

Development of 2020 H'ness CB350

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ABSTRACT

In India since the mid-2010s, middle and large size motorcycles are becoming popular and being enjoyed as a hobby, causing the market of such motorcycles to grow. This development is targeted at such a motorcycle that fills a wide variety of needs from daily use to long tours. In this newly developed model H'ness CB350, the chassis is designed for an upright riding position and a moderate steering response as well as ensuring stability and easy handling. The engine thumps to characterize strength. Another modern convenience is the connectivity that allows stress-free use of smartphone.

1. Introduction

While the global motorcycle sales dropped in 2020 due to COVID-19, an upward trend is seen in 2021. A single country contributing most greatly to the statistic is India, which is world's largest motorcycle market (Fig. 1). India has liberated international trades in 1990's and achieved remarkable economic growth later on. With the increase of labor force starting sometime around 2010, expectations are high as a hot market. Under such circumstances, a large number of people use motorcycles and scooters for

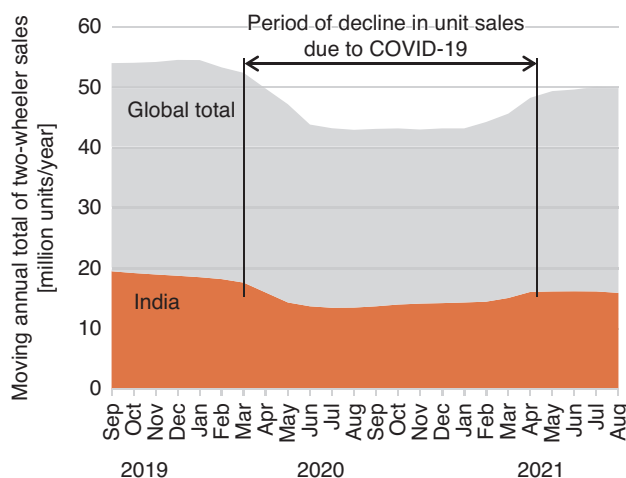


Fig. 1 Motorcycle sales trends (Market research data by Honda Motor)

daily commuting. Recently, in addition to smaller models for daily mobility, middle and large size motorcycles are increasing steadily. Figure 2 shows sales volume of middle and large size motorcycles having an engine displacement 161 cc or larger in India.

In this category, there are several models from a long-established Indian brand. The timeless styling design unchanged for tens of years and the thumping exhaust sounds from the single cylinder engine are well received by users. Such models still remain as a desirable item of consumers whose income is increasing due to the economic growth. The number of users of such motorcycles are increasing year by year because some models are in an affordable price range, creating a new market segment.

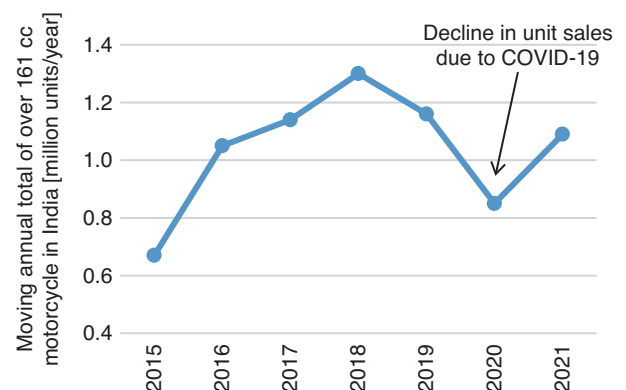


Fig. 2 Sales of over 161 cc motorcycle in India (Market research data by Honda Motor)

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In the meantime, Honda has striven for supplying of smaller motorcycles and scooters, which are convenient means of daily mobility, to the majority customers. The customer voices via dealers for high expectations of middle and large size motorcycles, however, are an indication of a potential desire of Indian customers for such motorcycles. What is expected from Honda at an entry into this segment is an advanced product rather than replication of existing model. To deal with such demands, we started development of H'ness CB350 for representation of high-tech identity of global Honda and beauty of classical motorcycle (Fig. 3).



Fig. 3 The H'ness CB350

2. Development Goals

In India, the core customers of middle and large size motorcycles having an engine displacement of 151 cc or larger are under 30 years old. Figure 4 shows the demography of purchasers in each segment in India. In view of the segment structure, we decided to analyze life style of young users at the start of this development.

First found is that approximately 80% of purchasers of middle and large size motorcycle live in an urban area (Fig. 4). It is evident that such users are influenced by world's trends on real-time basis via SNS information available from the widespread smartphones⁽¹⁾. Thereby changed is the value such customers seek from a motorcycle. Especially noteworthy is that motorcycle tours are starting to be included in weekend entertainment in that movies used to be predominant. Nowadays stories from a motorcycle tour are beginning to appear in SNS. Table 1 shows reasons to buy middle-class cruiser models, indicating a gradually increasing desire for comfort in long rides. Meanwhile the survey on the purpose of use of middle-size models shown in Fig. 5 shows that more than a half of the users frequently use the motorcycle for recreational purposes, which indicates that an increasing number of users enjoy long motorcycle travels. We consider from these findings that the purpose of use of motorcycles, which used to be a mere means of transport, is changing.

Table 1 Reason to buy middle class cruiser model

	2015	2016	2017
Top	Appearance	Appearance	Comfortable for long ride
2nd	Model reputation	Maker reputation	Appearance
3rd	Maker reputation	Exhaust sound	Riding comfort
4th	Riding comfort	Comfortable for long ride	Riding posture
5th	Exhaust sound	Riding comfort	Displacement cc

On the other hand, it has been revealed from the inhouse user interviews that such young users also find value in tradition. They often carry a family member or a friend as a passenger, want an awesome image when riding and prefer a timeless styling design rather than uniqueness. Similarly to users' adhesion to traditional values, the environment surrounding motorcycles has not yet undergone a complete renewal. Although infrastructures such as roads are rapidly developed recently in India to deal with urbanization, there are chronic traffic congestion in urban areas. A mixture of paved and unpaved roads is often seen. In view of the sense of value and environment new and old ones are mixed up, we set a target at new-generation users and filling of their diverse needs.

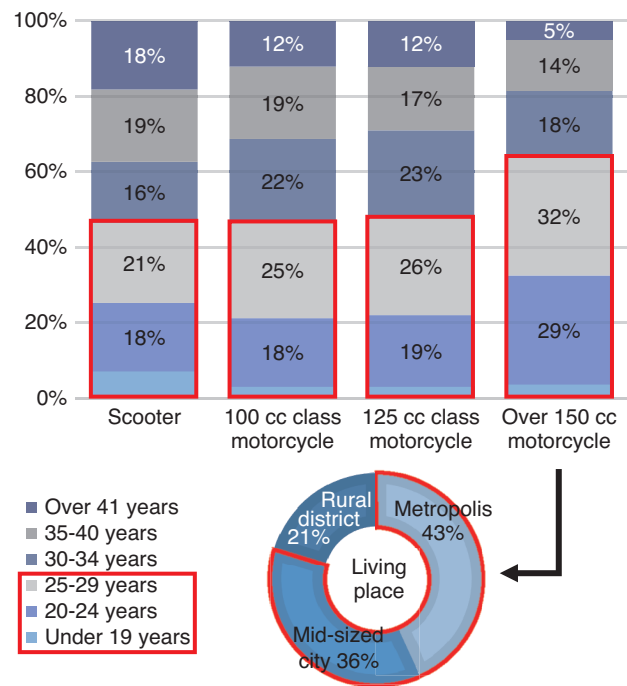


Fig. 4 Age analysis of people who bought new two-wheeler and living places of over 150 cc class motorcycle users (Market research data by Honda R&D India)

Usage of 350 cc class motorcycle

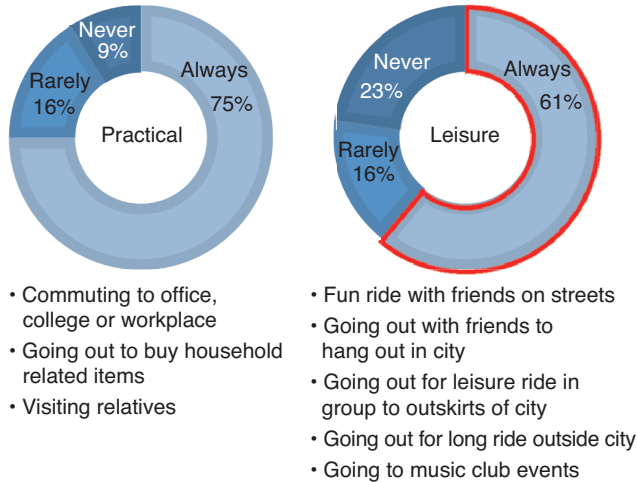


Fig. 5 Survey of usage applications for people riding motorcycles with displacement of 350 cc (Market research data by Honda R&D India)

3. Concept of Product

To satisfy needs of new-generation users having new/old mixed sense of value, we established such a theme “From daily use to long tours – The Honda Basic Roadster.” The following four key requirements have been set for realization of a motorcycle that meets the theme.

- (1) Allow the user to feel an imposing presence
A stately appearance full of characters and a relaxed riding position in that the key player is the rider.
Strong and massive thumping effect that provides the rider with such a sense of satisfaction that he or she is really motorcycling.
- (2) Allow the rider to ride with a peace of mind in long trips or even on unpaved surfaces

Table 2 Specifications of H'ness CB350

	H'ness CB350
Displacement (cm ³)	348.36
Bore x Stroke (mm)	70 x 90.5
Maximum power (kW/rpm)	15.5/5500
Maximum torque (Nm/rpm)	30.0/3000
Curb weight (kg)	181.1
Fuel consumption (km/L)	40.0 (WMTC)
Overall length (mm)	2163
Overall width (mm)	800
Overall height (mm)	1107
Wheel base (mm)	1440
Maximum steering angle (deg)	43
Fuel tank capacity (L)	15
Ground clearance (mm)	176

High stability and moderate steering response.

- (3) Easy to handle in a smaller space or congested roads in urban areas, pleasant to ride

Easy to handle in urban areas and fun-to-ride at lower speeds.

- (4) Provide high-tech images

Up-to-date connectivity to allow stress-free use of smartphone.

Table 2 shows major specifications. The major technical means for realization of the above requirements are sorted into three categories and explained from the next chapter.

4. Chassis

Though different from a region to another, the road conditions vary considerably in India. Figure 6 shows some examples of road conditions in India. In day-to-day



Fig. 6 Daily and leisure environments

use, the motorcycle is often used on unpaved roads and/or in a heavy traffic congestion. The motorcycle has to be easy to handle in a smaller motorcycle parking lot. For some recreational users, the beautiful Leh Ladakh in the Himalayan highland is a dream destination of motorcycle tour. To go there, it is presumable to ride hours on unpaved roads at a high elevation (as high as 5,000 meters). The technical considerations taken to realize a common riding position suitable for a wide variety of rider's build and riding conditions are explained hereafter.

4.1. Upright Riding Position

We aimed at a more upright riding position than an average middle-size naked motorcycle (Fig. 3). Comparison to an average middle-size naked motorcycle is shown along with the triangle composed of the locations of the handle grip, the hip point (H.P.), and the foot peg (Fig. 7). Setting the handlebar width at 616 mm and moving the handle grip position 44 mm to the rear of the motorcycle and 12 mm upward from the average position, rider's forward tilt is reduced. In this upright position, the broad front view provides the rider with a peace of mind. The foot pegs are moved 91 mm to the front of motorcycle and lowered 26 mm from the average position to bring the knee angle close to 90 degrees. With these considerations taken, the target riding position has been realized.

Figure 8 shows comparison of seat thickness from the H.P. As the handlebar position and the foot peg location are fixed, if the allowable seating position is limited to a smaller area on the seat, the riding position will be confined for some riders because rider's build varies. To realize comfortable upright riding position for riders of various builds, the flat seat bottom is employed along with the adequate pad thickness of 60 mm or more in the 120 mm range in the fore-and-aft direction of the motorcycle.

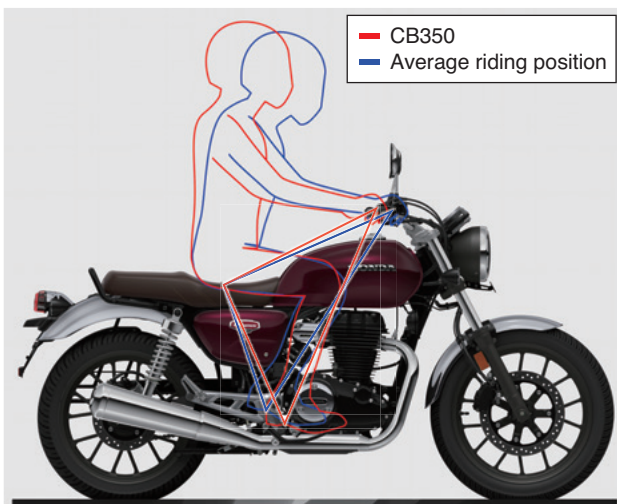


Fig. 7 Comparison of riding positions

Figure 9 is an image picture of the layout. The image lines are composed of the three parallel lines of frame components, i.e., the down tube, the pivot pipe, and the rear shock, the symmetrically-laid front fork line, and the horizontal line that splits the motorcycle into upper and lower parts. Thus, the comfortable upright riding position has been realized.

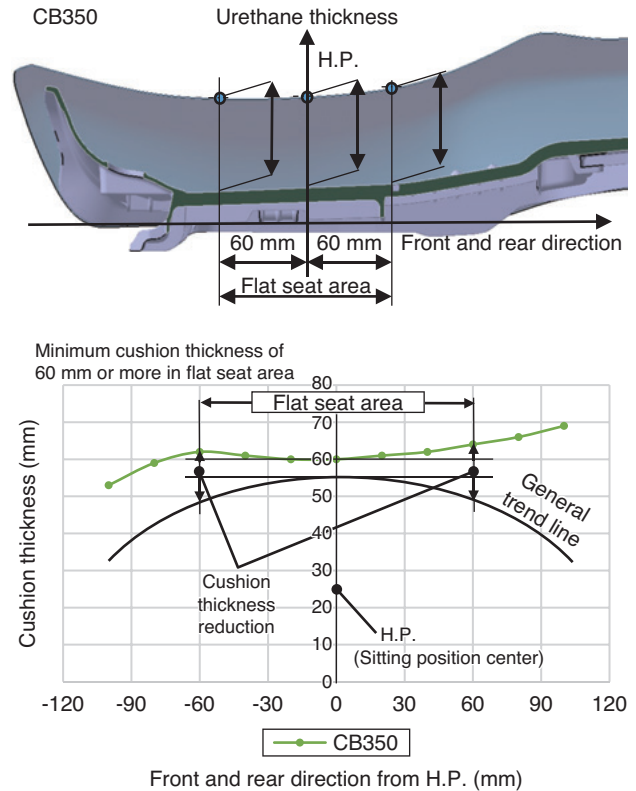


Fig. 8 Comparison of urethane thickness from center of sitting position

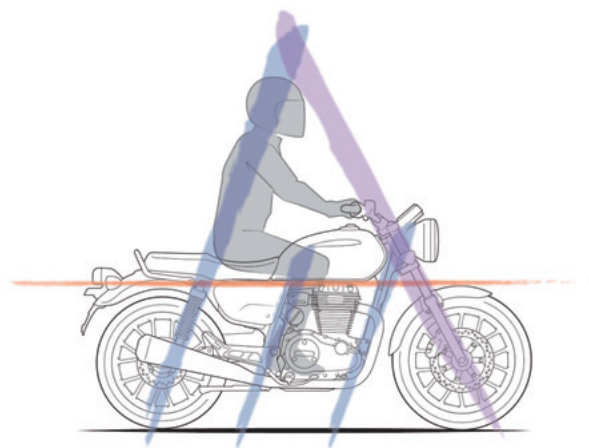


Fig. 9 Sense of unity between rider and vehicle

4.2. Moderate Steering Response

In conventional middle and large size motorcycles, the frame stiffness is maintained high for quick steering response by positively using the engine as a structural member. The mainstream construction is such in that the frame is connected to the cylinder head or the cylinder head cover (hereafter referred to as head hanger) in addition to the engine mount in the crankcase. As this model is aimed at a moderate steering response to deal with various road conditions, we consider that the frame requires flexibility that is unattainable from the abovementioned construction having a high stiffness. Accordingly, we used CAE and analyzed the construction to reduce frame body stiffness, to maintain flexible areas, and to achieve uniform deformation.

Figure 10 shows the frame constructions of this H'sness CB350 and CB400SS along with the relationship between the engine mount points and the flexible area. The red lines connect engine mount points. The CB400SS is an air-cooled, single cylinder model sold in Japan since 2001. This model uses a conventional design having a head hanger. Such a head hanger is non-existent in H'sness CB350, maintaining a long span from the lower end of the head pipe to the hanger mount point to allow the entire frame body to flex. Moreover, with the stiffness reduced by the inner pivot construction in that the frame body is laid inside of the swingarm, the torsional stiffness is lowered by 29% from CB400SS.

Figure 11 shows an example of frame body stiffness data analyzed by CAE when a lateral load is applied to the front and rear tire contact points. In this model, the stress is distributed widely from the lower end of the head pipe to the engine hanger mount. To equalize deformation, the cross-sectional areas of each frame member and the welded stays and other parts are designed to minimize influence on stiffness (Fig. 12). This flexible frame allows moderate convergence of body oscillation when subjected to an external force.

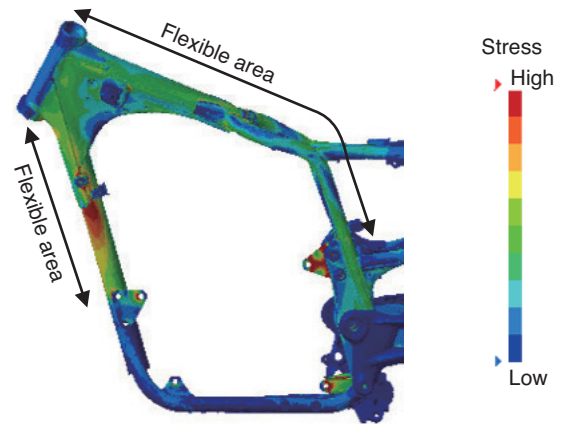


Fig. 11 Frame body analysis result

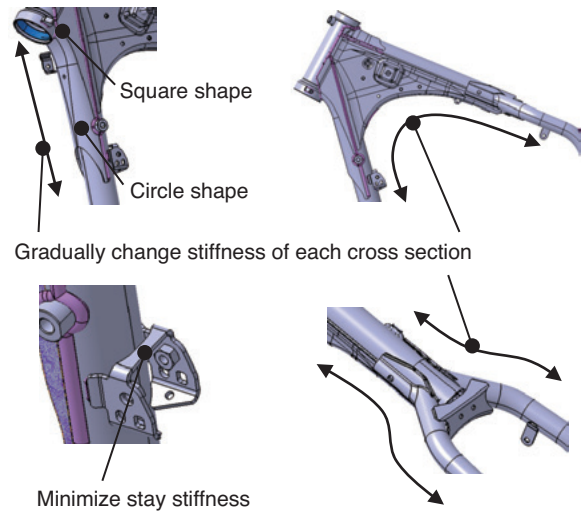


Fig. 12 Each part structure to make deformation uniform

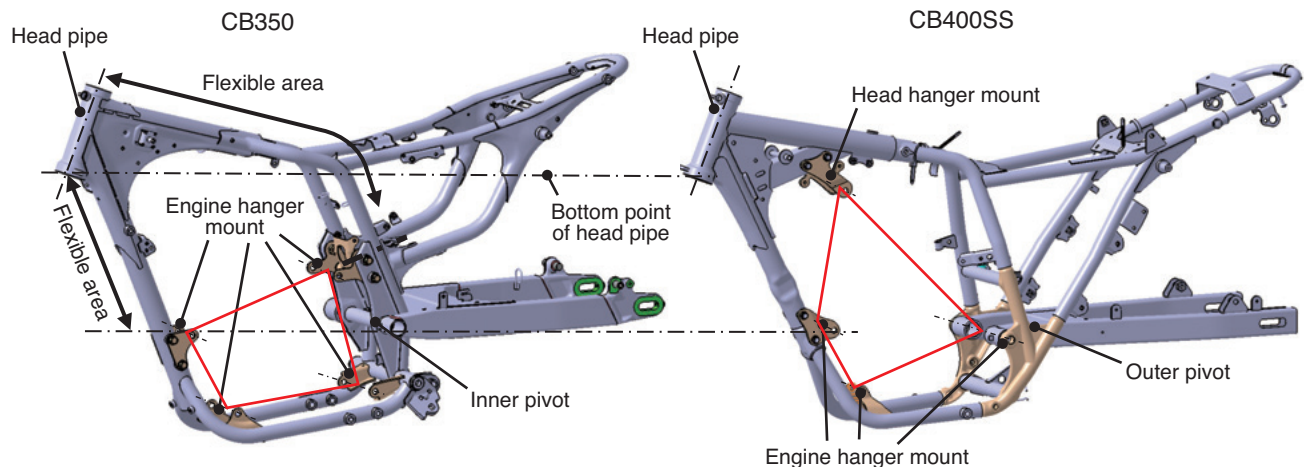


Fig. 10 Flexible areas in frame body

5. Engine

Figure 13 shows the relationship between the front wheel weight bias and the height of center of gravity (CG) of the motorcycle. The moderate steering response is achieved by reducing front wheel weight bias and lowering the CG from the basic sport motorcycles.

4.3. Stability and Easy Handling for Daily Use

In this model, the wheel base is set at 1,440 mm which is longer than other models in the same engine displacement category to enhance stability for relaxed riding. For easy handling in daily use, the maximum turning angle of steering is set large at 43 degrees. To realize the target turning angle, the caster is set at 27.5 degrees, the front fork pitch at 204 mm, and the fork offset at 45 mm. In addition to that, the fuel tank is shaped so as to allow easy handling as well as satisfying styling requirements. Thus realized is the turning radius as smaller as that of a smaller displacement motorcycle for daily commuting. Figure 14 shows the relationship between the wheel base and the turning radius.

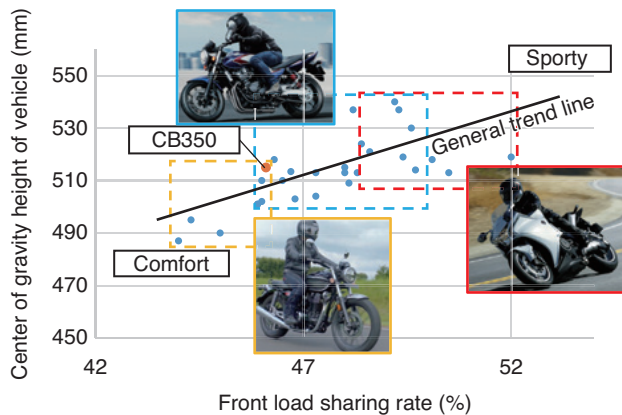


Fig. 13 Relationship between wheel weight bias and center of gravity height

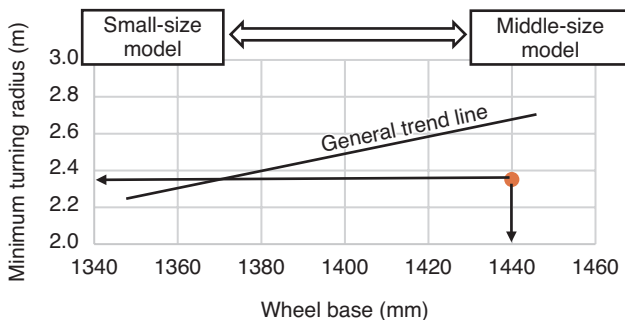


Fig. 14 Relationship between wheel base and minimum turning radius

Thumping sounds and sensation⁽²⁾ are important criteria for Indian customers when choosing a motorcycle for cruising. For in-town convenience, the engine has to be powerful and torquey in lower engine speeds, and the vehicle weight should be lower for easy handling. The configuration we have chosen to meet such demands is a single cylinder, long-stroke 350 cc engine that allows balancing of torque-to-weight ratio and engine weight. Such an engine is suitable for use in lower engine speeds. The rider can easily sense thumping of the engine of such a configuration because of its long combustion intervals. Employing the air-cooling system, the engine features simple appearance with an emphasis on the functional beauty of the cooling fins. In addition to the long-stroke configuration that excels in combustion efficiency, the upper part of the cylinder head is oil-cooled to meet BS6 emission norms enacted from 2020 in India.

5.1. Characteristics of Vibrations That Bring About Thumping Effect

The thumping effect is generally considered as a mixture of sensation from the sounds, especially exhaust sounds, and the vibrations. Both sounds and vibrations are important factors to provide the rider with a big thumping effect (Fig. 15). To provide strong thumping effect, studies were conducted in the frequency characteristics of the sounds and the vibrations. While listening to the exhaust sounds from the earphones at a constant speed of 3000 rpm, the tester was subjected to vibrations of various frequencies from the

	Exhaust sound	No sound
Engine vibration 	1 Good pulse feeling	2 Pushed up feeling (not pulse feeling)
No vibration 	3 Be able to feel pulse feeling, but not enough	

Test conditions

1. Feel the sound and vibration

Test vehicle: Single cylinder engine motorcycle
Test mode: Accelerate to speeds of 0-80 km/h

2. Feel only vibration

Test vehicle: Single cylinder engine motorcycle
Test mode: Accelerate to speeds of 0-80 km/h with earplugs

3. Feel only sound

Test vehicle: EV scooter
Test mode: Accelerate to speeds of 0-80 km/h
+ Play the exhaust sound with earphones

Fig. 15 Combination of exhaust sound and engine vibration for pulse feeling

large exciter machine, and assessed if the vibrations were matched with the exhaust sounds. The excitation was of a sine wave of 12.5 Hz, 25 Hz, 50 Hz, and 100 Hz. Three testers were deployed. An average of absolute assessment in 10 grades was taken. As shown in Fig. 16, it has been determined from the tests that the matching is best when the vibrations are at 25 Hz, which corresponds to the combustion interval, i.e., 0.5 order, of the engine speed. In other words, thumping effects can be enhanced if the vibrations from the 0.5 order excitation are emphasized and the vibrations of other orders are reduced. The vibrations from the 0.5 order excitation are hereafter referred to as 0.5 order vibrations.

5.2. Control of Vibrations to Achieve Maximized Thumping Effect

It was decided to attain the higher thumping effect in

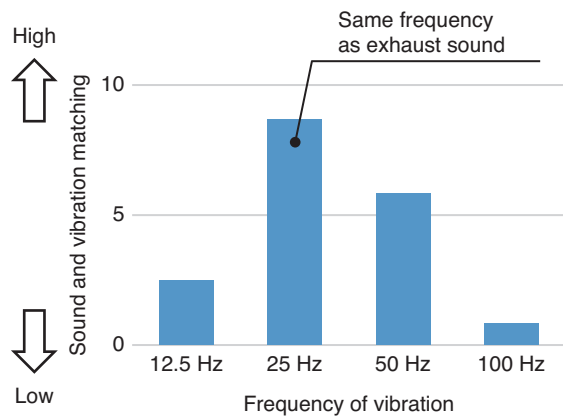


Fig. 16 Matching vibrations of different frequencies with exhaust sound

this model by setting the vibration characteristics in such a manner in that the 0.5 order vibrations are larger than those of the first order in the frequently-used speed range (up to 80 km/h in top gear). The vibration characteristics of CB400SS are shown in Fig. 17(a). The acceleration was measured at the frame pivot point in the full-throttle acceleration mode. The 0.5 order vibrations are mainly due to the torque fluctuations occurring predominantly from the combustion force that drives the rear wheel, and lowers along with an increase of engine speed. On the other hand, the first-order vibrations occur from reciprocating motions of the piston, and increase along with an increase of engine speed.

To increase 0.5 order vibrations, measures are taken to reduce loss of energy. First of all, the offset cylinder design is employed to reduce piston friction. Then, the sealed crankcase construction is applied to control oil agitation losses and air resistance from movements of the piston, crankshaft, and other parts. Figure 18 compares pressures at various places of this model to the 300 cc, air-cooled single cylinder engine without the sealed crankcase construction. It is evident that the crankcase pressure is lower in this model than the other model without the sealed construction.

The clutch damper and the rear hub damper are provided in most motorcycles to absorb shocks occurring from engine torque fluctuations when the power is transmitted to the rear wheel. While an excessively stiff damper may cause the motorcycle to become jerky, a soft damper reduces such a sensation as being kicked forward by the rear wheel. When assessing such a sensation as being kicked forward by the rear wheel, a number of factors have to be taken into account such as the combustion conditions, the inertia moment of power transmission parts, and the tire specifications. Conducting the multibody dynamic analysis⁽³⁾, a combination of damper characteristics for

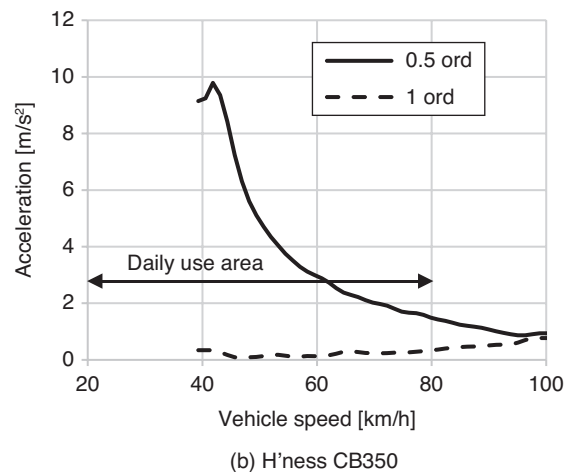
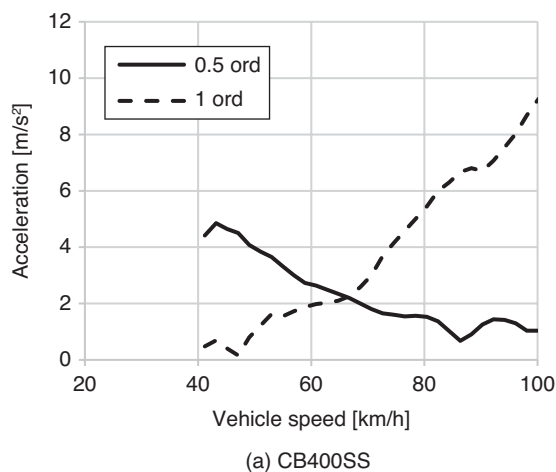


Fig. 17 Frame pivot vibration acceleration of CB400SS and H'ness when throttle is fully open in top gear position

the highest stiffness without causing a jerky-ness was determined to control 0.5 order vibrations.

A new counter balancing system is employed to suppress the first order excitation, which is usually quelled by a single-shaft counter balancer like the one used in the CB400SS. In the single-shaft balancer, a first-order couple occurs because the balancer shaft and the crankshaft are on separate axes. To reduce the first order excitation from the couple, the two-shaft balancer is employed. Figure 19 is an image picture of the counter balancer in this model. An independent rear balancer shaft is not provided because the rear balancer is located on the transmission main shaft behind the clutch. While the rear balancer location is dependent on the distance from the crankshaft to the main shaft, there is more freedom in the front balancer shaft location. It is located as close to the crankshaft as possible to realize a compact and simple layout of the balancer system. Although the front and the rear balancer shafts

are located at a different distance from the crankshaft, the overall balance is maintained by unevenly setting the front and rear balancer weights and the location of the weights in the right and left direction of the engine. Thus, the first order excitation and the couple are controlled to reduce vibrations occurring at a frequency different from that of exhaust sounds.

Figure 17(b) shows the vibration characteristics of this model measured at the same measurement conditions as those of CB400SS. Compared to the CB400SS, the 0.5 order vibrations are higher in lower speeds due to the reduced pumping loss and the optimum setting of damper stiffness. The vibrations from the first order excitation are lower in the entire engine speeds due to the employment of two-shaft balancer. In the frequently-used engine speed zone, the 0.5 order vibrations are higher than the first order vibrations.

5.3. Sound Management to Achieve Higher Thumping Effect

To achieve strong and massive thumping effect at the highest level, the quality of exhaust sound is crucial. The exhaust sound can be assessed in a quantifiable manner using the deepness and the pulsive sensation as the indicators⁽⁴⁾. The deepness indicates such characteristics as thickness, lowness, and heaviness. The pulsive sensation is an index for the intermittence (discontinuity) such as the crispness. In other words, the larger the deepness and the pulsive sensation, the more strong and massive thumping effect is attainable.

To enhance deepness, it is necessary to boost sounds in lower frequencies under 200 Hz. Accordingly, the muffling of lower frequency sounds is reduced by the tail pipe having a larger diameter than that of the models in the same engine displacement category. To boost pulsive sensation, it is necessary to increase sound pressure amplitude deviation in

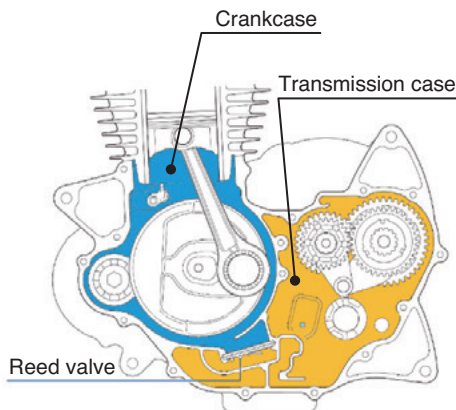
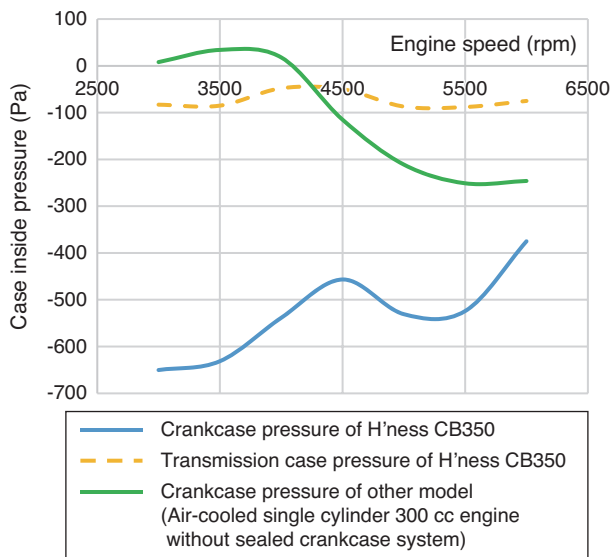


Fig. 18 Case inside pressure of H'ness CB350 (crankcase and transmission case) and other model (air-cooled single cylinder 300 cc engine)

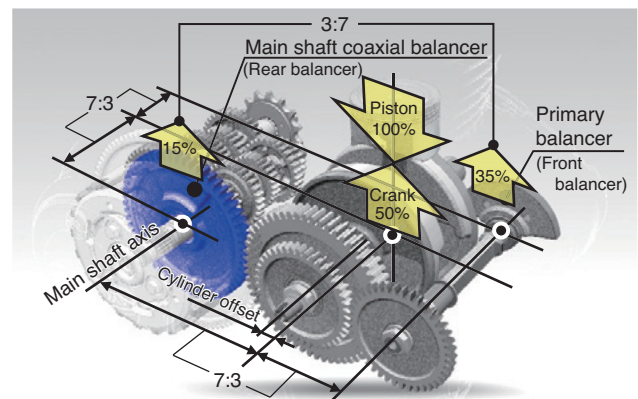


Fig. 19 General layout of single and dual axis balancers of H'ness CB350 engine for first order vibration

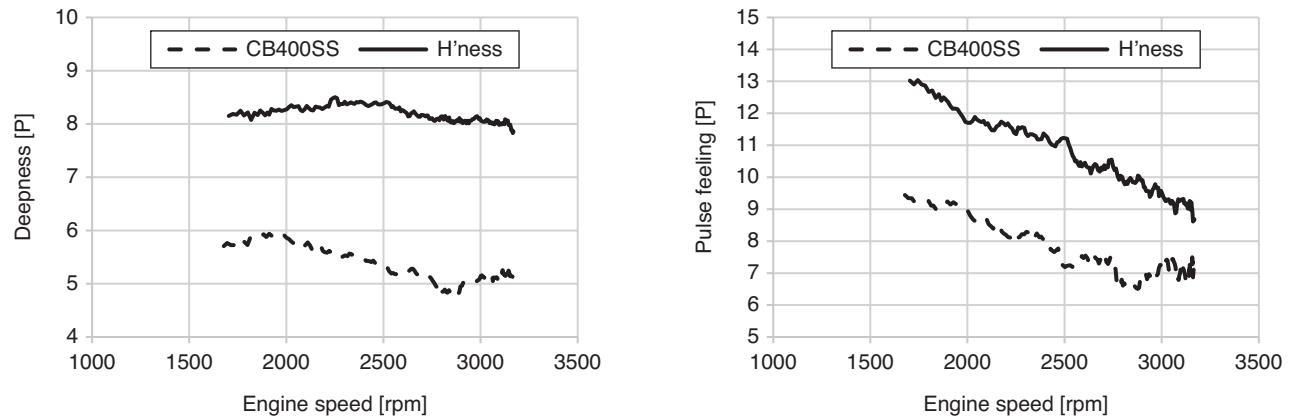


Fig. 20 Comparison of H'ness CB350 and CB400SS deepness and pulse feeling when throttle is 12.5% open

combustion cycle. As an increase of number of expansion chambers narrows the sound pressure amplitude, the single chamber muffler construction is employed to decrease excessive suppression of exhaust pressure pulsation and produce presence-full pulsive sensation. Moreover, the lower-revving, long-stroke, single cylinder engine configuration is employed to widen combustion interval for amplification of pulsive sensation and to achieve such engine characteristics that are strong yet torque-full in lower engine speeds. Figure 20 compares sound characteristics of this model to CB400SS measured during moderate acceleration at the throttle opening of 12.5%. It is evident that both the deepness and the pulsive sensation are greatly stronger in this model than the CB400SS. To meet the noise emission regulations, the noises other than the exhaust sound are suppressed as much noise as possible. The noise radiation from the engine, which affects most largely to the noise emission during running, is reduced by selecting appropriate shapes of engine cooling fins and optimum designing of engine cover stiffness using CAE.

Thus, the strong and massive thumping effect has been realized by the tuning of exhaust sound and the enhancement of the vibrations that best-match the exhaust sound.

6. Up-to-date Connectivity

With the number of users help predicted to exceed 60% of the population in India in 2022, the smartphone is an important item for everyday life⁽¹⁾. You may recognize quite a few riders using the smartphone when stopping at the traffic light or parking on the street in a city like New Delhi (Fig. 21). As the rider usually wears helmet, gloves, and other protective gears, there are many steps involved in just making a phone call. Along with the spread of smartphones in India where the motorcycle population exceeds 150 million units, the desire to use smartphone when riding has been growing. Accordingly, we have decided to

adapt up-to-date connectivity for interaction between the motorcycle and the smartphone.

6.1. System Concept

General-purpose headsets and related parts are already introduced in the market for control of smartphone when riding. Such products, however, require the rider to move a hand off the handlebar to take a phone call or to stand by for a certain period of time. To deal with such issues, we decided to develop a system that allows communication with the smartphone mainly by means of voice feedback. By using minimized hand switches together, the system allows stress-free operations when riding.

6.2. Basic Functions

A variety of smartphone functions such as text message, search, map, and navigation are generally used frequently⁽⁵⁾.



Fig. 21 Using smartphone while on motorcycle

After studying various options, we selected the voice navigation, music player, phone call, and message exchange as the basic functions that help riders when riding. The system is devised to give a priority to the phone call and message so that those functions interrupt other functions being used. Figure 22 shows detailed explanations of the functions.

6.3. System Structure and Hierarchy of Operations

Figure 23 shows overview of the system. The

smartphone and the motorcycle are connected via **Bluetooth** wireless. The rider can control the smartphone by operating the switch on the left handlebar. The headset and the smartphone are also connected via Bluetooth wireless, allowing the user to upload voice message and listen to music, phone call, and messages being read out loud.

The system is structured so as to permit reaching to the required command by repetition of selection from the simple menu of each hierarchy level. Though the hierarchy structure is different from a function to another, the

	Detail of function	Remark
 Navigation	Search places and set new destination	Can search destination by voice Navigate by using Google maps
	Set destination from favorites	Can register 5 favorite places (Home, work place, friend's house, and so on)
	Cancel navigation	-
 Call	Receive call	-
	Start call to your contacts	Can search contact by voice
	Start call to your favorites	Can register 5 favorite contacts
 Message	Read received SMS, WhatsApp, LINE, Facebook Messenger and reply by voice	Can input message by voice HSVCS changes voice message into text Can reply by using prepared quick messages as well (OK, I'm driving, etcetera)
	Start to send SMS to your contacts or favorites	Can search contact by voice Can register 5 favorite contacts HSVCS changes voice message into text
 Music	Play music (Google Play Music, Spotify, Amazon music, YouTube Music, and so on)	The availability of 3rd party apps depend on their updates
	Skip music (Next track)	-
	Adjust volume	Can manage volume of smartphone sound to 0, 20, 40, 60, 80, and 100%

Fig. 22 Basic function list

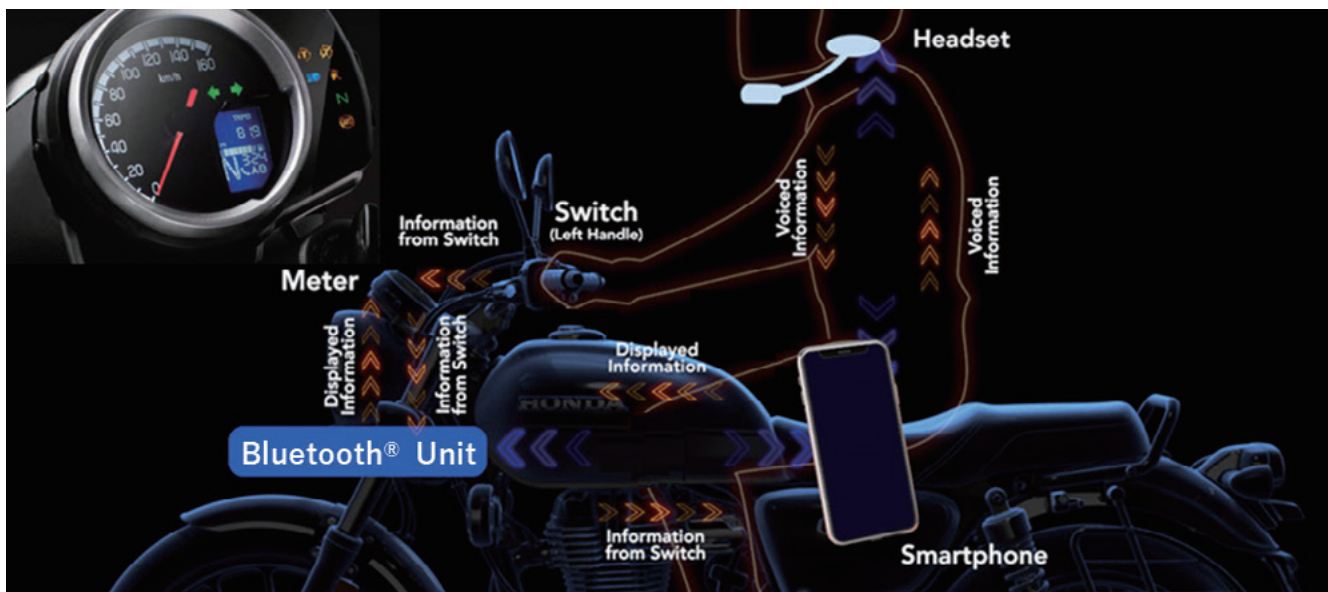


Fig. 23 Schematic diagram of system

number of levels is limited to 4 as Fig. 24 shows because when operating only by voice feedback, you become puzzled where in the structure you are in if the hierarchy is composed of a large number of levels. To determine the hierarchy structure, we conducted actual running tests using the test riders of 20-50 years of age who had undergone an advance assessment by the inhouse bioethics committee. With 3-to-5 levels of selection options provided for each function, we tested which level of the hierarchy is recognizable only by the voice feedback. Accordingly the levels are set at 4 because the operating hierarchy level becomes hard to recognize when there are 5 levels or more.

6.4. Common Switches for Control of Smartphone

To allow control of smartphone without taking a hand off the handlebar, we choose to commonly use the multi-function meter control switch being widely used in recent

motorcycles. Figure 25 shows the controller on the handlebar.

Pressing and holding the right button of the four buttons laid in a cross shape turn the mode to control of multi-function meter. Pressing and holding the left button turn the mode to control of smartphone. Thus, the system permits connected operation of the smartphone without increasing number of switches and compromising user-friendliness.

Thus, the up-to-date connected system has been realized by the coupling of the motorcycle and the smartphone so that the rider can use the smartphone without stress when riding.

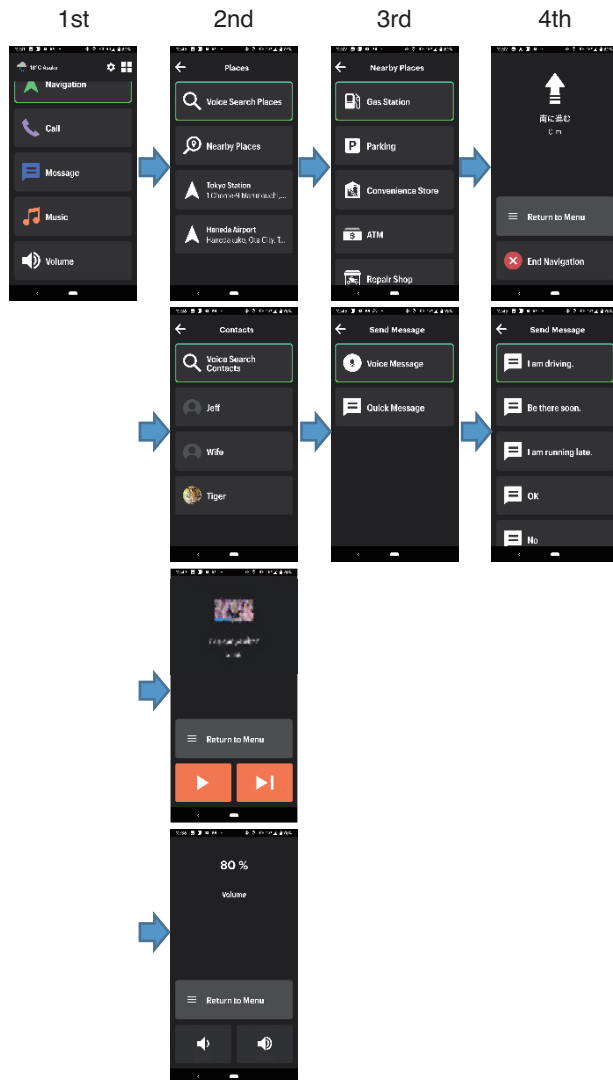


Fig. 24 Application hierarchy tree

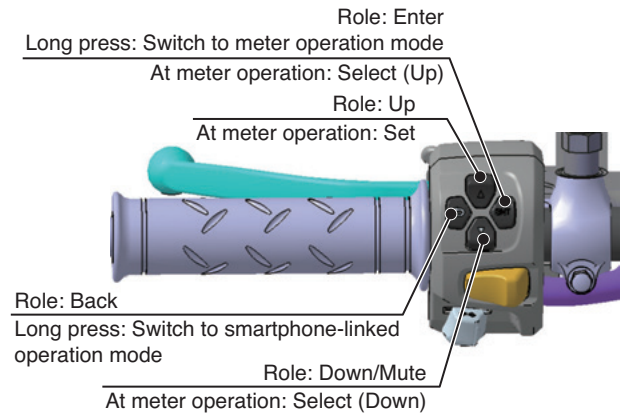


Fig. 25 Handle controller

7. Conclusion

In this development, the target was set at realization of such a motorcycle that satisfies a wide variety of user needs such as daily use and recreational activities. The chassis is designed on the basis of CAE analysis to achieve the relaxed upright riding position, the moderate steering response, and the stability while keeping the motorcycle easy to handle in city areas. To attain strong and massive thumping effect, the exhaust sound is tuned and the matching engine vibrations of the same frequency as the exhaust sound are emphasized. For convenience, the connectivity is added for easy use of a smartphone. The high-tech identity of global Honda and the beauty of classical motorcycle are thus realized in H'ness CB350.

With a theme "From daily use to long tours – The Honda Basic Roadster," this model matches global users' sense of value. Derivative models are imported into Japan. We hope a large number of customers enjoy this motorcycle.

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