Overwhelming performance motocrosser KX250F

The Kawasaki motocrosser KX250F comes loaded with numerous technologies directly derived from factory machines, including the Launch Control Mode, which gives riders an advantage in getting a good start in motocross races, and the Dual Injection System, which optimizes fuel delivery in both high and low rpm ranges. This paper presents an overview of the features of the KX250F and the technologies supporting them.

Preface

Motocross is a major motorsport in the US, its largest market. The pinnacle of stadium motocross racing, the AMA Supercross Championship (Fig. 1), is a grand event attracting over 50,000 spectators per race. Our KX450F motocrosser has won the title for three consecutive years in the main class, 450 cm³. This has done great things for the Kawasaki brand image.

Meanwhile, our KX250F, competing in the 250 cm³ class, has recorded great success in races all over the world since its release in 2003 (Table 1). In the last few years, it has consistently been ranked highly in "shootouts" with rival vehicles in motocross publications, establishing it as a major contender.

Table 1 Number of titles won by KX250F (2003–2012)

	Titles won	Total in 10 years
AMA Supercross	11	20※
AMA Motocross	7	10
All Japan Motocross	6	10

※2 titles/year, West Class and East Class

Fig. 1 American Motorcyclist Association Supercross (stadium race)

Fig. 2 Moment of start

1 Development concept

As this product is a commercial race machine, we set its development concept as "a machine that can win a race as-is, without modification." To achieve this, we aimed for two certain performance features: an engine that emphasizes not only power, but also ease of handling; and a body that obeys the rider's will.

After continued development of the machine according to this development concept, in recent years, the market has accorded it just the reputation we hoped for, as the most race-ready machine.

2 Engine technology

Aiming for an engine that can win a race, we set a development course towards the following two targets.

① Holeshot* win

② Fastest lap time** win

To reach these goals, the KX250F's engine has the following features.

*Holeshot: Being first in the first turn after the start

**Lap time: Time to go around a course once

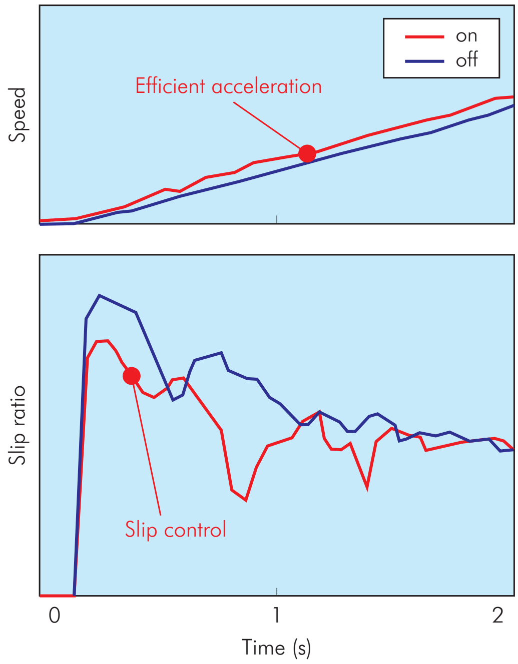


Fig. 3 Launch Control Mode operation

(1) Launch Control Mode operation
— Holeshot win

In a motocross race, the starting dash (Fig. 2) is a key point. Success in the holeshot depends on the slightest of differences. It is easy to slip in the sudden start, so winning the holeshot requires fine control of the throttle and clutch.

What makes the engine control help with this highly technically demanding start is Launch Control Mode operation. This control mode originates from Kawasaki factory machines competing in the AMA Supercross and Motocross Championships, and now it has been brought to the mass-produced motocrossers KX450F and KX250F. It is a system which switches the engine characteristics to optimize them for the start.

All the rider has to do is press the button on the handlebar, and the engine map switches to Launch Control Mode, with optimal ignition timing for the start. This controls sharp torque fluctuation when starting, reduces wheelspin, lowers slip ratio, and speeds up acceleration (Fig. 3). Launch Control Mode is only active right off the

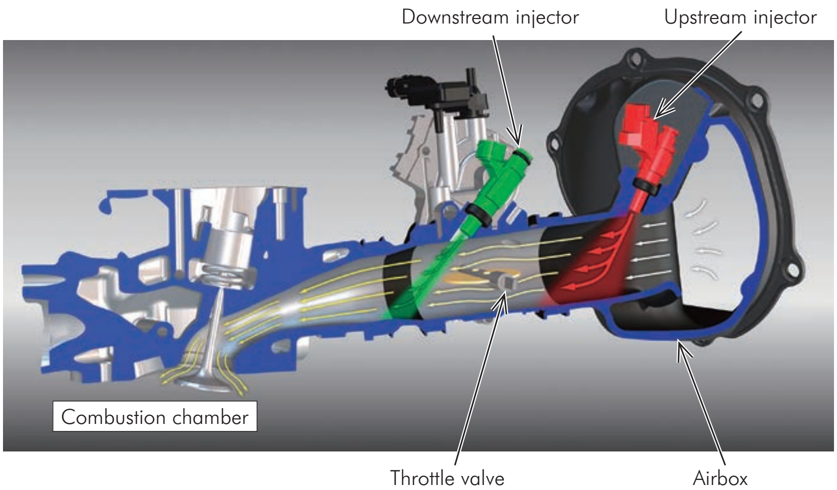


Fig. 4 Dual Injection System

start, disengaging and returning to the standard engine map automatically once certain conditions are fulfilled in driving.

Wise use of this system for the course conditions will make it an extremely effective tool for winning the holeshot.

(2) Dual Injection System
— Fastest lap time win

(i) System configuration

The KX250F is the world's first mass-produced motocrosser to feature a dual injection system. In our Dual Injection System, as shown in Fig. 4, there are two injectors around a butterfly-style throttle valve: one on the side of the combustion chamber and one on the side of the airbox. By using each of these injectors as appropriate, the vehicle can achieve both agile response in the low rpm range and high peak power in the high rpm range.

The downstream injector is the main force in the low rpm range, used in the starting dash, which requires rapid acceleration, and in cornering, which requires accurate and precise engine speed control. The injector is positioned close to the combustion chamber, so that the fuel injected will be delivered to the combustion chamber immediately,

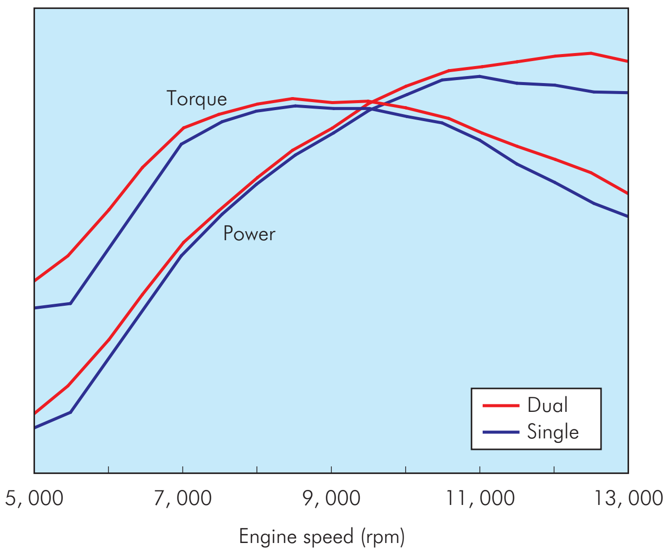


Fig. 5 Performance enhancement with the Dual Injection System

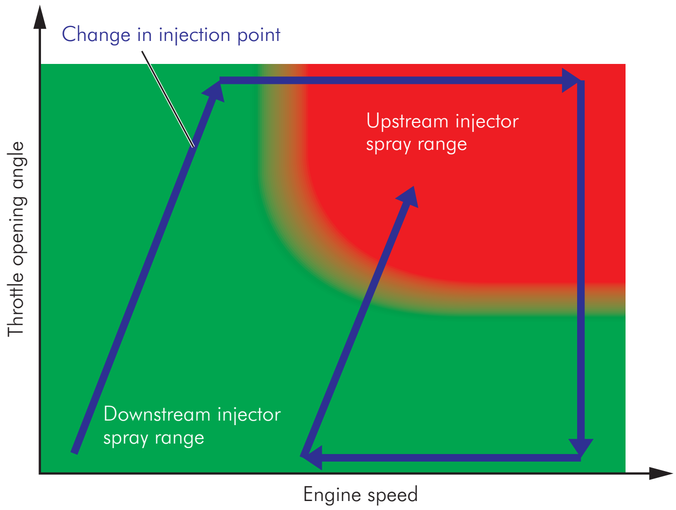


Fig. 6 Map of fuel injection

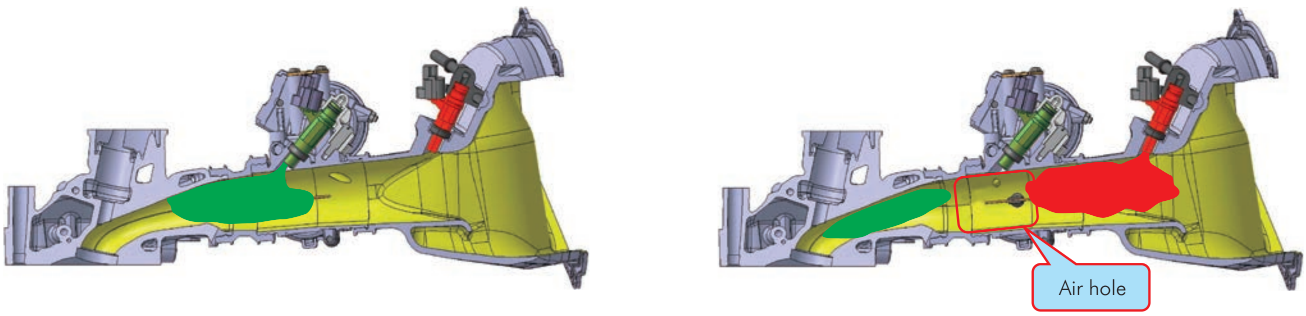
for quick response.

The upstream injector is the main force in the high rpm range, which are about power. This injector is positioned at a distance from the combustion chamber, so that the fuel injected has time before it enters the combustion chamber. This makes it easier for the fuel and air to mix (turning the fuel into a gas) and cool, which makes the air-fuel mixture fill the combustion chamber more efficiently and raises power (Fig. 5).

(ii) Rate limit control

A motocrosser changes engine speeds and throttle opening angle extremely violently. Therefore, the injection point goes back and forth frequently between the downstream and upstream injector spray ranges, as shown on the map of fuel injection (Fig. 6).

Figure 7 shows what happens in the switch from the downstream to the upstream injector. When injection is switched from the downstream to the upstream injector,



(a) With downstream only

(b) Switch from downstream to upstream

Fig. 7 Injector spray diagram

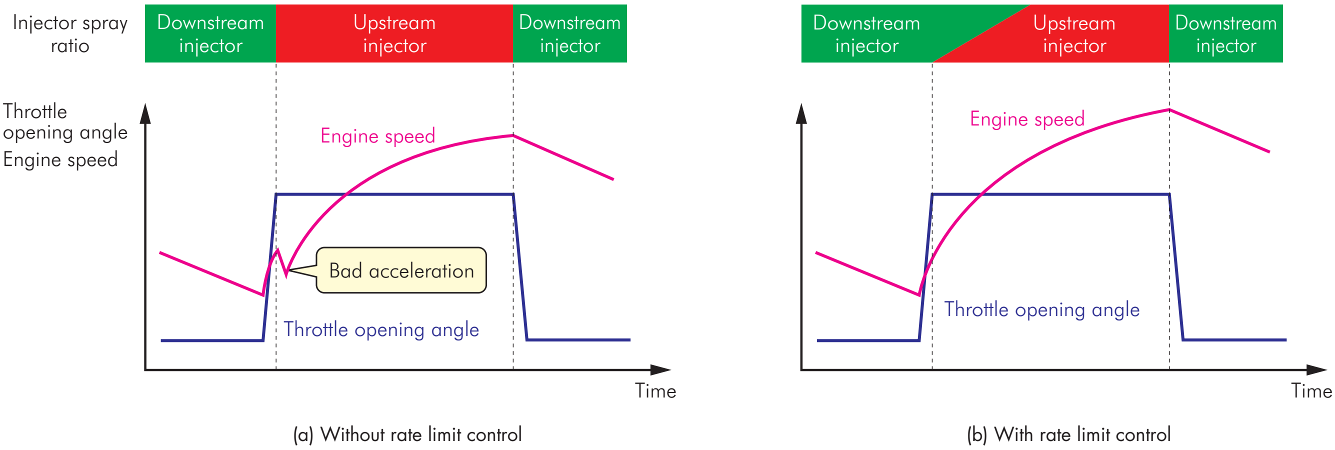


Fig. 8 Effect of rate limit control on engine speed

an air hole forms in the air-fuel mixture, which slows the fuel response and harms acceleration, as shown in Fig. 8 (a).

Our solution to this problem is rate limit control. By having the map of fuel injection draw a continuous transition in injection ratio instead of switching instantly from the downstream injector spray range to the upstream injector spray range, delay in fuel response can be eliminated.

On the other hand, when the engine speed is lowered, if rate limit control is still used, it creates the problem of fuel accumulating at the upstream side of the throttle valve. Therefore, we chose to have injection switch instantly from the upstream injector to the downstream injector in this case (Fig. 8 (b)).

This kind of rate limit control gives the Dual Injection System a clear edge over single injectors and contributes to winning the fastest lap time.

3 Chassis technology

Aiming for a body that obeys the rider's will, we set a development course towards the following two targets.

① Straight-line stability on rough roads
② Cornering performance that feels light and stable

(1) Main frame — Straight-line stability

For secure acceleration on rough roads, higher body rigidity is not always better. If the body is too rigid, it will not be able to absorb the bumps in the road and will behave without stability. To a certain degree, the body itself has to be able to bend and absorb shock, so the balance of rigidity is extremely important. Thus, we analyzed strength and rigidity and set balanced rigidity by assembling the main frame appropriately out of forged, extruded, and cast materials (Fig. 9). This secured high straight-line stability even when riding on rough roads at high speeds.

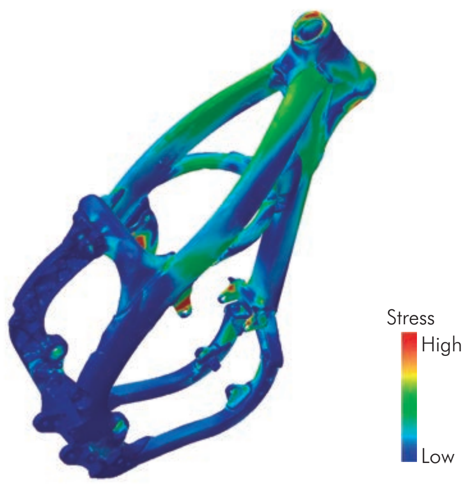


Fig. 9 Example of main-frame stress analysis

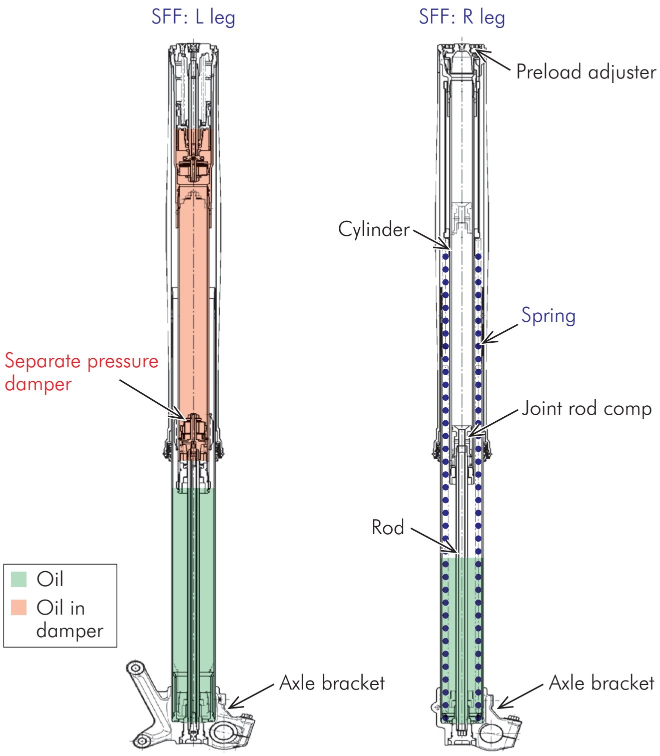


Fig. 10 Structual diagram of SFF (2014 model)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(2) SFF (Separate Function front Fork)
— Cornering performance

Previous front forks had both body retention (spring) function and damping function in each leg, left and right. In the SFF, developed jointly with Showa Corporation, as shown in Fig. 10, the functions are divided into a separate pressure damper on the left leg for the damping function and a spring on the right leg for the retention function.

This achieves the effects of lightening mass by reducing the number of parts and reducing sliding friction by using only one spring. Thus, we were able to make the front fork lighter and improve its absorption power. Also, to change the preload (the spring's initial load setting), it used to be necessary to take apart the front fork, but now we have installed a preload adjuster on the right leg, expanding the setting possibilities by enabling adjustment of preload with a complete vehicle.

The SFF inverts the right (spring) leg's internal components (joint rod comp: a part connecting a rod with cylinders), which improves external cylinder damping force, dependent on stroke. Also, on the left (damping) leg, we have expanded the damper size to an outer diameter of 30 mm for gains in both shock absorption power and sense of control. At the same time, we have expanded the inner tube to an outer diameter of 48 mm, adjusted the rigidity of the axle bracket region, and more to optimize rigidity over the front fork as a whole. This achieves cornering performance that feels both light and stable.

Concluding remarks

We have developed many technologies and applied them to the KX250F. Remembering how they have made the KX250F what it is today, we intend to keep on aggressively developing daring new technologies to improve its competitiveness yet further.