Product Introduction

Flow Control Valve-Less Vane Pump for CVT

SHIMONO Hiromi

1 Introduction

In recent years, the requirements for better fuel efficiency, lower carbon emissions and exhaust emission levels, are becoming more demanding in automotive industry. In response to meet such market needs, more and more models of car are equipped with an automatic transmission, continuously variable transmission (hereinafter referred to CVT) that provides the highly-efficient transmission ratios Variable Transmission This newly developed vane pump (Photo 1) is installed onto the Jatco's new model CVTunit for compact car and its production in KIMZ (KYB Industrial Machinery (Zhenjiang))has been started since July 2015.

2 New CVT

Photo 2 shows the appearance of CVT newly developed by Jatco. This new model CVT has the following features:

(1) Improved drivability
(2) World's best ratio coverage of 8.7 for CVT
(3) Improved fuel efficiency

Our vane pump functions as the hydraulic source for the new CVT and contributes to better fuel efficiency.

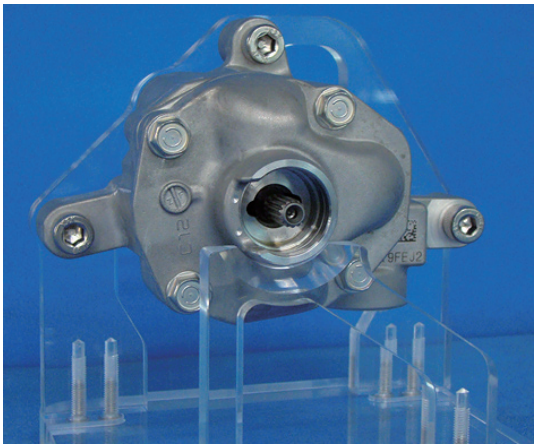

Photo 1 Appearance of Vane Pump for New CVT

3 Description

3.1 Structure and Main Specifications

The main specifications of advanced vane pump are shown in Table 1, and the structures of both existing and advanced pumps are shown in Fig. 1. The flow control valve is eliminated for the advanced pump unlikely as compared to the existing model. The flow control valve, which suppresses cavitation, is an important structural element in CVT for dealing with highly aerated hydraulic fluid. For advanced vane pump, even the torque rotation

Table 1 Main Specifications for Vane Pump

Basic Discharge Rate	10.5cm^3/rev
Cavitation Speed	7000rpm
Discharge Pressure	～6MPa
Oil Temperature	-40～140℃
Hydraulic Fluid Type	Nissan NS-3
Wight	1000g

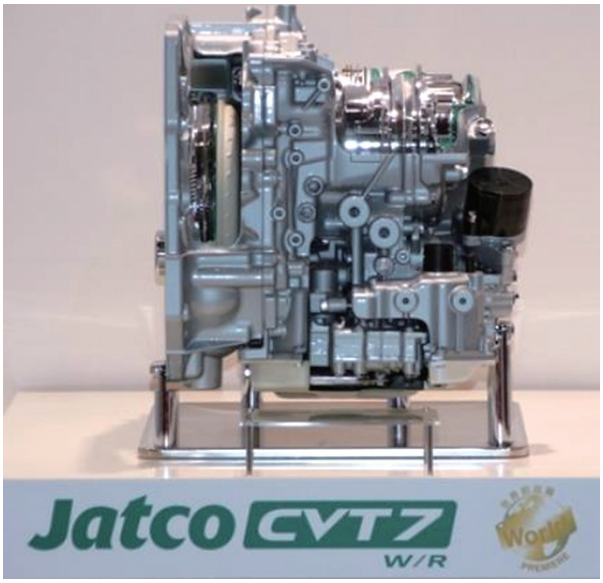

Photo 2 Appearance of New CVT

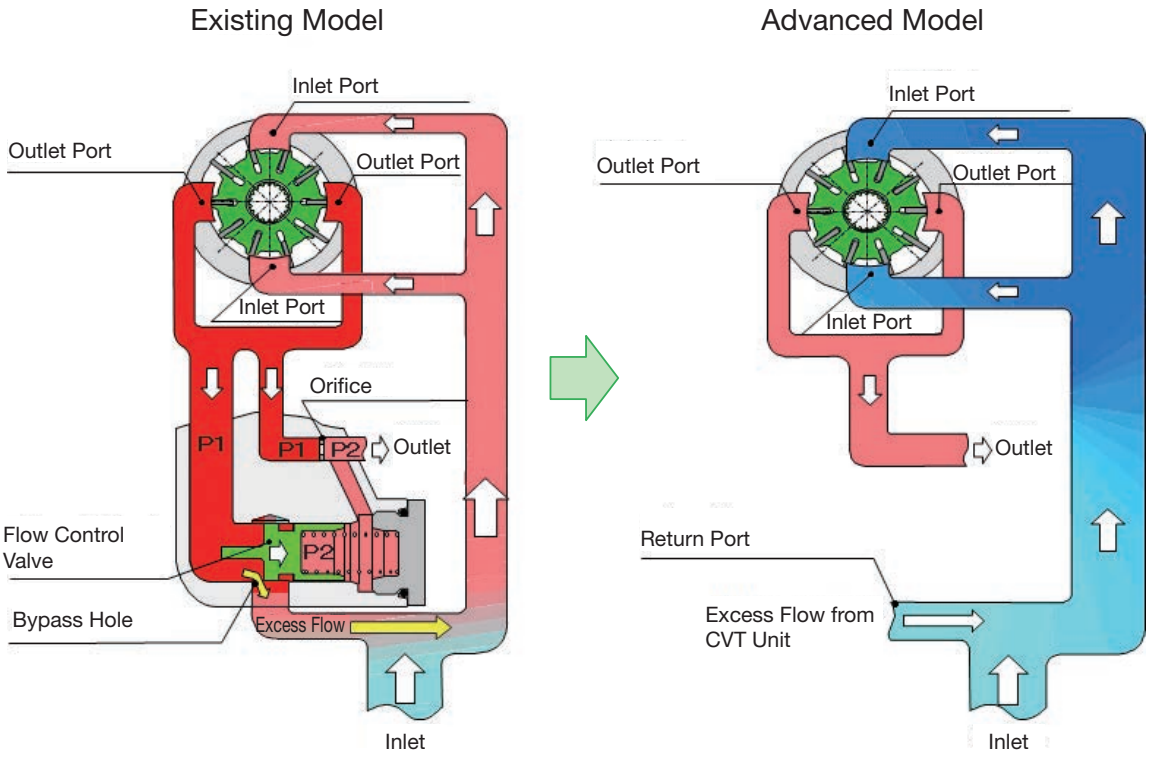

Fig. 1 Comparison of Existing and Advanced Models

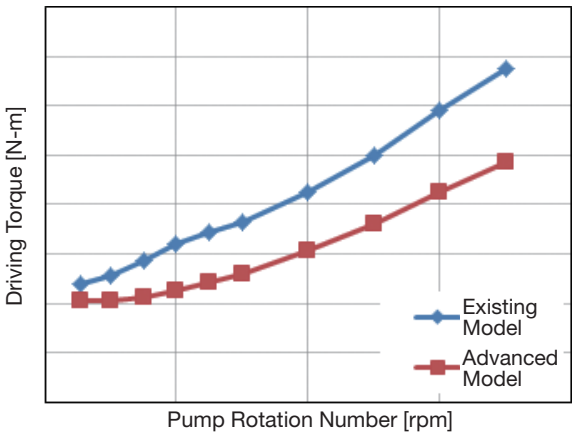

Fig. 2 Driving Torque of Existing and Advanced Models

caused by hydraulic fluid's pressure was reduced in order to achieve a reduction of rotational torque, which resulted in the contribution to better fuel efficiency.

3.2 Reduction of Driving Torque

The driving torques for both existing and advanced models is indicated in Fig. 2. The advanced model successfully prevents the differential pressure and reduces the pressure applied to the pump by eliminating the flow control valve. Furthermore, the absence of flow control valve resulted in eliminating fluid leakage from the flow control valve and could achieved reductions both in the basic discharge rate and torque rotation while the previous model utilizes the differential pressure given by an orifice to drive the flow control valve.

3.3 Cavitation Prevention

Flow control valve offers the function to prevent cavitation by circulating of the excessive flows at high pressure during the highly aerated hydraulic fluid condition. An alternative measure for cavitation prevention was required for the newly advanced model since it is not equipped with flow control valve. As the prevention measures, both the oil inlet channel and the pressure rise of vane chamber were optimized.

3.3.1 Adjustment of Oil Inlet Channel

The result of the negative inlet pressure analysis is shown in Fig. 3. The cavitation was successfully prevented with a larger size of oil channel and additional cutting port on cam-ring (Fig. 4) which reduced a negative pressure generated in oil suction. The optimum shape that prevents

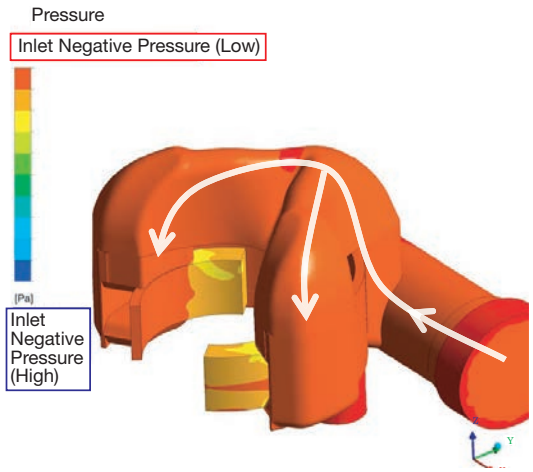

Fig. 3 Result of Negative Inlet Pressure Analysis

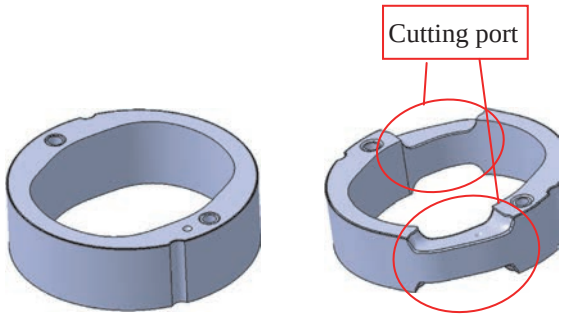

Fig. 4 Shape of cam-ring

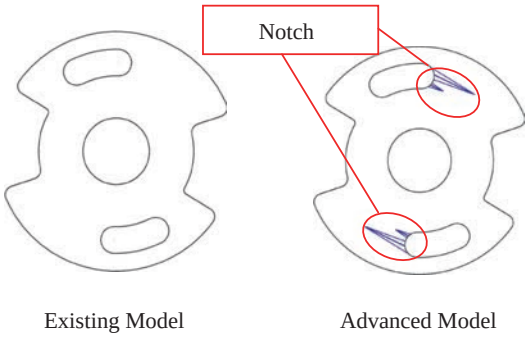

Fig. 6 Shape of side plate

the pressure loss was determined through a flow analysis.

3.3.2 Adjustment of Pressure Rise in Vane Chamber

The adjustment of oil inlet channel has reduced the negative inlet pressure potential due to elimination of flow control valve. However, the inlet pressure is still negative. The existing model can maintain a positive pressure by circulating of the excessive flows at high pressure. On the other hand, a delay in the pressure rise is experienced in the vane chamber of the advanced model due to its negative inlet pressure. The pressure fluctuation and the cavitation erosion caused by this delay may result in the noise and the damages to the pump. The measurements of vane chamber pressure are shown in Fig. 5. The supply of high-pressure oil was increased and the delay in the pressure rise during the highly aerated hydraulic fluid condition was reduced to almost same level with the flow control valve equipped model by additionally created notches (Fig. 6).

Quick voltage boosting indicates an improvement in performance. A faster voltage boosting ensures the performance that is equal to that of the current model.

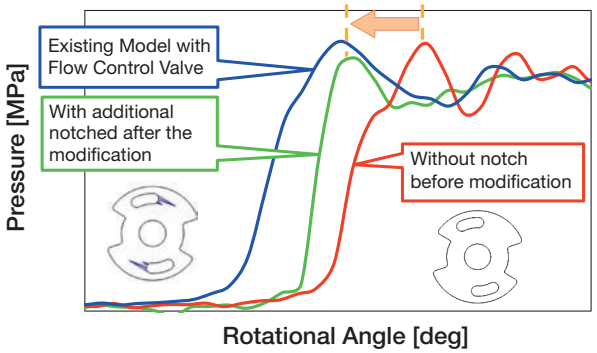

Fig. 5 Measurements of Vane Chamber Pressure

3.4 Localization

Since the newly developed flow control valveless pump would be produced locally in China, the materials available locally were preferably used, achieving local procurement rates of over 85 %. Improved localization of existing model allowed successful localization at production start-up.

3.5 Cost Saving and Weight Reduction

The structures of both existing and advanced models are shown in Fig. 7. Elimination of flow control valve enables up to a 27 % reduction in number of components comparing to the existing model, reducing processing positions to facilitate process, and body weight as well as a reduction in torque. Actively use parts common with existing model. The cost saving and weight reduction (9 % down) could be achieved through above mentioned practices.

4 In Closing

Newly developed flow control valveless pump has achieved the reduction in the torque rotation, weight, and cost, and its local production is established in KIMZ. With considerable cooperation and prompt actions given by everyone, including the project members of Jatco and relevant personnel within company involved in this product, the development of mass production in KIMZ has come to successful completion. I would like to take this opportunity to express my sincere gratitude to the relevant parties for their cooperation for this development.

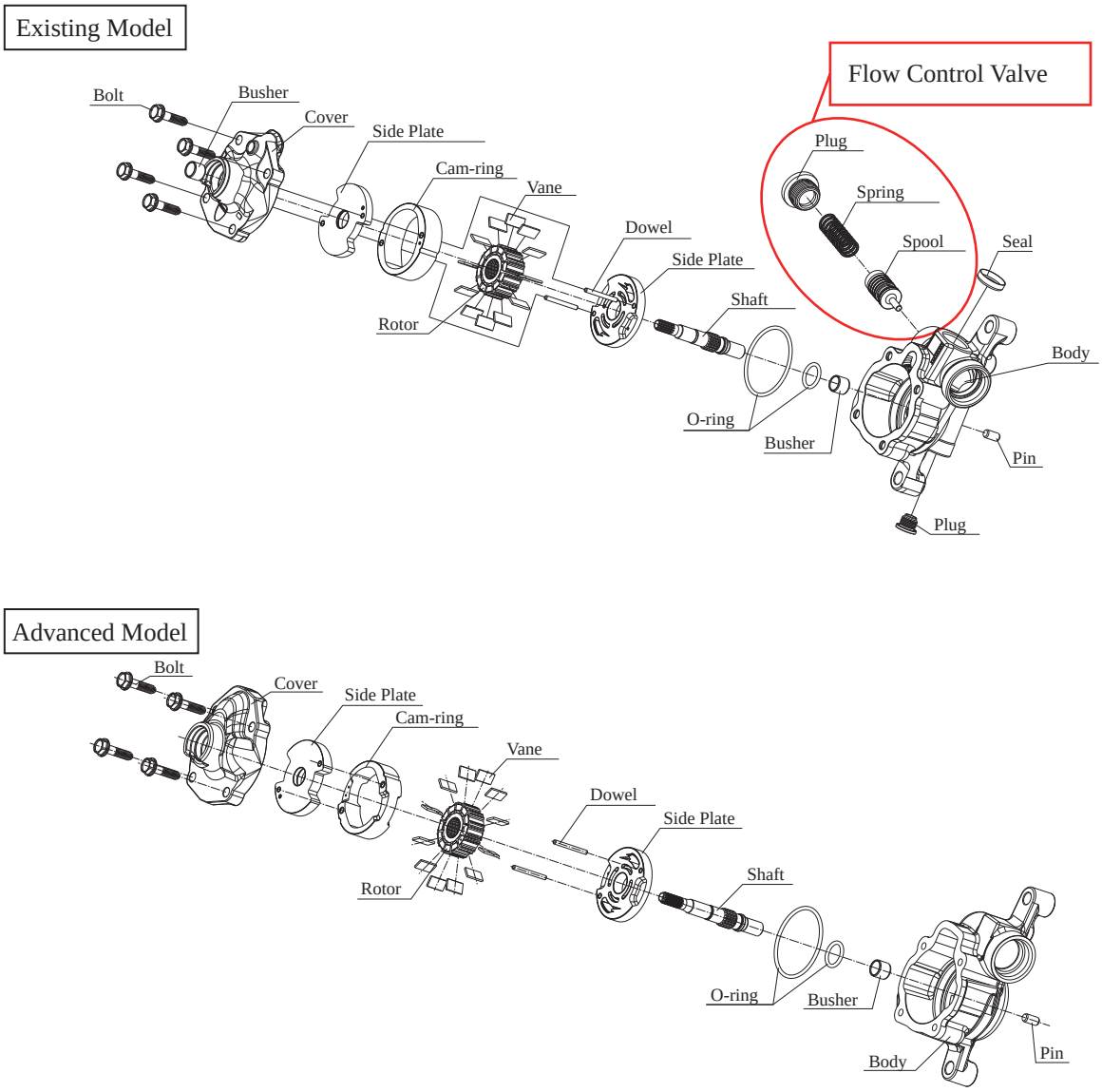

Fig. 7 Structures of Existing and Developed models

Author

SHIMONO Hiromi

Joined the company in 2006.
Pump Engineering Dept.,
Engineering Headquarters,
Automotive Components Operations.
Engaged in the work of vane pump design.