What Type of Beam Pumping Unit Will You Use?

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Much has been said and much has been written on the advantages of various types of pumping units. Features such as total weight, ease of maintenance, ease of relocation, size of pad or foundation, adjustment of counterbalance, and motion of rod have been thoroughly discussed. However, all the advantages do not belong to one type unit. The operating conditions change from location to location, and from well to well; and the advantage of one type unit in a certain size may turn into a disadvantage in a different size. Therefore, any discussion aimed as an aid in the selection of a pumping unit should be preceded by a brief description of the different types available. It is to be understood that the paper is concerned only with beam type units.

THE WEIGHT BALANCED UNIT

This is the older and more common type unit and is made in two types of construction. The first type, illustrated by Fig. 1, utilizes the principle of the first class lever, a lever in which the fulcrum is placed between the weight and the force. In this case, the well load represents the weight, while the force necessary to move the weight is furnished by the reducer and the counterbalance acting thru the pitmans to the beam or lever.

The second type of weight balanced unit is illustrated by Fig. 2 and utilizes what is known as a third class lever, in which the force acts on the lever at a point between the weight and the fulcrum. Once again, the weight is represented by the well load, while the force is furnished by the reducer and the counterbalance, acting on the lever thru the pitmans.

For either the Class 1 or the Class 3 levers to be balanced, the counterclockwise moments must be equal to the clockwise moments. In both cases, the clockwise moment would be the weight of the well load multiplied by its distance from the fulcrum. The counterclockwise moment would be a function of the force applied thru the pitmans at the yoke, multiplied by the distance from the yoke to the fulcrum. It is obvious that, with the Class 3 lever arrangement, the force must always be greater than the load.

Any calculation of moments must take into consideration the weight of the beam and its hardware. As seen in Fig. 2, it is apparent that the weight of the horsehead, wire line, hanger bar, cross yoke, and pitmans are acting in the same direction as are the well load, or clockwise. And the sum of their moments must be overcome by the counterclockwise moment supplied by the reducer and counterbalance.

Comparing this situation with that in Fig. 1, one sees that the weight of the horsehead, wire line, and hanger bar act in the same direction (clockwise) as does the well load, while the weight of the cross yoke and pitmans act in the opposite direction (counterclockwise). Thus, the moments tend to cancel each other, and, thereby, further reduce the force necessary to overcome the well load. However, one must not confuse force with power, for, since power is the force times distance divided by time, the Class 3 lever calls for a higher force acting over a shorter distance for an equal length of time. But this fact does not affect the torque demand on the reducer because of the shorter cranks used with the Class 3 lever system, although it does increase the load on the wrist pins, bearings, and pitmans. Also the increased overbalance must be cancelled out with extra counterbalance.

THE AIR BALANCED UNIT

The air balanced unit is similar in appearance to the weight balanced unit constructed as a Class 3 lever (Fig. 3). The counterbalance effect is supplied by compressed air, and this force is applied to the beam at a different point from that force furnished by the reducer. Thus, the magnitude of the forces in the system from the reducer to the beam is much less than in the weight balanced unit.

An interesting comparison between the Class 1 and Class 3 lever systems is polish rod motion. In the Class 1 system, the polish rod motion is opposite in direction to the motion of the pitman bearing, while, in the Class 3 system, the polish rod motion is in the same direction and proportional to the motion of the pitman bearing. A common means of demonstrating the motion is shown in Fig. 4. Here the pitman bearing has been compared to the crosshead of a reciprocating engine, and although the crosshead moves in a straight line while the pitman bearing moves in an arc, the principle is still true. As the crank moves thru an arc from "A" thru "B" to "C", the pitman bearing moves from "X" to "Y" and back to "X". Then as the crank continues to rotate from "C" to "D" and back to "A", the pitman bearing moves from "X" to "Z" and back to "X". From the diagram it is apparent that the distance that the pitman bearing traveled during the first 180 degrees of rotation is greater than the distance traveled during the second 180 degrees. Assum-

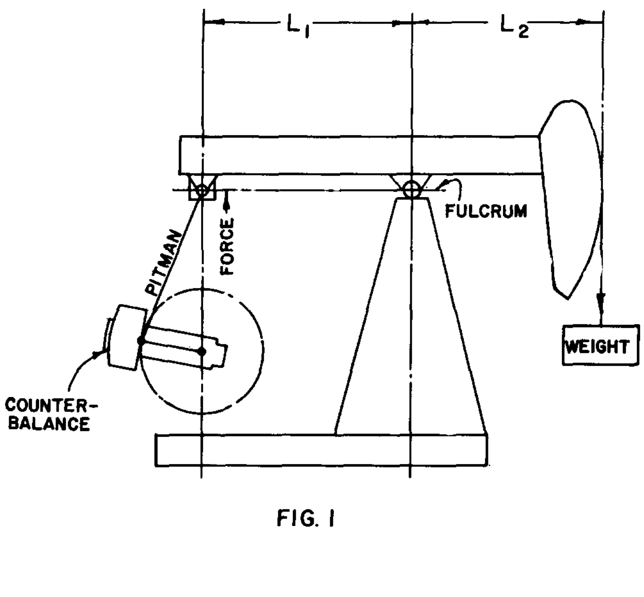

FIG. I

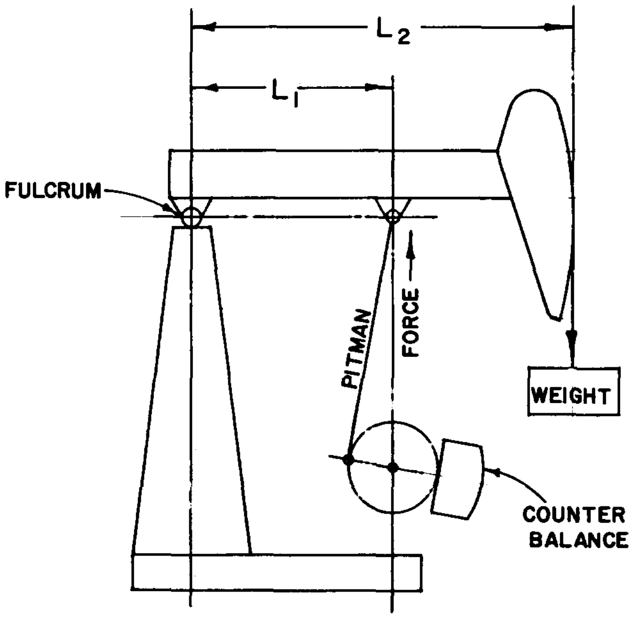

FIG. 2

ing constant angular velocity of the crank, one determines that the average velocity of the crosshead was greater for the top half of the crank circle, since, in the top half of the circle, the horizontal and vertical components of the wrist pin travel are additive. On the other hand, in the bottom half, they are subtractive.

If one applys these differences to the Class 1 lever system, he will find that the average velocity of the polish rod is higher during the bottom half of the stroke. By the same token, in the Class 3 system where the rod motion is comparable to and in the same direction as the pitman bearing travel, the average velocity is higher during the top half of the stroke.

Since velocity and acceleration are related and since acceleration affects rod loads and rod stretch, it is generally considered advantageous to have the lower acceleration and deceleration at the bottom of the stroke. Under certain conditions, this advantage allows better filling of the working barrel and also overtraveling on the plunger. In addition, the lower acceleration on the start of the upstroke should result in longer rod life.

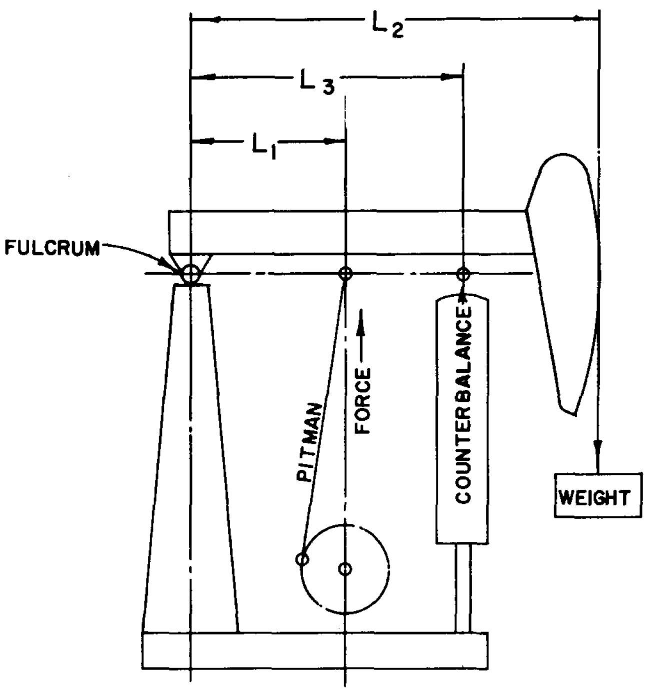

FIG. 3

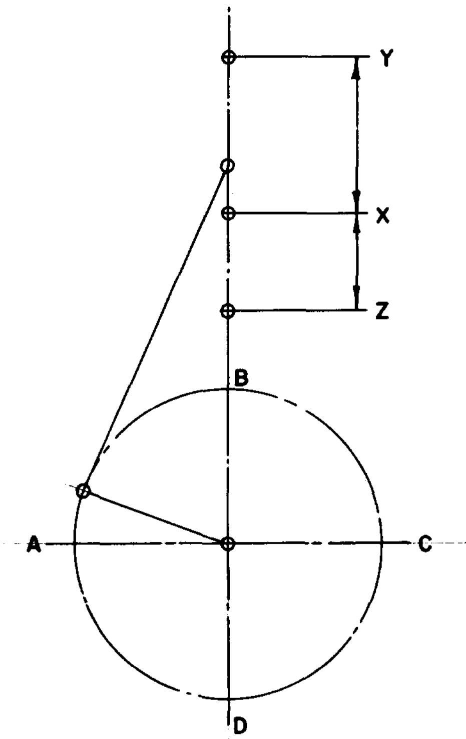

FIG. 4

OTHER CONSIDERATIONS

To this point the discussion has been confined to the basic construction principles of the beam type pumping units. However, all have other components, the most important possibly being the transmission or reducer, for without a doubt, the reducer takes more punishment than does any other part of the unit. And when the reducer is used on the weight balanced units, the overhung loads imposed on the crank shaft and the reducer case add to the normal torque reaction resulting from the power flow.

Reducers are available in either chain or gear drive. Both are closely regulated as to rating and construction by API, but, although both are used to accomplish the same end, the engineering aspects are quite different. For instance, the design rating of the gear reducer is primarily a function of the gear hardness and the face width, and as such, the rating can be closely controlled by an adjustment in face width. On the other hand, the problem with chain reducers is more complex. Chain is made by the manufacturer in various pitches and different numbers of strands. Invariably, the actual rating of the chain drive will exceed the API allowed rating for the reducer.

Both chain and gear reducers are precise pieces of equipment; and both are subject to the same characteristic reverse loading that occurs twice in every revolution of the crankshaft. To avoid excessive knocking as the load changes direction, the gear reducer is made with both the gear and the gear housing precisely controlled for minimum backlash. On the other hand, backlash and wear in the chain reducer is controlled by adjusting the intermediate shaft location. This adjustment is made in the field as often as required.

Lubrication requirements of the gear reducer are entirely different from that required by the chain reducer. To avoid scoring of the gear teeth, a rather high viscosity oil with a high film strength must be used, for tests conducted by General Electric Company indicated that the selection of the proper lubricant could double the load carrying capacity of a set of gears. However, if an oil of too high viscosity is selected, problems of free flowing and of excessive oil drag are encountered, expecially in cold weather. Selection of an extreme pressure oil of slightly lower viscosity and with an additive such as lead naphthenate is often made to overcome excessive drag and wear film strength.

Unit loading on rolling or sliding parts of the chain drive are lower because of being spread over a larger area. This lower unit loading reduces the film strength requirement on the lubricant to the point whereby SAE 30 Mineral Base Motor Oil may be used for year round service. And, since the lubrication requirements are not as critical with the chain maintenance costs over the years is so low with this type.

Other construction features of the various makes and models of pumping units differ from brand to brand, and their discussion here would not aid in making a selection of best basic type for a specific application.

Regardless of given conditions to be satisfied in making a selection of a pumping unit, the object to be accomplished is the same: to get the most oil at the least cost. But this accomplishment does not always mean getting the most BPD, for factors other than rate must be taken into account. However, once the desired rate is established, the size unit required can be established.

If the size unit required is small, one will be considering only the weight balanced unit; but, if the size unit required is exceptionally large, especially as to beam capacity, one will be considering only the air balanced unit. After beam requirements pass 35,000 to 40,000 lb the weight balanced unit is not too practical because of counterbalance and beam section problems.

Location of the well is also a factor. The small space requirements and smooth operating characteristics of the air balance makes an ideal unit for platform locations on off-shore or lake front sites; while for the heavy crudes, where a little extra filling time and slower acceleration on the upstroke is important, either the air balance or the Class 3 weight balance unit should get first consideration. And as a partable test unit, the air balance unit is ideal because of ease of portability as well as ease in adjusting counterbalance.

For wells located in areas where the weather is cold most of the time, the unit with the chain transmission will show a substantial power saving advantage. Also remote areas, far removed from repair facilities, are prime locations for the chain transmission equipped unit, for very seldom is the chain reducer removed from the unit for repairs.

The weight balanced unit, either gear or chain, has less moving parts and is generally found to be the most efficient. Maintenance is low; dependability is good. Its simplicity and ruggedness go a long way towards making this the work horse of the beam type pumping units.