

# Drive & Control profile

## Rexroth Hydraulics Help Power Unique 2WD Bike



The front wheel of the unique two-wheel drive Yamaha racing bike is powered by Bosch Rexroth hydraulic pumps and drives.

Rexroth hydraulic components are at the heart of this revolutionary two-wheel drive system featured on the world's first production motorcycle of its kind—the Yamaha WR450F 2-TRAC. The 2WD system developed by Öhlins Racing AB of Sweden, part of the Yamaha group, incorporates a Rexroth A2FO5 piston pump

and matching A2FM5 fixed displacement motor, supplied via Rexroth Sweden. Regarded as a major technological breakthrough for the motorcycle industry, the reliable, compact and relatively inexpensive 2WD system can be installed on virtually any bike without any significant modification to the frame or front

### Challenge

Provide components to help create unique two-wheel drive motorcycle

### Bosch Rexroth Solution

- Industrial Hydraulics
- A2FO5 axial piston pump
- A2FM5 motor

### Benefits

- Reliable, compact and relatively inexpensive 2WD system
- Hydraulic pump driven by bike's gear output shaft drives front-wheel hydraulic motor
- Axial piston pump far more efficient motor than external gear units
- Well-suited to application's high speeds, up to 12,500 rpm, and maximum operating pressure of 320 bar

forks, offering traction, stability and performance benefits both on- and off-road.

A Rexroth hydraulic pump driven from the machine's gear output shaft delivers hydraulic pressure to a compact motor built into the bike's front wheel hub. Automatic in operation and requiring no rider actuation or adjustment, it applies power to the front wheel when the rear wheel starts to slip, increasing and decreasing the amount of traction delivered in accordance with the amount of spin at the rear.

Rexroth was the only manufacturer able to meet Öhlins' technical requirements in a standard product, although modifications were subsequently made to reduce weight and tune efficiency to this high-speed application. The 2WD system, which is delivered sealed and ready assembled, has already been fitted to over 300 production bikes by Yamaha Italy and a similar number is anticipated in 2005. Interest has also been shown in the Yamaha-patented innovation by other motorcycle manufacturers and it is hoped the system will have the same impact as 4WD rally cars.

Development of the 2WD system for motorcycles was carried out at the purpose-built Öhlins Research center in Upplands Väsby, under the direction of Lars Jansson, R&D Manager for Future Projects. Unlike a car, where it is easy and efficient to fit a mechanical drive from the side of the wheel hub, a motorcycle is essentially two-dimensional and requires complicated mechanical transmission to drive the front wheel, resulting in overly complex

front suspension members and frame elements, together with unorthodox styling. In contrast, hydraulic transmission retains the standard bike layout and allows the use of proven components.

Öhlins Research identified the technical characteristics required of a hydraulic transmission system and found that the Rexroth axial piston units were a perfect match.

"The Rexroth A2F axial piston unit is one of the most efficient pumps on the market," says Lars Jansson. "The axial piston configuration is far more efficient than external gear units. It is also more suited to this application's high speeds, up to 12,500 rpm, and maximum operating pressure of 320 bar."

The first prototype was built in 1993, initially using machined aluminum housings for the axial piston units. Rexroth cast the aluminum casings specifically to reduce weight from a standard 5.5 lb to a lightweight 3.1 lb. It also incorporates a pressure valve into the pump to safeguard it against the enormous hydraulic pressure generated when the rear wheel loses all grip. Minor modifications were made to the piston and bearings to improve internal efficiency. The Rexroth A2F pump/motor units offer the compact dimensions, proven functionality, prolonged service life and favorable power/weight ratio of the standard components.

Fitting very neatly ahead of the rear suspension, below the carburetor and above the bike's gearbox, the hydraulic pump is chain-driven

by the gear output shaft so the speed of its rotation is directly proportional to that of the back wheel. The corresponding hydraulic motor is mounted in the machine's front hub and powers the front wheel by means of a reduction gear unit, produced by Öhlins. The pump and motor are linked mainly by a reinforced flexible hydraulic hose with steel tubes used for concealed sections. Normal engine oil is used to cope with high temperatures and the entire system is delivered pre-assembled, complete with hydraulic fluid and pressure tested, ready for fitting.

The pump and motor are tuned to rotate at the same rate, creating a system that is simple and self-regulating. When the bike transfers more power to the ground under acceleration, the back wheel rotates more quickly than the front, due to deformation of the rear tire; this slight difference in rotation speed causes the pump to supply more pressure, therefore transferring traction to the front wheel, through the geared hydraulic motor. The more the back wheel spins, such as on wet and slippery surfaces or when negotiating curves, the greater the power transferred to the front wheel. The pump's pressure relief valve also prevents dangerously high pressure in the system, should excessive rear wheel spin occur.

The front wheel actually transmits relatively little power, typically around 5%, but by utilizing some of the drive wasted by rear wheel spin, the hydrostatic system improves overall transmission efficiency. This results in better

traction, especially in sand, mud and snow, improved corner exit speed and handling, and greater stability at high speed and during wheelies. On the road, it delivers better traction, improved predictability around corners and better straight-line acceleration out of bends.

“The bigger and heavier the bike and the more inexperienced the rider, the more you benefit from 2WD,” says Lars. “An experienced rider will think he’s down on power, because he cannot spin the rear wheel as normal or do power slides, but timed on a race course he’ll be much quicker than before.”

In fact, the top speed of a Yamaha WR450F 2-TRAC on a sandy track is around 10% higher than its conventional counterpart, thanks to

improved traction. Öhlins Research also tested a powerful road bike and found that lap times in wet conditions were 5 seconds faster over a 1m 20 sec circuit.

“The Rexroth components are perfect for this application and thoroughly reliable,” concluded Lars. “We’ve enjoyed tremendous support from the company over the complete development project. At the moment, 2WD is a limited volume market, although if customer attitudes change and competition regulations are modified to accept it, the system would have a major impact on off-road events and road racing, even MotoGPs where they really have to handle too much power, as well as everyday motorcycling. Essentially, there are no drawbacks.”

**Rexroth**  
Bosch Group