Design and Research of Mechanical Gas Timing Shut-off Device

Shuzheng Zhang¹, Meng Xu¹, Xun Yuan², Cong Zhao², Xianning Li³ and Zhou Yan²,*

¹ School of Aeronautics and Astronautics, Shenyang Aerospace University, Shenyang, China
² Engineering Training Center, Shenyang Aerospace University, Shenyang, China
³ School of Aero-engine, Shenyang Aerospace University, Shenyang, China

*Corresponding author e-mail: sdyanzhou16888@edu.sau.cn

Abstract. With the generalization of the use of gas and natural gas, the design and research of the timing shut-off device for gas has become an indispensable factor to avoid gas poisoning incidents. In order to solve such problems, this paper proposes a mechanical gas timing shut-off device design, expounds the operation principle of the device, draws the device schematic diagram and assembly drawing, and introduces the key technological breakthroughs in the research of mechanical gas timing shut-off device. Clarified the innovation and promotion significance of the device.

1. Introduction

In recent years, the use of gas and natural gas has become widespread. However, when the user cooks for a long time or leaves the gas source for other reasons during use and forgets to close the valve, the gas leaks from the valve. When the gas reaches a certain concentration, it can cause fire, explosion, gas poisoning, and even casualties. In order to avoid this kind of phenomenon, a variety of gas detection and alarm devices have been developed at home and abroad. Most of these devices are controlled by electric signals or wireless to realize the opening and closing of the gas system.

A company designed an unconventional security monitoring robot [2], the robot will detect the gas concentration, and when it reaches a certain concentration, it will send the owner the real-time status of the scene; Based on wireless communication technology, Xiaopeng Li [3] realized the detection and alarm of gas leak, When a gas leak is detected, the alarm system will reflect the situation to the user and remind him to turn off the gas installation; Minghua Zhang [4] developed a gas leak intelligent monitoring APP using leading-edge Internet of Things technology, which can send real-time information and the current state picture of the scene in case of gas leakage to users through the Internet; Pengbin Jing [5] applied the principle of a single-chip microcomputer to design a gas leak alarm system. The system can detect the indoor gas concentration and send an alarm to the user when it reaches a certain value.

These gas-related shut-off devices either use electricity for operation support or use gas concentration as a warning. For electronic systems, when the gas itself reaches a certain concentration, it will also explode when encountering electric sparks. Moreover, among the gas users, the group that is likely to cause dangerous accidents is the elderly to a certain extent. And the operation of the electronic system...
is not too suitable for the elderly. Although the concentration alarm system is easy to use, its accuracy will be slightly reduced. In addition, it can only alarm and is not suitable for going out. Therefore, to a certain extent, the two existing gas shut-off devices have some drawbacks.

In addition, there are few researches on fully mechanically controlled gas timing shut-off devices. This paper proposes the design of mechanical gas timing shut-off device, using the principle of mechanical clockwork to control time. The clockwork with potential energy can drive the rotation of multiple gears and valve closing devices, and then the bidirectional thrust bearing is used for the rotation and stop between the dial and valve closing devices. These realize the artificial and semi-automatic gas timing shut down, to improve the personal safety of users.

2. Mechanical gas timing shut-off device design

2.1. Design content

The mechanical gas timing shut-off device uses the clockwork as the main driving device, and uses the principle that the clockwork \[5\] converts the elastic potential energy into mechanical energy. The clockwork that generates the reserve potential energy drives the rotation of the gear device and the drive mechanism, and then through the bidirectional thrust bearing, the switch of rotate and stop between the dial and the driving mechanism can realize the emergency shutdown of the gas under the control of time, thus realizing the design concept of the mechanical shut-off device. Among them, the partial structural engineering drawing of the device is shown in Figure 1.

![Figure 1. The partial engineering drawing of the device](image)

In terms of safety performance, the design of the device avoids the possible negative effects of electricity and concentration alarm devices, and improves the safety of the device to a certain extent. In terms of implementation promotion, in the existing technological development, the technologies that can promote the completion of device production and normal operation already have relatively complete relevant information. Using it as technical support can greatly improve the completion of the device.

2.2. Principle of operation

2.2.1. Power source. The device uses a mainspring as a power device. As shown in Figure 2, when the mainspring is wound, the stored elastic potential energy is converted into kinetic energy, which can become the power source of the timing device and the braking system at the same time. In the timing device, the clockwork firstly rotates gear 1, and the entire system is in operation. Through various setting conditions, gear 1 first drives gear 3 to rotate, and then gear 3 drives gear 4 to rotate, thereby driving the
pointer indicating the time on the dial to rotate, and then the timing starts, which is reflected as the starting point of the timing in the device. Among them, the dial is a normal clock dial, and the start time of the device and the set stop time can be read on the dial to facilitate the convenience of data acquisition and timing.

![Figure 2. Schematic diagram of the device and marking of necessary parts](image)

2.2.2. The stop of the pointer on the dial. As shown in Figure 3, a slide is installed on the outer edge of the dial, and a movable circlip is installed on the slide, so that it can slide arbitrarily along the circumference of the dial. The user adjusts the position of the circlip according to the time set by himself and sets it to any time required. A buckle is set above the circlip. When it is adjusted to the required time, the buckle can be closed to fix the circlip at the designated position, so that the time setting is realized. After the device is turned on, the clockwork drives the pointer to start to rotate. When it reaches the position of the circlip, the pointer is restricted by the circlip and cannot continue to rotate. At this time, the timing end point is triggered and the gear meshed with it stops rotating.

![Figure 3. Partial view of dial](image)

2.2.3. The movement of the drive mechanism starts. According to the characteristics of the bidirectional thrust bearing: when the outer end of the bearing is braked, its internal structure will start and rotate in the opposite direction due to the reverse thrust. The mechanical timing gas shut-off device needs to install a bidirectional thrust bearing at the gear 1 and gear 2, where the inside of the device is connected to gear 2 and connected to the brake device. The outer end of the device is connected to gear 1 and connected to a series of devices that can make the dial rotate. In this way, when the pointer on the dial stops, the gear 3, gear 4, and gear 1 stop rotating instantly, and at the same time, gear 2 will start to drive the brake device to run.

2.2.4. Realization of gas valve closing. As shown in Figure 4, when the gear 1 stops rotating, the bidirectional thrust bearing starts. At this time, the gear 2 starts to rotate. The gear is firmly connected
to the rod A in the figure. Therefore, the rod A rotates with the start of the gear 2, and the rods A and B are connected by hinges, rod A drives the chuck fixedly connected to rod B on rod B to move in a plane on the plane where the gas valve is located. The ring at the end of rod B is matched with different valve sizes to set the corresponding three-jaw protrusion structure, inserted or fixed at the gas valve, so that the movement of the rods A and B drives the gas valve to rotate, and finally the gas valve is closed and stopped.

![Figure 4. Drive device diagram](image)

2.2.5. *Time correction device.* Because the clockwork will be used for a long time, there will be a time error. The mechanical gas timing shut-off device is equipped with a time correction device to reduce the impact of the time error. According to the prompt, the operator first pulls out the adjustment knob, and then rotates the adjustment knob according to the corresponding time difference, so that the adjustment knob drives the time pointer on the dial to move, so as to realize the time difference adjustment similar to the time correction method on the mechanical watch.

3. **Analysis of key technologies and innovations**

3.1. *Breakthrough in key technologies*

3.1.1. *Mechanical power system.* The device uses a purely mechanical clockwork as the power system and gears as the transmission device. The normal operation of the machine is achieved through the meshing of the gears to a certain extent.

![Figure 5. Power Device: Clockwork](image)

According to analysis [7], the time for gas leaks to cause explosions and other injuries is about 2 hours. If people forget to turn off the gas when cooking, boiling water, etc., the time to cause mashing or even explosion is only about 20-30 minutes. According to the operating principle of the clockwork, setting the device's preset time within the range of 0-90 minutes can reduce the loss of personnel, property, equipment, etc. caused by such problems.
3.1.2. Application of bidirectional thrust bearings. Using bidirectional thrust bearings [8], the thrust direction of the bearing is changed according to the running time of the mainspring at different positions to realize the change of the running direction of the gear connected to the bearing, and the reverse thrust is used to make the braking system work, so as to realize the operation switching of the gas valve screw stop device and the time adjustment device, which realizes the function of driving two sets of sports equipment by one drive system, and also enables the function of the entire device to be achieved.

3.2. Analysis of innovation
The device adopts a mechanical operation structure, which avoids insufficient sensitivity or inoperability of the device due to power supply failure or poor contact of the power cord. It reduces the error rate of the mechanism, and also makes the service life of the mechanism greatly increased.

The design concept of combining the adjusting knob and the timing device allows users to adjust the time of closing the valve at will according to actual needs, and can modify and adjust the structure at any time to ensure the safety of the mechanism.

The device is simple to use and does not require other supporting equipment, and the device can automatically close the gas valve after the specified time has passed, which greatly reduces the difficulty of operating the device. And to a certain extent, it is more suitable for the elderly who have weak memory and are not familiar with the operation of electronic control equipment such as mobile phones. So this have achieved full coverage of the categories of users.

According to the operating characteristics of the device mechanism, the other structures besides the device connected to the braking system can realize the characteristics of the timing switching motion device. Therefore, the shut-off mechanism can be combined with other valves or switches, which will enable the device to obtain new performance and functions, which is conducive to product iteration and promotion.

4. Conclusion
The mechanical gas timing shut-off device uses a clockwork as a power device and adopts an automatic shut-off design, allowing users to realize barrier-free automatic gas shut-off according to the user's own control of time. At the same time, the potential safety hazards of electricity and concentration alarm devices are reduced, and the innovative design of the gas timing shut-off device is realized to a certain extent.

The application of bidirectional thrust bearing of mechanical gas timing shut-off device makes the device automatically reverse according to the present time, so as to achieve the purpose of automatically shutting down the gas switch, which is a major innovation in device research.

The design of the time adjustment knob in the mechanical gas timing shut-off device can adjust the time error caused by the clockwork characteristics, which not only guarantees the accuracy of the device's timing, but also reduces the maintenance cycle of the device and improve the service life of the device at the same time.

By changing the braking device, it is possible to achieve mechanical shut-down of other devices, or to replace the braking device with other operating devices. As a result, the functions of other timing devices are realized, which makes the design applicable to any system or tool that requires timing drive devices to a certain extent, which has great promotional significance for the promotion and in-depth research of the design.

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First author: Shuzheng Zhang (1999.10--), male, Junior, the main research direction is aircraft manufacture engineering.

Corresponding author: Zhou Yan (1982.12--), male, engineer, main research direction is the application of numerical control technology and mechanical design research.
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