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TECHNICAL PROGRESS REPORT

THIRD QUARTER REPORT-1992

THE DEVELOPMENT AND TESTING OF A FIELDWORTHY SYSTEM OF IMPROVED
FLUID PUMPING DEVICE AND LIQUID SENSOR FOR OIL WELLS
DEPARTMENT OF ENERGY GRANT # DE-FG01-90CE 15482

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During the Third Quarter of 1992, the following tasks have been in progress:

An economical gas lift system has been designed that uses the airlift principles of the APOP system to enable one to pump deep wells which have been initially pumped using jack pumps. It can be constructed and installed in oil and/or gas wells where jack pumps have been operating. The 2" tubing in the bore hole is left in place and the rods are pulled from the normally 2" tubing. A 1" or greater diameter tubing containing a one way valve near its bottom and several small holes near the bottom of the 1" tube and just above the one way valve is installed into the 2" tubing. The one inch tube extends the total length of the 2" tubing and is seated on the seating nipple at the bottom of the 2" tubing. The space between the concentric tubes can serve as the gas(air) line and the center 1" tube serves as the liquid discharge line. This enables this pump to be used in many marginal wells which ordinarily would be uneconomical to pump. This is especially true for deep wells because the cost of jack pumps and the tubing as well as the maintenance to pump liquids from bore holes that are several thousand feet deep is substantial.

Mr. Louis Beucler of Ohio continues to outfit his oil lease to install an Air Pulse Oil Pump system on his wells. His wells are about fourteen hundred feet deep. He has installed his compressor system at the closest point to electrical service and a 1" gas line has been run for about one mile to the first two wells in which the APOP system is to be installed. The agreement that the P.I. signed with Mr. Beucler was attached to the Second Quarter report. Figure 1 contains the arrangement that Mr. Beucler plans to install after having numerous conversations with the P.I. Installed into the well casing will be a 2" tubing which will extend from the top of the well head to about 50 to 75 feet below the oil and gas pay zone. The length of this tubing will be about 1450 feet with a seating nipple at the bottom of the tubing. A 1" tubing will be installed from the top to the bottom of the 2" tubing. At the bottom of the 1" tubing will be two one way valves in series so that if one valve gets something in it to keep that one valve from closing during a pumping cycle, the other valve will be a backup and will be forced to close. Just above the one way valves and near the bottom of the 1" tubing will be four or more holes about 0.25" in diameter drilled through the 1" tubing. The 1" tubing will be seated on the seating nipple located at the bottom of the 2" tubing. At the top of the casing the 2" tubing and casing are closed at the top and the top of the 2" tubing to the 1" tubing are closed with the provision that a gas(air) inlet exists which will enable the gas to be injected to the space between the 1" tubing and the 2" tubing. A valve will be located at the top of the 1" tubing and this 1" tubing will serve as the liquid discharge line. The space between the 1" tubing and the 2" tubing will serve as the air(gas) line. We may prefer to use either a 1.25" or a 1.50" pipe as the liquid

FIGURE 1.
Inner 1.25" steel tube inside
2" tubing for APOP system to
replace the jack pump.

discharge line because this would not require as much volume in the air line (concentric tube space). Also, one can obtain commercial rabbits to operate in these larger diameter pipes.

Refer to Figure 1 and consider that we use 1" inner diameter tubing which has a 1.25" outer diameter. This is installed inside of a 2" tubing. The volume per 100 feet of a 2" tubing is 16.32 gallons and the volume taken up by the 1.25" O.D. inner tubing is 6.37 gallons per 100 feet. For a length of 1400 feet the airline volume is equal to $14(16.32 - 6.37)$ or about 140 gallons. The volume per 100 feet for the 1" discharge line is about 4 gallons or a total of 56 gallons for the 1400 length tube. Hence, the total volume of gas during the pumping cycle for this arrangement will require about 200 gallons of gas (air). By using a 1.25" inner diameter pipe, the volume of the airline is about 98 gallons and the liquid discharge line is about 93 gallons; however, the fallback of the regular slug increases as the diameter of the liquid tube increases. To prevent the fallback, one can use a commercially produced rabbit to follow the slug up.

It is important to install the 2" line about 50 to 75 feet below the pay zone so that the liquid will fill up the line for good pumping action and also the pay zone will remain covered with liquid. A liquid 50 feet long in a 2" tubing will be 200 feet long in a 1" tubing and similarly a 75 feet slug of liquid in a 2" tubing will be 300 feet long in the 1" tubing. Better pumping action has occurred when we have pumped liquid slugs of lengths between 200 and 300 feet. Using a rabbit, one can pump shorter slugs because the fall back and mist is minimized.

One of the problems with this gas lift pumping system is that liquid can rise in the bore hole to a level that very high pressures are required to pump it off. A solution to this problem is to use a swab and swab liquid out of the liquid discharge system until the normal APOP system can take over. The P.I. cannot locate any swabs for the small tubes: therefore, an unique swab has been designed and demonstrated to work by using it in a water well to swab a 0.75" plastic tubing. Figure 2 is a picture of a 0.75" swab consisting of a Teflon slug with vinyl rubber at the top. The Teflon is bored out at the top so that as pressure of the liquid column is applied to the swab as the slug is being pulled up, the Teflon is forced to make a good seal with the tubing. Since friction between the Teflon and the tubing is small, a tight seal can be made without requiring significant additional force because of the minimum friction between the swab and the wall of the tubing as the liquid column is pulled to the top of the bore hole.

Because of fallback from the bottom of the liquid slug as it is rising in the liquid discharge tube, mist will form at the bottom of the slug and this can produce emulsion if water and oil

Figure 2. Swan for a 0.75" plastic tube.

Figure 3. Swan clippers, swans for 0.75" tube.

are present and also poor pumping characteristics result. This is especially a problem the deeper the well is that is being pumped. By using a rabbit which slides up and down the liquid discharge tube, the rabbit is located just below the slug. By preventing this fallback, one can pump using the rabbit and slug method to great depths, that is thousands of feet. The rabbit is used frequently in regular gas lift pumping systems but this system allows gas lift control from the top of the bore hole. Figure 3 is a picture of two rabbits constructed to the P.I. specifications to work in 1" and 0.75" tubings. They consist of Teflon with metal bolts and threads for attachment to be pulled up out of the hole.

Two solar computer controllers have been designed and constructed to operate Mr. Beucler's pumps. Figures 4 and 5 are pictures of them. A more detailed description and discussion of these controllers are attached.

Now to discuss the pumps and designs for installing the pumps on shallow wells. Figure 6 contains a picture of a stainless steel pump which has been in the P.I. front well for three years. Note the hole near the top of the pump where the normal weld joint was corroded by liquids and gases in the bore hole. The stainless steel chamber walls were in good condition. This demonstrates that it is very important to use stainless steel welds rather than normal welds on the pump tanks.

Figure 7 contains the top of the well head materials. A flange adapter screws onto the wellhead and a gasket is inserted. The top plate then screws onto the flange adaptor. The top plate contains four holes, two for 1" and/or 0.75" plastic tubing to pass through down to the pump. Small holes are available for monitoring the gas pressure in the bore hole and one hole can be used to release or insert gas into the bore hole. An eyelet is located at the top and bottom of the plate to enable handling of the pump and plastic tubings. A cable can be used if additional support of the pump and plastic tubing is desired.

Figure 8 illustrates the steel to plastic transition fittings used on the top of the pump chamber. Normally a 0.75" tube is used for the air(or gas) and a 1" tube is used for the liquid discharge tube. These plastic transition fittings are heat welded to the plastic tubes.

When one is installing the pump system into the bore hole, sometimes it is necessary to interrupt the installation. Figure 9 is a picture of a clamp designed by the P.I. It is made of aluminum and will hold 0.75" and 1" tubes without crimping them but will provide sufficient grip that the tubes will not move down the bore hole. The clamp just sits on the top of the casing and is sufficiently wide that it will not go down the casing while it is crossway of the casing.

Figure 4. Controller for Beucler's oil wells

Figure 5. Solar controller for Beucler's well.

Figure 6. Picture of defect at top of stainless steel pump tank.

Figure 7. Top of well head materials.

NOTE:
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HEAD AND (2)
EYE BOLTS AND
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PUMPHEAD

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Figure 8. Steel to plastic transitions
at the top of the pump chamber.

Figure 9. Specially designed and constructed
clamp to hold 1" and 0.75" tubes.

Overview of the Options Installed on Controller #1 and #2

Controller #1 and #2 have been equipped with batteries and a solar panel for use in locations without a.c. power. To make the systems easier to setup, a display, a multi-position switch and keys have been added. The display shows continuous status information and allows the user to list and modify the sleep, sample, pump and exhaust times. A socket has been added to accept a nonvolatile ram memory backup option. This option will be implemented if necessary. The electronics and valves are enclosed in a weather-resistant enclosure. The solar panel and thermistor(liquid level sensor) are connected via a barrier strip on the bottom side of the enclosure. The barrier strip allows for power to be applied to the system via internal batteries or an external 12v d.c. supply. In addition, the barrier strip has three terminals dedicated to a bidirectional serial data link to the microcontroller. In addition to the barrier strip, a BNC connector has been installed on the bottom side of the enclosure to allow the antenna for the RF Telemetry option. The RF Telemetry option has not been implemented on these controllers. A toggle switch has also been installed on the bottom of the controller to allow the user to manually switch on the air valve located inside the enclosure. The air inlet line to the valve is located on the bottom left of the enclosure. The air "switched" outlet is located on the left side of the controller. The remaining line on the bottom right is the air exhaust line.

Operational Procedures and Controls

The following information is a step by step procedure for the initial setup. The user will need a large flat-head screw driver.

1. Turn the mode select switch located below the display to RUN mode.
2. Loosen terminal labeled 1 on the barrier strip.
3. Short terminals #1 and #2 using the short wire connected to terminal #2. (This will apply power to the controller and the display will read "SLEEPING".)
4. Turn the mode select switch to SLEEP SET.
5. Press the UP key to increase or the DOWN key to decrease the hour setting.
6. Press the CONTINUE key to move to the minutes set.
7. Press the UP key to increase or the DOWN key to decrease the

minute setting.

8. Press the CONTINUE key to move to the seconds set.

9. Press the UP key to increase or the DOWN key to decrease the second setting.

10. To change any other times, turn the mode select switch to SAMPLE SET, PUMP SET or EXHAUST SET and Press CONTINUE. Proceed to step 5. If you have completed your changes turn the mode select switch to RUN mode and press CONTINUE.

Note:

It is suggested to minimize the power consumption of the system by maximizing the sleep time. If the well production causes the system to pump more than once an hour, another battery and possibly another solar panel will be needed. In this case, consult technical support.

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