

# Development of 2020 CRF1100L Africa Twin

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## ABSTRACT

Ever since the revival of the model name in 2016, Honda Africa Twin has been well-supported by the customers as an adventure motorcycle enjoyable on off roads as well as for touring on pavement. After four years since the initial launch in 2016, a full model change has been conducted in this project, renewing everything from the engine, frame body, suspension to the exterior, gaining more power by the increased engine displacement while reducing weight of the complete motorcycle. Accordingly realized are the more off-road friendly Africa Twin, and the Africa Twin Adventure Sports more suitable for touring with abundance of extra equipment for long, comfortable rides.

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## 1. Introduction

The first-generation Africa Twin was an adventure model in which the technical features were fed back from the NXR750, which won the Paris-Dakar rally four years consecutively since 1986. To win the rally, the motorcycle has to be highly rideable to travel through the hard route and comfortable for the rider to maintain concentration for a long period of riding. The Africa Twin has both the rideability and the comfort at a high level.

The first-generation Africa Twin was born as XRV650 in 1988. After undergoing model changes such as an increase of engine displacement, its production came to an end in 2003. Backed up by the strong voices from the enthusiastic customers for a revival of Africa Twin, it was reborn as CRF1000L Africa Twin<sup>(1)</sup> in 2016. Moreover in 2018, the Africa Twin Adventure Sports was added as an adventure model that extends the fun of riding including touring. Four years after the revival, a thorough model change has been conducted in the 2020 year model, renewing everything from the engine, frame body, suspension to the exterior, to further enhance the on and off road capabilities of the two types. The CRF1100L Africa Twin (Fig. 1) is more suited to off-road usage while the CRF1100L Africa Twin Adventure Sports (Fig. 2) is more for comfortable touring.

The technical features for enhancement for off road and touring uses are discussed hereafter.

Note that each model is referred to as per the following in this paper.

Previous model, STD: CRF1000L Africa Twin

Previous model, AS: CRF1000L Africa Twin Adventure Sports

Developed model, STD: CRF1100L Africa Twin

Developed model, AS: CRF1100L Africa Twin Adventure Sports



Fig. 1 CRF1100L Africa Twin

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<sup>1</sup> Honda Motor Co., Ltd.

Table 1 Comparison of specifications and equipment between developed and previous models

| Item                            | Developed model                  |                                             | Previous model                |                                             |
|---------------------------------|----------------------------------|---------------------------------------------|-------------------------------|---------------------------------------------|
|                                 | CRF1100L<br>Africa Twin          | CRF1100L<br>Africa Twin<br>Adventure Sports | CRF1000L<br>Africa Twin       | CRF1000L<br>Africa Twin<br>Adventure Sports |
| Displacement (cm <sup>3</sup> ) | 1083                             |                                             | 998                           |                                             |
| Bore x stroke (mm)              | 92.0 x 81.5                      |                                             | 92.0 x 75.1                   |                                             |
| Maximum power (kW/rpm)          | 75/7,500                         |                                             | 70/7,500                      |                                             |
| Maximum torque (Nm/rpm)         | 105/6,250                        |                                             | 98/6,000                      |                                             |
| Curb weight (kg)                | 226 {236}                        | 238 {248}<br>[240 {250}]                    | 230 {240}                     | 243 {253}                                   |
| Seat height (mm)                | 870<br>850 (Low position)        | 870<br>850 (Low position)                   | 870<br>850 (Low position)     | 920<br>890 (Low position)                   |
| Fuel tank capacity (L)          | 18.8                             | 24.8                                        | 18.8                          | 24.2                                        |
| Windscreen                      | Low height                       | High height<br>(Manually adjustable)        | Low height                    | High height                                 |
| Tire                            | With tube                        | Tubeless                                    | With tube                     |                                             |
| Electronic suspension           | -                                | -<br>[Equipped]                             | -                             | -                                           |
| Headlight                       | LED                              | LED                                         | LED                           |                                             |
| Cornering light                 | -                                | Equipped                                    | -                             |                                             |
| Meter                           | LCD                              |                                             | LCD                           |                                             |
| Display                         | 6.5-inch touchscreen colored TFT |                                             | -                             |                                             |
| Apple CarPlay*                  | Adopted                          |                                             | -                             |                                             |
| Cruise control                  | Equipped                         |                                             | -                             |                                             |
| Riding mode select              | 4 fixed modes and 2 user modes   |                                             | 3 fixed modes and 1 user mode |                                             |
| ABS mode select                 | 2 modes (on- and off-road)       |                                             | -                             |                                             |
| Torque control                  | 7 levels and off setting         |                                             | 7 levels and off setting      |                                             |
| Wheelie control                 | 3 levels and off setting         |                                             | -                             |                                             |

Numbers in { } show DCT model.

Numbers in [ ] show optional electronic suspension model.

\*Apple CarPlay is trademark of Apple Inc.



Fig. 2 CRF1100L Africa Twin Adventure Sports

## 2. Aims of Product Development

The heritage of Africa Twin is that the rider can enjoy both off road riding and touring on the pavement. As mentioned earlier, previous models were offered in two types; STD and AS. The STD is slim and light in weight for more agile off-road capabilities. With the bigger fuel tank

and the larger fairing equipped, the AS is more suitable for touring.

To make the features of the two types more distinguishable, we set a target at brushing up the off-road capabilities of STD model while enhancing the AS for more comfortable touring. If we pursue more comfort for touring using the previous AS model as a platform, a loss of the off-road capability is presumable due to an increase of weight from additional equipment, etc. An increase of weight would also be a limiting factor for enhancement of off-road capability in the STD model. Accordingly in this model, we decided to aim at realization of a STD model having good off-road capability and an AS model having enhancements for touring by reviewing all parts. Table 1 shows major specifications.

## 3. Enhancement of Off-road Capabilities

We have further enhanced the outstanding agility, which is a virtue of the Africa Twin among those in the large on-off road model category. The three major technical measures are;

- (1) Reduction of weight in the engine and the chassis
- (2) Reduction of inertia moment by centralization of mass in the complete motorcycle
- (3) Reviewing of frame stiffness

### 3.1. Weight Reduction

In this developed model, the weight of complete motorcycle has been reduced from the previous model by 4 kg in STD and 5 kg in AS while maintaining the same or better general characteristics such as the strength despite the higher power output from the latter-discussed increase of displacement and the abundant touring equipment.

#### 3.1.1. Reduction of engine weight

In this developed model, the engine displacement has been increased to enhance performance. Generally speaking, an increase of engine displacement often causes an increase of engine weight due to the enlargement of engine size and the increase of strength of parts to deal with the increased power output. Nevertheless in this developed model, the engine weight has been reduced by 2.5 kg in the manual transmission model and 2.2 kg in the DCT model from the previous model. Figure 3 shows major technical features of the new engine. The key measures for engine weight reduction are discussed hereafter.

The total weight of an engine depends very much on the weight of main motion system parts such as the pistons, crankshaft, etc. as Fig. 4 shows. The increase of stroke to increase the displacement also increases the inertia force from the reciprocating parts. If the reciprocating parts becomes heavy for retention of strength, the inertia force in the reciprocating parts increases further, causing the parts to become even heavier to deal with the inertia force. Accordingly, with an aim at control of the inertia force in the reciprocating parts at the same level as the previous model, we set a target weight reduction at 8.9% while maintaining the same durability as the previous model.

With respect to the reduction of reciprocating parts weight, the details are discussed here about the piston and the piston pin. For realization of an optimum piston shape by minimizing excessive material, the direction of die draw has been changed to reduce the weight in the piston crown. A reduction of piston crown weight lowers inertia force

in the direction of rotation around the piston pin, which contributes to a reduction of slapping noises between the piston skirt and the cylinder. This permits reduction of the piston skirt surface area required for control of the slapping noise, allowing further weight reduction. As a result, the skirt width is reduced by 11.4 mm, the height is less by 3 mm as Fig. 5 shows. Coupled with the reduction of material from the piston crown, the weight of piston as a single part is reduced by 7%.

The piston pin is required to help ensure lubrication even when subjected to loads and deformed. In the previous model, the deformation is controlled by the stiffness from the wall thickness and maintained oil film by retaining a constant oil clearance. In this developed model, the employment of the new surface treatment that makes the material harder and is able to better maintain

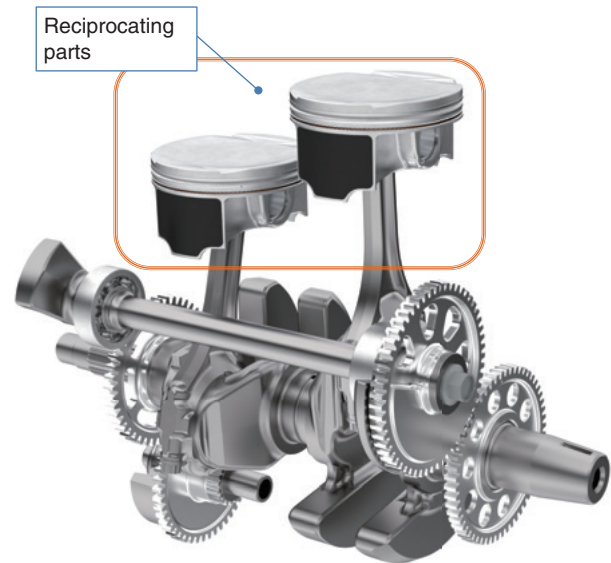


Fig. 4 Reciprocating parts in main motion system

|                             |                                               |    |
|-----------------------------|-----------------------------------------------|----|
| Changed point               | Displacement increased                        | 1  |
|                             | TBW: throttle boar diameter increased         | 2  |
|                             | Exhaust gas control valve                     | 3  |
| Weight reduction technology | Aluminum cylinder liner                       | 4  |
|                             | Balancer gear: scissors mechanism eliminated  | 5  |
|                             | Optimized reciprocating parts' shapes         | 6  |
|                             | Manual transmission: clutch size reduced      | 7  |
|                             | DCT: gear material changed                    | 8  |
| Characteristic technology   | Biaxial primary balancer                      | 9  |
|                             | 2 spark plugs per cylinder with phased firing | 10 |
|                             | 270° phased crankshaft                        | 11 |
|                             | Built-in oil tank dry sump system             | 12 |

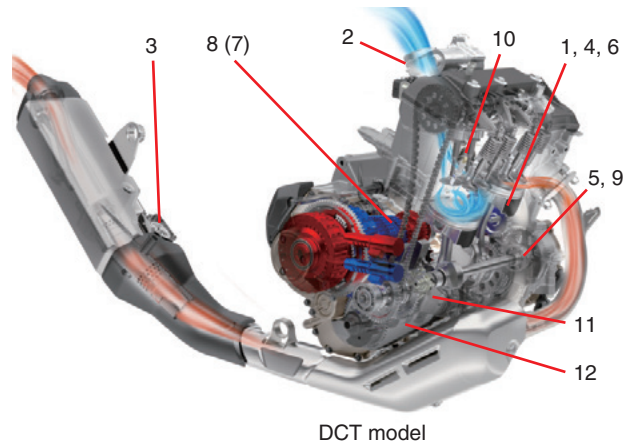


Fig. 3 Key technologies of powertrain

oil film helps ensure durability despite the lowered circumferential stiffness. Accordingly, the inside diameter has been increased by 1.8 mm while maintaining the same outside diameter, which corresponds to a 32% reduction of thickness (Fig. 5). Thus, the weight of piston pin as a single part has been reduced by 19%. Consequently, the total weight of reciprocating parts has been reduced by 8.9%, which equalizes the inertia force of reciprocating parts to that of the previous model.

The sub gears in the anti-backlash systems used in the balancer drive and the primary drive in the previous model for gear noise reduction have been eliminated for weight reduction. As a typical example, Fig. 6 compares the front balancer gear construction to that of the previous model. The two sub-gears help eliminate gear backlash by pinching the mating gear like scissors. In this developed model, we achieved the target performance by reducing the backlash by the measures such as the narrow tooth thickness tolerance realized by the revised tooth finish method, and the reduced tolerance of center-to-center distance of gears. Figure 7 shows sensual assessment of the front balancer gear noise by in-house specialists. With the backlash tolerance narrowed by 26% from the previous model, the target noise

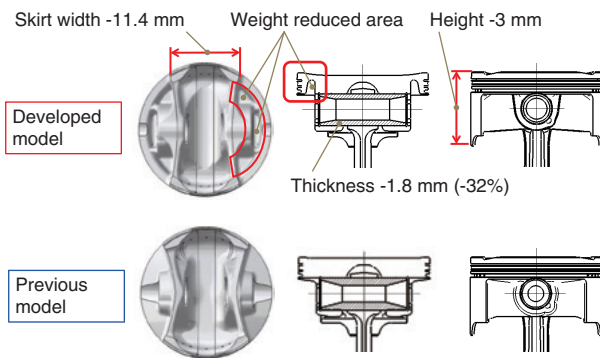


Fig. 5 Comparison of reciprocating parts

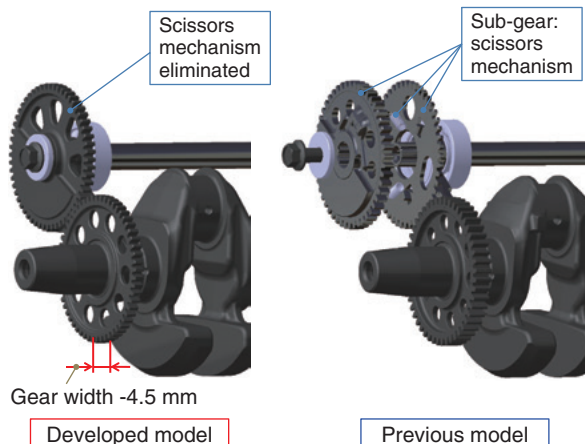


Fig. 6 Comparison of front balancer gear

level has been achieved.

Although the crankshaft becomes larger due to the 6.4 mm extension of stroke, its weight is maintained virtually the same as the previous model by the modification of the shape to the details such as the removal of excess material from various areas, and the reduction of gear width resulting from the elimination of the sub-gear in the anti-backlash system (Fig. 6). As a result, despite the increased engine displacement, the total weight of main motion system parts has been reduced by 820 g from the previous model.

Due mostly to the reduced weight of the main motion system parts, the center-to-center distance of major engine parts and the overall width of engine except those related to the stroke extension are maintained the same as the previous model. With more weight reduction measures taken such as the change of cylinder sleeve material from the cast iron to the aluminum composite, downsizing of the clutch, and the reduction of gear width by the use of high-strength material, the new engine is lighter and more powerful than the previous model (Fig. 8).

### 3.1.2. Reduction of chassis weight

With an aim at a thorough reduction of weight, elaborate studies were conducted on the chassis strength and stiffness, the materials, and the production method to redesign the

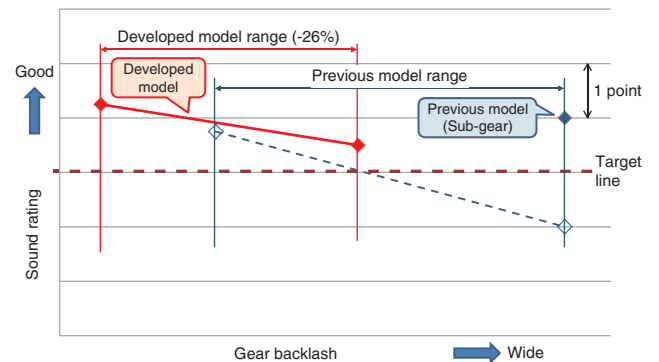


Fig. 7 Comparison of front balancer gear sound ratings

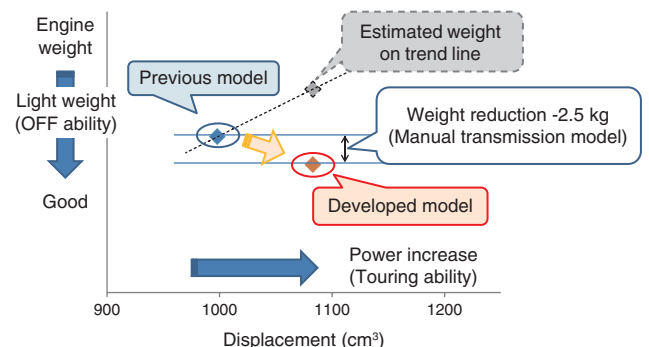


Fig. 8 Comparison of engine weights

frame body from the basic structures. Figure 9 shows the parts having effects for weight reduction of the developed model.

Unlike the front-rear integral construction of the steel frame body of the previous model, the developed model uses the two-split construction with the bolt-on rear frame made of light-weight aluminum. The reviewing of stiffness balance of the steel main frame to be discussed later in Section 3.3. allows elimination of the front cross pipe. Also, the various engine hanger parts are redesigned to the details to change the right-side lower pipe from the bolt-on split type to the welded one-piece construction while maintaining the same engine mount-ability as the previous model. Moreover, while the pivot plate uses the same construction as the previous model in that the two pressed plates are mated and welded, the plate thickness is reduced from 1.6 mm to 1.4 mm in the inner plate and 1.8 mm to 1.6 mm in the outer plate by the employment of high-tension sheet of 600 MPa grade for the inner plate.

To reduce weight in the rear frame and the swing arm made of aluminum, the cast parts having a high degree of design freedom and the forged parts featuring durability are combined and welded together using extruded pipes (Fig. 10). With these measures taken, the weight is reduced by 1.8 kg from the complete frame body, and 0.5 kg from the swing arm, totaling a 2.3 kg reduction from the main structural parts of the frame, contributing to the weight reduction of the complete motorcycle.

### 3.2. Reduction of Inertia Moment by Centralization of Mass in the Complete Motorcycle

To enhance agility, it is essential to reduce inertia moment of the complete motorcycle in three axes; yaw, roll, and pitch. Especially on bumpy or rolling off-road surfaces, a reduction of inertia moment that affects turning or up-and-down motions results in an agile handling and a

quick converging of vehicle motions induced by an external disturbance, allowing riding on rough roads in a more relaxed manner. Hence the weight should be reduced from the parts far from vehicle's center of gravity.

Especially a reduction of weight from the previously-mentioned rear frame and swing arm contributes to a mass centralization. In addition to that, the catalyst that purifies the exhaust gas is moved toward the front of vehicle in the proximity of the exhaust port for more efficient purification

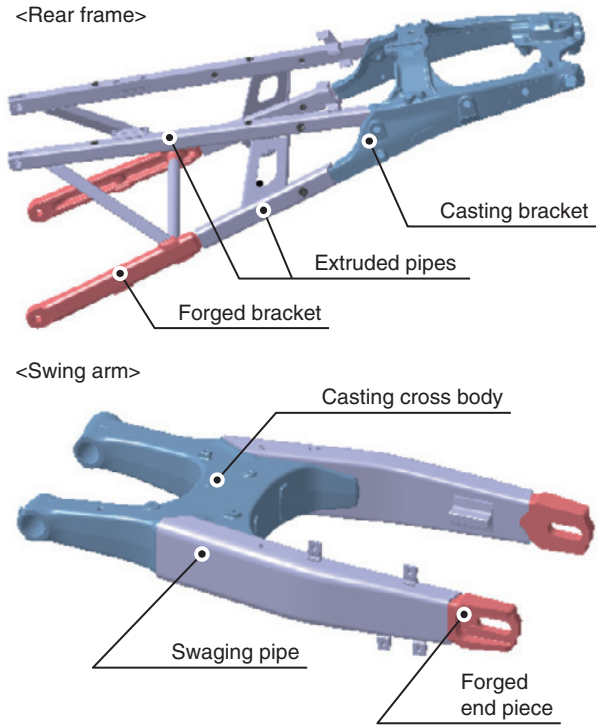


Fig. 10 Configurations of rear frame and swing arm

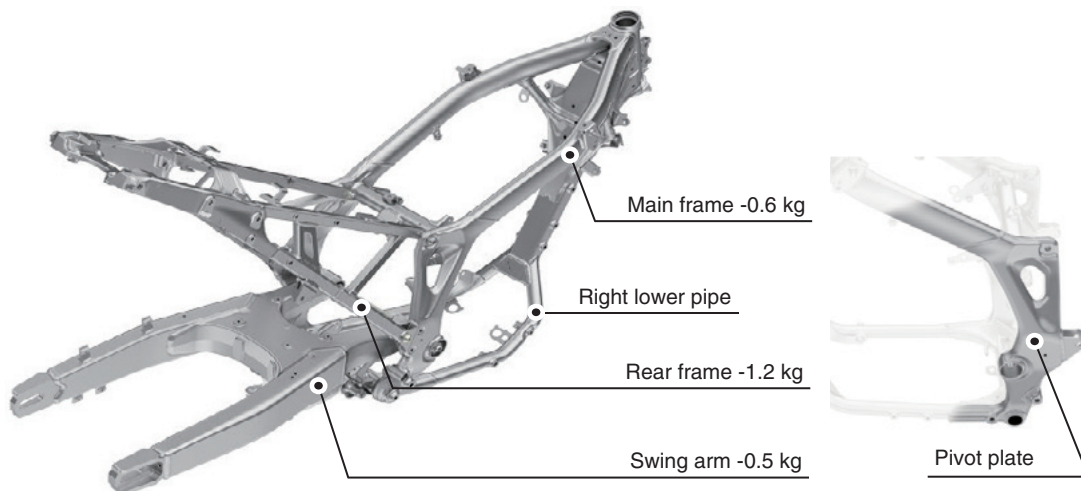


Fig. 9 Main points of modification of frame body and swing arm

to satisfy the emission norms. The catalyst relocation allows the muffler, which is a heavy item in the rear of the motorcycle, to be moved to 85 mm nearer to vehicle's center of gravity (Fig. 11).

With these measures for mass centralization taken, the yaw inertia is reduced by 4.0%, and the pitching inertia by 9.5%, contributing to the enhancement of agility (Fig. 12).

### 3.3. Reviewing of Frame Stiffness

When the motorcycle is shaken up and down vigorously from external forces on loose rough surfaces in off roads, it is important for the frame body to have sufficient flexibility to allow the motorcycle to respond to and follow rider's input so that the vehicle motions settle gently. Such frame characteristics reduce rider's fatigue and provide him/her with a peace of mind. In this developed model, we aimed at an enhancement of the characteristic handling of Africa Twin to allow the rider to travel through hard terrain with confidence by pursuing the flexibility.

In the previous model, the deformation of the main pipe occurring from the reaction forces from the road surface or at the time of braking is controlled by the front cross pipe. In this developed model, the deformation of the main pipe is

controlled by the reinforcement around the head pipe by the redesigned gussets and the reviewing of the main pipe layout in that the pipes are more parallel by the 20 mm reduction of width, allowing elimination of the front cross pipe (Fig. 13). These frame modifications contribute to the lateral flexibility while maintaining the same strength and durability of the frame body and vehicle stability at the time of braking as the previous model. Figure 14 shows an example of CAE analysis data of the frame body when the lateral force is applied to the front and rear tire contact patches. It is evident that the stresses are dispersed widely from the pivot plate to the main pipe in this model. This means that the entire frame body flexes, contributing to such characteristics that allow vehicle movements from external forces to settle gently. The resultant handling characteristics allow the rider to have confidence even on off roads. Moreover, the more agile handling from the reduced frame stiffness helps the rider enjoy off-road riding more than before.



Fig. 11 Comparison of muffler size

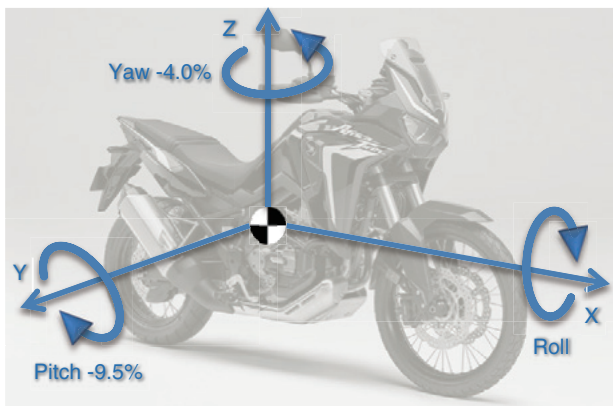


Fig. 12 Result of moment of inertia

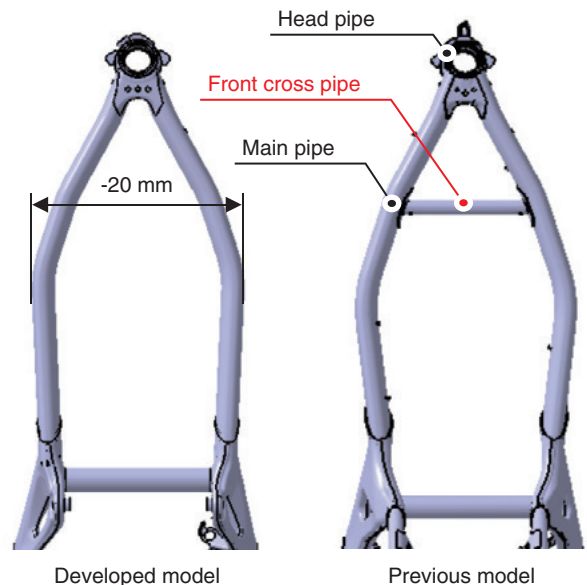


Fig. 13 Top view of main body frame

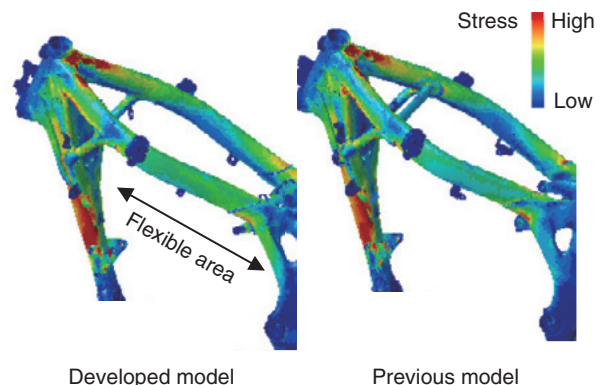


Fig. 14 Frame body analysis result

## 4. Enhancement for Touring Use

It is important for a touring motorcycle to reduce mental and physical fatigue from long rides. To deal with the mental fatigue, the engine performance is enhanced. Compared to the previous model, the extra torque in the low engine speeds helps assure stress-free acceleration even when having a passenger and/or luggage, which brings about psychological relaxation. With respect to the physical fatigue, the wind protection is enhanced, the riding position is reviewed and the seat comfort is enhanced. Among those, the following two measures are discussed hereafter.

- (1) Enhancement of engine performance
- (2) Enhancement of wind protection

### 4.1. Enhancement of Engine Performance

In Africa Twin models, one of the priorities is in the power output characteristics in the engine speeds customers use frequently. That said, a quick acceleration is important sometimes on motorways or the likes especially in the target market such as Europe. A stress-free acceleration with abundance of extra power enhances rider comfort. In this developed model, a target is set at an increase of power by 6% in the entire engine speeds so that an adequate acceleration is available from any engine speed. Taking into account a balance with the weight reduction, the engine displacement is increased by 85 cm<sup>3</sup> from the previous model to 1083 cm<sup>3</sup> (theoretical). Upon reviewing of other factors such as the intake/exhaust systems, the power is higher by 6% or more in all engine speeds with a maximum of 8% from the previous model (Fig. 15). As a result, the acceleration is approximately 5% better than the previous model (Fig. 16).

The increased power in all engine speeds provides the rider with an extra confidence regardless of the vehicle

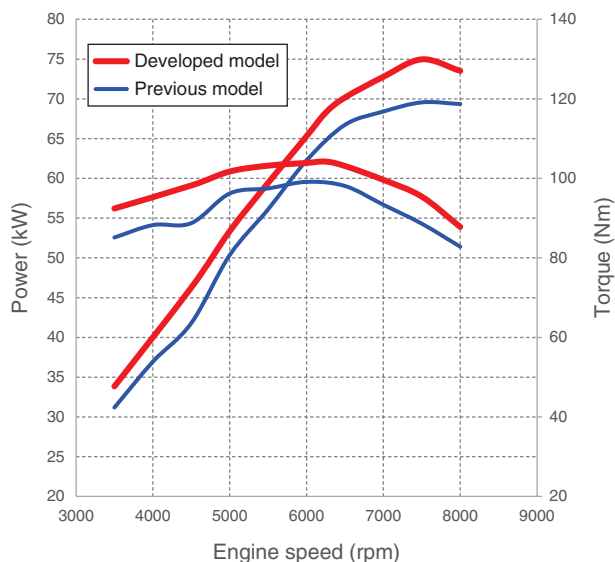


Fig. 15 Engine performance

conditions such as with luggage or the situation such as in uphill or at high speeds, enhancing comfort in touring. It also contributes to a fun of riding in off roads exclusively from a high engine performance.

### 4.2. Enhancement of Wind Protection

In the developed AS model, the wind protection is enhanced for more comfort in long touring. The wind protection in rider's head and torso areas is discussed here.

#### 4.2.1. Wind protection around head

In the developed AS model, the tall windscreen longer by 215 mm than the STD type is employed for a better wind protection around the head (Fig. 17). The manual five-stage height adjuster is employed in the windscreen retainer. The height adjuster is composed of the two angled rails and links, allowing setting of the screen at any of the five stages by operating the right and left adjuster knobs (Fig. 18). With this construction employed, the height is adjustable by 60 mm and the angle by 5° in the fifth stage to change the

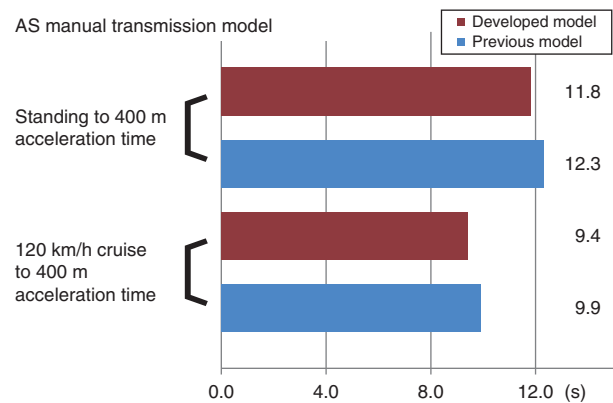


Fig. 16 Comparison of acceleration performance

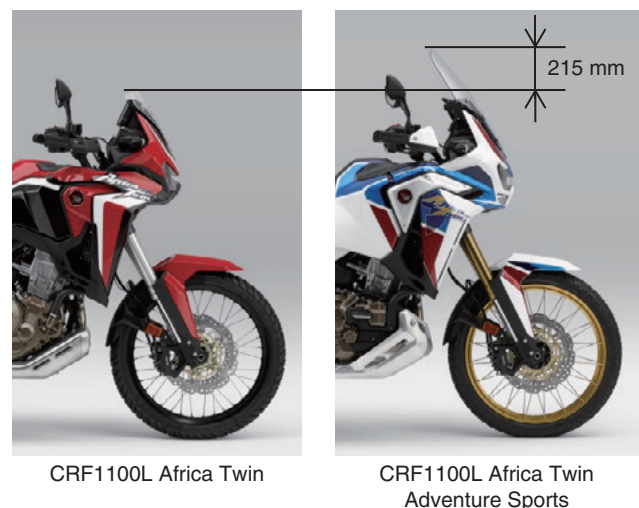


Fig. 17 Comparison of screen height

wind protection for rider's preference.

Figure 19 shows air velocity distribution around rider's head analyzed by CFD. In the first stage, the wind protection is targeted at the same level as the AS type of the previous model. The reduced air blasts on rider's head by this new screen helps ensure comfort in long touring. The second through the fifth stages are provided to permit adjustment in accordance with riding posture or rider's physique. Compared to the first stage, in which the height

is equivalent to the previous model, the wind pressure is lowered around the head in the fifth stage, which is an evidence of enhanced wind protection.

#### 4.2.2. Wind protection around torso

The fairing is exclusively designed for the developed AS model having 50 mm more width than the STD type for better wind protection around the torso. Figure 20 shows the air velocity distribution around rider's lower body by

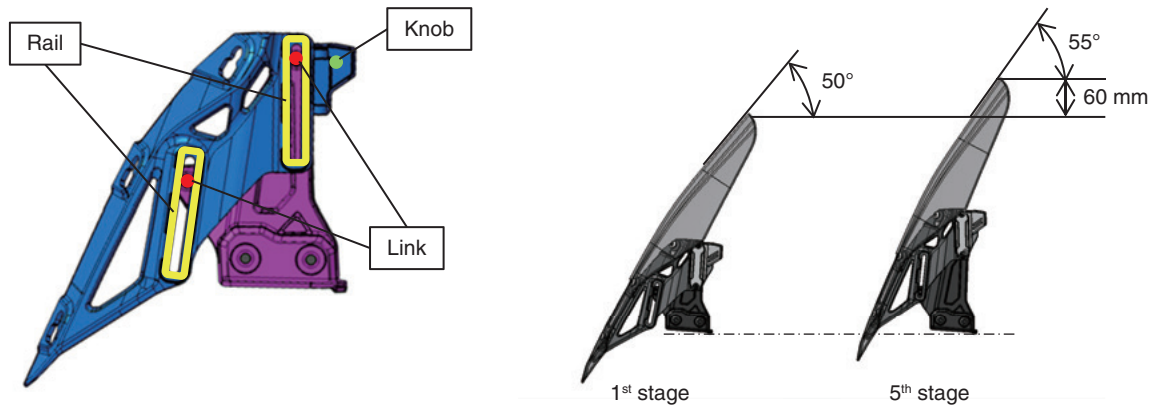


Fig. 18 External view of manually adjustable windscreen

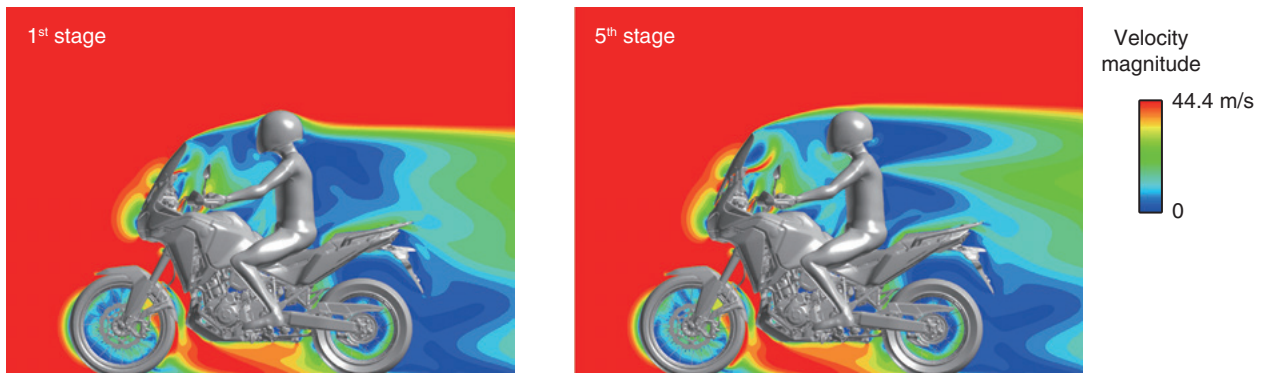


Fig. 19 Result of velocity distribution analysis of upper body by CFD

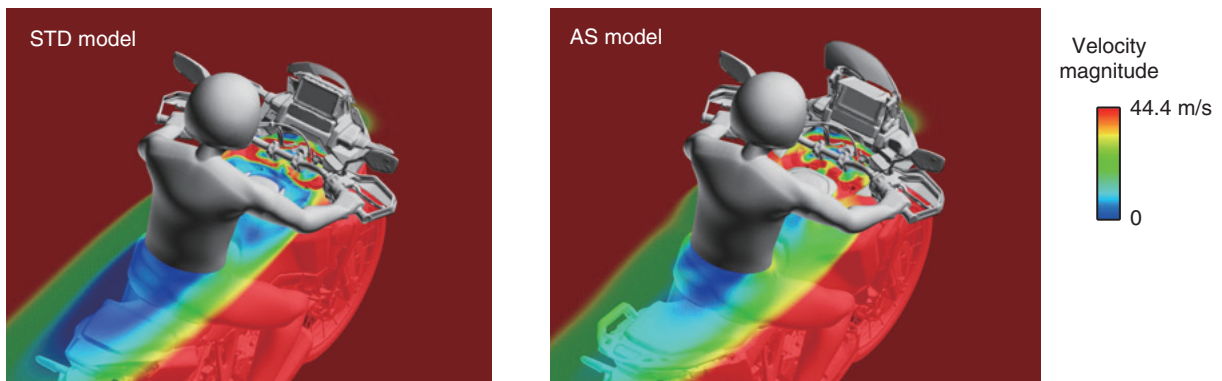


Fig. 20 Result of velocity distribution analysis of lower body by CFD

CFD analysis indicating that the modified fairing reduces wind blast to the rider.

As a result of the above, in addition to the high level of comfort the previous AS model features, the employment of the new windscreen adjustable for riding posture and/or rider's physique and the redesigning of fairing contour enhance the wind protection for the rider to reduce physical fatigue.

## 5. Enhancement of Vehicle Behavior Control

An enhancement is also realized in the control of vehicle behavior. With the Inertial Measurement Unit (IMU) equipped, six parameters shown in Fig. 21; the angular velocity of pitch/roll/yaw axes and the acceleration in the fore-and-aft/right-and-left/up-and-down directions are measured to identify dynamic motions of the vehicle on real-time basis. The use of the acquired data enhances preciseness of various controls to help ensure smoothness of vehicle behavior. The items subject to the control by the IMU are shown below.

(1) Honda Selectable Torque Control (HSTC):

The traction control to moderate behavior when the tire spins idle or slips sideways

(2) Wheelie control:

The traction control to restrict pitching angle and angular velocity when the front end is lifted up

(3) ABS:

The control of brake fluid pressure to moderate braking when cornering and to help prevent rear wheel lift at the time of braking

(4) Control of DCT by conditions:

Control of shift timing to help prevent unintended gear shift by the DCT when going uphill/downhill or cornering

(5) Cornering light (AS only):

Control of cornering light in accordance with the bank angle<sup>(2)</sup>

(6) Electronically-controlled suspension (optional only in

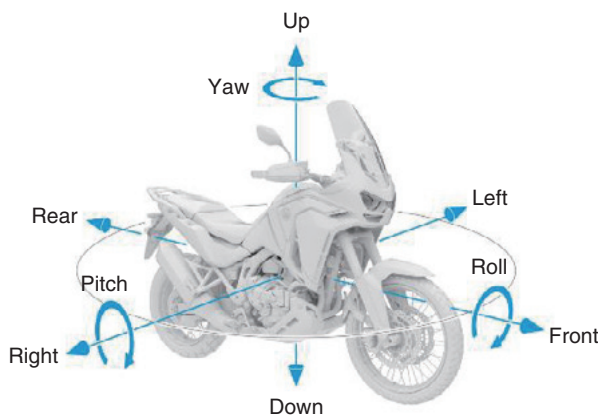


Fig. 21 Vehicle motion direction component from IMU

AS model):

Control of damping force to reduce jerky motions when braking or jumping<sup>(3)</sup>

(7) Quick shifter (optional equipment):

Control to identify erroneous operation to enhance shifting accuracy when cornering

## 6. Enhancement of Human Machine Interface (HMI)

The touch panel, 6.5-inch TFT display is provided to enhance communication between the rider and the motorcycle (Fig. 22).

The large color LCD is employed for easy viewing of abundant information to help ensure rider's acquisition of correct information from the meter while concentrating on riding. To allow instinctive setting of various functions, the meter is designed so as to permit setting operations from the touch panel when the motorcycle is staying still. Also, as shown in Fig. 23, connecting the meter with iPhone with a USB cable allows use of Apple CarPlay. Use of voice command by Siri for various apps such as navigation enhances convenience.



Fig. 22 Multi-information display



Fig. 23 Apple CarPlay

## 7. Conclusion

The Africa Twin more suitable for off road use and the Africa Twin Adventure Sports that allows more comfortable touring with the abundance of equipment have been developed through this project by increasing power output and reducing weight of the motorcycle. With the engine displacement increased, the power is higher by 6% or more in the entire engine speed range. A weight reduction is achieved by reviewing of the major components such as the engine and the frame. With the weight reduced by 4 kg from the previous STD model, the developed STD model is more suitable for off road use. The developed AS model is lighter by 5 kg than the previous AS model despite the addition of various features for comfort such as the enhanced wind protection. Coupled with the enhanced engine performance in the entire engine speed range, the AS model is even more suitable for touring.

We hope customers will enjoy new adventures on the Africa Twin which has realized at a higher level the model concept “Go anywhere - a true full-scale adventure model that allows riding on vast land of dream as well as for daily commuting” passed on from the previous model.

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