

# Research on Energy Saving and Emission Reduction Technology of Hot Mix Asphalt Mixture

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**Abstract:** It is found that the construction and energy consumption of asphalt pavement mainly focus on the production of asphalt raw materials and asphalt mixture. According to the characteristics of project construction, this paper adopts professional environmental protection technology to carry out full-node and continuous tracking monitoring on the two links of asphalt mixture production and pavement construction, combined with the construction site environment. The energy consumption and emission of aggregate heating process and materials in mixing station were monitored and studied. It is committed to standardize the energy saving evaluation and technical optimization of the expressway reconstruction and expansion technology in Shandong, so that the evaluation work can be based on evidence. The qualitative or quantitative research is mainly carried out from the technology of warm mixing asphalt, aggregate heating and asphalt heating process improvement. By studying the composition of energy consumption, the influencing factors of energy consumption, the calculation method of energy consumption, the unit energy consumption of each energy consumption item and the level of energy consumption, a perfect evaluation system and effective and feasible energy-saving measures are proposed, and an energy-saving evaluation system for highway reconstruction and expansion in Shandong Province is researched and developed.

**Keywords:** Mixture Production; Energy Consumption; Emission; Evaluate; Reduction Technology

## 1. Introduction

As the production equipment of asphalt concrete, asphalt concrete mixing station plays an extremely important role in highway construction. Mixture production, as the key point of asphalt mixture construction, accounts for more than 80% of the energy consumption in the whole production process, and is an important link of energy saving and emission reduction. In order to obtain higher economic benefits in construction and meet the requirements of national industrial development, construction enterprises should choose asphalt concrete mixing stations with stable performance and low energy consumption, and on this basis, take positive measures to tap its energy saving potential [1-3].

Asphalt concrete mixing station has two energy consumption points: Asphalt heating system and stone drying system. The former needs to heat all kinds of asphalt from normal temperature to about 160°C for use, while the latter needs to heat cold aggregate with a certain water content to about 190°C. The heating system of asphalt usually adopts heat transfer oil furnace for centralized heating, and the fuel sources are mostly lump coal, wood, heavy oil, residual oil, etc. The drum drying of aggregate mostly uses diesel oil (light oil), heavy oil, residual oil, pulverized coal, natural gas and so on. The combustion value and price cost are different. In today's increasingly fierce market competition, only by constantly creating energy saving link can we maximize the profit space of the project [4-6].

At present, the research on energy-saving technology of asphalt concrete mixing station in domestic and foreign markets is not systematic. Most of the work is done from the

aspects of strengthening on-site management, personnel training, controlling fuel quality, system thermal insulation, specifications of raw materials and water content control, but not from the perspective of existing technology and process innovation to tap the potential of energy saving. Moreover, the overall energy saving technology of the mixing station is not taken as the subject for system development and control. Based on this, the comprehensive energy saving system proposed in this paper has a very high market competitiveness and application prospects [7-10].

## 2. Production Technology Analysis of Asphalt Mixture

### 2.1 Analysis of Dry Heating Technology of Aggregate

#### 2.1.1 Fuel burning system

The combustion device based on fuel oil mainly consists of an oil atomizer and an air conditioner. The technical characteristics are as follows: 1) Full combustion; 2) easy to control; 3) high use cost and high emissions; 4) easy to block, high maintenance cost.

#### 2.1.2 Coal-fired combustion system

The pulverized coal air mixture (primary air) supplied by the pulverized coal preparation system and the secondary air needed for combustion are respectively injected into the furnace at a certain concentration and speed to realize stable ignition and combustion under suspension state. The technical characteristics are as follows:

1) The use cost is relatively low; 2) seriously affect the asphalt mixture, acidizing asphalt; 3) high energy consumption, combustion is not easy to be full, high requirements for coal quality, fineness and other indicators, pulverized coal production area is limited, special ball mill processing; 4) occupy the site, environmental pollution, emissions are not up to standard; 5) High maintenance cost.

#### 2.1.3 Natural gas combustion system

Compressed natural gas has the characteristics of high calorific value, stable combustion, clean and environmental protection, and replaces heavy oil as fuel. Technical features are as follows:

1) Compared with diesel oil, heavy oil, natural gas, high calorific value, burning full stability, has a more superior combustion characteristic, and more economical, the heat value of the

unit price of natural gas combustion efficiency higher than that of heavy oil, heat utilization efficiency increased by 10 to 20%, about 50% cheaper than diesel, and which do not contain any impurities, combustion produces no waste residue, waste water, Reduce the failure rate of equipment, equipment maintenance costs can be saved, thus greatly reducing the production cost.

2) Pipeline transportation of natural gas: on the premise of a certain gas transmission scale, pipeline transportation is the most economic and effective way of natural gas transportation.

3) Compressed natural gas transportation (CNG): small single-vehicle transportation volume; Small gas supply range (within 100 km); Gas supply is not stable; High storage pressure, gas supply and gas storage equipment are high pressure products, low safety; It covers a large area, and can be used for small-scale gas supply and small transportation volume.

4) Liquefied natural gas (LNG): simple gasification process; Convenient operation and management; High safety and reliability; Lowest operating cost, maximum unit storage capacity; Air source is guaranteed; Strong flexibility; High energy density; Small footprint; the investment in LNG gasification stations is higher than that in CNG decompression stations. The transportation is flexible and convenient. For the asphalt mixing station with large gas consumption, it is suitable for use. However, for the project with relatively concentrated construction period and project volume, it is necessary to consider the cost performance of investment.

#### 2.1.4 Clean coal gasification technology

Clean coal technology refers to a set of related technologies aimed at reducing pollution emissions and improving utilization efficiency during the whole process of coal development to utilization, including coal gasification (gasifier), combustion (power plant boiler), recycling (waste heat boiler) and a series of processes.

From the perspective of technological process, it mainly includes three types of technologies. The first type is coal processing and conversion technology before combustion. Including coal washing and processing and transformation technology, which is more cutting-edge is coal gasification technology; the second category is coal combustion

technology. Mainly clean coal power generation technology, including circulating fluidized bed combustion, integrated coal gasification combined cycle, etc. The third category is post-combustion flue gas desulfurization technology.

In this paper, the aim of equipment transformation is to synthesize artificial gas efficiently and cleanly in a specially designed reactor with dry coal as raw material and air as gasification agent. The gas can be directly used as the fuel in the drying device of asphalt mixing equipment. The main system of the supporting equipment adopts today's advanced pulverized coal flow gasification technology, in the case of small positive pressure, with air as gasification agent, synthetic artificial gas in the furnace, gas calorific value of about 800~1000Kcal /m<sup>3</sup>, gas outlet temperature 950~1150°C. After the high temperature gas enters the burner, it meets the combustifying air from the combustifying air nozzle and starts to burn automatically. The highest point of combustion temperature can reach 1650°C, which can fully meet the requirements of the aggregate drying system in asphalt mixing station.

The characteristics of the equipment system: 1)The carbon conversion rate can reach more than 98%, with a very high coal utilization efficiency; 2)The gas flow and calorific value are stable, the combustion speed is fast, the flame is stable, and the aggregate temperature is well controlled; 3)The content of dust in gas is small, which has no effect on the quality of asphalt mixture; 4)The gas does not contain tar, clean and environmental protection; The machine equipment is fully automatic operation, fast start and close, easy to adjust the load, suitable for various operating conditions, in the asphalt mixing station to fuel coal gas station instead of burning heavy oil, can save 50%-70% of the fuel cost.

## 2.2 Analysis of Cooling Technology of Asphalt Mixture

The asphalt used for asphalt mixture has a variety of matrix asphalt and modified asphalt (SBS modified asphalt, rubber powder modified, etc.). The production temperature of hot mix asphalt mixture is at least 145°C or above. When the discharge temperature of the mixture is too high, not only the heat consumption of asphalt and aggregate is large,

the cost is increased, but also the emission of harmful substances such as smoke is large. The emission of harmful gases and greenhouse gases in the mixing process leads to the poor working conditions of workers, which increases the damage to workers' health. At the same time, the physiological effects of the mixed asphalt pavement operation on the residents along the road also increase significantly. The research shows that when the temperature is higher than 100°C, the aging rate of asphalt will be doubled for every 10°C increase in temperature.

Asphalt mixture mixing temperature affect fuel consumption directly, even though the specification with limits are provided for the temperature control in the process of construction, but if we can through technical innovation, ensure that asphalt mixture compacting effect under the condition of constant temperature mixing technology are adopted to decrease the mixing temperature, there is no doubt that can significantly reduce fuel consumption. The heating temperature diagram of various cooling technologies is shown in the Figure1.

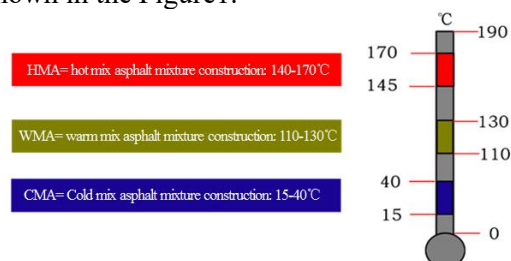


Figure 1. Heating Temperature of Various Cooling Technologies

## 3. Benefit Evaluation of Mixing Station Energy Saving and Emission Reduction System

### 3.1 Analysis of Energy Saving Benefit of Aggregate Heating System

#### 3.1.1 Clean coal to gas

1) Replace oil: per ton of material produced, saving 2.2kg standard coal and reducing energy consumption by about 24%; 65% lower than the fuel cost, saving 200,000 yuan per kilometer of highway.

2) It has been tested by the national authority to be better than the national emission standard: the carbon dioxide emission has decreased by 24%, and the smoke dust has decreased by 60% compared with the coal powder.

3) The burner is maintenance-free for life, no slagging in the furnace, and can run efficiently for a long time.

3.1.2 Oil to gas

Heavy oil, also known as fuel oil, is dark and thick. It is mainly composed of atmospheric oil, vacuum residual oil, cracking residual oil, cracking diesel oil and catalytic diesel oil in the process of crude oil processing. The mixing station consumes 7kg of heavy oil to produce 1t of mixing material, and the current price of heavy oil per ton is 3500 yuan, that is,  $3.5 \times 7 = 24.5$  yuan per ton of mixing material.  $7\text{m}^3$  natural gas is needed to produce 1t of mixing material, and 2.95 yuan per cubic meter of natural gas is needed, that is,  $2.95 \times 7 = 20.65$  yuan per ton of mixing material. It is not difficult to draw a conclusion: if the mixing station is changed from fuel oil to gas, the cost of each ton of mixing material can be saved by  $24.5 - 20.65 = 3.85$  yuan, and the cost can be directly saved by 385,000 yuan according to the annual production of 100,000 tons of mixing material.

Comparison of energy saving and environmental protection parameters of

various types of asphalt mixing equipment, as shown in Table 1. The comparison of energy saving and environmental protection parameters of different fuels is shown in Figure 2.

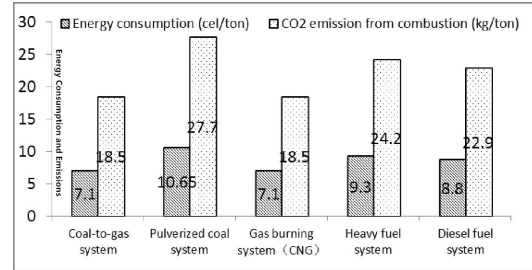


Figure 2. Comparison of Energy Consumption and Emissions of Different Fuels

By comparing the energy consumption and emissions of aggregate heating systems with different fuel types, it can be concluded that the energy consumption and emissions are ranked from high to low as follows: traditional coal burning system > heavy oil burning system > diesel burning system > clean coal to gas burning system and natural gas burning system.

Table 1. Comparison of Energy Saving and Environmental Protection Parameters of Various types of Asphalt Mixing Equipment

Fuel form	Coal-to-gas system	Pulverized coal system	Gas burning system(CNG)	Heavy fuel system	Diesel fuel system
Fuel combustion adequacy	High	Low	High	Ordinary	High
Degree of smoke and dust pollution	Low	Seriousness	Low	Seriousness	Low
Equipment maintenance cost	Low	High	Higher	Very High	Very High
Concrete quality	Up to standard	Up to standard	Up to standard	Up to standard	Up to standard
Number of fuel consumed (/ton)	About 10 kg	About 15 kg	About 10 kg	About 6.5 kg	About 6 kg
Energy consumption (cel/ton)	7.1	10.65	7.1	9.3	8.8
CO <sub>2</sub> emission from combustion (kg/ton)	18.5	27.7	18.5	24.2	22.9
More CO <sub>2</sub> emissions than coal to gas (kg/ton)	0	9.2	0	5.7	4.4
The price of fuel(yuan/kg)	1	1	3	4.5	8.45
Fuel cost (yuan/ton)	About 10	About 15	About 23	About 29.3	About 50.7
More than coal to gas (yuan/ton)	0	5	13	19.3	40.7

3.2 Analysis of Energy Saving Benefit of Dynamic Heating of Asphalt Tank

Taking SBS modified asphalt as an example, the storage time of asphalt is considered in

three ways, namely, timely use, storage for one day and storage for three days. The storage time of asphalt is 165°C and 130°C, which is heated by dynamic heating. The energy consumption of asphalt storage and heating

system is predicted as follows (in Table 2): The calculation results show that the consumption of natural gas can be reduced by 24.9% when the mixture is stored for 1 day, and by 25.0% when it is stored for 3 days. The use of dynamic heating system can significantly reduce the consumption of fuel

per ton of the mixture and reduce greenhouse gas emissions.

Adopt dynamic heating energy saving technology, greatly reduce fuel consumption, energy saving more than 20% compared with the traditional way, municipal construction energy saving more than 35%.

**Table 2. Energy Consumption Evaluation of Asphalt tank Dynamic Heating System**

Asphalt storage time	Storage temperature (°C)	Fuel consumption per ton of mixture (m <sup>3</sup> )	Heating energy consumption (MJ/t)	Energy reduction ratio (%)
Immediate use	165	1.20	27.1	/
Store one day	165	3.61	81.4	24.9
	130	2.71	61.0	
Storage 3 days	165	10.83	244.1	25.0
	130	8.12	183.0	

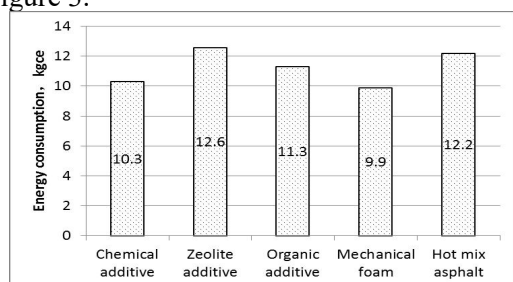
### 3.3 Temperature Drop Technology of Asphalt Mixture Based on Asphalt Foaming Technology

On the premise of ensuring the pavement performance of asphalt mixture, the mixing temperature of warm mixing technology can be reduced to 110-120°C, and the rolling temperature can be reduced to 70-110°C. Compared with hot mixing, the temperature can be reduced by 20~40°C. Save fuel 20% ~ 30%; the emission reduction effect is obvious, CO<sub>2</sub> is reduced by 50%, CO by 67%, SO<sub>2</sub> by 40% and NO<sub>x</sub> by 60%. The asphalt smoke can be reduced by about 90% during paving to reduce the damage to the health of construction workers. Extend the transportation distance and the construction season, as shown in Figure 3.

consumption is even slightly higher than that of hot mixing asphalt mixture. The mechanical foaming type of warm mixing technology has a lower energy consumption.

### 4. Conclusions

Aiming at the quantitative analysis of energy saving and emission reduction in the construction of highway asphalt pavement, this paper mainly relies on the construction of solid projects, defines the construction period of asphalt pavement as three stages of material physicalization, transportation and construction, and carries out research on the reduction technology of energy consumption and emission of asphalt pavement construction. The main research conclusions are as follows: (1) Through the transformation of the three main energy consumption links of the mixing plant equipment, the integration of energy conservation and emission reduction supporting equipment system can reduce the energy consumption in the production of mixing materials and reduce the waste of resources, so as to achieve the purpose of energy conservation and emission reduction. The three main energy consumption links of asphalt concrete mixing station and the supporting equipment transformation system adopt energy-saving technical measures as follows: 1)On-site coal gasification technology based on clean coal technology research; 2)Dynamic heating technology of asphalt tank based on eddy current hot film heat transfer; 3)Cooling technology of asphalt mixture based on asphalt foaming technology.



**Figure 3. Energy Consumption of Hot Mixing and Warm Mixing Asphalt Mixture**  
It can be seen from the above analysis results: From the perspective of the whole process analysis of construction period, not all warm mixing technologies have the benefit of energy saving and emission reduction. Based on the existing data, the zeolite additive type of warm mixing technology has a higher energy consumption, and its life cycle energy

(2) The economic benefits, environmental

protection and safety of the three energy-saving measures were comprehensively analyzed. The results show that: 1)The on-site coal gasification technology based on clean coal technology can greatly reduce the production cost, and the environmental benefits are significant; 2)The dynamic heating technology of asphalt tank based on eddy current hot film heat transfer can greatly reduce fuel consumption, save more than 20% energy compared with the traditional method, and save more than 35% energy in municipal construction, with obvious economic benefits; 3)The cooling technology of asphalt mixture based on asphalt foaming technology can reduce the temperature by 20~40°C and save fuel by 20~ 30% compared with hot mixing without sacrificing the pavement performance of asphalt mixture.

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