Journal of Materials, Processing and Design (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/jmpd.2022.060103
ISSN 2516-0923 Vol. 6 Num. 1

Research and Design of Modular Dust Removal Based on PTFE Fiber

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Keywords: Change waste material into things of value, Laminated film, New type of fiber coating, Turbulence model

Abstract: With the rapid development of Chinese economy, air quality problems have become increasingly prominent. Survey data shows that road dust is one of the main sources of inhalable particulate matter in the air. At present, the main method of dealing with road dust is spraying water cleaning, but it will cause damage to the road surface, and at the same time, it can only “dust suppression” for a short time instead of effective “dust removal”. In response to the call of the national air pollution prevention and control action, Fluent software was used to simulate the airflow field to simulate the particle trajectory. It is found that the particulate matter has a tendency to migrate to both sides of the road under the influence of the airflow.

1. Introduction

Therefore, the combination of dust removal module and sound barrier can achieve effective and lasting dust adsorption and cleaning. If this work is put into production, it will be of great significance to road dust pollution control.

2. Introduce

The report of the 19th National Congress of the Communist Party of China clearly pointed out:”Building an ecological civilization is a millennium plan for the sustainable development of the China. It is necessary to establish and practice the concept that green water and green mountains are golden mountains and silver mountains. “The State Council further issued the”Three-year Action Plan to Win the Blue Sky Defense War”, clarified the main tasks of air pollution prevention and control, and comprehensive dust control was listed as the primary task. The survey shows that road dust becomes the primary source of inhalable particulate matter in the air on a clean day, accounting for up to 20. 7%. The current urban expressway not only has the characteristics of large traffic volume and serious noise pollution, but also the dust problem seriously affects the daily life and health of nearby residents[1].

The main sources of road dust include: emission sources of automobile exhaust particles; non-emission sources such as wear and resuspension. Water spraying on asphalt pavements in autumn and winter has resulted in puffiness, looseness, potholes, pumping, net cracks, and grooves,

which further increase maintenance costs. Water spraying on roads in winter can easily cause road icing and cause car tire adhesion. decreased, the braking effect is reduced, leading to higher traffic safety problems[2].

Due to the serious hazards of road dust and the limitations of spraying water to control the dust, based on the law of road dust transportation, the team organically combined the dust treatment device with the original sound barrier of the road to control the dust pollution on both sides of the road[3].

The dust removal device adopts fiber filtration and adsorption method to collect and process the dust. Its working principle is: the PTFE film is combined with glass fiber. First, the PTFE film is used to filter the road dust. At the same time, based on its water repellency and easy ash removal, then the rain wash and noise are used to drive the resonator air column to blow back[4]. Self-cleaning.

3. Particle Transport Model in Airflow Field

GAMBIT software is used to build the Three-dimensional model of car driving and divide the grid to encrypt the grid around the car. Set the width of the car at 1. 7m, the length at 4. 8m, the height of the chassis from the ground at 0. 2m and the height of car at 1m. In order to simulate the actual road environment, the road width is 3 times the vehicle width. In order to ensure the full development of airflow, the length of the calculated domain is 10 times the length of the vehicle, and the height of the calculated domain is 5 times the length of the vehicle.

A three-dimensional model of the vehicle is shown in Figure 1.

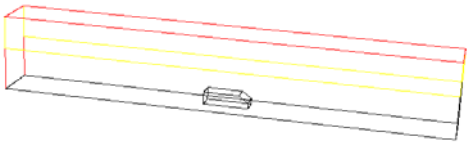

Fig. 1 Three-Dimensional Model of Vehicle Driving

The grid file is imported into Fluent for flow field simulation, and the $k-\varepsilon$ turbulence model is used to solve the flow field. When the flow field is close to convergence, set the DPM model to simulate the movement trajectory after particle incidence, assuming that the particles enter the road from both sides of the car. The trap boundary is set on both sides of the wall to represent the absorbed particles, the reflect boundary between the ground and the car body represents the reflection of the particles, and the other surfaces are escape to represent the particles flowing out.

The calculation results of DPM model are exported to obtain the mass flow of particles as shown in Figure 2. Zone8 and Zone9 represent the side wall surface. After averaging the mass flow of trapped on both sides the sound barrier receives the mass flow of particulate matter.

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Fate                    Number          Elapsed Time (s)
                                      Min         Max         Avg       Std Dev
----                    ------  ---------- ---------- ---------- ----------
Escaped - Zone 7          2223  3.746e+000 6.647e+000 4.467e+000 5.180e-001
Trapped - Zone 8            35  2.015e-003 2.959e-001 6.798e-002 4.199e-002
Trapped - Zone 9            20  1.521e-002 2.112e-001 1.152e-001 4.143e-002

                  (*)- Mass Transfer Summary -(*)

Fate                          Mass Flow (kg/s)
                           Initial      Final     Change
----                    ---------- ---------- ----------
Escaped - Zone 7       7.812e-004 7.812e-004 0.000e+000
Trapped - Zone 8       1.250e-005 1.250e-005 0.000e+000
Trapped - Zone 9       6.314e-006 6.314e-006 0.000e+000
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Fig. 2 Dpm Results

4. . Results and Discussing

4. 1 Sound Barrier Structure Design

The whole structure adopts sound-absorbing materials, and the upper part of the inclined roof structure can collect rainwater, etc. , which can be introduced through the water pipe to flush the filter. If the water volume is too large, it will flow directly from the riser. The glass windows in the middle layer are used to reflect the noise and observe the scenery outside. The lower part is a filter part, which is used to absorb road dust. All units are installed on Y-shaped columns. In order to collect dust from the best height, the size of each module can be adjusted according to the best sound absorption efficiencyt[5].

The filtering part is shown in Figure 3

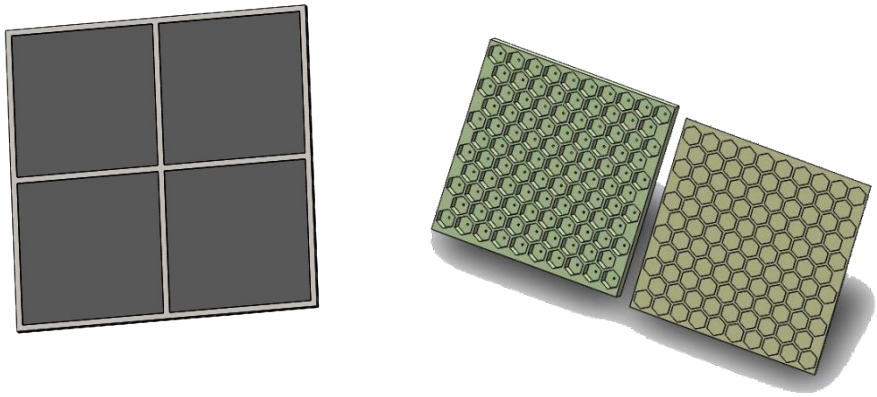

Fig. 3 Filter Section

4. 2 Dust Removal Unit Design

4. 2. 1 Filter Structure Selection

The filter structure is widely used in various types of dust removal technology and equipment, and its main principle is to use mechanical interception to achieve particle separation. According to the characteristics of the dust removal environment, different filter materials are selected and combined with certain technical means, the dust removal efficiency can reach 99%. Compared with other methods commonly used in traditional industrial dust removal, such as electrostatic dust removal, mechanical dust removal, etc. , filter dust removal methods have low cost, low equipment requirements, and fewer safety hazards, and are more suitable for road environments[6].

The development of filter structure materials and technology is very mature. The use of filter to

filter dust as a means of processing road dust has high dust removal efficiency, easy modularization of products, easy industrial production, good universality, and easy promotion.

Table 1 Performance Comparison of Different Dust Removal Methods

	Filter dust removal	Mechanical dust removal	Electrostatic precipitator
Dust removal rate	high	low	high
Secondary dust rate	low	high	low
Device dependency	low	high	high
Degree of difficulty	difficult	easy	easy
Working environment requirements	-	-	High standard There are security risks

As shown in Table1, traditional filter materials such as polyester and felt are not suitable for roads in a wind and sun environment due to their corrosion resistance, light fastness, water repellency and other characteristics. In the road environment, atmospheric pollutants such as NOx, sulfur-oxygen compounds, and incomplete combustion compounds in automobile exhaust accelerate the aging of the filter, shorten its service life and increase operating costs. At the same time, the cleaning methods of the traditional filter structure are mostly mechanical rapping or air blowback, etc. , which requires the addition of external devices and related technical personnel to perform periodic control to complete the cleaning, which increases labor costs and generally has incomplete cleaning. Problem, reduce the efficiency of filter dust removal. Therefore, the traditional filter is not suitable as the core structure of the simple device for dust removal on urban roads.

4. 2. 2 Filter Material Selection

The glass fiber coated filter material combines the high strength and low elongation, high temperature resistance, corrosion resistance of glass fiber, and the smooth surface of the PTFE film, hydrophobic and breathable, and good chemical stability. It has the advantages of high temperature resistance, high dust removal efficiency and long service life. Excellent characteristics, overcome the problem that traditional filter materials are not suitable for road environments.

5. Conclusion

PTFE fiber absorption method is used in the device to effectively solve the problem of dust raising and reduce secondary dust raising. Meanwhile, noise and rainwater are used to realize self-cleaning of the device, thus minimizing the maintenance cost of the equipment. In the process of dust raising treatment, the device also has a good effect on noise pollution. In addition, the device has simple structure and is easy to install on the traditional sound barrier device after improvement. The device can effectively solve the problem of controlling road dust from the aspect of practicability and economy, and has a good development prospect.

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