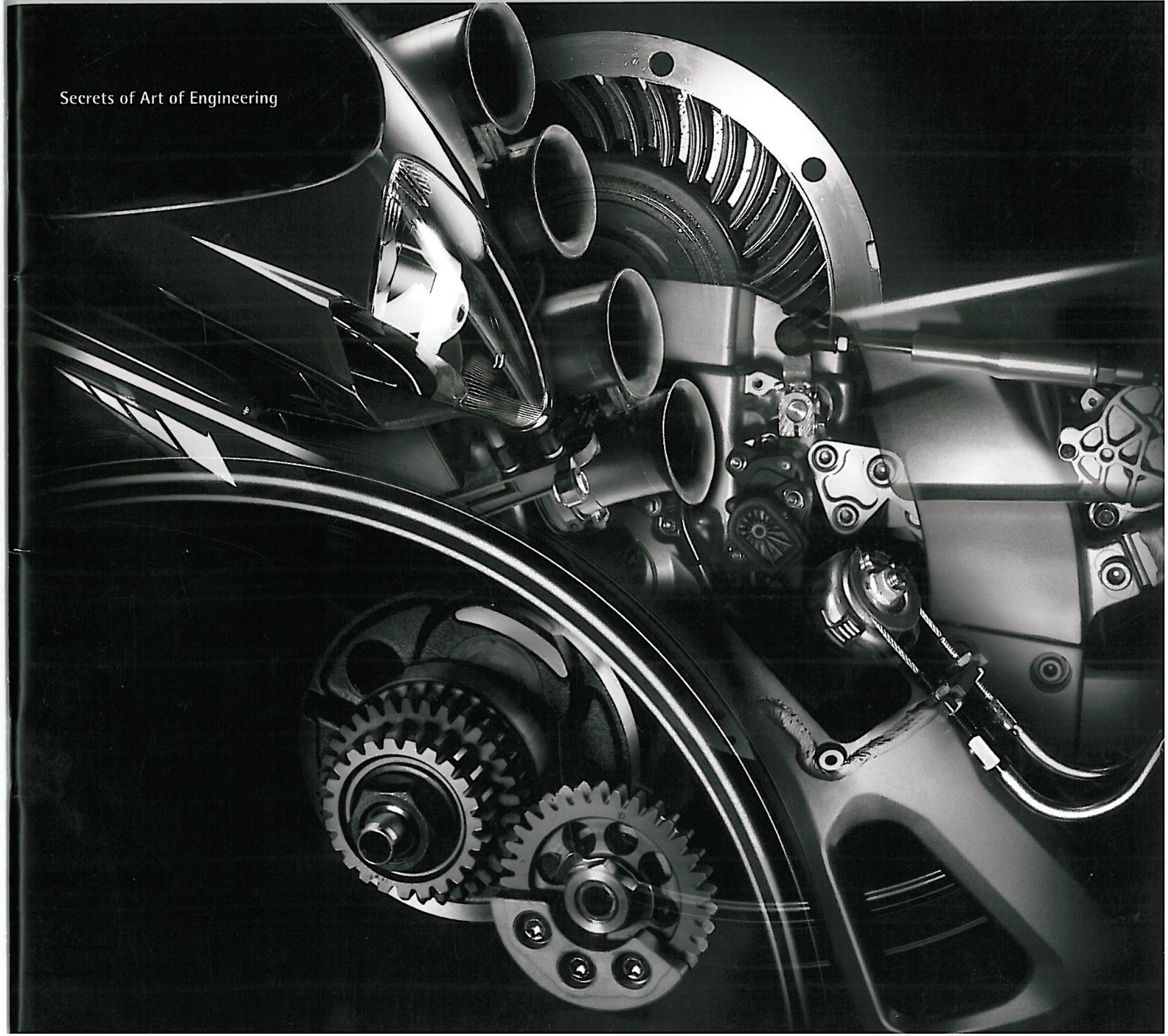
Yamaha technology

YAMAHA



Secrets of Art of Engineering

2007 YZF-R1

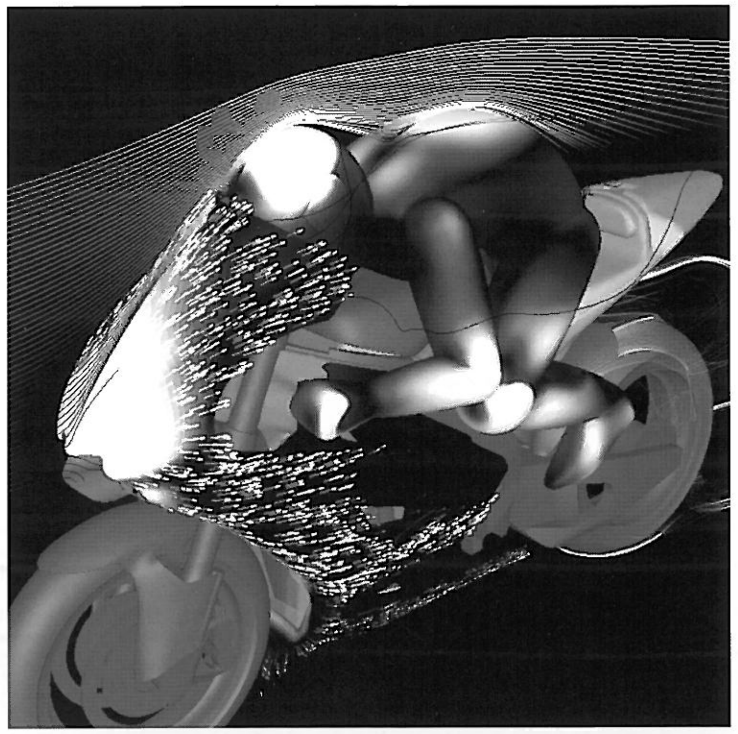
Contents

The models illustrated incorporate the technology as stated on the relevant page.

Two technology concepts behind Yamaha's Art of Engineering

GENESIS

GENICH



Through our theme Art of Engineering we seek to express our efforts to elevate to the level of art the unique Yamaha qualities in all aspects of our motorcycles, from the quality of their ride to the beauty of their styling. Yamaha applies two engineering ideas that support all these efforts and their names are 'GENESIS' and 'G.E.N.I.C.H.', pronounced 'JENIK'.

The history of Yamaha motorcycle development that began with our first YA-1 in 1955 has always been a challenge to create innovative new technologies. And it has been a continuing line of epoch-making innovations like the YPVS, Monocross suspension and Deltabox Frame born and developed on the GP race track, as well as revolutionary models such as the RZ250, the VMAX and the YZF-R1 that started new trends in sport bikes.

Our unchanging approach to motorcycle design has been to build machines that are fun to ride. For us, a motorcycle should be something that is a joy to handle, not just a machine that runs itself. Within the guiding concept of building bikes that are lighter, slimmer and more compact, the core competence we have sought is in the analysis and R&D skills that enable us to create driveability and handling that is judged by human sensibilities, not just specs.

The engineering ideal born of our belief that the rider's will is the most important element in riding a motorcycle, and that the development process should be aimed at building that kind of man-machine communication, is our GENESIS concept.

The GENESIS concept is to integrate the engine, frame and all the mechanisms right down to the individual parts into an organic whole aimed at achieving a high level of 'Man-Machine Communication'. The FZ750 released in 1985 was the first model to embody the GENESIS concept, and after that, GENESIS continued to evolve as the engineering ideal behind all Yamaha motorcycles. The kind of emotional world of riding that Yamaha proposes led to the concept of Man-Machine Sensuality (Jinki-kanno) that became our engineer's objective.

As this GENESIS concept continued to evolve through our wide-ranging research and development efforts, a new field of electronic control technologies also began to develop.

These control technologies seen in places like the ABS system of the FJ1200ABS and the fuel injection system of the GTS1000, as well as the EXUP and TPS technologies, all contain unique Yamaha programmes that develop the quality of the machine's ride, and always with human sensibilities as the guiding factor.

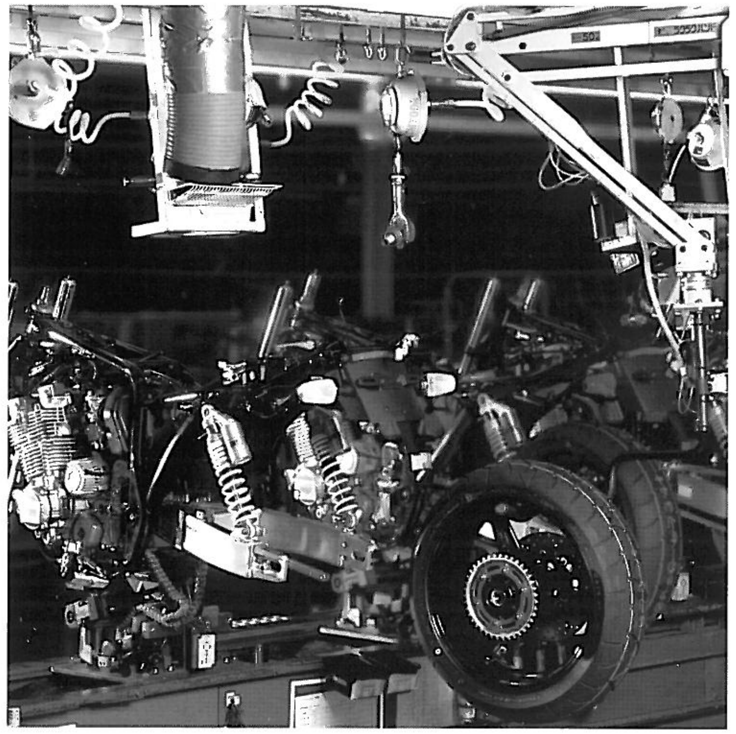
In 2005, these technologies evolved in new ways once more with the YCC-T electronic controlled throttle on the YZF-R6 and the YCC-S system that eliminates the need for clutch operation in gear shifting on the FJR1300AS, both of which were unveiled at the Paris Show. These advanced new examples of Yamaha control technologies are representative of our new next generation core ideal we have named G.E.N.I.C.H.

This new G.E.N.I.C.H. engineering concept is one that makes assertive use of state-of-the-art electronic control technologies in motorcycle development.

It is not simply a translation of analog functions into digital ones but programming with a unique essence that places top priority on human sensibilities and, in combination with the GENESIS ideal, leads to a new world of Man-Machine Sensuality.

With the GENESIS concept that seeks to develop machine character as a total entity, including engine and body, and the G.E.N.I.C.H. concept that makes organic use of electronic control technologies to achieve a ride that reflects the human rider's will, Yamaha ventures into its 51st year in 2006 on its own unique path for our next 50 years expressed by the words Art of Engineering.

G.E.N.I.C.H. is an abbreviation of the concept of GENESIS of Electronic engineering for New, Innovative Control technology with Human orientation. The GENESIS engineering ideal was first adopted by Yamaha Motor Co. Ltd in 1985 as a new-generation machine development concept. Its concept is to integrate the engine, frame and all the mechanisms right down to the individual parts into an organic whole aimed at achieving a high level of "Man-Machine Communication".



2007 YZF-R1

Aluminium forged piston

Lightweight aluminium forged pistons for improved performance and reduced vibration

Background

Pistons for car and motorcycle engines are usually cast by pouring molten aluminium alloy into a mould. This type of cast piston is used because of its strength, resistance to heat-induced distortion, good heat dissipation qualities and lightness. The other type of piston is the forge piston, with which the alloy is not melted but heated to the point where it can be forged into a mould under pressure. Since the aluminium is not melted in the forging process, there is less influence of the metallurgic matrix and it thus retains more of its original strength. This makes possible a thinner, and thus lighter, piston that has less reciprocating mass and also contributes to weight reduction.

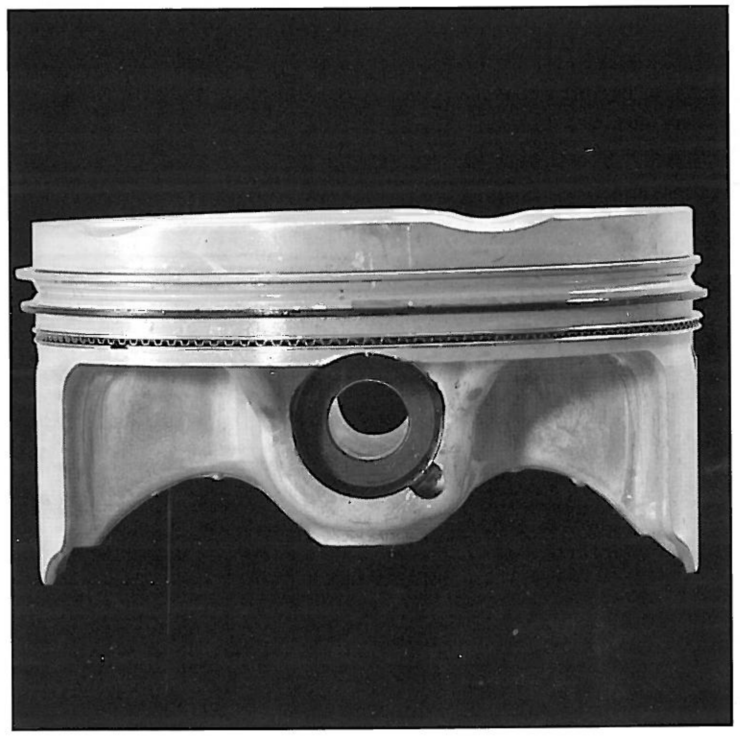
However, because of the exacting requirements involved in manufacturing a complex shaped piston by the forging method, such as metal and mould temperature control, and there is more cutting processing to be done, forged pistons have been more expensive parts to produce. Also, the high-strength aluminium alloy used in these pistons is harder to shape in the forging process because of its very strength.

Furthermore, because aluminium alloys for forging have a narrower temperature range suitable for forging, maintaining precise control of the forging temperature has been the key.

The 'controlled forging technology' Yamaha introduced in 1997 has been used successfully since for the mass production of forged aluminium pistons because it utilises a system of precise control of the piece temperature, mould temperature and the forging force.

Mechanism and Characteristics

Yamaha's controlled forging technology tightly controls the forging conditions, including (1) the initial heating of the work piece, (2) controlling the temperature of the mould so that it keeps the work piece in the ideal 400 to 500°C range, (3) applying just the right amount of pressure to the mould in the forging process and many more factors. The forged pistons made with this method have excellent strength characteristics that enable the design of a thinner, lighter piston with smaller reciprocating mass achieve higher rpm and performance as well as providing the greater reliability of the higher strength aluminium. For this reason they are used in many Yamaha motorcycles.



2007 YZF-R1

Fracture split (FS) carburised connecting rod

An exclusive manufacturing process for high-strength conrods

Background

The 'big end' of conrods (connecting rods) must be very strong and precise. With its 1998 model YZF-R1, Yamaha introduced a high-strength conrod made by a heat processing method involving carburisation of the surface of the conrod to increase the fatigue strength of the steel. After heating the steel to 900°C in an oven, it is impregnated with carbon and the temperature rapidly lowered with a special oil and water to produce harder crystallisation. After the heat processing the steel alloy is characterised by a high level of fatigue strength and ease of processing, and conrods made by this method have subsequently been adopted on the YZF-R series and other models. The reliability of these carburised conrods is further heightened by Yamaha's fracture splitting (FS) carburised conrod technology.

Mechanism and Characteristics

In order to be connected to the crankshaft, the conrods for multiple cylinder engines are normally divided into a rod portion and a cap portion. A method that has been the focus of attention in recent years as a way to increase the precision of the mating of these two parts of the conrod is the 'fracture splitting' method. In this method the 'ring' portion of the big end is split in two by applying sharp impact with a wedge. The result is two pieces that have perfectly matching split-surface contours that naturally produces a much more precise and stronger mating when they are bolted together again around the crankshaft. This method has long been used for conrods for marine engines and from the 1990s it has been used for some motorcycles produced in Europe.

However, in the case of carburised conrods that have a hard outer surface and softer inner portion, the greater elasticity of the softer inner portion has made it difficult to fracture split the rod in a way that produces the desired 'brittle fracture' surface that improves the mating when the parts are bolted together again.

In the development of Yamaha's 'FS carburised conrod,' simulation analysis revealed that the fracture temperature, splitting energy and position of splitting impact affected the quality of the split surface. By controlling these parameters, it was possible for Yamaha to develop a fracture splitting method that produced the desired 'brittle fracture' that when reassembled creates a good mating of the split surfaces. The 2004 model YZF-R1 is the first Yamaha motorcycle to adopt FS carburised conrods made by this method for increased reliability.

2007 XJR1300

Plated cylinder

A cylinder surface processing technology for outstanding cooling characteristics

Background

There is constant friction between the wall of the aluminium cylinder and the piston rings. Thus a high level of friction resistance is necessary, which is something aluminium by itself cannot provide. This is why aluminium cylinders are usually lined with steel sleeves (liners). However this structure makes for inefficient heat dissipation. Also, the fact that steel and aluminium have different heat expansion rates has made the manufacturing process complex.

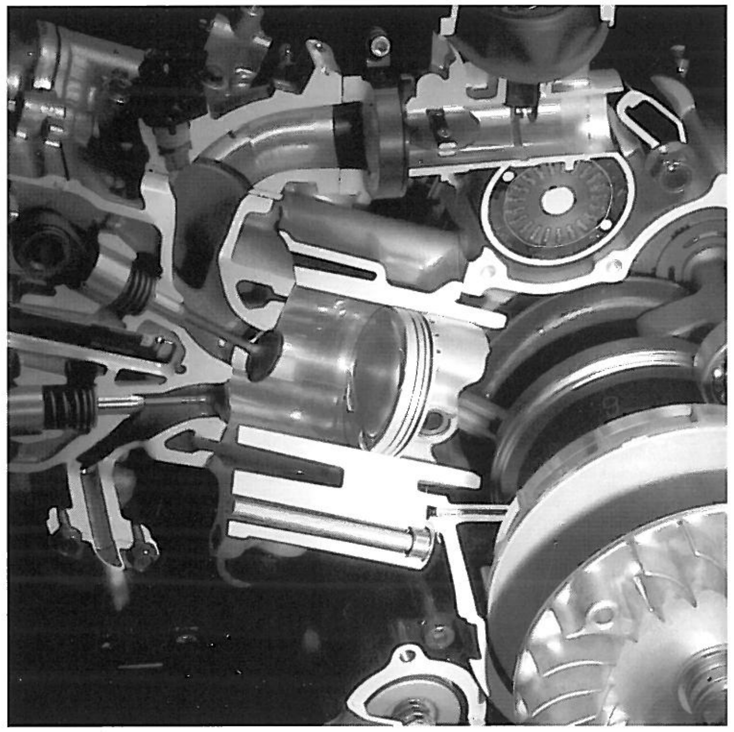
Mechanism and Characteristics

The plated cylinder is one solution to these problems that eliminates the steel sleeve by applying a layer of ceramic-based plating material (including silicon carbide particles) to the cylinder wall to increase friction resistance.

The 'direct plated cylinder' used on the YZF and FZ series models replaces the conventional aluminium liner and applies plating directly to the cylinder wall. This 'direct plating' method has been made possible by Yamaha's exclusive aluminium die-casting technology that produces stronger aluminium cylinders with fewer air bubbles in the metal, which makes it better suited for plating.

The plated cylinder is used to improve cooling characteristics and reduce piston friction. Also, because the piston and the cylinder wall are both made of aluminium with the same heat expansion rates, there is less heat-induced distortion of the gap between the piston and the cylinder, which contributes to more stable performance. This means cylinder weight is reduced and a higher compression ratio and higher performance can be achieved.

This technology is now being used on many Yamaha domestic market sports models, maxi scooters and four-stroke 50 cc scooters.



2007 X-MAX 125

DiASil cylinder

A high-performance non-plated all-aluminium cylinder

Background

The plated cylinder was originally adopted as a replacement for the steel sleeve that was used in conventional cylinders to achieve the high resistance to abrasion that a cylinder needs. These plated cylinders provided better heat dissipation and better oil efficiency.

Although it was known that adding silicon to the aluminium would make it harder, a silicon content of about 12% was the limit at which the die-casting process could be performed effectively. To solve this problem Yamaha developed the new DiASil non-plated all-aluminium cylinder that achieves the same level of performance as nickel-plated cylinders.

Mechanism and Characteristics

The Yamaha 'DiASil Cylinder' technology brings together an ideal combination of material, manufacturing technology and environmental friendliness. It consists of (1) a 20% silicon content aluminium alloy, (2) is manufactured with the Yamaha CF Aluminium Die-Casting Technology, which enables (3) the production of an all-aluminium die-cast cylinder. It is Yamaha's exclusive CF Aluminium Die-Casting Technology that enables the mass production of a die-cast cylinder made completely of 20% silicon content aluminium alloy, something that could not be done with conventional die-casting methods.

Having a highly friction resistant microstructure with an even distribution of hard silicon particles, this high-quality all aluminium die-cast cylinder can be mass produced by a method that eliminates most of the casting cavities created by pockets of gas that are common in conventional die-cast parts. In comparison with steel liner type aluminium cylinders, the Yamaha 'DiASil Cylinder' (1) has 60% better cooling performance, (2) has excellent recyclability, (3) enables 30% lighter design and (4) has a lower manufacturing cost.

This cylinder is used on the X-MAX125.

2007 XV1900A Midnight Star

OHV engine for large-displacement machines

An OHV engine to enable a low-profile style cruiser design

Background

The new cruiser model XV1600 RoadStar released on the US market in 1998 with a product theme of 'emotional spirit', became popular for its low engine rpm cruising performance and solid handling. One of the elements that contributed to this model's low centre of gravity and low-profile body was its large displacement OHV V-twin engine.

Mechanism and Characteristics

OHV stands for overhead valve and it is one type of intake/exhaust valve lift system. It involves positioning the valves on the engine 'head' that forms the upper portion of the combustion chamber and driving a camshaft from the side of the crankshaft that moves the pushrod up and down to lift and close the intake/exhaust valves via a rocker arm.

Also, unlike an SOHC or DOHC system, the OHV has no camshaft on the cylinder head, which enables a more compact design for the head assembly. This means that even when a longer stroke is adopted in the bore and stroke specification as is desirable for a lower revving engine character, a low engine height can still be maintained. It also has an advantage in the fact that the fewer number of parts in the head assembly means better cooling performance for this part of the engine that normally reaches high temperatures. These merits of the OHV engine were taken full advantage of in Yamaha's large displacement OHV V-twin engine.

This OHV engine is used on the XV1900A to achieve a low-profile body. The V-shaped pushrod cover that you see on the right side of these models is a symbol of the Yamaha cruiser design ideal.

In Europe the models are called XV1600 WildStar and XV1900A Midnight Star.

2007 XV1900A Midnight Star

Left-right divided balancer

A unique balancer for both low vibration and a sense of pulse

Background

There is a long history of development of measures to reduce the vibration felt by the rider through the use of two-axis balancers and engine mounting methods. The advances in analysis technologies has also contributed to the building of more comfortable low-vibration motorcycles in recent years. However, for cruising on the American continent where bikers will ride several hundred kilometres a day, there is demand not only for comfortable running performance but also a pleasing sense of engine pulse.

The XV1900A mounting a completely new-design 1854 cc engine was released in 2005 as the flagship of our cruiser series. This model achieves a sense of pulse from its air-cooled V-twin engine that is different from models of the past. One of the things that helped achieve this sense of pulse and a comfortable ride at the same time was the Yamaha-exclusive 'right-left divided balancer'.

Mechanism and Characteristics

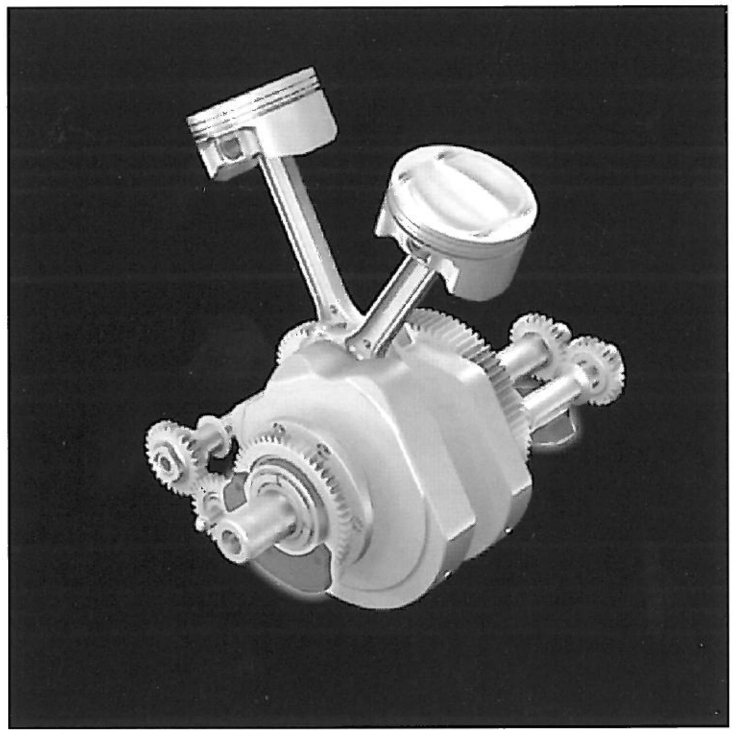
Normally because a balancer has a separate shaft from the crankshaft, the crankcase has to be made larger, and due to the fact that there is an offset between the crankshaft and the balancer shaft, coupled forces are created.

The device of limiting this creation of coupled forces by means of a two-shaft balancer system has been used for some time, but this also causes enlargement of the crankcase. (A two-shaft balancer was adopted on Yamaha's 1971 TX750.)

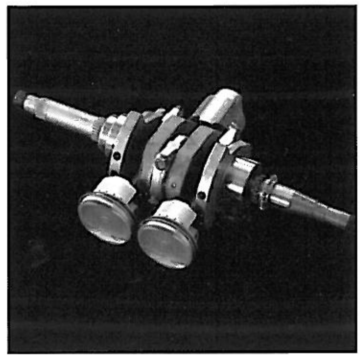
For the XV1900A's new engine, Yamaha's engineers themselves pursued the idea of reducing the coupled forces to a minimum, and they achieved a more compact design by splitting the required balancer weight between two balancers positioned to the right and left. The left-hand weight is on the same axis as the crankshaft and the right-hand weight is positioned close to the crankshaft. This creates what is in effect a single-axis balancer with the vibration reducing capacity of a two-axis balancer and also makes it possible to design a crankcase that is more compact.

The Roadliner is called XV1900A Midnight Star in Europe

And the RoadStar model is called the XV1600A WildStar.



2007 TMAX



Compact CVT-equipped engine with reciprocating balancer

A CVT unit that brings sports performance to the automatic category

Background

The TMAX XP500 model released in 2001 has won a strong customer following as a 'sports commuter' with the performance to enable enjoyable tandem touring the weekends on 100 to 300 km excursions from the city and fresh, attractive styling.

The present model also features a fuel injection system that boosts performance and environmental friendliness.

The specially developed power unit that gives the TMAX XP500 its outstanding running performance is a liquid-cooled DOHC twin engine with a horizontally opposed balancer.

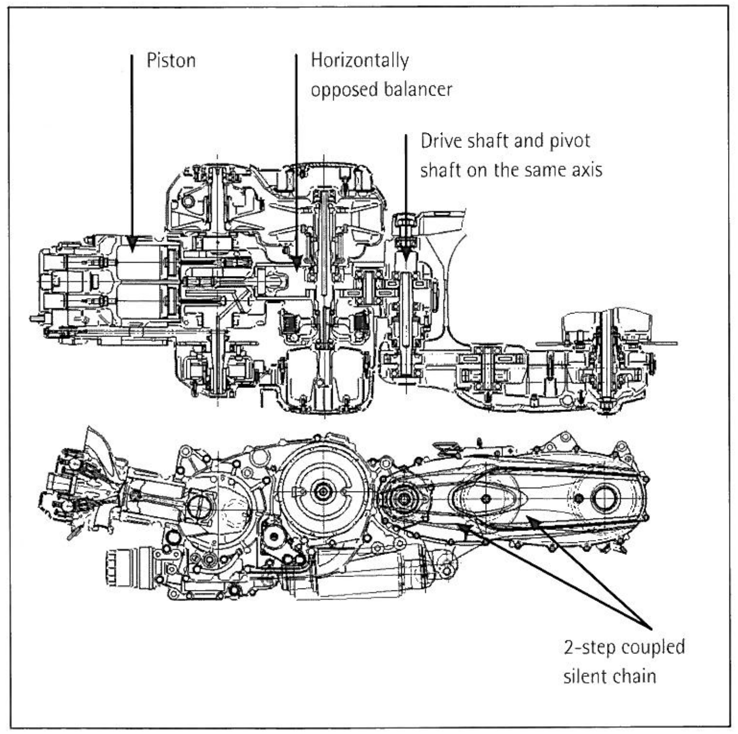
Mechanism and Characteristics

This engine is characterised by the overall compactness of the design and a reciprocating balancer (horizontally opposed balancer) with aluminium pistons on opposite sides of the crankshaft that effectively reduces vibration. This newly designed Yamaha-exclusive reciprocating balancer positions the moving parts as low as possible to make efficient use of space while contributing to a more comfortable ride by causing primary inertial force and secondary inertial force cancel each other out.

Furthermore, this model's specially developed CVT (continuously variable transmission) unit with rubber belt provides smooth running performance in combination with the wet multi-plate clutch. This CVT unit is positioned on the right side of the drive shaft (opposite side from conventional scooters) in a unique design that offers greater reliability by making use of the small amount of torque created before deceleration in the ratio control.

Also adopted is a Yamaha-exclusive rear arm (aluminium rear arm) design that places the drive shaft and pivot shaft on the same axis. Besides creating a more compact design by placing the pivot support axis and drive shaft on the same axis, this design also adopts a '2-step coupled silent chain' positioned on the left-hand inside of the rear arm to convey the drive force. By enclosing it in an oil bath inside the arm, it also becomes a maintenance-free design.

These innovative technologies that break out of conventional concepts are the main features that give the TMAX XP500 its especially sporty ride.



2007 TDM900

270° crank

A compact twin engine inheriting Yamaha's 'GENESIS' engineering ideal

Background

Generally, a parallel twin cylinder four-stroke engine usually has either a 180-degree crank (firing interval), for good power development in the mid- to high-speed range, or a 360-degree crank, which lets you feel the firing of the two cylinders and gives stronger torque in the low- to mid-speed range. On the other hand, with a 90-degree V-twin engine, an uneven firing interval (270-degree crank, etc.) is used because of the balance with the crank's torsional vibration characteristics to accentuate the engine pulse. However, due to the V-twin disadvantages of a longer engine length and the poorer cooling characteristics of the trailing cylinder, methods need to be found to achieve both pulse and a lightweight, slim design when being used on a high-performance sports model.

Mechanism and Characteristics

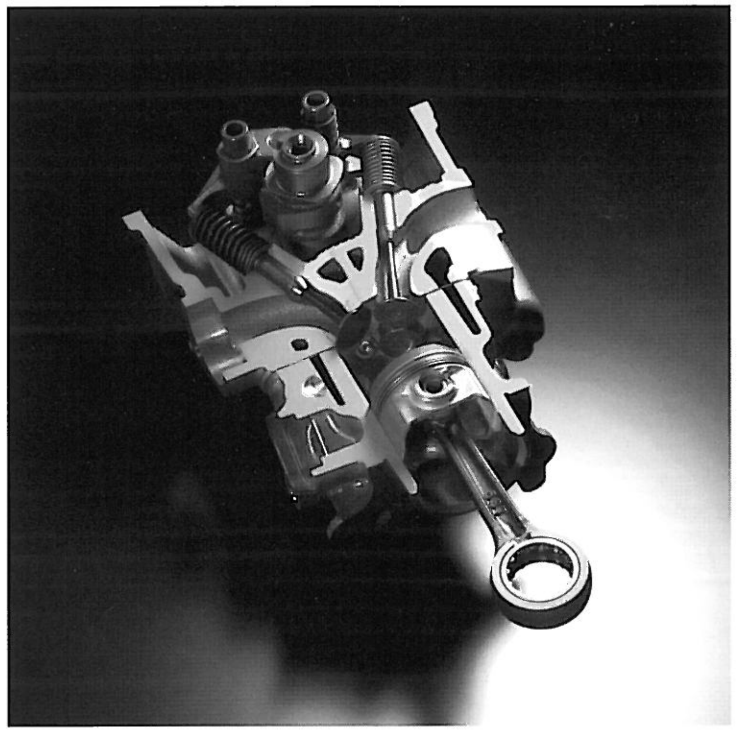
The engine for the TRX850 born in 1995 was a highly original 270-degree crank interval parallel twin that made it easy for the rider to feel the compound torque peak while also featuring enjoyable pulse feeling. This is because it was a power unit that upheld the forward-incline, low centre of gravity 'Genesis' engineering ideal while also having the lightweight, slim and compact design that is required of a motorcycle engine.

At the time this was the first parallel twin engine in the world to feature a 90-degree phased 270-degree crank interval. The repetition of firing intervals of 270 degrees and 450 degrees gave this parallel twin engine the same firing interval as a 90-degree V-twin. This model achieved both the light and invigorating running performance made possible by the compact engine design plus outstanding muscle and pulse.

The 270 degree crank interval technology used on this engine was actually a feed-back from the factory machines from the early 90s that competed in the Paris-Dakar Rally, a race where muscle, to power through the sands of the desert, was critical. It has since been carried on by the 1995 TRX850, and today's TDM900, which is the successor to the TDM850.

2007 Giggle

Three-valve SOHC engine



Small-displacement four-stroke engine with outstanding environmental performance

Background

Most smaller displacement four-stroke engines like in the 50 cc class have a two-valve design; one intake and one exhaust. To answer the growing call for bikes combining environmental friendliness and outstanding running performance, Yamaha developed this environment-friendly three-valve four-stroke 50 cc engine.

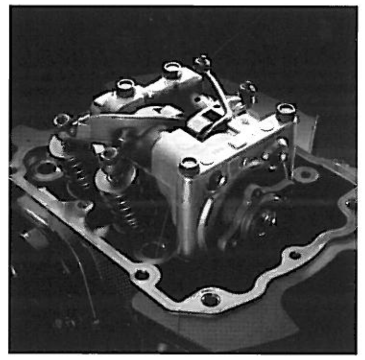
Mechanism and Characteristics

Yamaha's XF50 mounts this specifically designed SOHC three-valve engine. The two intake valves increase intake port area to provide excellent intake efficiency. These models adopt an exclusive pent roof combustion chamber design that gives the flow of the incoming air-fuel mixture a tumbler motion that produces quicker and more complete combustion.

Also, the slipper portion of the rocker arm features a specially designed super-thin needle roller bearing to create a continuous revolving motion that reduces reciprocating resistance with the cam. This increases reliability and gives a smoother feeling. The result is more enjoyable power feeling in the low- to middle-speed range and boosted exhaust performance.

2007 XT660R

Roller rocker arm



Valve lift mechanism for smoother engine performance character

Background

There are two methods for operating the intake and exhaust valves: a direct-lift method where a cam pushes directly on the valve to lift it, and the rocker arm method, which makes use of a 'lever' to lift the valve. The direct-lift cam is limited in terms of the lifting height that can be achieved but has the advantage of compactness. It also has fewer parts, retains its rigidity well and involves little friction loss at high rpm, which is why cams are used on many DOHC engines.

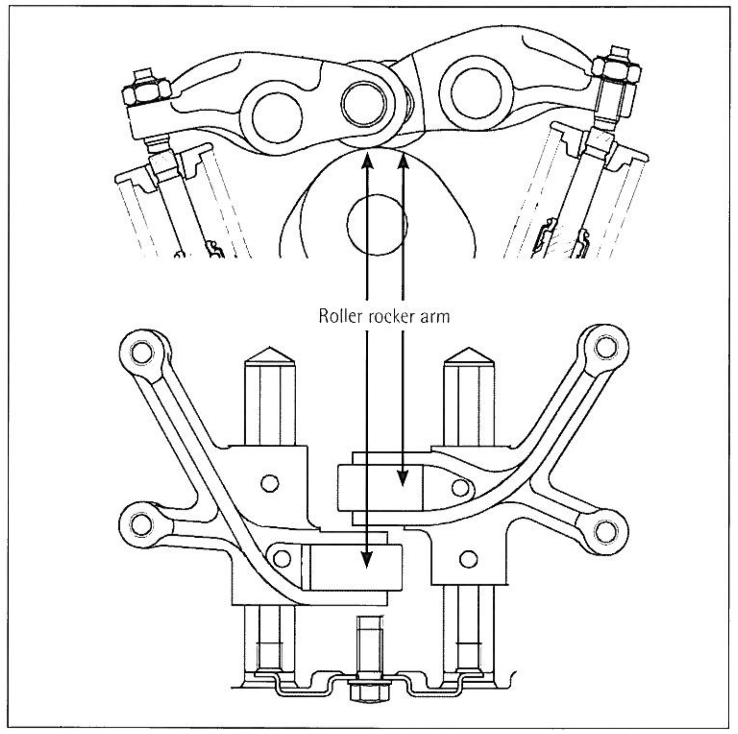
In contrast, the rocker arm system can achieve a higher valve lift than a cam because it employs a lever action, and thus has the advantage of enabling greater air-fuel intake volume. However, there is a structural problem in that increasing the lever ratio to get the desired valve lift also puts additional stress on the slipper (the place where the mound of the rocker arm contacts the cam).

Mechanism and Characteristics

To solve this problem, the roller type rocker arm employs a small ball bearing at the slipper that reduces the friction resistance. Although this type of rocker arm has been used in some automobile engines, applying it to a motorcycle engine required a more compact version.

The 2003 XT660R/X adopt the first roller type rocker arm valve lift mechanism ever on a Yamaha bike. In a unique Yamaha design, a needle roller bearing was used to create a continuous revolving motion at the slipper that reduces reciprocating resistance and thus improve reliability.

Furthermore, this system enables a high valve lift and shortens the overlap between the intake and exhaust valves. The result is an exciting power feeling in the low- to middle-speed range and excellent exhaust performance.



2007 YZF-R6

YCC-T (Yamaha Chip Controlled Throttle)

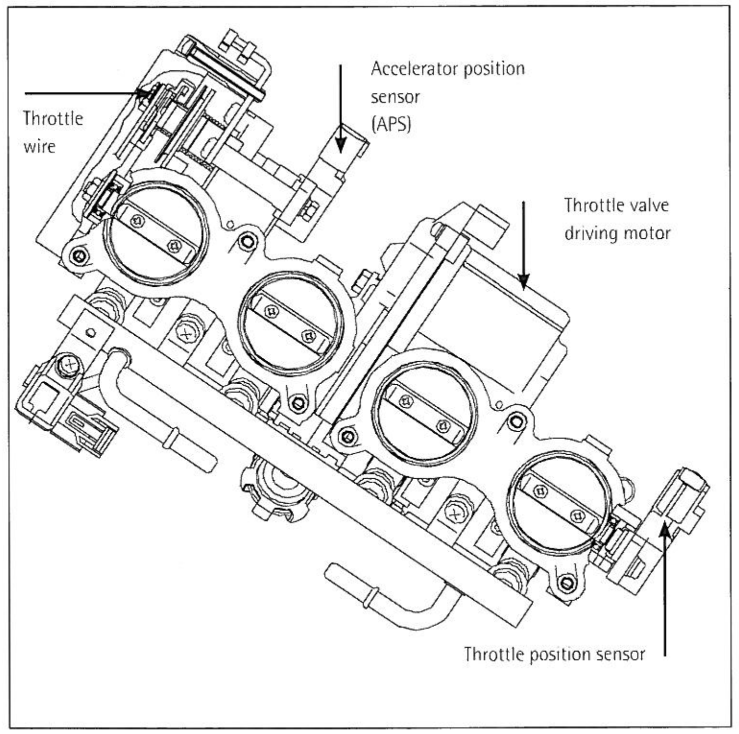
Intake air volume control for improved torque on super-high revving engine

Background

The YCC-T (Yamaha Chip Controlled Throttle) is a feature mounted on a production model for the first time (Yamaha survey) since the 2006 model YZF-R6. The system effectively brings out the performance potential of a large-bore, super high-revving engine and helps achieve smooth torque development across the full rpm range.

A conventional motorcycle fuel injection (FI) system functions to provide the right amount of fuel injection volume, pressure and timing in accordance with calculations based on sensor input on engine rpm, the degree of throttle opening and the temperatures of the different components.

But there was not active control of intake air volume. The FI system introduced on the 2002 model YZF-R1 featured a suction piston that contributed to intake air volume control, and this was followed by the FI system with a sub-throttle valve on the 2004 YZF-R1. However, for a model with the short manifold necessary for a super-high revving engine (2006 model YZF-R6) there is not sufficient room for these devices. Also, it is hard to get smooth torque characteristics in the low- to mid-speed range on such a high-revving engine.

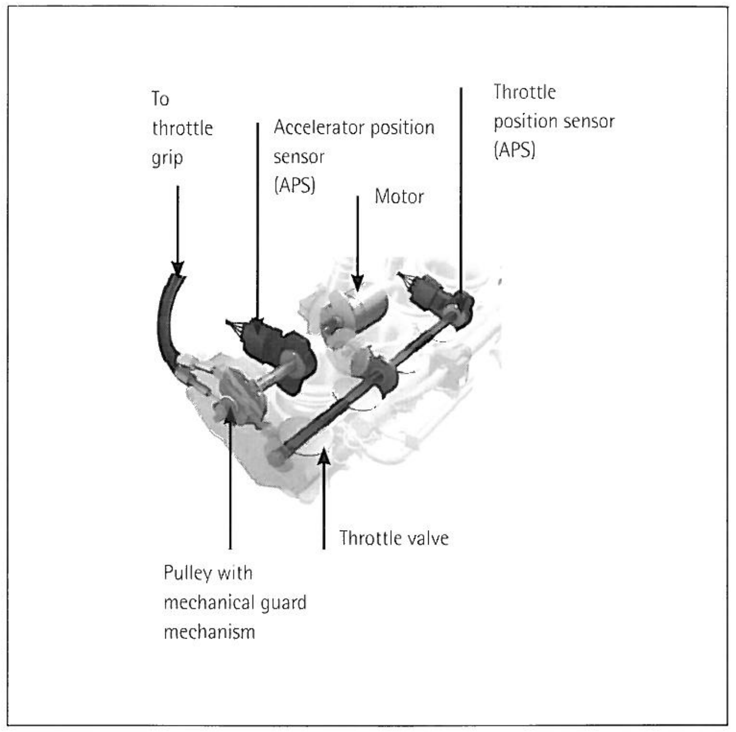


Mechanism and Characteristics

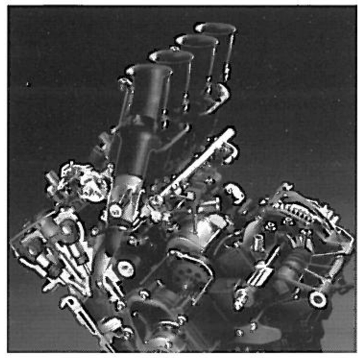
To solve this problem, Yamaha developed the YCC-T system employing the most advanced electronic control technologies. Electronic control throttle systems have been used on automobiles, but Yamaha has developed a faster, more compact system specifically for the needs of a sports motorcycle. The Yamaha-developed system has high-speed calculating capacity that produces computations of running conditions every 1000th of a second. (Control signals every 100th of a second)

The YCC-T system is designed to respond to the throttle action of the rider by having the ECU unit instantaneously calculate the ideal throttle valve opening and generate signals to operate the motor-driven throttle valve and thus actively control the intake air volume.

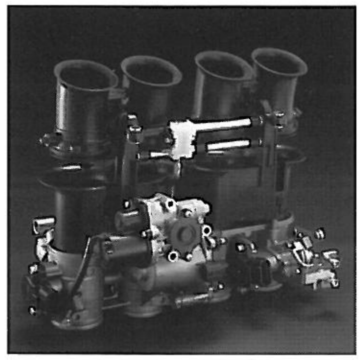
The ECU contains a 3CPU having a capacity about five times that of conventional units that makes it possible for the system to respond with extremely high speed to the slightest adjustments made by the rider. In particular, optimised control of the throttle valve opening provides the optimum volume of intake air which makes for easy to use torque characteristics despite being a high-revving engine.



2007 YZF-R1



YCC-I (Yamaha Chip Controlled Intake)



Servo motor-driven electronic-control variable intake funnel system

Background

The air intake duct and funnel affect the volumetric efficiency of an intake system. The down-stroke of the piston creates negative pressure in the intake passage and results in a difference in pressure with the air due to inertia that works to keep the air in place. This pressure difference causes a reaction in the direction of the intake valve that functions to increase volumetric efficiency. This also causes a pulsing effect that influences the engine character.

Generally, the intake passage length is designed to achieve the best volumetric efficiency in the rpm range at which the engine is most often used. A long intake passage length (including the funnel) is better for low- to mid-speed use, while a shorter length is better for high-speed use. A shorter intake passage produces a faster pulse to the pressure wave which maximises volumetric efficiency at a higher speed. Conversely, a longer intake passage has the opposite effect.

In other words, funnels of different lengths have different areas where they function best.

The electronic control servo motor-driven variable intake funnel system adopted on the 2007 model YZF-R1 has been developed to achieve a powerful, easy to use engine character by making active use of the characteristics of funnels of different lengths while also taking advantage of the FI system's capability to provide the right amount of fuel to the engine in accordance with changes in the intake

This electronic-control servo motor-driven variable intake funnel system is a feature that embodies Yamaha's 'G.E.N.I.C.H.' engineering concept that makes assertive use of state-of-the-art electronic control technologies to increase 'Rider-Machine Communication' in ways that create an even higher quality ride. This is the first of its kind in the world to be adopted on a production motorcycle.

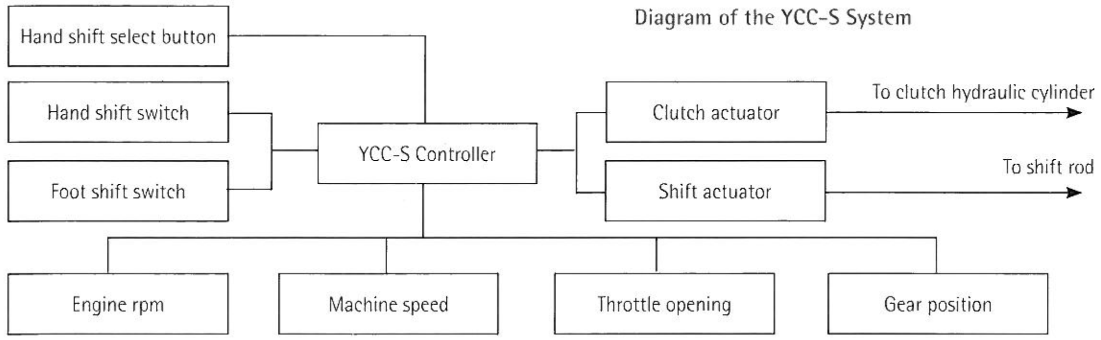
Mechanism and Characteristics

This servo motor-driven electronic-control variable intake funnel system adopted on the 2007 model YZF-R1 adjusts the length of the funnel between a long and a short length depending on engine rpm and throttle opening.

The four plastic resin lightweight funnels are each divided into upper and lower portions that in their normal connected position create a long funnel length. When engine rpm enters the high-speed range and exceeds a specific rpm and the throttle opening is also above a specific level, the funnel parts separate in a way that only the shorter bottom part functions. The switching of the funnels is performed instantaneously by means of electronically controlled servo motors.

By providing a mechanism to switch between a long and short intake funnel, with their respective torque and power curves, it helps the engine achieve larger usable torque and power curves. This makes it an engine with a broad power band that sacrifices no areas from low to high speeds and is sure to offer an exciting ride across the entire speed range.

Diagram of the YCC-S System



2007 FJR1300AS

YCC-S (Yamaha Chip Controlled Shift)

A system to eliminate the need for clutch action when cruising

Background

The YCC-S system mounted on the 2006 model FJR1300AS is an item that brings greater riding ease on the cruising scene. It is a system that contributes to the riding enjoyment and sporty performance of this tourer and eliminates the need for bothersome clutch operation in situations like traffic jams in city riding.

Mechanism and Characteristics

The FJR1300AS mounting the YCC-S system has no clutch lever and gear shifting can be performed either by means of the foot shift switch located where the conventional shift pedal would be or by a hand shift select button located in the left handlebar switch box. The YCC-S system eliminates the clutch operation while providing smooth running in all situations from start-ups through acceleration, deceleration and full throttle acceleration by automatically operating the clutch in accordance with engine rpm and throttle opening. Information about engine rpm, running speed, gear position and throttle position (TPS) is constantly fed to the YCC-S system's ECU so that calculations can instantly be made in response to the rider's gear selection to govern the appropriate clutch operation.

In the clutch mechanism, the clutch actuator moves the pushrod to create the optimum clutch stroke condition. Meanwhile, in the shift mechanism the shift actuator moves the shifter to perform a smooth and efficient gear change. When up-shifting, the system controls the ignition timing to adjust the engine rpm for an efficient and smooth gear change.

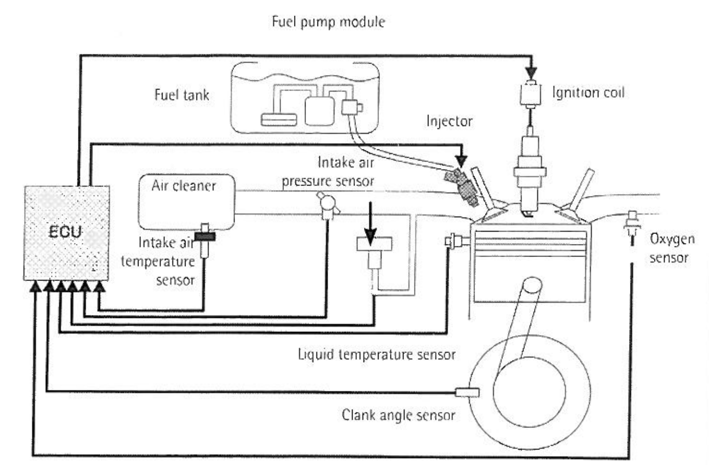
The YCC-S also links the FI and ABS systems to ensure outstanding riding ease and comfort. Rather than automatically performing the up- and down-shifting, this system lets the rider enjoy making the gear shifts at will.

YCC-S offers the merits of (1) eliminating bothersome clutch operation in around-town riding, (2) smooth acceleration/deceleration characteristics, (3) a big reduction in chassis reaction during shifting and a more comfortable ride, (4) greater convenience in shift operation (option of hand operated shifting) and more.


2007 FJR1300AS

Fuel Injection (FI) technologies

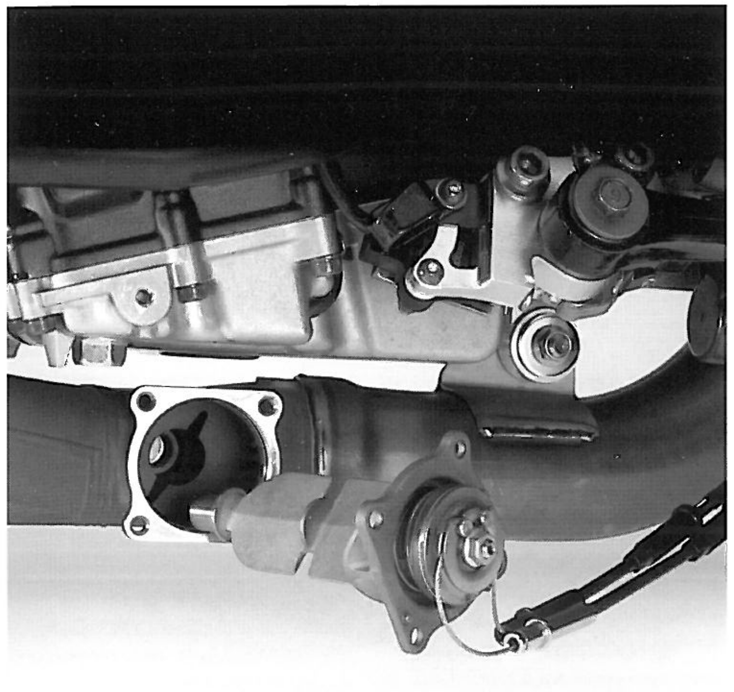
Yamaha began research efforts in turbo power and fuel injection (FI) systems in the 1970s while developing the Toyota 7 model. The first fruit of this research was the FI system mounted on the XJ750D motorcycle released by Yamaha in 1982. This system achieved high power output and good fuel economy by replacing the conventional air-flow meter, which caused a resistance factor in the intake with a hot wire type air-flow sensor installed in the air cleaner as part of the array of sensors feeding the microcomputer control fuel supply system.



The GTS1000 model released by Yamaha in 1992 further added a 3-way catalyser in combination with FI to achieve both excellent driveability and outstanding environmental performance. Employing a throttle sensor, intake pressure sensor and crank angle sensor as its main control sensors, it was possible to create a more compact FI system that eliminated the air-flow sensor. After that, Yamaha continued to refine its FI technology with the aim of achieving both excellent driveability and environment-friendly performance. These systems have been used on Yamaha's larger displacement models.

On the other hand, the complexity of system layout made the adoption of FI on motorcycles difficult. In answer to this need, Yamaha developed an FI system designed specifically for small displacement motorcycles in 2002. This system simplified both the sensor functions and the fuel supply system as much as possible so that up to eight sensors used on conventional systems could be reduced to just four sensors. This system has since been applied to many Yamaha scooters, from the YP400 to the XF50. For its sports models, Yamaha has developed FI systems that meet the specific needs of each model. These include the suction piston fitted system that creates smoother response when the throttle is applied and increases the speed of the intake air flow (2002 model YZF-R1), sub-throttle valve fitted system that utilises a motor-driven sub-throttle valve governed by ECU-processed information about engine rpm and throttle opening to adjust intake air volume (2004 model YZF-R1).

On the 2006 model YZF-R6, a twin injector fitted FI system has been adopted that supplements the main injector with a secondary injector that injects additional fuel in the mid to high-speed range. This combines with the YCC-S (electronic control throttle) to achieve very smooth torque characteristic despite the extremely high-revving character of the engine.




2007 YZF-R1

EXUP (Exhaust Ultimate Power Valve)

A device to improve torque characteristics by optimising exhaust pulse

Background

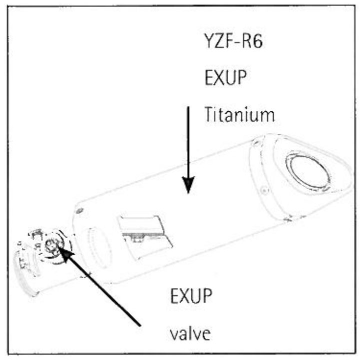
In high power output, high revving motorcycle engines, the overlap in intake and exhaust valve opening is usually set longer than in the average engine in order to create a smoother intake exhaust flow.

However, when this overlap causes exhaust gases reflected back from the muffler to the vicinity of the exhaust valve to interfere with the escape of the exhaust, it creates a disruptive effect called 'blow-back.' Correcting this effect was a long-time engineering theme.

Mechanism and Characteristics

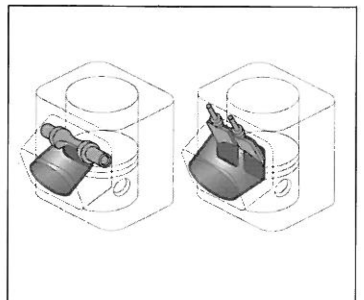
The Yamaha exclusive EXUP system employs a variable valve (constricting) in the muffler which functions to adjust the cross-section surface area of the exhaust pipe, in accordance with factors like engine rpm, in order to control the exhaust pressure pulse. It optimises conditions at the exhaust valve vicinity during the overlap period to improve intake/exhaust efficiency and reduce power loss due to blow-back effect. After first applying EXUP to the 1987 FZR400R, improvements were made to the system over the years as it was applied to a large number of Yamaha four-stroke models from four to two cylinders.

The 2004 model YZF-R1 adopts a new compact version of the EXUP system which places just two EXUP valves that control the pulse at the points where the two left and two right exhaust pipes are merged, instead of having a separate valve for each of the four pipes like the former system. The valve drive is operated on the basis of information about rpm, machine speed, throttle opening, throttle opening/closing speed, the gear the transmission is in, etc. This combines with the ignition timing control to achieve outstanding response.



2007 YZ250

YPVS (Yamaha Power Valve System)



YPVS on the YZR500

A power-boosting system born of environment-friendly engine development

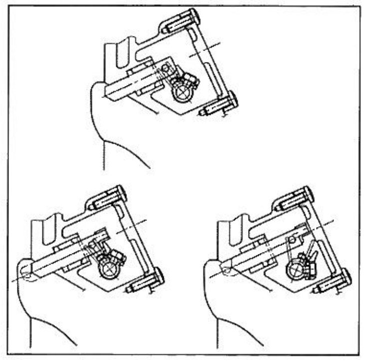
Background

Compared with the average four-stroke engine, the exhaust of a two-stroke engine has only about 1/10th as much NOx content.

However, because the two-stroke has no specialised intake and exhaust valves, blow-by occurs at a rate that gives the two-stroke's exhaust higher HC content than a four-stroke. Therefore, reducing the HC in two-stroke exhaust has long been a developmental theme.

The Yamaha Power Valve System (YPVS) is a system born of ideas that emerged from development of more environment-friendly engines which solve this blow-by problem and it was first refined on our factory race machines.

YPVS on the model YZ250



It was first unveiled on our YZR500 GP racer in the Finland GP of the 1977 World GP season. Then, from the 1978 season it was used as a full-blown system of the YZR500 road racer and the YZM250/125 motocrossers. Research results from these racers led to further development and finally adoption on our production models, beginning with the 1980 TZ500 (production racer). Since then, improvement has continued and it is presently used on our YZ250/125 motocrossers and our personal watercraft (WaveRunners). Because the system also serves the function of controlling exhaust temperature, a catalyser will function more effectively in combination with YPVS.

Mechanism and Characteristics

In general, quicker exhaust timing produces a high-speed, high power output engine character and slower timing produces better low-speed and torque performance. Since a high power output racing engine also needs strong torque for acceleration coming out of the curves, YPVS was an innovation that could provide both of these qualities which a racer needs.

The system is composed of a valve fitted to the cylinder's exhaust port and made to rotate or slide in accordance with the engine rpm to make the upper edge of the port narrower or wider, the effect of which is to quicken or slow the exhaust timing. The operation of the valve is controlled on the basis of factors including the engine rpm, degree of throttle opening, etc.

2007 YZF-R6

Forced air intake

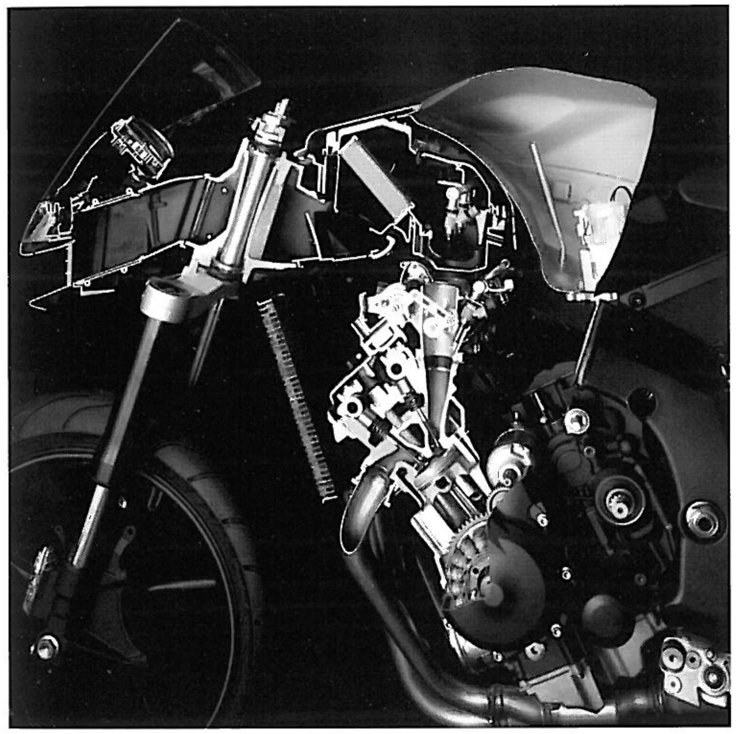
An item to increase power output by using the running air-flow pressure to pressurise the air box

Background

Intake/exhaust efficiency, combustion efficiency and reduction of horsepower loss are said to be the three main elements which determine engine performance. But, most important of all is the capability to supply the engine with more air to bring out the full performance potential.

The forced air intake system (supplied to the air box) adopted on the YZF-R1 and YZF-R6 directs the flow of air created when the machine is in motion into the air box to pressurise it, with the aim of increasing intake air supply as a means to boost power output.

It also has the advantage of supplying cooler and denser air. When riding in the high-speed range, this system can boost engine power output by several per cent (in Yamaha tests).



Mechanism and Characteristics

Yamaha's first forced air intake system was adopted in 1994 on the GP factory machine YZR500 and it has continued to be developed since. It is also used on the TZ250 production road racer.

The first time this system was used by Yamaha on a production sports model was with the 1999 YZF-R6. The special frame design adopted with this system provides for air intake ducts that run through the frame called the 'air induction design'. With subsequent development of the R6 the 2006 model now adopts a design like the 2005 MotoGP race machine which has air induction ducts running through the head pipe assembly. This minimises interference with the radiator assembly and helps contribute to both better cooling function and increased intake efficiency.

2007 YZF-R1

Deltabox frame

A frame design born of GP machine development

Background

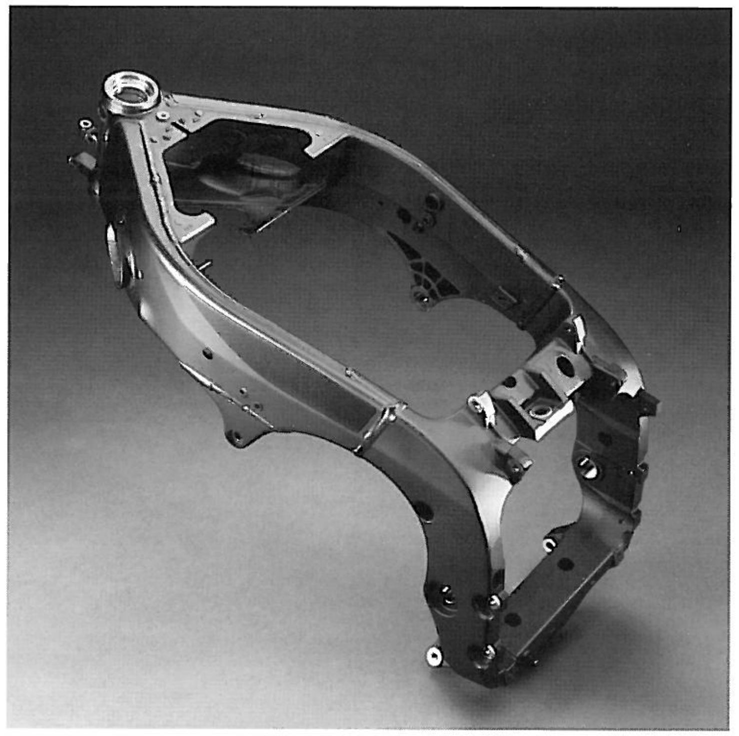
The aluminium Deltabox frame was first used on the 1983 model YZR500 GP factory racer. This aluminium Deltabox frame then went on to be used on a number of factory machines and eventually was fed back into Yamaha's production supersport models. The major impact of this frame can be seen today in the supersport machines of all the world's motorcycle makers.

Mechanism and Characteristics

The main distinguishing characteristic of the Deltabox frame is that it connects the head pipe and the pivot assembly with as straight a line as possible, in a way that provides outstanding rigidity. It also widens the upper and lower points of the head pipe in a shape that looks like a delta (triangle) when seen from the side. Another characteristic is the box-shaped cross-sections of the frame members that provide a large cross-section area. The frame is made of the ideal types of aluminium for the various sections, which are designed with attention to overall balance so as to achieve the light weight and high rigidity a particular model frame needs to ensure excellent handling characteristics.

With further development on Yamaha's race machines after its invention, this Deltabox frame created a sensation on the GP scene. With further development it was also used on many production models.

The latest Deltabox frame used on the 2006 YZF-R6, like the YZF-R1, is a hybrid of mould cast and pressed aluminium parts. As with Yamaha's MotoGP machines, optimisation of the engine mounting position and the rigidity balance of the rear arm in the vertical and lateral directions and with regard to torsion, makes this a frame that contributes to linear and sporty handling performance.



2007 MT-01

CF Aluminium die-casting technology

Aluminium die-casting technology that enables more highly designed exteriors

Background

Aluminium is only about 34% the weight of steel and it exhibits stable flow characteristics in the molten state, which makes it well suited to casting. These merits of aluminium are put to use in many Yamaha products. The Yamaha CF (Controlled Filling) Die-Casting Technology is one that has been developed to get superior results in cast aluminium.

This technology was first made practical use of in the rear arm and rear frame of the 2003 model YZF-R6, followed by use in the main frames of the 2004 model FZ6 and the 2004 model YP400. This method provides greater design freedom and also greatly reduces the number of parts needed and reduces weight in comparison with conventional steel frames.

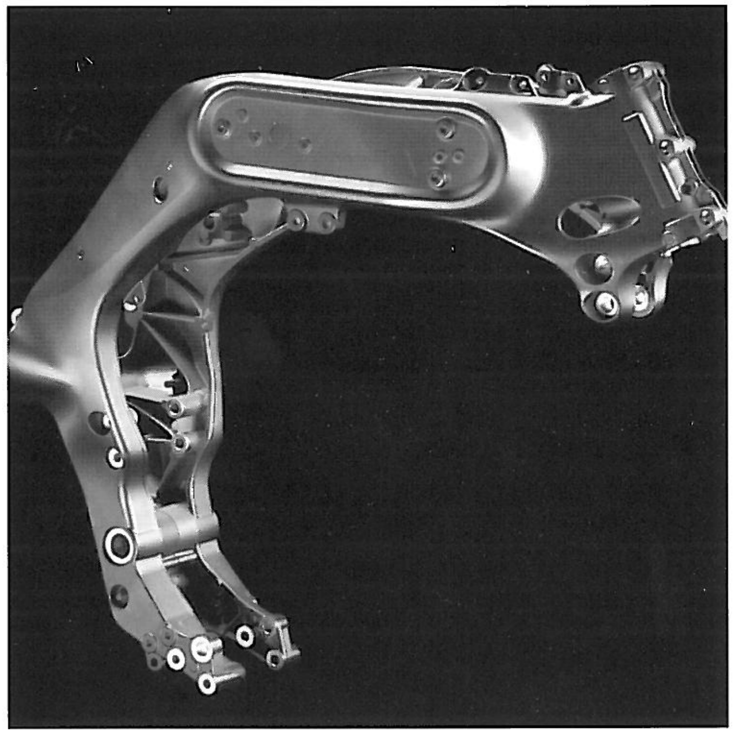
The lighter weight and outstanding rigidity balance made possible in frames made by this method improves handling stability and riding comfort while also contributing to the creation of distinctive exterior styling due to the great design potential for parts made by this method.

Mechanism and Characteristics

Conventional high-pressure die-casting methods that involve injecting molten aluminium into a die under high pressure and at high speed had the drawback of producing cast parts which included a considerable amount of air bubbles and oxidised material compared with other casting methods, and this weakness limited the ability to cast thinner parts or complex curved parts. The presence of the air cavities also make aluminium parts cast this way unsuitable for welding. Yamaha developed its CF die- casting method to solve these problems.

The method involves (1) using specially developed sealing material to create a more complete vacuum (six times more complete than conventional method) to reduce air resistance within the mould, (2) controlling the temperature of the mould so that the temperature of the molten aluminium remains more stable and (3) increasing the speed with which the molten aluminium is injected into the mould (five times faster). The combination of these measures produces cast parts with about one fifth the content of air cavities. The result is stronger parts that can also be welded together.

This makes it a mass production method with the capability to produce larger and thinner parts than was previously possible with conventional die-casting methods, while also increasing the design and styling freedom and reducing the number of parts necessary and the weight of the finished components. This enables the design of products with greater styling freedom.



2007 YZ250F

Monocross suspension

A unique technology that revolutionised suspension design

Background

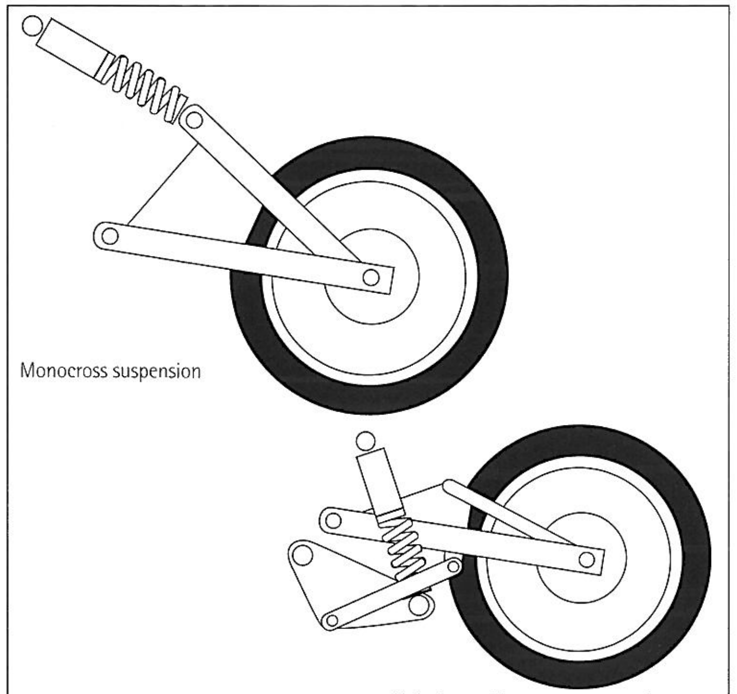
This is one of the truly epoch-making innovations in the history of Yamaha's technology development. By employing a single shock absorber which is positioned with its front end fixed to the intersection point of the head pipe and fuel tank rail and its rear end to a triangular rear arm, this system absorbs the shocks involved in the vertical movements of the rear wheel whilst redirecting that vertical movement into a horizontal one.

The basic structure of this suspension was the result of Yamaha research and development efforts based on an original idea for which Yamaha acquired the patent from a Belgian university professor named Lucien Tielgens in 1972. The first Yamaha motocross factory machine mounting this suspension won its debut race in 1973. The following year, a YZR500 road racer debuted with this suspension and brought Yamaha outstanding race results in both the on-road arena as well as off-road.

Mechanism and Characteristics

Because conventional rear suspensions until that time used two shock absorbers on the right and left sides to support a swinging arm, there was a problem with the effect on the rear arm and the ride of the machine as a whole when the two shock absorbers reacted differently to strong shocks from the road. With the monocross suspension,because a triangular rear arm with strong rigidity regarding lateral torsion was supported by a single shock absorber, this problematic tendency was reduced. Also, the different positioning of the shock absorber enabled greater wheel travel, improved road surface follow and running performance and made the ride more comfortable.

What's more, in a further evolution of the monocross suspension, a link was added between the rear arm and the shock unit to create a rising rate effect. With this, the suspension evolved into one that could react softly to small bumps and vibrations and then react firmly to large shocks of rapid actions based on the degree of stroke hard bottoming. Today, most Yamaha sports bikes use linked type monocross suspensions, but thanks to advancements in the shock units themselves, some models still function well today on unlinked type monocross suspensions.



2007 YZ450F

Titanium rear suspension spring

A spring made of titanium for weight reduction

Background

One of the things that distinguishes Yamaha as a maker, is our comprehensive approach to introducing new features which begins with research of new materials and continues all the way to the manufacturing stage. The titanium suspension spring adopted since our 2006 YZ motocrossers (except 85 cc) is a good example of this process.

Due to its strength, processing potential and availability, steel is generally used for suspension springs, but titanium has become the focus of attention as a metal with the potential to reduce the weight of springs. This is due to its advantages of high strength, resilience and durability compared with steel. However, there is difficulty in processing titanium that has kept it from being used in all but a few European automobiles and motorcycle factory racers. Yamaha's rear suspension titanium spring is the result of research and analysis of the metal's crystal structure, stress distribution and manufacturing processes, etc.

Mechanism and Characteristics

The reason that titanium is hard to process (shape) is its crystal structure. In terms of crystal structure, metals can be classified into three types: those like magnesium and titanium with complex close-face hexagonal crystal that are difficult to process, metals like aluminium with face-centred cubic crystal and those like steel with a body-centred cubic crystal that are easy to cold-work. Because of its close-face hexagonal crystal structure, titanium is inherently hard to cold-work. However, it exhibits a phenomenon by which the crystal structure converts to body-centred cubic crystal structure when vanadium or cobalt is added to it. Titanium of this type with a body-centered cubic crystal structured is called beta-titanium and is used in some industries.

Furthermore, in recent years, use is being made of so-called 'new beta-titanium' alloy that uses elements which are less expensive than vanadium or cobalt, such as molybdenum and aluminium. Yamaha took this new beta-titanium and started from zero to make a spring that would have good reliability and be comparable in strength and resilience to a beta-titanium spring, using analysis of factors like stress distribution per stroke and stroke frequency in different types of riding conditions. The resulting data was then applied to the spring design elements, like optimising a number of coils and size and shape, and programming the manufacturing process, to include the necessary shot peening and heat processing to achieve stable, high-level fatigue strength. The result is a spring with 30% lower weight and boosted performance in terms of suspension follow and functional feeling.

2007 FZ1 Fazer

Left-right independent cushioning system

2-way compression damping adjustment mechanism

A new mechanism that simplifies suspension setting

Background

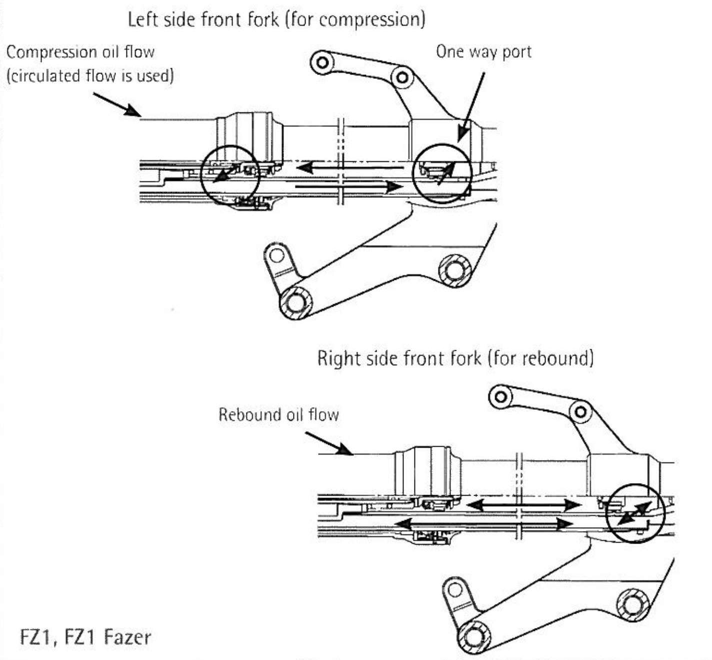
In the thirty years since the monocross suspension came into practical use, Yamaha has developed a wide range of suspension technologies. Lately, we are giving our different motorcycles a variety of mechanisms that make it possible to give fine adjustments to the suspensions to accommodate a wide range of riding conditions, from sporty circuit riding to general touring.

Mechanism and Characteristics

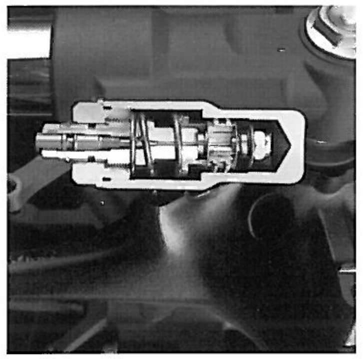
Left-right independent cushioning mechanisms

The FZ1 and FZ1 Fazer feature a front fork with separate damping force generation for the right and left shock absorbers. In this mechanism, compression stroke damping force is generated on the right side shock and rebound stroke damping on the left side and it is designed in a way that the oil creating the damping effect is always flowing in the same direction, which makes it easier to achieve the desired setting.

Independent damping front suspension

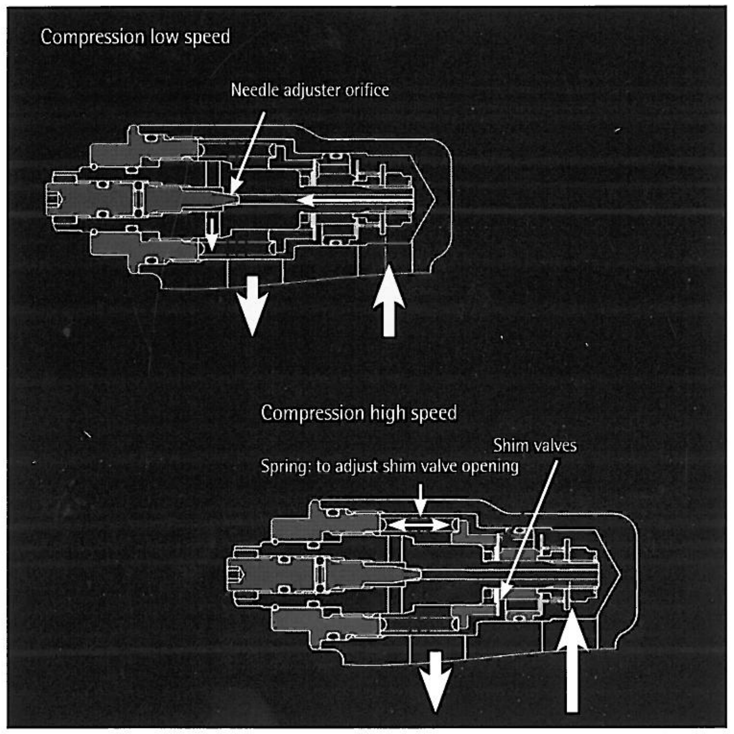


FZ1, FZ1 Fazer



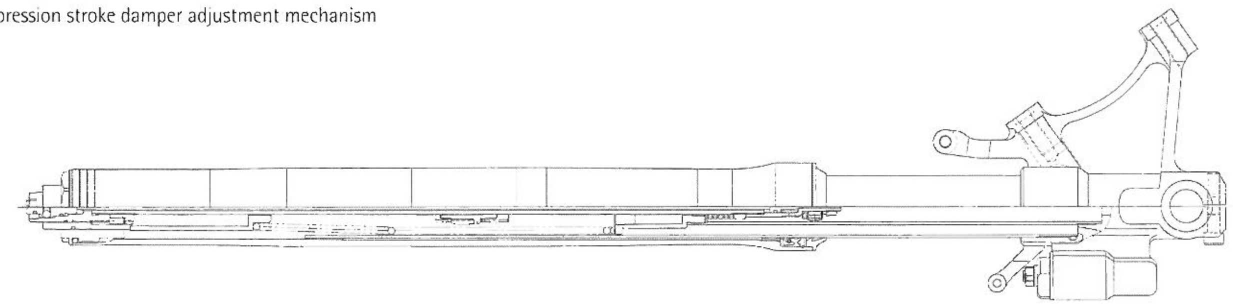
Two-way compression damping adjustment mechanism

The new mechanism featured on the 2006 model YZF-R6 is a two-way compression stroke damper adjustment mechanism for the front fork. This mechanism is characterised by the fact that compression stroke damper adjustments can be made via separate valves for the high-speed side and low-speed side. This makes it possible to make settings for both public road riding and circuit running. Meanwhile, the rear suspension features the same two-way compression stroke damper adjustment as the front fork. Adjustments can be made to the low-speed and high-speed sides to select optimum cushioning effect for different road conditions and uses.



YZF-R6

Two way compression stroke damper adjustment mechanism



2007 FJR1300AS

ABS* (Anti-lock Brake System)

UBS (Unified Brake System)

A system to control slipping in the direction of wheel rotation when braking

Background

This is a brake system developed to prevent the tendency for the wheels to lock during braking on a variety of different road conditions so that the full grip potential of the tyres is maintained. The system is designed so that signals sent from the front and rear wheel revolution sensors are processed instantaneously by the ECU (Electronic Control Unit) to control the brake hydraulic systems to effectively avoid wheel lock.

The front-rear independent ABS system developed by Yamaha was mounted first on the 1991 FJ1200A and 1993 GTS1000A production models, and in 1998 a more compact version was adopted on the Majesty ABS. Since then, this system has been used on several European market models. For 2006 the most recent type is mounted on the FJR1300A/AS.

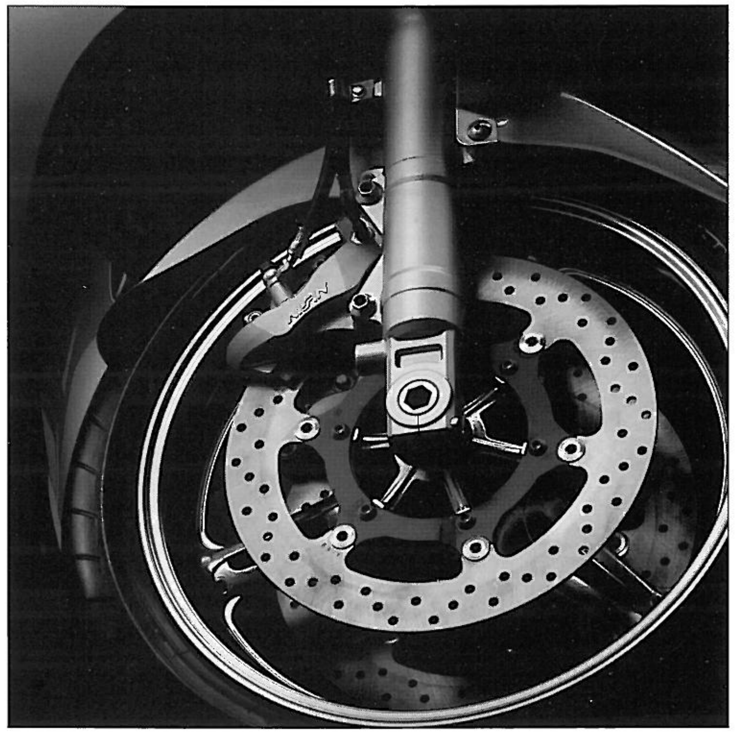
Mechanism and Characteristics

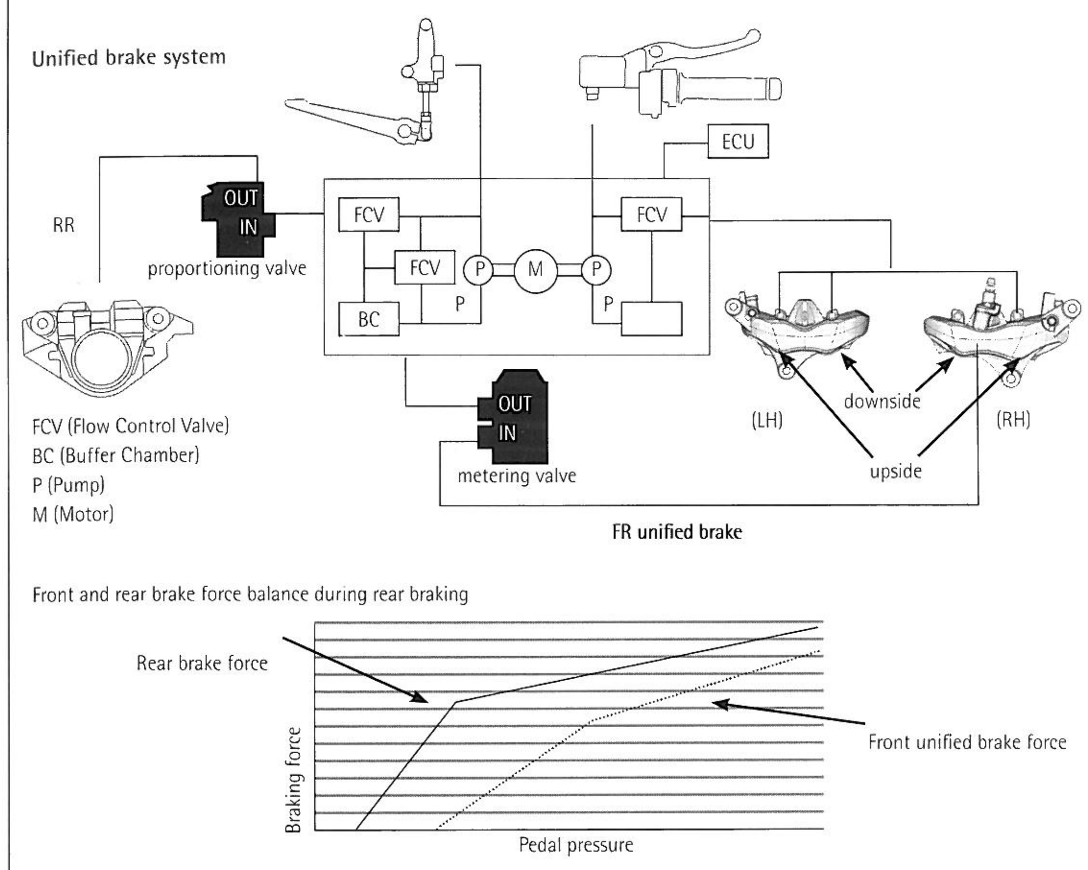
On these ABS units, the ECU monitors the revolution signals coming from the front and rear wheel sensors to calculate wheel revolution speed, deceleration speed, machine running speed and slipping, and is mapped to instantly recognise slipping and determine the occurrence of locking tendency when the deceleration rate exceeds a certain pre-determined value.

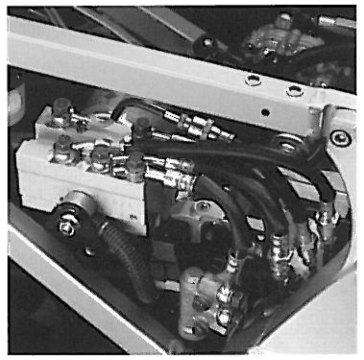
Then the ECU sends command signals to the hydraulic control systems. When the hydraulic control systems receive this information from the ECU, it functions to reduce hydraulic pressure in the brake system until it drops below the lock tendency level, at which point it then proceeds to increase the pressure to an appropriate rate.

The repetition of this process makes possible control which effectively eliminates wheel locking. When the ABS system goes into effect, it signals the rider that a lock condition exists and the system is in effect by means of an instantaneous repulse of the brake lever (pedal).

** ABS is a system that senses when a locking tendency exists in the wheels and controls the amount of pressure applied to the brake pads. It is not a system that prevents wheel locking due to engine brake effect. Also, just as with a vehicle equipped with regular brakes, side force is reduced when the brakes are applied. So you must be sure to avoid applying the brakes sharply during cornering, because it will result in vehicle instability no matter where there is an ABS function or not.*







For outstanding performance in touring

Background

The Yamaha Unified Brake System is designed to achieve an excellent brake feeling by automatically generating just the right amount of braking pressure on the front wheel whenever the rear wheel brake is applied. In combination with Yamaha's ABS, this system provides outstanding performance in touring-type riding conditions. The system has been standard equipment on the FJR1300A/AS since the 2006 model.

Mechanism and Characteristics

With the Unified Brake System mounted since the 2006 model FJR1300A/AS, the hydraulic pressure generated by rear brake operation is mechanically separated and when the hydraulic pressure exceeds a certain prescribed level, it generates hydraulic force in the front brake. The part of the front brake that this system activates in response to rear brake action is the lower opposed pistons of the four-pot opposed piston caliper on the right side. The front brake lever operates the remaining six pistons (the upper opposed pistons of the right-side caliper and the four opposed pistons of the left side) to provide forceful stopping power.


2007 XVS1300A Midnight Star

Pressing technology for low-profile design

A manufacturing technology that enables a low-profile cruiser design

Background

Motorcycle fuel tank manufacture usually begins with the shaping of three thin steel parts that form the left and right sides and bottom of the tank. These parts are formed in a press with a specially shaped mould against which the sheet metal is pressed within a matter of seconds. These three pressed parts are then welded together, then weld seams are hand polished after initial removal by robotic processing and the finished tank is painted.

However, when attempting to shape sheet metal of just a few millimetres thickness into the tight curved surfaces necessary for a super-flat shaped fuel tank, slight stretches are created in the steel that can result in discrepancies in thickness, wrinkles and even cracking (surpassing shaping characteristic limits). To solve this problem and get the kind of super-flat shaped fuel tank desired on its cruiser models, Yamaha developed an exclusive press-shaping technology.

Mechanism and Characteristics

In the case of the super-flat shaped fuel tank used on the Yamaha Road Star Warrior, the key was to (1) develop a new steel alloy with outstanding elasticity and (2) develop the tank design using forming simulation technology. The typical steel alloy used for motorcycle tanks contains titanium, niobium and boron. Yamaha sought to independently develop one of these is super-low carbon content steel alloys (less than 0.02% carbon content) with especially high elasticity. In this new alloy, titanium, with its excellent anti-rust qualities, was used instead of the conventional boron and the amount of niobium with its important role of fixing the carbon content in the steel was optimised to get a new alloy with excellent elasticity.

Furthermore, computer simulations of the forming process were run to achieve a comprehensive analysis of exterior design, stretch conditions of the metal, strength and rigidity all at the same time. This enabled the creation of a super-flat shaped fuel tank now previously possible on a cruiser model, with a look close to a custom-made tank.

Now, this integrated press shaping technology including everything from material research and development to design development using forming simulation is now being used actively on many Yamaha models.


2006 Passol

In-wheel motor and YIPU

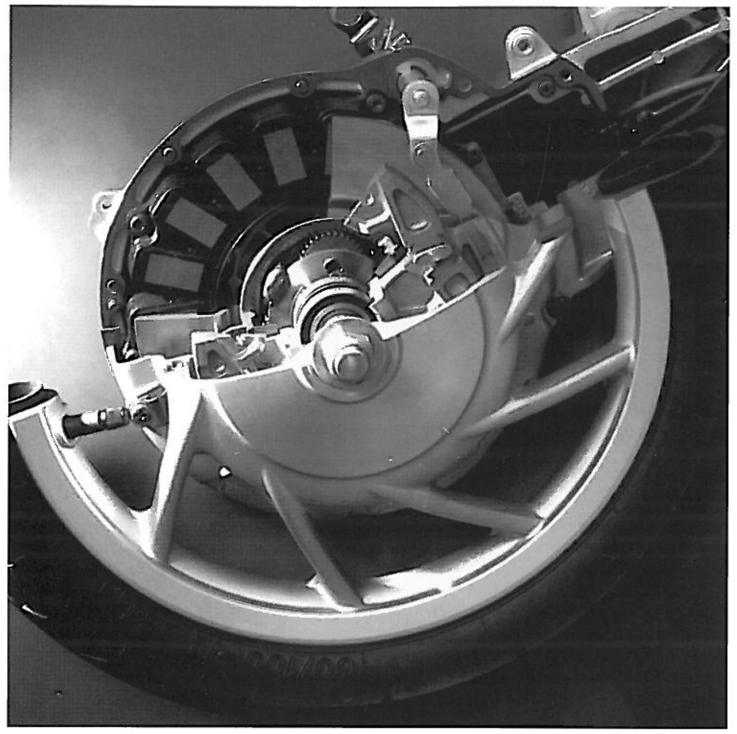
A lightweight, compact system and control technology for a two-wheeled EV

Background

Since 1993, Yamaha has been manufacturing and selling the PAS electro-hybrid bicycles with the aim of returning to the origins of the personal vehicle, the utility of the bicycle. Since then, the PAS has won support as a product that provides new potential for the bicycle that is relevant as an answer to today's environmental and traffic issues.

As for two-wheeled electric vehicles (EVs), Yamaha has engaged in many years of research and development, beginning with the concept model 'Frog' displayed at the 1991 Tokyo Motor Show. The Passol is Yamaha's proposal for a new type of commuter vehicle with a new type of power source for the near future that utilises control technologies developed for our PAS electro-hybrid bicycles along with a number of Yamaha-exclusive human interface technologies.

At the heart of the Passol is the YIPU (Yamaha Integrated Power Unit).



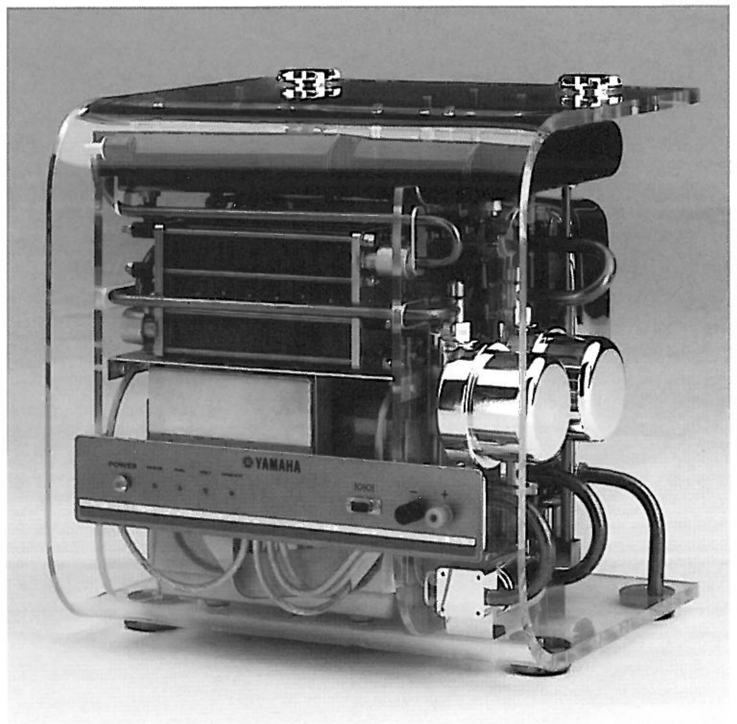
Mechanism and Characteristics

The super-slim YIPU power unit mounted on the Passol integrates into the rear hub (1) a super-flat opposing type brushless DC motor, (2) a super compact controller, (3) a planetary-type decelerator transmission unit and (4) a drum brake.

To achieve even greater compactness, this is all then built into the vehicle's rear arm. In combination with the electronic throttle and advanced motor control functions, this unit provides clean and smooth running performance.


FC-me

Direct Methanol Fuel Cell (DMFC)



A fuel cell system for small motorcycles

Background

An engine by nature accumulates heat when running and Yamaha has been involved in research concerning fuel cells as a clean-running, efficient power source since more than 20 years ago. As the fruit of these efforts, Yamaha unveiled in 2003 the FC-06, which is powered by a Direct Methanol Fuel Cell (DMFC) system. Since September 2004, the 'FC-06 PROTO' mounting this system has been licensed for use on public roads and has been used for gathering data for further research and refinement.

In September 2005 Yamaha announced the development of a new fuel cell motorcycle named the FC-me with further improved performance in areas like reliability and ease of use. This model has performance matured to the point that a contract has been signed with a Japanese government agency in the same month for use on a lease basis, which provide further data for continued development. The main technology in the model is the Yamaha DMFC system.

Mechanism and Characteristics

The fuel cell systems now being developed for automobiles is the Polymer Electrolyte Fuel Cell (PEFC) that uses hydrogen as its fuel. In contrast, there is also a direct methanol fuel cell (DMFC) that uses methanol directly as its fuel. For applying a fuel cell system to a small motorcycle with its limited space available, the DMFC is considered to be the most suitable system.

The DMFC is inferior to a compressed hydrogen gas type fuel cell, but it has many other practical advantages, such as the fact that it can use liquefied fuel and the fact that it does not freeze easily in cold conditions. Also, the DMFC requires less peripheral components like a hydrogen tank or a cooling system for the cell stack. This means that for achieving running performance equivalent to a gasoline engine small scooter, which requires an average consumption of several hundred Watts of electricity, a DMFC has the potential for being a lighter, more compact system than a PEFC using hydrogen as fuel. Yamaha's FC-me is a model built around these advantages of a DMFC system and designed as an EV personal vehicle that achieves sufficient running distance and ease of use as well as environment-friendly performance.

Thanks to optimisation of its control parameters for the fuel cell, the FC-me achieves an energy conversion efficiency that is 1.5 times better than the FC-06 PROTO and 1.8 times better than a four-stroke 50 cc gasoline engine motorcycle whilst maintaining a light machine weight of just 69 kg.