Product Introduction

High Pressure Aluminum Vane Pump for Power Steering of Trucks

SHIOZAKI Hiroshi

1 Introduction

The hydraulic power steering system (hereinafter "HPS" Note 1)) uses vane pumps as its hydraulic power source (hereinafter these vane pumps are referred to as "PS pumps"). KYB operates in the global PS pump market with annual production of two million units mainly for passenger cars.

The leading model of KYB's PS pump lineup is 4K (4th generation) Note 2). The 4K Series is used by many automobile manufacturers both inside and outside Japan. However, passenger cars started to use the electric power steering system (hereinafter "EPS" Note 3)) around 1990 for energy saving. Then, KYB has promoted to develop higher-pressure, higher-capacity 4K PS pumps (refer to Glossary "Making KYB Vane Pumps into a Series Product" on page 52) as new business models for trucks markets where HPS is expected to remain popular. Specifically, the new models include 4KS2, 4KL, 4KL2, 4KL3 and 4KL5 (Table 1).

With the need for offering products to European automobile manufacturers, KYB has just developed 4KT5 that is interchangeable with competitors' counterparts. The emergence of 4KT5 makes it possible to replace competitors' counterparts with this KYB product. This article introduces the outline of the development.

Note 1) Stands for Hydraulic Power Steering.

Note 2) Aluminum-body PS pump

Note 3) Stands for Electric Power Steering.

2 Background of Development

2.1 A challenge to KYB PS pumps for trucks

The KYB PS pump model that can meet the general specifications of large trucks is 4KL5 (Table 1). However, 4KL5 is designed to be installed onto the engine with its brackets having a shape different from that of competitors' products popularly used by many European automakers. This has been a barrier for KYB to offer its PS pumps to European automakers.

Specifically, the flow control valve (hereinafter “FCV” Note 4)) of 4KL5 is arranged orthogonal to the shaft axis (Fig. 1). As a result, the engine mount of 4KL5 may interfere with FCV depending on the installation position. For competitors' products in turn, FCV is arranged parallel to the shaft axis and the engine mount is unlikely to interfere with FCV.

Furthermore, KYB received an inquiry from a European truck manufacturer for PS pumps beyond the 4KL5 specifications. The company then decided to develop another model named 4KT5 aimed at achieving the requested pump specifications.

Note 4) Stands for Flow Control Valve.

2.2 Aims of 4KT5

In designing 4KT5 as a PS pump for medium/large trucks, the development team had the following aim:

2.2.1 Compatibility with European automaker trucks

In general, PS pumps for trucks must meet severe layout requirements since they can be directly installed to the

Table 1 KYB PS pump lineup

	For passenger cars and small trucks					For medium/large trucks		
Pump model	4KS	4KW	4KS2	4KL	4KL2/3	4KL5	BB	1K
Body material	Aluminum alloy die-cast						Iron casting	
Basic Displacement [cm^3/rev]	Max. 9.6	Max. 9.6	Max. 11.2	Max. 14.0	Max. 15.0	Max. 23.0	Max. 32.5	Max. 20.0
Relief pressure [MPa]	Max. 12.0	Max. 11.8	Max. 12.8	Max. 12.8	Max. 15.0	Max. 20.0	Max. 14.7	Max. 13.7
Control flow rate [L/min]	Max. 9.0	Max. 8.5	Max. 11.5	Max. 12.0	Max. 16.0	Max. 23.0	Max. 30.0	Max. 20.0

engine. This means that layout performance is essential. The new model has the mounting brackets in a shape equivalent to that of competitor products used by many European truck manufacturers, offering an equivalent layout performance as well.

2.2.2 Lower cost

To achieve lower material costs and lower working costs, the new model uses an aluminum die-cast body and sintered cam ring. Existing PS pump production equipment can be effectively used.

2.2.3 Higher capacity and higher pressure

The target maximum pressure was set to 22 MPa and the target maximum basic discharge was set to 28 cm^3/rev.

The existing cam ring and rotor of 4KL5 have been diverted for the new model to ensure part sharing. In addition, the pump has been enlarged in the direction of thickness of the cam ring for larger capacity. The suction port of the cam ring has been improved in profile to be able to accept higher pressure.

3 Basic Specifications, Structure and Features

3.1 Basic specifications and structure of 4KT5

The basic specifications and structure of 4KT5 are shown below (Table 2, Fig. 1).

Table 2 Basic specifications of 4KT5

Pump model	4KT5		
Body material	Aluminum alloy die-cast		
Basic Displacement [cm^3/rev]	～17.0	～25.0	～28.0
Relief pressure [MPa]	Max. 22.0	Max. 20.0	Max. 18.5
Control flow rate [L/min]	Max. 20.0	Max. 25.0	

In development, the following considerations were given in designing the new model:

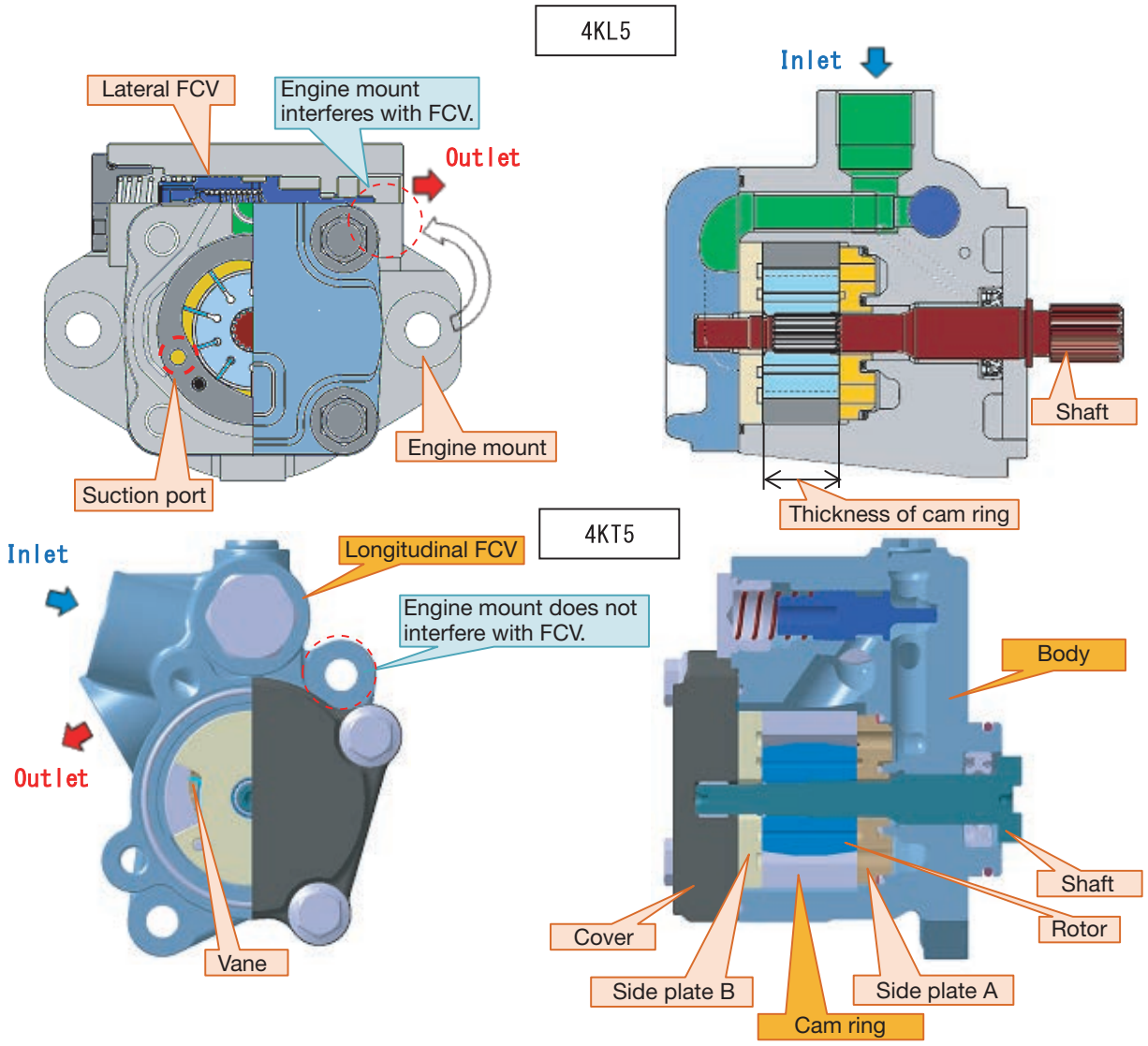

Fig. 1 Pump structure

3.2 Higher pressure resistance of components

3.2.1 Pressure-resistant body

For cost reduction, the pump body needs to be made of aluminum die-cast to reduce cutting allowance. In addition, the strength has been improved with heat treatment to achieve the resistance to a higher pressure (22 MPa).

To ensure the pressure resistance of the body internal high-pressure chamber and of the discharge oil passage, passage design has been optimized through FEM analysis to reduce internal pump stress, thereby achieving durability (Fig. 2).

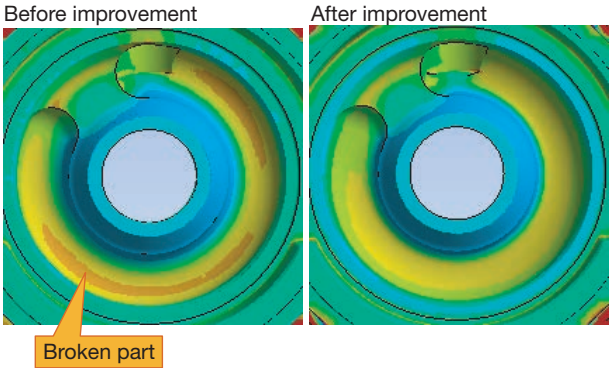

Fig. 2 Body strength improvement

3.2.2 Higher pressure resistance of internal components

In the built-in cartridge assembly [Note 5)], the cam ring is applied with a pushing force by the vanes. The new model designed to the higher-pressure specifications will have an increased pushing force. It is feared that the cam ring will have seizure or wear. Then, vane lift has been reduced so that the cam ring and vane tip have a lower PV value in order to prevent seizure.

Note 5) Consists of a cam ring, a rotor and vanes. When the rotor engaged with the shaft rotates, the vanes protrude in the radial direction and slide against along the inner circumference of the cam ring. As the internal chambers increase or decrease in volume, the pump sucks or discharges hydraulic fluid.

The conventional 4KL5 draws the oil into the body and guides the oil into the vane chambers via the cover core. For the purpose of improving the suction performance, a suction port is provided in the cam ring to feed the oil from the cover toward the side plate A.

The new model 4KT5 has a modified suction oil passage. With the longitudinal FCV introduced, the pump is designed to guide the oil drawn into the body to the vane chambers via the outer circumference of the cam ring (Fig. 3).

This new design eliminates the suction port provided in the cam ring (Fig .4). To increase strength, the cam ring of the new model no longer has a suction port and is thicker for lower stress. These changes prevent breakage caused by the higher pressure.

Consequentially, it is possible to use sintered material in the cam ring even with high-pressure specifications (22 MPa) of 4KT5.

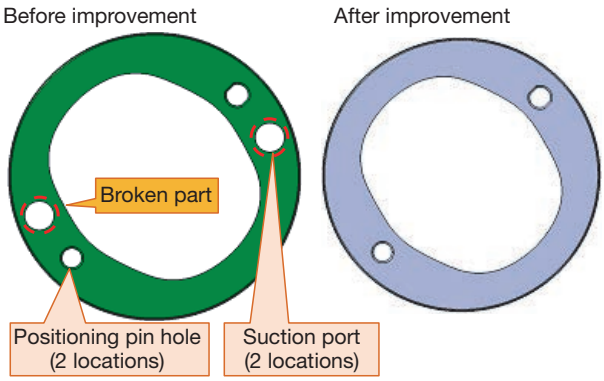

Fig. 4 Cam ring design

3.3 Higher efficiency

A higher-pressure pump is likely to have seizure between the rotor and the side plate. To prevent seizure, the clearance between the rotor and the side plate must be increased. However, the larger clearance is likely to lead

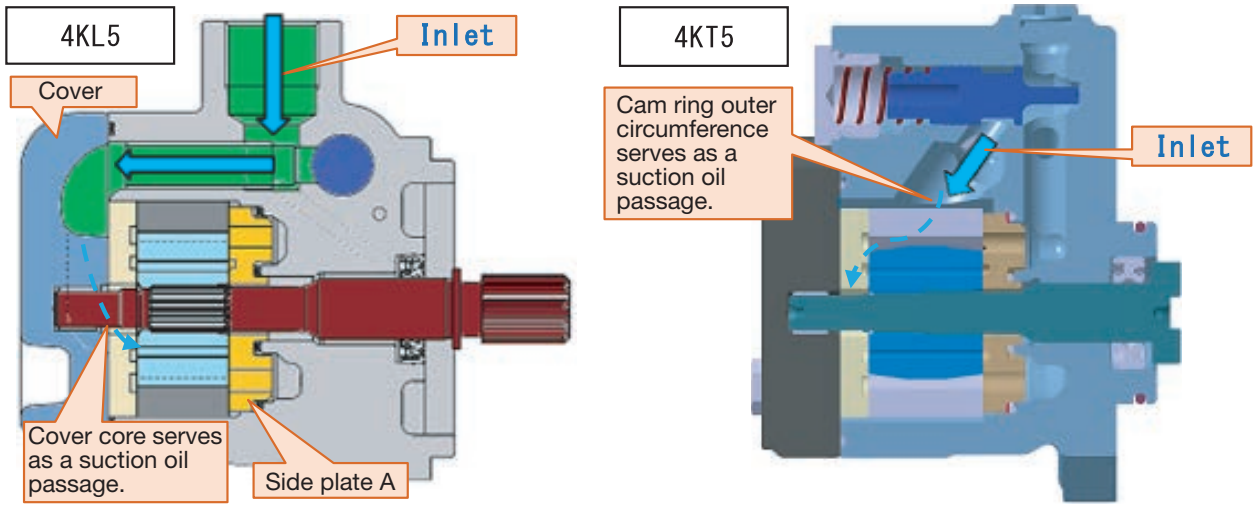

Fig. 3 Comparison of suction oil passage design

to lower volumetric efficiency under a high pressure.

4KT5 is designed to be able to maintain the high efficiency even under a high pressure to ensure pump energy saving. As a result, 4KT5 has higher volumetric efficiency than competitor products by up to 20 percent (Fig. 5).

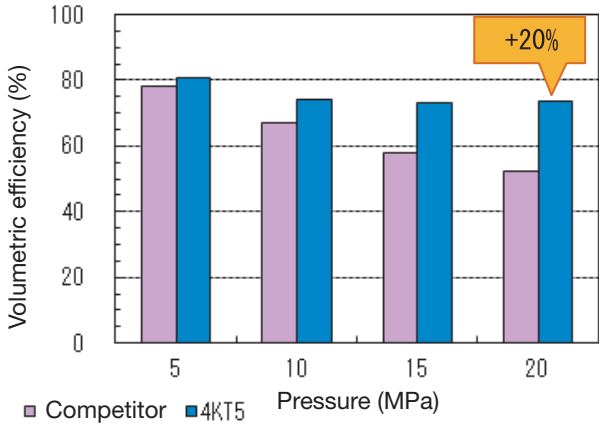

Fig. 5 Comparison of volumetric efficiency (500 rpm, 80°C)

3.4 Lower noise

One of the harmful effects of the higher-pressure specifications is larger noise under the low-speed and high-oil-temperature conditions. To search for noise reduction measures, how noise increases under a high pressure was analyzed.

Measurement of the pump chamber internal pressure and frequency analysis were conducted and noise reduction measures were taken. As a result, 4KT5 has less noise than its competitors (Fig. 6).

3.5 PS pump drives and bearings

In response to various needs of truck manufacturers, both the plain and rolling bearing types are available so as to be compatible with different drives such as gear or coupling driven systems.

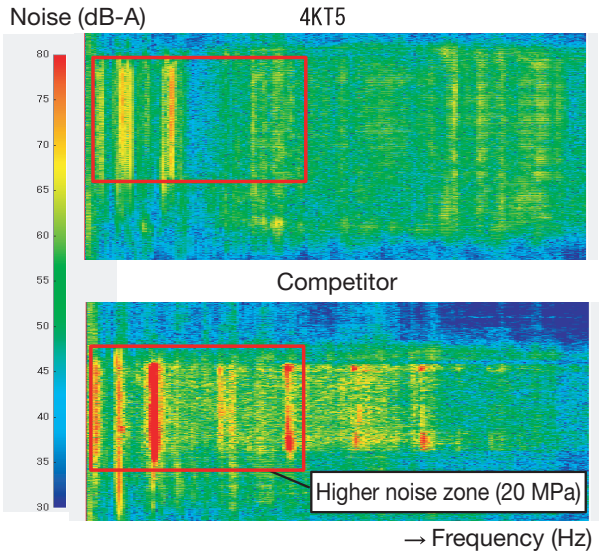

Fig. 6 Noise comparison (500 rpm, 120°C, 20 MPa)

4 In Closing

The development of the 4KT5 PS pump for medium/large trucks has been completed. This higher-pressure, higher-capacity 4KT5 has mounting brackets compatible with European trucks and achieves higher efficiency and lower noise than competitors. The use of the aluminum die-cast body and sintered cam ring leads to cost reduction.

Finally, on this occasion, I would like to deeply thank all those who were involved in this project.

Author

SHIOZAKI Hiroshi

Joined the company in 1997.
Pump Engineering Dept., Steering Headquarters, Automotive Components Operations.
Engaged in design and development of vane pumps for power steering.