Ultrasonic Mixing Technology for Warm Mix Asphalt

Yurun Han*, Xuan Yu, Shunji Fan, Zichuan Liu
Wuhan University of Technology, WuHan, China

*Corresponding author: hanyurun@whut.edu.cn

Abstract. At present the hot mix asphalt in the construction of pavement not only to consume a lot of energy, but also in the construction process will release a lot of harmful gases and dust, resulting in environmental pollution in order to improve the performance of asphalt materials, in order to promote energy conservation and emission reduction, the device in the warm mix asphalt technology, based on the use of ultrasonic cavitation technology and electric heating to disperse, heating asphalt, in order to obtain more excellent performance of pavement laying materials, while saving costs and reducing harmful emissions.

Keywords: warm mix asphalt, ultrasonic mixing, green environment.

1. Introduction
The device adopts organic viscosity reduction and warm mixing technology, which is divided into four modules. After the asphalt enters the device, the asphalt temperature is first increased through the heating module, and then slowly injected a certain amount of emulsifier into the device through the emulsion adding module. At the same time, the ultrasonic module of the inner wall of the device is used to promote the fusion of emulsifier and asphalt by ultrasonic wave, and generate small bubbles in water, and blow-up bubbles through small cavitation, so as to reduce the viscosity of the asphalt. So as to speed up the mixing and separation of asphalt.

2. Project background
As of 2019, China's total road mileage has reached 4,846,500 kilometers, 142,600 kilometers of highways, of which road maintenance is a class of important issues in the field of transport in China, China's current main highway repair project only, the annual production of asphalt pavement waste materials is as high as 160 million tons, the loss of more serious.

The existing asphalt production and processing methods for hot-mix asphalt technology. However, hot mix asphalt in the construction of pavement not only to consume a lot of energy, and in the construction process will release a lot of harmful gases and dust, resulting in environmental pollution. Compared with the traditional hot-mix asphalt technology, warm-mix asphalt technology does not affect the product into the material performance of the basis, greatly reducing the viscosity of asphalt, more excellent performance of road paving materials, improve the road performance, while reducing a large number of harmful gas emissions, improve the working environment for workers, greatly reducing the environmental pollution.
3. Project installation design

The device is composed of four modules, namely: emulsifier addition module, heating module, ultrasonic action module and stirring module.

The principle of asphalt mixer is to separate the viscous asphalt by mixing, this device uses ultrasonic and emulsifier to reduce the mixing time, reduce the mixing temperature required to reduce the mixing energy consumption.

The asphalt enters the device through the inlet of the device, and the device is heated by the heating module and the mixing module to increase the temperature of the asphalt to 90°C-120°C. Then through the emulsifier adding module from the emulsifier storage tank slowly transported into the device. At this time, the ultrasonic module emits ultrasonic waves on the asphalt at the bottom of the device, which generates small bubbles in the water and reduces the viscosity of the asphalt, thus speeding up the mixing time, reducing the energy consumption and the temperature required for mixing.

3.1. Ultrasonic action module

Ultrasonic role module is divided into ultrasonic generator, ultrasonic transducer two parts. Its working principle is the ultrasonic generator is responsible for alternating current into high frequency electrical signal, and the ultrasonic transducer is from the ultrasonic generator of high frequency electrical signal into high frequency mechanical vibration, that is, the role in the device used to process the internal ultrasound of asphalt.

After the role of the device two high temperature ultrasonic transducer at the bottom of the asphalt tank, the device contains water in the environment to produce more small bubbles, due to the temperature is more difficult to produce bubbles in water, ultrasonic generated bubbles to reduce the subsequent mixing process to produce bubbles in the work and increase the stirring waiting energy consumption, at the same time, ultrasonic can trigger a small-scale cavitation, when the bubbles in the water is violently cavitated, bubbles This can largely have a “lubricating” effect, i.e. reduce the viscosity of the asphalt, thus further reducing the mixing energy consumption and accelerating the penetration of the emulsifier.

![Ultrasonic action module model](image)

Figure 1. Ultrasonic action module model

3.2. Emulsifier dosing module

There is a valve at the front of the emulsifier adding module. The worker can control whether the emulsifier adding module adds emulsifier to the device by twisting the valve. The principle of adding emulsifier is that the motor on the base of the module rotates the gears, and the gears rotate the two movable rods, and the mechanical valve in front of the movable rods squeezes the emulsifier so that it can be squeezed into the device, and the one-way valve formed by the mechanical valve prevents the emulsifier from being squeezed back into the emulsifier storage bin. The device can control the speed of adding emulsifier by controlling the speed of the motor, in order to match the amount of asphalt required to add emulsifier.

In the selection of emulsifier, the device uses Sasobit (Sasobid) warm mixer produced by Chongqing Haien Construction Materials Co. It is currently in more widespread use.
3.3. *Heating modules*

The heating module of this device is the resistance wire arranged in the lower half of the tank on both sides, and the tank is heated directly by the electric power supply, compared with the original hot mixer that uses high temperature separated asphalt (working temperature 170℃-220℃), this device adopts the warm mixer asphalt technology—Evotherm warm mixer technology, which is the most widely used in the industry. Emulsifier is added to the asphalt to reduce the temperature required for asphalt separation, and this device adds an ultrasonic cavitation device to the emulsifier to further promote the separation of asphalt. The temperature required for warm-mixing asphalt is only 90℃-120℃, which can be satisfied by electric heating with resistance wire (the maximum heating temperature for electric heating is about 150℃). The electric heating method heats the ground more evenly and solves the problem of insufficient combustion of fuel and exhaust gas, which cannot be processed when gas heating is used.

![Heated module diagram](Figure 2)

3.4. *Mixing module*

This device adopts a new mixing method for the rotor blades of the original mixer, and the original spiral mixer can only mix asphalt by wide range agitation. The device adopts a spiral mixing structure, and the spiral belt is equipped with a small hole for extruding the emulsifier, through the hole and the emulsifier adding module, the asphalt in the mixing device can be broken up and mixed to the maximum extent, so that the emulsifier acts evenly on the asphalt in the device. This effect is superimposed on the effect of the shock wave generated by the bursting of the cavitation bubbles and the overflow gas which makes the asphalt mixture less viscous, making it easier to reduce the viscosity of the asphalt.

![Interior of the mixer](Figure 3)
4. Principle feasibility analysis

This device uses the ultrasonic cavitation effect and emulsifier combined method to adjust the viscosity and consistency of warm mix asphalt, in order to improve the quality of the finished product of warm mix asphalt, so that it has similar functional characteristics with the hot mix asphalt requirements.

In terms of consistency, with reference to the preparation of Li Yongzhen, "foaming warm mixer SBS modified asphalt performance of the impact of", it can be seen that with the addition of the emulsifier, the consistency of the asphalt does not change much, and even if it changes, it is in a decreasing trend, so it can be concluded that the device is feasible in terms of consistency.

In terms of viscosity, the device combines the ultrasonic cavitation effect with the existing emulsifier viscosity reduction method to achieve the purpose of reducing the viscosity of warm-mix asphalt. With reference to the Xia Junhua prepared the "new chemical warm mixer on asphalt viscosity and mixture performance", it can be obtained, the viscosity of the current hot mix asphalt at 175 ℃ environment is 0.58Pa-s, and in the Han Chunli prepared "two warm mixer on the performance of asphalt mixture research", when the asphalt is added to the emulsifier for warm mix treatment, the relationship between viscosity and temperature is shown in the following table.

Table 1. Relationship between viscosity and temperature of warm mix asphalt after adding emulsifier.

| Temperature (°C) | Pitch viscosity (Pa-s) |
|----------------|-----------------------|
| 120            | 0.69                  |
| 135            | 0.3                   |
| 150            | 0.19                  |
| 180            | 0.08                  |

According to the above table, can be obtained, in the addition of emulsifier, the device can produce warm mix asphalt viscosity can be reduced to 0.69, but still can not meet the current market requirements of 0.55 and below the viscosity, therefore, the project team designed the ultrasonic cavitation module.

With reference to "Reducing the viscosity of asphalt using ultrasonic treatment" prepared by Jianping Song [4], the treatment of asphalt with ultrasonic waves reduced its viscosity by 12.8% after 30 min of continuous treatment, thus according to Eq. (1).

\[ n = n_1 \times \left( 1 - 0.128 \right) \]

In the formula: \( n \) - viscosity of asphalt after ultrasonic treatment.

In the formula: \( n_1 \) - not treated before the viscosity of asphalt, can be calculated after treatment, 120°C warm mix asphalt viscosity can be reduced to 0.60, very close to the current use of viscosity of 0.55 hot mix asphalt, and according to the research of Lv Xiao-ting, ultrasonic treatment in combination with emulsifier, ultrasonic cavitation effect will be reducing the particle size of the emulsifier and thus enhancing its viscosity reduction effect, although not supported by relevant quantitative data, it can still be assumed that it will further reduce the viscosity of warm mix asphalt, making it close to hot mix asphalt. Therefore, the device is still feasible in terms of viscosity.

In summary, according to the data calculation and related literature, this device produces warm mix asphalt and traditional hot mix asphalt in the functional characteristics and will not produce big differences, so it can be considered, this device has the feasibility of device design.

5. Application prospects

In the field of transportation, the problems of high energy consumption and multiple emissions in the production of asphalt mixture are serious and need to be solved by a more advanced method to save energy and reduce emissions. Through the combination of ultrasonic cavitation and asphalt warm mixing technology, the device improves the roadworthiness of asphalt while greatly reducing the
temperature and mixing time required for asphalt recycling, thus reducing the cost and energy consumption of asphalt recycling. The device makes both energy-saving effect and can reduce the emission of combustion gases asphalt warm mixer technology can be popularized, through the improvement of the device to save the cost of asphalt recycling, in line with the national policy of energy saving and emission reduction.

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