ISSN 2616-5767 Vol.3, Issue 6: 131-142, DOI: 10.25236/AJETS.2020.030614

Application Analysis of Intelligent Traffic Based on V2x Technology in Pavement Management System

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ABSTRACT. *V2X technology is a wireless technology based on the Internet of Things, and is mainly used to improve road safety and traffic management. It is one of the key technologies of intelligent transportation systems. It can realize mutual communication between vehicles and everything, thereby obtaining instant traffic information. Pavement management system is based on practical experience, including road quality, damage condition, the reflection of structure, driving safety, fatigue, deformation, cracking, aging characteristics of pavement materials, etc., and technical and economical based on collected road information A quick tool for analysis. In the traditional road management system, road information collection mainly relies on road detection vehicles and manual detection methods, which have the disadvantages of low efficiency, high cost and poor accuracy. The application of road intelligent detection in road management systems based on V2X technology proposed in this paper can replace Traditional manual detection and automatic detection vehicles collect instant data such as the damage and flatness of the corresponding road surface according to the driving trajectory of the vehicle on the road and the sensor device, and transmit the road surface information to the database for big data analysis through wireless transmission technology And according to the corresponding evaluation standards to evaluate the pavement performance.*

KEYWORDS: *Pavement management system, V2x technology, Intelligent detection, Big data analysis*

1. Introduction

The highway pavement management system is completely different from the passive maintenance method that relies on experience. It is based on computer language to construct database modules, evaluation standard modules, evaluation method modules and maintenance program modules, and make full use of the computing advantages of computers to predict the road performance. The decision-making of the pavement management system is according to plenty and

ISSN 2616-5767 Vol.3, Issue 6: 131-142, DOI: 10.25236/AJETS.2020.030614

accurate data information[1]. The acquisition of data information relies on efficient and fast automated testing equipment which is used to collect road geometry, road damage, flatness, deflection, friction coefficient, traffic volume, vehicle speed and other data. Manual detection can be used when the testing conditions do not allow automated equipment detection[2]. At present, automated inspection mainly relies on rapid inspection equipment such as surface damage cameras[3]-[4], which are interpreted by computers or manually after being recorded by high-speed cameras. Manual surveys and inspections are the main focus for grassroots highway management agencies for now. On-site survey, summary, calculation and evaluation are proceeded by portable road condition data collectors in some areas with conditions[5]-[6].

With the rapid advancement of informatization, the fields of wireless communications, mobile networks and sensors have been greatly developed, and there is a trend of penetration and integration into intelligent transportation systems (ITS), prompting ITS to enter the advanced intelligent stage. V2X technology, as the most popular research direction in the field of ITS in recent years, realizes efficient information interaction and data sharing between vehicles,vehicles and road infrastructure through vehicle-to-everything. It provides a basic guarantee of resource optimization for the complex physical information fusion system composed of “man-vehicle-traffic flow” and the vehicle mobile network composed of “vehicle-vehicle-Internet”, and has made the traditional vehicle-mounted network transmission and control, transportation infrastructure, and the improved ways of comprehensive transportation efficiency experience unprecedented changes [7]-[8].

2. V2x Technology

V2X means Vehicle to X.X represents infrastructure, vehicles, people, roads, etc. X can also be any possible “person or thing”[9]-[10]. V2X is a wireless technology which mainly used to improve road safety and traffic management. It is an important part of the intelligent transportation system. It can realize the mutual communication between cars, cars and the roadside facilities, and cars and the Internet, so that a series of traffic information such as instant road conditions, road information, pedestrian information can be obtained to improve driving safety, reduce congestion, and traffic efficiency[11]. The main implementation method is to conduct instant data communication interaction with the vehicle, road facilities, people and even the network through the communication equipment loaded on the vehicle, gathering the surrounding information to the information terminal in real-time, providing intelligent decision basis for road travel, based on V2X Technology, not only the traffic safety can be greatly improve and the rate of traffic accidents can be reduced, but also provide a low-cost, easy-to-deploy support and basic platforms for autonomous driving, intelligent transportation and next-generation Internet of Vehicles[12] -[13].

3. Feasibility Analysis of the Application of V2x Technology in Road Intelligent Detection

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3.1 The Disadvantages of Traditional Road Detection Technology

Road inspection has been through three stages of development: manual on-site inspection,semi-automatic inspection,fully automated inspection. Traditional manual on-site inspection is increasingly unable to meet the needs of highway development. The main problems are: traditional manual field inspection is to collect data manually through the eyes of inspectors. Usually, it requires a lot of manpower and time to detect a road, also, can not guarantee the timeliness of the test results; traditional manual on-site detection often needs a long time to close the traffic because of its danger, which affects normal transportation; the objective assessment of the road damage cannot be made accurately because the results of traditional manual on-site detection are easy interfered by human subjective factors.

The road inspection vehicle developed and researched by the Australian Highway Research Institute (ARRB) has experienced a transitional period of semi-manual and semi-automated detection. Its working principle is to install a camera on the vehicle and drive the vehicle on the highway to collect images. The road image is stored on the hard disk by detection person, and the damaged location of the image is marked on the computer. the traditional manual on-site detection method can be replaced by this method.

With the development of digital image processing technology, fully automatic detection method has become possible and become a trend. This fully automatic detection system should possess these characteristics: it can have a high-resolution image photography device which shoots clear and usable images and stored in the computer directly as shown in Figure 1, and can process the collected images in real-time to ensure the timeliness of the detection results; the damage location that have been detected can be located on the road, providing a basis for the subsequent road maintenance work. However, the content of the road image collected by the inspection vehicle is generally complicated and will be interfered in many aspects. The general image processing method cannot meet the detection accuracy very well, so it will bring certain errors to the later road damage analysis. The current data collection of road conditions by multifunctional inspection vehicles mainly focuses on the geometric characteristics of the road and the condition of the road surface, and the internal damage of the road structure cannot be measured. For example, in the process of high-speed inspection, the length, width and range of the crack can be measured, but whether the crack is only on the pavement surface or has spread inside the pavement base cannot be measured. In addition, the road surface debris and road surface damage cannot be effectively distinguished during inspection. The current image recognition technology is still difficult to identify small cracks less than 1mm. The multifunctional inspection vehicle is powerless for important indicators such as the bearing capacity of the pavement structure and the thickness of the pavement structure layer. The bearing capacity of the pavement structure, the thickness of the pavement structure layer and the internal damage of the pavement

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still need to rely on manual inspection.

Fig.1 Pavement Crack Map

3.2 Application of V2x Technology in Pavement Information Collection

The application of V2X technology in road intelligent detection is mainly to replace the traditional manual detection and road detection vehicles to transfer the collected road conditions to the database for data analysis. The detection device is a strip-shaped high-sensitivity laser displacement sensor installed on the chassis of the car and an acceleration sensor installed on the four suspensions. The device diagram is shown in Figure 2.

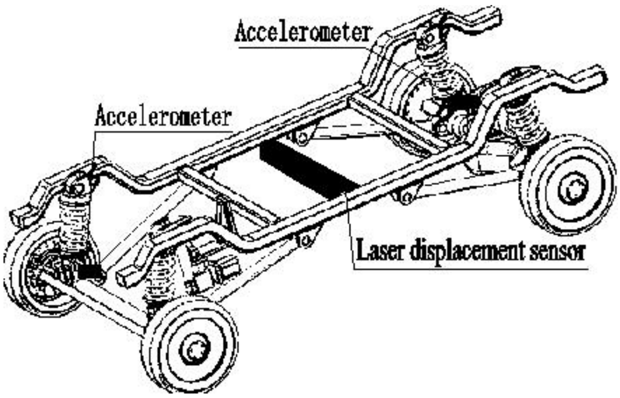

Fig.2 Detection Device Diagram

The laser displacement sensor installed on the chassis and the acceleration sensor installed on the suspension start working at the same time when the vehicle starts to move. The laser displacement sensor can record the relative height change between the vehicle and the road in the trajectory of the vehicle. The acceleration sensors on

ISSN 2616-5767 Vol.3, Issue 6: 131-142, DOI: 10.25236/AJETS.2020.030614

the four suspensions can record the vibration response of the four wheels in a section of trajectory. The collected vibration signals of the vehicle traveling on the road can be classified according to the vibration signals sensed by the sensor when the vehicle starts, travels, and passes through obstacles, as shown in Figure 3 below. V2X technology can realize real-time communication and interconnection among roads, vehicles and people. Vehicles in the same area will transmit the collected vibration signals to the database in real-time for data analysis.

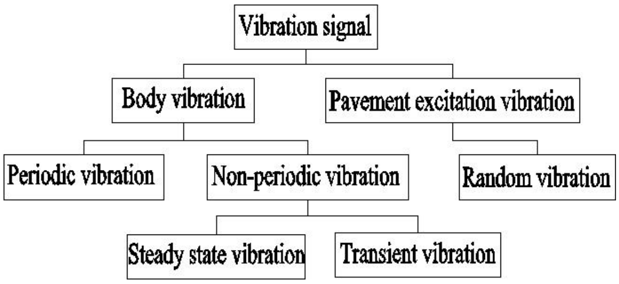

Fig.3 Vibration Signal Classification

3.3 Pavement Information Analysis

The car itself is a complex vibration system composed of multiple systems, and each vibration system has vibration problems, such as engine and transmission system, braking system, steering system, suspension system, body and frame. The vibration characteristics of the vehicle itself should be mastered before analyzing the road vibration signal fed back by the sensor. The analysis of the waveform is mainly performed on frequency spectrum analysis and time domain analysis at present. The following problems can be solved through vibration spectrum analysis: (1) Each frequency component and the distribution range of the spectrum table in the vibration parameter are obtained; (2) The amplitude and energy distribution of each frequency component in the vibration parameter are obtained, thereby the frequency value of the main amplitude and energy distribution are obtained; (3) The authenticity of each frequency component, amplitude and phase angle obtained from the analysis of the vibration waveform spectrum of the actual vehicle driving, used to correct the test waveform; (4) The The vibration signal of vehicle itself is filtered, so as to obtain the vibration information of the vehicle driving on the road.

Time domain analysis can analyze the time domain waveforms of multi-channel signals in time in the time domain. It displays the amplitude waveform of the signal over time. The amplitude of each time point of the signal can be obtained from the waveform graph, and the change of signal amplitude with time can be observed, you can search for obstacles on the road or the damage location of the road during the entire driving process,ulteriorly, and then combined with the laser displacement sensor to determine the relative height change between the vehicle and the road at the corresponding time to preliminary judge whether the road surface at this position

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is damaged. The device can be installed on different types of vehicles, and the degree of road damage is determined by comprehensive analysis of the vibration signals of different types of vehicles.

It can be seen that the road intelligent detection device based on V2X technology has a certain feasibility in theory. This article will conduct further simulation simulations on this detection method to verify its feasibility.

4. The Key Technology of V2x Technology to Send Inspection Data

4.1 V2x Vehicle Communication

According to the 3GPP TR 22.885 V14.0.0 standard, V2X communication requires specifications for terminal communication performance indicators in different application scenarios as shown in Table 1. Typical traffic scenarios involve suburbs, highways, various urban environments, campuses and shopping malls, etc. For the above scenarios, specific communication performance indicators include communication radius coverage areas, the maximum mobile speed of the supported terminal, communication delay, and The Reliability ratio of 100 millisecond transmission and cumulative transmission[14].

Table 1 Communication Performance Indicators in Different Scenarios

	Effective distance /m	Absolute speed of a UE supporting V2X Services /(kmh^{-1})	Relative speed between 2 UEs supporting V2X Services /(kmh^{-1})	Maximum tolerable latency/ ms	100 millisecond transmission reliability ratio /%	Example cumulative transnission reliability /%
suburban/major road	200	50	100	100	90	99
Freeway/motorway	320	160	280	100	80	96
NlOS/urban	150	50	100	100	90	99
Urban/intersection	50	50	100	100	95	-
Campus/shopping area	50	30	30	100	90	99
Imminent crash	20	80	160	20	95	-

Now, Zigbee and 4G, as V2X communication equipment, are responsible for wireless communication between vehicles and roads, and complete the data transmission in the system and the information interaction between vehicles. As the next generation mobile communication technology, 5G enhances mobile broadband, large-scale Internet of Things, and ultra-high reliability and ultra-low Latency communication. Among them, the URLLC scenario technical indicators are tailor-made for the field of Vehicles Networking, and the specific networking mode is still in the standard planning stage. In the V2X system, the combination of DSRC, LTE-V and 5G URLLC and distributed antenna systems and large-scale multiple of input and output systems can not only greatly increase network capacity, but also provide support for the realization of wireless positioning methods based on V2X signals.

4.2 Gnss-Based Collaborative Enhanced Vehicle Positioning

In the traditional vehicle location system, the GNSS module takes charge of vehicle location, the tracking of vehicle movement process is in charge of the inertial sensor matched with the kinematics model[15]. However, due to the relative limitations of its own technology, the traditional vehicle location system, such as the GNSS system will have inaccurate accuracy or location failure in the weak satellite signal coverage area, and the inertial sensor will experience speed drift after working for a long time, which is difficult to meet the higher quality requirement of vehicle location information with continuous development of Internet of Vehicles technology. Therefore, in order to further improve the vehicle location capability, not only the GNSS and inertial sensor modules in the traditional system, but also more sensing means such as cameras, lidar, radio frequency and maps need to be added to the vehicle. At the same time, at the spatial collaboration level, the shared location information of neighboring vehicles can be obtained through the vehicle-to-vehicle and vehicle-to-road communication technology in the system of Internet of Vehicles, so that the vehicle location ability can be enhanced; at the time collaboration level, the vehicle velocity and acceleration from the dashboard, heading angle data provided by the compass and empirical kinematics model knowledge, etc. can be used to further enhance the vehicle positioning ability through data fusion to optimize the filtering method. In summary, vehicle location will be deployed in two dimensions of time and space at the same time to tap the potential improvement space of location capabilities as much as possible to achieve the optimal location performance of the system.

5. Collection and Analysis of Test Data

5.1 Simulation

When the vehicle is driving quickly pass across the transient bumpy road, passive suspension because of its rigidity and damping coefficient are fixed and non-adjustable structural characteristics, different vibration signals will be generated when the vehicle passes across the road where damage occurs, and the height difference between the vehicle and the road will also change accordingly. This paper

ISSN 2616-5767 Vol.3, Issue 6: 131-142, DOI: 10.25236/AJETS.2020.030614

first investigates the real data of the road surface damage of the secondary road of Haitangxi Street, and then simulates the vibration response of the acceleration sensors on the four suspensions and the change of distance between the vehicle chassis and the road surface by Matlab when the vehicle passes across the road under different working conditions. This article uses the following transient bump model:

$$q=\begin{cases}\frac{a_q}{2}\left(1-\cos\left(\frac{(2\pi v)}{l}t\right)\right) & 0<t<\frac{1}{v}\\ 0 & t>\frac{1}{v}\end{cases} \quad (1)$$

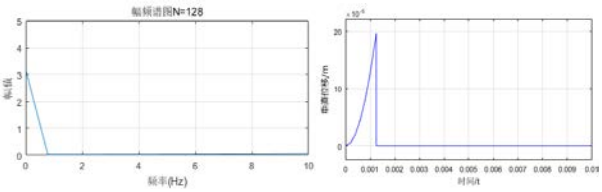
Among them, a q and l represent the height and length of the transient bump, respectively. The experimental conditions of this simulation are shown in Table 3 below.

Table 3 Experimental Conditions

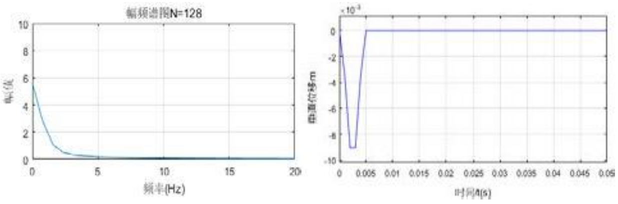
Working condition one	Speed bump 250cm×30cm×5cm (length×width×height)
Working condition two	Pit 100cm×20cm×8cm(length×width×height)
Working condition three	crack 1cm×1cm(length×width)
Working condition four	Road gravel
Working condition five	Small stones on the pavement 10cm×10cm(length×width)

5.2 Simulation Results

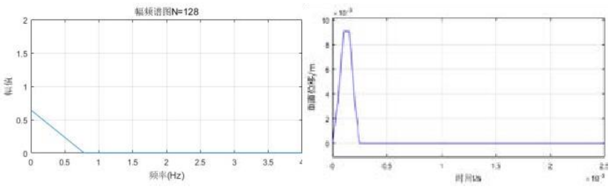
Different spectrograms and road excitation diagrams (the vertical distance between the chassis and the road) are drawn according to the simulation results of the front left suspension under different working conditions, as shown in the figure below:



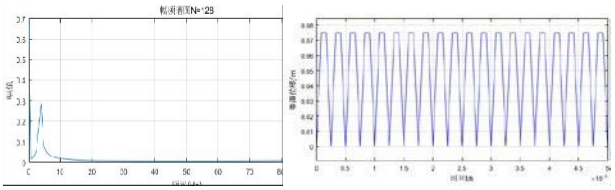
Working condition one spectrogram Working condition one displacement diagram



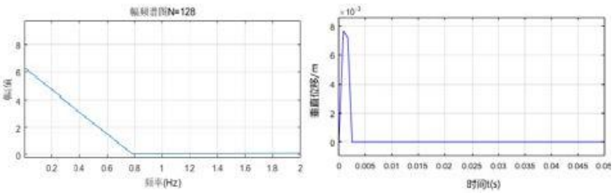
Working condition two spectrogram Working condition two displacement diagram



Working condition three spectrogramWorking condition three displacement diagram



Working condition four spectrogram Working condition four displacement diagram



Working condition five spectrogram Working condition five displacement diagram

It can be seen from the figure that the corresponding amplitudes of the frequencies under different working conditions are different. Take working conditions 1 and 3 as examples for comparative analysis. Working condition 1 is the deceleration zone. When the vehicle passes the deceleration zone, the frequency range is 0-0.8, the corresponding amplitude is 3, the pavement excitation graph is positive, the peak size is 2.0×10-4, and the working condition 3 is the road with cracks. The measured frequency range is 0-0.75, and the corresponding amplitude is 0.63. The road surface excitation graph is positive, and the peak size is 9.0×10-3. Firstly, according to the vehicle passing the deceleration zone, the front wheel first presses the deceleration zone, and the distance between the chassis and the road

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surface increases first and then returns to the original position. It can be seen that the displacement diagram of working condition 1 gradually increases before returning to the original position. When the vehicle passes across the cracks, the displacement sensor can scan the cracks during the vehicle trajectory, so the distance between the chassis and the road surface will increase, thereby the road surface condition of the vehicle trajectory can be judged according to the displacement of different sizes and directions. The frequency and amplitude range are different under different working conditions compared with amplitude corresponding to the frequency range under condition 1 to 5. Due to the limitation of the experimental conditions and other factors in this article, the amplitude corresponding to the frequency range under each working condition cannot be caculated. The simulation data in this article shows the difference of the spectrum images of vehicles driving on different types of roads, and the amplitude corresponding to the frequency range under the working conditions listed in this article can be roughly judged.

6. Conclusion

In view of time-consuming and labor-intensive, high risk, low timeliness of the traditional manual on-site detection in the current road detection methods, and high cost of multi-function detection vehicles, the data collection of road conditions mainly focuses on the geometric characteristics and surface conditions of the road, etc. The internal damage cannot be measured yet. In addition, the road surface debris and road surface damage cannot be effectively distinguished during inspection. The current image recognition technology is still difficult to identify small cracks less than 1mm. The monitoring method based on V2X proposed in this paper can effectively collect and analyze road information and draw the following conclusions based on the simulation results:

(1) The application of the V2X technology in road intelligent detection proposed in this paper shows that the road detection technology proposed in this paper has certain feasibility through theoretical analysis and verification of simulation results.

(2) The amplitude of the frequency distribution of the vehicle driving on the road with different degrees of damage is different according to the spectrogram under different working conditions, and the damage condition of the road can be judged by the amplitude, ulteriorly.

(3) According to the displacement map under different working conditions, when the vehicle is driving on the road surface with different degrees of damage, the type of damage on the road surface can be judged as the road surface uplift or local crack, according to the direction of its displacement, and combined with the size of the displacement and the frequency spectrum, details of the damage of the road surface can be further judged.

(4) Compared with the existed fully automatic road detection vehicles, the detection speed of the intelligent detection technology described in this article is faster, and corresponding detection equipment can be installed on each vehicle. With the development of big data technology, compared with the amplitude corresponding

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to the frequency range of different damaged road, and analyze the collection results comprehensively, then the damage of the road surface can be correctly judged.

It can be seen that the intelligent road detection technology based on V2X technology proposed in this paper is relatively feasible. However, the road conditions studied in this paper and the location of the simulated acceleration sensor are not incomplete due to irresistible factors such as time and test conditions, further simulation tests or real road tests are needed to complete the database. The wireless connection between V2X technology and sensors is also an issue that needs further research in the future.

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ISSN 2616-5767 Vol.3, Issue 6: 143-156, DOI: 10.25236/AJETS.2020.030615

Numerical Simulation of Combination Form of External Spray Nozzle for Roadheader

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ABSTRACT. *In order to study the influence of the combination of external spray nozzles on droplet size in the atomization superposed area, according to different nozzle combinations, spray pressure and jet axial distance, the droplet size of the atomization superposition area was simulated by FLUENT software under the combination of single nozzles and 4 nozzles according to the combination of different nozzles, and the optimal nozzle combinations were selected according to the dust trap theory. The changing trend of droplet size in atomization superposed area was analyzed by combination of nozzle, spray pressure and jet axial distance. The results showed that the spray combination had an obvious effect on improving the atomization effect. The spray pressure was inversely proportional to the droplet size of the atomization superposed area. With the increase of the axial distance, droplet size decreased first and then increased, but the minimum value was different. When the spray pressure is near 2MPa, the droplet size is close to the theoretical value in the atomization superposed area of the three nozzle combination. The experimental study of the atomization superposition area of the nozzle combination form has important guiding significance for the treatment of the underground dust.*

KEYWORDS: *Roadheader, Nozzle combination, Droplet size, Numerical simulation*

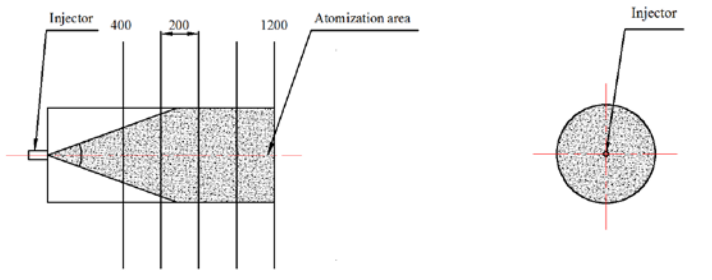
1. Introduction

In recent years, with the rapid development of industry and the improvement of people's living standards, coal, as the basic energy in China, still plays an important role in social production. Scholars predict that this phenomenon will not change in the next 30 years. In order to meet the people's demand for coal, many researchers and scholars work hard on the efficiency of coal mining. With the increase of coal mining volume, the mechanical power is also increased, which makes the working face environment worse and worse. The dust control also brings serious hidden danger to the underground safety.When the dust concentration is too high, it will not only cause harm to the miner's body, but also accelerate the damage of underground equipment[1],visibility will also be greatly reduced, so dust control has become the top priority of mine safety.In order to solve this problem and improve the efficiency of dust deposition, this paper proposes a new type of nozzle combination dust reduction method, which is of great significance to the treatment of underground working environment. In recent years, nozzle assembly has been widely used in fire protection, oil drilling, agricultural irrigation and other important fields, but no one has paid attention to it in mining machinery,in the process of oil exploitation, Li Zhaomin tested the jet velocity field of streamlined combined nozzle with experimental method[2], analyzed the axial velocity and radial velocity of the velocity field of the combined nozzle, and obtained the internal law of the velocity in the mixing section of the flow field.Xu Yi found that the disadvantages of ultra-high pressure jet rock breaking drilling[3], using different nozzle combinations to improve the nozzle, greatly improving the drilling speed, and subsequently, the drilling cost has been further reduced, and according to different nozzle combinations, the method of numerical simulation is used to analyze the downhole flow field.Liu Zhichao proposed that the arrangement of nozzles had different effects on the pressure drop of gas in the pipeline transportation process[4], which was further verified. In the process of computer simulation, the relationship between the arrangement of nozzles and pressure drop was obtained, and the combined arrangement of nozzles had an important relationship with the transportation of low concentration gas.Therefore, this paper will use the experimental research method to study the combination form of double nozzles, and deeply explore the size and distribution range of the particles with different axial spacing when the nozzle combination form changes in different pressure, which will lay a good foundation for the underground environment treatment.

2. Numerical Simulation

2.1 The Establishment of Geometric Model

In this paper, the atomization flow field under different nozzle combinations is the focus of the study. Therefore, the main research is the change of droplet size in the outflow field, and the numerical simulation of atomization effect under different nozzle combinations.



(a)Nozzle structure (b)Schematic diagram of guide core

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Fig.1 Injection Diagram

Aiming at the key point of the research, the combined geometry model of nozzle is established and meshed. The schematic diagram of nozzle combination is shown in Figure 3-1 (a). The main consideration of nozzle combination type atomization is the change of fog particles in the fog drop superposition area of atomization flow field. After checking the relevant Atlas of roadheader, the distance between the two nozzles is about 100 mm. Therefore, the center distance of nozzle combination type is set to 100 Mm. In the process of numerical simulation, the three-dimensional finite element model of atomization flow field is a cylinder with a diameter of 500 mm and a height of 1200 mm. The nozzle is placed on the end face. The center of the figure formed by each nozzle and the center of the end face circle are the same point and the nozzle spacing is 100 mm.

In order to make the atomization area more regular and convenient to measure the distribution range of droplet size in the atomization superposition area,the combination of nozzles adopts regular polygon layout[5],the layout is shown in Figure 2.

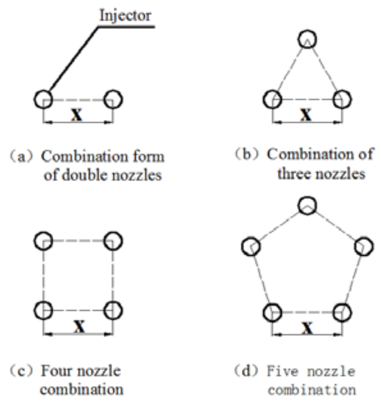

Fig.2 Layout of Nozzle

The 3D model is established by using the 3D mapping software CATIA, and the 3D model is imported into ICEM for mesh generation. The mesh type is tetrahedral mesh, and the finite element model is shown in Figure 3-1 (b).

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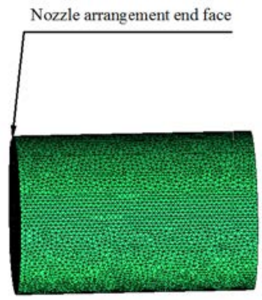


Fig.3 Finite Element Model

2.2 Mathematical Model

(1) Gas phase control equation

In the rectangular coordinate system, the general equation of the gas phase control equation is[6]

$$\frac{\partial(\rho\phi)}{\partial t}+div(\rho u\phi)=div(\Gamma grad\phi)+S \qquad (1)$$

In the formula ϕ --General variable,It can represent u, v, T and other solving variables;

Γ --Generalized diffusion coefficient;

S --Generalized source term.

(2) Droplet motion equation

For the gas-liquid two-phase flow, considering all kinds of forces on the droplet, the equation of droplet motion can be obtained by Newton's second law[7]

$$\frac{\mathrm{d}U_{\mathrm{P}}}{\mathrm{d}t}=F_{\mathrm{D}}\left(U-U_{\mathrm{P}}\right)+\frac{g\left(\rho_{\mathrm{P}}-\rho\right)}{\rho_{\mathrm{P}}}+F \qquad (2)$$

$$F_{\mathrm{D}}=\frac{18\mu}{\rho_{\mathrm{P}}d^{2}{}_{\mathrm{P}}}\frac{C_{\mathrm{drag}}\,\mathrm{Re}}{24} \qquad (3)$$

In the formula UP --Droplet velocity,m/s;

ρp--Droplet density,kg/m3;

Re--Relative motion Reynolds number,Reynolds number

$\mathrm{Re} = d_p \rho \left(u - u_p\right) / \mu$;

Cdrag--Drag coefficient.

(3) Turbulence model

The choice of turbulence model depends on the size of Reynolds number, which is the physical quantity to measure the flow characteristics of fluid. In this study, Re is more than 4000, which is turbulent state, so turbulence model is selected[8].

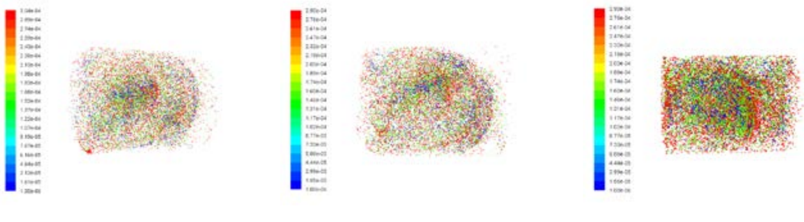
2.3 Boundary Condition Setting

The boundary condition of the inlet is nozzle nozzle, and the outlet of the nozzle is set as pressure inlet. Because the nozzle is free jet, the outlet is full outlet boundary, the wall is set as wall, and the type is escape. It is assumed that the wall is approximately isothermal and has no slippage. The numerical simulation uses a three-dimensional single precision simulator to solve the convection field in a coupled way. The pressure rotating atomizer model is selected as the atomizer model and water as the dispersion phase.

3. Results and Analysis

Based on the theory of spray Dustfall and the theory of dust collection, the optimum droplet size is not 30~120 μm when the dust of 2~12 μm is collected.The three-dimensional simulation of the atomization flow field of different nozzle combination forms under different pressures is carried out in a coupling way. At the end of the iterative calculation, the particle size at different positions of the nozzle superposition area in the atomization area under the nozzle combination form is extracted. After the extraction, the unit of the droplet size is converted into μm, and the unit of the axial distance is converted into mm.In order to make the expression more convenient, the axial distance of spray nozzle is expressed as a, B, C, D and e respectively, which is 400 mm, 600 mm, 800 mm, 1000 mm and 1200 mm.

3.1 Analysis of Atomization Particle Size Characteristics of Single Nozzle

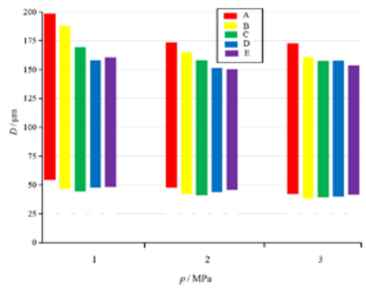


(a)1 MPa (b)2 MPa (b)3 MPa

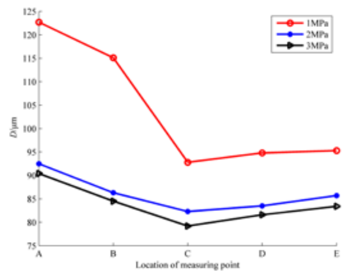
Fig.4 Cloud Chart of Droplet Size Distribution of Single Nozzle

ISSN 2616-5767 Vol.3, Issue 6: 143-156, DOI: 10.25236/AJETS.2020.030615

From Figure 4, we can see that with the increase of spray pressure, the droplet size in the atomized area increases gradually. The droplet size of the front droplet increases with the increase of the distance between the spray axis and the spray nozzle. The droplet size increases with the increase of the axial distance. The droplets were polymerized into larger size droplets.



(a)Droplet size distribution range of single nozzle



(b)Average particle size curve of single nozzle

Fig.5 Particle Size Distribution of Single Nozzle

From Figure 5 (a), it can be seen that droplet size of single nozzle is smaller than that of 1MPa when the spray pressure is 2~3 MPa, and the droplet size distribution is 38~198 μm. Based on the theory of dust collection, it can be seen that the droplet size of single nozzle is generally larger than the optimal range of droplet size. In order to make the atomization effect more uniform, the influence of nozzle combination on the atomization effect is proposed. From Figure 5 (b), it can be seen that there is a negative correlation between the spray pressure of single nozzle and droplet size. Under the same spray pressure, droplet size decreases first and then increases with the increase of jet axial distance, and the minimum droplet size point appears at C point.

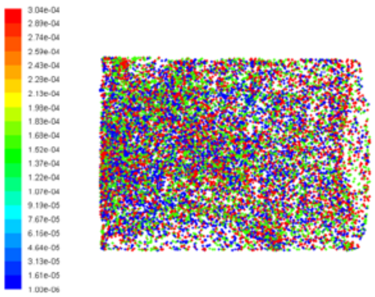
3.2 Analysis of Particle Size Characteristics of Combined Atomization of Nozzles

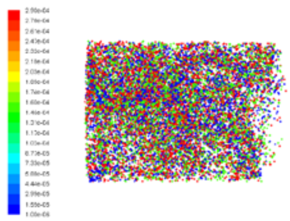
ISSN 2616-5767 Vol.3, Issue 6: 143-156, DOI: 10.25236/AJETS.2020.030615

In order to analyze the effect of nozzle combination on droplet size in atomization superposition area, the droplet size characteristics of atomization superposition region under different spray pressure and different axial distance between 4 different nozzle combinations were analyzed.

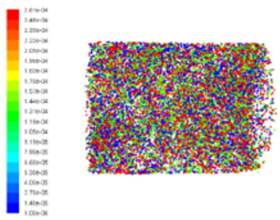
(4) Combination of two nozzles

The cloud figure of droplet size distribution in the combined form of double nozzles is shown in Figure 6. Compared with the single nozzle, the number of particles in the combined form of double nozzles is significantly increased, and the water consumption is increased. For more intuitive analysis, the combined form of double nozzles is extracted numerically, and the droplet size distribution in the combined form of double nozzles is drawn, as shown in Figure 7.





(a)1 MPa (b)2 MPa



(b)3 MPa

Fig.6 Cloud Chart of Droplet Size Distribution in Combination of Two Nozzles

It can be seen from Figure 7 (a) that compared with the droplet size of single nozzle, the droplet size in the superposition area of double nozzle combination atomization is significantly reduced, which shows that the nozzle combination has a significant effect on the improvement of atomization effect, and the droplet size distribution range is 37-159 m. From Figure 7 (b), it can be seen that droplet size decreases with the increase of spray pressure when the measuring points are the