Integrated controls ease precision cementing

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OVER THE YEARS, cementing equipment has been refined to maximize the performance of new materials and processes, and to accommodate the requirements of increasingly complex cementing jobs. Now, technology is taking cement quality control to an even higher level with a new integrated control system.

For the first time in the industry, on-the-fly adjustments to a complex, multiunit cementing job will not require a 4- to 8-man coordination effort. The new system consolidates the controls of all units into one computerized system, allowing an operator to monitor and simultaneously control all units on location when making an adjustment to the job. The new integrated control system is already being field tested with stimulation jobs, and will soon be available for use with conventional and foamed cement systems.

The importance of precision in controlling a job increases with the complexity of the job and the number of units involved. With the advent of foam cementing, for example, a single job requires the installation of mixing, pumping, liquid additive, and nitrogen equipment on location. More equipment demands more operators, and coordinating changes during an operation becomes logistically difficult.

Advanced computer technology provided a functional and economical solution, allowing a cost-effective step-change in the performance of cementing equipment. Because the new system fully integrates the controls of the cementing skid, the liquid additive injection unit, and the nitrogen unit, an operator can query any or all of the operating systems for data to be displayed on a computer screen, and send set point changes to any system as needed.

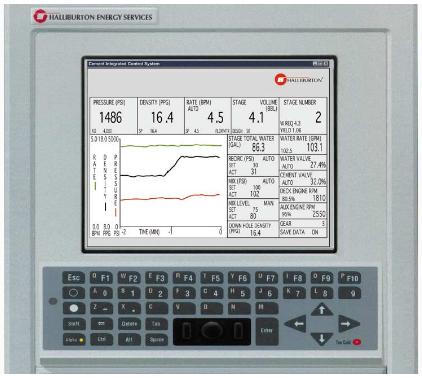


Figure 1: The cementing unit PC controller features a color touch screen to maneuver through the software menus. Data can be added or changed by touching a selected color block.

Consequently, the operator can detect and act on potential problems with a few quick computer keystrokes, without leaving his post to investigate a problem, or using hand signals to relay information. The system also features remote-control capabilities for off-site monitoring and control, which can greatly enhance the safety and efficiency of offshore cement jobs.

The "brains" of the control system are housed within a PC-platform industrial computer that is powered by a high-speed microprocessor and operated through the Windows NT operating system. To help ensure maximum efficiency, a user-friendly interface was critical to the system's design. Developers accomplished this with a color touchscreen, allowing the user to quickly maneuver the software menus and add or change data quickly by touching a selected color block on the screen (Figure 1). Other features include a small keypad and a built-in mouse that aids in setup and operation and provides backup to the touch screen. Because the system uses a controlled area network (CAN) bus for data input/output, the system can be easily expanded, and can be incorporated into a rig area network. The system is also available in a hazardous-area use configuration, featuring the same easy-to-use touch-screen interface.

AUTOMATION

Because of the increased use of foam cementing, liquid additive systems, and other sophisticated cementing techniques and materials, the number of jobs requiring high-tech control capabilities is growing steadily, and placing greater demands on equipment. Over the years, refinements of cementing equipment have significantly improved reliability and expanded the operating envelope. The basic functions required have not changed, however, and the custom-designed equipment that has delivered reliable service for decades—the 400-hp triplex pump (in use since 1957), the industry's first recirculating mixer (introduced in 1975), liquid-additive pumps (used offshore since 1977), and

Cementing equipment: Figure 2 (left) shows a cementing skid equipped with recirculating cement mixer (RCM) and automatic density control systems. The RCM has evolved to allow routine mixing of high-density or thixotropic slurries at high through-puts. Figure 3 shows continuous metering system (CMS) liquid-additive tanks. The CMS allows highly accurate injection of additives at various points in the mixing/pumping process.

nitrogen equipment (in use since 1974)—remains the foundation for the cementing system.

Cementing unit. Introduced to the industry in 1975, the recirculating cement mixer (RCM) system has evolved to allow routine mixing of high-density and/or thixotropic slurries at high through-put rates (Figure 2). Reliability and service quality have remained at the forefront of RCM technology. In 1989, an automatic density control (ADC) system was added to the RCM, improving control of the mixing process for even higher quality cement. Mixers equipped with the ADC system soon became the industry standard, with more than 400 systems installed to date.

Liquid additive system. In 1990, the batch process for adding liquid additives to the slurry through measuring (displacement) tanks was replaced by a continuous metering system (CMS), allowing additives to be injected at various points in the mixing and pumping process (Figure 3). This system is more accurate than the batch process, and accommodates foamed cement jobs, which contain surfactants that are introduced downstream of the mixing process. Halliburton's injection unit continuously meters any number of additives required for a job, and can inject additives into the mix-water stream or into the downhole-pump suction header, for customizing various applications.

Integrating the liquid additive system with the cementing unit not only makes it easier for the operator to monitor flow rates; it also allows the use of actual cement mixing rates as the main input for controlling additive proportioning. With this arrangement, an operator can alter the actual cement-mixing rate to suit his specific needs, with confidence that the additives will be reproportioned automatically to maintain the preset concentrations.

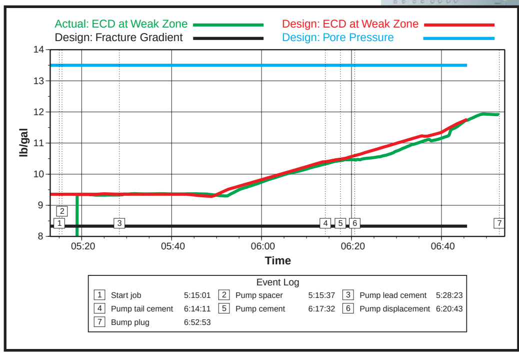
Technological advancements have also increased the metering accuracy for liquid additive concentrations that are critical to the slurry's performance. A mass flowmeter option has been developed for the CMS to provide an alternative measure of flow rate. With this option, the user can monitor the flow of additives by both the pump rate and the mass-flow indicator, and use either signal for control-system feedback. Because the mass flowmeter is not subject to calibration errors, it provides the accuracy required for some liquid additives, and provides a dependable system for quality control. In the first application, performed offshore Eastern Canada, metering accuracy was better than 1%, based on the total volume pumped.

Nitrogen System. A foamed cement's capacity to provide long-term zonal isolation is determined not only by the density of the base cement, but by the precision with which it is foamed through the injection of nitrogen. Traditionally, maintaining density integrity during stage changes has presented a challenge for operators. Today, with automated nitrogen injection, operators simply preprogram the stage changes into the operating system. Automated nitrogen injection has also allowed operators to ramp the foam concentration by programming the unit, and achieve the desired foamed-cement density throughout the annulus.

DATA MANAGEMENT

Mobile Control Center. The mobile control center, a van for land use and a skid for offshore use, provides a central focal point for monitoring and/or controlling the cementing job (Figure 4). With the use of data acquisition systems and real-time wellbore-simulation software, data from all cementing components as well as discrete sensors can be fed into a mobile control center, where the operation can be monitored by operators and/or customers. Mobile control centers are currently being used in land and offshore cementing operations throughout North America.

Wellbore Simulation. Advanced wellbore simulation models are greatly improving the design of both conventional and foamed cementing jobs. The wellbore simulator has now been incorporated into the data acquisition software so that, when conditions warrant, and especially when running foamed slurries, the actual job parameters can be compared to the design values in real-time. These parameters include not only the traditional pressure, rate, and density values, but also wellhead pressure and fluid positions and pressures at any point in the wellbore. With this information, the risk of an unforeseen problem is minimized, and in the event that the operator must make a last-minute adjustment, the information generated by the simulation program can provide invaluable downhole information. Figure 5 shows a post-job data graph from a conventional cementing job in California. The equivalent circulating density, which can now be displayed and monitored in real-time, can help an operator to run the job and stay within the limits of low fracture gradient or high pore pressure.



Charting the job: The mobile control center shown in Figure 4 above allows customers to observe cementing parameters. Figure 5: Post-job equivalent circulating density graph compares design parameters vs actual field results.

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