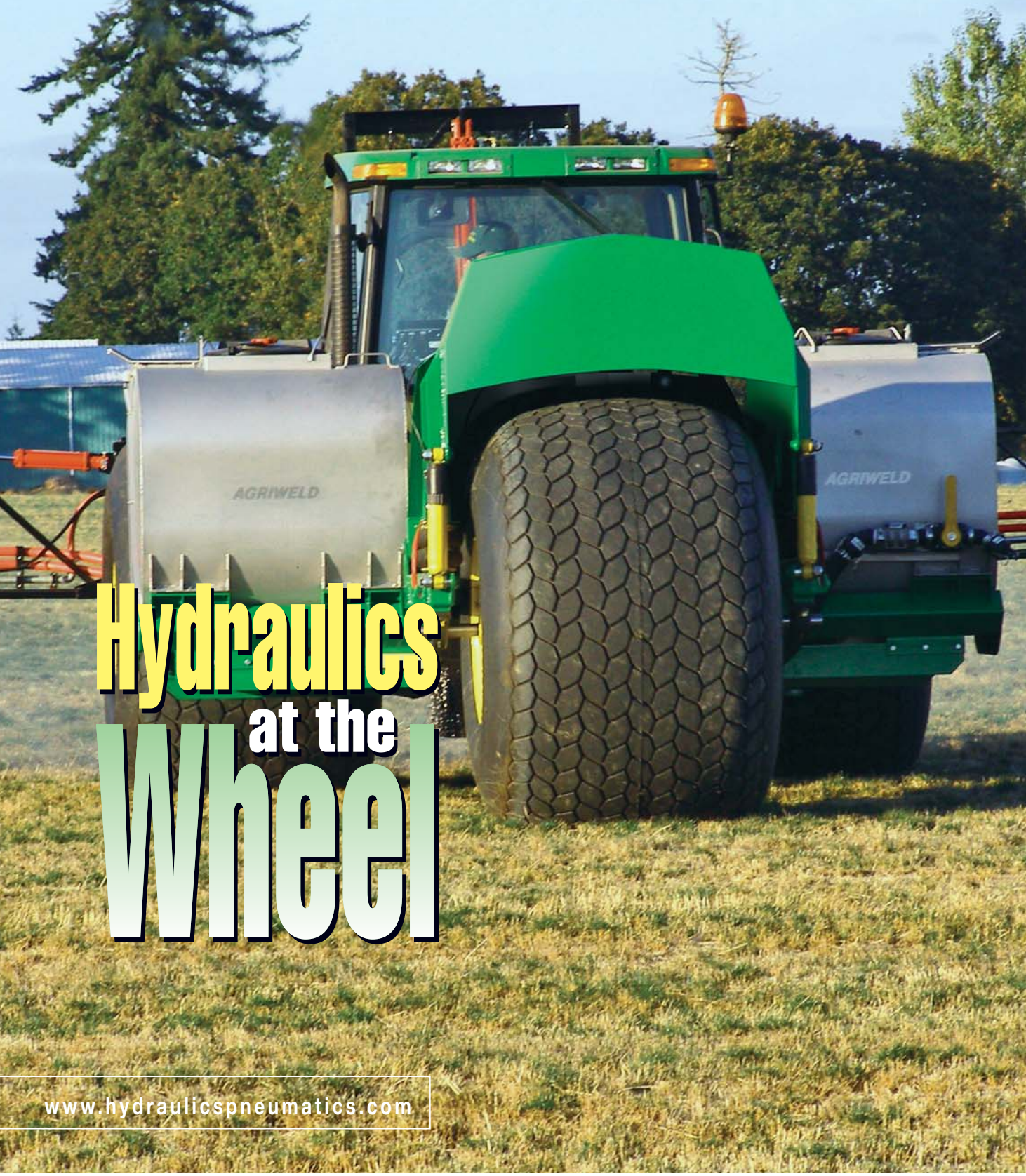


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Hydraulics at the Wheel

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Sprayer steers clear of the ordinary

Retrofitting a two-wheel-drive tractor chassis into a three-wheel agricultural sprayer incorporates innovative steering technology using a rotary actuator.

Custom built three- and four-wheel agricultural sprayer machines were the norm until Agriweld, Monmouth, Oreg., retrofitted a tractor chassis and applied unconventional technologies to create a three-wheel flotation spraying applicator. Custom-built commercial applicators in the market are much bigger and heavier, cost 20% to 50% more than the retrofitted solution, and aren't as versatile because they are designed for only one function.

"We've built both custom and retrofitted versions of the commercial applicator sprayer. Custom-built machines take a lot more time and expertise to manufacture, plus you have the up-front expense of purchasing all the components needed to build a machine from scratch. The custom machines on the market today don't come

Cut-away view of Agriweld sprayer shows placement of Helac rotary actuator that provides simple and efficient steering.



with the benefits and features available with today's tractor technologies," explains Craig Pope, president of Agriweld.

The custom-built three- and four-wheeled sprayers that had saturated the agricultural market were heavy, expensive, and couldn't easily be used for other farm applications. Sprayers are used for applying herbicides, insecticides, and fertilizer. Naturally, then, a machine that could be used for other functions — such as tilling, load-

ing, and baling — would be more practical than a custom-built machine dedicated to a single function.

Agriweld Inc., an agriculture equipment manufacturer offering more than 30 proprietary products in North America, acted on this opportunity by introducing an agricultural sprayer that exerts lower ground pressure and is smaller, lighter, and more affordable than custom-built alternatives. Agriweld designed a three-wheeled commercial applicator by retrofit-

ting a mid-range (50 to 120 hp), two-wheel-drive tractor chassis with three major innovations:

- hydraulic wheel steering,
- a suspension fork, and
- flotation tires.

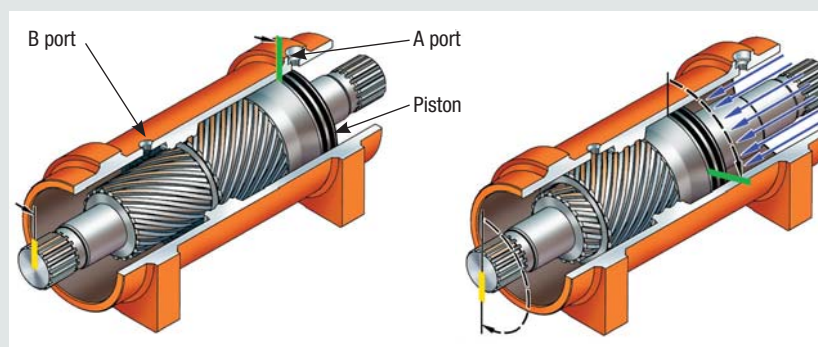
A break from convention

Tractors of this size generally have hydraulically assisted steering using a hydraulic cylinder and mechanical linkage assembly. The front wheel steering cylinder Agriweld uses is not a cylinder at all,

Actuator operation

The actuator used in Agriweld's sprayer retrofit is composed of three basic parts: a housing, a central through shaft, and an annular piston. Helical gear teeth on the shaft mesh with matching teeth on the inner circumference of the piston; a second set of helical teeth of opposite hand on the outer circumference of the piston engage the housing's integral ring gear. (See illustration for explanation of operation). The double helix gear design works to compound shaft rotation: The rotation of the shaft is almost twice that of the piston. The result is a slender, compact, symmetrical design that generates high torque, is highly tolerant of shock loads, and has none of the housing protrusions found in alternative designs.

Characteristics of the helical rotary actuator make it ideal for applications requiring high torque within a small envelope, attributable, primarily, to its sliding-spline operation. Because all spline teeth remain engaged at all times, loads are equally distributed over the teeth. This results in high tolerance to the



Cutaway on left shows initial positions of piston (green line) and output shaft. (yellow line). Pressurized fluid entering the inlet port pushes on the piston; a stationary ring gear causes the piston to rotate clockwise. At right, teeth on the output shaft mesh with those on in the ID of the piston, causing the shaft to rotate clockwise relative to the piston. Pressuring the B port returns the piston and shaft to their in initial positions.

shock loads. Backlash is minimal — approximately 1°. Furthermore, integral bearing design enables the actuator to support heavy radial, moment, and thrust loads without the need for additional, external bearings. The integral bearing design also produces a clean, compact assembly for a wide variety of applications, including construction and mining equipment, refuse cart dumpers — anywhere compact size, high torque, and wide angle of rotation are needed.

Aside from the inherent compact size of the actuator, the integral bearings and large drilled-and-tapped mounting holes make it easy to design the actuator into a structure and simplify installation. According to Helac, this design is the most compact of any rotary actuator available when it comes to output torque and angle of rotation available.

but a helical hydraulic rotary actuator manufactured by Helac Corp., Enumclaw, Wash. Helac's L30-65E-FT-180 rotary actuator produces a steering angle of 100° and contains bearings to support the load.

The rotary actuator is actually part of the steering structure, providing the strength and flexibility the vehicle requires without unnecessary weight, complexity, and maintenance required of mechanical linkages. It supports a thrust load of 6000 lb and accommodates 340,000 lb-in. of bending moment capacity. It can transmit 55,000 lb-in. of steering torque when fully loaded. The actuator's design makes it capable of more than 100° rotation, but an internal piston stop limits its rotation for this application.

The tractor's original-equipment hydraulic power unit supplies pressurized fluid for steering and other hydraulic functions. Maximum system pressure is 2950 psig with 8 gpm of flow, but the steering function generally operates at pressures of 1500 to 2000 psig.

The only modification needed to the tractor's original hydraulic system is a higher displacement steering unit. This is because the rotary actuator requires more fluid to move the wheel through its entire range of motion than a cylinder does. The plumbing of the steering control unit is routed directly to the actuator, eliminating sections of hose and fittings otherwise required by the cylinder.

Height and orientation of the sprayer boom is also controlled with hydraulics. A 5-spool solenoid valve routes hydraulic fluid to and from cylinders that raise, lower, rotate, and pivot the sprayer boom. Furthermore, an open-center motor, controlled by an electronic flow-control valve, supplies the driving torque to apply the fertil-

izer or other substance to crops.

The retrofit package also includes a suspension style swing arm fork with twin air springs capable of supporting loads to 8000 lb above the front tire. The air springs' pressure is adjustable for different loads for smooth riding in the roughest of field conditions. Agriweld supplies an electric air compressor to generate the pneumatic power for raising pressure in the air springs.

The fork's open front allows easy access for changing or repairing the front tire. The fork is 50 in. wide, allowing use of huge, 44.00-in. tires for maximum flotation and the potential for ground pressure as low as 4 psig.

An integrated solution

The actuator used for steering and load support is Helac's L30-65E-180/100. This actuator not only provides a simpler, less expensive structure than alternative designs, but also can generate the high torque needed to steer such a large wheel assembly under full load.

Agriweld used steering cylinders, bearings, and multiple joints before designing in Helac's sliding spline actuator. With cylinders, all the external moving parts were exposed to the elements. The stress on the joints was high because each steering cylinder had a clevis pin at each end. Stress concentrated on each pin created high wear points, which increased maintenance. Worn pins also allowed side loads to be transmitted to the piston rod. This accelerated wear on the rod and piston bearings and increased the occurrence of seal leakage.

Benefits provide an edge

According to Pope, three significant benefits Agriweld resulted from switching to Helac's rotary actuator.

1. The load bearing and steering capability was integrated into one package — Helac's actuator allowed Agriweld to replace multiple external components and operate as a complete steering and bearing system in a single rugged component.

2. Low maintenance and zero leakage — bearings, seals, and torque-generating splines are completely sealed and lubricated by the hydraulic fluid inside the actuator housing, resulting in low maintenance and zero leakage.

3. Compact design and simple installation — Agriweld simply uses bolts to mount the feet of the actuator directly to the modified tractor frame. The tractor's steering yoke attaches directly to the top and bottom threaded bolt circles of the actuator's load-bearing shaft.

Pope explains, "The actuator offers a compact package that provides all the support for the load as well as the hydraulic turning needs without adding unnecessary weight. Seal leakage is eliminated, and there are fewer maintenance issues since all moving parts are safely enclosed in a cylindrical envelope."

"Helac's rotary actuator technology has given us a competitive advantage and has added credibility to our machine with the level of engineering behind the design. Customers are amazed at what we're doing with the [small package.] It really sets us apart when we show it," states Pope.

To learn more about Helac rotary actuators, contact Leslie Morgan at (360) 825-1601, or e-mail lmorgan@helac.com. For more information on Agriweld, visit its website at www.agriweld.com.