Development of the Latest Retro Sport Model Z900RS

In the motorcycle market, many customers like standard sport models. These customers focus on the history the brand has rather than vehicular performance, such as speed, and prefer relaxing motorcycles. For this reason, we developed a motorcycle that focuses on a neutral steering feel and an engine sound that inspires fun.

Introduction

In advanced countries, many people enjoy motorcycles as a hobby, so it is important to offer attractive models that appeal to customers' sensibilities. Especially in the Japanese market, many people prefer standard sport models.

1 Background

To develop an attractive model like the Kawasaki' standard sport model ZRX1200 DAEG and classic model W800, we conducted a market survey. The survey found that customers who select these categories place more importance on the style and history the brand has than vehicle performance such as speed.

2 Development concept

Based on the results of the market survey, we decided to focus our development on the Z brand, which has a long history beginning with the Z1 released in 1971, and continuing until the latest model, the Z900.

With "Timeless Z: Z, which has modern functions but an appearance that allows us to share timeless values," as the development concept, we decided not to develop a mere nostalgic model, but to incorporate the Z1's traditional style and the latest model's (Z900) performance into a new model. We thought that doing so would allow us to develop a model that could appeal to a wide range of customers from those who know the Z1 to young people. To achieve this, we needed to achieve a good balance between ease of riding and fun.

Therefore, we decided to develop a neutral steering feel that allows the rider to turn at corners as intended so that a wide range of customers can go for a relaxing ride. Moreover, because customers who own standard sport models demand a better sounding engine, we decided to develop comfortable engine sounds and focus our development on the exhaust system.

3 Development of steering feel

To allow a wide range of customers to go for a relaxing ride, a "neutral steering feel" is required, which allows the rider to turn the handlebars without conscious effort when turning. Therefore, we first identified the vehicle specifications that influence the steering feel when the vehicle is turning. Then, we developed a "neutral steering feel" with simulation technology before making prototype vehicles. Finally, using actual vehicles, we verified that a "neutral steering feel" had been achieved.

(1) Quantitative association of steering feel during steady turning with vehicle specifications

Steering feel during turning is closely related to steering torque, which is the force needed for the rider to turn the handlebars. Basic research found that a state in which no steering torque is applied during turning is a "neutral steering feel."[1)] In addition, among various parameters of the vehicle, the steering torque during running is greatly affected by the caster angle and trail, shown in **Fig. 1**.

First, we defined steering torque during steady turning as shown in **Fig. 2**.

・Positive torque: Handling torque in the forward direction with respect to the turning direction

・Negative torque: Handling torque in the reverse direction with respect to the turning direction

Next, we quantitatively evaluated how the caster angle and trail affects steering torque. As shown in **Fig. 3**, as the caster angle widens, or as the trail shortens, the positive torque increases. For vehicles having a negative torque, therefore, the caster angle is widened or the trail is shortened to decrease the negative torque, thereby achieving a "neutral steering feel."

(2) Development of steering feel for the Z900RS

In the early stage of development, we developed the steering feel for the Z900RS by using the riding simulator shown in **Fig. 4**. The riding simulator is a real-time simulator that can simulate actual operations, including steering torque, throttle operation, and brake operation, and vehicle roll and pitch motion shown in **Fig. 5** in real time. The riding simulator enables us to experience a steering feel close to that of the actual vehicle even in the conceptual stage before a prototype vehicle has been made, allowing for efficient development.

In this development, we verified that the target steering feel of the Z900RS had been achieved with varying caster angles and trails in various riding situations. We then determined the caster angle and trail so that the most "neutral steering feel" would be achieved and so that the steering feel would remain the same even if the tire characteristics change.

(3) Verification of the steering feel of the Z900RS with the actual vehicle

We made a prototype vehicle having the vehicle specifications confirmed with the simulator and verified

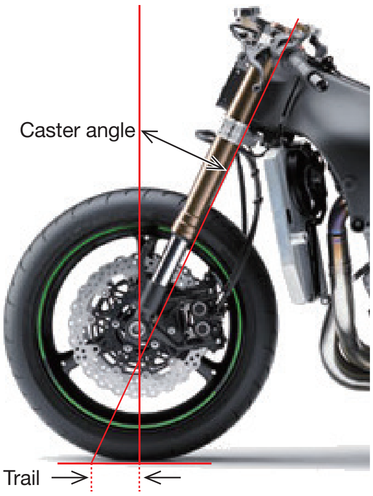

Fig. 1 Caster angle and trail

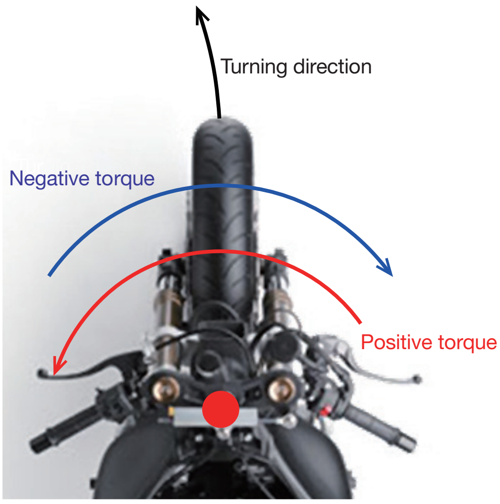

Fig. 2 Positive torque and negative torque

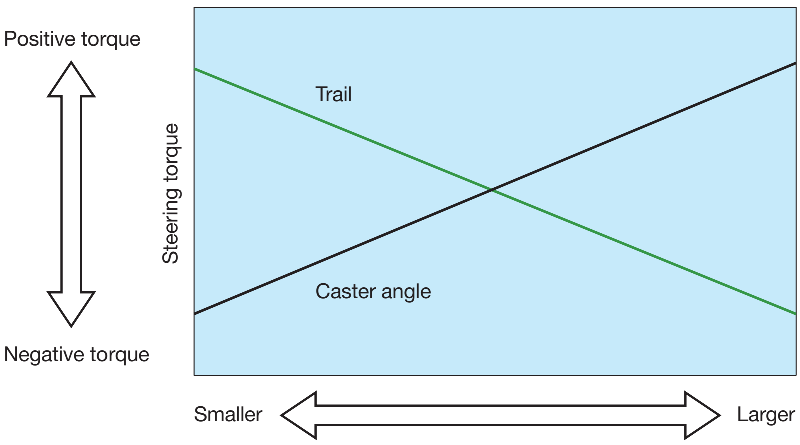

Fig. 3 Effects of caster angle and trail on steering torque

Fig. 4 Riding simulator

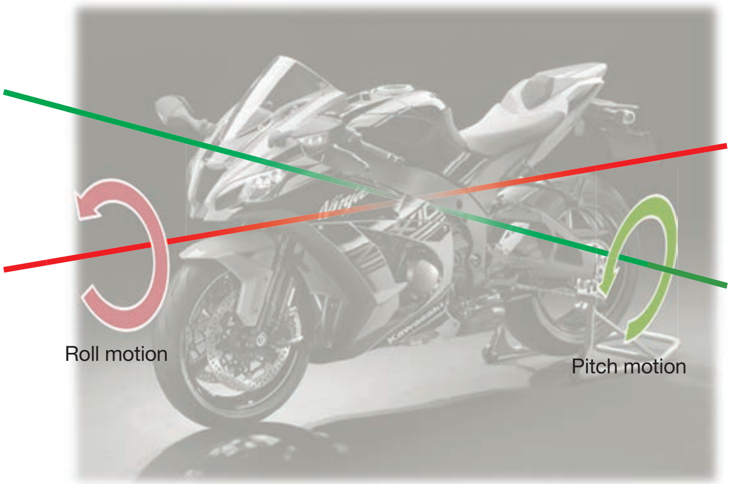

Fig. 5 Roll and pitch motion of motorcycle

the steering feel. Based on the riders' evaluation and measurement data, we confirmed that the target steering feel had been achieved.

Using the simulator enabled efficient development of the steering feel based on the vehicle specifications with a limited amount of time and ride testing.

4 Development of engine sounds

Engine sounds can be classified into the intake sound, exhaust sound, and mechanical sounds of the engine. To add value that could replace speed and performance to the Z900RS, we focused on the exhaust sound during idling and low-speed riding. To meet customer demands, the exhaust sound must be louder at lower engine speeds, where the rider enjoys listening to the exhaust sound, and must be deadened at higher engine speeds, where the exhaust sound is subject to noise regulations. We developed an exhaust system based on the technologies we cultivated for developing the intake sound for the Z1000 and other models[2].

(1) Target setting with sensory evaluation technology

To scientifically determine what exhaust sound is attractive, or the target exhaust sound, we used an experimental method called the SD (Semantic Differential) method[3]. The SD method is a sensory evaluation technology to objectively evaluate how humans sense something.

First, we recorded the exhaust sounds from representative models as samples. We had several people listen to these exhaust sounds and evaluate them from a prepared set of adjectives. We conducted a principal component analysis with the aggregation results, and represented the results of the impression evaluation of the exhaust sounds with a map consisting of evaluation and potency factors as shown in **Fig. 6**. Based on the directions of the lines indicating the models and adjectives in the map, we settled on a powerful and heavy sound as the target sound of Z900RS.

Next, we quantified the features of the exhaust sound of each model as physical quantities of sound. By conducting a multiple regression analysis with these values and plotting these values in the image map, the relationships between the adjectives and physical quantities can be identified, thereby enabling the quantification of the target exhaust sound.

(2) Development of the exhaust system

A powerful exhaust sound requires a certain level of sound but volume is limited by noise regulations. In addition, low-pitched tones, which are not contained in the original exhaust sound, are required to achieve a heavy sound. To meet these requirements, we developed a new exhaust system. The following describes the exhaust chamber that has a great influence on the exhaust sound. The exhaust chamber refers to the silencer between the exhaust pipe and muffler as shown in **Fig. 7**. The exhaust gas from the engine first reaches the silencer, making the

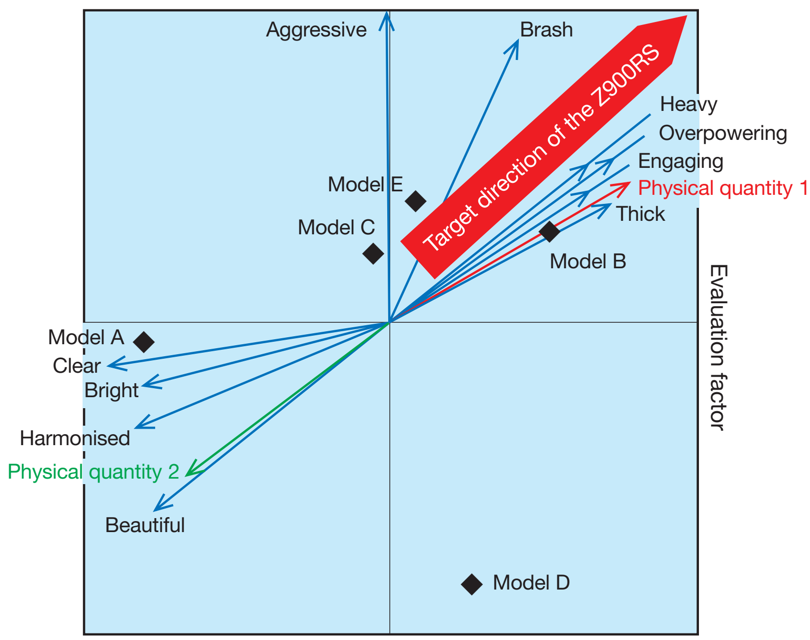

Fig. 6 Image map of engine sound

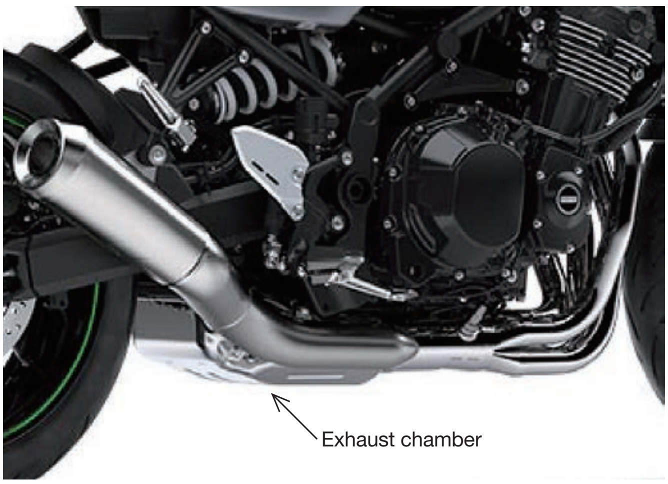

Fig. 7 Location of exhaust chamber

silencer an important part in the development of the exhaust sound.

Achieving the required exhaust sound requires controlling the flow of exhaust gas in the exhaust chamber at different engine speeds. In the exhaust chamber of the Z900RS, a tapered pipe having side holes is placed where the exhaust gas flows into the exhaust chamber from the exhaust pipe as shown in **Fig. 8**, so that the flow of exhaust gas and exhaust pulsation change according to the engine speed as shown in **Fig. 9**. At low engine speeds, a sound close to the original exhaust sound is emitted, which is moderately loud and has a low-pitched tone. At high engine speeds, the expansion chamber in the exhaust chamber is used effectively so that the exhaust chamber works as a silencer.

Using this exhaust chamber with the exhaust system, we successfully developed a "powerful and heavy exhaust sound" that complies with noise regulations.

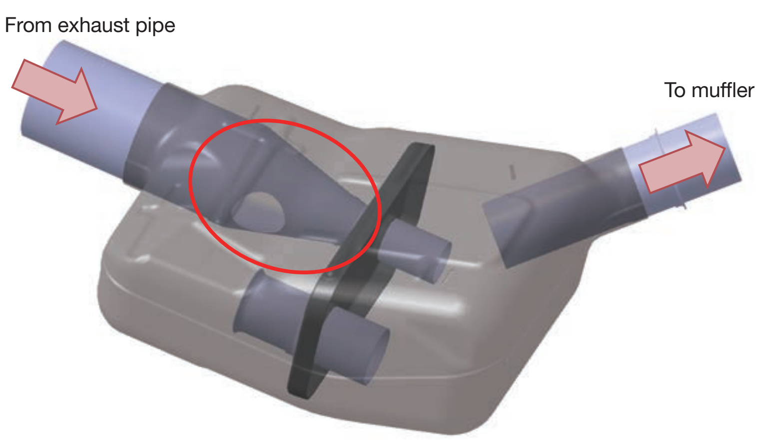

Fig. 8 Internal structure of exhaust chamber

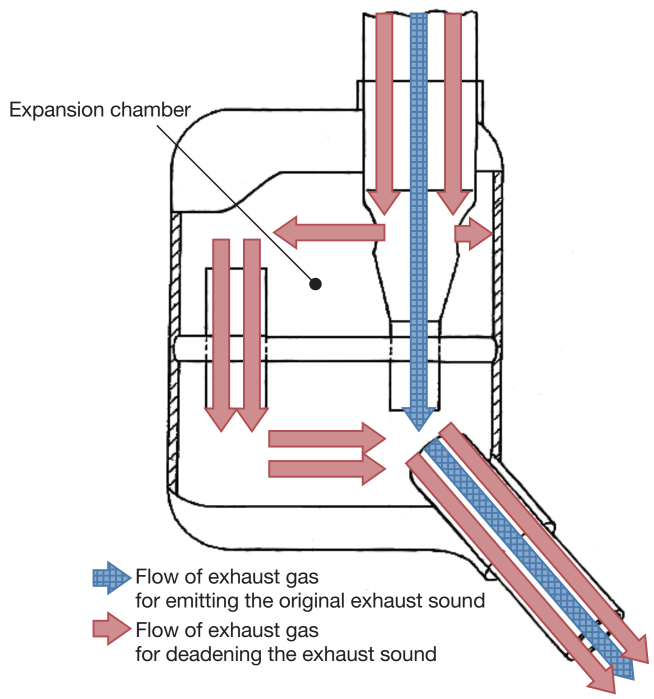

Fig. 9 Exhaust gas flow in exhaust chamber

Conclusion

We began mass-production of the newly developed Z900RS in September 2017, and the Z900RS CAFE, which is equipped with cafe style cowling as a derivative model of the Z900RS, in January 2018, both of which enjoy a high reputation not only in the Japanese market but also in the global market.

In the future, the motorcycle market is expected to become more competitive, and we are required to develop models that can more effectively appeal to customers' sensibilities. Based on the technologies we have so far cultivated and market survey results, we will continue developing our unique technologies and models to offer motorcycles that meet customer demands.

Reference

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