

Variable compression ratio system using a free piston

- A new mechanism that enables the Atkinson cycle-

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This paper proposes a novel internal combustion engine system that enables the compression ratio to be changed during engine operation. In recent hybrid vehicles, the Atkinson cycle is widely used because it can improve thermal efficiency by making the expansion ratio greater than the compression ratio. This allows the engine to extract more work from the combustion gases before they are exhausted. However, conventional Atkinson-cycle engines usually require complex crank mechanisms or delayed intake-valve closing. In addition, their compression ratio is normally determined during the design stage and cannot be changed while the engine is operating.

To overcome these limitations, the authors apply a variable-compression-ratio control method previously developed for a Stirling engine to an internal combustion engine. The proposed system places a free piston inside the same cylinder as the conventional power piston. The power piston is connected to the crankshaft, whereas the free piston is not connected to the crank mechanism and can move freely in response to the pressure of the working gas. When the power piston moves upward during the compression stroke, the gas pressure pushes the free piston upward. During this movement, the gas is maintained at nearly constant pressure, so effective compression does not immediately occur. When the free piston reaches an adjustable stopper, compression begins. Therefore, changing the stopper position changes the free piston's stroke and allows the effective compression ratio to be controlled.

One important advantage of this system is that the compression ratio can be adjusted during engine operation according to conditions such as engine speed and output. This flexibility could allow the engine to operate at a more appropriate compression ratio under different operating conditions, potentially improving fuel economy and reducing exhaust emissions. The system can also realize an Atkinson-type cycle without using the complicated mechanisms found in conventional designs.

The proposed system has another possible application in engineering education. If the free piston is allowed to move through a range corresponding to the full stroke of the power piston, the engine can operate with almost no conventional compression stroke and produce a triangular cycle on a P-V diagram. Although this cycle is theoretically less efficient than conventional Otto or Diesel cycles, its relatively low pressure rise during combustion could make it suitable for educational demonstrations. For example, a transparent cylinder could potentially be used to visualize the combustion process.

Overall, the proposed free-piston system provides a simple and flexible approach to variable compression-ratio control. It offers potential benefits for fuel-efficient internal combustion engines while also creating new possibilities for heat-engine education and the development of unconventional thermodynamic cycles.

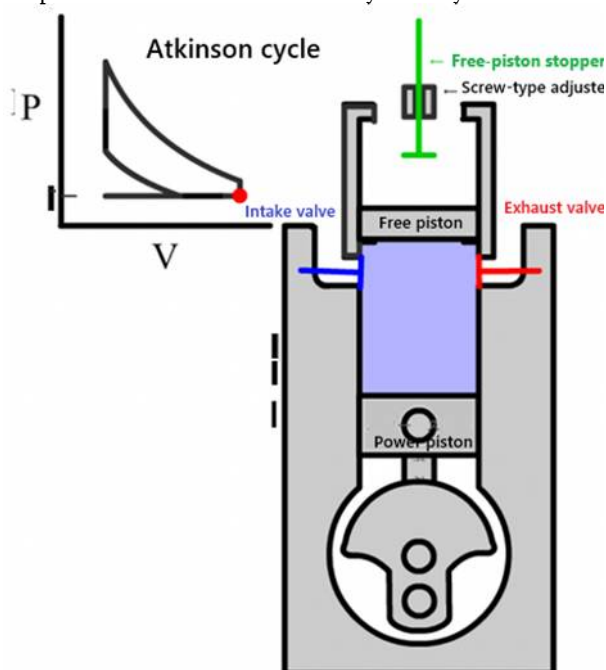


Fig.1 Schematic Diagram 1 (At the bottom dead center)

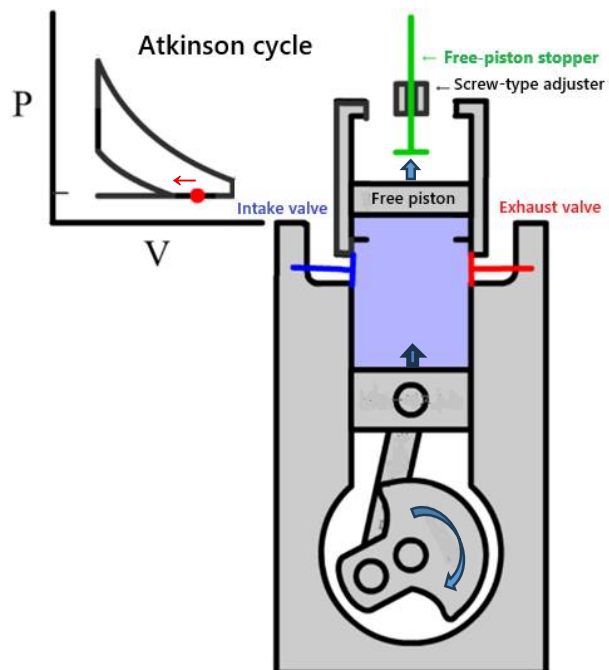


Fig.2 Schematic Diagram 2 (Moving free piston)