hand on the crank pin cover and follow it around the cycle. You will be able to "feel" any roughness in the bearing.
7. Note a possible oil seal or gasket leak at each crank pin bearing.
8. Evidence of crank pin being loose in crank pin hole.
9. Note if sheave key is loose.
10. Note whether belts are slipping or turned over in their grooves.
11. Check brake adjustment.
12. Note any apparent looseness of counterweight bolts.
13. Is there excessive noise in the gear box?
14. Oil seal or gasket leaks on gear reducer.
15. Oil leak at parting line on gear reducer.

On air balanced units this monthly inspection should include stopping the unit and engine and listening for air leaks. If there is no engine noise, the operator will very often be able to locate an air leak if there is one.

Oil in Gear Reducer

After the oil has been in service for one year the operator should give the oil a good visual inspection for possible dirt, sludge, water emulsion or other forms of contamination. It should also be noted whether there is any evidence of thinning out.

After this first inspection a similar inspection should be made every six months.

It is also highly recommended, where it is at all possible, that a quart sample be taken from the sump of the gear reducer every year and checked for acidity by the operating company's testing laboratories.

Lubrication of Structural Bearings

Unless a regular inspection of the structural bearings indicate that there is an oil seal or gasket leak, it is recommended that additional lubricant not be added. It is assumed, of course, that the bearing was adequately lubricated before it was ever operated. If it is necessary to add lubricant, add slowly so that no damage is done to the oil seals. (Note: Most manufacturers provide a safety relief fitting at each bearing. Make sure this fitting is operative before adding lubricant.)

Structural Bolts

1. Check tightness with an adequately sized wrench after 24 hours of operation.
2. Recheck tightness after one week of operation.
3. Thereafter, check every six months.

NOTE: The above applies to all bolts on the walking beam, foundation bolts, crank pin nuts, engine hold down bolts, etc.

SUMMARY

This paper has been written with the idea of presenting a method of installation, and operation that, if put into practice, will assure satisfactory service of the beam type pumping unit.