Exploration of the lubrication system of the internal mixer

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Abstract: This article conducts research and analysis on the design, working principle, and application of the mixer lubrication system in the rubber industry. It explores the classification of lipid-based lubrication and thin oil lubrication, and evaluates the impact of the lubrication system on equipment performance and the precision of rubber compound formulations. At the same time, based on actual needs and existing technologies, it points out the direction for reducing production costs and increasing product profits.

Key words: internal mixer; lubrication system; performance optimization; environmental protection; intelligence

Classification number: TQ32 **Article number:** 1009-797X(2026)01-0043-06

Document code: B **DOI:**10.13520/j.cnki.rpte.2026.01.013

According to market research reports, the market size of China's rubber products industry in 2023 was approximately 828 billion yuan, and it is estimated that the global market size of rubber products will reach 150 billion US dollars by 2025.

With the rapid development of the rubber industry, the requirements for the performance of internal mixer have been continuously improved. Good lubrication can play a role in cooling, heat dissipation, and sealing of key components, and it is also the guarantee for the long-term stable operation of the internal mixer. The absence of a lubrication system can lead to an increased failure rate of the internal mixer, or even prevent it from working properly. At the same time, the quality of the lubrication and sealing performance of the rotor end face of the internal mixer directly affects the accuracy of the rubber compound formula and the stability of the rubber compound quality. It can be said that the small lubrication system plays a crucial role in the normal operation of the internal mixer. This article will analyze and discuss the working principle, design, and future development of the internal mixer lubrication system.

1 Classification and configuration of lubrication system

The lubrication system of the internal mixer is mainly divided into two categories: grease lubrication and thin oil lubrication.

Lipid lubrication is suitable for applications such as rotor bearings, discharge door shaft bearings, feed door shaft bearings, sealing copper strips, ram piston rod bearings, and locking device support bearings. Usually, one or more electric grease pumps are equipped, and the grease pump is typically equipped with a 0.25 kW motor with a rotational speed of 710 r/min. A single grease pump usually comes with a level switch for low oil level alarm, facilitating timely oiling and avoiding equipment damage due to oil shortage. Some grease pumps are also equipped with automatic greasing systems to enhance automation levels, but they require a higher level of on-site environmental conditions.

The other type is thin oil lubrication, which is mainly applied to the surfaces of the stationary and rotating rings, as well as the lubrication between the rotor end face and the wear plate. Except for small-sized internal mixers, most internal

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mixers are generally equipped with two thin oil pumps, which are distinguished according to the type of oil used and the location of use. The pump used for lubricating the surfaces of the stationary and rotating rings is usually called a lubrication pump; the pump used for gap lubrication between the rotor end face and the wear plate is usually called a process lubrication pump.

Currently, there are several configurations available for the thin oil lubrication center:

1.1 Configure a thin oil pump

The motor power is 0.25 kW. This type of thin oil lubrication center is applied to situations where there are fewer lubrication points or where the lubrication requirements are not high. The lubrication oil pump and process lubrication oil pump are integrated, and the lubrication oil and process oil use the same type of oil. It is equipped with 8 to 15 oil filling ports. It is commonly used in small laboratory internal mixers such as GN1.5, GE5, and GN10.

1.2 Configure two thin oil pumps

The motor power is 2×0.25 kW. The lubricating oil pump and the process lubricating oil pump supply oil separately. The lubricating oil pump is equipped with a standard motor, while the process lubricating oil pump is equipped with a variable frequency motor. Different types of oil can be used for lubricating oil and process oil. The material cylinder is equipped with an electromagnetic valve and a level switch, which can achieve automatic oiling through a PLC program or relay circuit. This form is mainly used in small models (GE135 and below) or equipment with lower configuration requirements.

1.3 Structural form of lubrication center

Two thin oil pumps are installed together, with a motor power of 2×0.55 kW. The lubrication center is equipped with an electric control box, which can achieve multiple functions. Currently, this type of thin oil lubrication center is the most widely used.

1.4 Configure an electric high-pressure pump with a distributor

The motor power is 2×1.1 kW, and its function is basically the same as "1.3". This type is mainly equipped on large internal mixer, which can provide higher pressure and greater flow for lubricating oil.

1.5 Servo motor drive

The motor power is 2×1.0 kW, and both oil pumps can quickly adjust the oil output according to the working conditions. Currently, this type of thin oil lubrication center is gradually becoming mainstream.

The basic parameters and configurations are shown in Table 1:

Table 1 Parameters and configuration features of the lubrication center

Project	Motor type				
	General-purpose motor	Ordinary motor + variable frequency motor	Ordinary motor + variable frequency motor	Ordinary motor + variable frequency motor	Servo motor
Motor power/kW	0.25	0.25+0.25	0.55+0.55	2×1.1	2×1.0
Motor speed ($r \cdot min^{-1}$)	840~910	840~910	1 300~1 390	1 300~1 390	2 000
Rated pressure (MPa)	32	32	32	64	64
Pump type	plunger pump	plunger pump	plunger pump	High-pressure pump + distributor	Plunger pump and distributor
Number of oiling points	8~15	16~30	16~30	Determination of the number of dispensers	16~30 or determined by the number of dispensers
Oil output per point/mL/time	0~0.23	0~0.23	0~0.38	The distributor port determines (total oil output is approximately 151 mL/min)	0~0.38 or determined by the distributor port (total oil output is approximately 151 mL/min)
Remarks	It can refuel automatically	Process oil and lubricating oil are injected separately, and the speed of the process oil pump can be adjusted	With flow rate and pressure alarm	Integrated lubrication center, higher oil pressure	The oil output can be adjusted according to the working conditions

2 The function and working principle of the lubrication system

2.1 Grease lubrication system

Most internal mixers are equipped with only one electric grease pump (see Figure 1), but there are also some equipped with multiple electric grease pumps depending on different lubrication points. The appearance of the electric grease pump is shown in Figure 1, and it is generally fixed near the internal

mixer equipment. The material cylinder adopts a transparent shell, which is convenient for observing the condition of the lubricating grease. A level switch is equipped on the top of the material cylinder, and as the lubricating grease decreases, the grease level gradually lowers. When the level switch is triggered, the lubrication control system will alarm or start the automatic grease addition function.

Figure 1 Outline drawing of electric grease pump for internal mixer

After the lubricating grease comes out of the electric grease pump, it is channeled through a pipeline to the body of the mixer equipment. Figure 2 is a schematic diagram of the grease lubrication pipeline,

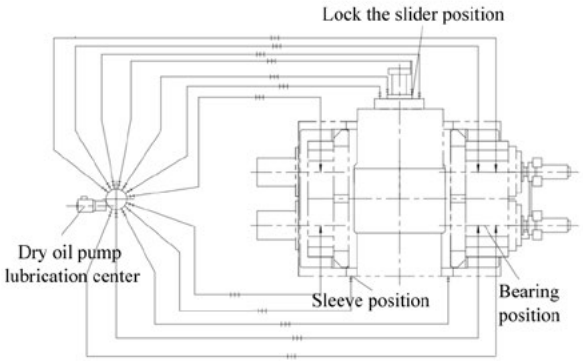

Figure 2 Schematic diagram of dry oil lubrication pipeline

Before the operation of the internal mixer, it is necessary to use an electric grease pump to fill lubricating grease into the spaces of various bearings and other parts that require lubrication. After the internal mixer starts operating, the lubricating grease forms a continuous film on the metal surfaces of the parts. This film separates the direct contact surfaces between metal parts, converting the friction between solids into friction within the lubricating grease, thereby significantly reducing the friction coefficient. By reducing friction, the wear and tear of the parts during operation is correspondingly reduced. For those parts in the internal mixer that bear heavy loads and operate continuously, grease lubrication can prevent wear phenomena such as scratches and pits on the metal surface due to excessive friction, greatly extending the service life of these parts and reducing the cost of equipment maintenance and replacement.

During the operation of the internal mixer, especially during situations such as rubber feeding, discharging, and uneven material mixing, certain vibrations and impact forces are generated. At this time, the lubricating grease layer formed on the surface of the components by the grease lubrication can play a buffering role, absorbing and dispersing some energy, and reducing the impact of these vibrations and impact forces on the components. At the bearing part of the internal mixer, the lubricating grease can alleviate the impact caused by unstable rotor rotation, protecting the bearing and other connected components from excessive vibration and impact damage. By buffering and damping, it helps to maintain the stability of the internal mixer during operation, reduce equipment failures caused by vibrations and impact forces, and improve the reliability and work efficiency of the equipment.

In addition, the lubricating grease filled in the sealed space can also serve as a sealing function, preventing external impurities such as dust, moisture, and corrosive gases from entering the interior of the components.

Before a new internal mixer is put into production, or before an old internal mixer is restarted after a long period of downtime, it is necessary to operate the electric grease pump first to ensure that fresh lubricating grease is injected before starting the machine. After normal operation, the electric grease pump usually works intermittently, and the time can be adjusted on the human-machine interface according to actual needs. Figure 3 shows the control program block and setting interface of the electric grease pump.

2.2 Thin oil lubrication system

The lubrication system for the internal mixer is mostly equipped with two independent oil pumps. The lubrication pump is used for lubricating the contact surface between the

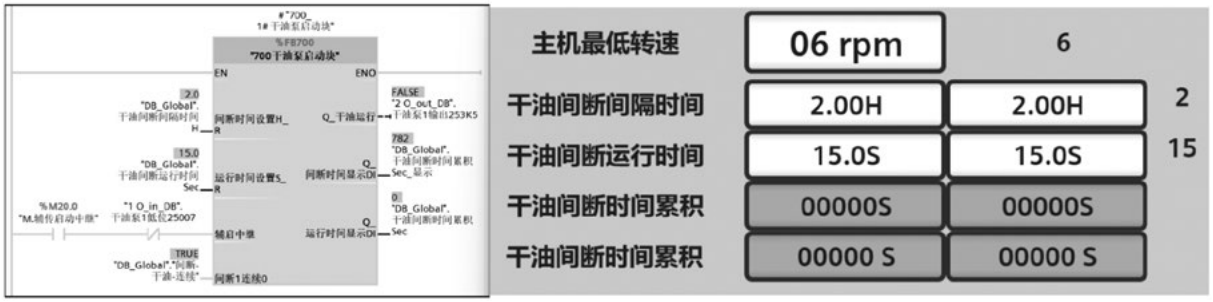

Figure 3 Control program and setting interface of electric grease pump

stationary ring and the rotating ring. The process lubrication pump is used for lubricating the gap between the rotor end face and the wear plate. The appearance is shown in Figure 4.

Figure 4 Outline of the thin oil lubrication center

Similar to the material cylinder of an electric grease pump, the material cylinder of a thin oil lubrication system is also mostly made of transparent materials, which facilitates the observation of the amount of oil inside the cylinder. A level gauge and a refueling solenoid valve are installed on the top of the material cylinder, and the solenoid valve is externally connected to an oil pipe. When the ambient temperature is too low, the fluidity of the oil in the storage tank is poor, which will affect the lubrication effect and also have an impact on the service life of the pump. Some lubrication centers will install a ring heater in the material cylinder (made of steel). At low temperatures, the heating system of the storage tank is activated to heat the oil inside the storage tank. The heater is controlled by a solid-state relay. As the oil temperature approaches the set temperature, the control system performs PID control on the heating power. As the temperature gradually approaches, the output voltage of the solid-state relay decreases, and the output power of the heater decreases. As the liquid level changes, the corresponding set of heaters is started or stopped. Because there is a need to collect many signals such as pressure and flow rate, thin oil lubrication centers are generally equipped with control boxes, as shown in Figure 5, which illustrates the internal structure of a thin oil lubrication center control box. Nowadays, more and more thin oil lubrication centers are starting to be equipped with CPUs and human-machine interfaces, along with network interfaces. This allows them to work independently or in conjunction, providing better scalability and compatibility.

Figure 5 Internal structure of control box

After being pressurized by the oil pump, lubricating oil and process oil are delivered to various parts of the internal mixer through high-pressure oil pipes, as shown in Figure 6.

The thin oil lubrication system of the internal mixer has unique functions. During rubber mixing, leakage of carbon black and other substances can damage the sealing ring,

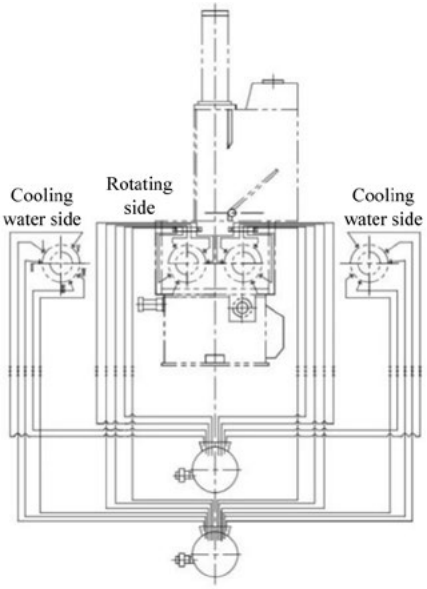

Figure 6 Schematic diagram of thin oil lubrication pipeline

and accumulation of rubber compound can wear parts and decompose at high temperatures, affecting quality. The system injects high-pressure process oil to form a seal, reduce friction, lower temperature to prevent vulcanization, and simultaneously form an oil film on the contact surface to achieve lubrication, sealing, and impurity cleaning.

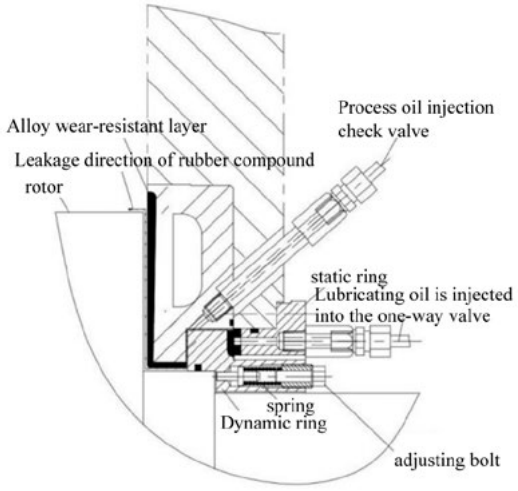

Figure 7 Rotor end face seal lubrication diagram

To ensure the quality and performance of rubber compound products in the mixing chamber, and considering the impact of directly injecting process oil into the mixing chamber on the products, the design of the lubrication system using thin oil has gradually shifted towards a multi-barrel configuration. This design allows for the selection and use of corresponding types of process oil according to different rubber compound formulation requirements. With the development of technology and the deepening of application, the multi-barrel lubrication system using thin oil has been gradually introduced into actual production to achieve more refined management of process oil. Figure 8 shows a lubrication center with multiple barrels.

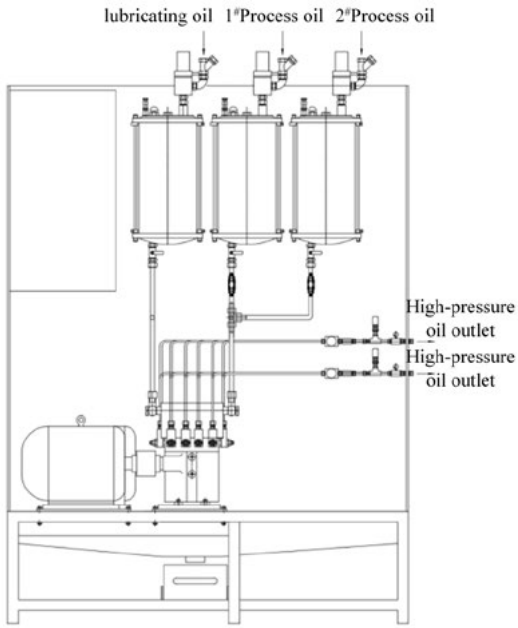

Figure 8 Schematic diagram of multi-barrel lubrication center

3 Development trend and vision of lubrication system

Technological innovation, green development, and intelligence are the core issues in today's industrial development. Against this backdrop, the evolution of the internal mixer lubrication system has also followed this trend, continuously moving towards green and intelligent directions.

In the future, dry oil lubrication systems will adopt multi-pump precision oil injection to address the issue of significant differences in oil consumption across different parts. For instance, there is a notable difference in oil consumption between large and small bearings, and a single-pump system lacks sufficient adjustment accuracy, which can easily lead to insufficient or excessive oil injection. Therefore, multi-point lubrication systems are employed in parts with similar oil consumption, while small pumps paired with distributors are used in parts with significant differences. The multi-

pump system can reasonably match oil injection according to working conditions, ensuring lubrication while reducing waste. Additionally, the use of environmentally friendly lubricants is also an important development direction.

Figure 9 Distributor for dry oil pump

The thin oil lubrication system faces the problem of insufficient supply of process oil and lubricating oil. Insufficient process oil can lead to damage to the mixer seal, accumulation of rubber compound, and high equipment temperatures, affecting product quality. Insufficient lubricating oil can cause dry friction between the rotating and stationary rings, resulting in wear, screw breakage, and rubber compound leakage, disrupting production. The system needs to increase the oil volume, but thin oil lubrication is a consumable lubrication method, and most of the waste oil needs to be disposed of, increasing costs. Optimization directions include precise oil volume control and waste oil recycling. Dynamic oil supply adjustment through sensors and intelligent systems, and the adoption of closed-loop lubrication mode, reduce waste oil. Internet of Things technology can remotely monitor the lubrication status, enabling intelligent control and energy saving.

The PLC controller achieves intelligent and precise oil injection by integrating load, pressure, and temperature data. The servo motor enhances the system's response speed, thereby improving the efficiency and reliability of the lubrication system. The modular design allows the lubrication system to be quickly adjusted and upgraded to adapt to complex working conditions, achieving precise control and energy conservation through multiple lubrication centers. In the future, the lubrication system of the internal mixer will shift to a regenerative cycle mode, reducing waste oil generation through a closed-loop system. Waste oil is collected, filtered, and deeply purified for reuse, enabling resource recycling, reducing operational costs, and environmental burden. Enterprises need to strengthen management and maintenance, improve the waste oil treatment system, adopt advanced technologies to enhance treatment efficiency, and promote green and sustainable development.

4 Conclusion

In modern manufacturing, green production, intelligent control, and energy conservation and consumption reduction are key development directions. The lubrication system of the internal mixer plays a crucial role in equipment operation, cost reduction, and profit enhancement. Enterprises should embrace a people-oriented philosophy, enhance their level of intelligence, reduce labor intensity for workers, and improve the working environment, with precise control of lubricating oil being a key aspect. Through technological innovation, enterprises can achieve a win-win situation for both economic benefits and environmental responsibility. With technological advancements and increasing environmental awareness, the lubrication system of the internal mixer will provide continuous momentum for the sustainable development of the rubber industry.