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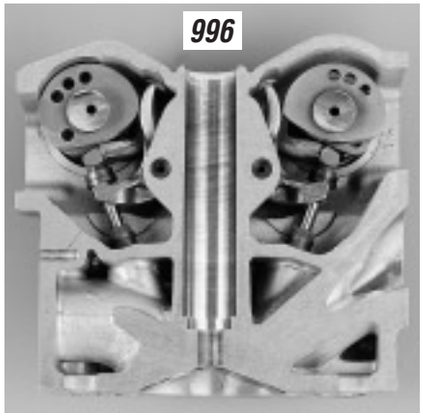
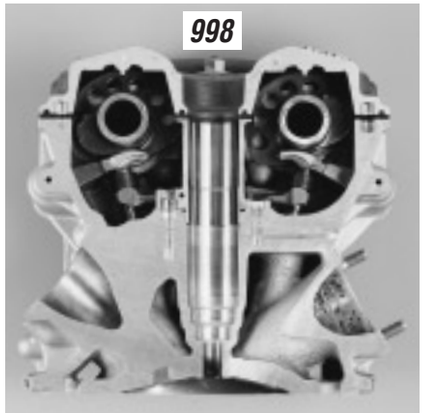
Ducati 998 Testastretta Engine





When Colin Edwards' Honda RC51 overpowered the Ducati opposition to win the World Superbike crown in 2000, it was obvious that the 996 Ducati motor was past its prime. Efforts to squeeze more power from the engine had begun to compromise its legendary ridability, as well as its reliability. Something had to be done, and soon. But, what would it take to win? Rumors that the Desmodromic valve operating system would be replaced by pneumatic, F1-style air springs were bandied about, but Ducati's legend was founded on the desmo design, and abandoning the system would be like throwing the baby out with the proverbial bathwater.

The problem was that the 996's desmo arrangement took up too much space between the valve stems, forcing a wide, 40° included valve angle—well behind the state of the art. An engineer who had recently retired from Ferrari's Formula One team was assigned the job of bringing the Desmo into the 21st century. His breakthrough was in shifting the pivots for the opening rockers to the outside edge of the head, and mounting the pivots for the closing rockers to a steel tube that also doubled as the upper shell of the spark plug pipe. The result is a compact cylinder head with a very contemporary 25° included angle; the intake valve at 12°, the exhaust at 13°, hence the name "Testastretta" or "compact head." The 998's flatter, less triangular combustion chamber produces a faster, more powerful burn, and also prevents as much short-circuiting of the intake charge out the exhaust port during valve overlap. A tiny 10mm (vs. 12mm) spark plug now lights the fire.

A cascade of other benefits were obtained from the new arrangement, too, all of which increased breathing and combustion efficiency. Because the new intake ports were only tilted 35° off the cylinder centerline (they had been 43°), there was less bend slowing the flow to the valve seats. This also dramatically improved the mixture swirl.

Ducati's chief development engineer, Gennaro Cugnetto, on hand for the American debut of the 998, explained that the 996 produced desirable swirl only near the cylinder head, while the straighter 998 ports create swirl deep into the cylinder. This is significant because charge swirl that can be maintained during compression greatly speeds flame travel during combustion, maximizing pressure on the pistons, and thus horsepower.

Also, the 998's more oversquare 100 x 63.5mm bore and stroke (the 996 is 98mm x 66mm) allows a higher redline and larger valves. The intakes valves are bumped to 40mm from 36mm, and the exhausts enlarged to 33mm from 30mm. The ports are likewise larger; 33mm vs. 29mm on the intake side and 29mm vs. 27.5mm on the exhaust.

In addition to the revised desmo mechanism, the new head uses pressure-fed plain bearings instead of rollers to support its camshafts. More compact, this also saves weight and, overall, the 998 Testastretta motor is 4.4 lbs. lighter than the 996.

In the interests of reliability, the 998's cams have been given less aggressive openings and closing ramps but, in exchange, actually lift a bit higher. A reduced overlap period on the new profiles also improves fuel economy while reducing emissions. To turn the new cams with greater reliability, the cam belts and idler sprocket sizes and locations have been changed. New, wider belts, 21mm vs. 17mm, with more teeth per inch are fitted to new *adjustable* 20-tooth cam sprockets (vs. 18 before). The idler pulleys are also larger, 48mm diameter vs. 39.5mm, to create less pressure angle on the belts and are placed closer to the centers of the long runs, for less slap. The result is more precise valve timing.

The water pump is also new. A larger 60mm impeller (vs. 54mm) made of superior material provides 15% more flow.

The fuel injection arrangement reveals another major change. The throttle bodies are larger on the 998, 54mm vs. the 996's 50mm throats. And, where the 996 used two injectors per cylinder, place beneath the throttle butterfly, the 998 uses a single "showerhead"-style injector standing above the air horn, like last year's Ducati Corsa racebikes. The showerhead injector sprays in a tight 15° pattern straight down into the port, where the angle-mounted twin-injectors of the 996 used a 30° pattern to avoid squirting so much fuel directly onto the port walls, where it caused fuel sheeting. This was a problem because raw fuel running off the port walls is unlikely to achieve full combustion, but fuel that remains atomized will burn rapidly. Additionally, a larger airbox is fitted and lighter throttle position sensors and ultrasonically welded plastic vs. aluminum air horns on the new injection system save precious weight.

Also, a more powerful CPU, part of the 998's upgraded Marelli 5.9 EFI has more than twice the mapping points of the 996's Marelli 1.6 system. Despite its extra power, it's much smaller, just one-quarter the size and faster, with a 20Mhz clock speed vs. the older system's 16Mhz.

To work at the higher rpm range expected from the new engine, the pistons are lighter and the ring package is extensively revised. Computer simulations indicated the extent of the piston rocking in the bore, which caused continual ring "flutter" that interferes with sealing. To deal with that, the 998's top ring is now steel rather than cast iron and just 1mm thick (1.5mm before). In addition, it has been given a angled profile, as if it came from the rim of a cone shape and it's edge is barrel faced. Under the pressure of compression/combustion, the ring flattens out, but returns to its cocked position when the exhaust valve opens—a subtle improvement that's said to be current Formula One practice at Ferrari. The second ring is also thinner than before, again just 1mm vs. 1.2mm.

The factory says the 998 is 11 hp stronger than the 996, producing 123 hp at 9750 rpm. To handle the extra power, the crank's output shaft now rides in twin ball bearings, instead of the single unit used before.

Benefitting from the factory team's R&D, the production 998 combustion chambers and crankcases are now high-accuracy die-castings instead of machined sand-casting.

An even more highly tuned 139-hp 998R will be available for track-use only. The *998R* will have a 104mm bore, and an even shorter 58.8mm stroke to displace 999cc. Carbon fiber and magnesium will reduce the weight, Brembos innovative new four-piston, four-pad brakes will be fitted up front to handle the deceleration duties and Ohlins will again provide the complete suspension.

—Dave Searle