

Danfoss wheel loader solutions

Performance. Uplifted.

Integrating transmission, steering, work function and thermal management solutions for one powerful machine.

Wheel loader industry challenges

When it comes to wheel loaders, OEMs face multiple challenges. These can include optimizing vehicle performance, time-to-market and gaining market share within an extremely diverse global customer network.

Looking at today's wheel loader landscape, there are four main challenges to achieving higher profitability: increasing productivity, resolving the availability problem for experienced labor, managing the energy transition and meeting diverse market expectations.

1 Increasing productivity

Successful OEMs identify and execute solutions that provide advantages in the all-important "output cost/input cost" ratio, whether that be reducing machine costs, maintenance or fuel consumption.

2 Inexperienced workforce

The workforce as we know it has changed. In the past think 1940s through the 1960s — it was common for young workers with experience driving agricultural equipment to find operating jobs on the worksite that led to extended employment. An intrinsic knowledge of machinery and efficient work was common within the labor force. Today, however, that basic footprint of labor is either not present or not intrigued by the opportunities associated with a construction equipment operator career path.



Because of this, fleet managers and construction companies struggle to find career equipment operators. The pool of willing and experienced employees is dwindling, particularly in Europe and North America.

3 The energy transition toward zero emissions

The volatility of the energy market makes overall wheel loader efficiency even more important. Utilizing energy sources and conversion methods, and weighing options like an internal combustion engine vs. hybrid vs. electric (battery only) are new challenges OEMs must navigate to succeed. The influence of disruptive technologies and regulatory decisions adds to the complexity in a competitive marketplace.



Danfoss

4 One company, varied markets

For global manufacturers, the expectations of machine performance may differ greatly, depending on which region of the world their machines are being sold. Varying factors can include emissions compliance, operator comfort requirements or vehicle productivity, among others.

For example, China tends to emphasize machine function with operator comfort typically considered much less important, particularly relative to North American or European markets. A resulting challenge for OEMs is supporting the various market needs with minimum overall complexity for the design and fulfillment of their wheel loader platforms.



Streamlining operations and simplifying a wheel loader design will **increase productivity**, **improve safety**, **boost performance** and **shorten time-to-market** — ultimately leading to improved profitability.

True Optimization — looking beyond the subsystem

When it comes to wheel loader design, four main subsystems work together:

- Transmission system
- Work functions system
- Steering system
- Thermal management system

And while it's easy to think of them as independent of one another, doing so contributes to significant problems for the final customer, machine owner or operator.

Allocating power

For example, consider a wheel loader that uses a torque converter power shift transmission system. When treating the ground drive and work circuit as separate items on the wheel loader, the typical sizing process would involve allocating a discrete amount of engine torque to each function. This way, the sizing of the machine always assumes both of those functions — the work hydraulics and ground drive — are active at the same time to avoid stalling the engine and achieving required tractive effort.

For this classic sizing method, the problem occurs when the machine is utilizing a small portion of the ground drive or work function hydraulics — meaning there's a certain amount of installed engine power that isn't needed. This leads to oversized engines, increased engine speed and higher parasitic losses — increasing the initial cost of production, reducing production efficiency and increasing operating costs.





When you start evaluating the entire machine as one cohesive system rather than several concurrent, independent systems, all functions can be optimized to work together. In this scenario, it would mean the wheel loader would be designed to allocate engine power to exactly where it's needed (based on operating conditions) rather than working within firm allocation restrictions.

Increasing efficiencies

Scenarios like this are attainable when the engine and components all operate on the same network. That enables continuous adjustment of power provided versus demand — whether it's ground drive, work functions, fan drive or commanding engine speed changes. The parameters can be infinitely adjusted to achieve optimal performance at all times.

Fuel consumption is inherently reduced when a wheel loader is optimized at a machine level, providing better return on the wheel loader investment. Fundamentally, you use more of the available engine power at a much more efficient operating condition.

Meeting varying market needs

Optimizing the entire wheel loader machine design can also help OEMs meet diverse needs for a global customer base. Consideration of integrating hydraulics and electronics allows the final product to be customized to a particular set of user demands. Much like commonly available drive modes in automobiles, you can configure the characteristics of the loader to the particular situation of customer, application and region.

These customizable systems allow OEMs to streamline design processes. For example, if ground drive requirements in China are more aggressive than for Northern European customers, different parameters and settings could be implemented within the same design with a few software parameter tweaks. Additionally, there are even subtle differences for customers in Northern versus Southern Europe. OEMs with a more localized, yet still differentiated, customer base can adjust wheel loader settings to meet either the Northern European operator comfort requirements or the heightened performance expectations of Northern Europe without changing the machine design.

Compare this route to a traditional torque converter transmission, which would require implementing an entirely new transmission and/or torque converter in order to adjust the system output. Each revision requires hardware definition, Danfoss can help **lower fuel consumption** by **up to 15%** while improving machine productivity.



acquisition, installation and, finally, testing. These changes lengthen design cycles and manufacturing time, ultimately increasing overall costs and time-to-market.

Why you need to consider wheel loader **operability**

Optimizing the hydraulic system of the wheel loader is one of the most significant levers an OEM can implement when optimizing productivity.

Wheel loaders "back in the day" used a mechanical connection to the main control valve. The problem with that setup is that it was complex, noisy, tiring for the operator and wore out quickly. OEMs then turned to hydraulic pilot controls, which created smoother operating conditions, a lower operator force level, better feel and a higher power for a given package size.

Both of these, however, have limitations in their controllability and flexibility. Whatever movement was created on the joystick created a proportional control of the valve spool — decreasing design and functionality flexibility. Functions were constrained by the hardware of the wheel loader design — the performance of the machine was set by the components installed and changing said performance required a hardware revision.

Moving toward an electrohydraulic system allows the OEM flexibility of machine reaction to different operating inputs. These would be established based upon set software parameter changes — revising machine performance in minutes instead of weeks.



Customized functionality

Consider a new operator, for example. With an electrohydraulic system, it's possible to program a "novice setting," meaning that the system would react less aggressively so the operator can become more comfortable on the machine — all without changing any hardware. This allows a nominal level of productivity and increases safety and overall comfort. Doing so allows the operator to become proficient at an accelerated rate. As operator skill advances, the setting can be adjusted to increase response and aggressiveness based upon the OEMs desired capability for their highest level of performance.

Increased flexibility

In another instance, for mini or compact wheel loaders, an electrohydraulic system increases overall machine design flexibility. On any given day, a compact loader may need to operate with multiple attachments, ranging from the traditional bucket, to those needing high-flow rotary attachments, such as a broom, mower or road planer. The demands of each are quite unique and require significant differences in machine control and management.

With a pilot system, designing the wheel loader to react to these different needs would require unique customization, increasing time-to-market and design complexity. To change machine behavior with an electrohydraulic system only requires a mode change.

There are other aspects of an electrohydraulic system that provide additional benefits, as well. These can include endof-stroke cushioning, variable kick-outs, electronic leveling, and variable return to dig as a small sample. Essentially, you can design the wheel loader to do whatever you want it to do within a streamlined design process.

With these capabilities, one wheel loader can have different functionalities tomorrow than it can today — all with a few parameter changes.

How improving comfort in your wheel loader **increases productivity**

The recent implementation of joystick steering not only increases wheel loader operability, but it also has a significant impact on operator comfort and machine productivity.

Aalborg steering study

Danfoss recently partnered with the sports technology department at Aalborg University in Denmark to measure the full impact of different steering systems on a wheel loader. Their method included monitoring 15 healthy, right-handed male students as they operated a wheel loader simulator to complete a specific task. Different steering input devices were used, including a standard steering wheel, a steering wheel enabled with a Quick Steering feature from Danfoss, and joysticks. Completion time, task deviation and muscle activity of the hand, arm and shoulder were measured.

Inexperienced subjects were used for the study to best represent a novice workforce and to not alter any results with pre-developed preferences.

A significant impact

The traditional steering wheel performed the worst regarding productivity and muscle strain. In fact, using any of the alternative steering inputs resulted in a 6 percent decrease in task completion time. And while 6 percent may seem like a small change at first, consider that within a 40-hour workweek — 6 percent equates to 2.4 hours of additional productivity, or over 100 hours within a year. Using an improved steering configuration allows the operator to complete a given task faster, allowing more work to get done in a day and timelines to stay on track.

The most significant results occurred when participants used a joystick steering method. When compared to conventional steering, using a Danfoss JS1-H joystick reduced the user's average workload by 65 percent. This is the lowest work demand for any steering input.



Consider the shoulder — a 65 percent difference in muscle activity can significantly reduce repetitive motion, positively impacting operator wellness for years to come.

With these findings, OEMs can integrate new steering solutions into their machines, knowing they can improve operator comfort and increase productivity.

Performance. Uplifted.

New technologies and capabilities can significantly enhance wheel loader operability, comfort, productivity and safety all while helping OEMs address their most pressing market challenges.

A partner to make it happen

And while all of this sounds great, it begs the question — "Why isn't everyone doing this?" Machine level technologies are being integrated, and software capabilities are still being implemented the off-highway industry, and OEMs are still working through how to best implement it into their machine/vehicle portfolio offering.

Yet, to be on the cutting edge of machine performance and technologies, working with a skilled partner can make the move an easier process.

Danfoss offers a wide range of product, system and design solutions specifically engineered for wheel loaders. This includes its vehicle management technology called Best Point Control (BPC), which facilitates machine networking to where it's established optimal operating conditions. In addition, Danfoss hydrostatic drive solutions and control architectures also enable machine management. Lastly, Danfoss offers a wide range of solutions, including anti-stall functionalities and electronic torque limiting (ETL) logic for our work circuit.

ENGINEERING TOMORROW

At its core, Danfoss can supply the building blocks for a machine management network and architecture. Beyond that, it's able to offer its expertise on how to make it work for your specific wheel loader needs.





Danfoss

About Danfoss Power Solutions

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electric components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market as well as the marine sector. Building on our extensive applications expertise, we work closely with you to ensure exceptional performance for a broad range of applications. We help you and other customers around the world speed up system development, reduce costs and bring vehicles and vessels to market faster.

We offer you expert worldwide support for ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide you with comprehensive global service for all of our components.

Danfoss Power Solutions - your strongest partner in mobile hydraulics and mobile electrification.

Products we offer:

- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Hydrostatic motors
- Hydrostatic pumps
- Orbital motors
- PLUS+1[®] controllers
- PLUS+1[®] displays

- PLUS+1[®] joysticks and pedals
- PLUS+1[®] operator interfaces
- PLUS+1[®] sensors
- PLUS+1[®] software services, support and training
- PLUS+1[®] software
- Position controls and sensors
- PVG proportional valves
- Steering components and systems
- Telematics

Go to www.danfoss.com for further product information.

Danfoss Power Solutions (US) Company

2800 East 13th Street Ames, IA 50010, USA Phone: +1 515 239 6000

Danfoss Power Solutions GmbH & Co. OHG

Krokamp 35 D-24539 Neumünster, Germany Phone: +49 4321 871 0

Danfoss Power Solutions ApS

Nordborgvej 81 DK-6430 Nordborg, Denmark Phone: +45 7488 2222

Danfoss Power Solutions Trading (Shanghai) Co. Ltd.

Building #22, No. 1000 Jin Hai Rd Jin Qiao, Pudong New District Shanghai, China 201206 Phone: +86 21 3418 5200

Danfoss can accept no responsibility for possible errors in catalogues, brochures and other printed material. Danfoss reserves the right to alter its products without notice. This also applies to products already on order provided that such alterations can be made without subsequential changes being necessary in specifications already agreed. All trademarks in this material are property of the respective companies. Danfoss and the Danfoss logotype are trademarks of Danfoss A/S. All rights reserved.