

Development of 2018 Gold Wing

Kihoko KAITA* Yutaka NAKANISHI*

ABSTRACT

The Gold Wing is a grand tourer type motorcycle of Honda, which was first released in 1975. In the development of the new Gold Wing, we endeavored to create the motorcycle with the most enjoyable maneuverability throughout all the models appeared in the chronicle of the Gold Wing by applying the latest technologies while inheriting their DNA of reliability and safety conscience. To achieve this goal, a light weight and highly dense packaging was set as the most crucial objective, and its packaging design was reviewed throughout the entire vehicle. For the power source, a light weight compact engine, which is water-cooled four-stroke horizontally-opposed six-cylinder engine with 1,833 cm³ displacement, was developed. As its transmission, a dual clutch transmission, which has seven-speed and reverse gears with slow speed forward and backward moving functions, was applied first in the Gold Wing series. A double wishbone type suspension uniquely designed by Honda was developed for its suspension. Thanks to those advanced technologies, the downsizing was realized compared to the previous model by 40 kg in weight, 55 mm in vehicle length, 40 mm in vehicle width and 25 mm in vehicle height, and that made it possible to realize the motorcycle with the most enjoyable maneuverability throughout all the models appeared in the chronicle of the Gold Wing.

1. Introduction

Ever since the introduction in 1975, the Gold Wing, which is a Honda motorcycle model belonging to the grand tourer category, has kept evolving on the basis of inputs from the customers and the market. Approximately 795,000 units have been produced cumulatively. Primarily for the North American market, the first generation Gold Wing was born with a concept “King of motorcycle,” meaning the motorcycle sitting atop all the motorcycles beyond the category or brand classification. To maintain dignity and elegance appropriate for “King” such as majestic presence and composed manner of running, we aimed at a model featuring quietness and comfort. To achieve aforementioned goal, the basic packaging arrangement of the Gold Wing, which is composed of a water-cooled four-stroke horizontally-opposed cylinder engine featuring low vibration, excellent quietness and low center of gravity and coupled with shaft drive system and an under-seat fuel tank, was applied. With its high reliability, sense of security, low vibration and high quality of running, the first-generation Gold Wing was appreciated by the riders fond of long-distance touring like the one across the American Continent. They customized Gold Wing by adding a large fairing, a rear trunk and panniers, and enjoyed motorcycle

trip with the partner. Responding quickly to such needs of the market, the second-generation Gold Wing GL1100 Interstate was introduced in 1980. To enhance performance when carrying a passenger or heavy loads, the engine displacement was increased to 1,100 cc to add torque in low to middle engine speeds. In addition to the standard model, the large fairing, the rear trunk, and the panniers were provided as standard equipment in the Interstate model. The Gold Wing Aspencade was introduced in 1982. This model was equipped with the audio system, CB radio, passenger seat back, etc., serving as a benchmark of modern-day Gold Wing. Moreover in the third generation (1984), the engine displacement was increased to 1,200 cc. In the fourth generation (1988), the number of cylinders was increased employing the horizontally-opposed six-cylinder configuration, and the engine displacement was further increased to 1,500 cc. In the most recent fifth generation (2001), while the horizontally-opposed six-cylinder configuration was maintained, the engine displacement was increased to 1,800 cc⁽¹⁾. While undergoing minor changes such as the application of antilock brake system (hereafter as ABS), world’s first motorcycle airbag, cosmetic restyling, the GL1800 have been appreciated by the customers over the last 17 years.

Undergoing those changes, the Gold Wing has kept

* Motorcycle R&D Center

evolving as a grand tourer motorcycle. It was a matter of course that the body size grew large and the weight increased as a result of evolution. Meanwhile in recent years, the F6B (2013), the F6C (2014) were developed on the basis of the fifth generation GL1800 to strengthen the model line up having the Gold Wing in its core. The fifth generation GL1800 is sold in more than 70 countries and territories. The environment in which the product is used is globally diversifying.

Keeping in mind the aforementioned backgrounds, hearings from the customers in various regions were conducted to set concept of the sixth generation Gold Wing. The hearings revealed some changes of customer demands for the Gold Wing. Especially such comments as “being grand and luxurious impair user-friendliness in some situation,” “the comfortableness sometimes makes me feel boring” called for in-depth rethinking of the long-lasting (more than 40 years) theme “The King” itself. Accordingly at the start of product development, we liberated ourselves from the preconception “The King” which used to be a precondition, considered what the fundamental attractiveness of the motorcycle was, and redefined the value that the sixth generation Gold Wing should offer to the customers.

The total update was conducted by employing the latest technologies into the sixth generation, 2018 Gold Wing GL1800 while maintaining the aura and high-quality image of Gold Wing models of the past generations.

The aims of product development and the technical means to achieve the goals are discussed in this paper.

Figure 1 shows sixth generation Gold Wing.

Figure 2 shows previous generation Gold Wings.

Figure 3 shows fifth generation Gold Wing, F6B and F6C.

Figure 4 shows vehicle size and weight.



The Gold Wing Tour DCT Airbag (2018)

Fig. 1 Appearance of 2018 Gold Wing Tour



Fig. 2 Appearances of successive Gold Wings



Fig. 3 Appearances of fifth generation Gold Wing series

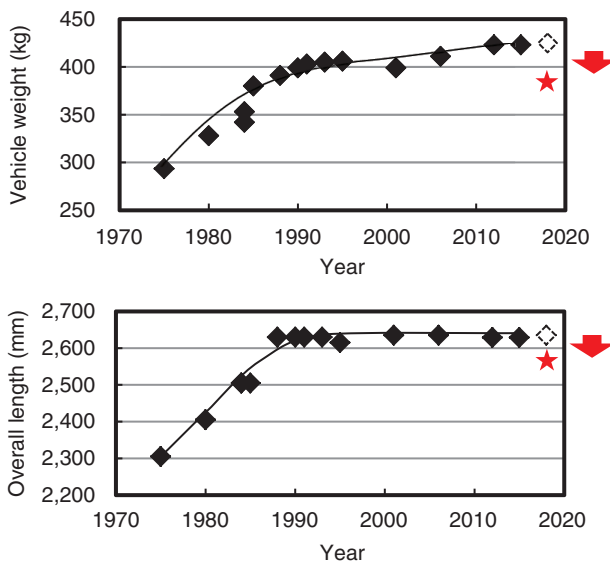


Fig. 4 Weight and overall length of successive Gold Wing series

2. Aims of Product Development

2.1. Concept

The concept of this model was set as “The Honda Premium Tourer-More exciting and fulfilling riding experiences for rider and passenger.”

When hearing in the market in order to set the concept, such voices are addressed from the baby-boomer generation, in which majority of the users of the previous models belongs to, that while the customers who accumulate ages along with the Gold Wing want to continue riding a Gold Wing, they want mitigation in weight and a better slow speed maneuverability. In the meantime, the product should also appeal to men and women in the Generation-X, who are the target users of the next generation, to stay as a long-loved motorcycle. They also addressed such voices that “I also want casual use of the motorcycle for a trip to escape from everyday life using a short spare time in daily life.” From such changes of users and usage, we considered it was

necessary to leap from the gorgeous & luxurious, massive and heavy line and to regain youthfulness.

The core concept of Gold Wing that has lasted over the past 40 years is the fun of travelling accompanied by the partner. We aimed at a motorcycle with the most enjoyable maneuverability throughout all the models appeared in the chronicle of the Gold Wing by brushing up the core concept and applying latest technology while maintaining reliability and sense of security, which are brought about by the unique horizontally-opposed six-cylinder engine and what the Gold Wing is known for.

To realize the aim, the theme in various fields has been set as per the following.

(1) Complete vehicle and chassis

Light weight and high-density packaging of complete vehicle to allow wide variety of applications from daily use to a long touring

(2) Power unit

Light weight and compact horizontally-opposed six-cylinder power unit, smooth yet aggressive when required

(3) Electrical systems, control systems

Advanced technologies to realize premium feel

(4) Styling

Taut lines with contemporary edge

Based on the above themes, studies were conducted on what kind of technologies, specifications and equipment should be applied, and practical actions were taken accordingly.

2.2. Types and Specifications

In this product development project, two types were developed simultaneously to allow customer in a broader range of generation and preference to enjoy the new model. The model with the conventional rear trunk was designated as “Gold Wing Tour,” and the one without the rear trunk as “Gold Wing.” The overview of the models is shown in Fig. 5.

The manual transmission (hereafter MT) and the dual clutch transmission (hereafter DCT) are provided to each model.

In the Gold Wing Tour, the type with an airbag is also provided as “Gold Wing Tour DCT Airbag.”

With these combinations, a maximum of five types are provided for a destination country or region. Furthermore, designating derivative models and various equipment specifications to satisfy the needs of each destination country or region, a total of 48 derivative models have been developed for a total of 18 destination countries and regions.

Unless otherwise specified, the Gold Wing Tour DCT Airbag type for the USA is referenced in this paper.

2.3. Specifications and Equipment

Employing new technologies suitable to create premium image, the equipment specifications were determined at this occasion of full model change. The major equipment specifications are listed in Table 1. The bold letter cells in the table indicate new mechanisms and/or new technologies.

2.3.1. Engine

Aiming at light weight, compactness, more power output and fuel economy, the 1,833 cm³, horizontally-opposed six-cylinder engine has been developed (Fig. 6). Characteristics such as the adequate torque in lower engine speeds, the relaxed manner when cruising, the strong acceleration from cruising state, low vibration, quietness had to be enhanced from the previous model. To achieve the goal, the bore/stroke ratio was reviewed, and the Unicam valve train⁽²⁾ using the finger follower rocker arm in the intake

side just like in CRF450 (motocrosser) was employed. The power output and fuel economy were enhanced by the modifications such as the higher compression ratio, the redesigning of combustion chamber from the two-valve bath-tub type to the 4-valve pent roof type, etc. (Fig. 7). The details are discussed in the separate paper titled “Development of Horizontally-opposed Six-cylinder Engine for 2018 Gold Wing”⁽³⁾.

In the starting and charging system, the integrated starter generator (hereafter ISG) having the functions of starter motor and alternator is employed first time in a large-size motorcycle, thus quietness at engine start-up has been enhanced. By combining the ISG and the DCT, idling stop function enabling smooth start and stop is also provided. (not in USA type and MT type)

2.3.2. Transmission

Two types of transmission, the MT and the DCT are provided. The new Gold Wing is equipped with 6-speed manual transmission compared to the 5-speed for the previous model. The gear ratio from the first to the fifth gear is almost identical to the previous model to maintain adequate traction. The addition of the higher ratio of sixth gear helps ensure quietness while cruising as well as improving fuel consumption. The cam-type assist slipper clutch is employed in the manual type. With the assist system employed, the clutch pull is lighter by approximately 20%. The slipper system reduces shocks when engaging the clutch after down shifting.

Meanwhile in the DCT employed first time in the Gold Wing, the forward gears are increased to 7 speeds. While maintaining the same ratio as the sixth gear of the MT in the seventh gear, a gear is added in the lower gears. With the closer lower gear ratio, the differences of engine speed before and after shifting are reduced, which lowers noises and shocks when shifting. The shift timing is adjusted to the purpose of each of the four ride modes. The details are discussed in separate paper titled “Development of Ride Modes for Various Conditions for 2018 Gold Wing”⁽⁴⁾.

The comparison of gear ratio distribution for new model and previous model converted to the vehicle speed is shown in Fig. 8.

The reverse system, which is unique only in the Gold Wing, has been modified from the type driven by the starter motor to the one driven by the engine. (only in DCT type. For the MT type, the reverse utilizes the starter motor just like the previous model.) With the chain used in the reverse power train, the compact and light weight construction has been achieved without adding an idle shaft. Moreover, as the direction of driving force transmission from the two clutches is such that it is in the reverse direction from the clutch for odd-number gears and in the forward direction from the clutch for the even-number gears, the system permits forward /reverse switch only by altering clutch engagement. Using this system, the walking speed mode has been developed to allow forward and reverse travel at the



The Gold Wing Tour DCT Airbag



The Gold Wing

Fig. 5 Appearances of sixth generation Gold Wing series

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

Item		Developed model		Previous model
		Gold Wing	Gold Wing Tour (DCT, airbag)	GL1800 (airbag)
Engine	Cylinder arrangement	6 horizontally opposed		6 horizontally opposed
	Cooling system	Liquid cooled		Liquid cooled
	Valve train	4 valve OHC (Unicam)		2 valve OHC
	Bore × Stroke (mm)	73 × 73		74 × 71
	Displacement (cm ³)	1,833		1,832
	Throttle bore	$\phi 50 \times 1$ with TBW		$\phi 40 \times 2$
	Starter	Integrated starter generator		Motor
	Generator			Excitation formula
	Transmission	Manual 6 speed	Dual clutch 7 speed + Reverse	Manual 5 speed
	Clutch system	Mechanical with assist slipper	Hydraulic control	Hydraulic assist
	Reverse	Motor driven ※1	Engine driven	Motor driven
Body	Frame body	Aluminum twin tube		Aluminum twin tube
	Windscreen	Electrically adjustable (low height)	Electrically adjustable (standard)	Manually adjustable
	Airbag	—	equipped	equipped
	Drive type	Shaft		Shaft
	Front suspension	Double wishbone type		Telescopic type
	Rear suspension	Swing arm type (PRO-LINK/PRO-ARM)		Swing arm type (PRO-LINK/PRO-ARM)
Electrical equipment and control	Lighting devices	LED		Bulb
	LCD display	7 inch multi display		6.5 inch multi display
	Apple CarPlay ※3	adopted		—
	Ignition	Honda SMART Key system (electrically)		Mechanical key
	Steering lock system			Mechanical key + remote controller
	Rear trunk and pannier lock system			
	Cruise control	equipped		equipped
	Mode select	4 modes		—
	Honda Selectable Torque Control	※2	equipped	—
	Hill Start Assist	equipped		—

※1 No reverse mode for US model

※2 Only equipped for Japan model

※3 Apple CarPlay is trademark of Apple Inc.



Fig. 6 Appearance of sixth Gold Wing's engine

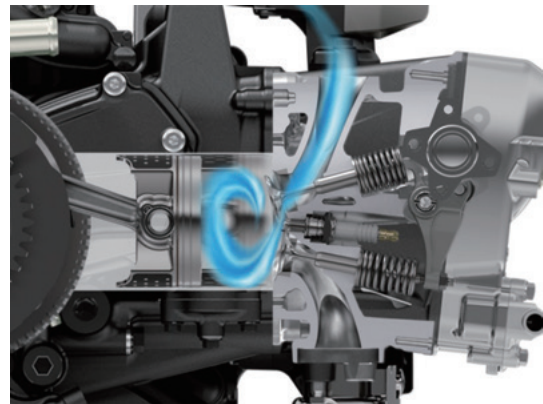


Fig. 7 Internal view of engine

very slow speed by operating the switch on the handlebar. This system makes back and forth maneuver and parking easy, enhancing convenience. The DCT gear arrangement is shown in Fig. 9.

The details are discussed in the separate paper titled “Development of 7-speed Dual Clutch Transmission for 2018 Gold Wing”⁽⁵⁾.

2.3.3. Front suspension

The Honda’s unique double wishbone type suspension for motorcycles has been developed for the front end. With this suspension design employed, as well as realizing the highly dense packaging as mentioned later in section 3.2.1., an enhancement of riding comfort is intended. In the conventional telescopic type front suspension, the suspension itself is used as the structural members.

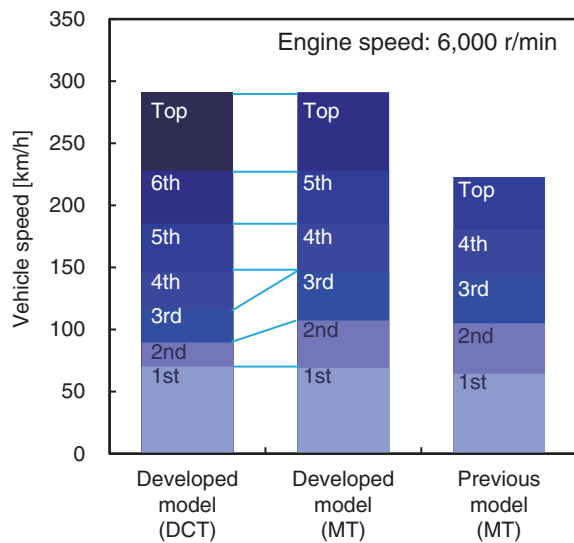


Fig. 8 Vehicle speed on each gear position at 6,000 r/min

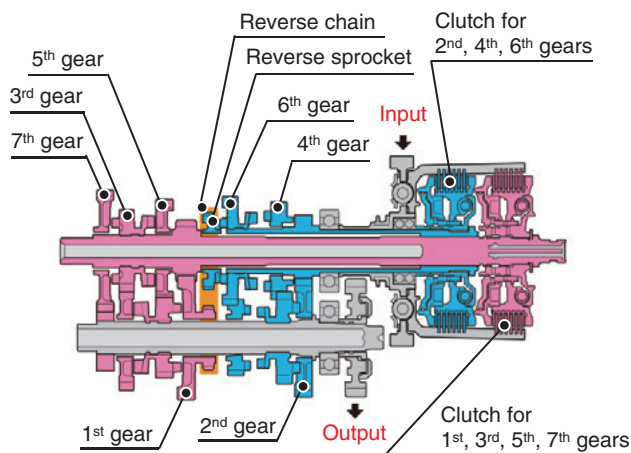


Fig. 9 Gear arrangement of dual clutch transmission

Accordingly, large side forces occur in the outer and inner fork tubes, causing an increase of sliding friction.

In the newly developed double wishbone type, the function to absorb shocks is separated from the steering function of the fork holder. Both of the said components are held by the upper and lower arms (Fig. 10). With a roller bearing incorporated in all the pivots of the linkage, the friction at the time of suspension stroke or when steering is reduced. Consequently, the sliding friction of the cushion has been reduced, and the shocks transmitted from the road surface to the handlebar have been reduced by approximately 30% from the previous model. With the shock unit separated from the steering system, the steering moment of inertia has been reduced by more than 40% from the previous model, which enhances steering agility.

Consequently, the agile handling, when doing frequent steering in a city associated with changing vehicle leaning directions and/or lane changes, was realized, as well as smooth ride without large shocks when doing acceleration/deceleration or passing over a bump/ditch on a road surface.

The details are discussed in the separate paper titled “Development of Double Wishbone Type Front Suspension for 2018 Gold Wing”⁽⁶⁾.

2.3.4. Electrical systems & control systems

The system that allows the rider to select a ride mode that best suits the conditions by controlling five variables has been developed. In this system, the integrated control is conducted by linking variables such as the engine power response and the traction at the time of rear wheel slip, which are controlled by the throttle by wire system (hereafter TBW), the gear shift timing (DCT type only), the suspension damping force characteristics and the front/

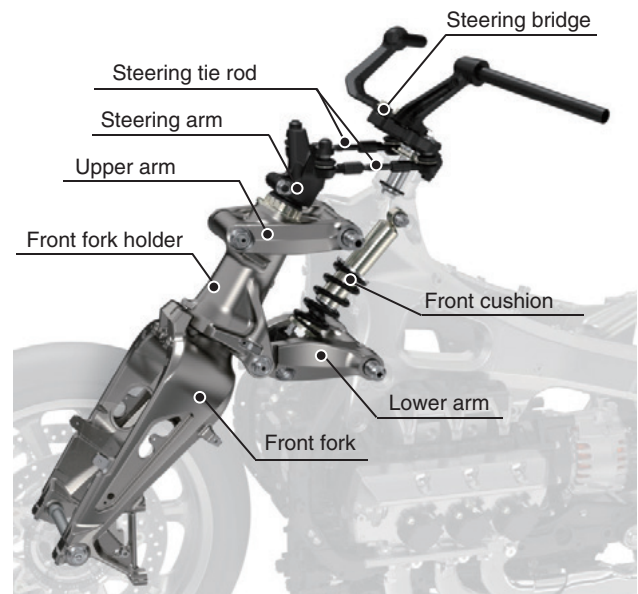


Fig. 10 Configuration of double wishbone type front suspension

rear brake force distribution. The details are discussed in the separate paper titled “Development of Ride Modes for Various Conditions for 2018 Gold Wing”⁽⁴⁾.

The hill start assist system, which is the first in Honda motorcycles, is employed to enhance sense of security and convenience when starting on a hill. When rider’s squeeze of brake lever at the speed and load above the prescribed level is detected when the motorcycle is stationary, the hill start assist mode starts functioning. As the rider starts to launch the motorcycle, the brake force is maintained for a prescribed time period even after releasing the brake lever to help ensure sense of security when starting from a hill.

Furthermore, the cruise control is equipped just like the previous model. Apple CarPlay (Apple CarPlay is a trademark of Apple Inc.), firstly applied in motorcycles, 7-inch multi-function display and Bluetooth compatible audio system were employed as the built-in infotainment system. The Honda SMART Key system is applied to allow ignition switching and handlebar locking without using the hard key (Fig. 11). This system is linked with the locks of the side pocket, panniers, and rear trunk for convenience.

The appearance picture of the whole instrument panel is shown in Fig. 12.



Fig. 11 Honda SMART Key



Fig. 12 Instrument panel

Table 2 Comparison of dimensions and other properties between developed and previous models

		Developed model		Previous model
		Gold Wing (MT)	Gold Wing Tour (DCT, airbag)	GL1800 (MT, airbag)
Curb mass	kg	356	383	423
Overall length	mm	2,475	2,575	2,630
Overall width	mm	925	905	945
Overall height	mm	1,340	1,430	1,455
Wheelbase	mm	1,695		1,690
Seat height	mm	745		740
Ground clearance	mm	130		125
Caster angle		30°30′		29°15′
Trail	mm	109		109
Fuel tank capacity	L	21		25

3. Configuration of Complete Vehicle

3.1. Main Dimensions of Complete Vehicle

The main dimensions of the complete vehicle have been set to achieve the stability that allows relaxed riding and the maneuverability that allows positive control of the motorcycle. The stability of the motorcycle is maintained by extending the wheel base to 1,695 mm, which is longer than the previous model by 5 mm, and employing the less-steep caster angle. The comparison of the dimensions and other properties between developed and previous models is shown in Table 2. The main dimensions of developed model are shown in Fig. 13.

Pursuing a light weight and highly dense packaging, the complete vehicle has been downsized. The size of this model and the previous model is compared in Fig. 14. The overall length is shorter by 55 mm, overall width by

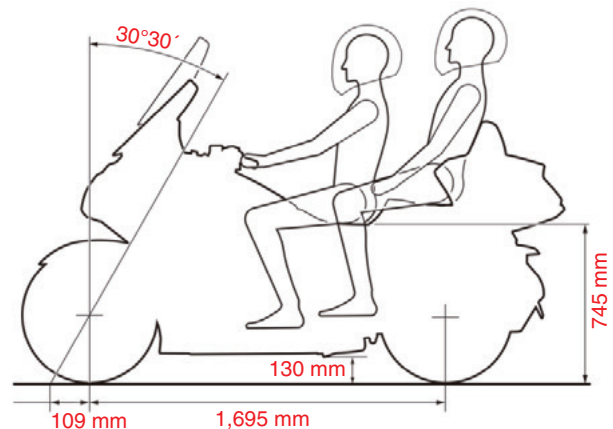


Fig. 13 Main dimensions

40 mm, and overall height by 25 mm from the previous model (comparison by the highest grade models with airbag for the USA).

3.2. Weight of Complete Vehicle

Aiming at a curb weight of complete vehicle less than the previous model by 30 kg, the target was set at realization of a weight as low as F6B (refers to the trunk-less type of previous model. Compared to the previous Gold Wing with trunk, curb weight less by 28 kg), on which anyone can sense the difference when riding, in the type with the trunk.

By means of the technologies mentioned later in section 3.3.2., the engine weight was reduced by 6.2 kg in the MT type and 3.8 kg in the DCT type. The weight was reduced by 18.2 kg in the body parts by means of the latter-mentioned technologies. In the electrical department, a total of 13.1 kg was reduced by the reduction of number of wire harness and sensors by the use of multiple communications, the combining of control units, the optimum layout of various parts, etc. In addition to those, the amount of fuel, oils, coolant, etc. were reviewed. Thus, the curb weight of complete vehicle has been reduced by 40 kg from the previous model (comparison by the highest grade models with airbag for the USA).

3.3. Packaging of Complete Vehicle

The packaging of complete vehicle and the newly-employed technologies are addressed in this section. These contributed to the downsizing and weight reduction of complete vehicle. Moreover, the weight distribution on the front wheel is increased to 46.5% from 44.9% in the previous model. The inertia moment of motorcycle is reduced by approximately 15% from the previous model both in the yaw and roll directions. Consequently, the motorcycle with the most enjoyable maneuverability

throughout all the models appeared in the chronicle of the Gold Wing was realized.

The packaging is shown in Fig. 15.

3.3.1. Reduced length and width of motorcycle by double wishbone-type front suspension

Generally in motorcycles, it is preferable to locate the engine as close to the front as possible to shorten the overall length. However, the mounting location of the engine depends on the relative position of the front wheel. When the motorcycle has a conventional telescopic type front suspension, the front wheel moves toward the upper rear part of the motorcycle as shown by the green lines in Fig. 16. Meanwhile in the newly developed double wishbone type suspension, the trajectory of front wheel stroke can be shifted to the more upright location by setting of the geometry of two links as shown by the red lines in Fig. 16. This suspension design allows 24 mm reduction of longitudinal travel of the front wheel when the front cushion is fully compressed. Consequently, the mounting location of

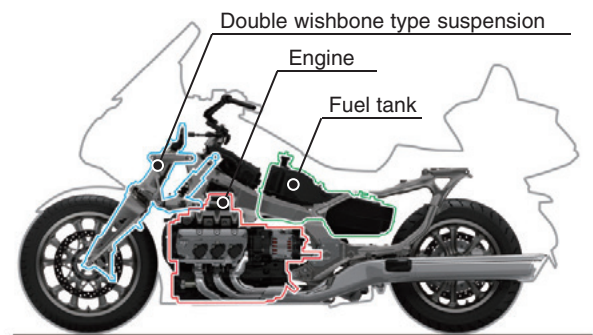


Fig. 15 Packaging

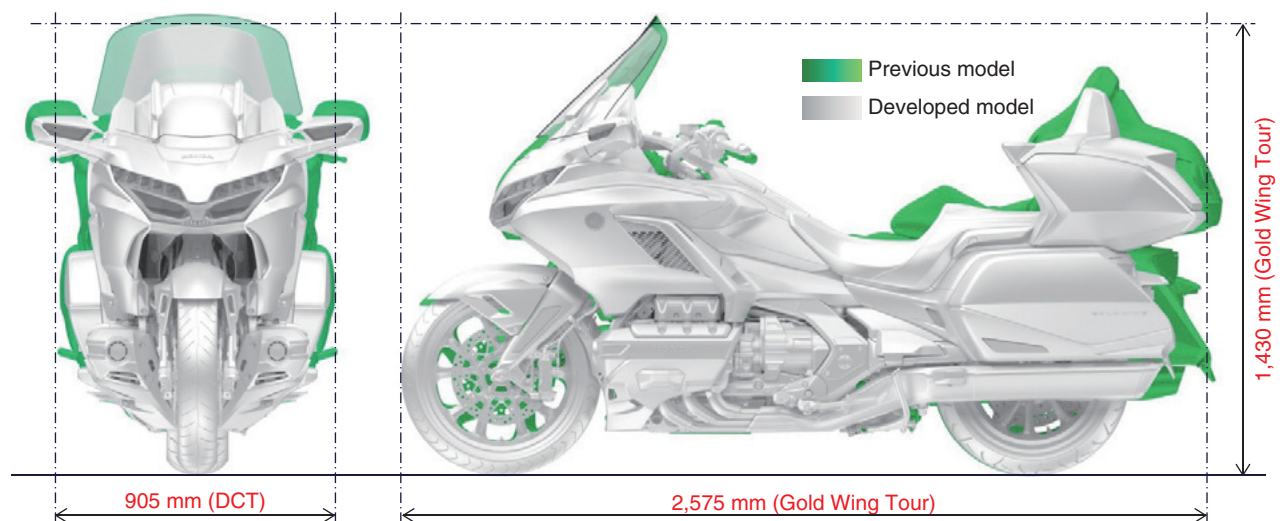


Fig. 14 Comparison of vehicle size

the engine was able to be moved forward.

The employment of the double wishbone type front suspension design also permits reduction of the width of complete vehicle. In the telescopic type front suspension, the right and left fork pipes that hold the front wheel in between turn around the steering axis when steering. Since no parts can be laid in the trajectory of fork pipe movement, the parts have to be located outside of the trajectory of two fork pipes. Meanwhile in the double wishbone type, as the stanchion above the fork that holds the front wheel in between can be a single shaft, the space necessary for turning of the steering can be reduced. Accordingly, the side radiators located outside of the steering space and the inner areas of the fairings that work as air guides were able to be gathered to the locations closer to the center of the motorcycle. Coupled with the latter-mentioned optimum layout and efficiency enhancement of the cooling system as discussed latter in Chapter 5, the maximum width of the fairing has been reduced by approximately 90 mm from the previous model.

3.3.2. Lightweight and compact design of engine and its mounting location

To contribute to realization of the target as the vehicle “a light weight and highly dense packaging,” the key goal of the engine design was lightweight and compact configuration. While there were factors that could increase weight such as the change from two-valve per cylinder to four-valve design, the employment of seven-speed DCT, the goal of weight reduction was set at 6 kg in the MT type, and 3.5 kg in the DCT type from the previous model. It was also targeted to reduce the longitudinal engine length from the front end of the front cover up to the rear end of the left cylinder head by 30 mm from the previous model to enhance maneuverability of the complete vehicle as well as shifting the riding position toward the front of motorcycle.

Measures for the engine weight reduction are such as the downsizing of basic engine dimension, the change from

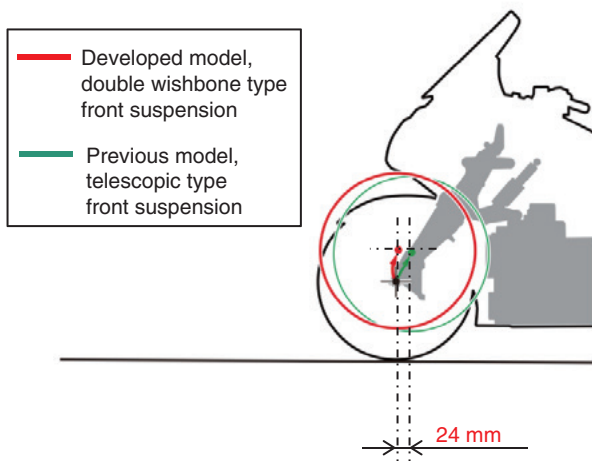


Fig. 16 Trajectories of front axle

the previous two throttles bore design to the single throttle bore type, the elimination of starter motor and related parts due to the employment of the ISG. The measures for weight reduction extend further to the abolishment of parts exclusively for reverse function which became unnecessary due to the addition of the walking speed mode in the DCT type. With all those measures taken, despite the weight increase factors mentioned above, the engine weight has been reduced by approximately 6.2 kg (manual transmission) and approximately 3.8 kg (DCT type).

The longitudinal length of the engine from the front end of the front cover up to the rear end of the left cylinder head has been reduced by 29 mm by the modification of cylinder bore from $\phi 74$ to $\phi 73$, the reduction of length of crankshaft by the application of high-strength alloy steel (Fig. 17).

3.3.3. Seating positions of rider and passenger

Generally in a motorcycle having horizontally-opposed cylinder engine, as the cylinder heads stick out sideways, how to maintain spaces for rider's feet is an issue. With the engine downsized and mounted toward the front, rider's seating position can be relocated by 36 mm toward the front from the previous model. And the relocation of rider and passenger more toward the front allows relocation of the panniers and the rear trunk, which are located in the rear end of motorcycle, more toward the front. As a result, the vehicle inertia moments are reduced while maintaining adequate space for the rider and the passenger. These contribute the further enhancement of stability from an increase of weight on the front wheel. Furthermore, sporty

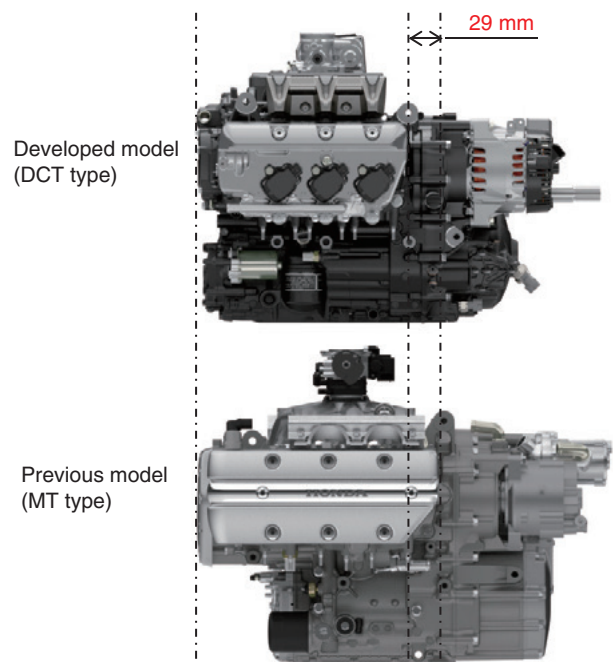


Fig. 17 Comparison of engine lengths between developed and previous models

maneuverability is realized by moving rider's seating position close to motorcycle's center of gravity. In addition, the rider's seating position located closer to the windscreen than the previous model allows reduction of windscreen size and enhancement of wind protection for the heads of the rider and the passenger. The details of wind protection are discussed later in Chapter 5.

In association with the frontward shifted seating configurations of the rider and the passenger, fulfilling both requirements for having the space for the airbag system installation and for keeping the space for fuel filler mouth installation became another issue. To deal with these issues, airbag module was newly developed for this model and its longitudinal length was shortened from 160 mm to 125 mm and its weight was reduced from 4.2 kg to 3.4 kg. As a result, this issue was overcome. The comparison of the riding position of this model to the previous model is shown in Fig. 18. The triangle in the picture indicates the riding position composed of the hip point, grip point and the foot peg point. In this model, while retaining the same basic triangle as the previous model, the hip point is relocated toward the front of motorcycle.

3.3.4. Fuel tank

The traditional under-seat fuel tank of previous Gold Wings is employed with an aim at a low center of gravity. The issue in the under-seat fuel tank design is how to maintain necessary fuel capacity while ensuring easy reach of rider's feet to the ground. Since the cruising range is very important for touring models such as Gold Wing, a target was set at improvement of fuel consumption in WMTC mode by 20% and reduction of fuel tank capacity to 21 liters, which is 4 liters less than the previous model, to maintain the same cruising range as the previous model.

The means to improve fuel consumption are the reduction of complete vehicle weight and aerodynamic drag

along with the employment of fuel-efficient engine design. Accordingly, the fuel consumption has been improved by 20% in the WMTC mode^{*1} and 35% in the 60 km/h constant speed mode^{*2} from the previous model.

*1 Comparison by the highest grade types with airbag for Europe

*2 Comparison by the highest grade types with airbag for Japan

The details of aerodynamic drag reduction are discussed in Chapter 5. The fuel-efficient engine design is discussed in the separate paper titled "Development of Horizontally-opposed Six-cylinder Engine for 2018 Gold Wing"⁽³⁾.

Similarly to the previous model, the multi-layer blow-molding method is applied to the plastic fuel tank to take advantages of a high degree of freedom in the designing of shape. The front part of tank is widened to allow natural knee grip for the rider. The part where the rider sits astride is narrowed for easy reach of rider's feet to the ground when stopped. With all the above measures taken, the weight of fuel tank as a unit has been reduced by 0.6 kg under 21-liter fuel capacity. The external view of fuel tank is shown in Fig. 19.

3.3.5. Cooling system

The challenge in the reduction of width of the fairing in front of the rider was how to achieve both the engine cooling performance and the rider protection from heat (prevention of entry of excessive hot air into the rider space and control of temperature increase.) The side radiator design having a radiator in both sides of the frame body was employed for the previous model. The cooling fan was located inside of the radiator core beside the frame body to keep the rider from hot air.

In this new model, the fin pitch of radiator core is reduced from the previous model. The cooling fan is located outside of the radiator core beside the frame body and housed in the bulged part of the fairing. With the said measures taken, the width of the fairing near the radiator

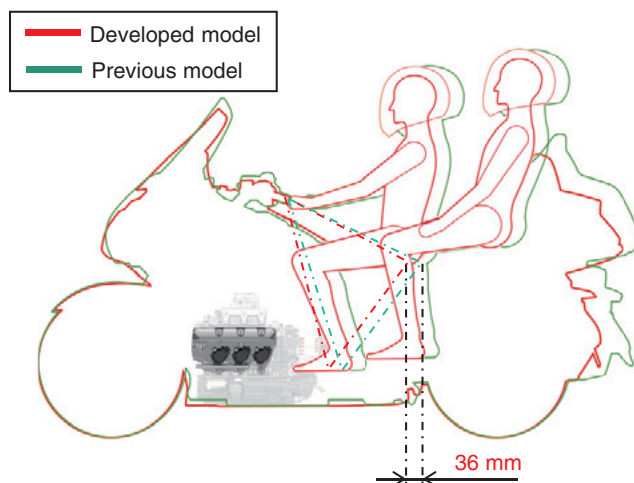


Fig. 18 Comparison of rider positions between developed and previous models



Fig. 19 Fuel tank assembly

has been shortened. Meanwhile regarding the potential rider comfort issues from heat when the cooling fans are located outside, the openings are provided in the front of fairing to take in fresh air to lower the temperature of air flowing to the rear by mixing the hot air from the radiator with the fresh air. In addition to it, the fairing shape near the rear of the radiator is designed so as to help prevent entry of the hot air after the radiator into the rider space. The air temperature distribution around the rider's and passenger's feet analyzed by Computational Fluid Dynamics (hereafter CFD) is shown in Fig. 20. It can be confirmed that the wind exhausted through the radiator flows outside the foot of the rider and the passenger.

Accordingly, the volume occupied by the radiator core (not including the retainers and attachment to frame body) has been reduced by 15% from the previous model while maintaining the same level of comfort as the previous model. Thus, the weight of the cooling system is reduced by 2.6 kg. The maximum width of the fairing in front of the rider is also reduced by approximately 90 mm from the previous model.

3.3.6. Luggage system

The capacities of the panniers and the rear trunk have been reviewed in this model. In the previous model, the 150 liter capacity was provided to allow carrying of luggage for two persons for a week-long trip presuming an across-the-continent tour. Taking into account the changes of travel environment and user-friendliness for riders and passengers in younger generations, the total capacity of the panniers and the rear trunk in this new model is set at 110 liters, which corresponds to the luggage for a three-nights-and-four-days travel. In both of the panniers and the rear trunk, in order to achieve high-quality image and sturdiness when opening, closing or touching, the outer and inner two-panel construction is employed just like in the previous model, and the overlapped area and thickness are totally reviewed. Thus, a total of 6.2 kg has been reduced from the panniers and the rear trunk.

Also, considering the need of having more luggage capacity, the trunk rack having a larger size and loading capacity than the previous model has been developed as an accessory. For the model without the trunk, the carrier that

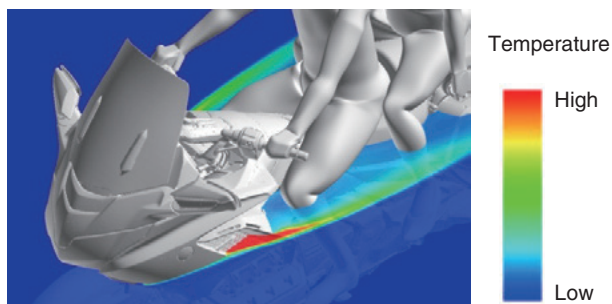


Fig. 20 Result of thermal distribution analysis by CFD

can be mounted on the cowl in the rear of the seat has been developed as an accessory.

3.4. Rider Comfort and Riding Position

3.4.1. Handlebar position

In the previous model, the target was set to achieve both a relaxed riding position suitable for a tourer motorcycle and easy handling while employing the telescopic type front suspension. Accordingly, the longitudinal offset between the front suspension pivot axis and the handlebar grip points was increased, and the space between the handlebar grips was increased in the sideways direction. Consequently the travel of the grip points was increased when the handlebar was turned.

Due to the employment of the double wishbone type front suspension in this model, where steering axis and handle bar pivot axis are separated, the degree of freedom of handle bar pivot axis position has been increased, allowing handling bar pivot axis to be positioned closer to the rider. Also, the grip points were relocated upwards by approximately 20 mm, the space between the handlebar grips in the sideways direction was reduced by 10 mm, and the hand grip angle was increased to make the rider feel more relaxed in his upper arms. This makes the grip points turn at a smaller turning radius than the previous model, which makes turning of the handlebar easy. The handle movable extents are compared in Fig. 21.

This construction enables downsizing of the handlebar and reduction of turning radius, contributing to the compact and slim appearance of the motorcycle.

3.4.2. Seat contour

In the previous model, the seat was contoured in such

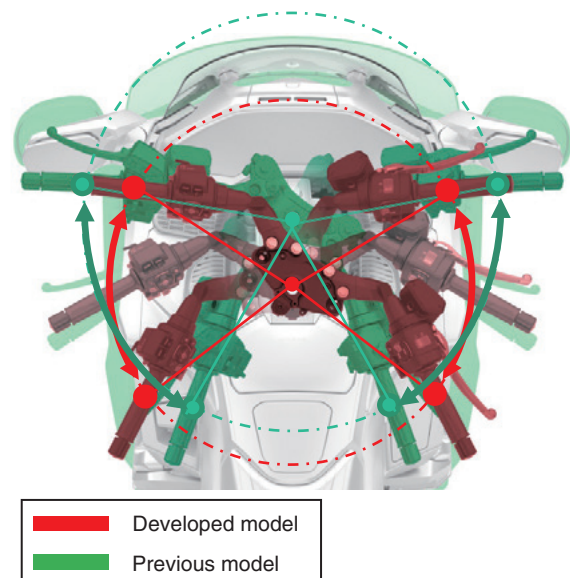


Fig. 21 Comparison of handle movable extents between developed and previous models

a manner that the space for the rider was separated from that of the passengers so that the rider could enjoy control of motorcycle with comfort and the passenger could enjoy comfortable touring. Maintaining the same concept, the basic seat contour of the previous model has been applied to this model. The seat contours of this model and the previous model are shown in Fig. 22.

In this new model, the bucket behind rider's hips is eliminated to allow active control of the motorcycle by shifting weight of rider. With the seat back contour modified, rider's shifting of hips for feet to reach the ground, which used to be necessary in the previous model, is no longer necessary. Coupled with the earlier mentioned reduction of fuel tank capacity, this contributes to easy reaching of the feet to the ground. The appearance is changed from the soft image of the previous model to the modern and edgy image to match the styling of this model.

The seat appearance shapes are shown in Fig. 22.

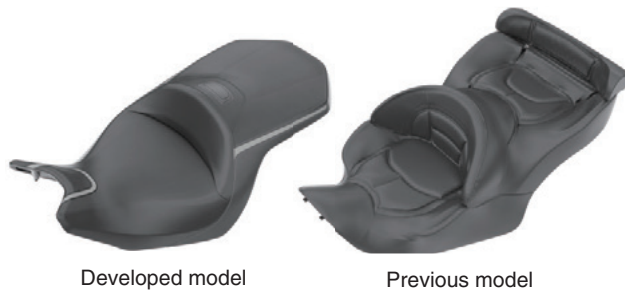


Fig. 22 Comparison of seat shapes

4. Chassis

4.1. Frame Body

While maintaining the traditional twin-tube aluminum frame design, the frame body has been redesigned with an aim at both stability and agility. In the newly designed main frame structure, as well as applying the thin aluminum die cast technologies to all parts, the component parts are upsized and integrated, reducing the number of component parts from 23 pieces in the previous model to 4 pieces. Accordingly, the number of welding of the component parts is reduced and the total welding length is reduced from 8.0 m to 3.6 m, which allows automated welding and contributes to weight reduction, high productivity and consistent quality. The application of thin aluminum die cast method allows fine adjustment of thickness necessary for each portion. The employment of the new swing arm pivot construction to be discussed in the following Section 4.2. allows frame body weight reduction by reducing the number of cross pipes, which used to be laid above and under the pivot axis.

In the rear shock unit, the pillow ball is employed in

the top and bottom pivots to absorb torsional deformation of Pro Arm component parts for enhancement of riding comfort. Coupled with the employment of the earlier mentioned double wishbone type front suspension, the smooth functioning of front and rear suspensions allows reduction of frame body stiffness from the previous model.

Thus, the frame body weight has been reduced by 4 kg while enhancing the maneuverability and the riding comfort of the motorcycle.

The frame body structure is shown in Fig. 23 and the rear cushion in Fig. 24.

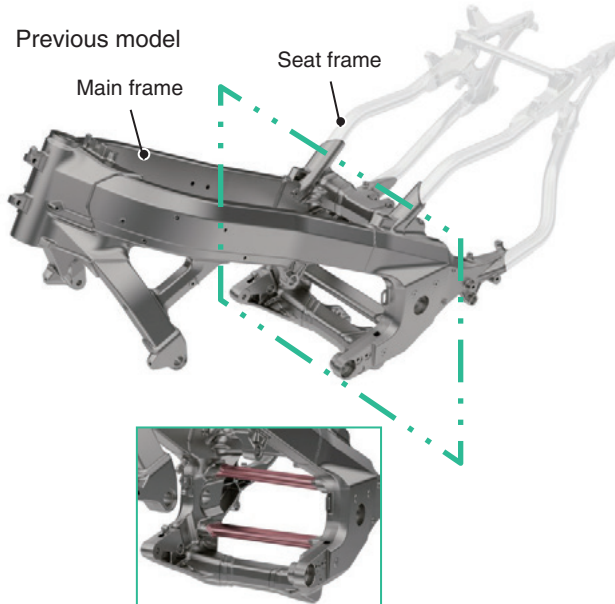
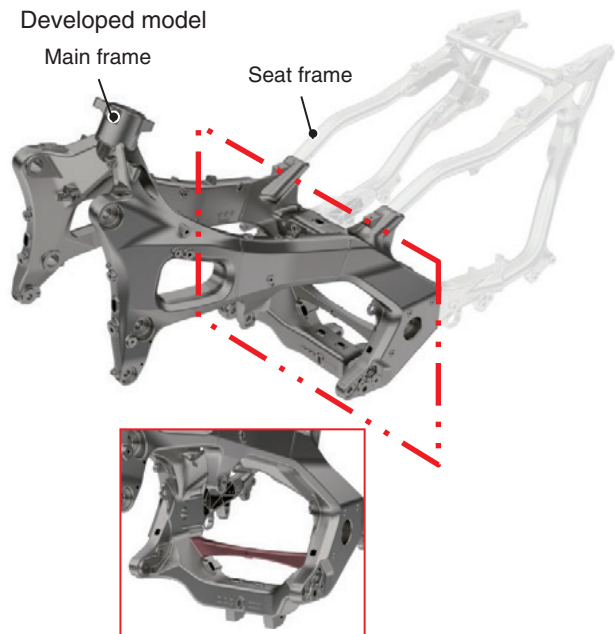


Fig. 23 Comparison of frame bodies

4.2. Swing Arm

The swing arm pivot is redesigned to reduce weight and enhance handling stability and riding comfort while maintaining the same single-sided arm construction containing the drive shaft in the right side of the motorcycle.

In the previous model, the swing arm was held by the taper roller bearings in the right and left sides. Due to the said construction, the frame body had to be stiff to withstand the preload necessary for the bearings, causing an increase of weight. In this model, the ball bearing used only in the left side locates the swing arm onto the frame body, and the needle bearing is used in the right side.

This design eliminates influence of axial retaining force of the right side pivot to the stiffness on the frame body side, enhancing degree of freedom of frame body design.

By the optimum stiffness in the frame body side from all those modifications, the handling stability and supple riding quality have been realized.

The construction of pivot is shown in Fig. 25.



Fig. 24 External view of rear cushion

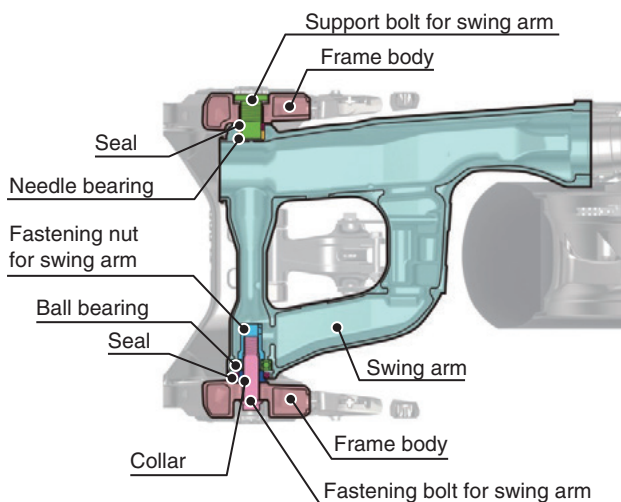


Fig. 25 Structure of swing arm pivot shaft

5. Air Management

The challenge in the air management department in this new model development was how to achieve all of the performance targets, such as the comfort of rider and passenger (wind protection, heat management), fuel consumption (reduction of aerodynamics drag), enhanced maneuverability, and compact appearance.

Generally, the streamline bordering the inside and outside of the apace protected by the wind screen draws an arc, reaches to the apex near the head of the rider, and gradually comes down. Accordingly, even when the screen size is the same, the wind protection performance is less affected by the lowering of the streamline when the wind screen is closer to the rider. In this model, both the rider and passenger seating positions are moved to the front of motorcycle by 36 mm from the previous model to maintain wind protection for the rider and the passenger.

Moreover in this model, with the employment of the electrically adjustable wind screen and the air ducts, the air is positively introduced to inside of the wind-protected area to allow the rider enjoy “nice breeze” unique in motorcycle riding.

Thus the target level of comfort has been achieved while realizing the compactness, which reduces aerodynamic drag coefficient by 13% from the previous model, contributing to the enhancement of fuel consumption and maneuverability.

Coupled with the fuel consumption improvement of the engine, the fuel consumption is improved as mentioned in Section 3.3.4. In addition to it, the weight of the fairing is reduced by 2.4 kg.

5.1. Electrically Controlled Wind Screen

The wind screen was manually adjustable in the previous model. The motor-driven, electrically controlled wind screen is employed in this model. This system provides continuously adjustable screen height by the handlebar switch to fit to the situations and speeds at running in town or on freeway. Also, the round shape of slide rail allows simultaneous altering of height and angle of the wind screen, allowing more changes of stream lines from a certain length of screen travel. Thus, the compact and light weight system has been achieved.

The trace of wind screen travel is shown in Fig. 26.

5.2. Air Management Analysis by CFD

In this new model development, the air management was analyzed by CFD.

The steady-state analysis is generally used to analyze the streamlines that border the inside and outside of the wind-protected zone. This method is also used in this new model development to clarify wind-protected zone. Meanwhile in actual riding, the air pressure fluctuates near the border due to the turbulence, causing such a phenomenon that the rider’s head is shaken side to side or longitudinal directions in some cases. As the steady-state

analysis does not permit reproducing of fluctuations of flow speed and/or air pressure, it used to be unlikely to analyze the phenomenon. Thereby in this product development, the unsteady-state analysis was introduced in addition to the steady-state analysis⁽⁷⁾, to visualize the pressure fluctuations as a physical quantity.

The distribution of average flow speed determined by the steady-state analysis is shown in Fig. 27 (a) and (b). The screen height was set at the highest within the



Fig. 26 External view of electronically controlled wind screen

adjustable range in all cases.

As shown in the picture (a), the border is above the helmets of the rider and the passenger in this new model, indicating the space for the rider and the passenger is within the wind-protected zone. Similarly in the previous model as shown by the picture (b), the border was also above the helmets of the rider and the passenger, indicating no significant difference in the wind-protected zone.

The distribution of pressure fluctuations determined by the non-steady-state analysis is shown in Fig. 27 (c) and (d).

As the comparison of pictures (c) and (d) indicates, the pressure fluctuations are less in this model than in the previous model especially at passenger's head. Actual wind tunnel tests and riding tests revealed that shaking of rider's head was less in this model than in the previous model. As such, the analysis of correlation between the simulation and the rider feedback from actual riding test allows enhancement of simulation accuracy and proper designing of details of shape.

With all the measures taken, the screen width of this model at the widest part is reduced by 185 mm from the previous model, the height from the ground up to the upper end of screen is reduced by 25 mm (Comparison at the lowest position within the adjustable range) contributing to the compactness and the comfortableness necessary for a tourer motorcycle.

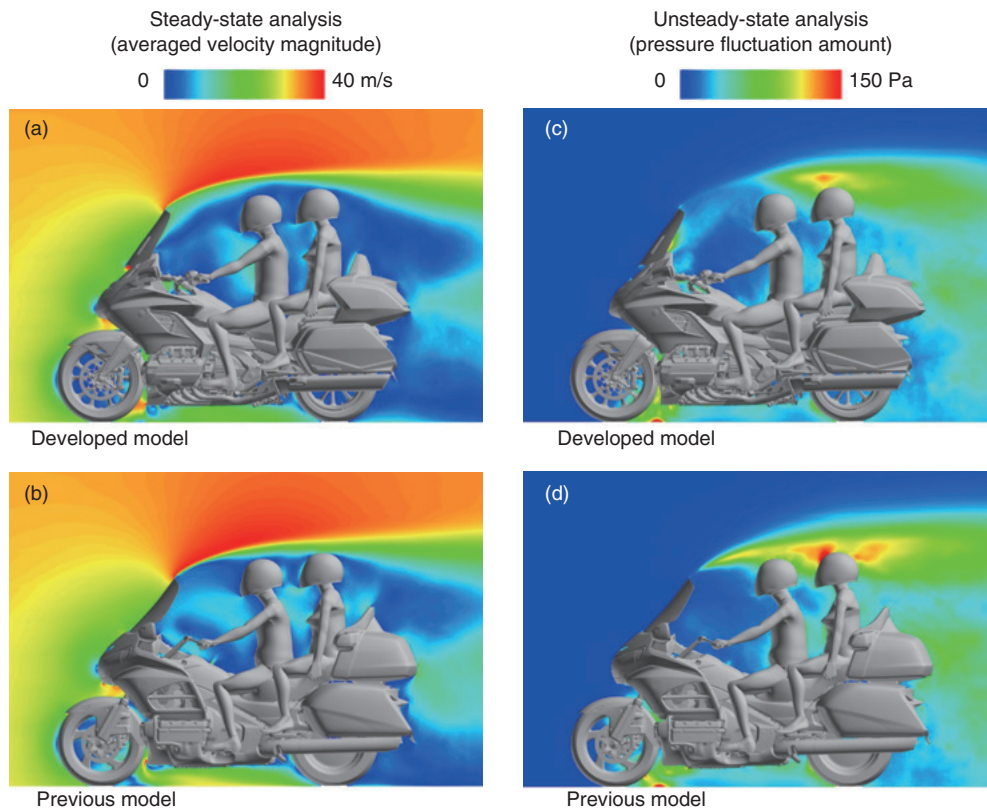


Fig. 27 Results of verification for wind protection performance by CFD analysis

6. Conclusion

In the newly developed Gold Wing, a lot of latest technology is introduced while maintaining the legacy and tradition continued in the Gold Wings of past generations. The curb weight of complete vehicle is reduced by 40 kg. Regarding the compactness of complete vehicle, the overall length is less by 55 mm, the width by 40 mm, and the height by 25 mm from the previous model.

Thus created is the modern-edition premium grand tourer that the owner can enjoy together with the passenger a high quality travel full of “fun to ride, fun to control,” which is the essential attractiveness of a motorcycle.

References

- (1) Aoki M., Tosaka T., Minami H., Ishihara H., Kano K.: Introduction of Gold Wing GL1800, Honda R&D Technical Review, Vol.13 No.2, p.13-26
- (2) Hoshi N., Shimura Y., Okuma T., Nomura A., Goto K.: Introduction of 4-stroke motocrosser CRF450, Honda R&D Technical Review, Vol.14 No.1, p.21-30
- (3) Yokota, H., Nojima, S., Sonoda, Y., Osaki, Y., Kontani, M., Yamasaki, S.: Development of Horizontally-opposed Six-cylinder Engine for 2018 Gold Wing, Honda R&D Technical Review, Vol.30 No.2, p.16-30
- (4) Kusuda A., Yokogawa Y., Nakai K.: Development of Ride Modes for Various Conditions for 2018 Gold Wing, Honda R&D Technical Review, Vol.30 No.2, p.38-46
- (5) Hirayama T., Yokogawa Y., Fujimoto Y.: Development of 7-speed Dual Clutch Transmission for 2018 Gold Wing, Honda R&D Technical Review, Vol.30 No.2, p.31-37
- (6) Kuwabara N., Mishiro J.: Development of Double Wishbone Type Front Suspension for 2018 Gold Wing, Honda R&D Technical Review, Vol.30 No.2, p.47-52
- (7) Nishiwaki D., Ozawa H.: Analysis of non-steady-state flow that causes head shake of motorcycle rider, JSAE 2018 spring convention, technical paper presentation, No.15-18, p.1-5 (2018) (in Japanese)

■ Author ■



Kihoko KAITA



Yutaka NAKANISHI