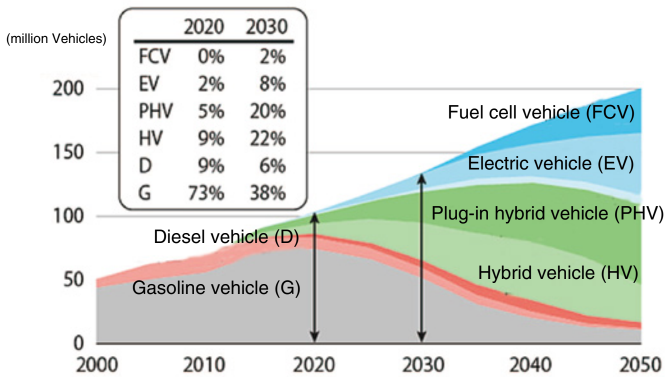
Award-Winning Technologies

Air Control Valve for Fuel Cell Systems

1. Overview of the Invention

In order to achieve carbon neutrality by 2050, there has been increased attention on hydrogen as a fuel source because it does not emit CO_2 and contributes to energy security by diversifying resource procurement sources. As shown in Figure 1, fuel cell systems that use hydrogen as fuel are expected to become widespread in the form of fuel cell vehicles (FCVs) as well as stationary power generation equipment.

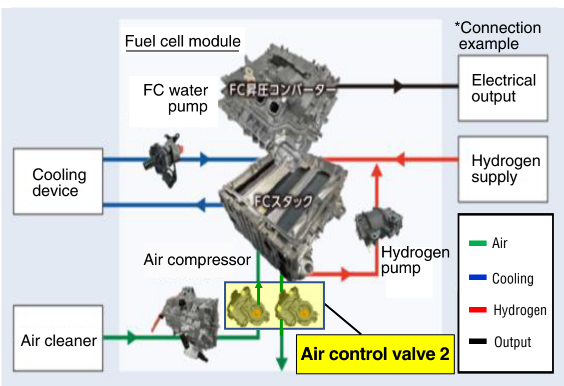
Figure 1 Forecast of future global vehicle sales by type (Source: SPEEDA Research Institute)



In addition to the hydrogen supply line, fuel cell systems have an air supply line that generates electricity through a chemical reaction with hydrogen. The air supply line is equipped with an "air control valve."
(See Figure 2)

The air control valve regulates the airflow rate to achieve the necessary power generation capacity. It also seals the air when power generation stops, preventing a decrease in generating efficiency due to oxidation and deterioration of the fuel cell.

Figure 2 Fuel cell system diagram (Source: Toyota)

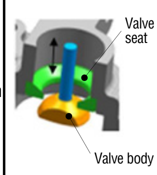
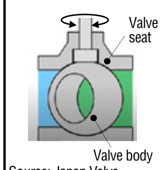
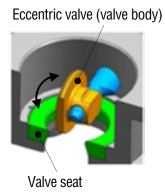


The air control valve requires the following characteristics, so a double eccentric valve type was selected for the configuration. (See Figure 3)

(1) The opening area is large and capable of handling high flow rates.

(2) Wear is less likely to occur when the valve body contacts the valve seat when the valve is closed.

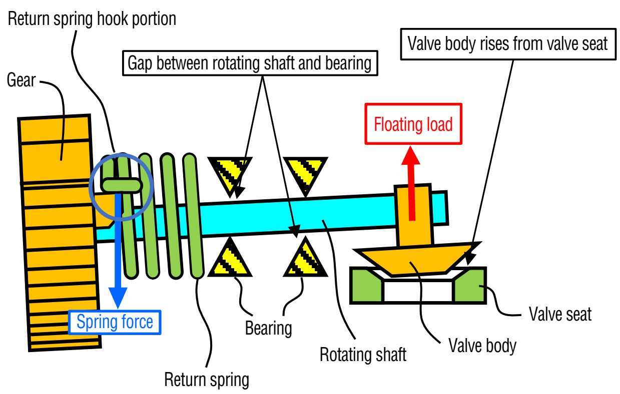
Figure 3 Comparison of valve configuration characteristics

		Poppet valve	Ball valve	Double eccentric valve
Configuration			 Source: Japan Valve Manufacturers' Association	
Characteristics	①	×	○	○
	②	○	×	○

2. Issues with Conventional Inventions and Development Needs

Although there is a conventional invention for double eccentric valves, as seen in Japanese Unexamined Patent Application Publication No. 2012-72793, when not driven (i.e., when the motor is not energized), the spring force of the return spring causes the rotating shaft to tilt within the gap between the rotating shaft and the bearing. This results in a load, or floating load, that causes the valve body to rise from the valve seat, thereby reducing sealing performance. This necessitates the use of a double eccentric valve capable of maintaining performance when not driven. (See Figure 4)

Figure 4 Conventional invention issues (schematic diagram)



*The shape of the parts differs from that of the original invention because this is a schematic diagram.

3. Features of the Invention, etc.

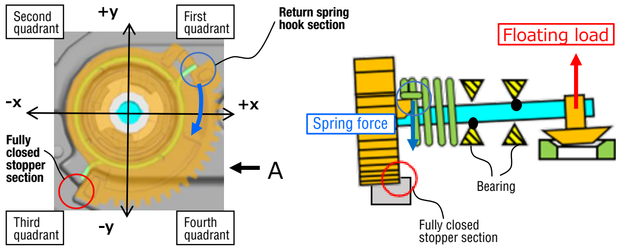
The configuration was devised based on the understanding that the floating load when not driven is determined by the relative positions of the "fully closed stopper section" and the "return spring hook section" on the rotating shaft. An xy coordinate system was set up that is perpendicular to the rotating shaft. When this coordinate system is divided into quadrants 1 to 4 for each positive and negative direction of the xy coordinates, the "fully closed stopper section" is positioned in the first quadrant, and the "return spring hook section" is positioned diagonally in the third quadrant. This configuration converts the floating load into a pressing load that presses the valve body against the valve seat, thereby reducing air leakage flow and ensuring sealing functionality. (See Figures 5 and 6)

<Features of the present invention>
The following unique effects can be obtained without adding any new mechanisms.
(1) Floating load can be converted into pressing load.
(2) Pressing load can be maximized.

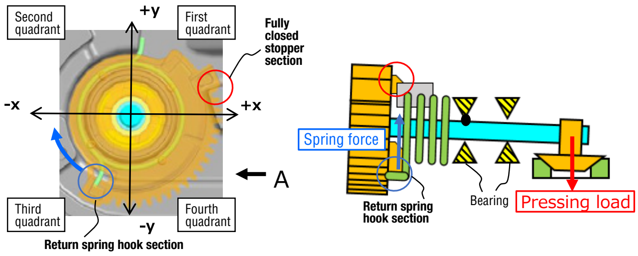
The present invention suppresses the decline in power generation efficiency caused by the oxidation degradation of fuel cells. This is achieved by ensuring the air sealing function of double eccentric valve-type air control valves when power generation stops.

By promoting the widespread use of fuel cell systems equipped with these air control valves, we are helping to establish a carbon-neutral society and reduce CO_2 emissions.

Figure 5 Behavior when not driven

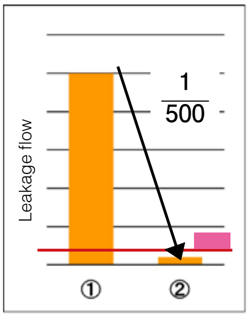


(1) Conventional movement: Behavior when the motor is not powered (floating force generated)



(2) Movement of the invented technology: Behavior when the motor is not powered (pressing force generated)

Figure 6 Comparison of leakage flow



Award-Winning Achievements

FY2024
Aichi Invention Commendation: Aichi Invention Award (Aichi Prefecture Invention Association, a General Incorporated Association)
Chubu Region Invention Commendation: Invention Encouragement Award (Japan Institute of Invention and Innovation, a Public Interest Incorporated Association)