

2007 Model CBR1000RRW for Suzuka 8 hours World Endurance Championship Race

Eiichi KANDA*

Masamune OHIGASHI*

Hiroshi UNUKI*

Nobuo SHIGEMIZU*

Yukihide AKITSU*

ABSTRACT

An endurance motorcycle has been developed to take part in the 2007 Suzuka 8 Hours Endurance Road Race. The calculation performance of the ECU has been increased against that of the 2006 model to enable more precise control, resulting in a 2.7% increase in power and the achievement of a balance between engine performance and fuel efficiency with no decline in the former. Increasing the inertial mass of the ACG rotor has moderated the transient characteristics during acceleration and reduced the engine brake load during deceleration. In addition, the use of slip control has increased stability and controllability and traction performance. The newly developed racing motorcycle displays reliable racing performance, and is capable of posting lower and stable lap times.

1. Introduction

From 2004, a change was made in the regulations in the Superbike class for racing motorcycles. Whereas previously 2-cylinder 1000 cm³ bikes competed with 4-cylinder 750 cm³ bikes, both 2-cylinder and 4-cylinder 1000 cm³ bikes will now be fielded. A balance between competitors is now achieved by basing the range of allowable modifications on the number of cylinders of the bikes. Honda has also pressed ahead with the development of production models to form the basis of its racing lineup. It has developed the 4-cylinder CBR1000RR to replace the previous 2-cylinder VTR1000SP and has commenced racing the bike. Figure 1 shows the 2007 model Honda Racing (HRC) race machine.

Honda won the Suzuka 8 hour world endurance championship race in 2004 and 2005.

From 2006 onwards, at the request of the organizers, Honda began competing in the Superbike category of the All-Japan Championships, the Japan Superbike (JSB1000) class. Compared to the previous Superbike regulations, the range of modifications that can be made to the engine is narrow, and thus, major increases in power cannot be expected. Honda has worked to enhance the performance and functions of the parts that are able to be modified and has conducted development programs that have resulted in enhancement of the total performance of the complete bike, but has not yet achieved an overall victory in the JSB1000 class.

The base performance of the 2007 model has not been considerably enhanced, but ECU performance has been enhanced and traction control has been employed, mainly focusing on slip control, in order to increase the level of power control. In addition to these changes, the motorcycle's fittings have been modified to enable the achievement of a consistent reduction in pit work times, which represents an important factor in an endurance race. This paper will discuss the technologies applied to the 2007 base model CBR1000RRW, including the parts that effectively increased performance, and unique parts employed for endurance race.



Fig. 1 2007 model HRC race machine

* Motorcycle R&D Center

Table 1 Comparison of regulations

	JSB Japan superbike	SBK FIM world superbike
Crankcase	No modification allowed	May be modified by welding or machining
Cylinder head	Only machining port area and base surface are allowed	May be modified by welding or machining
		Valve seats may be altered or replaced
		Valve guide may be altered or replaced
		Combustion chamber may be modified
Cylinder	No modification allowed	Sleeves, liner material may be changed
		Surface finish is free
Crankshaft	No modification allowed	May be altered or replaced
Piston	No modification allowed	May be altered or replaced
Piston ring	No modification allowed	May be altered or replaced
Piston pin	No modification allowed	May be altered or replaced
Piston pin clip	No modification allowed	May be altered or replaced
Connecting rod	No modification allowed	May be altered or replaced
Camshaft	May be replaced or modified	May be altered or replaced
Valve	No modification allowed	May be altered or replaced
		Valve diameter must remain as homologated
Valve spring	May be replaced. Material must remain as homologated.	May be altered or replaced
Valve retainers	No modification allowed	May be altered or replaced
Oil pump	No modification allowed	May be altered or replaced
Clutch	Clutch springs, friction disks, plates may be altered or replaced.	Aftermarket or modified clutches are allowed
	Quality of disks and plates must remain as homologated.	Back torque limiter is permitted.
	Addition of back torque limiting device is not allowed.	

2. Development Orientation

Until 2005, the Superbike class allowed an extensive range of engine modifications, enabling the desired performance level of the racing bike to be achieved without any major changes needing to be made to the performance of the production model used as the base model. Since 2006, the JSB1000 class has narrowed the range of allowable engine modifications, making it more challenging to achieve the desired peak power and partial power characteristics. It has therefore become necessary to enhance the total performance of the complete motorcycle in order to compensate for the decline in engine performance. In 2007, the company's second year of competition in the JSB1000 class, in addition to enhancing ECU performance in order to achieve an overall performance increase, Honda focused on the following areas:

- (1) Control of electrical equipment: Satisfaction of necessary drivability objectives while achieving a balance between traction performance and fuel efficiency.
- (2) Engine: Within the range of allowable modifications, the achievement of higher engine speed and enhanced functions and durability.
- (3) Frame: In addition to the use of parts designed

specifically for endurance race, the achievement of enhanced traction performance to enable effective transmission of power.

- (4) Fittings: Enhancement of maintenance operability in order to achieve a consistent reduction in pit work times.

3. Engine

Table 1 shows the range of engine modifications allowed in the Superbike and JSB 1000 regulations. Modifications can only be made to a limited number of parts in the JSB1000 regulations, and here only parts in which modifications have had an effect on performance and endurance are discussed.

3.1. Increase in Inertial Mass of Cam Shaft

In terms of the engine, increased rev cut engine speed and valve lift are necessary in order to achieve increased power. The cam chain is one of the parts for which the mass production specifications cannot be modified, and the reduction of the load on the part therefore represents an issue. Fluttering when the cam chain engages with the sprocket was focused on to increase durability, and the inertial mass of the cam shaft and the cam sprocket was increased to reduce the level of fluctuation in the speed

of the cam shaft. This increased the cam lift and the rev cut engine speed, maintaining the achievement of the necessary cam chain durability. In combination with these changes, valve timing was modified, contributing to increased power. Figure 2 shows a comparison of the form and inertial mass of the camshafts. Figure 3 compares the speed variation of the camshafts.

3.2. Increase in Inertial Mass of Crankshaft System

Reducing torque fluctuations during acceleration and reducing engine braking during deceleration were issues in the design of the bike. Class regulations prohibited modification of the mass production specifications of the crankshaft or clutch mechanism. Modification of ACG rotor was allowed, and the inertial mass of the rotor was therefore increased. To achieve the maximum mass in a limited space, the previous outer rotor configuration was replaced by an inner rotor configuration. As shown in Fig. 4, the inertial mass of the outer circumference was increased, which helps prevent sudden increases in engine

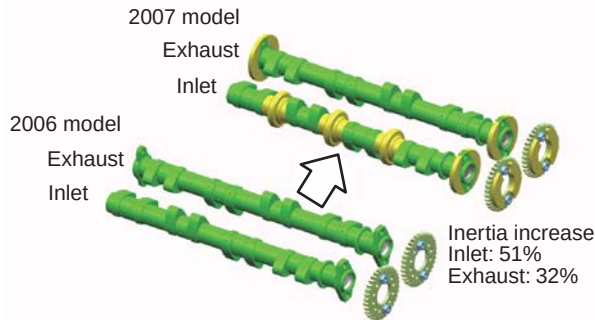


Fig. 2 Comparison of camshaft

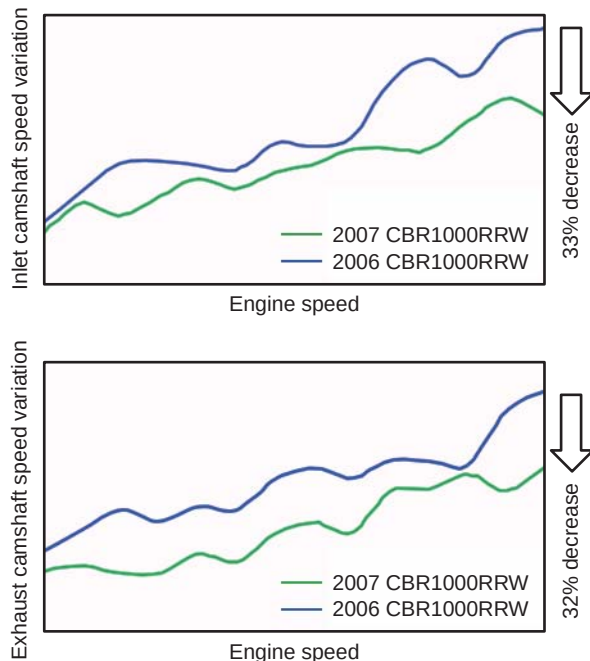


Fig. 3 Camshaft speed variation curve

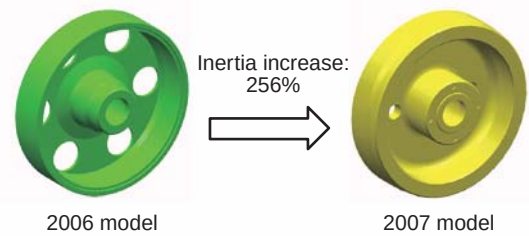


Fig. 4 Comparison of ACG rotor

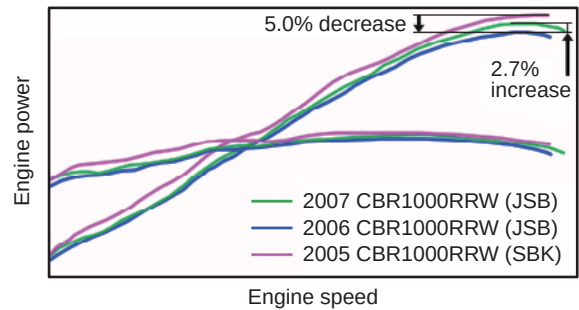


Fig. 5 Engine performance curve

speed that occur as a result of throttle operation, resulting in the achievement of a relaxed control characteristic. The increase in mass also reduced engine braking during deceleration, resulting in a smoother deceleration characteristic.

3.3. Increased Power

Building on the base of modified valve timing and increased cam lift, integrated management of parts tolerance selection and production lots was employed to control variations in specifications for each engine, resulting overall in a 2.7% increase in power and the reduction of power variation to 0.8%. Figure 5 shows a comparison of the power characteristic at wide-open throttle with Honda's 2004 Superbike. While a reduction in power is unavoidable, the modifications have enabled power to be stably provided.

4. Electrical Equipment/ Control

In order to respond to the decline in fuel efficiency with increased engine speed and realize traction control with a focus on power control, it was necessary to achieve fine ECU control. The ECU used until 2006, which was based on the production model, was therefore replaced with the higher-performance ECU used in MotoGP in 2007, which features a built-in data logger. This section will discuss the main benefits achieved through this change in the ECU.

4.1. Drivability

Until 2006, sudden increases in engine speed were judged as slip, and when they were detected, Δ ME engine

control (instantaneous change of engine speed) was applied to suppress them. In 2007, in addition to this system, the speed of the front wheel is being employed as a control parameter, and traction control that goes into effect when the speed of the front wheel is detected to differ from the speed of the back wheel is being employed. Δ ME controls sudden changes in engine speed and helps prevent slip from occurring. The employment of traction control in addition to this enables response to decline in tire grip and to changes in tire slip caused by deterioration of the quality of the road surface, etc. Figure 6 shows a comparison of riding data between the 2006 and 2007 models. Slip is reduced and smoother acceleration is achieved in the 2007 model.

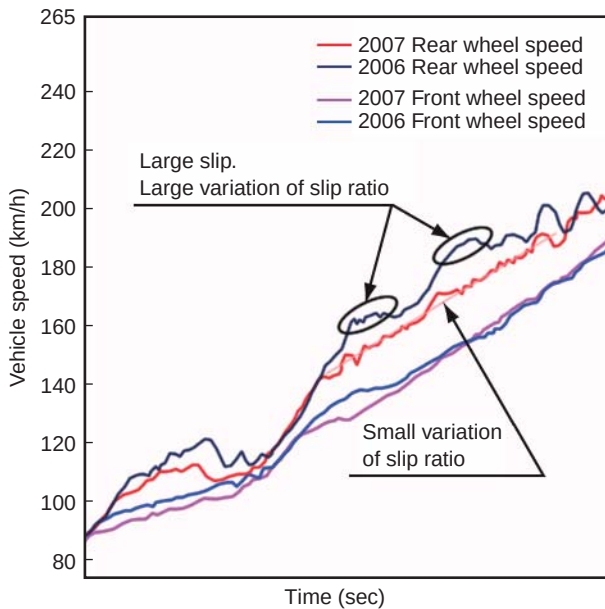


Fig. 6 Comparison of ECU control riding data (Hairpin exit on final lap of seventh stint)

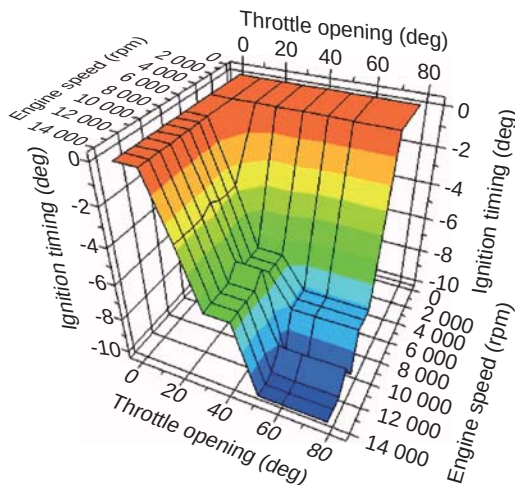


Fig. 7 Comparison of ECU control map

4.2. Fuel Efficiency

The use of an optional map without increasing the leanness of the base air-fuel adjustment has enabled an increase in leanness, which would cause a decline in the level of power achieved to date to be minimized, in turn enabling power to be used effectively and increasing fuel efficiency. In conditions under which tire grip declines and slipping occurs frequently, the rider is able to use the map switch to reduce loss of fuel efficiency due to slipping. Figure 7 shows the configuration of the map.

4.3. Setting Performance

The ability to find the optimum setting in a limited time is also an important factor. The modification of the ECU enabled the volume of setting data to be increased, enabling optional settings programmed as maps. Until 2006, the base map was adjusted and employed, but because riders are now able to select options while riding using a mode switch, in the 2007 model the settings have been made simpler and the amount of time it takes to set a mode has been decreased. The number of modes has been increased from two to three, increasing responsiveness to conditions during the race.

In addition, the integration of the data logger increased the ease of taking additional measurements of control parameters and control values, and the accuracy of the settings has been increased based on these measurements.

4.4. Pit Work

Wireless sending of setting data and wireless reception of riding data has been enabled. This has made pit work smoother, despite the fact that the mechanics who service the bike and the staff responsible for the settings are crowded together in a narrow space. In addition to reducing the time needed for pit work, wireless sending and reception has also enabled more time to be spent on adjusting settings.

5. Frame

The change in regulations involved in the change in class from Superbike in 2004 to JSB1000 did not considerably affect the frame. Because the base production model underwent a minor model change in 2006 and few changes were made for the 2007 model, this section will discuss only the changes made in the racing model to enhance the performance of the complete bike and the unique parts employed for endurance race.

5.1. Achievement of Enhanced Performance in Complete Bike

5.1.1. Swing arm and rear cushion

The width of the wheels had been increased to increase

the ease of replacing tires in the pit. This demanded the achievement of increased stability and controllability, and enhanced traction performance via the swing arm. The shape of the swing arm was modified to achieve increased rigidity and reduced weight, and the rear cushion reserve tank was positioned laterally, concentrating mass and making effective use of the space layout. The swing arm and rear cushion layout is shown in Fig. 8, and a map of swing arm rigidity is shown in Fig. 9. Maintaining torsional rigidity while reducing yaw angle rigidity and increasing the rear tire slip angle has enhanced turning performance (escape from cornering, etc.) and traction performance.

5.1.2. Front fork

From the 2005 model onwards, it was necessary to modify the rigidity of the front fork in order to balance stability during deceleration and cornering performance. Reinforcement of the outer tube with carbon fiber enabled longitudinal rigidity to be increased while maintaining lateral rigidity. In the 2007 model, the total length of the outer tube has been increased, resulting in increased stability and enhanced cornering. Increasing the rigidity of the outer tube itself would not have enabled the achievement of a balance between longitudinal and lateral rigidity, making reinforcement with carbon fiber the optimum method to be employed. Figure 10 shows the shape of the front fork and a comparison of rigidity.

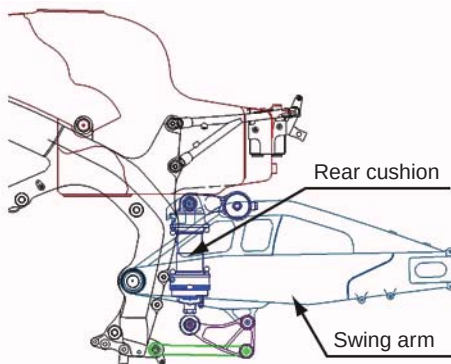


Fig. 8 Layout of swing arm and rear cushion

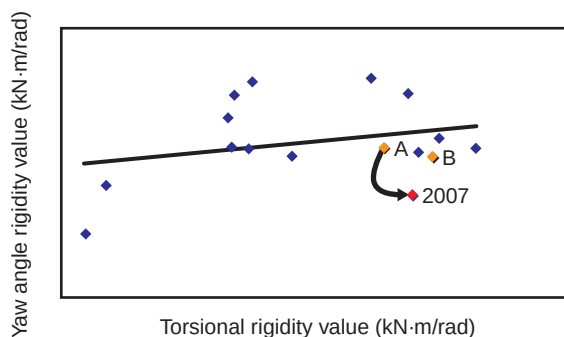


Fig. 9 Comparison of swing arm rigidity

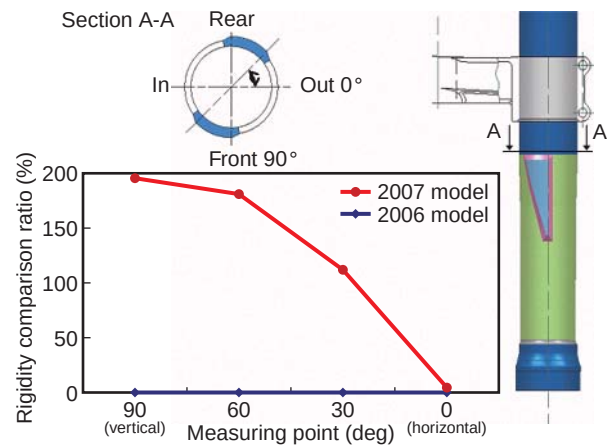


Fig. 10 Comparison of front fork rigidity



Fig. 11 Seat cowl shape

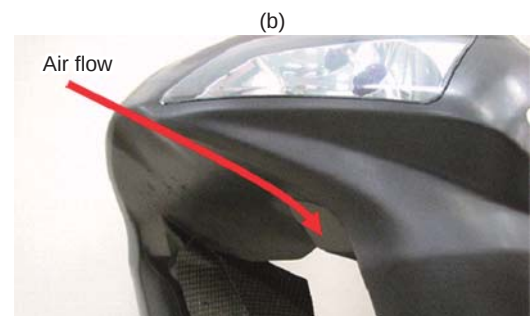
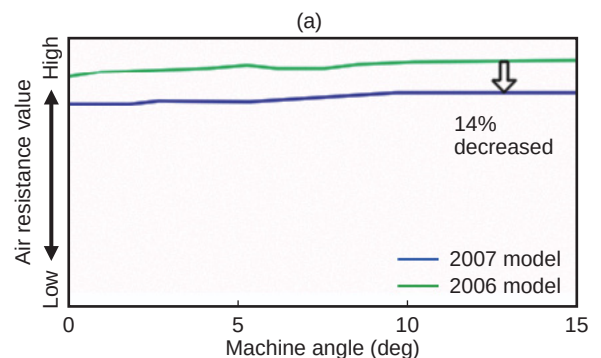


Fig. 12 Front cowl shape and characteristics

5.1.3. Aerodynamic performance

Maintaining the basic form of the production model while enhancing aerodynamic performance was established as a development goal, and the detailed shape of the bike was modified. A spoiler was added to the lower section of the front cowl and a duct was added to the rear of the seat cowl, reducing the amount of lift. Figures 11 and 12 show graphs of the front cowl and seat cowl lift characteristics.

5.2. Unique Parts employed for Endurance Race

5.2.1. Fuel tank

The design of the fuel tank sought to increase rider comfort and controllability while maintaining the maximum capacity of 24 L allowed by the regulations, in addition to producing a form that would reduce the necessary filling time as well as increase the accuracy of filling in terms of the volume of fuel supplied. Modifying the shelter type employed in the production model, the fuel tank in the racing model has been manufactured using aluminum, with the front half formed from carbon fiber, enabling the achievement of the requisite capacity while reducing weight. The fuel tank is shown in Fig. 13.

5.2.2. Accident guards

To protect the bike from damage in the event that it falls, plastic sliders have been fitted to the side of the frame, and a carbon fiber guard has been fitted on the swing arm to protect the rear axle. Figures 14 and 15 respectively show photographs of a slider and the axle guard. This has reduced the frequency with which parts need to be replaced if the bike falls, and has also reduced the rate at which bikes are retired from the race.

To increase safety if the bike falls, since the 2006 model, a quick filler with a locking function has been employed in order for the fuel filler to not open during a fall. The quick filler is shown in Fig. 16. The 2006 model used three claws, but the 2007 model has been provided with six claws to enhance the locking function.

5.2.3. Increased rider comfort

Because each session lasts approximately 1 hour, rider



Fig. 13 Fuel tank



Fig. 14 Slider



Fig. 15 Axle guard



Fig. 16 Quick filler with lock function



Fig. 17 Handle pipe weight

comfort is also an important consideration.

To reduce handlebar vibration, the small weight shown in Fig. 17 was fitted in the handlebar pipe. This measure has reduced vibration by approximately 10% against the handlebars of sprint bikes.

To protect the rider from heat, an air outlet duct has been added to the front cowl (Fig. 18), a large carbon fiber heat guard has been fitted around the step exhaust pipe, a heat-isolating washer has been used on the step arm, and a double-layered bottom plate, containing a layer of air, has been used for the seat.

To enhance visibility, an air duct has been used to help prevent misting of the windscreen, maintaining visibility when racing in rainy weather (Fig. 19).

5.2.4. Headlights

Because the 8-hour endurance race is also run after dark, headlights are a necessity. In order to maintain the basic configuration used in the production model while maintaining sufficient intensity at a low weight, high-intensity discharge (HID) headlights were fitted in a carbon fiber case, and the assembly was mounted in the cowl (Fig. 20).

5.3. Parts related to Pit Work

5.3.1. Front stand jack

During pit work, a front stand jack is inserted from

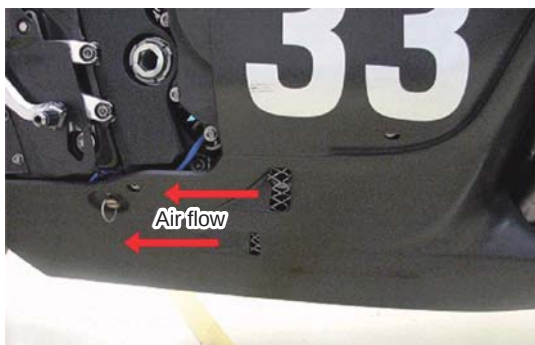


Fig. 18 Lower cowl air outlet duct



Fig. 19 Wind screen air duct

the side and used to raise the bike. To enable quick replacement of tires and refueling, it is vital that the bike be balanced stably when raising and lowering it. In the 2007 model, this has been achieved by replacing the link-type front stand with a slide pipe-type. In addition, in order to increase the ease of fitting the jack, the form of the guide on the insert section has been modified and the tire-type roller used to move the front stand has been replaced by a free caster-type, reducing the effort involved in using the jack. Figure 21 shows comparative photographs of the front stands.

5.3.2. Ease of replacement of tires

An opener mechanism that allows the brake calipers to be rotated while attached to the front forks is used for the front wheel, enabling the wheel to be removed by simply removing the axle shaft and pulling the wheel. In the 2007 model, the shape of the guide mechanism has been modified in order to reduce the amount of time to insert the wheel and assure consistent insertion times. Figure 22 shows a photograph of the wheel guide.

To increase the ease of removal of the wheel, a special rear wheel is employed with the rear brake disk fitted to the exterior. The change in the regulations in 2004 prohibits the driven sprocket from being fixed to the frame, making it challenging to employ a “pentagon.” Positioning of the driven sprocket at the side of the wheel means that the drive chain should be removed in pit work. A chain holder and a sprocket cover have been employed



Fig. 20 Head light mounting layout

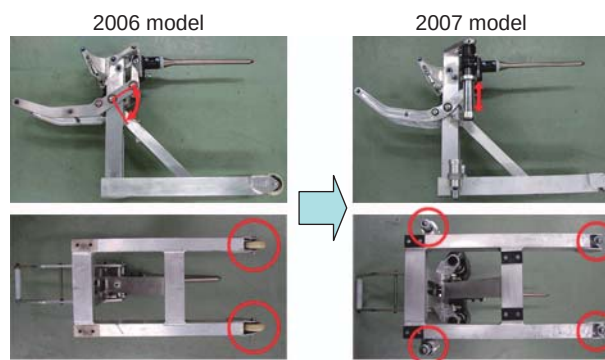


Fig. 21 Front stand

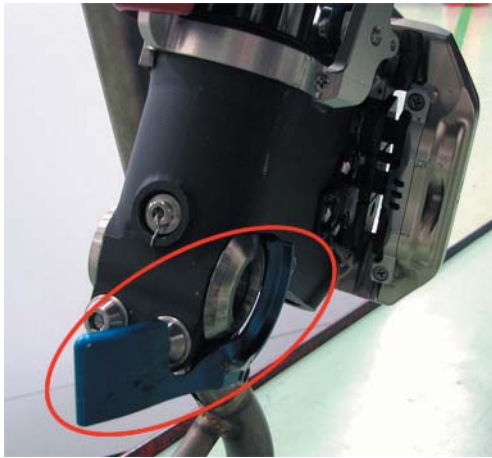


Fig. 22 Front axle wheel guide

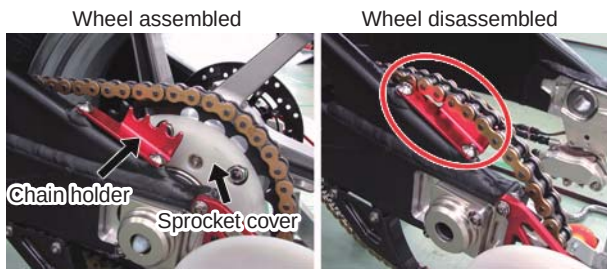


Fig. 23 Rear chain holder wheel guard

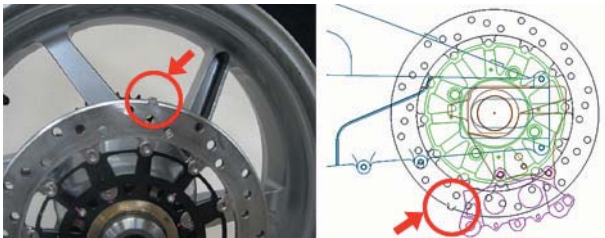


Fig. 24 Rear brake disk projection

to increase the ease of removal. Figure 23 shows a photograph of the chain holder. During the race, foreign matter collects around the rear brake disk and impedes removal work. A projection has therefore been used on the outer circumference of the rear disk brake that scoops out this foreign matter while the bike is running. The layout is shown in Fig. 24.

6. Performance Evaluation

The 2007 bike was run through more than 25 laps of the Suzuka circuit by both a test rider and an actual race competitor, enabling comprehensive evaluation of all parts. The average lap time achieved by the bike showed

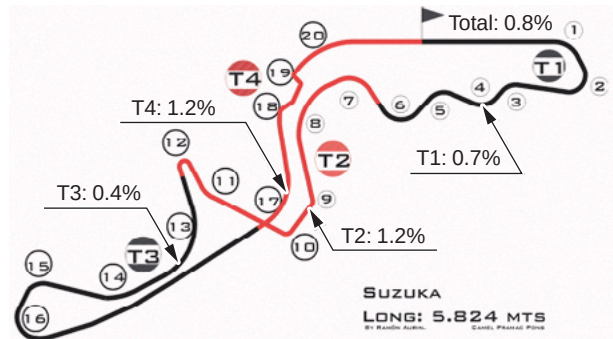


Fig. 25 Section performance enhancement at SUZUKA circuit

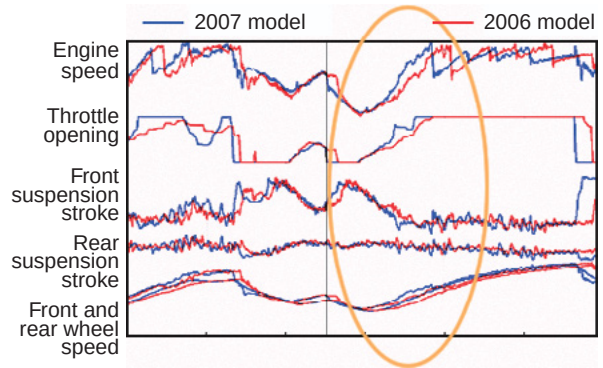


Fig. 26 Running data

a 0.8% increase against that in the former model.

As Fig. 25 shows, the new bike recorded lower times against the previous model on all sections of the course, as follows: T1 (0.7%); T2 (1.2%); T3 (0.4%); T4 (1.2%). The bike also recorded a 3 km/h increase in maximum speed on the back straight.

Figure 26 shows the enhanced performance of the new bike in terms of actual running data. The main area of enhanced performance is acceleration during cornering and escape from cornering. The results show that ECU control is functioning normally, and that traction control has been enhanced.

Rider comfort was evaluated under a number of different conditions (dry, wet, night, strong wind, etc.), and was demonstrated to be adequate.

Average pit work times were reduced by 7% against times recorded in the previous year. In particular, the time needed to change tires was consistent, as well as less time being necessary for refueling.

7. Conclusion

A variety of specifications were changed in the design of the 2007 model CBR1000RRW with a major focus on enhanced ECU performance, resulting in the achievement of a balance between enhanced engine performance and

fuel efficiency, while maintaining durability. The enhancement of the control system has resulted in better traction performance and the achievement of overall performance exceeding the previous year model. During the race, however, a penalty for a flying start meant that one Honda racing bike was unable to close the gap with the leader and took number two position. The other bike had to withdraw due to a fall.

While victory eluded the Honda team on this occasion, we will work to make continuous enhancements to the endurance bike, striving to realize the machine's full potential.

■ Author ■



Eiichi KANDA



Masamune OHIGASHI



Hiroshi UNUKI



Nobuo SHIGEMIZU



Yukihide AKITSU