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Production Optimization of ESP Wells Using the Proportional, Integral, and Derivative (PID) and Feedback Mode System in Sangasanga Field

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Abstract

Sangasanga Field is one of main production contributor in PT Pertamina EP Asset 5 with production of 5525 BOPD or 31% to total production of Asset 5. Number of production wells in Sangasanga is 136 wells, which are 33 wells use ESP as artificial lift with total production 1763 BOPD or 32% to Sangasanga production Field. This shows that ESP performance in Sangasanga Field is an important aspect in achieving production target.

Some producing wells in Sangasanga Field have depleted pressure reservoir, so they have to be produced in low flowing pressure (less than 100 psi) to get oil rate according to their potentials. Based on the theory, ESP has intake pressure (Pi) limitation, usually the minimum intake pressure is 50 psi. If ESP runs in fixed frequency at depleted reservoir pressure wells, the Pi can reach below the minimum limit so the ESP will be off. In order to avoid ESP off due to low Pi alarm and to get continuous production, ESP has to be set in Pi feedback mode. It means that the frequency will be adjusted automatically according to the Pi target. System that can be used in Pi feedback mode is Proportional, Integral, and Derivative (PID) and Feedback Mode System. By using Pi feedback mode, the lifetime of ESP will be longer because it reduces frequency of trip due to low Pi alarm.

There are 9 wells in Sangasanga Field that are set in Pi Feedback Mode, that totally produce 827 BOPD (equal to USD 20.6 million per year). By using Pi feedback mode, we can continuously maintain 15% production of Sangasanga Field.

Keywords: Electric Submersible Pump (ESP), Proportional, Integral, and Derivative (PID), Feedback Mode, Intake Pressure

Introduction

Sangasanga field is included in the Kutai Basin which is divided into the Upper Kutai sub-basin in the West, and the Lower Kutai Sub-basin in the East. Sangasanga Field consists of several structures with 130 production wells (6 Natural Flow wells, 80 PU wells, 27 ESP wells, 15 HPU wells).

The North Mahakam, Muara-Tanjung Una, and South Mahakam areas are in the Mahakam Delta deposition environment with a reservoir in the form of sandstones that develop in the Balikpapan Formation. While the Samboja Field reservoir is a sandstone reservoir with a deltaic depositional environment with a relatively thin layer thickness range between 2-11 meters and a very limited lateral spread (lenses).

Sangasanga Field is a brown field, so one of the challenge to produce this field is depleted reservoir pressure. Several wells are produced with ESP that which must be able to produce oil optimally at low flowing pressure. In order to avoid ESP off due to low pump intake pressure alarm and to get continuous production, ESP has to be set in Pi feedback mode.

Data and Method

Electrical Submersible Pumps (ESPs) have been used for nearly 100 years in the oil and gas industry (*Takas; 2009*). From the original applications utilizing fixed-speed control through the advent of variable-speed/variable-frequency drive units, the technology for controlling ESPs has paralleled the ever-advancing challenges in modern well completions. These challenges are deeper wells, hotter temperatures, higher gas-oil-ratios (GORs), production techniques such as water-alternating-gas (WAG) cycles, multi-lateral completions, and horizontal wells. Although control loop algorithms have been used in various forms (*Nestlerode, 1963; Blick, 1989*) for many years systems were primarily controlled by the actuation of valves. It wasn't until variable-speed technology was introduced that control loops were used directly for controlling an ESP during operations.

There are many forms of control loops, however, the most widely accepted in industry dates back to the work of Nicholas Minorsky, a Russian born in 1895, is the ideal lead-lag compensator otherwise known as the "Proportional + Integral + Derivative" (PID) controller (*Nise; 1995*). This type of compensator is a very flexible controller that can be implemented in passive and active systems and in modern computer-controlled systems.

Example of PID application in ESP system to maintain pump intake pressure in one well at Sangasanga Field.

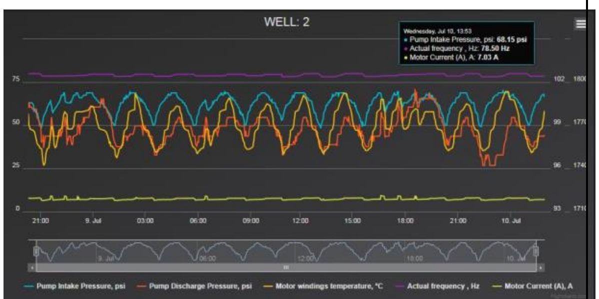

Figure 1: PID application in ESP system to control pump intake pressure automatically

The other method to control ESP parameter is using Feedback Mode System. The device that be used is UniConn. UniConn is a motor controller that provides protection, monitoring, and control and data acquisition for fixed and variable speed three-phase induction motor systems. UniConn and its optional expansion cards monitors: Motor current dan voltage, Variable Speed Drive (VSD) parameters, Control supply voltage, External switch contacts, Process Analog signals, User I/O Interface Summary, Data sensor downhole.
UniConn Feedbcak in VSD provides a feedback feature to control motor speed to attain a target value, constantly monitors the feedback data and incrementally changes the VSD output frequency, and the rate of change and the amount of change is configurable, during operation the VSD output frequency will fluctuate up and down.
UniConn Feedback parameter is consist of:

- VSD Speed Source
  - UniConn will control VSD speed/frequency based on the value on this input.
  - Pump intake pressure
  - Pump discharge pressure
  - VSD motor amps
  - Target speed
- The sensor operation may be proportional or inversely proportional with changes to motor speed.
- Set point; the VSD will change motor speed to attempt to match the target value.
- Step size; this parameter defines by what amount the motor speed should change during each step.
- Step interval; how often the change step take place. This time takes into account how long a change in motor speed will take to effect the sensor.
- Value; These parameters set the maximum and minimum range of the feedback window.
- Dead band; is a range of values around the target value for which the UniConn will make no speed adjustment to the VSD. Outside the dead band range, the UniConn will make and adjustment in attempt to reach target value.

Example of Feedback Mode application in ESP system to maintain pump intake pressure in one well at Sangasanga Field.

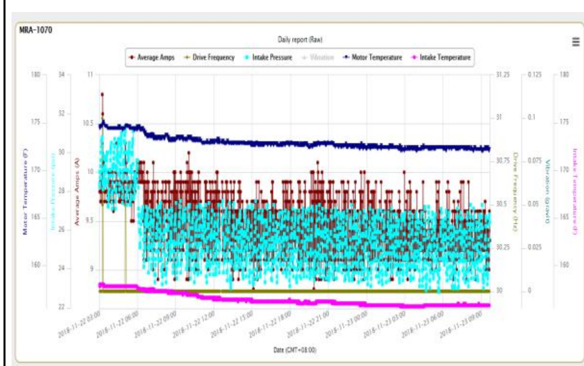

Figure 2: Feedback Mode application in ESP system to control pump intake pressure automatically

Result and Discussion

By using Proportional, Integral, and Derivative (PID) and Feedback Mode System, pump intake pressure can be maintain in range 30 – 100 psi and stable flow rate. In PID and Feedback Mode, the frequency will be adjusted

automatically according to the Pi target. The ESP can run normally without start-stop, so the lifetime of ESPs are longer.
There are 9 wells in Sangasanga Field that are set in Pi Feedback Mode, that totally produce 827 BOPD (equal to USD 20.6 million per year). By using Pi feedback mode, we can continuously maintain 15% production of Sangasanga Field.

Conclusions

Proportional, Integral, and Derivative (PID) and Feedback Mode System are the solutions for ESP wells that have low flowing pressure (below 100 psi). By using Pi feedback mode, the lifetime of ESP will be longer because it reduces frequency of trip due to low Pi alarm.

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