HydraForce

POWER FORWARD

CONSTANT TORQUE CONTROL

www.hydraforce.com

HydraForce Constant Torque Control

Speed control for rotating devices can be simple and straightforward, but sometimes achieving stable performance can be a challenge. It's intuitive to apply a meter-in flow control when you have a motor that needs a constant velocity. This is an effective strategy for many applications. However, a fair number of rotary systems will benefit in terms of stability with a constant torque control.

Instead of controlling the flow through the system with a proportional throttling valve, the HydraForce constant torque control maintains the pressure in the circuit limiting the torque applied to the rotating load.

Ideal Systems for Constant Torque Control

Any rotating device can be a candidate for a constant torque control. Fan drives have achieved superior performance for years using pressure controls. If your system has the following characteristics, it is a prime candidate for a constant torque control.

Flywheel Effect/Inertia

Large rotating masses resist speed changes. Effecting a change in speed can require a large torque resulting in huge pressure spikes.

Instability

Long hoses can act as a accumulators in the system, while the rotating load acts as a flywheel. These components combine to form an oscillator which can make the system unstable.

Unbalanced Loading

Like the runaway clothes washer, an unbalanced reel, blade, or broom tends to oscillate the load at the frequency of rotation.

Mechanical Play/Backlash

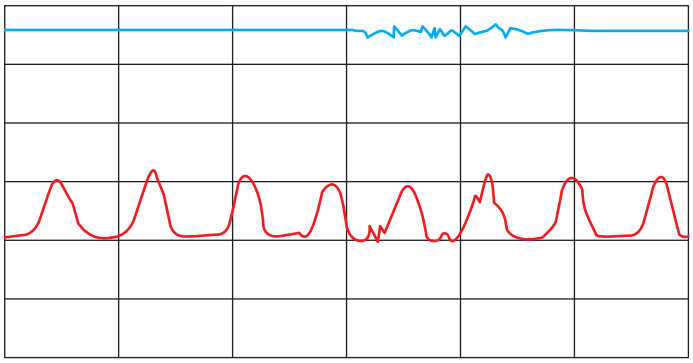
Play, backlash, or flexibility in the system components can set off oscillations. This only adds to the difficulty in achieving a stable control. You may observe these effects on a pressure trace

Better Control

for high inertia rotary applications

A Technically Better Solution

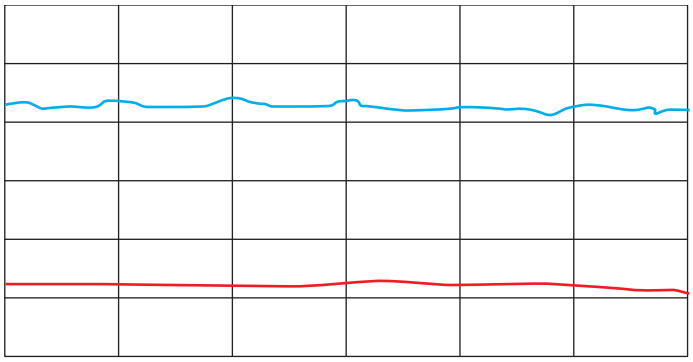
Limitations of Flow Control



Pressure at the motor inlet swings dramatically (red trace) as flow (blue trace) remains constant

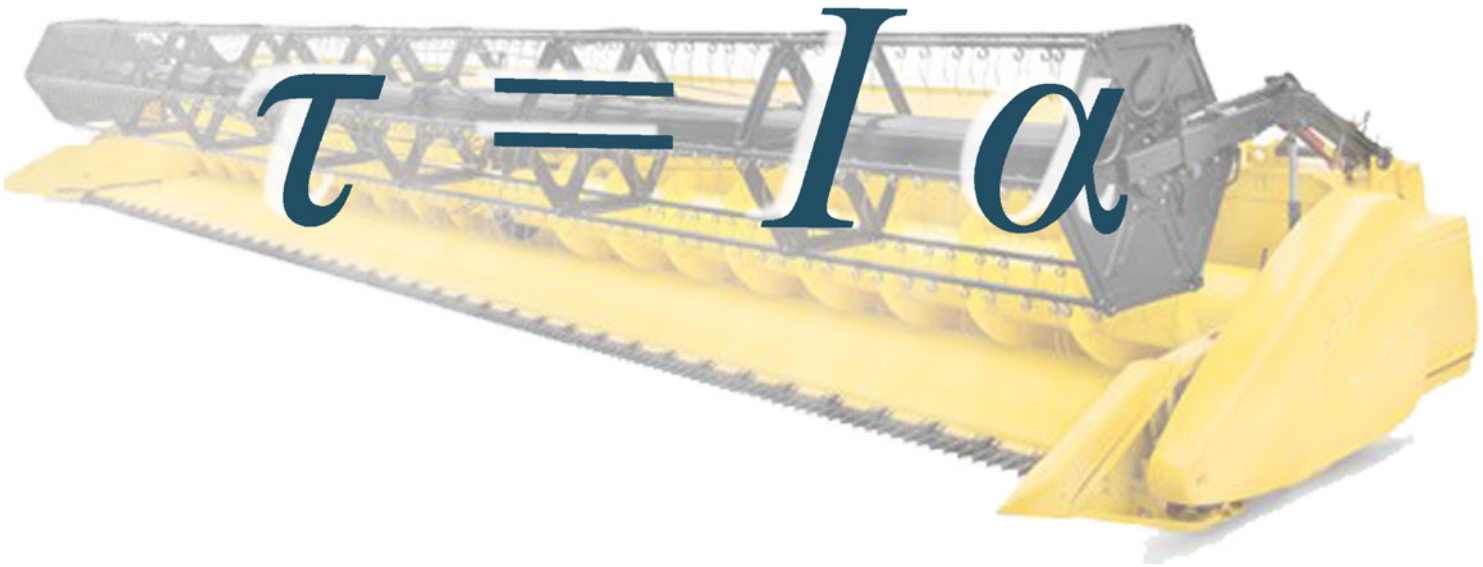
Why is a meter-in flow control problematic in the systems described? Looking at Newtons second law for rotational motion ***(τ=I•α)***: small changes in acceleration ***(α)*** are multiplied by a large inertia ***(I)*** resulting in a very large torque ***(τ)***. This leads to wild variations in pressure. Damping the compensator response is a typical strategy to apply when pressure changes rapidly, however because of the low frequency of these oscillations, it is not practical.

Why Torque Control Outperforms



Pressure (red trace) is stable, while flow (blue trace) varies slightly

Why does the constant torque control outperform the compensated flow control? Because this strategy controls pressure in the circuit. Taking another look at Newton ***(τ=I•α)***: we control torque ***(τ)*** and given the large inertia ***(I)***, the acceleration ***(α)*** settles out. The result is a much more stable control without wild pressure oscillations and some very minor variation in flow. Applications appropriate for this type of control will benefit from the increased stability and tolerate the minor speed variation.



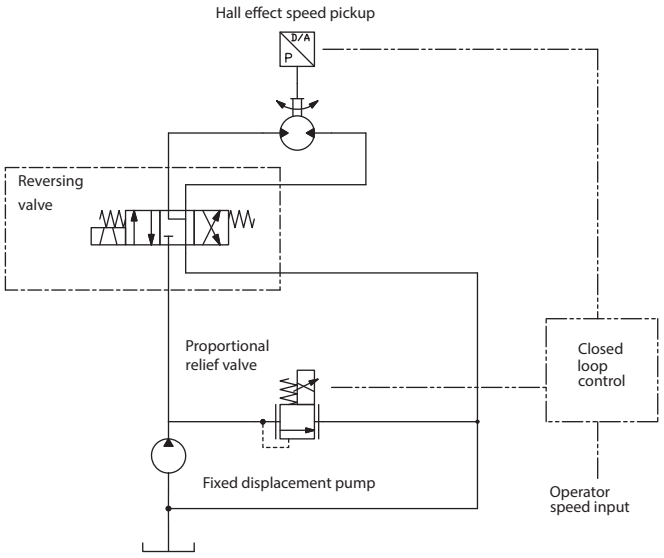
Reduce Oscillation

smooth out pressure ripples

Two Types of Torque Control

HydraForce can custom design a constant torque drive for your application based on one of two types of circuits:

Gear Pump



Suitable for fixed displacement pumps, this circuit uses a proportional relief valve to control pressure in the drive circuit. The valve can operate wide-open to bypass flow at a very low pressure drop (7 bar/100 psi typical) when the system does not require any. The motor-center directional valve allows the motor to float in neutral. Applications requiring positive stop position can use a cylinder spool or can be coupled with a number of different load-holding solutions, including pilot-to-open checks, counterbalance valves, or poppet-style valves. A hall-effect speed pickup provides feedback to a closed-loop PID control.

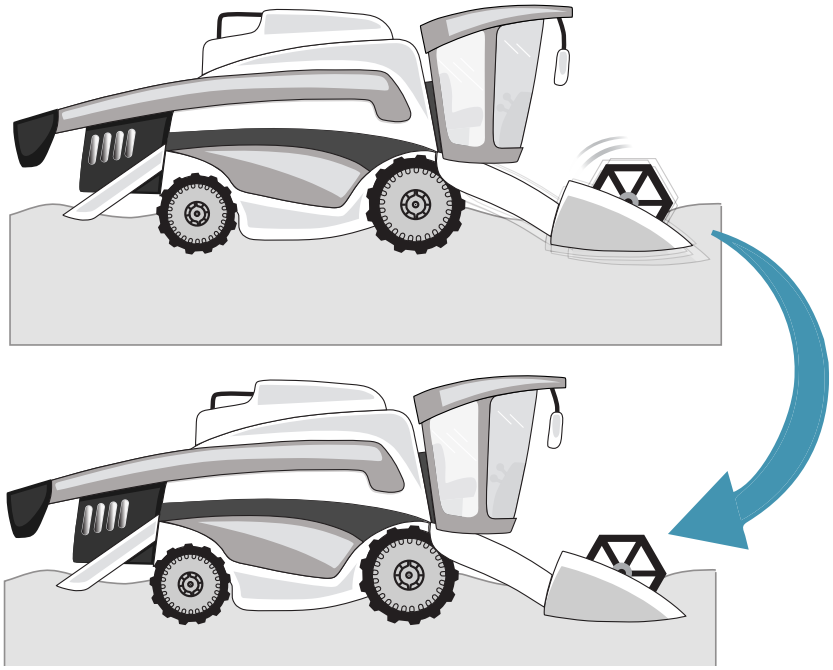
Benefits of Torque Control

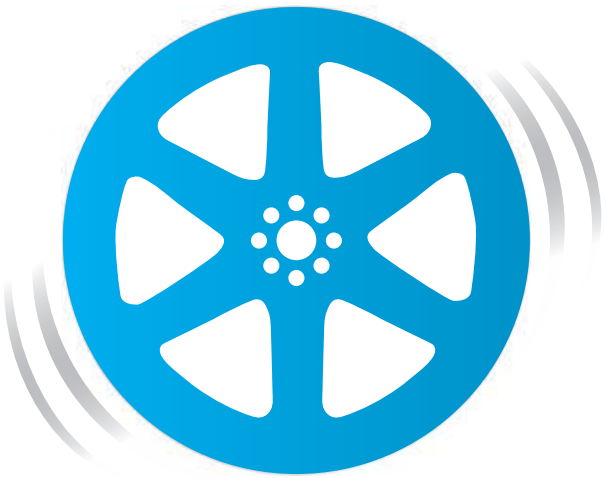
Improved Stability

Flow controls can become unstable because of the high torque required to affect minor adjustments to the rotational speed of the load. Controlling and limiting the torque makes for a more stable system.

Reduced Oscillation

Because of the flywheel effect, systems with a large rotating mass naturally resist changes to rotational speed. Unwanted pressure oscillations can lead to vibration and resonance that affects system performance.

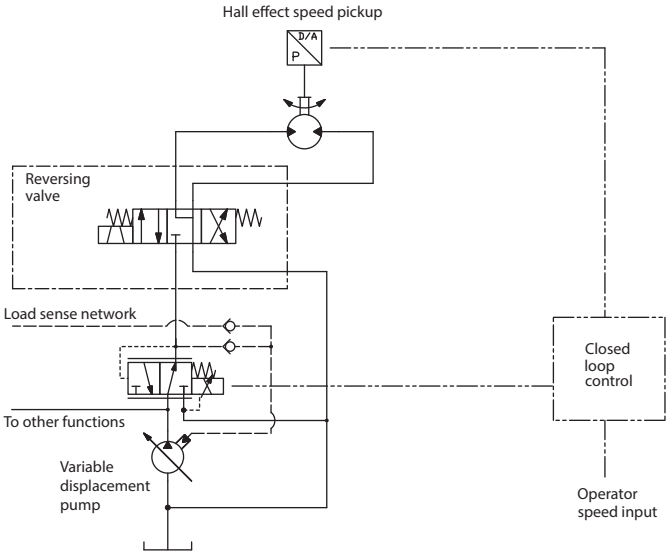




Improved Stability

eliminate surging and loping

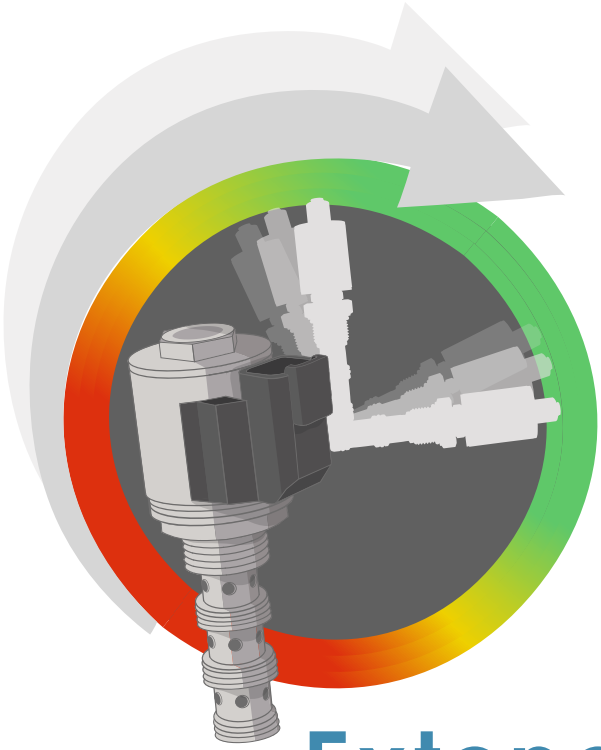
Load-sensing Variable Pump



Suitable for variable displacement load sensing pumps, this circuit uses a proportional pressure reducing/relieving valve to control pressure in the drive circuit. This valve increases pressure with increasing current. When flow isn't required for the rotary function, downstream pressure is reduced to about 7 bar/100 psi. The pump senses the load in the entire system to determine flow demand. The motor-center directional valve allows the motor to float in neutral. Applications requiring positive stop position can use a cylinder spool or can be coupled with a number of different load-holding solutions, including pilot-to-open checks, counterbalance valves, or poppet-style valves. A hall-effect speed pickup provides feedback to a closed-loop PID control.

Longer Component Life

Reducing pressure oscillations and controlling torque can lead to more balanced loading of system components and can extend service life.



Easy Set Up and Tuning

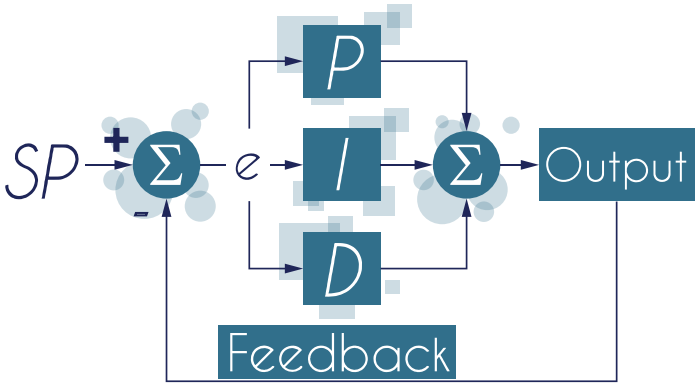
Because the constant torque control is an electrohydraulic control, setup and tuning of control response are achieved through software. Electronic PID control with closed-loop feedback sums all the factors affecting performance, such as operating load, component friction, and hydraulic efficiency and makes adjustments on-the-fly to achieve superior control.

Extend Component Life

smooth stable operation

Closing the Loop

The electrohydraulic approach is key to the success of the constant torque control. Adding a HydraForce ECDR allows speed feedback so the control can respond to varying loads on the system. You don't need to be a software engineer to set up the ECDR. A fully featured PID control loop, as well as any needed logic and computation features, are accessible in easy-to-use function blocks that let you adapt your control to work perfectly under all operating conditions. The I/O of the ECDR is completely flexible with inputs configurable for voltage, current, resistance, frequency, and digital signal types. The frequency input is perfect for Hall-effect speed pickups, and ECDR is CAN capable so any input or output can be read or transmitted on the control network. There is even a little I/O to spare if needed for another function.



Closed Loop
accuracy

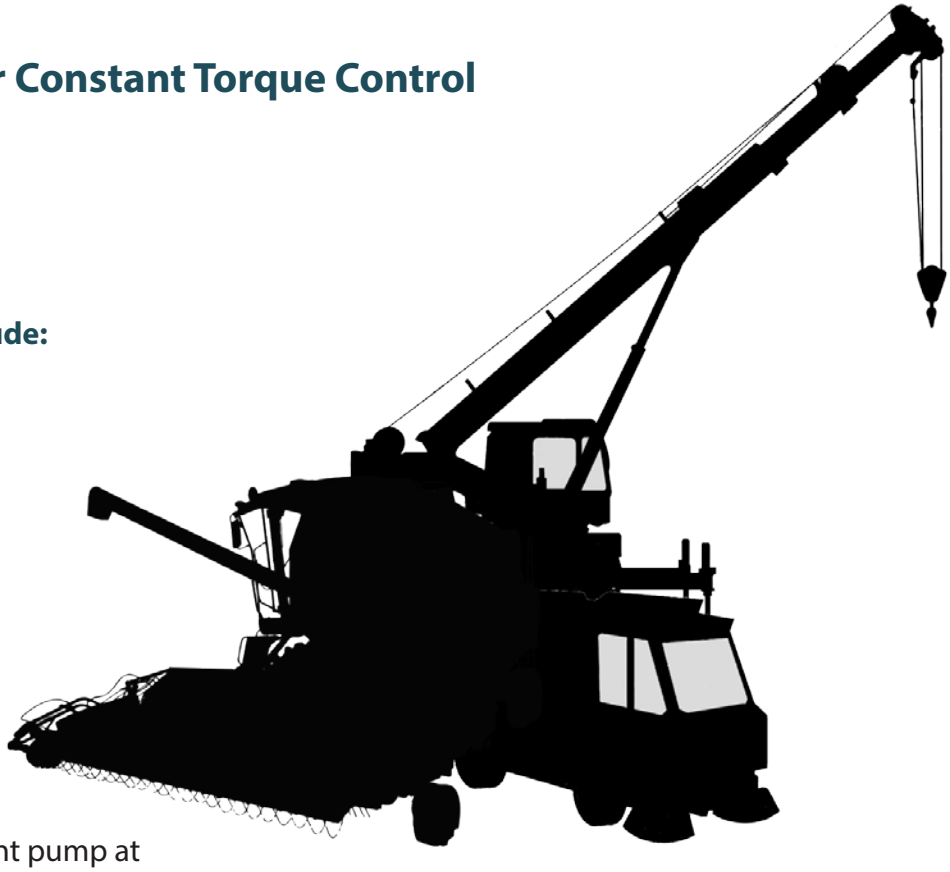
Good Candidates for Constant Torque Control

Typically have:

- Large rotating mass
- Relatively constant load
- Low frequency instability

Potential applications include:

- Reel drives
- Brooms
- Mowers
- Grinders
- Conveyors
- Fan drives
- Centrifugal pumps
- Boom swing



Other Benefits

- Unload fixed displacement pump at very low pressure
- Compatible with load sensing networks
- Reduced oscillation
- Reduced wear on mechanical components

Application Considerations

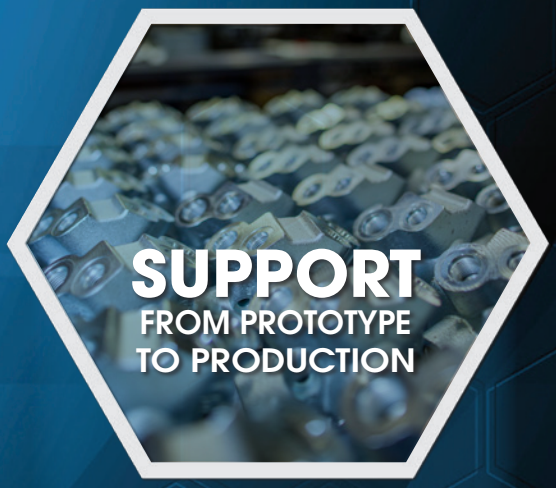
- The constant torque control performs best in applications with fairly steady load dynamics.
- Rotating devices with a high mass moment of inertia are ideal.
- As the control modulates the working pressure to balance torque, speed can vary slightly. Suitable applications will not be sensitive to small variations.
- As shown in the previous circuits, the load is allowed to freewheel or float in neutral. If load holding is necessary, you can add PO checks, counterbalance valves, or poppet-type valves. The motor center directional valve will not trap pressure that can interfere of the operation of motion control devices.

Your Custom Solution

In hydraulics there is always another way to achieve the desired result. Flexibility is one of the biggest advantages to using cartridge valve technology. While each system is unique, HydraForce has an arsenal of available technologies to apply and improve performance. The constant torque control is one of those forward leaps that comes from approaching challenges creatively. At HydraForce it's what we're known for, and what our customers have come to expect.

WHY CONSIDER HYDRAFORCE?

- World's largest privately owned cartridge valve manufacturer focused on EH system controls
- Broadest range of cartridge valves
- Designed EH systems for mobile equipment in every industry



- Free design support
- Simulation software
- Fast prototypes

- Integrate sensors, fittings, ancillary valves, and other custom components into a single manifold
- Simplified circuit design
- Consolidated or distributed hydraulic systems

- All manifolds are end-of-line function tested
- Use of Lean and Six Sigma practices
- Five year warranty on valves and manifolds

RoHS COMPLIANT HydraForce valve and manifold products comply with the European Council and Parliament RoHS directive 2002/95/EC limiting the use of hazardous substances. For all other products, consult factory.