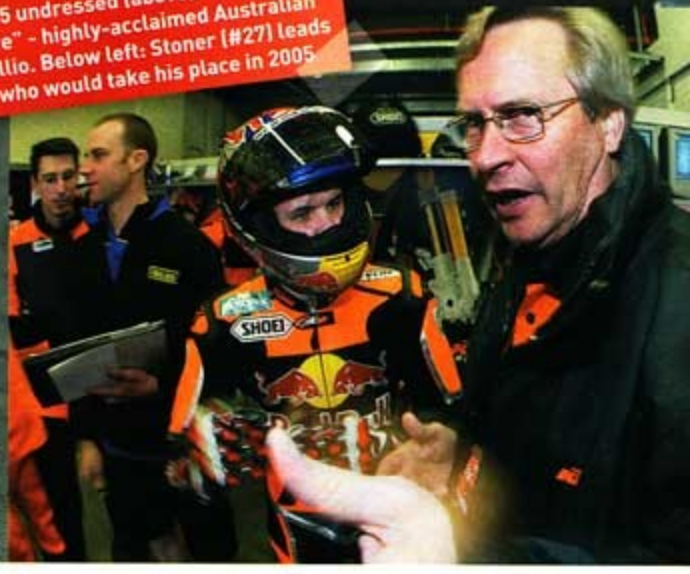


Gotcha! A rare shot of the KTM 125 undressed (above). Below right: "Get that camera out of here" - highly-acclaimed Australian engineer Warren Willing with Kallio. Below left: Stoner (#27) leads Talmacsi (#14) in 2004, the man who would take his place in 2005

KTM's little 125 grand prix racer, ridden last season by Aussie wonder kid Casey Stoner and this year by Hungarian Gabor Talmacsi and Finn Mika Kallio, has proven to be a technological marvel. In a GP125 world where development now takes place in very small fractions of horsepower, the KTM has proven itself again and again at the top of the field.

Famed engineer Harald Bartol is in charge of the KTM two-stroke program, and the current version of the bike – now in its third year – has several details differentiating it from its competition.

"It's not easy anymore – it takes three years to get competitive," says Bartol. "In the beginning with the KTM I didn't want to make another Derbi engine *(Ed: which Bartol also designed)*. First time I ran it on the bench I was very disappointed – it took nearly half a season to get things as I wanted."

The major new technology being used is supplementary fuel injection. Rather than switch across to full fuel injection, as Honda did back in 1993 with its PGM-FI NSR500 experiments, Bartol has identified areas where an automatic fuel-injection program could provide fuel and oil mixture in such a way as to complement the standard carburettor.

One of the main problems for racing two-strokes is the need to keep supplying the fuel and oil mixture when the throttle is closed, to keep everything inside the engine lubricated and cool.

PRAGMATIC SOLUTION

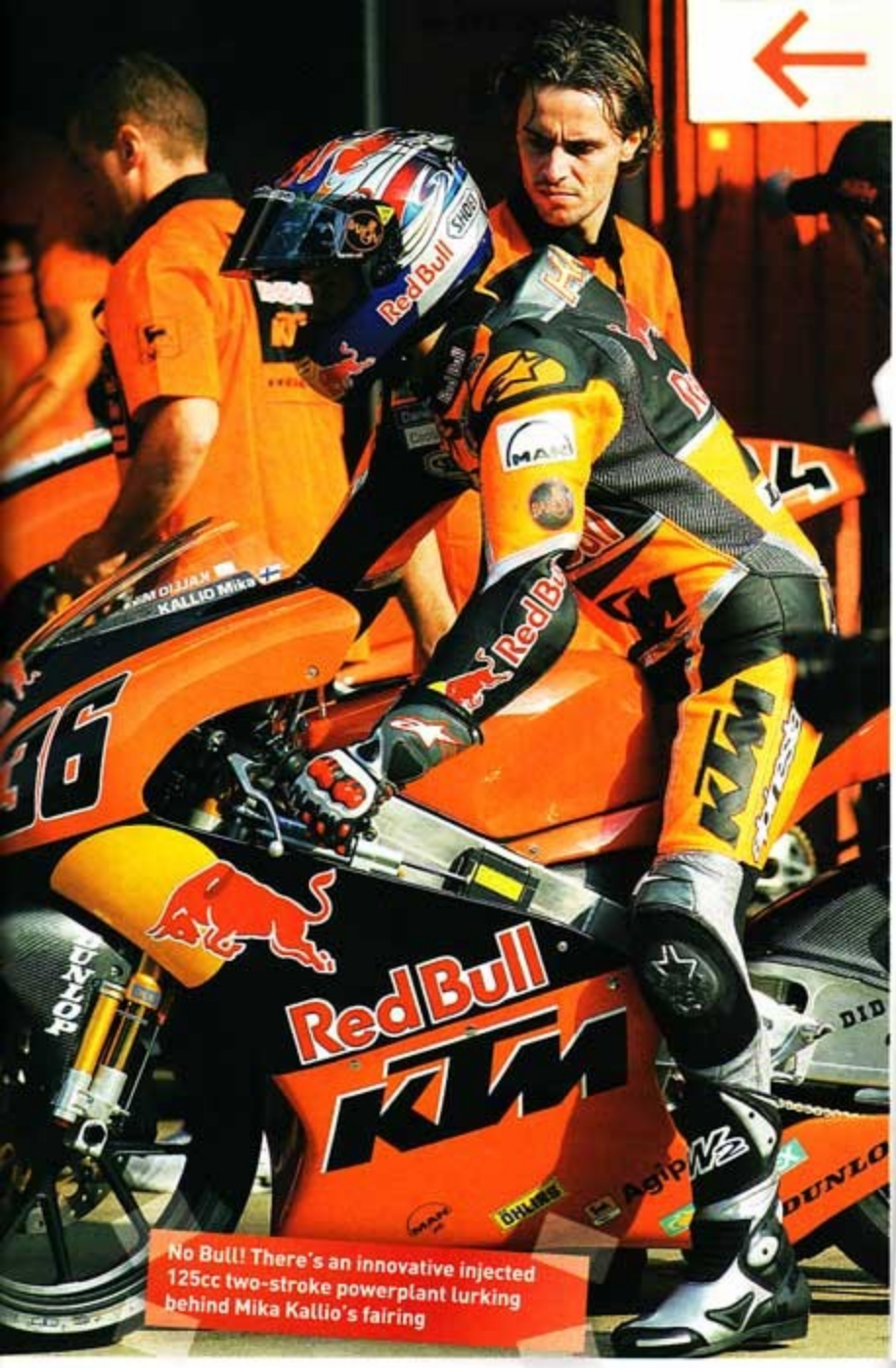
Bartol's solution is more pragmatic. Fuel injection isn't like carburettors – it fires in fuel whenever the computer controller tells it to. Bartol admits to "using fuel injection together with the carburettor".

"I control things with the fuel injection that I cannot control with the carburettor," says Bartol. "With a carburettor you cannot control anything without flow.

"We needed something to deal with Mr Stoner as he was shutting the throttle, shifting it down and revving it to 16,000. With a carburettor you have to jet it very rich to stop it seizing under those conditions."

Adding a system to change fueling separately from the carburettor jets is not in itself new, but using a fuel-injection system in conjunction with carburettors is. Bartol has chosen not to try and replace the carburettor – he is using it for what it does very well and enhancing its fuel delivery using the individual triggering systems from a modern day engine management system.

This ensures the KTM crew can set the



No Bull! There's an innovative injected 125cc two-stroke powerplant lurking behind Mika Kallio's fairing

"We needed something to deal with Mr Stoner..."

bike's fueling very accurately for power and throttle response, and then add fuel where the carburettor wouldn't normally be able to do so.

POWERING AHEAD

There is a long history of two-stroke carburettors that have additional systems on them to try and get more accurate fueling than can be achieved just with the standard jets.

Yamaha for instance had the Powerjet system on its TZ250s in the early 1980s. This was designed to add fuel mixture independently of the carburettor main jets at certain revs, again allowing more precise metering of fuel than could otherwise be achieved. Unlike the KTM's fuel injection this however did not use positive pressure.

"I am running an electric pump with a constant pressure of 3.5 bar," says Bartol. "The rest is controlled by a special ECU we have developed.

"We started working on fuel injection way back in 1988, not with the fuel injector but with the software. It is only in the last two years that I have been able to get injectors that are satisfactory.

"We inject mixture when we need it. I cannot tell you where the injector is placed, that would make it too easy for other people – and no you cannot take a photo," adds Bartol.

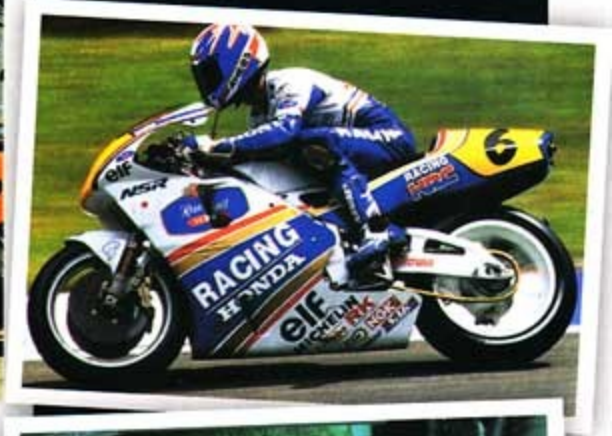
HONDA'S EXPERIMENT

During 1993 Honda experimented with a fuel-injection system on its works NSR500. Honda announced the existence of the system in a press statement at the Assen TT of that year as though it had only just been debuted. But at the previous GP at Hockenheim Shinichi Itoh set the fastest top speed of the meeting at a then sensational 320km/h (200mph).

Honda claimed that Itoh had not used the fuel-injection system to set the top speed. However, paddock gossip at the time insisted that Mick Doohan and Daryl Beattie used fuel-injected NSRs at the first GP of that year in Australia, and that the top riders didn't use it again.

We can only assume HRC never quite got it to work and the works NSR500s stayed with their standard carburettors all the way until the days of the 500 two-strokes ended.

At the time Yoichi Oguma, vice president of HRC, admitted that the purpose of running the system was to learn how to make environmentally friendly two-strokes in the most demanding circumstances possible. He also confirmed that the NSR500 system was a development of a system used in the Japanese 250 championship in 1990.



Top: Shinichi Itoh aboard the injected NSR500 at Hockenheim in 1993. His 200mph (320km/h) top speed was a record. Above: Caught! After denials, HRC owned up to an injection program

"We have rules — no engines open at the racetrack"

"The system is throttle and rev linked as well, but it picks up information from sensors over the bike such as detonation, temperature in the airbox, pressure in the airbox, and so on.

"The settings on the computer allow us to set the carburettor accurately for power. For instance, I can run very small pilot jets, but everyone else has to run much bigger pilots. It gives us much better pick-up off closed throttle. It's quite easy to adjust too – we can adjust it easily with a flashload system."

SECRET BUSINESS

The engine is a standard single-cylinder 125 two-stroke with the bore-stroke of 54mm x 54.5mm. Last year the engines were machined from billet, while this year's bikes have cast crankcases, made in England from two suppliers.

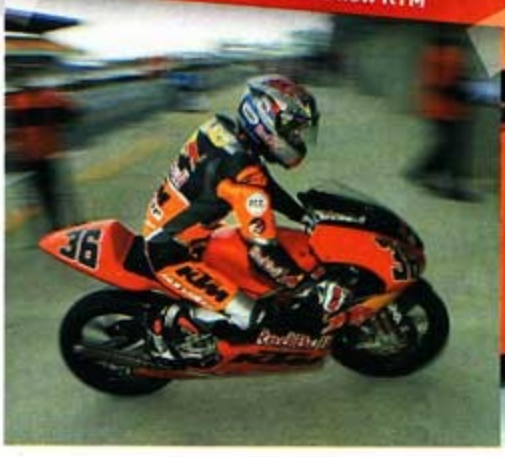
"Overall two-stroke reliability is improving too," says Bartol. "If you had gone to a new racetrack like China, with over 1.2km of straight, over two years ago there would have been many seizures.

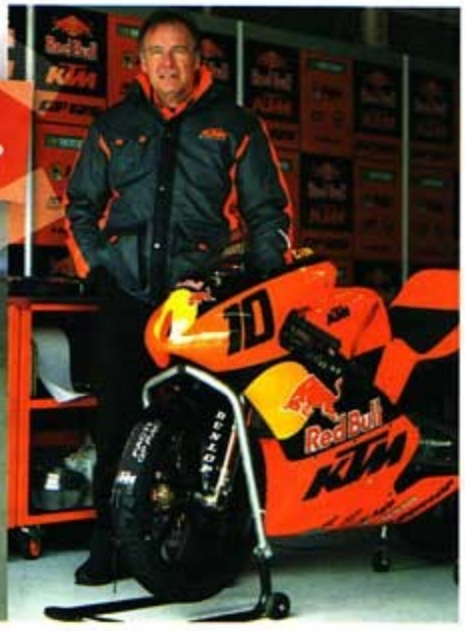
"Now there is no problem – we do a whole meeting on one piston. A new one goes in for the warm-up and it stays there until the end of practice.

"We have rules – no engines open at the racetrack. Some of the reasons are the specification of the parts, but also design."

The KTM is also quite unusual because the team is using Ohlins, when KTM actually owns WP.

Bartol again: "I have always wanted to run Ohlins. When we started this project I talked to my boss and said we would be driven purely by results. Even when I started with Derbi I wanted Ohlins in the beginning, but we went to Showa, but the service wasn't very good at the time. But I find Ohlins has a very good level of engineering and service." ■





Talmacsi (above) and Kallio (below) - results in 2005 have been impressive. Right: Two-stroke guru. Bartol was the man behind Yamaha's 125 GP program, then Derbi/Gilera – and now KTM

HOW DOES IT WORK?

Fuel injection is a pressurised fuel delivery system that provides precise amounts of fuel in accordance with instructions received from an Electronic Control Unit (ECU). The trick is to deliver exactly the right amount of fuel at the right time to get the engine to work most efficiently.

The fuel is delivered in individual pulses from an injector in each inlet port. Using a pump to provide a constant fuel pressure (usually 3.5 bar, but increasingly higher) the computer varies the amount of fuel by controlling the length of time each injector is open.

The basic calculation is based on how many degrees the throttle is open and what revs the engine is running, with more fuel required the longer the injector is open.

In addition to the basic throttle/revolutions calculation, the duration of the fuel pulse is varied by sensors placed over the engine. A simple road system would also consider air temperature, air pressure, coolant temperature and on some even an exhaust gas analyzer.

The data from these sensors is used to change the length of the fuel pulse to the one most appropriate for the vehicle's situation. In an extreme situation such as starting a cold engine on a freezing morning in Death Valley (USA) the sensors would add as much as 60% extra fuel.

As systems have become more complex they can change the fuel pulse duration and control other effects depending on their programming. On turbocharged cars they can vary the boost, on the race variants of supercharged cars water can be injected if cylinder temperatures get too high, and additional fuel can be added, and ignition retarded if detonation is detected.

On the latest MotoGP bikes ignition and throttle positions can be varied depending on traction and wheel speeds.