THE PROGRESSIVE CAVITY PUMP-- NEW DEVELOPMENTS

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The Progressive Cavity Pump (PCP) has been used in down-hole applications for over fifteen (15) years and has progressed from only one model and one elastomer to over twenty models and several different elastomers. The depth range for the rod driven pump system has increased from 1000' to 6000' and even a few 8000' applications. These applications call for special elastomers and considerations as to the fit and/or design of the pump and the system. Down-hole pump displacements have increased from 5 to over 1000 bpd/100 rpm. The resultant torsional requirements for the large pump designs have reached the limits of conventional sucker rods, therefore, new methods for rotating and transmitting torque to the pump are being conceptualized, designed and tested.

New developments, in the past two to three years, that will be covered in the following text consist of: elastomers; rotor coatings; drive systems; rod centralizers; and rod-less systems as well as new applications where PCP's are being utilized, i.e. high temperature, CO_2 and H_2S.

MATERIALS OF CONSTRUCTION DEVELOPMENTS

Elastomers

The stator elastomer is recognized as the heart of the PCP. How well the given elastomer maintains mechanical strengths and properties under conditions of temperature and pressure effects the operating life and efficiency of the system. Much of the focus in the past has been on changing the acrylonitrile content in the nitrile based elastomers to give more resistance (less swell in aromatic hydrocarbons) and increase strength in water producing applications. Recent developments focus more on different types of nitrile compounds and cures, more specifically hydrogenated or highly saturated nitriles (HSN) and flourelastomers.

The HSN compounds offer better resistance to CO_2, H_2S and methane gas permeation while maintaining sufficient resistance to swell from aromatic hydrocarbons. HSN compounds also maintain good mechanical properties under elevated temperatures and have been successfully used to temperatures of 250 F. HSN's have been used successfully in applications of upwards of 2% H_2S and CO_2 in-solution in the fluid.

Flourels or "Viton" like materials have long been considered for high temperature (>300 F) environments, but have always lacked the mechanical properties to offer sufficient operating life. Recent formulations have upgraded the desired properties and have been successfully field tested at 260 F with operating times to eight months in applications where even HSN compounds only operate for three to four months.

Additives in the elastomers to reduce the friction between the rotor and stator are being evaluated, specifically for high water cut applications where the water offers less lubrication than oil. The benefits are more pronounced in heavy brine applications and where both free gas and water are produced through the pump.

Rotor Coatings

Boronizing the surface of rotors has been tested and proven to increase the cycle life over chrome plated rotors in both abrasive and corrosive environments. Lab results indicated and field test substantiated that the boronized surface offers up to five (5) times the life of conventional chrome in abrasive environments. Tungsten-carbide coatings have also proven to increase cycle life over the conventional chrome. Both of these coatings offer increased hardness and reduced porosity which are necessary for successful operation in abrasive corrosive environments.

DRIVE SYSTEMS

Most of the drive heads on the market today are hollow quill drives in which a polished rod extends through the hollow shaft of the bearing and stuffing boxes. This configuration allows the bearing or gear box to be removed from the well head with out having a rig on location. All drives have a back spin limiter or back stop brake as an integral part. The different style limiters consist of hydrodynamic, hydraulic, centrifugal and discs that limit the speed at which the system runs in reverse after the prime mover is stopped. The brakes are generally overrunning clutches held by brake bands that do not allow the system to backspin at shut down, but can be mechanically released when necessary.

The recent trend in the type of prime mover is variable speed drive (VSD) systems. Either electrical variable frequency or mechanical variable pitch sheaves (fixed center distance) are being considered. Both VSD's offer the potential for using smaller electric motors to operate the system . This is achieved through low speed start up that offers high torque with fixed horsepower.

CENTRALIZERS

Most of the recent work with regard to centralizers has been in enhancing the "spin-through" design. This style has proven to be the most efficient with reduced drag and pressure drop across its surface, but its resistance to abrasive wear is recognized as the area requiring improvement.

Elastomer coated couplings have been designed, manufactured and are currently being tested. The elastomers used are the same as those used in stators, therefore offer similar wear characteristics as the stators. The operational difference is the surface smoothness of a polished rotor versus the inside wall of the tubing. The field tests are on going with some promising results.

ROD-LESS PC PUMP SYSTEMS

The concern in most deviated, slant or horizontal applications is rod and tubing wear due to a high percent of solids produced with the fluid and/or wear from the rod contacting the tubing in highly deviated or long radius/horizontal applications. Two rod-less PC Pump concepts have been designed and are now being tested; a hydraulic submersible motor drive and an electrical submersible motor drive.

The hydraulic submersible motor drive (HSPCP) consists of a pc pump driving a pc pump. The top pump actually is a motor and can be either a 1:2 or a multi-lobe configuration. The two pump rotors are supported by a sealed bearing pack above the pump assembly. The top pump, driven by power fluid, turns the lower pump. Produced fluid commingles with the power fluid in the production tubing and is lifted to the surface. The original field tested design was a 1:2 motor and pump configuration with a 5:1 ratio of power fluid to production fluid. As expected, the bearing pack has proven to be the critical part in the system and enhancements in its design are being developed and tested.

The electric submersible motor drive (ESPCP) is very similar to the conventional ESP with the pc pump replacing the centrifugal pump. The configuration of the system varies with the pump size required for the application and the ESP manufacturer. The gear reducer is the critical design component. The field tests to date have proven successful. The market focus is in horizontal applications producing viscous sandy crude.

PUMP DESIGNS

Slim-hole High Volume Pumps

One manufacturer has designed a series of high volume pumps (up to 4500 bpd and depths to 3500 feet) designed to fit in 4.5" casing. These models offer increased clearance and more flow area around the pump than the conventional 4.5" stator tube when installed in 5.5" casing. Some users report improved operation of the system using the slim-hole models in 5.5" casing, especially in heavy viscous crudes.

Multi-lobe Pumps

A 3:4 multi-lobe pump was successfully field tested for four months and operated at an average volumetric efficiency of 60%. The theoretical capacity of this pump was 1250 bpd/100 rpm. The concept was proven to work, but vibration of the system due to normal multi-lobe operation proved to be critical to the fatigue life of the rods and tubing. An alternate multi-lobe design that would reduce this vibration is being evaluated.

Highest Volume PC Pump Available For Down-Hole Production

The same manufacturer as above has designed and marketed a pump with the displacement of 1040 bpd/100 rpm and a depth limitation of 1400 feet. The pump is called the "Parallel Pump". This displacement is achieved through a manifold design that allows for two pump inlets and common discharge with two pumps in series each driven by the same rod string. The next design step is to replace the 520 bpd/100rpm pumps with 750 bpd/100 rpm pumps to achieve a pump displacement of 1500 bpd/100rpm or a 7500 bpd pump.

Insert PC Pump

An old idea taken to market recently is a PCP that can be inserted in 2 7/8" tubing. This idea was attempted in the late 1970's and proved to be more problematic than beneficial. One drawback to the insert is the limitation on the displacement of pump. Currently the largest insert yields 270 bpd. Producers report that solids like scale and sand cause problems in pulling the pump, therefore the tubing must be pulled anyway. This defeats the purpose of an insert pump. This design does have its application.