Prinoth Case Study: Smarter machines provide quicker response times for challenging conditions and simplified manufacturing

**Punishing, demanding conditions**

Prinoth Snow Groomers operate on the edge of what is mechanically possible. These advanced vehicles combine a number of mechanical systems that must function within rigid parameters. But these systems must work flawlessly enduring thermal shocks that alternate between icy and wet, floating above three meters of fresh snow, climbing at -30º C on blue ice, with inclines that quite often exceed 45 degrees.

Snow groomers typically operate in the dark, after skiing hours. Operators must continually adapt blade positions to collect the right amount of snow given the snow moisture level, temperature and other variables. Operators depend on feedback to know their blade settings, which is a delicate art and science. They require fast reaction times and the ability to sense the blade position when starting or stopping a movement.

By 2010, Prinoth had made great advances in engine management, joystick operation, and touchpanel operation. But hydraulics in these punishing conditions still lagged. Eaton responded with innovative components that helped Prinoth make smarter machines. In particular, the CMA valve which allows for Dynamic Machine Control (DMC).

**New hydraulic technology for improved operator responses**

Older hydraulic technology applied to such wide and heavy accessories could have generated noise and wasted energy using restriction points to control movement. Orifices that restrict flow also generate heat. Applying traditional hydraulic approach, the result could have easily been sluggish response times that were hard to predict. Viscosity changes in the oil as temperature changed affected response times and made precision hard for operators. Older hydraulic systems had a typical control response of 1.1 s, which was simply too slow.

**DMC for quieter, efficient & quicker operation**

The Eaton CMA valve runs on a Pro-FX Technology platform to produce remarkable changes in response times. Where older systems had a typical response time of 1.1 s, systems making use of the CMA valve produce response times of 0.1 s. For the operator, this appears as a nearly instant response, which allows for precise control on the slopes no matter the outside conditions.

**Remote diagnostics**

Prinoth is in the business of manufacturing and selling snow groomers and other hard-working vehicles. Real-time service and the capability to propose a solution to the customer are the keys of success in this kind of business.

By incorporating Eaton CMA valves, Prinoth is able to support almost in real time any customer, wherever they are operating in the world with Leitwolf: connecting remotely to perform the first analysis and sometimes even immediately fixing the problem; or sending the right spare parts in shortest possible time, with clear benefit of time and money for the final customer.

**Simplified manufacturing/ improved service**

Because the CMA valve functions as an embedded system, it communicates on the CAN bus and does not require dedicated wiring. An embedded system simplifies both the manufacturing and the subsequent servicing.

With the Leitwolf model in particular, Prinoth used CMA valve technology to make dramatic leaps in improving serviceability. The CMA valve allowed Prinoth to use fewer hydraulic components, which meant lower service costs and less service spending. Service engineers use a diagnosis...
program to effectively monitor valve status. Failures are reported to the driver to further identify and resolve potential problems.

And with embedded systems in more and more vehicles, logic became available for more service encounters.

**DMC INNOVATIONS**

Dynamic machine control is the driving force behind smarter machines, including snow groomers. Several innovations become available when using Eaton products that provide for DMC.

**Electronic load sensing**

Load sensing with the CMA valve allows great flexibility of control system architecture and easily supports varying machine working settings along with a variety of pumps.

**Flexible system architecture**

Flexible architecture reduces routing complexity, saves on lengths of hose and provides improved weight distributions on the vehicle chassis. All of these are a result of the CMA valve sets which allow for multi-sectional (up to 8 x bank) and multibank combinations.

**Ease of integration: use any pump**

The CMA valve delivers dynamic machine control, but it is not limited to Eaton load-sensing (LS) pumps. In fact, most conventional LS pumps can be used with the CMA valve, which turns any LS pump into a better-controlled unit, delivering better cycle performance through pressure Rate-of-Change active management. The CMA system continuously monitors the flow balance at the inlet port of the valve set along with the pressure and temperature of the oil. The CMA valve then controls and modulates the pressure provided by the pump with varying logic. With the same base LS pump an integrator can mimic LS load following or keep the pump at fixed level of pressure while needed and eventually define a torque limiting curve so to avoid saturating the PTO (power take off) power. The control acts through a pressure modulation in the LS hose back to the pump.

**Dynamic improvement through a variable DELTA_P setting**

The Eaton CMA valve offers exceptional flexibility with the option of setting a specific LS DELTA_P for any of the working sections into the system. Program the CMA valve to maximize energy savings when a service does not need aggressive dynamic response (lower DELTA), or it can be shaped to respond quicker and more aggressively when a specific load needs to be accelerated/ decelerated very fast due to the vehicle operation.

**P-Q approach**

Independent metering on the CMA valve allows the capability to unlock the mechanical link between the amount of oil sent to an actuator and the amount of oil allowed back to tank. This capability opens up a wide range of control criteria to achieve simultaneous control of pressure and flow. This dynamic response and inertial management allows for a very customizable tuning of the load control response, which was not possible with older, non-independent metering elements.

**Inertial load management with local high dynamic load sensing**

The CMA valve monitors the pressure signals from any work port in the system at roughly 700 Hz. At that monitoring level, the CMA valve is fast enough to control pressure phenomena also thanks to its main stage spool dynamic (-100%/+100% in 20 ms).

The CMA architecture offers the possibility of directional control that automatically senses the inertia discharged back into the hydraulic system and regulates the flow delivery so as to limit the pressure-induced spike by modulating accelerations and decelerations also to control the dynamic pressure of the actuators.

**Load oscillation dampening (long booms)**

Any harmonic resonance induced by the mechanics (for example, long flexible arms) can be managed by the CMA to eliminate up to 70% of the oscillation amplitude (note that residual 30% is typically difficult to noticed from outside). In add

**Fine-tune the dynamic response for a customized drive feeling**

The IFC controller embedded in the CMA has a complex and very tunable algorithm that can control inertial directional control on the METER IN line and a dynamic tunable pressure control on the METER OUT line. This combination of separately tunable and synchronized controls on the two independent spools delivers superfine dynamic response tuning possibilities as well as a very customizable “load feeling,” which is much appreciated in the industry.

**Various types of controller logic: IFC (intelligent flow ctrl), RATE CTRL, PRESS_CTRL, SHAKE, SAFE FLOAT**

CMA offers a multitude of different controllers also to perform customizable shake control of an actuator, or a safe floating control which always monitors any load overrunning conditions to keep load under control or an active pressure control that substitutes a proportional pressure control valve acting independently on any work port of the system.

**CMA + BoomLoc**

Perfect solution for safety cylinder lock with no energy waste in negative load control combined with superior dynamic inertial control of the load suspended by the cylinder.

The industry today is highly focused into raising a machines safety level to follow the zero accidents culture. A critical challenge into hydraulics has always been balancing safety associated to counterbalance valves with energy waste associated.

Today this limit gets broken by CMA combined with another EATON technology: SPHAR. This is a family of control options available as counterbalance solutions in the range of 30 Lpm to 400 Lpm. One of these options combined with CMA allows for super-accurate dynamic response, narrow to zero energy waste compared to actual solutions and a standard automated hydraulic lock at the stop of the directional control.

This is made possible by special SICVs (Screw in Cartridge Valves) that will ensure reduction on the minimum pressure necessary to drive a load in the sense of gravity from today 60/80 Bar down to 15 Bar. Since the standby pressure of a LS system is never lower than 20 Bar we can say Eaton is able to deliver narrow to zero energy waste combined with super fine metering for any overrunning load.