Design of Asphalt Spraying System of Ultra-thin Wearing Paver

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ABSTRACT

Asphalt spraying system is an important working mechanism of ultra-thin wear layer paver, which is mainly used for the accurate spraying and spraying of emulsified asphalt in the process of machine spreading. In this paper, the asphalt spraying system of ultra-thin wear layer paver is designed, including asphalt circulation system, hydraulic control system and gas path control system. Then, the main components of the system hydraulic pumps and hydraulic motors were selected.

INTRODUCTION

It is very important to restore the normal operation of expressway by adopting appropriate conservation measures to deal with the damage of expressway asphalt pavement. Ultra-thin wear layer maintenance construction technology is a method to ultra-thin (10-25mm), off-grade hot mix and asphalt mixture paved in a special modified emulsified asphalt membrane. It is characterized by the use of special equipment for quick operation, and the open traffic can be opened after the spread of 30 min at room temperature. The technology combines the advantages of the strength of hot mix asphalt and the flexibility of the ultra-thin curing process, which can solve the problem of sealing water and drainage, and can be used for the preventive maintenance and corrective maintenance of asphalt pavement [1, 2]. Ultra-thin wear layer paver is the construction of this process construction of new construction equipment.

The asphalt spreader of Ultra-thin wear layer paver is to have certain pressure evenly sprayed on the pavement with asphalt nozzle, and the width of spraying and road paving width is consistent [3]. The main parameters of asphalt spraying system are as follows.

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Table 1. Setting Word’s margins.

| Name                      | Value     | Name               | Value |
|---------------------------|-----------|--------------------|-------|
| Paving speed (m/min)      | 0–20      | Nozzle spacing (mm)| 255   |
| Asphalt tank capacity (L) | 2500      | Injection pressure (bar) | 3     |
| Spray amount (kg/m²)      | 0.2–1.2   | Number of nozzles  | 24    |

**ASPHALT SPRAYING CIRCULATORY SYSTEM**

Asphalt spraying system consists of asphalt pump, filter, pressure sensor, control ball valve, asphalt tank, pneumatic ball valve and spraying actuator, etc. The spray actuator comprises three fixed spray bars arranged on the front side and the rear side of the paver and two rotatable spray bars arranged on both sides of the paver, the rotary spray bar can be changed by the angle to adapt to different Paving width requirements, in the fixed spray rod and rotatable spray rod spacing evenly arranged on a number of nozzle components [4]. The working principle is as follows: before the construction, the heating system is first opened to heat the asphalt in the asphalt tank. Heating to the required temperature, open the asphalt from the circulatory system, the asphalt in the tank is pressurized by asphalt pump and then flow back to the tank, so that the asphalt temperature within the tank is distribution, as well as asphalt pump and pump around the pipeline are heated. Then open the valve, make the asphalt through the filter into the main pipe and the spray bar, and then back into the asphalt tank to form the outer loop. In the construction, according to the construction requirements of the spraying rate and spray speed control nozzle components to achieve accurate and uniform asphalt spraying. Its structure and principle are shown in Fig.1.

![Figure 1. Schematic diagram of asphalt spraying system.](image)

1. Front side spray bar; 2. Left side spray bar; 3. Right side spray bar; 4. Left rear spray bar; 5. Right rear spray bar; 6. Pneumatic ball valve; 7. Asphalt tank; 8. Asphalt pump; 9. Asphalt filter; 10. Control valve.
ASPHALT SPRAYING CIRCULATORY SYSTEM

Spraying hydraulic control system includes variable piston pump, load-sensitive valve, hydraulic motor and hydraulic piping and other components. Its function is to adjust the motor speed according to the system pressure feedback control valve opening, and then change the flow of the asphalt pump to keep the spraying system pressure stable. The system uses the load-sensitive hydraulic drive system and pressure sensing technology, closed-loop control to make the emulsified asphalt system to maintain constant pressure to achieve uniformity and stability of a single nozzle [5]. The schematic diagram is shown in Fig.2.

Selection of Hydraulic Motor

The asphalt pump working load is small, so the hydraulic system design should give priority to ensure the torque and power, in addition to consider the spread of the accuracy of the system and the degree of simplicity, so the asphalt pump using closed type hydraulic drive circuit. The driving power of asphalt pump is determined by the following formula.

\[ P = \frac{Tn}{9549} \]  

Where, \( P \) is the driving power of the asphalt pump (Kw), \( T \) is the driving torque of the asphalt pump (N.m), \( n \) is the rotational speed of the asphalt pump (r.min-1).

The displacement of the hydraulic motor is expressed by the following formula.

\[ q_m = \frac{2\pi T}{\Delta p \eta_1} \]  

Where, \( q_m \) is the displacement of the hydraulic motor (mL.r-1), \( \Delta p \) is the rated pressure of hydraulic system (MPa), \( \eta_1 \) is the mechanical efficiency of hydraulic motors.

According to the speed of the asphalt pump, we can determine the speed of the motor high-efficiency zone should be in its vicinity of the stable speed, access to well-known foreign manufacturers of hydraulic parts quantitative motor sample data, select the 90 displacement SAI motor, its efficiency curve are shown in Fig.3 and Fig.4.
The rated pressure of the hydraulic system is calculated to be 250 bar. Considering the reliability and life of the hydraulic system, the principle of derating is adopted. Therefore, it is appropriate to select 20 MPa for the hydraulic system, so that the power and torque of the closed system Reserve a large, and it can adapt to a wide range of external load changes.

The output torque is 274 N.m and the power is 16.7 kW at a pressure of 20 MPa. According to these calculated values, it can be seen that the actual output torque of the motor is greater than the driving torque of the asphalt pump. It can also be seen that the actual output power of the motor is larger than that of the asphalt pump. Therefore, the use of the hydraulic motor of SAI 90 displacement as the power of asphalt pump is more reasonable.

**Selection of Hydraulic Pump**

Take the maximum displacement of the hydraulic pump, and take the volumetric efficiency of hydraulic pump and hydraulic motor is 0.95, the maximum flow required by the hydraulic pump is expressed by the following formula.

$$Q_p = \frac{q_p \eta_m}{\eta_p}$$  \hspace{1cm} (3)

Where, $Q_p$ is the maximum flow rate required for a hydraulic pump, $q_p$ is the displacement of hydraulic pump, $n_p$ is the speed of the hydraulic pump, $\eta_m$ is the volumetric efficiency of hydraulic motors, $\eta_p$ is the volumetric efficiency of hydraulic pump.

According to the above calculation, we selected LINDE's 55 displacement HPV55-02REIX350-EA hydraulic pump, which integrates a relief valve and a charge pump.

**PNEUMATIC CONTROL SYSTEM**

Pneumatic control system mainly includes air tank, air drying cylinder, nozzle control components, pneumatic ball valve and gas pipeline and other components. The working principle is as follows: compressed air from the air compressor is cooled by the radiator first, then filtered and dried by a double-cylinder drier, and the loop pressure is stabilized to 8.1 bar. The compressed air through the air storage tank is divided into three paths: the way through the nozzle control unit for spraying the left and front nozzle automatic control; another way through the nozzle for spraying nozzle on the right side of the control component automatic control; the end way through the pneumatic valve control spraying system "on" and "off".
"off". Finally, when the spray is complete, the purge line is opened by a manual switch, and the asphalt line can be cleaned with compressed air. The schematic diagram is shown in Fig.5.

Figure 5. Schematic diagram of pneumatic control system.

SUMMARY

Ultra-thin wearing course paver is the equipment which can add emulsified asphalt spraying system on the basis of conventional crawler paver to achieve simultaneous emulsion asphalt seal and asphalt mixture with a thin layer of rapid paving synchronous construction operations. In this paper, a set of asphalt spraying system has been developed, which mainly includes spraying hydraulic control system, asphalt spraying circulation system and gas path control system. The system can be optimized to be configured on an ordinary paver. Before the asphalt concrete paving asphalt, through the nozzle with certain pressure evenly sprayed on the asphalt pavement, to avoid the phenomenon of skip sticky material during the construction step to effectively improve the construction quality of pavement.

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