FIVE BASIC COMPONENTS
THE FOUNDATION OF BEAM PUMPING

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ARTIFICAL LIFT METHODS IN THE USA

There are many different forms of artificial lift methods used in oil and gas wells in the United States. Eighty percent of the wells in the USA that are using a form artificial lift use a beam pump; to lift the fluids out of the well bore. Lifting the fluid out of the well bore lowers the hydrostatic pressure acting on the producing formation allowing greater in-flow and increased productivity. There are several reasons for the popularity of the beam pump; they are rugged, forgiving and easy to automate. Good diagnostics exist due to many companies developing dynograph systems. This focus of this paper is on the five basic components of any beam pump, why they are important and how they interact.

THE SYSTEM

Although the beam pump is the heart of the fluid producing system, many other components are needed to actuate the beam pump and provide a means of getting the fluid to the surface. The two main components are the pumping unit and the sucker rod string.

BASIC OPERATION

For the sake of this explanation, we will consider the barrel and standing valve to be stationary and the plunger and traveling valve to reciprocate (up & down) in the barrel. On the upstroke, fluid is drawn past the open standing valve into the "compression chamber" between the two valves. As the plunger starts back down, the standing valve closes and the fluid between the valves is compressed. When the pressure of the compressed fluid is higher than the fluid pressure above the traveling valve, the traveling valve opens and the compressed fluid flows through the traveling valve as the plunger falls through the fluid. When the plunger starts back upward, the traveling valve closes and the fluid now above the traveling valve is lifted toward surface. Also a new cycle of pumping is started because the standing valve opens, admitting more fluid into the compression chamber. This cycle repeated for a twenty-four hour period accounts for the production rate in barrels per day.

THE FIVE BASIC COMPONENTS

The basic parts of the beam pump are quite simple but are built to great precision to ensure interchangeability and efficient operation. The basic parts are the barrel, plunger, standing valve, traveling valve and hold down. There are many more parts that make up a beam pump but the five basic components must be in good working condition in order to lift fluid to surface, if any of these five components fail, fluid will no longer be lifted to surface regardless of the condition of the other parts.

API INSERT AND TUBING PUMP BARRELS

Basically, there are two major classifications of barrels, insert and tubing pumps. There are several variations in each of these, such as wall thickness, method of threading and material choices to name a few. For any given barrel material, the strength of a barrel is directly related to its outside diameter and wall thickness. There are thin wall-barrels for shallow to medium depth wells and heavy-wall barrels for larger bore pumps or for use in deeper wells where the loads are greater. The barrel configuration, threads, wall thickness, the dimensional tolerance and the inside diameter of barrels are covered by API's standard 11AX. Barrels for metal plungers have an inside diameter tolerance of base minus zero to base plus two thousands of an inch. Barrels for beam pumps categorized by the API with a letter designation; RW, RX, RH and TH. RW or thin wall barrels have a wall thickness of one eighth of an inch. They are internally threaded and the fittings shoulder to the end of the barrel RX is a heavy wall barrel with a wall thickness of three sixteenths of an inch. They are also internally threaded but the extra wall thickness will allow this barrel to be run to a greater depth.

RH or heavy wall barrels have a wall thickness of three sixteenths of an inch. Each end of the barrel is threaded on the outside diameter and is made to shoulder up and seal inside the extension coupling. The inside seal makes a stronger connection because the threads are not exposed to the high-pressure fluid inside the pump barrel during operation. The heavy wall barrel plus the stronger connection results in a stronger pump for use in the deepest wells. RH barrels are also called stroke through barrels because it can be configured with longer extensions to allow the plunger to stroke out of the top and bottom of the barrel during the pumping unit stroke. The application of the stroke through set up can be very advantageous in wells producing scale and sand as the stroke through action acts as a wiper to keep sand or scale from entering the barrel / plunger interface.

TH or tubing pump barrels have a wall thickness of one quarter of an inch and are part of the tubing string. It needs to be strong and rugged to withstand the higher differential pressure that can exist between the inside and outside of the tubing string. The ends of a TH barrel are threaded on the outside diameter and shoulder on the on the inside of the fitting attached to it which adds strength to the joint. This also allows for a stroke through feature for use in wells that produce scale or particulate laden fluid. Tubing pumps have the largest displacement possible for a given tubing size with out the use of an oversize pump and an on-off tool in the rod string.

Barrels are available in many different materials and a variety of process can be performed to these materials. Well depth and fluid volume control the style and size of the barrel used. Well conditions (corrosion, sand, etc.) and economics govern the material used. Barrel material include carbon steel, corrosion resistant steel, brass and monel. There are several different methods of hardening carbon steel barrels; induction hardening, carburizing, carbonitriding and nitriding. Other processes that are commonly performed on barrels are; inside diameter chrome plating and nickel carbide plating to add resistance to abrasion.

PLUNGERS

Plungers are identified as either metallic or non-metallic, which refers to the sealing section of the plunger itself. Plunger dimensions have been standardized by the API and state that the nominal sealing length in whole feet plus three inches expresses the actual pitch length of a plunger. Outside diameter shall be base size minus the specified clearance fit with a tolerance of plus zero to minus one half thousandth of an inch. Metallic plungers are offered in box or pin threaded connections with pin threads being the most popular. Wear surfaces of the metallic plunger are normally a flame sprayed nickel based alloy powder with a hardness range on the Rockwell C scale of 48-62. There are some composite metal sprays that contain very small particles of carbide for wear resistance and push the hardness on the Rockwell C scale past 65. All sprayed metal coatings are metallurgically bonded to the base material. The plungers inside diameter can be flash plated with nickel and monel pins can be added to provide additional corrosion resistance. Plungers can be chrome plated and were very popular at one time due to the hardness of chrome is 70 on the Rockwell C scale but there are limitations. A chrome plunger cannot be used in a barrel with a chrome inside diameter as they tend to gall when installed together. Chrome does not perform well where hydrogen sulfide is present and cannot be used where hydrochloric or other acids are used.

Soft packed plungers were used in the original beam pumped wells and are best suited for shallow well where the lubrication quality of the produced fluid is poor or when produced sand can stick metallic plungers. Soft pack plungers are made up of a variety of components on a mandrel; the sealing elements are either a cup or ring made from cotton ducking with natural or neoprene rubber, nylon, plastic or other compositions. A short soft packed plunger can be added to metallic plunger to protect the leading edge when producing particulate laden fluid as a way to increase pump run time. There is a wide range of specialty plungers available for specific applications.

STANDING AND TRAVELING VALVE

The standing and traveling valve controls the fluid intake and discharge through the compression chamber formed by the barrel and plunger of the beam pump assembly. A valve consists of a ball and seat that acts as a check valve and a cage that controls the movement of the ball. The valve must be able to resist the corrosive nature of the well fluid and produced particulates.

Valve cages are available in a variety of materials; carbon and alloy steel, stainless steel, brass, monel, etc. They are divided into two basic categories; open cages where the fluid flows out fluted openings and closed cages where the fluid travels through the cage.

Where the ball contacts the cages inside diameter are 3-6 ball guides, these guides keep the ball centered above the seat as it travels up and down to reduce the damage to both the ball and the seat. These guides can be made more wear resistant with the addition of stellite welded to the face of the guide; stellite hardness is in the Rockwell C range of 41-46.
Ball and seats are also available in a variety of material. Seats are made of stainless steel, cobalt alloy, tungsten and nickel carbide. Balls are made from the same materials plus many variations of ceramic materials like silicon nitride. The seats are lapped to a precise fit with a precision ball and each combination is vacuum tested and all API specifications must be adhered to. Balls are available in two sizes for each seat, API and alternate. The alternate ball is smaller which allows viscous fluids and produced particulates to pass through the greater clearance provided between the ball guide of the valve cage and the ball.

HOLD DOWN SEAL ASSEMBLY

The hold down seal assembly provides two basic functions for the beam pump; first it provides frictional resistance to hold the pump in place while the rod string is raised and lower by the pumping unit, the second is to provide a seal between the pump and production tubing so that the fluid lifted by the pump is held in the production tubing and not allowed to leak back into the casing. Hold-down seal assemblies are classified as either cup type or mechanical type and are available in a variety of material to match the producing conditions. Both materials have excellent sealing properties and are recommended for all depths. Where bottom-hole temperatures greater than two hundred fifty degrees Fahrenheit are encountered the mechanical sealing element is recommended. Mechanical hold-downs feature spring steel fluted element that hold a metal seal in place. Pumps that are used in particulate laden fluid can stick a bottom hold down pump and can cause pulling issues, the hold down can be located at the top of the pump to reduce the chances of the pump becoming stuck in the tubing. Either cup or mechanical top hold-downs are effective in reducing the chance of the pump becoming stuck in the tubing providing the pump type and depth of well allow their use.