Product Introduction

# Development of Swing Valves on Motorcycles

SAKAWAKI Toshihiko

## 1 Introduction

Motorcycles in the Supersport (SS) category are positioned as flagship vehicles prioritizing driving performance. They are also used as the basis for racing vehicles.

These motorcycles are manufactured using cutting-edge technologies to provide the high performance expected of a flagship model.

To enhance riding performance, these motorcycles' suspension systems are designed with top-of-the-range structures from suspension manufacturers. Some vehicles have electronically controlled suspensions.

KYB provides a lineup of high-performance front forks for SS motorcycles, including an air-oil-separate system (AOS II)[1] and a large cylinder structure. Conversely, rear cushion units (RCUs) use a general aluminum gas piggyback structure in many models.

## 2 Aim of Development

In this project, we focused on “road feel”, which is a critical sensory evaluation factor for motorcycle performance. Road feel must be improved due to its close relationship with handling and stability.

Improving road feel requires stabilizing the load that the tires press against the road (ground contact force), i.e., minimizing fluctuations in this load. Adjusting the suspension spring reaction and damping forces according to the vehicle and road conditions provides riders with a high level of road feel (Fig. 1).

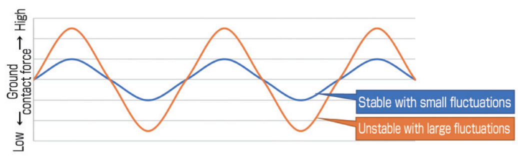


**Fig. 1** Ground contact force during driving (conceptual drawing)

In general, the damping force is adjusted using leaf valve and orifices. While it is possible to adjust the damping force from low to high speeds, fine adjustments are impossible in the very low speed range (Figs. 2 and 3).

This makes it difficult to control the initial movement of the suspension, which sometimes results in riders not having the desired road feel.

Thus, achieving the damping force characteristics in the very low speed range for the high-level road feel required in SS motorcycles is difficult with conventional suspension structures alone. A new suspension structure was then needed to enable control in the very low speed range (Fig. 4).

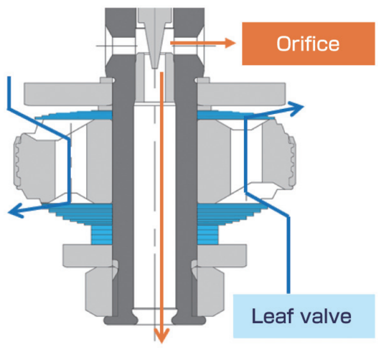


**Fig. 2** Conventional structure

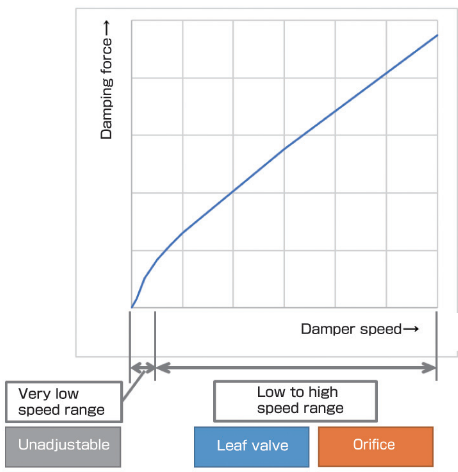


**Fig. 3** Damping force characteristics

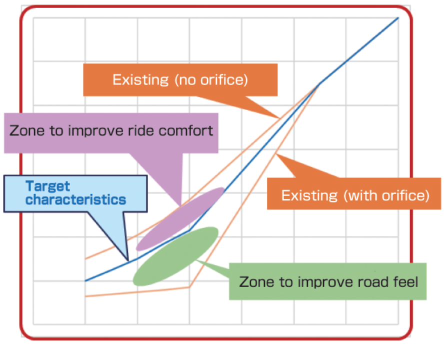


**Fig. 4** Damping force characteristics (very low speed)

## 3 Overview of Development

The following describes the comparison and evaluation of the swing valve structure for four-wheel cars and the swing valve structures developed for motorcycles.

### 3. 1 Structure Study

#### 3. 1. 1 Swing Valve for Four-wheel Cars

Fig. 5 shows the structure of the swing valve that controls the damping force at very low speeds. This valve is mass-produced for four-wheel cars.

A non-seating leaf valve is installed in series with the main valve to control the damping force at very low speeds, ensuring a high-quality comfortable ride.

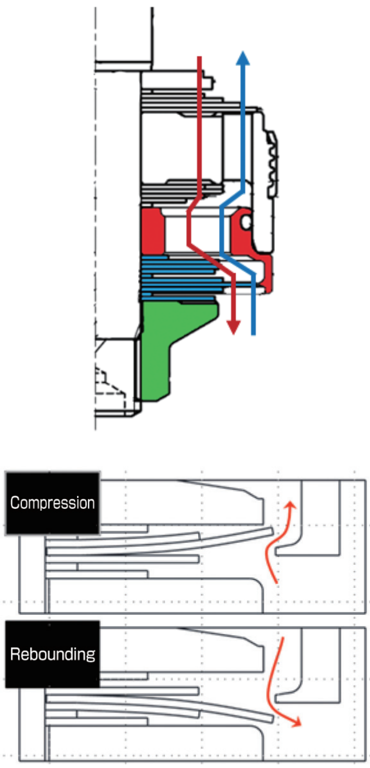


**Fig. 5** Swing valve structure for four-wheel cars [2]

#### 3. 1. 2 Swing Valve for Motorcycles

We studied the use of swing valves in motorcycle applications to control the damping force at very low speeds.

If a swing valve is installed in series with the main valve, it may deform and crack when the damper speed increases to raise the flow. To address this, we installed a swing valve in parallel with the main valve, dividing the flow of operating fluid into two lines. This reduced the load and alleviated the stress occurring in the valve. The goal was to control the damping force at very low speeds, which can be achieved with a low flow rate. Thus, both durability and damping control were achieved.

As shown in Fig. 6, installing a non-seating leaf valve in parallel with the main valve enabled control of the damping force in the very low speed range while suppressing the effect on the damping force characteristics of the main valve.

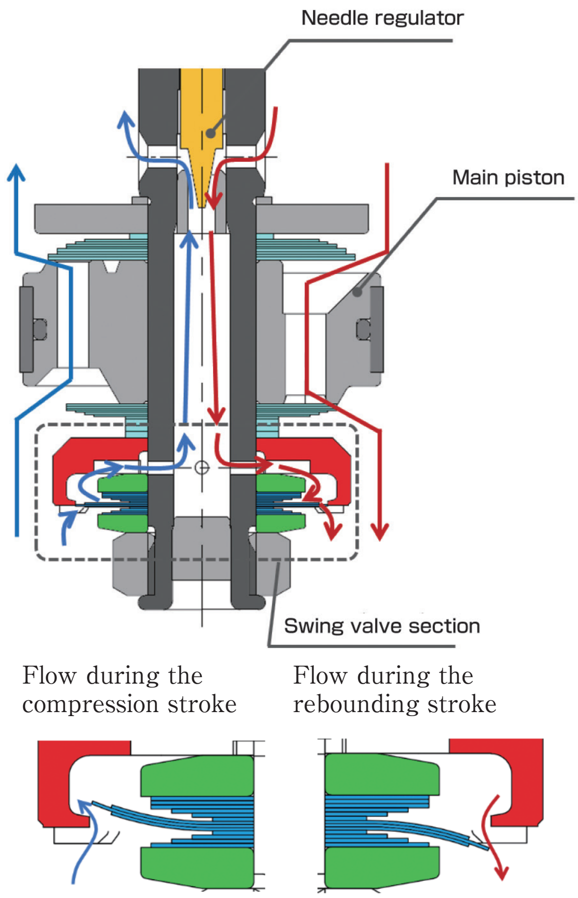


**Fig. 6** Swing valve structure for motorcycles

In this project, we also studied the oil passage design to enable parallel installation of the swing valve. To support the various damping force characteristics required by each model, we designed the oil passage so that the main and swing valve specifications can easily be changed.

### 3. 2 Characteristics

Figs. 7 and 8 show the damping force characteristics of the different structures in the very low speed range.

The red lines represent the damping force characteristics of the conventional structure with the narrowed orifice at very low speeds, while the blue lines indicate the characteristics of the swing valve. The swing valve shows a linear rise in damping force, whereas the conventional structure shows an increase that is not linear. Narrowing the orifice in the conventional structure shown in red increases the damping force at very low speeds, resulting in a steep rise in damping force that is not linear.

The swing valve for motorcycles has achieved the linear damping force characteristics in the very low speed range. In response to input from the road surface, the swing valve generates an appropriate amount of damping force, giving the rider a high level of road feel.

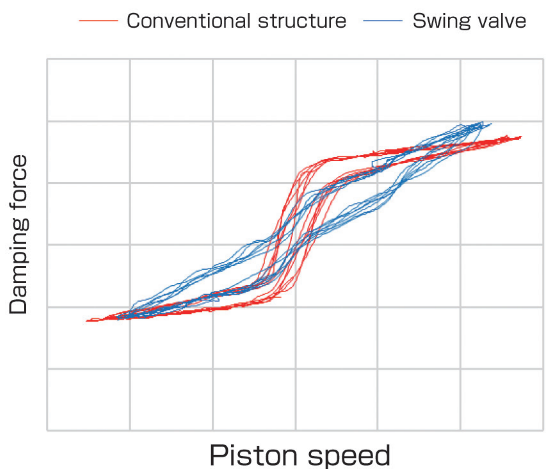


**Fig. 7** Damping force-speed waveform

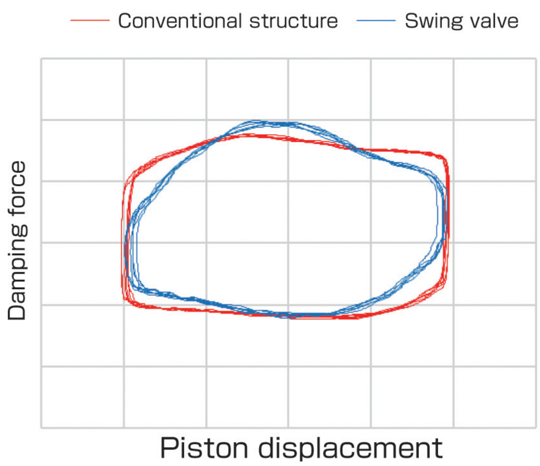


**Fig. 8** Damping force-displacement waveform

### 3. 3 Riding Evaluation

The riding evaluation focused on road feel and handling, which were the primary goals of the development.

The results showed that the swing valve improved the absorption of small gaps and swells during cornering with the appropriate damping force in the very low speed range, resulting in higher road feel compared to the conventional counterpart.

According to measurements of RCU movement on the actual vehicle, the conventional product exhibited unstable structure with significant movement in response to road surface input during cornering. In contrast, the swing valve exhibited limited movement. Thus, the measurement data taken on the actual vehicle confirmed that road feel was improved by minimizing fluctuations in ground contact force (Fig. 9).

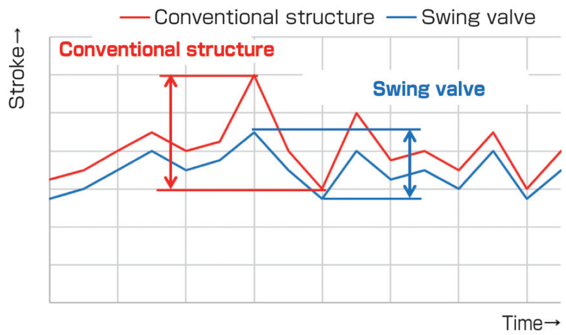


**Fig. 9** Measurement data on actual vehicle (during cornering)

Additionally, the swing valve enabled control of the suspension movement from the beginning, offering a high-quality feel and improved ride comfort.

However, concerns arose that the higher damping force in the very low speed range would restrict suspension movement and inevitably make handling heavier, worsening maneuverability. Fortunately, the swing valve's linear increase in damping force in the very low speed range did not excessively suppress suspension movement. Instead, it enhanced ground contact feel while maintaining handling feel.

Measurement data from the actual vehicle proves that the swing valve delivers movement equivalent to that of the conventional counterpart when changing direction. Handling performance, including the light feel when changing direction, remains the same (Fig. 10).

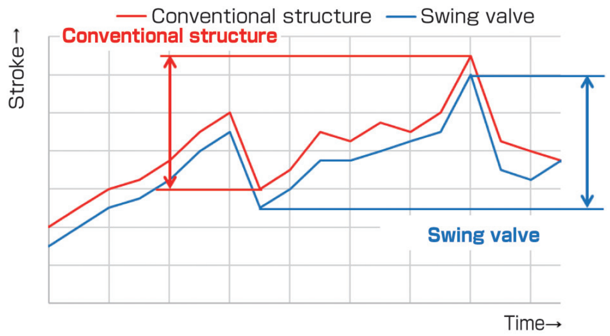


**Fig. 10** Measurement data from actual vehicle (when changing direction)

During the riding evaluation, the damping force was intentionally increased in the very low speed range. While road feel improved, the motorcycle felt heavier when changing direction, resulting in worse maneuverability.

These findings showed that controlling the damping force at very low speeds with the swing valve enables adjustment of the balance between road feel and handling according to vehicle characteristics.

## 4 Conclusions

We successfully developed a swing valve as a new suspension structure for SS motorcycles. Riding evaluations showed that the swing valve improved road feel during cornering without compromising maneuverability.

Although the swing valve was developed for SS motorcycles, road feel during cornering is an important feature for all motorcycle categories. Therefore, the swing valve can also be applied to vehicle categories other than SS.

## 5 Prospects

The swing valve, which was developed for motorcycles, can be added to the standard motorcycle valve structure. It can be used with any structure, including steel single-tube gas and aluminum piggyback structures. We plan to offer the swing valve to SS motorcycle manufacturers and other Japanese and overseas vehicle manufacturers as a performance improvement.

## 6 In Closing

Finally, we would like to take this opportunity to express our sincere gratitude to the related departments for their support and cooperation in developing this product.

### References

1) TOMIUGA: "Development of the Front Fork (AOS II) for Super Sport Motorcycles", KYB Technical Review No.50 (April 2015).

2) YASUI: "Development of Valve for Ultra-Low Speed with High Damping Force", KYB Technical Review No.57 (October 2018).

## Author

**SAKAWAKI Toshihiko**

Joined the company in 2007.
Engineering Dept., KYB Motorcycle Suspension Co., Ltd.
Engaged in design and development of motorcycle suspensions.