Electronic Fuel Control For Small Diesels

Woodward's APECS 4800 system is designed to provide greater precision than mechanical controls.

For several decades, mobile industrial and stationary diesel engine applications have used mechanical governors to control fuel pump output. While traditional injection pump technology offers a proven, reliable, low-risk means of delivering the proper amount of fuel to the engine, the mechanical governors that control them can be limited in terms of precision and functionality. Electronic solutions continue to grow in popularity as manufacturers look for simple, low-cost ways to add precision fuel control to small diesel engines.

Woodward Inc. developed its APECS (Advanced Proportional Engine Control System) family of speed control solutions to meet the requirements of today's diesel engines. Its new APECS 4800 controller provides full authority control or fuel rack limiting with position feedback for mechanically actuated PFR-style diesel injector pumps on engines up to 50 hp. It combines a digital electronic controller with a linear actuator to provide fuel control.

"When combined with an actuator to translate the electronic signal from the controller into an action that operates the injector pump, electronic governor control offers precision and functionality," said Marty Chiaramonte, product line manager, Woodward, Loveland, Colo. "Although electronic fuel rack governing is nothing new, the requirements that are placed on electronic controls and actuators for operating traditional pump-type fuel systems continue to expand."

Such requirements include tighter speed regulation, improved engine responsiveness, reduced smoke emissions, altitude compensation, improved subsystem interaction, enhanced diagnostics, engine health monitoring, and fault information.

The 48000 digital controller provides isochronous speed control, actuator position control, torque limiting, glow plug control, CANbus J1939-based communications, and additional engine management and protection functions to optimize engine operating efficiency, said the company.

The controller also provides NOx emissions control with EGR valve control and particulate matter reduction through smoke limiting and altitude compensation. This helps OEMs meet the particulate matter limits set by the U.S. Environmental Protection Agency (EPA) Tier 4 emissions requirements or the European Stage 3B standards for engines under 25 hp, Woodward said.

Overfueling is a significant cause of particulate-laden black smoke. An engine is susceptible to this condition during starting, load transients, and turbocharger delays. The APECS 4800 controller helps alleviate the causes by maintaining the engine's optimal airfuel ratio throughout the operating range, even at high altitudes, said the company.

"Black smoke comes from too much fuel relative to available air," Chiaramonte said. "As I travel through countries such as China, India and Brazil, I see a lot of smaller tractors that use a mechanical throttle. They work, but to start the engine, the operator will usually throw the fuel rack wide open and grind on the starter until the engine gets enough fuel. That causes overfueling on a starting event. We know where that fuel rack needs to be to start the engine, so APECS controls that fueling event electronically."

When the engine's coolant temperature is below a preconfigured level, the start fuel is limited so the engine's fuel rack cannot go beyond a preset position until the coolant temperature rises. It works the same for the instantaneous application of a load. The controller looks at the engine's speed, ambient pressure or manifold absolute pressure (MAP), and the actuator position to limit the fuel rack's position. As the speed and pressure increases, the limit point also increases at the response rate of the control algorithm.

These algorithms work to keep the visible smoke to a minimum and also provide altitude compensation to optimize airfuel delivery.

The controller's torque-limiting capability also prevents excessive smoke. Based on actuator position, torque limiting sets the maximum amount of fuel according to a configurable speed and fuel-limiting curve. A second function of the torque-limiting feature is that it prevents possible engine damage if the engine is overloaded at a particular speed, said the company.

Algorithms in the APECS 4800 also continued on page 32.
use engine speed, actuator position, and engine temperature to control the exhaust gas recirculation (EGR) valve, activating it at the correct time to reduce NOx emissions.

The controller includes a limp-home function that derates the engine for a configurable period of time in the event of a critical fault, which can include low oil pressure, high coolant temperature or a faulty speed or actuator position sensor.

The linear actuator is designed to mount directly on the engine. It uses an internal, noncontacting Hall effect sensor to provide fuel rack positioning, which Woodward said provides optimal fuel delivery and closed-loop feedback on rack position in full-authority applications. The company said it also eliminates rack control errors due to engine-to-engine variations, fuel pump oil viscosity changes, engine and fuel system linkage wear, and changes in system friction. Sensor information is also used by the control algorithm to estimate fuel burn and soot loading as part of a diesel particulate filter (DPF) regeneration strategy.

Woodward is targeting compact tractors and construction equipment, small generator sets and light towers. "Because this controller can also protect the engine, it's a good fit for equipment on rental fleets," Chiaramonte said. "A customer might not care what condition the engine of a rented machine is in as long as it works for the time they're renting it. Rental yards can use APECS to ensure the rental machine's engine is in good condition before it goes out, and if it does have a problem, the APECS 4800 will shut it down and tell you what's wrong."

Of particular interest are manufacturers in countries where emissions standards are pending, such as China or India. "We are talking to customers that have aspirations to export into regulated markets or that are working to be ready for upcoming emissions regulations," Chiaramonte said. "For the most part these guys have not really had to touch electronic engines yet in the nonroad markets."

The electronic control/actuator combination can easily be incorporated into the design of engines in production, he said. "We have a very simple sealed board that mounts near the engine, and it's a relatively minor change to the actuator, especially when compared to tearing out simple pumps to go to a high-pressure common rail system," Chiaramonte said.

"Small-diesel engines are developing their strategies and trade offs for emissions control for their legacy mechanical engines, both for customers working in regulated markets and those looking to export. Woodward's APECS products offer a simple path to minimize development, application, and installation costs and risks while meeting performance and emission requirements."