Foundation And Installation Of Beam Type Pumping Units

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With pumping units as with any other structure, the foundation is one of the most important items. No architect would even consider designing a building without proper foundation. The foundation of a large structure is a considerable portion of the cost of the entire project. Highway and railroad bridges require well designed and installed foundations often reaching down to bed rock, where available. All types of machinery such as generators, process machinery, forges, machine tools, etc., are mounted on rigid and heavy foundations.

The pumping unit is no more nor less than a piece of machinery designed in such a way and with suitable capacity to move a string of sucker rods up and down in a well thereby actuating the pump. In order for this machine to operate properly and give satisfactory service, it must be mounted on a suitable foundation. If it is mounted in such a way that it can move about, flex or settle, it is inevitable that trouble of one sort or another will develop.

The oldest and still most popular type of pumping unit foundation is the concrete block. This type falls in two general categories, namely the flat slab and the floor clearing block. The flat slab consists of a level mat of concrete at approximately ground level with a contour to suit the shape of the pumping unit skid and prime mover mounting. The unit to sit on this type of foundation must be designed so that the cranks will clear the ground as they revolve.

Beam counterbalanced units usually are no problem as the cranks are short enough that they will not strike. However, with rotary counterbalanced units, some means of raising the gear box is employed to give the weights the proper ground clearance. At one time pits in the ground were employed for crank clearance. However, these filled with water and were hard to drain. The floor clearing type foundation is elevated at least high enough for the rotating crank weights to clear the ground without the employment of a gear box pedestal. Quite often these units are even higher to provide safety from flooding in the area. It is necessary for this type of foundation to be narrow enough to clear the crank weights and for that reason usually follow the contour of the pumping unit skid quite closely. This is not necessarily the case with the flat type which often is poured in a wide slab.

As both the flat type and floor clearing units are so similar, design and requirements are practically the same. Modern pumping unit design has been so compacted that much less concrete is required for the foundation. This feature must not be carried to extremes however, as it will result in a foundation so light that the unit will not be properly anchored. The foundation should be heavy enough by its weight alone to resist the overturning force of the polished rod load. If it is not, the unit will tend to tip forward, causing the foundation to settle unevenly, thereby throwing the unit out of level and alignment.

As is the case in most concrete construction, reinforcement of pumping unit foundations is very desirable. A concrete one has a very low tensile and bending strength. Unless some method of holding the concrete together is employed, it will usually crack when it is put under load. Deformed bars are usually placed in the foundation while pouring to produce the desired tensile strength of the slab. However, other types of reinforcing are sometimes employed such as old sucker rods, scrap iron and wire mesh. Old wire line has been quite popular but is of little effect as a reinforcing material. The deformed bars are the most satisfactory as they are designed to produce the best bond between the rod and the concrete. The forces imposed on a foundation are quite large. The downward thrust at the samson post is approximately twice the value of the polish rod load. The upward force immediately under the gear box is approximately equal to the polish rod load minus the weight of the gear box, cranks, and counterweights. Thus, there is a fairly high upward force not too far removed from a very high downward load. As the skids in most pumping units are not rigid enough to resist this type of loading, most of the forces are transferred directly to the foundation. It is for this reason that the foundation must not only be designed with sufficient weight, but also with enough rigidity to withstand these forces without cracking.

Until recent years it was customary to imbed anchor bolts in the concrete in order to attach the pumping unit to the foundation. This method is still widely used. However, other methods are becoming more popular and will be discussed later. When anchor bolts are used, it is very desirable to incorporate the use of grout tubes to facilitate the mounting of the unit. Grout tubes are small cylinders placed around the anchor bolts before the base is poured in such a manner that the concrete is held away from the upper few inches of the bolt. Their diameters and length depend upon the size of the anchor bolt. They are usually one to two inches larger in diameter than the diameter of the bolt and have a length of approximately twice their diameter. These grout tubes are usually made of gutter pipe or old iron pipe. However, heavy cardboard tubes and tin cans have been used quite frequently.

The anchor bolts are usually furnished by the pumping unit manufacturer and consist of a piece of steel bar threader for a few inches on the upper end with a short length of the lower end bent at a right angle. The bolt should be imbedded deep enough in the concrete that there is no possibility of it pulling loose. A good rule-of-thumb of minimum length is eight times the diameter of the bolt in the concrete. When grout tubes are used, this minimum distance should be that amount under or below the grout tubes. It is very desirable that the bottom of the foundation bolt extend below the top layer of reinforcing steel. The foundation bolts must be placed in the concrete as near to the pattern of holes in the skid as possible. Most manufacturers furnish foundation prints with the dimension of the location of these bolts. Some types of template to hold the bolts in their desired position should be used and will more than save the time required to construct. When the unit is mounted, the grout tubes will permit the bolts to be bent slightly to allow for any discrepancy in the setting of the bolts or in the location of the holes in the skids.

At the June 1955 meeting of the API, a recommended practice for the installation of beam type pumping units was adopted subject to letter ballot. Two methods were designated; the preferred one being the use of foundation bolts and grout tubes. The first step in this recommended practice is to pour a level foundation as was described previously. The second step is to strike a center line on the top of the hardened foundation, using a chalk line from the center of the well to the end of the foundation away from the well. The unit is then set on the foundation with the center line indicator marks on the front and back of the skid which are provided by the manufacturer to coincide with the center line mark on the concrete. Wedges are used under the skid to level the top of the base. The level in both the longitudinal and crosswise directions should be checked. After the samson post is mounted, a plum line is dropped from the center of the samson post top and should coincide with the center line on the top of the foundation. If it does not, the unit should be adjusted either by the wedges or some other method.

After the walking beam has been mounted and the pitmans connected to the cranks, a plumb line should be dropped from the center of the horsehead, half the diameter of the wire line out from the face, down to the center of the well tubing. The walking beam should then be adjusted so that the plumb bob will fall within 1/16" of the center of the well tubing. After the unit is aligned in all respects, the space under the skid should be thoroughly grouted and allowed to harden before removing the wedges. The foundation bolts are then uniformly tightened and all structural bolts in the unit should be checked. After running the unit for two weeks, all the fasteners of the unit including wrist pin nuts should be rechecked for tightness.

An alternate method consists of installations using universal clamps or other types of flexible foundation mountings. In this case the unit is mounted directly on the slab without

the use of grouting, therefore requiring an exceptionally smooth finish on the concrete. The check for level in most cases will be found reasonably satisfactory if the block has been properly prepared. If such is not the case then it will be necessary to adjust by wedges or shims. If shims are used it is advisable to weld them together and to the base of the beam to make certain that they stay in place.

Most pumping unit manufacturers provide various adjustments for aligning the units. The walking beam is usually mounted in such a way that it may be moved toward or away from the well a reasonable amount. This is accomplished either by providing a slotted connection between the center iron saddle and the walking beam or between the samson post top and the center iron support. Some smaller units have longitudinal slots for the foundation bolts in the skid, thus permitting the entire unit to be moved forward and backward for proper horsehead alignment. Many horseheads have means of lateral adjustment so that the horsehead may be hung vertically regardless of minor twists in the walking beam. It is very important that the horsehead be accurately aligned with the well in all positions of its cycle as any great departure will result in certain trouble. If the horsehead is too far away from or too close to the center of the well, the polish rod will be bent, causing undue strain and wear on the polish rod and stuffing box. Any lateral displacement of the horsehead will not only cause polish rod and stuffing box trouble but will also result in undue strain on the pumping unit and will usually result in premature bearing failures and shorter wire line or hanger life. A majority of the walking beam lateral vibration difficulties are caused by improper alignment of the horsehead to the well.

Many manufacturers furnish so-called packaged units. This simply means that as much of the unit as is possible is assembled before it is delivered to the location. Small units may be completely asembled and ready to run when they are delivered. Because of hauling limitations this is not practical on larger units but packaged units usually consist of skid, reducer and crank assemblies, pitman sub-assemblies, equalizer sub-assemblies, etc. Some manufacturers also assemble the rotary counterweights to the cranks. Any assembling that can be done in the shop, reduces field installation time, thereby reducing contractors costs. It is always good practice to check the tightness of all bolts whether they are field installed or shop installed after the unit has been mounted. It is further recommended that all bolts be again checked after the unit has run approximately two weeks.

There are a number of other types of pumping unit foundations than the ones just discussed. One of these is the Pier Type. This method of construction consists of a number of vertical posts or piers set into the ground with the tops usually extending slightly above the ground in such a pattern that they support the pumping unit skid. Some operators have used creosoted wooden posts for this purpose. However, the most satisfactory material is concrete. If possible, some type of bell bottom design should be employed so that the piers will not be easily pulled out of the ground. As the unit is supported only at intervals, it is usually necessary that the unit skid be more rigid than required for conventional mounting. This method is usually employed where a large volume of concrete would be impractical or uneconomical to procure.

Another type of foundation which has become popular due to a reduced requirement of concrete is the short block. This consists of the usual flat slab of concrete but it is shortened by one of several methods. One way of accomplishing this is to have the prime mover mounted on a cantilever support at the back of the gear box, thus eliminating any concrete under the motor. The same may be accomplished by mounting the prime mover, usually an electric motor, underneath the samson post, thereby permitting the foundation to terminate at the end of the gear box. It is still necessary to provide enough weight in the foundation to prevent an overturning tendancy of the unit.

One very popular method of mounting pumping units is the universal tie-down. The number of variations of this system are nearly as great as the number of operators using it. One method is to provide a pipe imbedded in the surface of the foundation slab with a slot running its full length in such a way that "T" headed bolts may be anchored in it. These bolts extend up through a suitable cross member either on the upper or lower flange of the skid, thereby anchoring the unit to the slab. Another method very similar to this is two channels facing each other spaced far enough apart to allow the body of a bolt to pass through. These two channels are imbedded in the concrete with the top of the channels flush with the surface. Still another method is a row of cast or fabricated "T" slot anchors imbedded in the concrete usually down the center line of the unit. An anchor bolt head may then be slipped into this "T" slot and a cross member, as previously mentioned, used to anchor the unit. One company casts a recess or trench down the center of the foundation with hairpin shaped steel bars imbedded in the concrete with the loop sticking up into this trench. A pipe is then slipped in through these loops and U-bolts are then placed under the pipe with their threaded ends sticking up and through the cross members that extend over the tops of the skids. One very simple method of providing a universal tie-down is to provide flush type nut anchors in the concrete. These are suitably anchored in the foundation and the unit secured by placing long bolts through cross tie-down members and threading them into the nuts.

There are many more variations of the universal tie-down but all of them are designed for a certain amount of flexibility in the mounting. Quite a wide range of sizes of pumping units may be mounted on the same foundation without alteration, thus providing a very simple method of moving units from one location to another or changing the sizes of a unit as well conditions vary.

Some operators feel that a certain amount of noise and vibration may be eliminated by mounting the units on a cushion. This can be accomplished by placing some type of resilient material between the foundation slab and the skid of the pumping unit. This material could be rubber belting, wooden sills, etc.

In some areas of the country, portable skids have become quite popular in recent years. These are used where for one reason or another, it is not desirable to put in a permanent type foundation. One method which has had quite an acceptance is the wide base unit. This consists of a skid which may be an integral part of the main skid or as a separate unit upon which the main skid is mounted. These bases are considerably wider than a standard skid and are somewhat longer in both directions. Many manufacturers furnish this skid as optional equipment and are usually constructed of beams, channels and angles. Many wide base skids are made in the field or in small shops and quite often consist of the old drill pipe welded together to make a suitable skid. Most operators require that this skid be extended toward the well a considerable distance with some of them being extended as far as the center line of the well itself. This is very desirable in that it reduces the tendency of the pumping unit to tip forward due to the polish rod load. However, very frequently when these units are installed in the field, there is no support provided under this front end extension, thereby completely eliminating any benefit which may be derived from it.

At least one manufacturer has provided cast iron slabs which may be bolted to the underside of the main skid, thereby providing a flat area for the unit to rest on the soil. Ribs are provided on the underside of these slabs so that they may dig into the soil and reduce any tendency of lateral movement of the unit.

Many units are temporarily mounted on wooden timbers. It must be remembered however, that weight is very important for holding a unit in place and either these timbers must be very large and heavy or some auxiliary means of holding the unit down must be provided.

A few operators have mounted pumping units on trailers or truck chassis. These are advantageous in a field where the same total amount of production may be obtained from pumping a well a few days out of the month as compared to continuous pumping. By the use of suitable guides and stops at each location, it is then possible to move a unit from well to well, thus greatly reducing the investment necessary for a large number of pumping units.

As was mentioned at the first of this discussion, it is very desirable to have

a heavy and rigid foundation for pumping unit mounting. Most portable units lack this feature. However, for one reasson or another, it is desisrable to compromise. They are advantageous in that installation cost is low and under some conditions such as short lived wells, this is very desirable. There are some drawbacks to this method of mounting units. It is difficult to keep the units level and in proper alignment with the well. Where the soil is soft and the climate is wet, it will be necessary to re-level and re-align the units at frequent intervals. Where the loads are great or vibration is severe, the units will tend to walk or creep away from their original position. This tendency may be reduced by suitable stops such as stobs driven into the ground. If the members to which the unit is attached are not rigid enough, there will be a certain amount of flexing as the unit operates, causing undue strain in the unit itself. This can result in broken bolts, broken welds, and even bearing trouble in severe cases.

The mounting of the prime mover of a pumping unit is probably the most neglected part. Not enough thought is given to the proper anchoring of the engine or motor, resulting in severe vibration, causing trouble. The four common pumping unit prime movers in the order of their severity of vibration are the electric motor, the multi-cylinder internal combustion engine, the high speed single cylinder engine and the low speed single cylinder engine. The vibration and inertia forces of this last mentioned engine are sometimes so great that the manufacturer will not recommend its mounting on any type of adjustable slide rail.

There are a number of methods of mounting these engines and motors. Probably the most satisfactory in the smaller sizes is the long skid. This consists of the main skid of the pumping unit being extended as an integral part far enough to the rear for the prime mover to be mounted directly on it with the use of slide rails. When electric motors or small single cylinder engines are used, they may be mounted on this extended skid without the use of any outriggers. However, when a multi-cylinder engine is employed, it is quite often necessary to provide an outrigger to one side of the skid for proper support of the radiator end of the engine. Another method which is quite similar to the long skid is the short skid design with a skid extension which is bolted on. This provides more flexibility as the skid extension may be designed to receive a particular type of prime mover with various extensions being furnished for various types of engines.

A so called universal mounting has been used with varying degrees of success. Some of these are tied to the main skid for rigidity and consists of slide rails mounted in such a way that the engine may be moved both fore and aft and laterally with a minimum amount of effort. Some of these mountings are so flexible that electric motors, multi-cylinder engines or single cylinder engines may be mounted without the use of any additional equipment. A variation of these universal rails are ones that are entirely independent of the main skid and are tied only to the concrete foundation. It is then absolutely necessary that the foundation be rigid enough to maintain the proper spacing between the engine and the unit.

As was mentioned earlier, some of the low speed single cylinder engines can be mounted directly on the concrete. It is then necessary that alignment between the unit and the engine foundation be held accurately. The engine manufacturer usually provides a base for his engine which will provide a small amount of adjustment for belt tensioning. Quite often this is the only type of mounting which will overcome severe engine vibration on more conventional type of engine mountings.

Well head clearance or the space between the top of the stuffing box and the under side of the carrier bar at its lowest point should be considered when setting a unit. The very minimum that this distance should be is that required for placing a safety clamp on the polish rod, usually about eight inches. This should be considered as an absolute minimum and it is desirable to have considerably more than this. As previously mentioned, any misalignment of the horsehead with the center of the well produces bending in the polish rod and excessive wear in the stuffing box. The greater the distance between the top of the stuffing box and the bottom of the carrier bar, the more flexibility the polish rod will have, thereby reducing the forces produced by any slight misalignment of the unit with the well. This is even more important with rein type hangers. The only way by which this dimension may be varied is by varying the elevation of the foundation or the well head. For that reason careful study of the manufacturers foundation plan should be made before the foundation is started. This plan shows the height of the carrier bar above the ground. By determining the height of the stuffing box, it is then possible to calculate what the well head clearance will be. If it is too small it is then necessary to raise the foundation sufficiently to provide the desired clearance if lowering the well head is not practical.

Many operators, and rightly so, consider safety above all else. Usually a safely operated field is also an efficiently operated field. All moving parts which may injure humans or animals should be well guarded. Rotary counter weights, drive belts, engine flywheels, etc., should be protected with rigid but easily removable guards. Some locations are completely surrounded by a fence designed to keep out any creature that may frequent the area. When this is done, a suitable belt guard should be used to protect belts from the elements. Many states require very rigid safety measures. In addition to those already mentioned, there are safety oiling platforms, ground level lubrication systems, hinged horseheads, wire mesh on the guards, etc.

There are many other types of pumping unit foundations. Most of them have certain advantages peculiar to particular areas in which they are operating. However, the points to be considered and the reason for considering them have been pointed out and if these are kept in mind when mounting units or designing new foundations, a great deal of pumping unit trouble may be greatly reduced or entirely eliminated.