FORKS...

OPEN-CHAMBER VS CLOSED-CHAMBER

We explain the key differences between the two main fork designs used in modern-day dirt bikes, and how each affects performance, tuning and maintenance costs.

NICK DOLE iKAPTURE IMAGES

There's a lot of talk these days about open- and closed-chamber forks, but what's the real difference between the two? Is one better and, if so, where? Should we all be scrambling to fit a closed-chamber fork, or does an open-chamber still have advantages?

For 20 years, conventional wisdom has said that open-chamber forks worked better in the bush, while closed-chamber forks were built for the demands of motocross and supercross. But if that's the case, why have so many production enduro bikes recently been fitted with a closed-chamber fork? Off-road models from Husaberg and TM have sported a closed-chamber fork for a few years, while the 2012 Gas Gas range and Yamaha's flagship new WR450F have both appeared with them for the first time.

Given this growing trend toward closed-chamber forks (also known as "closed-cartridge" or "twin-cartridge" forks), we asked suspension specialist, Teknik Motorsports' Nick Dole, to offer an insight into each fork's design elements, and their impact on performance, tuning options, durability and maintenance costs...

FORK EVOLUTION

We all know that forks contain springs and oil and a few other bits. Up until the mid-1980s, dirt bikes used fairly rudimentary damper-rod forks. But for more than 20 years since, a majority of dirt bikes have used an open-chamber cartridge fork. In 1996, a new closed-chamber fork was released by Showa on the Suzuki RM250, and Honda followed suit on their 1997 CR250 with a 47mm twin-chamber Showa.

So how do we define the difference between the two major designs used in modern-day dirt bikes? For the sake of simplicity, we'll use the term "open-chamber" when referring to a fork that runs one common oil and "closed-chamber" for a fork that uses two separate oils – one in the inner cartridge and another in the outer chamber.

OPEN-CHAMBER FORKS

This same basic design has been with us since the mid-1980s. A tube (cartridge) is sealed at both ends and when the fork compresses, a rod is plunged in the oil-filled tube, displacing oil. A valve assembly at the base of the cartridge meters the oil coming out of the cartridge when the fork is compressing. When the fork returns, or rebounds, the piston assembly attached to the end of the shaft (which has a similar arrangement of shims) produces a rebound damping force. The fork also contains a hydraulic bottoming device and, like all forks, uses oil capacity to manipulate the air spring, which affects the final one-third of the compression stroke (read up on Boyles Law for more detail).

As the oil is under no pressure (and little consideration was given to cavitation in the design and settings), it can become heavily aerated under hard use – and the inside of the fork resembles a milkshake! As the oil breaks down, a few things occur. First, this 'cavitation' affects the dampening character by weakening it significantly. Second, the fork loses its responsiveness as 'hysteresis' (the delay between an compression movement and a rebound movement) increases. And finally, the oil also loses its 'lubricity' (its capacity to lubricate) as the oil molecules are torn apart by the cavitation process.

PERFORMANCE

This design has been around for 30 years and won a lot of championships, so there is nothing wrong with an open-chamber cartridge fork. Earlier designs, however, lacked an understanding of the relationship between the base valve and the mid valve, causing them to feel harsh over roots and rocks and dive excessively under brakes. WP only started to produce well specificationed open-chamber forks after 2007. Yamaha's poppet valve Kayaba fork (used on the WR-F) was famous for its deteriorating performance after not so many hours. Suzuki's DR-Z400 and other trailbikes are still in the early-'90s in terms of their fork design.

MAINTENANCE

Every fork has seals and bushes and they all wear out after extended use. But the open-chamber fork is certainly a lot easier for the home mechanic to maintain and service. Yes, you still need to keep an eye on the shims – especially the mid valve's shims for cupping against the face of the piston – and the top cartridge bush can wear, which releases dampening pressure. But, really, that's about it. Sure, shims wear, and a complete cartridge disassembly and inspection is suggested at every service. Do that and change the oil every 50 hours, and they'll be sweet. In general terms, they're a pretty robust design.

TUNING

There is a huge scope to adjust the action and feel of an open-chamber cartridge fork.
It's very easy to swap out the springs as it doesn't require you to remove the dampening cartridge first.
In general, it's easy to change preload settings, and the WP forks even have an external adjuster. No inner seals means no fear of damaging a lower cartridge seal during disassembly.
There are plenty of aftermarket vendors who offer piston and valve kits to alter the fork's dampening character. And remember, a well set-up pair of open-chamber forks will still out-perform a poorly set-up closed-chamber fork.

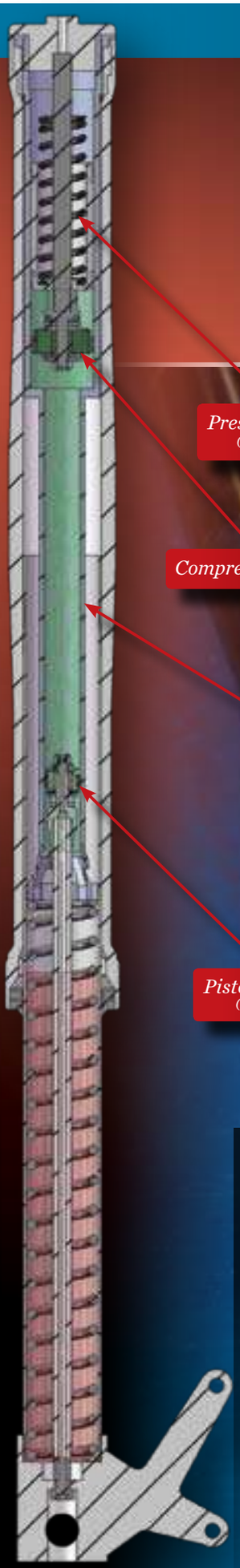
CLOSED-CHAMBER FORKS

The key difference with the design of a closed-chamber fork is that its cartridge is inverted, and a spring or bladder element is added to keep the oil under pressure. There is no air present in the inner chamber (or cartridge), but this alone does not eliminate cavitation.

Pressure springs are used in the Japanese-made forks, usually in the range of 1.6 to 2.2 kg/mm. WP forks, on the other hand, use a bladder system inflated to approximately 25psi to keep the oil under pressure. Marzocchi use a low-pressure bladder system, whereby the displacement of the compression piston assembly entering the cartridge inflates the bladder.

It's not an oversimplification to say the damper assembly is simply inverted from an open cartridge fork, and there are interchangeable parts between open- and closed-chamber forks. The outer tubes are often the same in both fork types; as are major service items, such as seals, bushes and springs.

As the oil in the inner chamber is separate to the outer's, different viscosities can be used, and the seals and bushes will benefit from using a heavier-grade oil. Varying the oil height still adjusts the air spring effect in the fork, but there is the added complexity because the spring is housed low in the fork leg. This creates a secondary dampening action when the upper spring seat is plunged into the oil. This occurs about halfway through the compression stroke.



PERFORMANCE

The sealed system creates both pros and cons. Oil under pressure alleviates the cavitation problems, so you get consistent performance, fast response times and low hysteresis. And riders all love the feeling of having no (or very little) un-damped section of the travel (or lag). But the fact that it's sealed also causes some problems. There has to be a seal at the bottom and top of the cartridge – which are both sources of friction. If either seal leaks, the fork's performance goes off very quickly. The pressurised system also causes an initial force that must be overcome before the fork starts moving. Pro riders won't feel it, but riders who like a very plush fork, will.

MAINTENANCE

There is a tendency for owners to disassemble the outer legs of a closed system only, and to leave the inner chamber alone altogether. Considering the inner chamber only holds about 180ml of oil, that's a false economy. The inner needs to be inspected for leaking seals, cracked free-pistons (which are common on Kayaba forks) and worn damper shafts. If a cartridge can't hold pressure, you need to find out which seal is leaking and replace it immediately. If the inner is leaking, you won't see any oil on the fork outer because it's an internal leak. But you will notice the forks just don't work how they ought to.

TUNING

As well as all the adjustment options of an open-chamber fork (springs, valving and piston kits), the cartridge spring pressure can also be altered in the Kayaba and Showa. Often the stock 1.9-2.1kg/mm springs will be swapped for softer 1.6-1.8 units if the fork is intended for off-road use and/or a lighter rider. The spring seats can also be changed to more restrictive types, giving a higher secondary dampening character for supercross; or very open, free-flowing versions for off-road use. One drawback is that you need to separate the fork legs and remove the cartridge just to change fork springs. It's not the five-minute job it is for an open-chamber fork.

WHO USES WHAT...

While Showa got the jump in 1996/'97 with their 47/49mm closed-chamber fork, it has been Kayaba who's set the bar for production fork performance in more recent years. Kayaba's first closed-chamber attempt in 2005 had problems, but the 2006 fork was so good, it's largely unchanged in 2012. Even Honda jumped on the Kayaba bandwagon in 2009 with the flagship of their motocross range: the much-revamped CRF450R.

In 2010, it looked like Showa almost gave up. Honda's CRF250R arrived with a 48mm Showa fork – with parts that were interchangeable with the Kayaba's! All other 47mm Showa closed-chamber forks date back to the last major redesign in 2003. That said, it's a good design and has created very few problems.

For 2012, after six years using a fork that was the weakest component of an otherwise excellent bike, Yamaha's WR450F finally gave in and fitted an enduro-spec version of the Kayaba closed-cartridge fork their motocross range already ran.

The Marzocchi closed-chamber fork has been used on Husky, TM, and Gas Gas. It has moved over for the Kayaba fork on the Husqvarnas in 2012, but Gas Gas is sporting a new 48mm closed-chamber Marzocchi fork that looks like it's a Kayaba-inspired design. As 'inspired' as the CRF250R's Showa fork? Maybe.

As the closed-chamber fork is more expensive to produce, manufacturers are less inclined to fit it to every model. Showa addressed this with their SFF (Separate Function Fork), which runs damping in one leg and a spring in the other. While we all jeered at it in 2010, the SFF has proven its worth in competition and will surely be more widely used in future years, and the addition of an external spring preload adjuster on it is very helpful.

So why does KTM persevere with the open-chamber WP fork for its entire off-road range? Because the open-chamber fork still offers advantages for off-road riding. It's lighter; it has spring preload adjustment; it has fewer seals and less sliding friction; it's easier for the owner to service; and it allows faster spring changes. If only we could have a pressurised fork with the open-chamber's ease of maintenance. Too late; Ohlins did it in 2005 with a semi-pressurised system that used a floating seat on the cartridge. It works well, it's cheap to make and adapts to existing designs. There must be a patent lurking around there somewhere!


Kayaba has moved from a 46mm and 48mm open-chamber fork, to a closed-chamber 48mm specimen.


The old open-chamber 41mm Showa fork on your XR400 has evolved into 47mm closed-chamber units.


WP's 43 and 48mm open-chamber forks remain, while the 48mm closed-chamber fork is fitted to MX models.

CLOSED-CHAMBER FORKS APPEAR WHERE?

- **Kayaba 48mm** – used on Yamaha's YZ and YZ-F from 2005; Kawasaki's KX450F from 2006; Honda's CRF450R from 2009; Husky TCs from 2010; and Yamaha's WR450F from 2012.
- **Showa 47mm** – used on Honda's CRs since 1997 and all CRFs; Suzuki's RM-Zs from 2007; and Kawasaki's KX250F from 2006.
- **WP 48mm** – used on all KTM SX and SX-F models since 2007; Husaberg TC models from 2010, and TE models from 2011.
- **Marzocchi 48 or 50mm** – used on Husqvarna's TC and CR range from 2006 and 2009; Fantic's TZ range from 2012; Gas Gas EC range from 2012; and TM's entire off-road range from 2007.

In short, if your compression adjuster is on the top of your fork, it's a closed-chamber fork.