

# Research status and development trend of blowing dust removal device for subway vehicles

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**Abstract:** Subway vehicle blowing dust removal generally has poor blowing operating conditions, serious environmental pollution and manual work intensity and other problems, which has long plagued the operation and use of the sector. With the development of society, the subway vehicle blowing dust removal device towards the direction of intelligent development, increasingly perfect. To date, many scholars and universities have conducted research on the subway vehicle blowing dust removal device, but lack of systematic summary. This paper summarizes the research results of subway vehicle blowing and dust removal devices in recent decades, analyzes and compares the advantages and shortcomings of various dust removal devices, and provides an outlook on their future development and research directions.

**Keywords:** Subway vehicles; Blowing and dusting device; Intelligence; Three-vehicle synchronisation; Three-dimensional reconstruction; Efficient dust collection

## 1. Introduction

With the rapid growth of the world economy and population, urban traffic congestion is becoming more and more serious, and subways are widely used as public transportation around the world. Due to the friction between the bottom rail and the wheels of the subway, particulate matter (PM10, PM2.5) will be generated in the confined underground space, which will be spread to the subway platform as the subway runs and has a great impact on the air quality of the subway platform, and if the content is high, it will lead to respiratory diseases and asthma and affect human health [1-3]. Therefore, it is especially important to blow and dust the subway vehicles, and the subway vehicle blowing and dusting equipment urgently needs to be updated and iterated, and the corresponding blowing and dusting scheme urgently needs to be improved.

Therefore, the author reviews the representative research results in recent decades in the area of blowing and dust removal of subway vehicles, and aims to investigate the shortcomings of the existing research status and propose the direction of future development by comparing different blowing and dust removal equipment and blowing and dust removal solutions.

## 2. Simple dust removal device for subway vehicles

In the early days, limited by the development of technology, the dust removal device for subway vehicles was relatively simple.

Tokarek and Bernis [4] installed electrostatic precipitators [5] in Paris metro stations, which can be used to remove dust particles near the platforms. Li and Jo [6] built beam-type electric filters [7] in the mechanical ventilation and air conditioning (MVAC) system of the metro, which led to an increase in the number of particles passing through while improving the efficiency of removing fine particles. Ryu [8] and others applied an air curtain [9], which reduced the concentration of pollutant dust and particles in the tunnel and improved the ventilation efficiency. Son [10] et al. reduced the discharge of particles by installing a magnetic filter [11] on the subway ventilation equipment. Jung [12] sampled dust particles in some subway stations in Seoul and showed that most of the particles in the air were less than 10  $\mu\text{m}$ . Subsequently, Sim [13] installed a louver dust collector at the bottom of the subway based on Jung's study [14] for bottom dust, especially coarse particles, and improved the efficiency of PM10 removal. Since the louvered dust collector has a simple shape, generates low pressure drop, and collects dust into the collector using particle inertia, it is considered effective for rapid removal of bottom dust under

high-speed running subway vehicles.

Although the simple subway vehicle dust removal device has a certain dust removal effect, but still has not changed the workers blowing operation intensity and the poor operating environment.

### 3. Fixed subway vehicle blowing and dust removal device

In order to further improve the effect of subway vehicle blowing and dust removal and improve the environment of workers blowing, fixed subway vehicle blowing and dust removal device is gradually proposed, because its overall structure is fixed, so collectively referred to as the fixed type.

Yang Gang et al. of the Harbin Railway Bureau Institute of Science and Technology discussed an automatic control system for blowing and dusting the bottom of subway trains [15], and later developed the VEIC-MMB type bottom blowing and dusting device [16], as shown in Figure 1. The device consists of a blowing system, control system, dust hood system, and dust removal system, and uses a combination of manual blowing and equipment dust removal to improve the efficiency of blowing and dust removal and reduce the escape of dust. Yi Jian and Wono [17] of Ningbo Railway Transportation Group Co., Ltd. designed and developed an enclosed blowing and dust removal system for subway vehicles. The system consists of a closed system, a blowing device, a dust removal system, a control system, dust removal piping and an air volume control valve. The same blowing and dust removal method combining manual blowing and equipment dust removal is used, but its closed design makes it more effective than VEIC-MMB bottom blowing dust removal device in preventing dust escape.

Fixed subway vehicle blowing dust removal device than the simple subway vehicle dust removal device has a greater progress, but there are still many shortcomings, such as the need for manual blowing dust removal, blowing efficiency there is room for improvement.

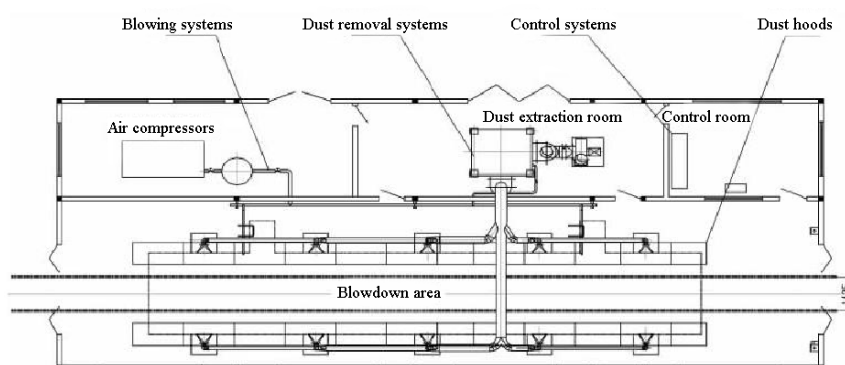


Figure 1: VEIC-MMB type bottom blowing dust removal device layout

### 4. Mobile subway vehicle blowing and dust removal device

In response to the shortcomings of the fixed subway vehicle blowing and dusting device, researchers have proposed a mobile subway vehicle blowing and dusting device. The device is equipped with a mobile platform with automatic blowing device, which can replace manual blowing and dust removal.

A more representative one is a set of mobile dust removal device for light rail designed and developed by Chen Kui [18] from Chongqing University, which is mainly composed of dust removal system, battery car, guiding device, dust blowing device, chassis and electrical control system, etc. It adopts the method of negative pressure dust suction and the mechanism of filtering and dust removal, and the dust removal efficiency reaches more than 90%. Since then, other researchers have also conducted in-depth research on mobile subway vehicle blowing and dust removal devices. For example, Ping Zhang [19] from Chongqing University designed and developed a set of dust removal device for the bottom of subway trains. The device is mainly divided into a blowing system and a dust extraction system. The air compressor in the blowing system provides the blowing air source to separate the dust on the surface of the electrical equipment at the bottom of the subway train, and the dust collection hood in the dust extraction system captures the separated dust-containing gas into the dust extraction pipeline, and then enters the dust collector, which is filtered and purified before being discharged into the atmosphere, further improving the dust extraction efficiency. Liu Xudong [20] from the Institute of Science and

Technology of Harbin Railway Bureau analyzed a set of bottom blowing dust removal system for subway trains. The system consists of five parts: mechanical system, compressed air system, dust removal device, control system, and process procedures, etc. The application has reduced the labor intensity of workers and avoided dust flying. Hu Xiong [21] from Chongqing University designed and developed a metro vehicle body blowing and dust removal system. The system consists of a blowing system, a dust suction system, a control system, a walking system, and a wind curtain system. The authors made a relatively comprehensive functional design and structural design of the system, which enabled the dust removal vehicle to perform blowing operation by remote control, which greatly improved the working environment of the operator. Guifeng She [22] from Chongqing University designed and developed a mobile dust removal system for the bottom of metro vehicles. The dust removal device mainly consists of an air compressor, a dust removal vehicle, and a wind curtain. Among them, the dust removal vehicle is located at the bottom of the subway vehicle, and the air curtain is located at both sides of the subway vehicle to prevent the dust from escaping during the blowing process. The walking guidance of the device is in the form of steel rail - steel wheel, which has the advantages of strong bearing capacity, high guidance accuracy and low friction resistance. At the same time, the device also adopts the dual operation mode of operating console and wireless remote control. A mobile exhaust purification device was designed and developed by He Zhiping [23] et al. of Guangzhou Metro Group Co. The device is composed of walking system, exhaust system, purification system, and control system. The device is flexible in walking, versatile, flexible in operation, and has a high dust capture rate, and can accurately and quickly collect the dust generated during blowing. Jiang Heng [24] from Chongqing University designed and developed a mobile dust removal device for the bottom of the subway. The device consists of a blowing system, a dust suction system, a mobile system, and an electric control system, etc. And the device adds a plate filter and a feeder control system to the mobile dust removal system for the bottom of subway vehicles proposed by Guifeng She, which not only improves the dust removal efficiency but also reduces the energy consumption of blowing. Compared with other mobile dust blowing and dust removal devices mentioned above, this device is the most perfect, and the overall arrangement of the dust removal vehicle in this device is shown in Figure 2.

Although the mobile subway vehicle blowing dust removal device to replace the manual blowing, but the bottom of the subway vehicle some dead-end position is still difficult to be completely clean, still need intelligent blowing dust removal device to the bottom of the subway vehicle dead-end position to focus, repeat the blowing.

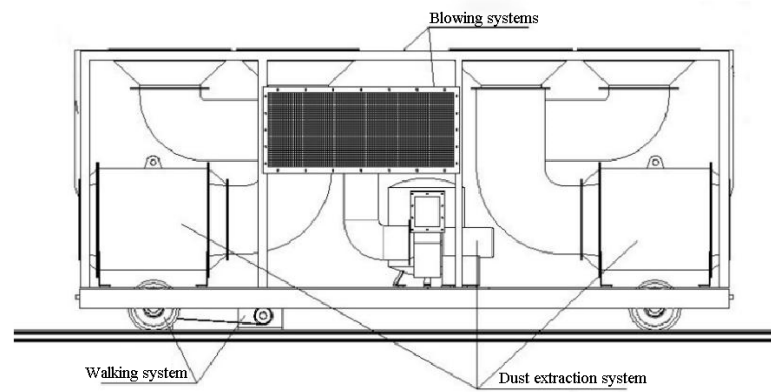


Figure 2: Overall arrangement of dust collector

## 5. Intelligent, mobile subway vehicle blowing and dust removal device

Today, with the development of robotics, machine vision, autonomous navigation and other science and technology, an intelligent, mobile subway vehicle blowing and dust removal device is gradually proposed by researchers. The device can completely replace the manual blowing and dust removal, greatly improving the efficiency of blowing and dust removal, and can focus on the bottom of the subway vehicle dead-end location, repeated blowing.

Zhao Wentao [25] of China Railway Fourth Survey and Design Institute Group Co., Ltd. designed an intelligent blowing system for metro trains. The system consists of central control system, electric control system, positioning system, blowing system, etc. The schematic diagram of the whole set of devices is shown in Figure 3, which can realize three cars synchronous intelligent blowing and dust

removal, combined with the flexible mechanical arm to realize the blowing of the key parts of the bottom of the subway vehicle, one key intelligent start, the whole process is completed automatically, and the blowing operation efficiency is greatly improved. Dai Gang [26] of the Fourth Survey and Design Institute of China Railway designed an intelligent blowing system for urban rail transit trains. The system consists of intelligent blowing robot under the car and intelligent blowing robot on the side of the car, which can realize blowing of key parts, walking according to the planned path, synchronous operation of three cars, collaboration of mechanical arm and efficient recovery of dust collection. Lu Zhihong [27] et al. of Shanghai Railway Line 18 Development Co. designed an intelligent blowing system for metro trains. The system consists of AGV trolley, six-axis mechanical arm blowing system, dust removal system, intelligent identification system, and control system, etc. It is the first time to propose a 3D reconstruction of the bottom of the subway vehicle through a 3D camera to establish a 3D model database of the bottom of the vehicle for identifying vehicle information during blowing, and then obtaining information such as the calibrated position and quantity of the operating area of this vehicle model to realize intelligent blowing.

At present, intelligent, mobile subway vehicle blowing and dust removal device is the most perfect, the most intelligent, can well meet the needs of subway vehicle blowing and dust removal, but the research on it is still in the theoretical design stage, has not really applied to the reality.

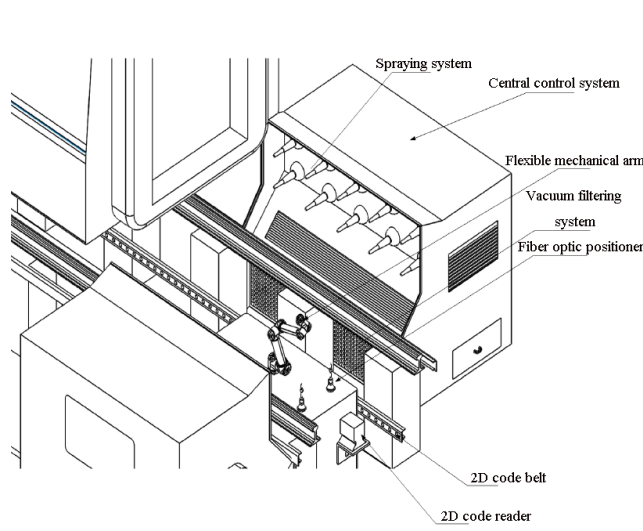


Figure 3: Schematic diagram of intelligent blowing device for metro trains

## 6. Conclusion

Intelligent operation and maintenance of rail transportation is the current industry development hotspot, but also the urgent needs faced by the production management process of operating units, which in turn promotes the development of subway vehicle blowing and dust removal device.

At present, intelligent, mobile subway vehicle blowing and dust removal device to be truly applied in reality, there are still many technical difficulties. For example: the optimization of three-dimensional reconstruction algorithm and robot arm trajectory planning algorithm, in order to improve the reconstruction accuracy and blowing accuracy, to achieve rapid and accurate blowing of the key parts of the bottom of the subway vehicle; path planning of the AGV car, so that the dust removal device flexible mobile, accurate positioning. With the rapid development of science and technology, researchers tireless exploration, subway vehicle blowing dust removal device will certainly not be limited to this, but with the current boom in artificial intelligence, towards a more intelligent, humane direction.

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