Z1000 – The Supernaked that delivers the ultimate excitement

The Z-Series is one of the most popular brands of Kawasaki motorcycles, and the Supernaked Z1000 sits at the pinnacle of Z machines. This paper will discuss various technologies incorporated into Z1000, from technologies that realize its aggressive styling concept, to those that enable the nimble and sure handling as well as the powerful acceleration feel adding to the exciting riding character of this model.

Preface

As represented by the ZEPHYR, the conventional naked bikes were a genre where the classic style was considered to be ideal. When the Z1000 was released in 2003, it established a new genre called the Supernaked with its radical design and exceptional agility and riding performance. Although motorcycles with similar concepts were subsequently released by competitors, we carried over the status and advantages from the previous model as the pioneer of this genre, and developed the 2014 model Z1000.

1 Concept

We examined what is required in the 2014 model Z1000 as a Supernaked from various angles, and decided to focus on enhancing the following elements.

① Styling/design

② Exciting riding character

An "exciting riding character" refers to the sum of all elements the rider feels when riding a motorcycle, such as the feeling of power, handling, and acceleration sound.

2 Styling/design — Pursuit of *sugomi*

The design concept of the new Z1000 was summarized into one word: *sugomi*. Meaning "awe-inspiring energy and intensity" in Japanese, this word set the tone for the styling image, which can be expressed as a "predator in a crouching posture, gathering its energy in preparation to

Fig. 1 Front styling

strike" (Fig. 1). In order to realize this image, it was particularly necessary to make the headlamp thinner and smaller. To this end, we developed an LED headlamp which meets the requirements in collaboration with Stanley Electric Co., Ltd.

In order to develop a smaller headlamp, we worked on the following issues.

(i) Maintaining radiation performance while reducing headlamp size

The high luminosity LED used for the headlamp generates heat on the side opposite from the light emitting direction. Therefore, it was necessary to attach a radiator to maintain the LED performance. While the built-in type where the

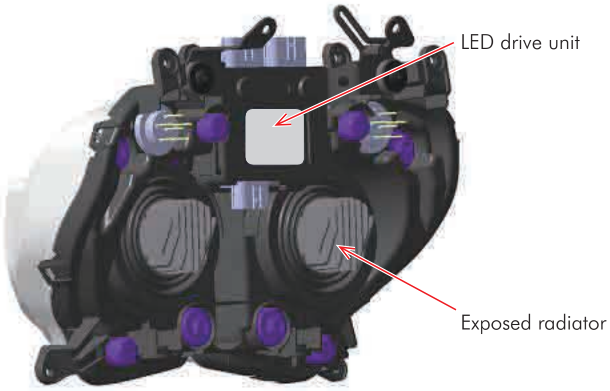


Fig. 2 Headlamp structure (rear side)

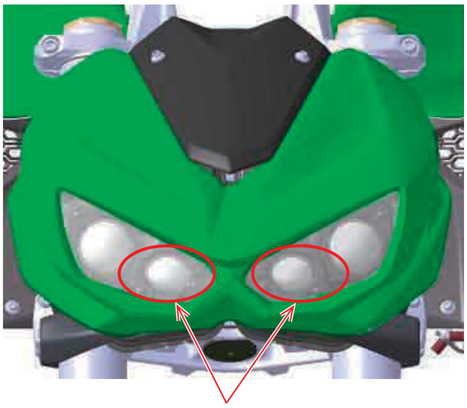


Fig. 3 Inner oval lenses

radiator is embedded in the housing is mainly used in four-wheel vehicles, this would make the overall headlamp too large. To address this issue, we designed a portion of the radiator to be exposed on the back side so that the headlamp can be made smaller without compromising radiation performance.

The drive unit of the constant current which lights the LED at a constant brightness was installed in the space on the back side of the headlamp to develop a smaller headlamp. Accordingly, the distance between the headlamp and drive unit became closer, which enabled the harness to be shortened and simplified.

The structure of the headlamp is shown in Fig. 2.

(ii) Optimizing irradiation range while reducing headlamp size

It is necessary to provide a reflector or an inner lens to condense the light from the LED element to irradiate the road surface. Since priority was given to achieving a smaller size, an inner lens was adopted for this model. Furthermore, in order to make the lens opening look narrower when viewed from the front, an inner oval lens was adopted on the low beam side (Fig. 3). This allowed us to narrow the irradiation range in the vertical direction so that the lights will not blind oncoming vehicles, while widening the irradiation range in the horizontal direction.

Improvements were also made to the routing of the cables and the optical axis adjustment mechanism, making the structure far more compact than the previous model, and allowing us to express the design concept of *sugomi* (Fig. 4 and Fig. 5).

Reducing the size of the headlamp, which greatly affects maneuverability, and bringing it closer to the steering axis decreased the moment around the steering axis, and also contributed to improvement in the handling.

(a) Previous model (b) 2014 model

Fig. 4 Styling comparison (front)

Fig. 5 Styling comparison (side)

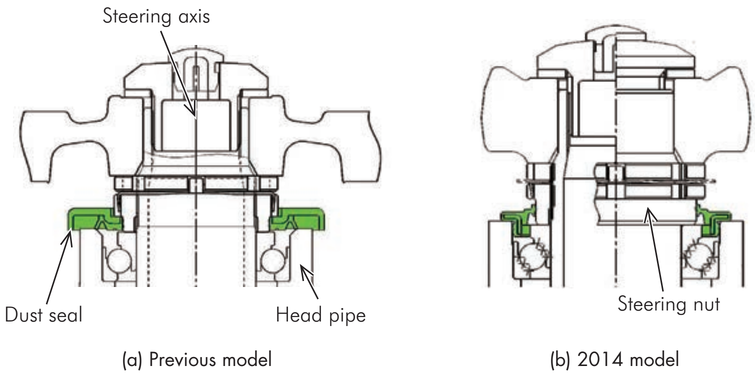


Fig. 6 Configuration of steering dust seals

3 Exciting riding character — Pursuit of riding impact

Improving the engine output or the throttle response also increases the impact that the rider feels while riding. However, the rider also feels the acceleration from the riding position, handling, and even the various sounds while riding.

(1) Nimble and secure handling

(i) Aggressive riding position

The riding position is an important factor which greatly influences the character of a motorcycle. In order to improve the exciting riding character, the handle position was moved forward even further than that of the previous model. This design change made it easier to handle the front wheel, which led to improvement in maneuverability.

(ii) Weight reduction

The total weight of the front and rear wheels, which has the greatest impact as an unsprung weight, was reduced by 1.5 kg from the 12 kg of the previous model, while ensuring the same level of strength was maintained through analysis. As a result, the gyro effect decreased, making it easier to change the direction of the vehicle body.

(iii) Reduction of friction loss of steering

As shown in Fig. 6 (a), the dust seals of the steering axis used to slide along the top of the head pipes in the previous model.

As shown in Fig. 6 (b), the shape of the dust seals was changed so that they slide along the side of the steering nut, which reduced the sliding radius and the rotation resistance. This change dramatically improved the handling, particularly while riding at low speeds.

(iv) Optimization of suspension settings

Since the previous model had established a reputation for excellent balance, the 2014 model was designed so that the rider would be in almost the same position as the previous model. However, the set height of the suspension was lowered in an unloaded state, and the springs of the shock absorbers and the damping force were substantially enhanced (the damping force in the elongation direction was nearly doubled compared to the previous model). As a result, we were able to minimize the change in the posture in the front and rear directions during acceleration and deceleration. With this improvement, we were able to achieve secure handling while delivering quick convergence and a nimble ride, even on the rough and winding roads of Europe.

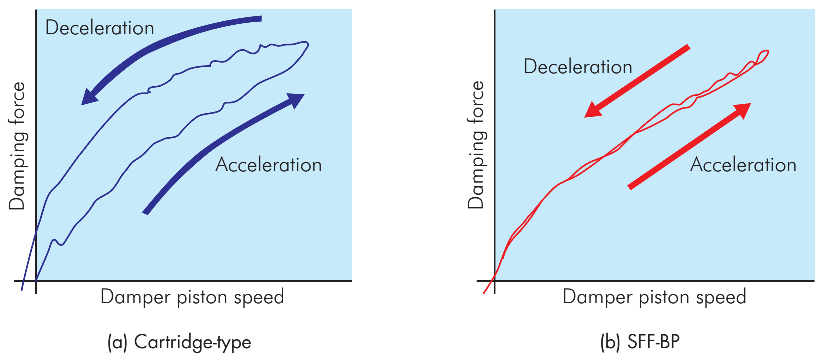


Fig. 7 Comparison of responsiveness of the front fork

(v) Improved response by adoption of Separate Function Fork-Big Piston (SFF-BP)

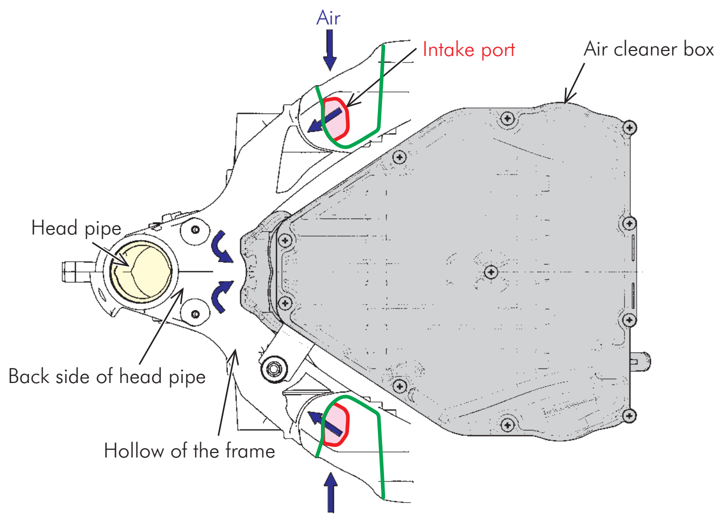
As shown in Fig. 7 (a), in the cartridge type damper that was used for the front fork in the previous model, the damping force is applied late during acceleration and convergence also begins late during deceleration. However, the Showa SFF-BP adopted for the 2014 model has minimal delay in the damping force. As shown in Fig. 7 (b), the damping force kicks in smoothly during acceleration, and quickly converges following the same trajectory during deceleration.

Moreover, while the previous model was equipped with springs and dampers on both sides of the wheel, the new Z1000 has a damper only on one side to achieve a weight reduction of about 300 g.

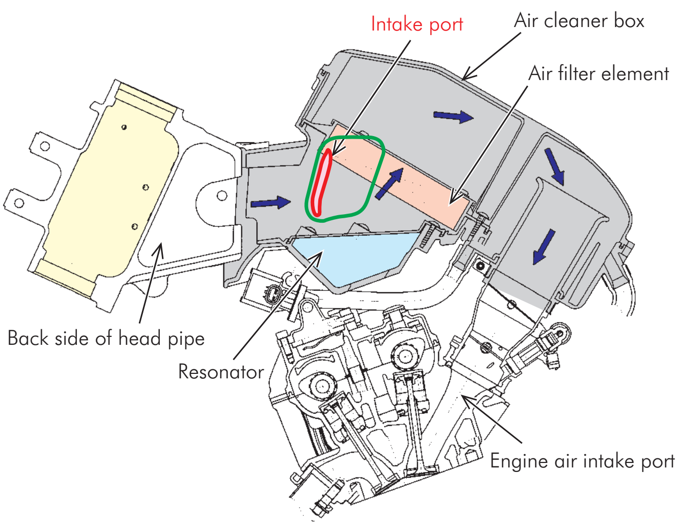
(2) Intake howl which produces the powerful acceleration feeling

Among the sounds which occur during acceleration, we focused on the intake howl experienced by the rider, and attempted to improve the acceleration feeling by correlating the engine characteristics with the intake howl characteristics.

The channel of the intake air is shown in Fig. 8. Air is taken in from the intake port of the frame, and is guided to the air cleaner box from the back side of the head pipes via the hollow part of the frame. Furthermore, foreign matter, etc. in the intake air are removed by the air filter element before the air is supplied to the engine.

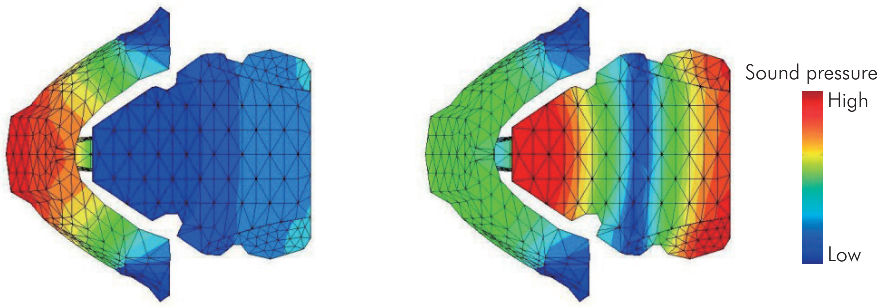


(a) Top view (Cross section)



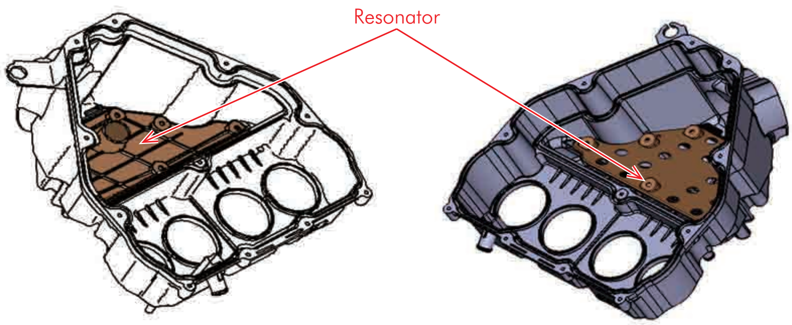
(b) Side view (Cross section)

Fig. 8 Air cleaner box structure and intake air channel



(a) Resonance in hollow of the frame (b) Resonance in front/rear direction of air cleaner box

Fig. 9 Analysis results of sound pressure distribution



(a) Previous model (b) 2014 model

Fig. 10 Changes in the resonator structure

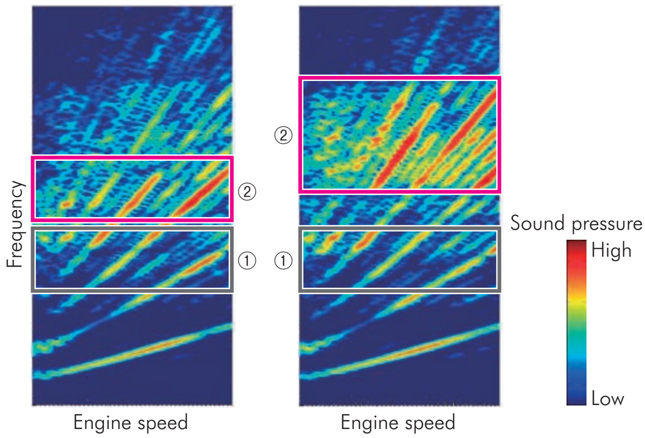
(i) Sound pressure distribution
In order to understand the intake howl which occurs when air passes through the intake path in more detail, we analyzed the sound pressure distribution in the frame and air cleaner box. As a result, two types of resonance were identified in the hollow part of the frame and the front and rear directions of the air cleaner box (Fig. 9).

(ii) Enhancement of intake howl
We designed a structure that enhances the auditory note of the intake by utilizing the resonance which occurs in the front and rear directions of the air cleaner box as the sound is radiated outside.

The resonator in the air cleaner box resonates the air in the enclosed space provided in the middle of the intake path with the intake howl, and reduces the noise of the intake howl. As shown in Fig. 10, this structure was changed from a single pipe configuration to a multi-hole configuration in the 2014 model, to reduce the noise with a specific frequency. Furthermore, the internal structure of the air cleaner box was modified to raise the frequency of the intake howl to promote its radiation.

(iii) Measurement results of sound experienced by the rider
In order to clarify the acoustic effects of the structural change, a test motorcycle was used to measure the sound experienced by the rider. The results of the frequency analysis are shown in Fig. 11.

From the measurement results and sound analysis, we believe that the gray framed portion ① of the previous model shows the resonance in the hollow part of the frame, and the pink framed portion ② reflects the resonance in the front and rear directions of the air cleaner box. In the 2014 model, the resonance (pink framed portion ②) in the front and rear directions of the air cleaner box shifted toward a higher frequency. The red portions increase along with the engine speed, indicating that the sound experienced by the rider is increasing.



(a) Previous model (b) 2014 model

Fig. 11 Measurement of sound experienced by the rider (during acceleration in 3rd gear)

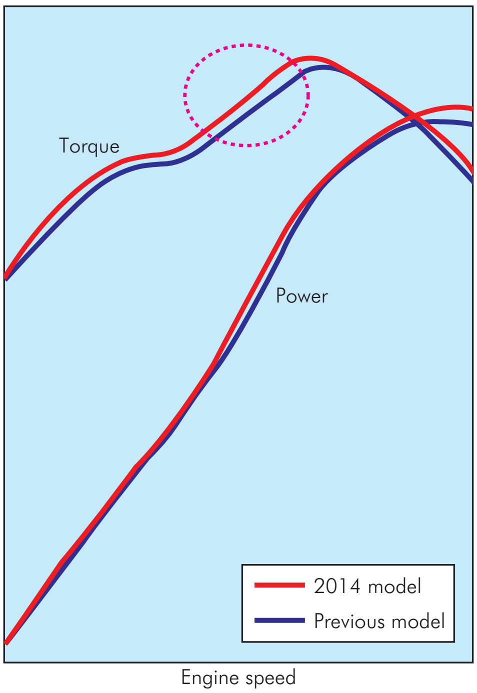


Fig. 12 Enhanced acceleration feel through intake howl

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As a result, the sound experienced by the rider (intake howl) increases at the juncture where the torque increases along with the engine speed (Fig. 12), and the intake howl is synchronized with the increase in the torque. We were thus able to improve the acceleration feeling actually felt by the rider.

Concluding remarks

The Z1000 is the highest-end model of the Kawasaki Z brand. This report introduced the technologies with which we achieved its design concept and exciting riding character.

The Ninja 1000 (Z1000SX), which was developed at the same time, made huge advances in functionality by adopting the Kawasaki TRaction Control (KTRC) and the Pannier system, jointly developed with GIVI of Italy. We will continue to expand these two brands in the future, and develop products which respond to the expectations of our customers.