A PORTABLE PRODUCTION TEST SYSTEM FOR EVALUATION OF ARTIFICIAL LIFT REQUIREMENTS

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ABSTRACT

Evaluation of artificial lift requirements and selection of appropriate lift equipment for an oilwell must take into account the well inflow performance under anticipated producing bottom hole conditions. Controlled well test at these conditions will generate the necessary inflow performance data for this purpose.

This paper describes a portable Production Test Unit and related well equipment which permits multi-rate production testing for the purpose of developing IPR data. Description of the Hydraulic Jet Pumping System used and examples of test procedures are included.

INTRODUCTION

Throughout the producing life of an oilwell, the operator is concerned with maintaining a cost effective operation which will optimize overall performance of the well and the field. When artificial lift becomes a requirement for maintaining this performance, selection of the most appropriate method of lift and the system's cost effectiveness have a major impact on the success of the producing operation. As changes occur in downhole conditions, including gross fluid volume, water cut, GOR, pump intake pressure (fluid level) and others, further review of the lift system and equipment sizing becomes appropriate.

Initial selection of the lift system may be based on earlier decisions for other wells in the field. This can provide significant benefits from operating and maintaining uniform lift equipment in the field, but may miss the mark on optomized well performance. Physical characteristics of the wellbore, e.g. small casing or high deviation, or environmental factors such as space or height restrictions may also dictate the lift system selection. But in any case, a fresh evaluation of current producing conditions for the well under consideration is likely to prove beneficial in choosing the right lift system or simply improved equipment sizing for optimum lift operations.

PRODUCING WELL EVALUATION

The objective in well testing for artifical lift system evaluation is to acquire as much accurate data as is practical for the well characteristics which effect inflow performance and lifting effectiveness.

Review of historical data is an initial step, however this may not be accurate for either current or future well characteristics. If the well is presently equipped with a lift system, testing the well at different rates while recording bottom hole pressures and other inflow data may be possible. Or the commonly used swab test may be suitable for sampling well performance at higher withdrawal rates.

However, the most informative test is one which permits operating the well under stabalized conditions at three or more producing rates while accurately recording pertinent data leading to development of a current IPR curve. This IPR data, combined with the volumes and characteristics of the produced liquids, gas and solids, provide essential information for predicting performance of the various methods of artificial lift and for designing the selected system.

This paper describes and Figure No.1 illustrates a highly portable hydraulic lift system specially developed for the purpose of acquiring well performance data under an extreemly wide range of pumping conditions.

HYDRAULIC PUMPING SYSTEM

The hydraulic pumping system utilizes produced fluid, either oil or water, to transmit energy to the downhole pump. Basic equipment consists of a surface reservoir for the power fluid, a high pressure surface pump to circulate pressured power fluid downhole, and the downhole pump assembly. For most installations the downhole pump can be run as a "free pump", meaning that the pump can be circulated into or out of the well with the power fluid system. No other pulling equipment is required. If a "free pump" arrangement cannot be accomodated, the pump may be run and retrieved on wireline or on a small diameter tubing string as a "fixed pump" installation.

For the most common "free pump" installation, power fluid is circulated down the tubing and produced fluid plus exhaust power fluid is lifted up the tubeing-casing annulus. Many variations of well tubular arrangements are possible in providing the downflow and upflow circuits required for the system. The downhole pump in this system may be a positive displacement reciprocating piston pump or a jet pump. The jet pump has been found to be most suitable for the well test application because of its wide ranging capabilities.

Jet Pump

Figure No. 2 schematically illustrates the hydraulic jet pump in the most common "free pump" downhole arrangement described above. Primary pump components consist of the nozzle, throat and diffuser, all assembled in a configuration to provide appropriate seals and flow passages. Energy transfer from the power fluid to the produced fluid takes place within these three components. The pump assembly is landed

in a bottom hole assembly which has been run into the well on the tubing string.

The extreme simplicity of this pump design accounts for its unique characteristics which make it ideally suited to the well test application. The pump can be operated over a wide range of lifting rates simply by surface control of the power fluid rate and pressure delivered to the pump. Selection of nozzle and throat sizing adapts the pump for an appropriate volume range and for shallow to very deep lifting depths. The jet pump can handle free gas in the production and is tolerant to abrasive and corrosive well fluids. It is compatable with downhole pressure recorders which may fit within the fluid retrievable pump assembly.

Surface Equipment

Figure No.3 identifies major components on the trailer mounted Production Test Unit which provides all surface equipment required to operate the downhole hydraulic pump. Major components include a 5 ft X 10 ft pressure vessel (fluid reservoir), a 200 hp triplex pump equipped to to circulate oil or water to the well at high pressure, a gas engine drive to the triplex suitable for operation on natural gas or propane, and all operating controls and flow piping for the fluid circulating system. Swivel jointed flow line piping is provided for connection of the Test Unit to the wellhead and lease flow line.

In operation, the mixture of produced fluid plus exhaust power fluid from the well is directed into the pressure vessel where initial seperation of oil, gas and water takes place. Power fluid to be reciculated to the downhole pump is directed from the vessel through a hydro-cyclone system to remove entrained solids, and then into the triplex suction. The power fluid is discharged from the triplex at high pressure, into a pressure control to regulate system operating pressure, through a flow meter for measurement and to the wellhead for injection to the downhole jet pump.

The produced fluid volume which has entered the vessel is discharged into the flow line through piping which maintains the operating fluid level in the vessel. The produced liquid and free gas discharged from the vessel may be directed into the lease facilities or to a separate test circuit for measurement.

HYDRAULIC WELL TESTING

Downhole Equipment

Preparation of the well for conducting a hydraulic production test involves intallation of the pump in a tubular system which provides the required downflow and upflow circuits. The most versatile tubular arrangement is the "casing free" system as illustrated in Figure No. 2.

This requires running the bottom hole assembly on 2-3/8" or larger tubing and landed on a casing packer. A parallel tubing string may be used for the upflow circuit if use of the casing annulus for this purpose is not desirable. Both of these arrangements retain the benefits of the free pump. If the well tubing is already in place with a rod pump seating nipple at the desired pump setting depth, it may be possible to seat a jet pump in this nipple by running the pump on a small diameter tubing string. In this case, the small tubing is used for downflow and the annulus inside the larger tubing forms the upflow circuit. The jet can be retrieved by pulling the small tubing. In another possibility a gas lift mandrel located above a packer may be suitable for a wire line set and retrieved jet pump placed in the mandrel between a straddle packer, using the side pocket port to discharge production plus exhaust power fluid into the casing annulus.

Any of these downhole arrangements should include provision for a downhole pressure recorder. Generally this assembly can be run and retrieved with the jet pump.

Wellhead

The wellhead assembly must be arranged to accommodate suspension of the tubing strings involved and to provide separate fluid connections for the downflow and upflow circuits. Necessary valving is supplied with the Test Unit for control of flow direction in these two circuits during operating or retrieving operations.

Test Unit Hookup

The trailer mounted Test Unit is spotted adjacent to the well and secured on it's support stands. The swivel jointed piping is used to connect the test unit to the wellhead, flow line and gas line. If a special liquid and gas measurement system is to be used, additional hook-up piping may be required. Fuel supply to the triplex engine will generally be natural gas available at the wellsite. If gas is not available, a propane supply must be furnished. Test unit hook-up and system start-up can generally be completed within four to six hours after well work is completed.

TEST PROCEDURE

Specific procedures for conducting the well test can vary considerably depending upon well data currently available and the operators objectives for the test. A minimum test would be accomplished simply by pumping the well for several days at the target production rate to confirm the well's capacity for sustained production at this withdrawal rate. Any variation of this approach may be followed up to an extensive production test which would provide carefully documented performance data throughout a procedure in which the well is operated at stabalized conditions for each of three or more producing rates. Recorded data would include static and producing

Bottom hole pressures, producing rates for oil, water and gas, plus power fluid rate and pressure at frequent intervals throughout the test.

The operating schedule and duration of the test can also vary considerably. The most extensive procedure would include five or six steps of possibly 48 hours each, making a twelve day test. This schedule starts with a shut-in period for a pressure build-up to SBHP. The jet pump is then operated to produce the well at 50% or less of the maxium target rate for the test. After stabalized production is reached, the producing rate is increased in two or three successive steps to the target rate. The well is again shut-in for buildup to SBHP to conclude the test.

EXAMPLE

Hydraulic well testing has been successfully used by major and independent operators for evaluation of well performance and lift requirements over a wide range of conditions. Some examples illustrate the flexibility of this system.

- Reduced production from a 15000 foot flowing well prompted a swab test which indicated a substancial rate increase could be obtained. Sustained production achieved by the Test Unit lowered bottom hole pressure to 300 psi with only a modest production increase, estimated by IPR evaluation to be rearly 90% of the well's maximum producing rate. Purchase of artificial lift equipment was deferred by the operator.

- A 6500 foot dual completion to be commingled required increased lifting capacity. Hydraulic test confirmed a large volume of 97% water cut production achieved with high PBHP. Electric submersible equipment was available for the well.

- A 9000 foot well with an 85% water cut to be produced to the limit of available water disposal capacity. Hydraulic test indicated this achieved at 40% drawdown and 60% of maximum producing rate. A perminent wellsite hydraulic system has been set having capacity for higher rates as added disposal capacity becomes available.

- Testing of a 4000 foot well after workover confirmed the anticipated rate increase was not achieved. A surplus rod pumping system met the lifting requirement.

- A well equipped with an ESP system experienced erratic operation brought on by a combination of high GOR plus build-up of asphaltenes in the pump. Testing with the jet pump varified the ability of this system to handle both conditions. A perminent wellsite hydraulic system is being prepared for this well.

- A jet pump operated by a Test Unit was run through 70% of deviation in a horizontally completed well to evaluate well performance. Initial production will be lifted by a rod pump set in the vertical section of the well.

CONCLUSIONS

1. Evaluation of current producing conditions can contribute to maintaining cost effective artificial lift operations.

2. The hydraulic pumping system utilizing a portable Test Unit and downhole jet pumps provides a highly flexible system for testing current producing conditions.

Figure 1 — Hydraulic production test unit

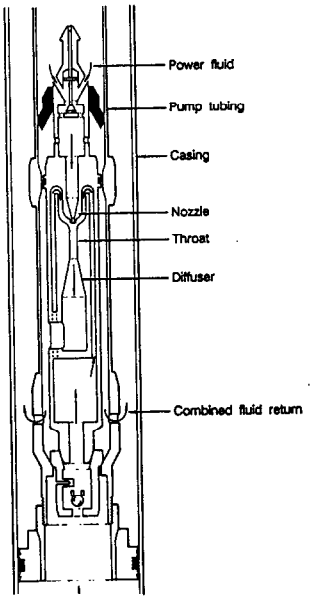

Figure 2 — Hydraulic jet pump

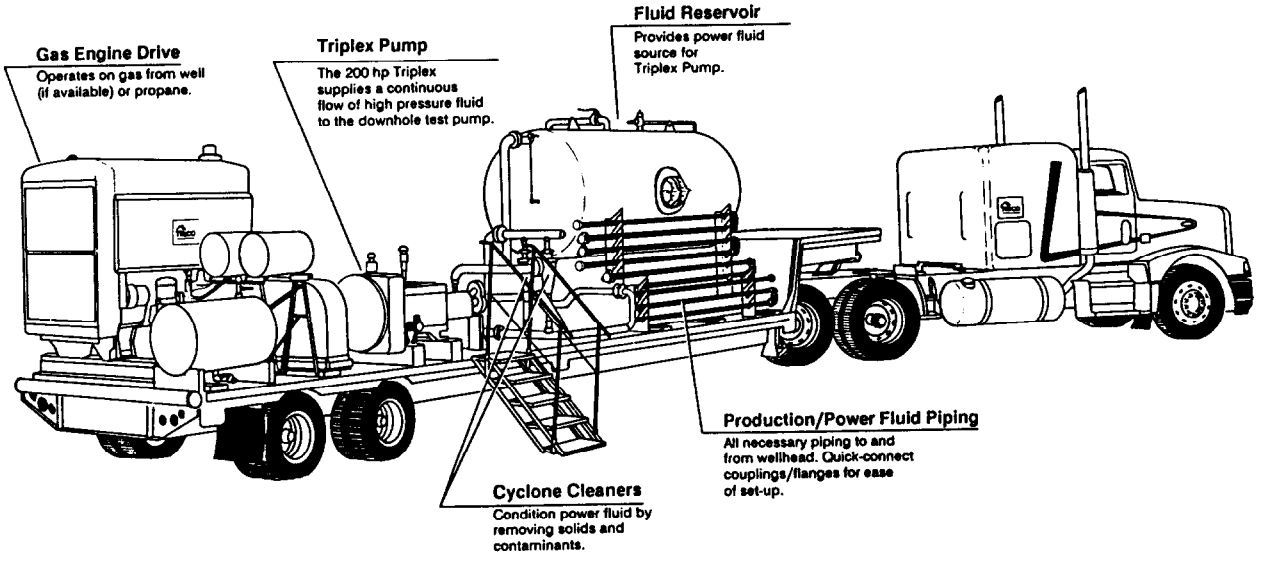

Figure 3 — Major components — production test unit