Today’s diesels used in mid-size, off-road and construction equipment are clean, efficient power sources, but they are far from indestructible. Stalling a turbocharged diesel is to be avoided at all costs and carries with it a high probability of cooking the turbocharger lubricant. It may also cause the unit to self-destruct when the engine is re-started, a reason why engine builders include a mandatory cool-down period in the normal shutdown sequence.

Since most functions on these types of machines are hydraulically powered, OEMs have turned to hydraulic suppliers for solutions. One approach that has been successful on large equipment is the use of a pump equipped with an automatic hydro-mechanical torque control system to limit the amount of torque extracted from the engine.

“The idea here is to limit the torque at the pump shaft across a wide range of engine speeds,” says Todd McIntyre, product manager for Eaton Corp. “It’s the mirror image of a power control system that limits the amount of power at a fixed speed. The OEM essentially has to choose which engine parameter they want to optimize, and if it’s torque then this is the answer.”

“For compact and mid-size equipment it is almost always torque that needs to be controlled,” McIntyre adds. “The problem was that, until now, such a system was not readily available on pumps in this size range.”

An example of the pump’s impact is in a telehandler application with engine specifications of 50 hp, 2,650 rpm and 1.194 inch-lb of torque. Designed without torque control, in order to lift with 3,000 psi, the design requires a 2.50 cid (41 cc) 420 pump and flow is limited to 29 gpm — even for light loads.

By using torque control, the engineer is able to specify a 3.80 cid pump, and the larger displacement allows greater flow (faster operation) of the bucket when empty or not lifting with 3,000 psi. Engaging torque control and de-stroking the pump to 2.50 cid prevents engine stalls with heavy loads.

The new Eaton 420 Series pump with hydro-mechanical torque control is essentially an enhanced version of a standard pressure-compensated pump using a mechanical feedback loop to control swash plate position. In simple terms, the pressure compensator setting is varied according to swash plate position rather than acting at a single set point. Since torque is a function of pressure and displacement, torque is now held constant. The mechanical feedback determines the amount of flow the pump can deliver at a given pressure, because the pressure

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**Eaton 420 Pump with Hydro-Mechanical Torque Control**

- **Load sense compensator**
- **Hydro-mechanical torque control limits maximum torque back on an engine by decreasing flow in high pressure situations, and preventing engine stalls**
- **Zero leak technology results in higher efficiency**
- **Adjustable maximum torque level allows control to be tuned to exact application and optimize efficiency**
- **Compact design fits in tight spaces**

The stable and fast response of the Eaton 420 pump is achieved by careful design of a hydro-mechanical proportional torque control that limits flow to the control piston. The responsiveness of the control is improved with the help of a “variable gain methodology” which provides higher control flows to reach the desired torque limit and then smaller flows to maintain the torque level. The result is minimized swash plate oscillation and torque ripple which increases responsiveness and stability while reducing noise and wear.
Fluid Power/Power Transmission

T O R Q U E C O N T R O L

Hydraulic assembly failures may be caused by excessive pressure surges, flexing, kinking, crushing, exceeding the minimum-bend radius of the hose or reaching the end of the useful life of the assembly.

To avoid hose failures, Gates recommends design engineers:

1. Select a hose that has a working pressure rating that is equal to or higher than the maximum pressure (including surges) of the application.
2. Consider a spiral wire-reinforced hose rather than a braid-reinforced hose if the application has a heavy-duty cycle or frequent pressure surges that approach the maximum working pressure of the assembly.
3. Reroute hoses to eliminate excessive flexing.
4. Make sure hose bends are not tighter than the minimum published bend radius for the hose. Use bent tube couplings, adapters or bend restrictors to relieve stresses on the hose.

For hydraulic hoses containing fluid with a pressure of more than 5MPa (50 bar) and/or having a temperature over 122°F (50°C), and which are located within a three-foot line-of-sight of the operator, Gates recommends an extra safeguard – a double-layered protective sleeve.

Gates LifeGuard™ sleeve has an inside layer that elongates to absorb the energy of a burst or pinhole leak. The outer layer restrains the fluid and redirects it safely to the clamped ends.

Both nylon layers of the LifeGuard sleeve provide containment of 6,000-psi bursts and 3,000-psi pinhole leaks at 212°F, thus protecting operators, equipment and the environment from the hazards of catastrophic hydraulic hose failure. Visit www.gates.com/lifeguard-dn

determines the swash plate angle.

“In practical terms, that means the 420 pump will not extract more than a fixed amount of torque from the engine,” McIntyre says. “An added benefit is faster function speeds when the work load is low because the flow rate changes.”

He cites the example of how raising a backhoe bucket filled with concrete might happen slowly due to the torque control setting protecting against engine stall. But if the operator empties the bucket, it will move faster because the flow rate will be higher. “Curling a bucket at 20 gpm can require 10 to 15 more engine horsepower than curling the same bucket at 17 gpm on a small machine,” he says.

The same amount of engine torque is available in both cases because the pump automatically limits the torque used no matter what the demand. It will not stall the engine, regardless of what the operation may require.

Based on customer input, McIntyre says Eaton engineers chose to utilize a mechanical feedback system for the new 420 pump. “The mechanical system provides the functionality required by today’s equipment at a lower cost than a comparable electronic solution,” McIntyre notes. He says the next generation of machines will almost certainly need electronic controls. But by then, new emissions requirements will be in place and the engines will already have extensive electronic management systems.

“It makes good sense to tie the pump control into the same system,” he adds. “It’s yet another example of the emergence of electro-hydraulic solutions as the wave of the future.”

For the present, though, Eaton’s hydro-mechanical solution offers a number of advantages to OEMs in addition to controlling torque. In some cases, it can help them keep their equipment from migrating into operating areas covered by tighter emission regulations.

“At the moment, a piece of equipment with a 68 hp engine falls under a different set of emission requirements than the same piece of equipment would with a 75 hp engine,” McIntyre says. “If the OEM can provide the necessary machine functionality with the smaller engine by using a 420 pump to control torque, they potentially can reduce their exposure to additional costs associated with more stringent standards.”

This factor will likely become increasingly important as new regulatory requirements impact the power density of diesels. For example, being able to stay with the smaller engine could mean avoiding the cost of re-designing engine mounts, cooling arrangements and engine compartment geometry.

“But beyond that, the pumps themselves are more durable because bearing loads are constant across the whole operating range. That translates into longer bearing life which directly impacts both operating and maintenance costs,” McIntyre says. “They also are more efficient because it is relatively easy to achieve an optimum corner horsepower where both pressure and flow are maximized simultaneously for maximum output.”

While the concept of hydro-mechanical torque control is not new, the ability to package the necessary functions in a pump small enough to meet the needs of compact and mid-size equipment required a good deal of engineering. In addition to hydro-mechanical torque control, the new “B” design 420 Series pump also offers a more robust casting and the option of a low-noise compensator.

Later this year, Eaton plans to introduce a new 620 pump (98cc, 280 bar continuous) for moderate flow, high-pressure applications. It is reported that this pump will provide excellent power density and up to 135 hp (at 2,200 rpm). The unit is 12-percent shorter than Eaton’s PVH pumps and provides improved reliability, 28 percent fewer parts and a proven compensator. Target markets include wheel loaders, motor graders, rail and highway maintenance and excavators.

For more information:
Eaton’s piston pumps:
http://designnews.hotims.com/27744-508

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