Development and Research Status of Road Cleaning Vehicle

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Abstract. Road cleaning vehicle is efficient cleaning equipment. It integrates road cleaning, garbage recycling and removing. This paper introduces the research background of road cleaning vehicles briefly. Then it summarizes the representative products of road cleaning vehicles, and analyzes the current status of technology development. At present, the multifunctional cleaning car on the market has the functions of suction and sweeping combination, no need to spray water, dust suppression, full filtration, purification and emission. Some companies even integrate advanced technologies such as automatic driving and intelligent identification. Finally, it predicts that the road cleaning vehicle will be developed in intelligence and environmental protection.

Keywords: Sweeper; Road cleaning vehicle; Horse-drawn cleaning vehicle; Self-driving cleaning vehicle; Development; Intelligence; Environmental protection.

1. Introduction
In recent years, people have higher and higher requirements for the road environment. Traditionally, road cleaning and maintenance only mean removing ground garbage and preventing dust by the cooperation of cleaning personnel and mechanical garbage trucks. However, this method is often difficult to effectively prevent inhalable particles entering into air, which poses a serious threat to the environment and people's health [2]. In addition, traffic is developing rapidly, and daily cleaning tasks are becoming more and more arduous. In order to ensure driving safety and improve the efficiency of man-machine cleaning operations, road cleaning vehicles came into being [3].
So far, people are no longer satisfied that road cleaning vehicles only perform single cleaning task. Road cleaning vehicle is more a collection of cleaning, mopping, and vacuuming. It also incorporates many advanced technologies such as mechatronics, sensors, computer, control, communication, etc.. It can replace the cleaning staff to perform regular maintenance of road cleaning on some highways, underground tunnels and other dangerous pavements [4,5]. In addition, with the development of artificial intelligence, people have even proposed a smart cleaning vehicle that can achieve self-driving cleaning, intelligently recognize traffic lights, and autonomously overcome obstacles [6].
This article summarizes the development status of road cleaning vehicles, and analyzes the existing problems, and looks forward to the development trend of road cleaning vehicles.

2. Development History
The development history of road cleaning vehicles can be traced back to 1904. Counting from the invention of the first horse-drawn cleaning vehicle in Britain, the development history of cleaning vehicles has been over 100 years [7]. By the 1920s, large and medium-sized cleaning vehicles had been sold in markets. In 1925, tractor-type cleaning vehicles appeared on the streets of Denver. From this
tractor, modern road sweepers entered a new era of rapid development. By the 1960s, the mass production of road cleaning vehicles had formed in markets. With the advancement of robots, sensors, and control technologies, the level of mechatronics of clean vehicles continued to increase, and the research on control methods of smart clean vehicles has also made great progress [8]. Taking the sweeping truck of American ELGIN company as an example, its intelligent control performance is reliable, easy to operate, and has as many as 57 function designs. It uses a variety of sensors to intelligently identify various complex roads and avoid obstacles. It is the result of the technical innovation of mechanical cleaning vehicles.

In China, people began to research road cleaning vehicles in the 1960s. The vehicles development history can be divided into three stages [11]. In the first stage, the pure sweeper was successfully developed from the 1960s to the end of the 1980s. As the first generation of sweepers in China, it opened the curtain of independent research and development of road cleaning vehicles. The second stage is from the 1980s to the end of the 1990s. Sweepers were developed rapidly during the stage. The sweepers were used in large, medium, and small cities, and were not limited to urban roads. They were also used for Highways and expressways. The development has entered into the third stage since 2000. During the stage, the road cleaning vehicle market begun to diversify, with many different cleaning principles and modes of cleaning equipment. With the increase of people's awareness of water conservation and environmental protection, people designed a series of dry dust removal road sweepers without water spraying and dust suppression. The sweeper is a cleaning truck that integrates cleaning, sweeping and sewage recovery. In addition, with the development of machine vision and sensors technologies, people have began to develop self-driving clean vehicle and they are carrying out the vehicle experiments [6].

3. Representative Products on the Market

Shown in Figure 1 is a VT series cleaning vehicle produced by Johnston, UK [16]. The VT series is the most reliable and durable vehicle-mounted road sweeper in the Johnston product line. It has automatic fault diagnosis and USB output for work records. It can also use a filter and a special air vortex to cooperate with the spray system to control dust.

![Figure 1. Johnston VT801 road vacuum sweeper](image)

A new type of driving sweeper Ronda was specially designed by Italian RCM company for urban road cleaning [27]. The cleaning vehicle has three powerful brush heads, which can sweep a total of 3,400 meters of straight line trash every hour.

ICC small sweeper is produced by Karcher Germany [9]. The machine is fully hydraulically driven with stepless speed regulation. The dumping of the trash can be completed by hydraulic operation, which prevents the operator from directly contacting the dirt and garbage.

Road treasure cleaning equipment was developed by Italy [17]. The machine can be equipped with a front snowboard or a roller brush for snow removal operations, or the side brush or middle brush can be used to directly collect relatively thin snow into the trash bin.

Omnia32B floor scrubber is produced by Comac Group, Italy [18]. The powerful functions and high efficiency performance of the 36-volt battery ensure long-term cleaning on various floors.

Italy's TSM company launched the first urban waste cleaning vacuum cleaner Ariamatic240 equipped with a system [19]. The car can automatically follow the operator's steps without separation.
In China, YZT5075TSLBE4 road sweeper was developed by Yangzhou Shengda Special Vehicle Co., Ltd. [22]. In terms of environmental protection and energy saving, this product has the characteristics of green, energy saving, and low pollution. It uses natural gas fuel and is recognized as the "guardian of environmental protection" in the industry. LTZ5162GQX5DF cleaning truck is produced by Henan Lutai Road Maintenance Machinery Co., Ltd. [23]. It is widely used for watering, spraying, cooling, dust removal and washing dust on various roads. BAQ5130TSL, BAQ4000 sweeper is manufactured by Beijing Aiqing sweeper manufacturing company [12]. The product adopts the cleaning device of American ELGIN company. It has the remarkable characteristics of high efficiency and reliable performance. Ruixing S22 pure electric road sweeper was developed by Anhui Airit New Energy Special Purpose Vehicle Co., Ltd. [24]. As an energy-saving and environmentally-friendly cleaning vehicle, the vehicle is operated electrically with no noise and no exhaust emissions. Chusheng CSC5160TSLD4 road sweeper is manufactured by Chusheng Group [25]. This Chusheng road sweeper has a tonnage of 5900kg with low cost. Chengli road sweeper is produced by Chengli Special Purpose Vehicle Co., Ltd. [26]. The sweeping disc of this type of road sweeper has the functions of anti-collision and automatic avoidance. It can also optimize the sweeping method of the sweeping disc according to the severity of the ground and the sweeper speed. In addition, a lot of companies in other countries also produce many road cleaning vehicles with different functions. The development is gradually towards intelligent directions, such as driverless driving and machine vision recognition [7,19,21].

4. Technology Development

In the 1980s, vacuum suction sweepers were widely used. The vacuum suction sweeping type has the advantages of higher working speed and less environmental pollution than the brush sweeping type. It can also adjust the suction mouth size of the cleaning car according to different road conditions [10]. At present, people are constantly improving the intelligent level of electromechanical and hydraulic integration of cleaning vehicles. The functional design includes the use of computer technology to process the detected information. Therefore, the sweeper can recognize road obstacles. It is equipped with display equipment and warning devices, memory. It has storage, self-protection and other functions. The most important thing is that many sensors are installed to monitor temperature, pressure, road condition, etc.. The control system issues various commands in response to the signals detected by the sensors, and the actuators perform various corresponding functions [7]. While pursuing functional breakthroughs with intelligent technology, people have also begun to seek breakthroughs in environmental protection. In addition, how to make cleaner cars smarter, and how to reduce noise and emissions have become the research direction of various companies, such as TSM in Italy. TSM recently developed a sweeper that can follow the operator's forward movement at a precise distance. And the engine of these electric sweepers not only does not produce any carbon dioxide, but also has a filtering system to filter and trap fine particles, and the only noise made by the machine is the sound of the brush rotating on the ground [20].

Although China's road cleaning vehicles started late, they have been developed rapidly [1,4]. At present, people are closely following the advanced level of integration of electromechanical and hydraulic systems, and pursuing the development of clean vehicles toward multifunction and environmental protection benefits, and investing in the development of intelligent clean vehicles. The multifunctional cleaning vehicle developed integrates cleaning, cleaning, and sewage recovery. It has the functions of suction and sweep with full filtration and purification. However, it doesn’t need to spray water. The cleaning device can not only sweep the curb, but also effectively control sweeping dust. The suction nozzle does not emit dust and has strong suction power without secondary dust pollution. The all-weather sweeper can solve the problem of water spraying and dust removal in winter in northern China. At present, people has developed clean vehicle that burns clean energy such as natural gas. The vehicle is efficient with low noise. People carried out a lot research to inteligentialize the driverless clean cars [13]. In 2018, the world's first pure electric driverless cleaning team was successfully developed in Shanghai Songjiang, and it was the first to conduct a late-night trial operation in a science and technology park. Unmanned cleaning vehicles will automatically wake up at the set time of the program, and start slowly from the parking space, and complete a series of cleaning tasks by themselves.
During the operation, they can intelligently identify obstacles on the route, and pass traffic lights smoothly, and even self handle unexpected conditions. After cleaning, they move to the garbage collection area to dump the garbage, then return to the starting point, and automatically drive themselves into the parking space.

5. Future Direction
With the rapid development of the automation industry, road cleaning vehicles will combine sensor technology and use a variety of effective information extracted by computer integrated sensors to solve the limitations of single functions of traditional cleaning vehicles. As shown in Table 1, intelligent manufacturing is a production method that can make enterprises more “smart” in R & D, production, management, and service. Industrial intelligent manufacturing has changed manufacturing form from digitized to networked and intelligentized. Road cleaning vehicles should also keep pace with the times and will be developed toward intelligent direction. Not only that, with the strengthening of people's awareness of environmental protection, designing humanized and environmentally friendly road cleaning vehicles will also be one key development direction.

Table 1. Typical events of industrial intelligence

| Digitizing | In 1952, the United States Parsons cooperated with MIT to develop the world's first CNC milling machine [13]. |
| Networked | The World Wide Web was invented in 1989. |
| Intelligent | In 2019, the new MixPad was equipped with the home AI system independently developed by Oerlikon, realizing smart home operation throughout the house [15]. |

6. Concluding Remarks
Road cleaning vehicle is a comprehensive interdisciplinary research project, mainly involving materials, machinery, control, Internet of Things, environmental science and safety engineering and other disciplines. Since the development of road cleaning vehicles, it has changed from a single cleaning function into a multifunctional cleaning vehicle that integrates sewage recycling, with functions such as suction and sweeping combined with full filtration and purification. With the continuous improvement of the level of integration of electromechanical fluids and the increasingly high requirements of people's living environment, cleaning vehicles in many countries have begun to be developed in intelligence and environmental protection, and have made some achievements. Today, different types of cleaning vehicles are applied to various occasions, and the abilities to clean roads, suppress dust and protect the environment are becoming stronger and stronger. With the continuous innovation of science and technology, it is believed that more and more intelligent road cleaning vehicles will be developed.

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