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Test and analysis of temperature field of asphalt pavement heated by asphalt pavement maintenance equipment

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Abstract. In the construction of asphalt pavement recycling technology, hot air circulating type heating method is one of the more widely used methods. Therefore, the research on the heating effect of this method in mobile asphalt pavement maintenance equipment is of great significance to improve the heat utilization rate of the equipment and optimize the hot air system structure of the equipment. This paper takes an area of the heating wall as the research object, and uses the contact temperature measuring method to test the heating effect in different areas and depths.The results show that there is almost no temperature change after the effective depth of hot air heating for asphalt pavement heating is 30mm and 50mm, and the temperature measuring method by indirectly monitoring smoke and air temperature to heat asphalt pavement is not very accurate, so a more direct and accurate contact temperature measuring method can be explored.

Keywords: Hot air circulation; Temperature field; Heating depth; Test.

1. Introduction

Social progress has promoted the rapid development of China's highway maintenance industry. The mileage of highways at all levels has increased rapidly, and the scale of highway network has been expanding.However, in recent years, most asphalt pavements have entered the maintenance period, and perfect regeneration equipment is needed to renovate the existing diseased pavements. Asphalt pavement maintenance equipment is a multi-purpose and efficient pavement maintenance machinery for asphalt pavement maintaining and repairing . The equipment can be widely used to repair all kinds of damaged pavement such as pits and cracks of asphalt pavement, and can use all kinds of waste asphalt materials to be regenerated into usable materials through heating rotary recycling silo, so as to reduce the cost of pavement repair. Understanding the heating temperature distribution of the heater of asphalt pavement maintenance equipment can fundamentally avoid the local aging of asphalt pavement, so as to reduce the "asphalt smoke" caused by asphalt overheating, which is also of great significance for environmental protection.

At present, the heating methods adopted by asphalt pavement maintenance equipment mainly include infrared radiation, hot air circulation and microwave heating [1].The equipment studied in this paper mainly adopts the heating mode of hot air circulation, uses diesel as fuel, burns the fuel to heat the air during operation, and sends the high-temperature air to the heating box through the circulating fan. The hot air is sprayed to the asphalt pavement through the orifice on the orifice plate of the heating box [2-3], so that the pavement temperature can reach the range of target temperature within a certain time.During the heating process, the heat of the high-temperature air is transferred to the road surface, and its own temperature gradually decreases. When the air temperature decreases to 350 ℃, it is sent back to the heater through the circulating fan for heating, so that the air temperature rises to 600 ℃ again to form a hot gas cycle.In the whole operation process, the heating temperature is controlled by the automatic control device, and the hot air temperature value is preset. The automatic control system timely adjusts the air-fuel ratio with the help of the air valve and fuel injection nozzle control system of the burner according to the feedback signal of the thermocouple, so as to control the air temperature within a certain range. Mobile asphalt pavement maintenance equipment is equipped with hot air circulating heating system on the truck chassis with good mobility. Compared with the fixed operation equipment, its model is small, but flexible, and

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can be equipped with machines and tools such as old pavement excavation and cutting, old material recycling and paving, and pavement compaction at the same time. It is suitable for completing the on-site rapid repair of small-area local diseases of high-grade asphalt pavement on the basis of on-site recycling of old pavement [4].

2. The research object and test method

The research object of this paper is an asphalt pavement maintenance vehicle with hot air circulating heating mode. The component of the equipment to realize the heating function of asphalt pavement is the heating wall, which is symmetrically distributed and consists of two heating areas with the same structure and heating area. Each heating area is mainly composed of burner, hot blast stove, circulating fan and heating box.A heating area of the heating wall is selected as the research object, and different temperature measuring points are arranged on the asphalt pavement in this area, The arrangement principle is that the temperature measuring points in the special area are dense, and the temperature measuring points are evenly distributed at different depths. The asphalt pavement temperature measuring equipment adopts K-type armored thermocouple and is equipped with 24 channel intelligent temperature inspection instrument. 20 measuring points are arranged, and the depth direction of the measuring points can be divided into 7 levels. The effective heating depth of heating wall for asphalt pavement is determined by multiple measurements.

3. Test and analysis

3.1 Test situation

During the test, the hot air outlet temperature of the heating wall is set as 320 ℃ as the control temperature of the heating pavement. Intermittent heating is adopted, and the cumulative heating time is 15min. The temperature changes of the ground surface and measuring points at different times and depths during the working time of the heater are measured. It can be seen from the measured data that the temperature at each point on the surface varies little during the initial heating time, but the rising rate of the temperature at each point varies with the extension of time, which is related to the ground laying conditions at each point. The temperature change curve of asphalt pavement at each temperature measuring point with time is shown in Figure 1. The test focuses on measuring the temperature change at different depths below the surface of asphalt pavement. Taking a certain point as the research object, it can be seen that the temperature change with different depth is obvious. The measurement data of temperature change with different heating time along depth are shown in Table 1.

Table 1 temperature change of a measuring point along the depth direction at different heating times

Heating time / min		0	3	6	9	12	15
Heating depth mm	0	31.9℃	162.8℃	193.2℃	207.0℃	213.0℃	218.0℃
	-30	34.7℃	41.8℃	54.5℃	67.5℃	78.3℃	89.5℃
	-60	32.7℃	33.4℃	35.0℃	38.5℃	42.4℃	48.4℃

The heat transfer of asphalt pavement heated by hot air shows a two-stage linear heat conduction law along the depth. Within the range of pavement to 30mm, the thermal conductivity of asphalt mixture is small and the curve slope is large; For the road layer 30mm below the ground, the thermal conductivity is large, the curve slope is small, and the temperature change is not obvious.

According to the current road surface layer conditions and heating methods, the temperature change at the depth of 50mm below the ground is very small, as shown in Figure 3.

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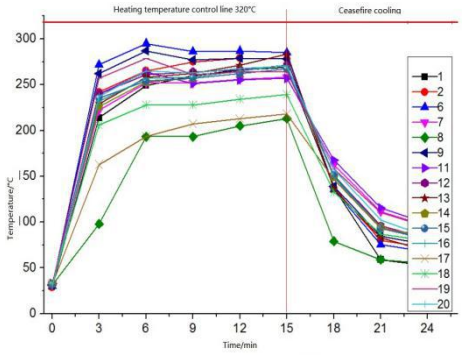

Fig. 2 temperature variation of asphalt pavement at each measuring point with time

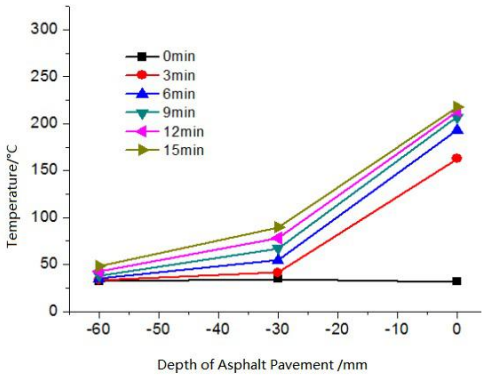

Fig. 3 temperature change along the depth direction at a measuring point at different times

3.2 Temperature measurement and control

Through the test process, it is known that the on-board temperature measurement control method of asphalt pavement maintenance equipment is to control the start and stop of the burner according to the comparison of the air outlet temperature of the hot blast stove so as to achieve the purpose of temperature control. The key is to control the surface heating temperature of asphalt pavement within the appropriate range below 180℃, so as to ensure that the asphalt mixture can not burn when heated to a certain depth. During the actual measurement, the air outlet temperature of the hot blast stove is set as 320℃, that is, the mixed gas temperature of the combustion flue gas and the heating return flue gas in the furnace. At the same time, the road temperature is monitored with reference to the heating wall temperature, which can not directly and accurately control the road surface and even the deep layer to achieve a reasonable heating temperature. Generally, the operation process is to use a very high asphalt road temperature, It can be quickly heated to the lower layer of asphalt pavement to complete the subsequent harrowing, patching and other processes.

4. Conclusion

Through the temperature field test of hot air circulating heating asphalt pavement maintenance equipment, the following conclusions can be drawn:

(1) The effective heating depth of asphalt pavement is within 30mm. The depth of the temperature sensitive zone is less than 30mm. After exceeding 30mm, the heating effect is not obvious, and there is almost no temperature change after 50mm;

(2) There is a temperature difference in the depth of asphalt pavement, and the temperature distribution in the heating zone is uneven. It is found that the highest temperature point is 134.3 ℃, while the lowest temperature point is 87.4 ℃, and the difference is 46.9 ℃;

(3) The method of measuring and controlling temperature needs to be improved. Indirect

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monitoring of smoke and air temperature to heat asphalt pavement is not very accurate, and a more direct and accurate contact temperature measurement method needs to be explored;

(4) From the measured curve, the asphalt mixture layer 30mm below the pavement has the same thermal conductivity, and the temperature change is linear.

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