

The Design of a Slider Type Engine Valve Structure

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Abstract

In this paper, for reciprocating piston engines, a sliding block type engine valve structure is designed which based on the traditional umbrella valve structure, in order to change the traditional working characteristics of the engine valve, and reduce the quality of the engine valve, thus, reducing valve motion inertia and working noise, and ultimately improve the performance of engine. Finally, the advantages of the slider type engine valve structure used in reciprocating piston engine are summarized.

Keywords: reciprocating piston engines: umbrella valve: sliding block valve

I. Introduction

The engine intake and exhaust valves are not only a component of the combustion chamber, but also the passage for gas to enter and exit the combustion chamber, which bear high mechanical and thermal loads during operation. In particular, the exhaust valve is often scoured by high-temperature gas, which is more prone to air leakage, corrosion and burnout, leading to harsher working conditions. The consequences will affect the air exchange quality in the cylinder, and lead to deteriorated combustion in severe cases, thereby reducing the engine economy, power and reliability ^[1].

The valve mechanism controls the gas exchange process of the internal combustion engine and often operates under high temperature and high pressure. Therefore, valve mechanism is not only the core part of the engine, but also a part most prone to failure. Hence, whether the engine valve structure is reasonable and reliable will directly affect the vehicle performance.

For the reciprocating piston engine, a slider type engine valve structure is designed in this paper.

II. Technical status of automobile engine valve structure

At present, the valve of automobile engine adopts an umbrella structure, and the intake and exhaust of the cylinder is implemented via the lifting of the intake and exhaust valves. This is the only structure and intake and exhaust way for the current reciprocating piston engine valve. In operation, according to the ignition sequence of each cylinder and driven by the camshaft and valve spring, the valves are opened and closed in sequence to complete the intake and exhaust of each cylinder. When it is opened, the corresponding cam on the camshaft overcomes the force of the valve spring to drive the valve movement; when it is closed, if the valve spring returns, the drive valve moves in the opposite direction and closes. As shown in Figure 1, this traditional umbrella valve mechanism has many transmission parts and low transmission efficiency. Moreover, when the engine is running at high speed, there will be impact noise between the valve and the valve seat. In addition, for the sake of normal engine operation, the valve clearance must be strictly guaranteed, so there are strict requirements for regular adjustment.

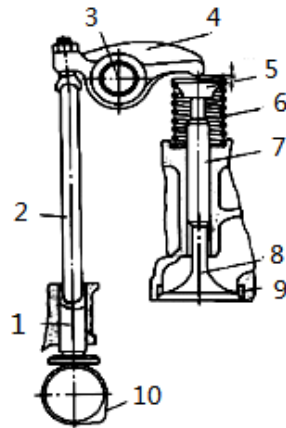


FIG. 1 Traditional umbrella valve mechanism

1 - valve lifter ; 2 - the push rod; 3- rocker arm shaft; 4 - rocker arm; 5- valve clearance;
6- valve spring; 7- valve guide; 8 - valve; 9- valve seat; 10 - cam

In the domestic design of diesel engines, on the one hand, it is hoped that valve acceleration is high enough to quickly open and close the valve, so that there will be better ventilation effect for better power and economy. Therefore, it is necessary to strengthen the science and technology development, apply new technologies to guarantee better engine performance. At present, the valve-cam type valve mechanism is widely used, which can ensure air tightness of the cylinder. The research content of the valve mechanism system can be summarized in two main aspects. On the one hand, it involves the design of the parts, including cam profile design, design of the valve rocker mechanism, design of the valve spring, valve, etc. Where, cam profile design is particularly critical, because the cam directly controls the movement of the entire mechanism as the original moving part of the entire mechanism. On the other hand, it involves the mechanism dynamics. The research on dynamic performance of the mechanism is mainly concentrated on the valve movement law and the valve structural improvement. There are some reports about the foreign studies on vibration model, friction, valve phase and variable valve timing of the valve mechanism^[3]. Domestic efforts are also devoted to the study of more accurate valve vibration models, dynamic lubrication of cam tappets, asymmetric cam profile and cam profile fitting. The domestic reports on the combination of shaft valve rotary engine and valve in the past few years enable higher development in valve mechanism innovation. However, no mature technology is achieved in research of slider valve, which is a direction worth studying.

III. Structure design of slider type engine valve

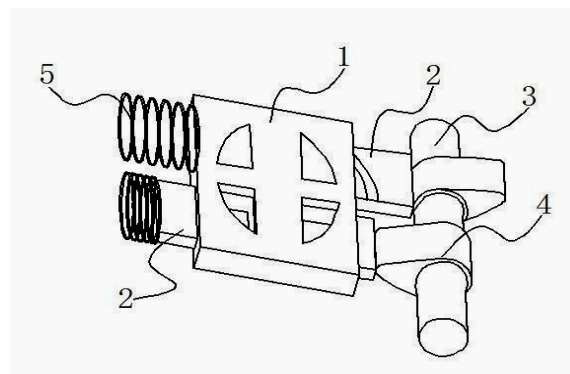


Figure 2 Schematic diagram of the structure design of the slider valve

1-valve seat; 2-slider valve; 3-camshaft; 4-cam; 5-return spring

The slider type engine valve, as shown in Figure 2, contains:

- 1) Valve seat with vent holes and slider, the camshaft and cam with drive slider cooperating with the valve seat traction are arranged on both sides. The valve seat has a hollow structure. The slider is inserted from the end face opening of the valve seat to support traction.
- 2) One end of the valve seat is provided with a camshaft, and a cam with position corresponding to the slider is installed on the camshaft. The other end of the valve seat is provided with a return spring, and one end of the return spring is pressed against the end surface of the slider valve.
- 3) Both sides of the slider valve are provided with valve holes with the same position and size as the vent holes on both sides of the valve seat. A longitudinal baffle is arranged inside the valve seat, which divides the internal space into two separate spaces, each of which is closely matched with the slider valve. The upper and lower sides of each independent space of the valve seat are provided with two left and right mirrored vent holes, and the slider valve is provided with a valve hole with position corresponding to the vent hole.

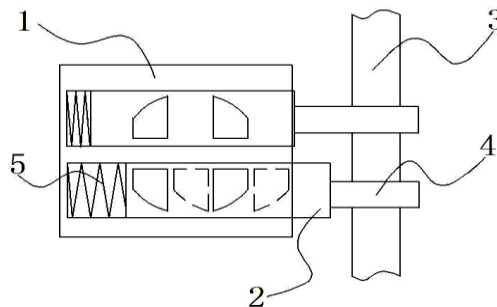


Figure 3 Front view of slider valve structure design

1-valve seat; 2-slider valve; 3-camshaft; 4-cam; 5-return spring

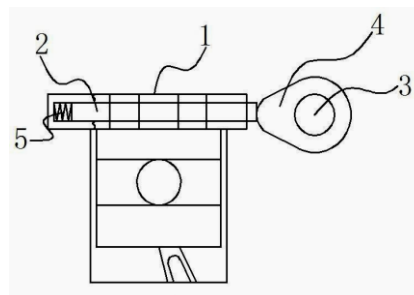


Figure 4 Top view of the slider valve structure design

1-valve seat; 2-slider valve; 3-camshaft; 4-cam; 5-return

Same as the traditional valve, the slider valve is driven by the cam, otherwise, the way of opening and closing mode is altered. The opening and closing of the intake and exhaust valves are achieved by the relative movement between the two sliders and the valve seat, as shown in Figure 3.

As shown in Figure 4, when operating, the engine power is transmitted to the camshaft through a pair of timing gears (or timing belt pulleys and timing belts), so that the camshaft rotates at a certain speed. According to the ignition sequence of each cylinder, when the corresponding cam on the camshaft rotates to lift, it pushes the slider valve to move to the left. When the two holes on the slider valve gradually align with the two holes on the slider valve seat, the valve opens gradually. When the two holes on the valve are completely aligned with the two holes

on the valve seat, the two valves of the same name are in a fully open state, as shown in the section BB in Figure 5. Since the valve opening is a gradual process, under the premise of reasonable and correct design of the cam lift, early opening of the valve is totally possible.

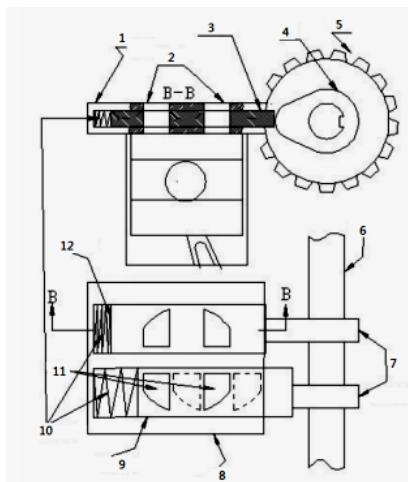


FIG. 5 Schematic diagram of slider valve structure (State B)

1, 8-valve seat; 2-exhaust passage; 3- slider valve; 4 - cam; 5- timing gear;
6-camshaft; 7- intake and exhaust cam; 9- intake valve closed; 10- reset spring;
11- inlet; 12- exhaust valve open

Valve closing process:

As shown in Figure 4, when the corresponding cam on the camshaft rotates to descend, driven by the return spring, the slider valve is pushed to move to the right. When the two holes on the slider valve and the two holes on the valve seat are gradually staggered, the valve gradually closes. When the two holes on the valve are completely staggered with the two holes on the valve seat, the two valves of the same name are in a completely closed state, as shown in section AA in Figure 6.

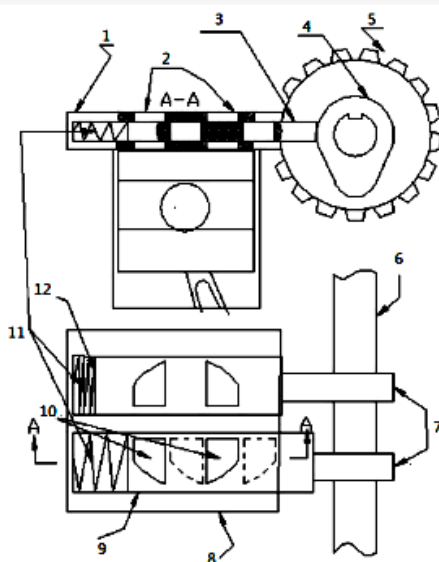


FIG. 6 Schematic diagram of slider valve structure (State A)

1, 8-valve seat; 2- intake passage; 3- slider valve; 4 - cam; 5- timing gear;
6-camshaft; 7- intake and exhaust cam; 9-intake valve closed; 10-inlet ;
11- reset spring; 12- exhaust valve open

Since valve closure is a gradual process, valve can be fully closed under the premise of reasonable and correct design of the cam return. When the valve is closed, a good sealing effect is needed to ensure the required pressure in the engine cylinder. Compared with the traditional valve structure, valve sealing in the scheme mechanism does not require spring force, but is achieved through close contact between specific material (tentatively determined to be ceramic material), high-precision machined slider valve and sliding seat. As long as the manufacturing and assembly accuracy meet the requirements, when the two holes on the valve are completely staggered with the two holes on the valve seat, the valve can be completely closed without gas leakage. In the closed state, reliable sealing is required without interference from the spring force of the valve spring.

IV. Conclusions

Slider type valve mechanism has less transmission parts, high transmission efficiency, small valve structure size, with no need to assemble guiding ducts. Also, the sealing of the valve and the valve seat can be strictly guaranteed. In addition, due to the good sealing effect when the valve is closed, engine performance in all aspects can be improved under the same conditions. In particular, the power performance and fuel economy are significantly improved.

Using the above technical solution, the designed structure has the following advantages:

- (1) No noise and long life. As there is no collision between the valve and the valve seat in the designed mechanism, the relatively soft operation reduces the high frequency impact of the valve and the valve seat during the working process, and the contact surface of the valve and the valve seat is not easy to wear. Therefore, there is less noise generated by the collision between the traditional valve and the valve seat, with valve mechanism life and engine life prolonged.
- (2) Smooth intake and exhaust. When the valve is opened, there is no obstacle to intake and exhaust from the valve head of the traditional valve, which increases charging coefficient and intake and exhaust efficiency, thereby reducing natural suction resistance and forced intake and exhaust resistance, with engine efficiency greatly improved.
- (3) Compact structure, with no need to adjust the valve clearance. Compared with the traditional valve structure, the designed valve structure adopts the combination of slider and sliding seat, and the movement is along the radial direction of the cylinder, which greatly reduces the dimension of the engine cylinder along the axis, meets the structural requirements of small-sized engine, so that transmission part is greatly simplified and the route is shortened. When the engine operates, there will be no thermal expansion of valve lifter and other driving parts which reduces the valve clearance. Therefore, there is no need to adjust the valve clearance.
- (4) Few transmission parts, no need to assemble guiding ducts, simple valve structure. The valve slides back and forth in the hollow valve seat, which relies on manufacturing and assembly accuracy to ensure correct and stable relative movement. The traditional valve mechanism has many transmission parts, resulting in low transmission efficiency and high manufacturing and maintenance costs. This solution involves few valve structure transmission parts with relatively high transmission efficiency, and the manufacturing and maintenance costs will also be lower.
- (5) More reasonable opening and closing in reliable approach. Since this mechanism is operated by the relative movement position between the slider valve and the sliding seat, the opening or closing of the valve is a gradual process, which allows early opening and delayed closing of the valve in engine operation. It does not require spring force to close the valve, but is completed by the relative movement between the slider valve and the sliding seat. Compared with the traditional valve structure, it is not affected by spring force of the valve spring, and the closing is reliable, with more reasonable valve opening and closing.

Acknowledgments

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