

Caterpillar Continues to Test New System

By the MorElectric System Design Team

Fuel prices and anti-idle legislation are the two topics sure to stir debate and rancor in the heavy-duty/off-road vehicle world. Diesel fuel prices, often higher than pump gasoline, continue to climb and the movement to reduce diesel idling affects both over-the-road and off-road segments, as communities enact environmental legislation against it.

Commercial vehicles may idle for significant hours to provide a comfortable cab temperature or to enhance cold weather starting. The EPA estimates that 11 percent of a typical Class 8 truck's total annual fuel is consumed at idle. Overall, it's estimated that heavy-duty vehicles at idle consume approximately one percent of U.S. diesel fuel. Even part of the National Energy Policy is specifically focused on reducing fuel consumption and emissions from idling trucks.

A heavy-duty truck can consume up to one gallon per hour while idling, and with a per-truck average of 1,800 hours per year of idling time, the trucking industry spends over \$1 billion annually to provide operators a comfortable cab environment. Additionally, the emissions produced during idle are equivalent to that from 15 million cars.

The challenge is to find a cost effective alternative to idling trucks during extended rest periods and to reduce fuel consumption in over-the-road use.

Caterpillar, a major manufacturer of engines and over 300 heavy and special-application vehicles, is working on the problem. Some of the engine accessories in use were originally derived from the automotive industry where the focus has been a lifetime of approximately 150,000 miles. That's not good enough for today's heavy-duty trucks with their expected useful life of 1,000,000 miles.

Cat's new MorElectric system will drive various engine accessories electrically to improve fuel economy, and increase reliability, durability and serv-

iceability. System components and engine accessories are specifically designed with the life and robustness needed for heavy-duty mobile equipment. Powering these accessories at only the actual speed, flow or pressure required enhances fuel economy and vehicle performance.

Modular plug-in subsystems allow for cost effective common parts usage and enhanced serviceability. This technology is not limited to on-highway vehicles, but is also applicable for construction equipment, emergency and military vehicles, and RVs.

The technology also allows better flexibility in locating components and can reduce the heat load on the radiator system. Various pumps, compressors, and other accessories all compete for space, and through their belts and pulley rob the engine of fuel and performance. The new technology drives these accessories electrically increasing the power available to the driveline and offering solutions to reduce idling.

The system is currently undergoing field validation testing, and units are being operated on both highway trucks and a variety of off-road applications. The hardware under test uses production-intent tooling and processes.

The MorElectric system is a product of Caterpillar's Electronic & Electrical Systems business unit and will be sold to OEMs for installation at their assembly facilities. The system is designed to be compatible with any engine an OEM elects to use.

Power Generation

Alternators have historically been one of the top reliability problems for heavy-duty mobile equipment. The MorElectric generator incorporates switched-reluctance technology and is specifically designed for heavy-duty mobile applications. It is expected to provide more than double the reliability and durability of current automotive style units.

The new generator is engine-mounted and belt-driven like today's alternator. It has roughly the same package size as the typical 12-volt alternator, but provides 7,300 watts on a 340 volt DC bus. A voltage converter provides the 12 or 24 VDC needed for the vehicle's conventional systems.

If the concept and power numbers look familiar, they are. Cat is using technology found in today's hybrid vehicles to achieve high power densities and fuel savings for the same technical reasons. The company's engineers found that the power needed to run accessories on heavy-duty mobile equipment is the same as that needed to launch an automobile from a stop sign.

The system's generator may be used to power additional electrical devices such as boom equipment, tailgate lifts, or (with the use of 110/240 VAC inverters) could also power appliances, hand tools, or emergency lights. Additional electrical devices will operate off this electrical system bus in the future, and are being developed by various industry providers. Look for electrical water and oil pumps, and electric power steering systems in the not too distant future.

One key to extended longevity of the new generator is elimination of sand and debris that enter through the air cooling fan on today's alternators. MorElectric's generator is cooled using the engine coolant system, allowing the unit to be totally sealed against outside dirt (no fan) and also remain unaffected by rising underhood temperatures.

A Modular Approach

Caterpillar engineers found that air conditioning systems are often among the top five product reliability problems as well. Current vehicle a/c systems use a distributed design, with components spread throughout the engine compartment and operating in conditions of extreme heat and vibration. There are two predominant weaknesses in the current automotive air conditioner system design: the loss of refrigerant gas around the compressor shaft seal, and through the flexible hoses.

The Cat MorElectric system HVAC module is similar to a window air conditioner, with an electrically powered, hermetically sealed compressor. The unit can provide 24,000 Btu per hour of cooling. The compressor itself is a variable-speed, high-efficiency scroll. The control system eliminates the system losses of on-off clutch cycling experienced with conventional systems and is expected to provide improved reliability over traditional distributed automotive-based refrigeration systems.

Combining all HVAC elements into one package allows the use of rigid refrigerant tubing and brazed connections to eliminate refrigerant permeation through the hoses. It also removes the condenser from the radiator area, removing the air conditioning heat load from the radiator air stream and improving engine cooling.

Driving the compressor electrically allows removal of the compressor from the engine area as well as eliminating a drive belt and pulley, and the high horsepower radiator fan is no longer required to operate for a/c purposes.

The HVAC module improves serviceability. It comes precharged and can be replaced or dismounted without opening the system (discharging the refrigerant) in about an hour. This allows quick service to put the vehicle back to work.

The compressor itself is a variable-speed, high-efficiency scroll. The control system eliminates the system losses of on-off clutch cycling experienced with conventional systems and is expected to provide greatly improved reliability over traditional automotive-based refrigeration systems.

Driving the compressor electrically allows removal of the compressor from the engine bay as well as eliminating a drive belt and pulley, and the high horsepower radiator fan is no longer required to operate for a/c purposes. The unit can provide 24,000 Btu per hour of cooling.

Caterpillar is working with vehicle OEMs on designs that require only one a/c system for either on-road or overnight use. For example, think about a recreational vehicle with two a/c systems. Typically, the RV has one a/c system built into the engine and dashboard and a second, redundant a/c system mounted on the roof. One is almost always not in use.

On-Road Fuel Savings

The fuel savings opportunity comes from a combination of component and system operating improvements. The scroll air-conditioning compressor is 30 percent more efficient than conventional piston compressors, and the generator operates at roughly twice the efficiency of typical automotive-style alternators. Depending on vehicle application and driving profile, the system can provide

up to two percent on-road fuel savings.

Idle Management

With an electric HVAC system already on board, the new system can be leveraged to offer cost effective alternatives to idling the main engine. This may not improve the miles per gallon over the road, but certainly reduces the total amount of fuel consumed by the vehicle.

There are two idle management options for a MorElectric-equipped vehicle. With the "shorepower" option package, an operator plugs the vehicle into an electrical outlet to eliminate idling at truck stops, rest areas, loading docks, or fleet terminals. Connected to a 240 VAC, 30-amp electrical outlet, the system provides heating and air-conditioning (as well as 12 or 24 VDC) equivalent to what the engine typically provides at 900 rpm. The shorepower package weighs 44 pounds.

If no external power is available, another option is an auxiliary power unit or APU. The APU is a small diesel-powered generator set that eliminates the need to idle the main diesel engine. In this case, the power unit is a Caterpillar two-cylinder, 0.5-liter displacement, 4-cycle, water-cooled diesel engine that powers the 340 volt system by driving a small generator. The operator has the freedom to park anytime or anywhere and know that both a/c and heating will be available during rest periods.

The small power unit uses less fuel, generates fewer emissions and produces less noise than idling the larger main diesel engine. Cat's APU is integrated with the vehicle subsystems to lower cost and weight, and the MorElectric unit shares coolant with the main engine. Additionally, the APU engine oil sump capacity is designed so that its oil change interval coincides with the main engine oil change interval, eliminating separate maintenance visits.

Fuel Savings

The fuel savings from using the APU during rest periods is, of course, dependent on the application and number of idle hours, but for a typical Class 8 long-haul truck, the APU is expected to reduce annual fuel consumption by up to six percent. That's a significant saving over a year's operation.

The company estimates that its new

system can provide a total fuel savings of up to eight percent when the two percent on-road gain is combined with the six percent gain from reduced idling.

Caterpillar and other manufacturers expect APU usage to grow significantly over the next five years as anti-idle and emission restrictions become ever-tighter. As a Tier 1 supplier to vehicle OEMs, Cat expects a standard space envelope and chassis location to emerge on vehicles for installation of auxiliary power units.

The MorElectric system is planned for commercial introduction in 2006 and will be sold and serviced through a variety of truck manufacturers. It will be installed by the OEMs under their quality control process. Caterpillar states that the system will not be available as an aftermarket product due to the difficulty of assuring quality installation.