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UniStar

Downhole protection VSD system

APPLICATIONS

- Automated control of rod lift operation

BENEFITS

- Optimizes production under changing conditions
- Protects gearbox and downhole equipment
- Improves energy management
- Reduces number of sensors

FEATURES

- Surface and pump dynacard generator
- Pump fill optimization
- Pump speed control
- Gas interference limiter
- Rod load control
- Bridle separation control
- Gearbox torque control
- Motor current, torque, and thermal control
- Power monitoring and control
- User-friendly displays
- Data capture and communication
- Production monitors
- Automatic restart
- System modeling and simulation

The UniStar* downhole protection variable speed drive (VSD) system maximizes production and equipment performance through sophisticated modeling that makes use of all available parameters, with particular focus on protecting downhole equipment.

Multiple constraint optimization

At any instant during well operations, in particular within a pump cycle, there is a single constraint that limits production, places equipment at risk, or both. Production can be maximized and equipment protected by "automating" the system to operate at the particular limiting constraint at each instant of time. Determining the applicable limits and operating smoothly across them in real time is the key differentiator of the UniStar system.

Multiple-constraint optimization is particularly beneficial in applications with variable inflow conditions, such as those found in unconventional and shale, high gas/oil ratio, thermally stimulated, and coalbed methane wells.

Sophisticated modeling for precise control

The UniStar system's models of all the system elements are run in real time by the controller to detect appropriate limits and enforce associated control strategies. Monitoring equipment contains embedded mathematical models of drive, motor, pump unit, rodstring, pump, flowline, tubing, casing, fluid, and reservoir that use component specifications and well completion information, along with field setup parameters. Identification routines automatically determine installation-dependent system parameters. The models capture the thermal, mechanical, electrical, and hydraulic behavior of the pumping system, enabling more precise control of the pumping process than ever before.

Downhole equipment protection

Protecting downhole equipment begins with rodstring design. A rodstring calculator establishes rod load and resonance parameters for continuous, coupled, straight, and tapered rod configurations. Rod load is corrected for well deviation and rod friction is automatically identified. Rod and pump monitors continuously measure and display polished rod and downhole pump loads, velocities, and positions. Rod force can be measured directly from a load cell or internally computed without the need for external instrumentation (i.e., sensor-free).

UniStar downhole protection VSD system optimizes production and maximizes efficiency and reliability.

A rod load limiter automatically adjusts downstroke speed to eliminate rod float by maintaining minimum rod load while maximizing production. Independent maximum and minimum rod load limits can be preset to reduce rod stress. Rod load damping can be used to suppress oscillations and improve pumping system efficiency without the need for specific load limits.

Gearbox protection

Gearbox torque is monitored and controlled to protect against damaging overload conditions. A crank position monitor provides a continuous reading of the angle of the crankshaft. The crank angle is referenced by a proximity switch, limit switch, or inclinometer. A belt slip monitor detects and reports excessive drive belt slippage or breakage, while a starting-torque manager eliminates inrush currents and extends the life of the system by reducing the violence associated with starting the pump.

The existing counterbalance effect is determined by a counterbalance monitor, and an associated counterbalance assistant makes it easy to adjust the counterweights to minimize gearbox stress.

Efficient power usage

Improving energy efficiency and protecting equipment are mutually aligned benefits delivered by the UniStar system. The system uses detailed information on energy consumption, including system input power, motor output power, polished rod power, and pump lift power to optimize performance.

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Peak and regenerative power limiters allow the maximum and regenerative power supplied by the drive to be conserved. Power flow control can be used to smooth power flow, reduce gearbox stress, and increase pumping efficiency without specifying power limits. A power flow optimizer maximizes production for highly variable inflow conditions by operating the drive and motor at their maximum thermal capacities. Special provisions optimize performance with generators and solar cells in alternative power systems.

An input power meter displays cumulative energy consumption, while a pumping efficiency monitor shows the effectiveness of input energy in producing useful lift work.

Pump fill control to reduce stress and prevent sanding

The UniStar system accurately determines and regulates the percentage of pump fill without requiring separate sensors or control hardware. Instead of stopping a pump completely during a pumpoff condition, the system adjusts upstroke and downstroke speeds to maintain a target fill value and maximize production. This allows the pump to automatically adapt to changing well inflow characteristics, eliminating fluid pound, reducing peak rod load, preventing standstill sand infiltration, eliminating stresses associated with start and stop cycling, and improving pumping efficiency by reducing viscous friction.

The drive automatically slows down prior to fluid impact for a soft landing, protecting the reservoir and subsurface formation. A pumpoff controller allows the pump to dwell for a period in wells with low inflow. The off time is optimally selected by the control. A dwell period minimum pump speed can be used to prevent sanding in the well.

Sensor-free operation

The system uses a number of unique methods for precisely determining polished rod and downhole pump position, velocity, and load without requiring external rod position or load sensors. System variables can be observed through monitor displays or recorded as time-based graphical plots of motor velocity, motor torque, pump speed, pump velocity, gearbox torque, rod velocity, rod position, rod load, pump position, and pump load, as well as dynamometer plots of surface and downhole conditions.

Pump speed control

The UniStar system provides a number of options for controlling pump speed, including potentiometer adjustments, keypad presets, serial data communications, and internal optimization controllers. Single, dual, and triple speed control options allow pump upstroke, downstroke, and cornering speeds to be adjusted independently. The system automatically calculates braking distances for the transition from straight to cornering speeds, as well as points for accelerating out of the corners. In certain applications the motor can be operated at up to twice the base speed at constant power. This allows the overall gear ratio to be increased, thereby increasing low-speed torque while smoothing gearbox torque at high pumping speeds.

Dynacard generation without a load cell

A motor torque monitor and pumping unit geometry can be used in place of a load cell to plot surface dynamometer graphs, using either a personal computer, tablet, or smartphone. The system also estimates downhole pump stroke and pump flow. Predicted surface and downhole dynamometer graphs are available for diagnosing well and pump issues on site.

Production and fluid-level monitors

A pump flow monitor provides a continuous estimate of flow without the need for additional instrumentation. Pumping speed and pump effective volume are used to estimate the production rate. Pump flow is totaled in a resettable production accumulator. Estimated well production is displayed for the operator and is available for remote well monitoring through a serial communication port.

A fluid-level monitor provides a continuous estimate based on pump load, fluid properties, tubing pressure, and casing pressure. Tubing and casing pressures can be entered as parameters for relatively fixed pressures or input from analog sensors for significantly variable pressures.

Automatic restart

The drive can automatically recover from fault conditions and intermittent power outages to ensure continuous operation with unattended wells. Start and stop events are automatically logged for subsequent retrieval.

Data capture and communication

A data sampler captures real-time information for generating torque, velocity, and position plots, as well as surface and downhole dynamometer cards. A data logger records time-stamped fault, warning, and event logs that can be viewed through the keypad and display, uploaded to a personal computer or tablet, or retrieved by a network server. Typical events include start, stop, mode change, power-up, power loss, overvoltage, overcurrent, bridle separation, belt slip, balance fault, low load, and high load. Pump fill and speed are periodically logged for subsequent trend analysis.

Various key parameters and event logs can be displayed at the wellsite or accessed remotely.

Several industry-standard serial protocols are available for communicating with popular programmable controllers, personal computers, or network servers. These protocols include Modbus® RTU, Modbus Plus, ControlNet®, and PROFIBUS®. Optional software is available for monitoring the pumping system using an iPhone® or iPad®. User-programmable reports can be generated using software that connects system parameters to Excel spreadsheets.

System simulation

A pumping system simulator allows actual or hypothetical setup parameters to be evaluated over a broad range of operating conditions. Simulations can be run in the field using the UniStar system without powering the motor or on the desktop using a well monitor and emulator unit.

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