Linear Actuators for Throttle Control in Off-Highway Vehicles

Al Wroblaski, Product Manager – Linear Actuators
Thomson Industries, Inc.
Wood Dale, IL
540-633-3549
www.thomsonlinear.com
Thomson@thomsonlinear.com

Throttles on drive and auxiliary engines on off-highway vehicles have traditionally been controlled by cables connected to the driver's cab. Problems with this approach include the need to place controls in non-ergonomic positions in the cab, difficulty in running cables to auxiliary engines, and the risk of inefficient or even unsafe operation due to reliance on the operator to control engine speed. A new generation of linear actuators can overcome these problems by making it possible to easily and inexpensively control the throttle through an electrical wire or communications bus. Speed controls can be placed in ergonomic positions to increase operator safety and productivity. With electronic controls, speed can be automatically controlled based on the state of the vehicle to increase productivity and reduce fuel consumption, noise and emissions. A wide range of control and mounting options reduce design and installation costs.

Mechanical throttle challenges

Off-highway vehicles typically have a diesel or sometimes a gasoline engine to drive the vehicle and in many cases also provide a power take-off (PTO) to operate equipment. Often the drive engine is used to power a hydraulic pump that in turn drives a cylinder to perform work such as driving a boom and bucket on an excavator. Many off-road vehicles also have auxiliary engines to operate equipment. Controlling the speed of these engines presents many challenges. Typical examples of off-highway vehicles where speed control can be difficult include skid loaders, excavators, street sweepers and sprayers, asphalt pavers, trenchers and concrete pumps.

Various equipment functions often require that the engine be operated at a specific rpm for a certain function and frequently a number of different speeds are required for different tasks. Operators do their best to hold these rpm levels but with many other tasks to perform the potential always exists for equipment to operate at less than optimal levels or even be damaged due to operator errors. Busy operators often leave the engine running at operating speeds even when the equipment is not being used which increases fuel consumption, noise and emissions. Off road equipment manufacturers have been making increasing use of electronic controls to improve vehicle operation, however, electronic controls cannot interact with mechanical cables.

The need to run mechanical cables from the cab to the engine or engines creates design and installation challenges. Wire-wound cables have a large bend radius which often limits the areas that they can be run and creates difficulties during installation. Wire-wound throttle cables are often limited to specific areas of the cab and these areas are frequently not the easiest to reach and operate the throttle. Auxiliary engines are particularly difficult to reach with mechanical cables because they are frequently located far from the cab. Periodic lubrication required for wire wound cables is also very difficult to complete, often overlooked causing issues.

Advent of linear actuators

Linear actuators offer the potential to eliminate many of these difficulties. Linear actuators eliminate the need to run cable from the cab to the motor. Instead, the actuator is installed by the throttle and two wires can easily be run from the cab to the motor. The switch to operate the throttle can be placed in any location in the cab to improve ergonomics and safety as opposed to the limited positions available to wire wound cables. The actuator can be controlled by a simple potentiometer with or without limit switches. The actuator itself can also be positioned for easy installation because no direct access is required for maintenance. The actuator is lubricated for life and maintenance free.

Interfacing with control system

The actuator can also easily be interfaced with a control system that can deliver substantial improvements in performance, fuel economy, noise and emissions by automatically optimizing the speed of the motor based on the work that is being performed. Controlling the engine speed with an electronic control system enables the throttle control to be integrated with the vehicle control system so that, for example, when a particular function is turned on the actuator can automatically be configured to move the throttle to the correct set point.

The onboard controls can coordinate multiple functions requiring specific power levels and automatically change the speed as needed to ensure that adequate power is provided while minimizing fuel consumption, noise and emissions. For example, if an operator of a crane is manually controlling the throttle, he or she is likely to keep the engine at the speed required to operate the crane, even when the crane is not being operated for a short period of time. On the other hand, a control system can easily be configured to drop the engine speed to idle when the joystick is not moved for a defined time interval. When the operator touches the joystick, the control system is typically configured to immediately increase the throttle to pre defined operating engine RPM.

Bus communication advantages

The new generation of linear actuators builds on the proliferation of bus communication that substantially reduces the cost and complexity of integrated vehicle operation. With bus communications a single control unit can replace the need for multiple single function controllers. This approach also substantially reduces the amount of wiring required in the vehicle. Bus communication has already been proven in the automobile industry and is used in many of today’s off-road vehicles. Manufacturers of off highway vehicles can utilize the technological advancements and economies of scale that have been developed for the automotive industry in order to increase the functionality and reduce the cost of their own vehicles. The bus can provide additional savings by requiring only a very simple control in the actuator to take commands from the CAN bus.

With a traditional approach an electronic control unit (ECU) is required for each actuator. By using a smart actuator (this is good try to use the term smart actuator, in a few more places, as it is one of our descriptions we publish for this line of actuator) with a bus, rather than running a separate cable from the controller to each actuator, only a single cable needs to run from the controller that passes each actuator. Each actuator control has a unique address, listens to every signal from the vehicle control system and responds only to signals with its own address. Actuators also offer the advantage of providing status information. The command goes out to an actuator to travel to a certain position. When the actuator reaches that position, it sends a clear signal to the control unit. The actuator can also return position and speed information. The implementation of the bus system also makes it simple to add additional sensors that can include other measurements such as temperature or load.

Linear actuators also provide the opportunity to integrate the throttle with other vehicle functions. For example, suppose that the engine must be operated at a speed of 2000 rpm to power a hydraulic pump for a specific vehicle function. The control system simply sends out a command to the actuator to increase the speed of the engine. The control system watches the response from the tachometer and turns off the actuator when the engine has reached 2000 rpm. Then the control system turns on the equipment to perform the specific function.

Linear actuators are also designed to withstand underhood temperatures, vibration and moisture and high cycle life to survive in the tough off-highway environment. Throttle actuators designed for off-highway applications typically meet IP67 or IP69Kstandards so they can withstand water and particles. A typical model is designed for 500,000 cycles and can operate on a 50% duty cycle at maximum dynamic load. Models are offered with basic limit switch control, potentiometers with or without limit switches, SAE J1939 is available as an onboard control and custom control capability. Integrating the control into the actuator housing saves the cost of a separate enclosure for the control. Actuators are available that can operate from -40C to 125C. They are also designed to withstand the shock and vibration seen in the off highway environment. A typical unit is tested at 100K cycles at 60 pounds at a shock load and 10,000 cycles at 90 pound as well as

Random Vibration per MIL-STD-810, Category 24, Level 2
0.014 g^2/Hz acceleration, 20 to 2000 Hz frequency, (5.2 G's)
8 hours in each of three mutually orthogonal planes

Applications

Manufacturers of off-highway equipment have been quick to use linear actuators for throttle control to improve the performance of their products. For example, a manufacturer of street sweepers uses a custom control to manage linear actuators for throttle control. The street sweepers have many different functions, each of which requires a different throttle speed. The custom control and linear actuator ensure that the engine is always operating at the correct speed. A manufacturer of skid steerers builds one model with Tier 4 diesel engine technology including an electronic throttle to meet emissions standards in developed countries. The company also builds the same model for emerging nations without the Tier 4 technology but faced the challenge of how to operate the throttle in the second engine, offering the benefits of electronic Throttle control (e.g. Auto Idle, RPM pre set points, etc.). The OEM discovered that it could use the same engine for both developed and emerging markets by replacing the electronic throttle with a linear actuator on the engine for emerging markets. The big advantage is that the company only needs to manufacture and stock a single engine for both markets.

Electric linear actuators give operators an unprecedented range of control, for greater productivity, safety and sustainability. Actuators allow much more ergonomic location of controls for less operator fatigue and more agile operation. Interfacing linear actuators with electronic controls enables automatic speed adjustments, lower fuel consumption ,greater noise management and reduces downtime and operator fatigue. The end result is that off-highway equipment vehicle manufacturers can deliver a better product with a competitive advantage.