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The Application of using Low Cost Data Logger and Controller in Optimizing Oil Production using Progressive Cavity Pumps

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Abstract

Optimum Oil Production is hampered by a number of problems, these present challenges to the field personnel maintaining the equipment, and provides little or no data for engineers to provide production solutions. Much of the field personnel's time is spent behind the wheel rather than concentrating efforts on maintenance and optimization. Other challenges are High Sand, Gas Influx, Pump Off, Tubing Leaks, equipment wear and other problems that compromise production. SCADA systems are helpful, but are very costly and limited to the amount and type of data handled.

In the operation of Progressive Cavity Pumping Systems, Rod Torque is a simple measurement, which can be achieved inexpensively with all types of Prime Movers, where all pumping conditions are reflected in the torque in some manner. Data may be viewed at the Well Site and/or transferred to the office, or connected remotely. Sufficient data is the key to be able to observe trends, create graphs and reports, which are essential in making logical decisions before a problem occurs, aid in optimizing production, and lowering operating costs. From the data simple controls may be then implemented to counter and control the effects of sand, gas, pump off, excessive water or other events, which degrade production.

Additional sensors can be added to monitor flow line pressure, temperature, Flow, bottom hole pressure, and WaterCut. Control Algorithms can be applied, dynamically in a closed loop system, to optimize Oil Production by adjusting the speed of the Prime Mover for optimum Oil production, for example using a Water Cut Sensor. Data is necessary to make knowledgeable decisions and implement controls to optimize production and profits on each well.

Introduction

A typical Progressive cavity (PC) pumping system consists of a prime mover whether electric or hydraulic, a bearing and gearbox, a rod string to the bottom of the well, and the PC pump rotor and stator. Each well is different, and each system is designed to meet the lift requirements, production rates, fluid compatibility, gas, sand and water cut, rod and tubing wear, based on the completion information on a well after drilling. Once installed down hole, there is little or no control of the down hole system and conditions of the reservoir.

Well operation today typically consists of a routine drive by the Well once a day by a trained operator, and reading a display or gauge representative of the load being drawn by the prime mover. If the Well is connected to a flow line, it can be put on test, typically once a month for a few days which would give flow rates, water cut, and sand production. Fluid level shots are taken periodically, depending on the Well, to determine the fluid level.

From this minimal data, all decisions are made in the operation and optimization of the well. The amount and type of data gathered is reasonable within these traditional methods, though a daily snap shot does not give the user a full picture of the other 95% of the day.

Trying to optimize a well and implementing a preventative maintenance program is very difficult without complete data, and analyzing a failure is surrounded by a number of variables, which also hampers improvements. Also, the traditional controls provided for the prime movers do not offer any ways of countering adverse affects of sand, gas, and pump tightening which lead to down hole failures which are very costly usually requiring a service rig and down time.

Solution

The development of a low cost Data Logger and Controller specifically designed for operating with all types of Progressive Cavity Pumping systems, which is easy to use, and setup at a low cost, would be an invaluable tool in operating and Optimizing a Well. This technology allows the data to be gathered 24 hours a day, 7 days a week.

Since all wells require data, even at its basic form, we start at the most commonly relied upon measurement of Torque as the basic building platform and add from there. It is also the most cost effective measurement to be used for all systems, on each well.

On Electric Systems, Torque is derived from measuring the power being supplied to the electric motor, for hydraulic systems pressure is used to calculate torque, and for less commonly used direct gas engines, a torque meter on the output shaft is required.

In some manner all Well conditions will show a change in the torque, for example:

1. Sand, shows an increase in torque as it enters the pump, either gradually or in a spike if an avalanche effect occurs. Carried sand in the fluid also results in the weight of the tubing fluid to become heavier which also results in an increase torque.
2. Lifting of the fluid from the static fluid level in the casing is also reflected in torque, the lower the level the higher the torque to lift the fluid to surface. Note: That since other conditions can affect the torque as well, this method would be considered an estimation depending on the effects of other conditions.
3. Gas, or Pump Off conditions are shown as an incompletely filled pump. If the condition persists, the pump begins to heat from friction resulting in an increase in torque.
4. Tubing leaks are shown as a drop in torque, since fluid is no longer lifted completely to surface.
5. Broken rods are shown as a torque drop.
6. Pump tightening due to aromatics in the Well or other fluid incompatibility results in increases in torque.

These are some of the more prevalent conditions, where some are more obvious than others. Other sensors such as RPM pickups, flow line pressure, flow, flow line temperature, water cut, and down hole pressure and temperature, can easily be added for enhancing the overall data and add knowledge to the operation.

Since producing and optimization requires cooperation between the operators in the field and the engineers in the office the data must be usable and friendly to both users at both locations.

At the field site, the equipment consists of a durable unit capable of withstanding extreme temperature ranges and weather. A graphical screen brings information to the operator's view on site in the form of a digital line graph, as well as real time values of Torque, RPM, etc. Data from the different measurements e.g.: Torque, RPM, Amps, Estimated Fluid Level, Flow, and Pressure can be retrieved from its onboard memory and displayed on screen historically from minutes to days to a month at a touch of a button.

Figure 1 shows a data logger screen with a comprehensive display of information.

Downloading data
Downloading the data from memory to be analyzed in the office brings the data into an engineering environment. To bring the data to the office there are several options, from trans portable memory devices, to laptops, and wireless options.

Windows Software
Once in the office, and with the development of a specific windows based reporting, graphing, and analysis program, designed for ease of use, the data can be analyzed with greater detail. The data can now be presented in a report or graphical format with different values being compared simultaneously on the same time line. Having concise summaries and graphs allows quick analysis of the information.

Figure 2 shows a plot of Torque and RPM vs. time on data from a well.

The software also automatically creates an ongoing database for each well, adding the new data each time it is downloaded to it, for a complete history of the well. From this information a month-by-month summary is created as shown in Figure 3. Key information such as average torque, up and down times, torque trend whether increasing or decreasing can be shown. It can also create estimates for accounting purposes on the amount of oil and water production based on the RPM, displacement of the pump and water cut in the well. Further summaries can be generated for the entire field with important statistics in a month by month basis as shown on Figure 4
Data in this format, shows more clearly the effectiveness of the optimization program in the field.

Wireless Possibilities
Having the logger self supporting with its own memory, allows not only the operator at the field to take advantage of it, but allows the use of lower cost remote monitoring systems to compliment the system. With the application of low cost cell modems, data can be transferred at a fixed cost similar to a cell phone, to the World Wide Web. Once on the Internet, the world becomes a closer place, and the data can be easily brought into the windows analysis program. If cell coverage is not available, reasonable costing

satellite systems are also available.

With the addition of a wireless system, alarms can be set on the Data Logger to send a voice or email alarm on a given condition.

This is an economic advantage over traditional SCADA systems, which are still quite costly to implement and support. Data is also gathered at the well, not relying if the SCADA system is working or not.
Having a low cost wireless connection from the well to the internet allows operators to view their wells from their office prior to checking on them. This allows them to prioritize their day, optimizing their time and skills.

Controls at the Well Site
By having a Data Logger on site monitoring Torque and other important measurements, protective controls can be added. Figure 5 shows the basic control settings to catch adverse conditions of sand, gas or pump off, tubing leaks and pump tightening.

Figure 6 shows a good example of a well without any controls. This particular well is operating fairly smoothly, when a sudden avalanche of sand entered the pump. This system had no controls in place and the torque climbed to the rod torque limit setting, setup in the Variable Frequency Drive operating the electric motor (Prime Mover). Having the torque climb from 180 ft lbs to 530 ft lbs can seize the pump tight, and once stopped the sand in the fluid then settles on top of the pump which can make it next to impossible to lift the rotor out of the stator and circulate fluid with a conventional flush by truck. This situation would now require a service rig.

If for example a High Torque Preset was set to 220 ft-lbs, the system would signal the prime mover to slow down and attempt to manage the sand through the pump for a programmed time period before returning to its normal set speed. If that did not solve the problem and the torque continued to climb, the system would shutdown and alarm on the High Torque setting of 250 ft-lbs. Having stopped the system at a lower torque results in less sand, and gives a chance for the lower cost flush by truck to lift the rotor out of the stator and circulate some fluid before continuing to pump again. This procedure may have to be repeated several times to clear out a well, though production is maintained at a reasonable level during this time and does not involve more costly service rig time and new equipment.

Figure 7 shows a small Progressive pump, Pumping Off. Note that the pump can remain lubricated for some time prior to heating up from friction. Stopping the system on a High Torque setting much lower than the rod torque protection setting of the prime mover would save the pump. The system can then stop for a period of time to allow for new inflow to come into the well bore, and then start up again automatically.

If a tubing leak or rod break were to occur, the system would stop, and (if equipped) alarm on a low torque shutdown, thereby saving energy and increased wear and tear on the system.

Dynamically Controlling the Well
A dynamic speed control algorithm can be set to maintain a certain set point e.g. Torque, pressure, or water cut in a closed loop system. For example by monitoring the water cut

of a well from a water cut sensor at surface, an algorithm is written to optimize a well automatically by searching for the maximum oil cut, by sending a dynamic signal to the prime movers controller and measuring the response back from the well. Tests have shown in high water cut wells that increasing speed for maximum production may not be the optimum pumping level for achieving maximum oil production and/or following possible oil cycles created by the reservoir dynamics.[1]

Conclusion:

In order to be competitive, every ounce of oil is important, replacing equipment, and downtime, are costly, reducing potential profits. There has been a significant investment into developing the Well from seismic exploration to drilling, and then completion and production. The goal is to have the well produce consistently with a long life and few failures

An inexpensive Data Logger and Controller brings concise and useful data to the operators and engineers which will allow them to provide knowledgeable decisions for optimizing the wells performance, reduce operating costs, and increase profits.

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References

#1 - Oil Water Cut Data Logging (OWCDL) www.oilwatercut.com

Figures

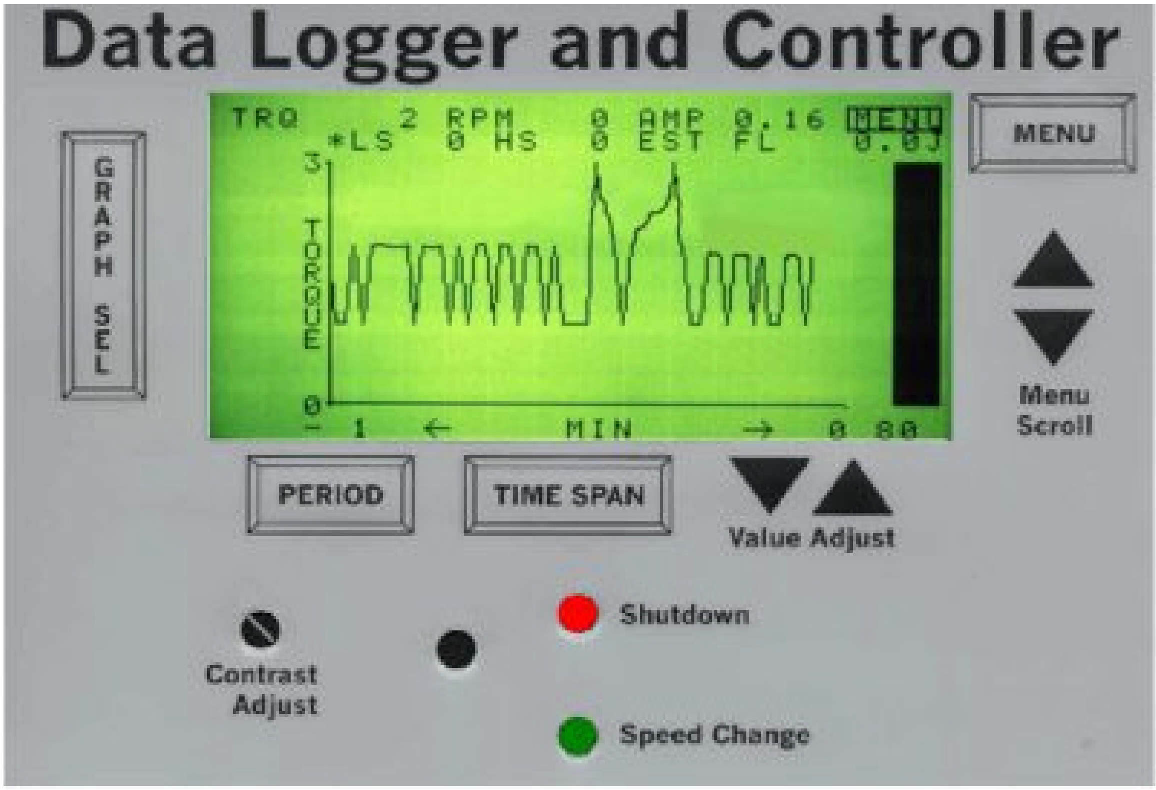

Figure 1

A Data Logger Screen with a comprehensive display of information

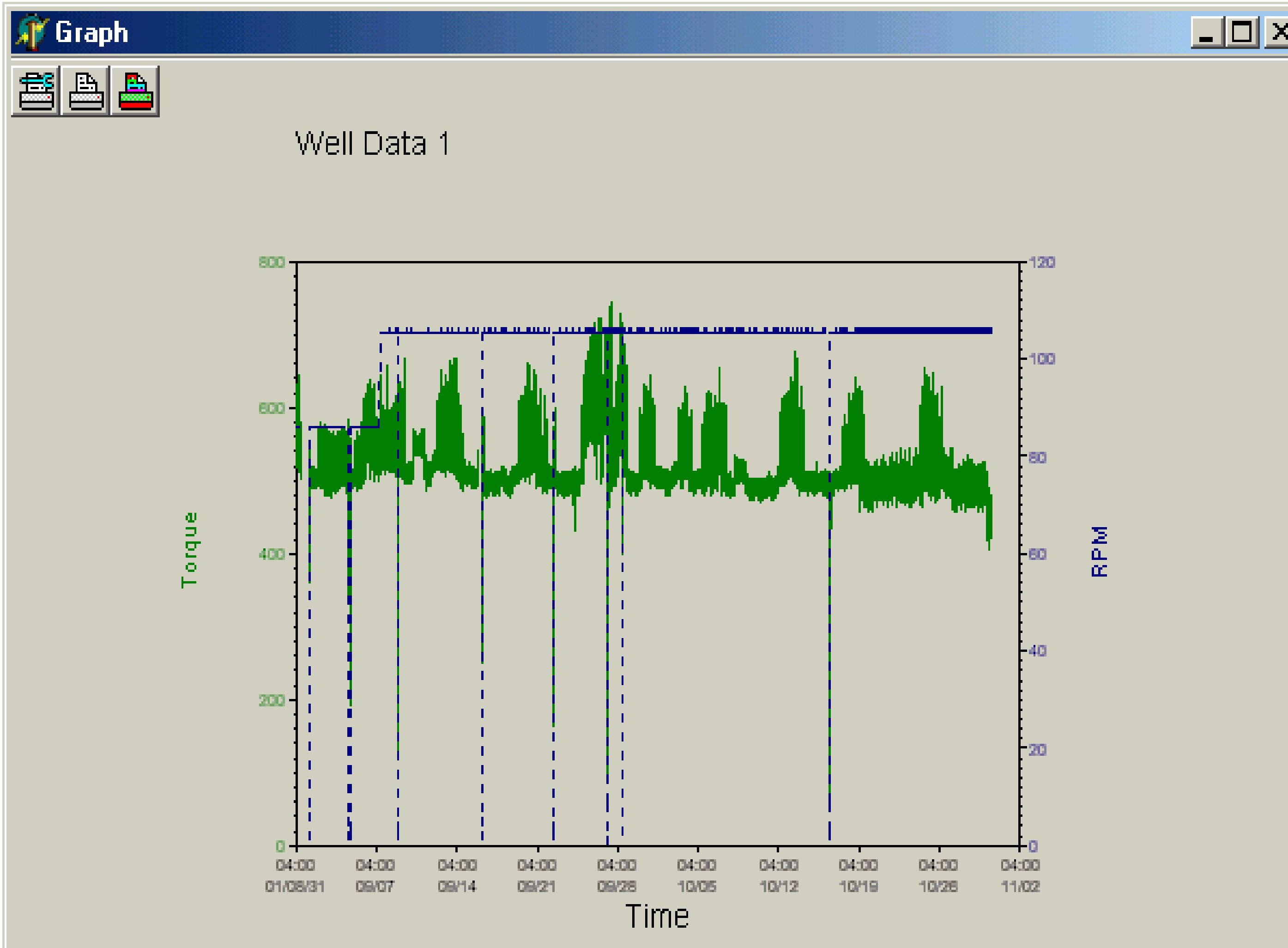

Figure 2

Well Data, Torque vs RPM graphed with an analysis Program

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Company:   Well Data 1
Id #:      184

Production Estimates based on:
  64.0 m³/day at 100 RPM.
  WaterCut: 83.0%
  Price:    $19.48/bbl




Summary for October 2001 (partial 1st to 31st)
  Up Time:            99.9%  (719.0 hours)
  Down Time:           0.1%  (0.9 hours)

  Power Failures:      1

  Total Shutdowns:     0
  Total Alarms:        0
  Total Presets:       0

  Total Run Faults:    2

  Running:            Min    Max    Avg
   Torque:            357    677    511
   Amps:               12.8   24.3   18.3
   RPM:               105    106    105

  Amp Trend:            6.0% decreasing
      Trend confidence high (94.9%)

  Est. Oil Production:    2132 bbl  ($41534)
  Est. Water Production:  10410 bbl

Overall Summary for 61 Days   01/8/31 to 01/10/31
  Up Time:            97.9%  (1429.1 hours)
  Down Time:           2.1%  (31.1 hours)

  Power Failures:      3

  Total Shutdowns:     0
  Total Alarms:        0
  Total Presets:       0

  Total Run Faults:   18

  Running:            Min    Max    Avg
   Torque:            338    745    523
   Amps:               12.2   26.8   18.8
   RPM:                86    106    103

  Amp Trend:            8.5% decreasing
      Trend confidence high (93.9%)

  Est. Oil Production:    4173 bbl  ($81296)
  Est. Water Production:  20376 bbl
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Figure 3, Single Well, Month-Month Summary Sheet created from an analysis Program

Optimization Chart

ID	Location	Parameters	SEPT	OCT	NOV	DEC	JAN
184	106/XX-XX-XXX-XXXXX	Average RUN Torque	536	511	514	504	499
		Average RPM	101	105	122	121	124
		Maximum RUN Torque	745	677	610	551	546
		TREND	+4.4%	-6.0%	-1.2%	-3.6%	-4.1%
		UP TIME	96.80%	99.90%	96.30%	88%	98.30%
191	107/XX-XX-XXX-XXXXX	Average RUN Torque	532	526	551	549	547
		Average RPM	117	117	140	140	146
		Maximum RUN Torque	617	553	627	617	615
		TREND	-1.4%	-8.1%	+1.8%	-0.5%	+6.2%
		UP TIME	98.70%	99.90%	99.90%	99.70%	98.10%

ID	Location	Parameters	SEPT	OCT	NOV	DEC	JAN
160	105/XX-XX-XXX-XXXXX	Average RUN Torque	785	779	768	769	768
		Average RPM	114	117	132	132	132
		Maximum RUN Torque	833	816	845	816	823
		TREND	+0.6%	-0.5%	-2.5%	0.0%	-0.2%
		UP TIME	99.30%	97.40%	98.10%	96.50%	97.90%
173	103/XX-XX-XXX-XXXXX	Average RUN Torque	628	629	633	648	656
		Average RPM	56	56	55	55	55
		Maximum RUN Torque	656	787	668	915	799
		TREND	-1.9%	+0.3%	-1.6%	+2.5%	+3.2%
		UP TIME	99.80%	98.90%	97.70%	96.30%	94.10%

Figure 4

Overall Field Summary

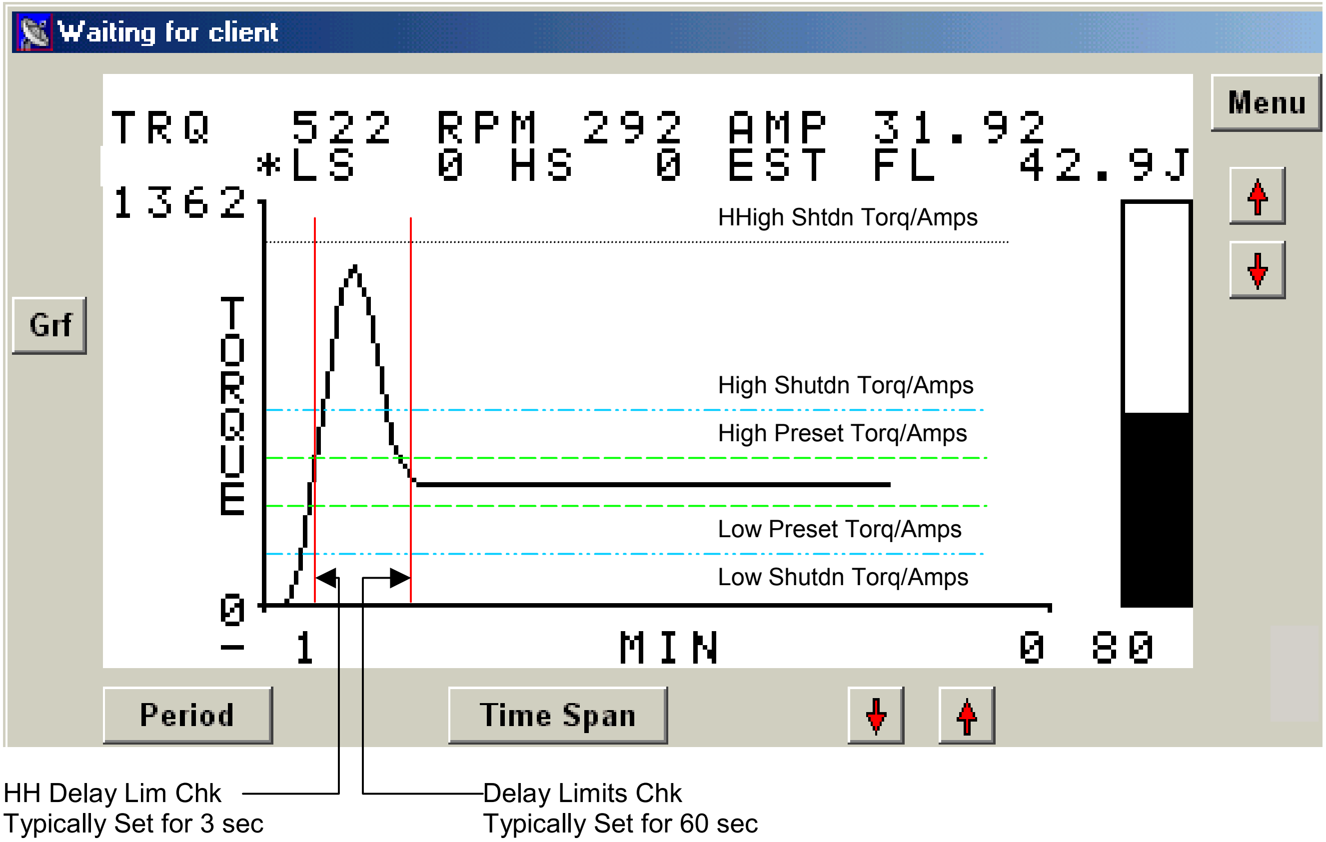

Figure 5

Torque control settings, shown on a Torque vs Time graph

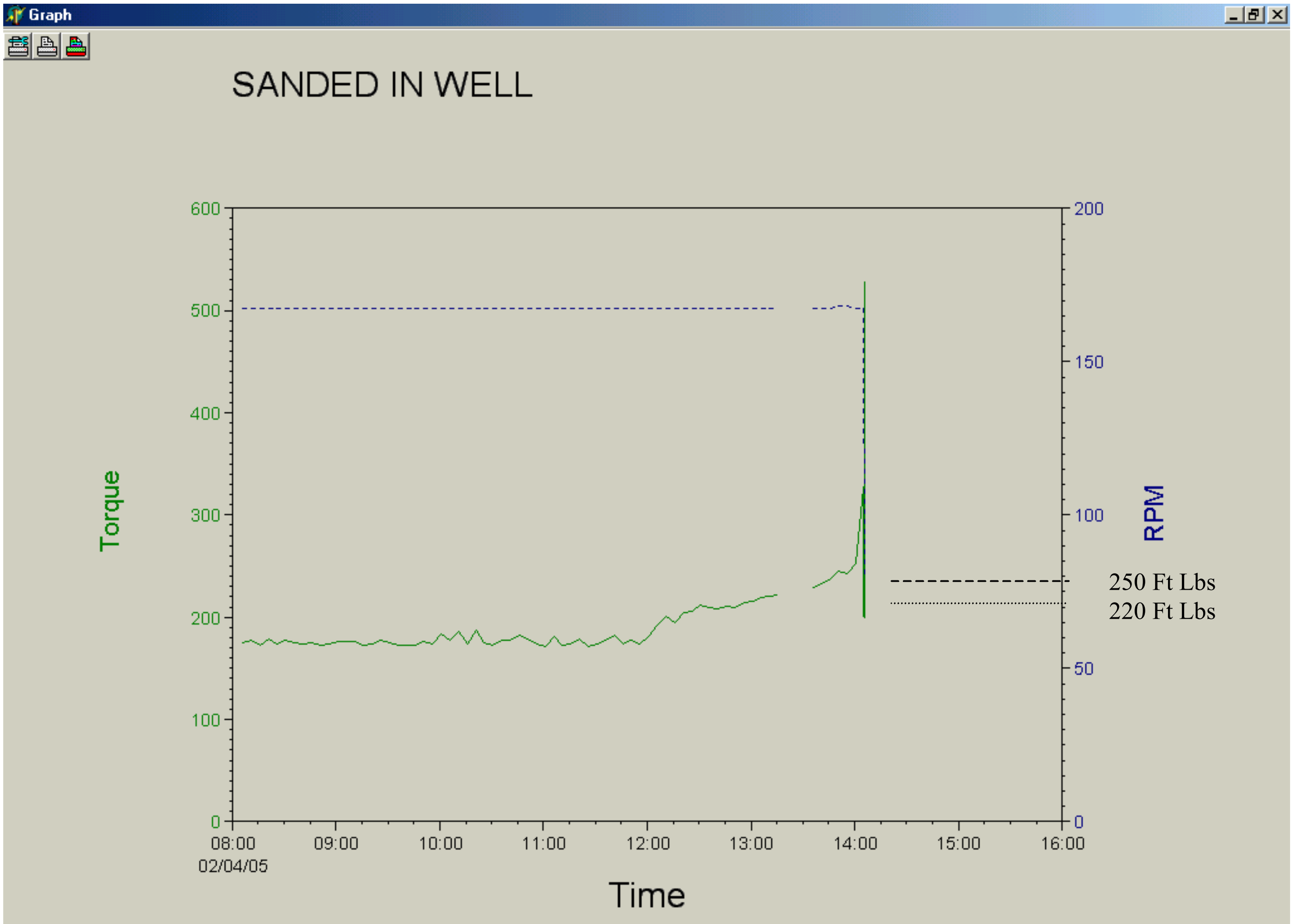

Figure 6

Well Sanding In, without any controls, Torque vs Time

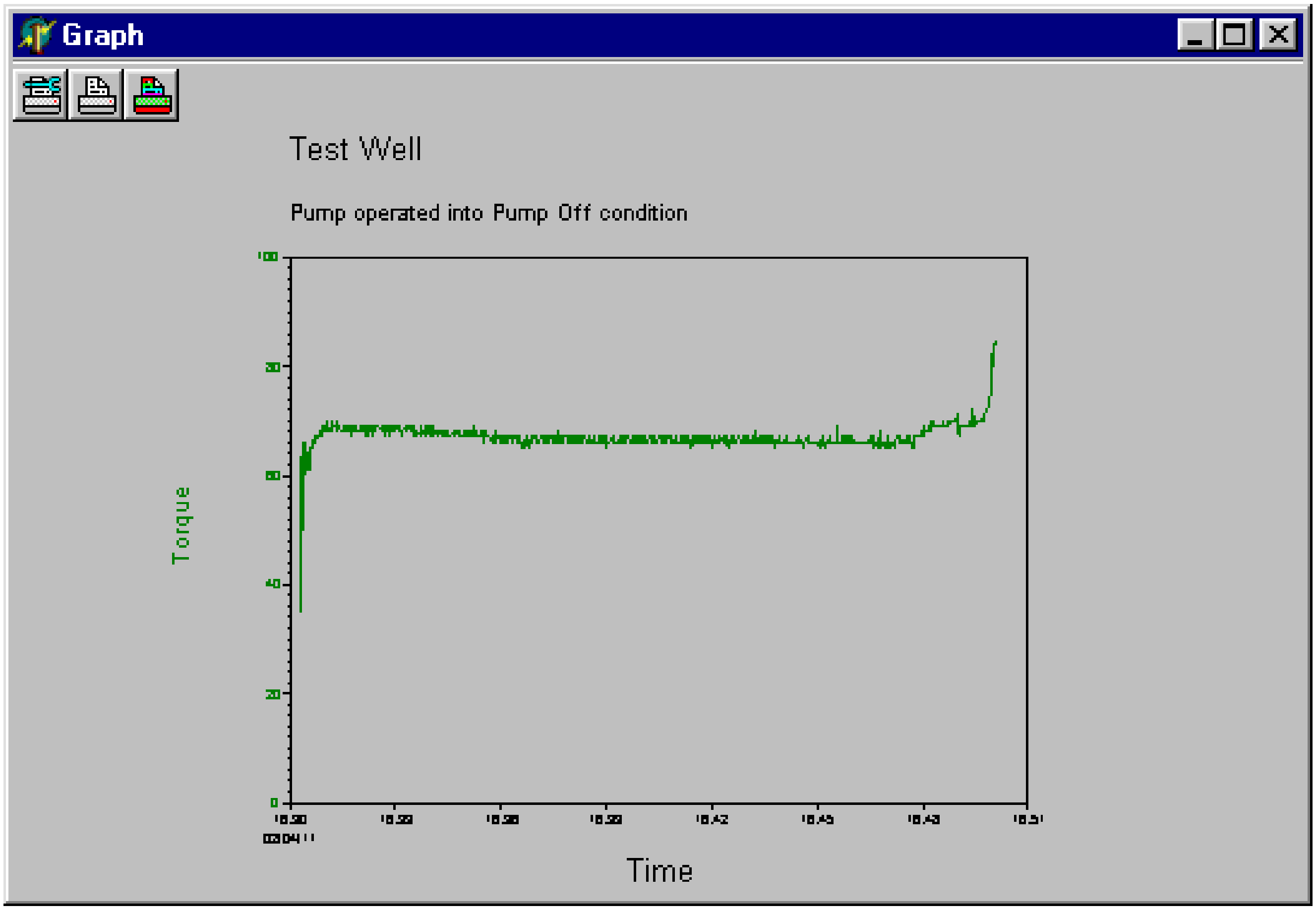

Figure 7
Test Well Operated into Pump Off Condition