

## Study of Gas Diffusion Multivariate Regression Model

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**Abstract**-With the rapid economic development, social demand for chemical products is increasing and the attendant problems have also emerged which the chemical gas will spill during transport. Therefore, understand the leaking gas diffusion trend has great effect on emergency rescue. Around the diffusion problem to tank leak source that may occur during road transportation, under the conditions, a diffusion model of gas leakage are established based on fluent simulation data. It means, establish a multiple regression model reference to regression analysis. The diffusion model was analyzed under the conditions of simulation data in MATLAB. The results show that the Multi-Regression Model can predict the spread of the gas leak in a certain extent. And the paper's research provides a theoretical basis for a gas leakage accident emergency rescue.

**Keywords**-gas leakage; regression analysis; multiple regressions

### I. INTRODUCTION

Happened in recent years, successively more dangerous chemical transportation vehicle traffic accident caused the wide attention of the society. So after these accidents, how to scientific guidelines to the disposal of the accident rescue workers become more and more important. Gas diffusion behavior research is the basic theory of instruction for emergency rescue. Expert of our country's scholars in the field of leakage gas diffusion simulation research has achieved some results. In 2002, Jianke Du<sup>[1]</sup> through the leakage gas diffusion model build the harm of gas regions division and estimation, And it could provide scientific and effective guidance at gas leakage accident rescue. In 2004, Ping Li<sup>[2]</sup> analyzed the dangerous substances in tunnel before and after the release of the flow field during the vehicle movement, to study the dangerous chemical gas concentration distribution in vertical and horizontal directions. Dong Yan<sup>[3]</sup> and others combined Gauss formula and three-dimensional finite element method to construct the leakage diffusion model of hazardous substances, and the model can be the rend of diffusion of dangerous substances and concentration distribution for effective estimation and evaluation. To sum up, although for the leakage of gas diffusion model, research has made certain achievements. But how to make the established model, constraint conditions, which has more extensively applicable scope is less, or create a new model to simulate the spread of leakage gas concentration, is still the problems we need to continue to study.

The establishment of the multiple regression models is

based on fluent simulation data. First establishing single factor and diffusion concentration of monadic regression model. According to univariate regression model provide function relation, using the least squares algorithm, establish the direction of the wind speed and different diffusion distance and diffusion concentration between the multiple regression model and utilized fluid dynamics model calculation results as the reference standard, the inspection of the validity of the model. By the established leakage gas diffusion model, expect it could provide for road transport gas leakage accident emergency rescue.

### II. ALGORITHM RINCIPLE

After the gas leak, it will be spread near the source under the influence of various factors. Gas diffusion process is not only influenced by its own nature, and also by the influence of factors such as wind speed and atmospheric stability. Apply EXCEL to establish wind speed and the diffusion rate, the concentration of the diffusion distance and the diffusion of univariate regression model.

#### A. Establishment Of Univariate Regression Model

In establishing univariate regression model and multiple regression model, that assume a homogeneous fluid flow the gas does not react in the diffusion process and the environment temperature is 300 k, turbulence intensity of 10, leakage rate constant was 2.5 m/s, had no effect on the surface roughness of gas diffusion.

1) Under different wind speed conditions, the leakage of univariate regression analysis, the diffusion of the gas concentration by wind speed and the diffusion concentration of fitting formula is as follows:

$$y = -0.0026x^4 + 0.0134x^3 - 0.0196x^2 - 0.0005x + 1.1762 \quad (1)$$

In the formula:

$y$  —Leakage of gas concentration;

$x$  —The leakage accident of wind speed

2) Under the different diffusion distance, he leakage of univariate regression analysis, the gas concentration and diffusion concentration diffusion distance fitting formula of the specific as follows:

$X$  axial distance and diffusion concentration of fitting formula is:

$$y = 2.2E - 6x^3 + 5.3E - 6x^2 - 4E - 5x + 1.1766 \quad (2)$$

In the formula:

$y$  —Leakage of gas concentration  $kg/m^3$ ;

$x$  —X axial gas diffusion distance/m

Y axial distance and diffusion concentration of fitting formula is:

$$y = -(4.3E-6)x^4 - 0.00005x^3 + 0.0002x^2 - 0.000084x + 1.1766 \quad (3)$$

In the formula:

$y$  —Leakage of gas concentration  $kg/m^3$ ;

$x$  —Y axial gas diffusion distance/m

**B. Establishment Of Multiple Regression Model**

On the basis of regression function in a univariate regression model using SPSS software to establish the wind speed, diffusion distance and the diffusion concentration of multivariate regression model, respectively the three input variables(wind speed ,X, Y diffusion distance) of primary, secondary and third power data and output variables (diffusion concentration) data entry in the form of column. Then return to operation, they will get the order variable regression coefficient of diffusion concentration, written formula as shown in the type:

$$y = 1.17223 + 0.00016x_1^3 - 0.00086x_1^2 - 0.00259x_1 + 0.00385x_2^3 - 0.016395x_2^2 + 0.01175x_2 + 0.000493x_3^3 - 0.0052x_3^2 + 0.01344x_3 \quad (4)$$

In the formula:

$x_1$  —the leakage accident of wind speed m/s;

$x_2$  —X axial gas diffusion distance/m;

$x_3$  —Y axial gas diffusion distance/m

**III. SIMULATION AND RESULT ANALYSIS**

Due to the uncertainties in the diffusion process of the leaked gas, the model is established through different degrees of approximation and simplification. Therefore, in this paper, the most basic linear fitting algorithm is used to model the leakage data with three diffusion factors under certain conditions, and the fitting degree and prediction accuracy of the constructed diffusion model are tested by simulation experiments.

**A. Univariate Regression Model Simulation**

Leakage of gas diffusion concentration in different wind speed conditions are shown in table 1. By EXCEL the data in table 1 univariate regression analysis results (as shown in figure 1-1). Get wind speed and the diffusion concentration simulation result as follow:

TABLE I. TABLE GAS DIFFUSION CONCENTRATION UNDER DIFFERENT WIND CONDITIONS

wind speed (m/s)	gas diffusion concentration (kg/m <sup>3</sup> )	wind speed (m/s)	gas diffusion concentration (kg/m <sup>3</sup> )
0.000000	1.176344	1.500002	1.163207
0.100000	1.175502	2.000000	1.162125
0.500010	1.173079	2.500000	1.158409
1.000000	1.166243	3.000004	1.146456

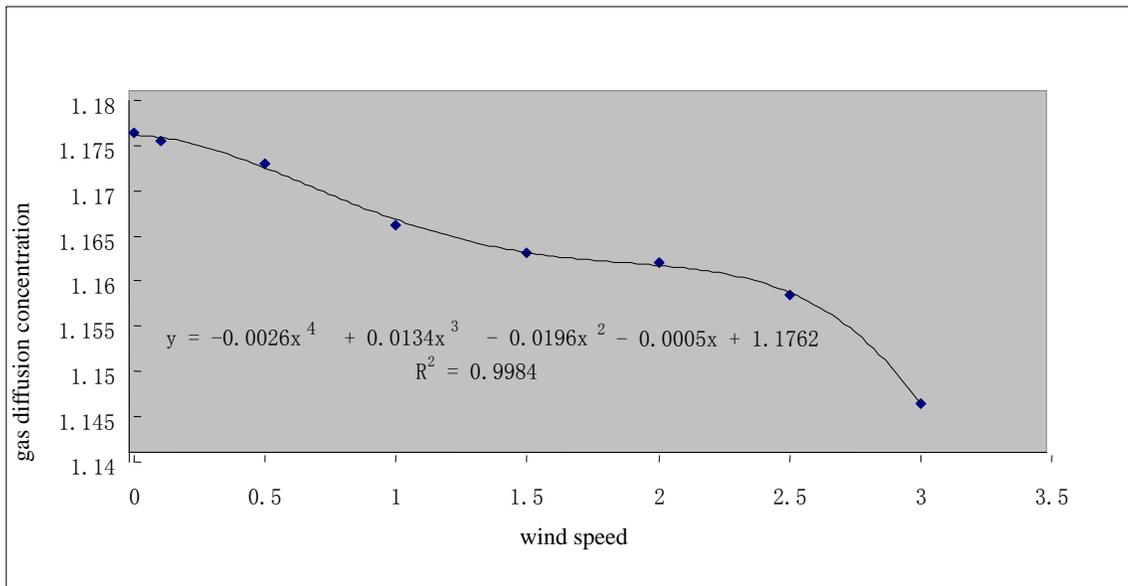


Figure 1-1. The relation chart of wind speed and the gas diffusion concentration.

From figure 1-1 wind speed and the concentration of gas diffusion fitting figure can be find that wind speed and

concentration of four times univariate regression model can be better to response the relationship between wind speed

and the diffusion concentration. Leakage of gas diffusion concentration under the conditions of different diffusion distance are shown in table 2 to 3. In order to study its regularity, through analysis the application of EXCEL in table 2 and the data in table 3 univariate regression, the result can be obtained that diffusion distance and the diffusion concentration of specific simulation result is as follow:

TABLE II. TABLE X AXIAL DISTANCE AND THE GAS DIFFUSION CONCENTRATION

X axial distance (m)	Diffusion concentration (kg/m <sup>3</sup> )	X axial distance (m)	Diffusion concentration (kg/m <sup>3</sup> )
0.10000	1.17663	1.90000	1.176593
0.30000	1.17662	2.00000	1.176594
0.50000	1.17662	2.09999	1.176595
0.80000	1.17661	2.20000	1.176596
1.00000	1.17660	2.40000	1.176599
1.10000	1.17659	2.50000	1.176602
1.40000	1.17659	2.80000	1.176609
1.50000	1.17659	3.00000	1.176627

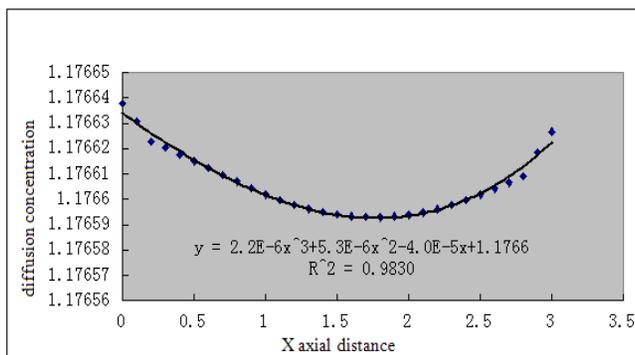


Figure 1-2. The relation diagram of X axial distance and the gas diffusion concentration.

TABLE III. TABLE Y AXIAL DISTANCE AND THE GAS DIFFUSION CONCENTRATION

Y axial distance (m)	Diffusion concentration (kg/m <sup>3</sup> )	Y axial distance (m)
0.10000	1.176638	2.90001
0.50000	1.176619	3.00000
0.80000	1.176602	3.20001
1.00000	1.176589	3.40001
1.30000	1.176567	3.90001

From figure 1-2 and figure 1-3 can be seen, X axis diffusion distance and the diffusion concentration of three times univariate regression model fitting degree is 0.98; Y axis diffusion distance and the diffusion concentration of four times univariate regression model fitting degree is 0.98; The two unary regression model to the original data of the

fitting effect is considerable. The figure 1-3 shows as following:

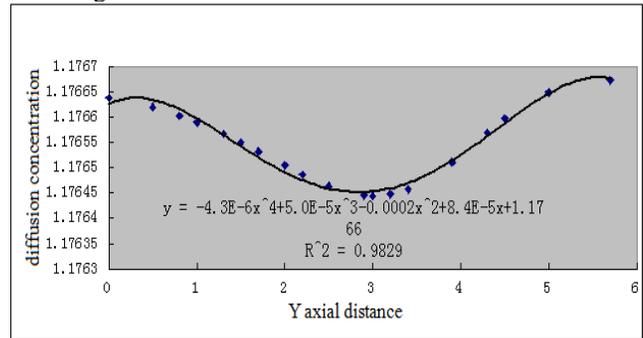


Figure 1-3. The relation diagram of Y axial distance and the gas diffusion concentration.

### B. Multiple Regression Model Simulation

On the basis of a univariate regression function relationship, Use SPSS software to establish wind speed, diffusion distance and the diffusion concentration of multivariate regression model to inspect the accuracy of the inspection and test data model. Fitting test, it is for inspection has built prediction model of the most commonly used method, and it is always apply to the measure the model of the predicted results and the actual value, the fit of the commonly used computation formula is as follows:

$$R^2 = 1 - \frac{\sum (Y - \hat{Y})^2}{\sum (Y - \bar{Y})^2} \quad (5)$$

In the formula, Y represent the actual value of diffusion concentration,  $\hat{Y}$  represent the prediction of diffusion concentration,  $\bar{Y}$  represent the average value of diffusion concentration. Through the calculation of type 5, the fit of the model of the value is .So it could be think that can better reflect the characteristics data, the test data and calculated results are shown in table 4. All test data of fluid dynamics model calculation results and the result compared with the predictive value of multivariate regression model is shown in figure 1-4.

TABLE IV. TABLE TEST DATA AND DATA ERR

wind speed (m/s)	X axial distance (m)	X axial distance (m/s)	actual concentration((kg/m <sup>3</sup> ))	predict concentration (kg/m <sup>3</sup> )	error (kg/m <sup>3</sup> )
0.000	3.0000	0.0000	1.1624110	1.16390	0.0015
0.000	0.0000	5.8000	1.1766738	1.17140	-0.0052
0.570	1.8999	1.5000	1.1711825	1.17020	-0.0010
0.570	0.6000	6.0000	1.1766511	1.17240	-0.0043
3.000	1.8999	6.0000	1.1478528	1.15050	0.0027
5.000	1.7000	5.9000	1.1515193	1.14890	-0.0026
0.300	2.0000	7.0000	1.1766739	1.16840	-0.0082
0.310	0.1000	3.5000	1.1764046	1.17680	0.0004
0.315	1.3999	2.0000	1.1762710	1.17620	-0.0009
0.265	1.3999	4.5000	1.1741571	1.16650	-0.0077
0.100	0.6000	3.0000	1.1765254	1.18080	0.0042

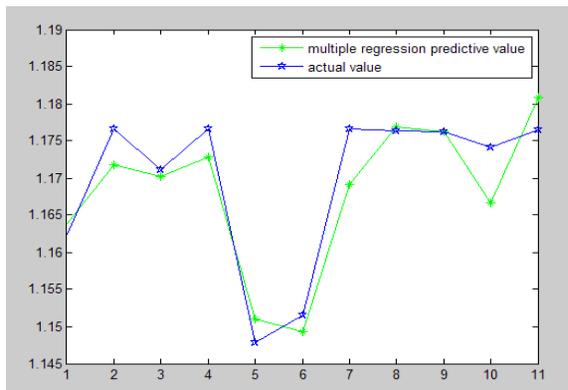


Figure 1-4. Actual and predicted values of diffusion concentration.

The actual value in Figure 1-4 is refers to the calculation results of fluid dynamics model, the green star line represents the multiple regression model prediction, Blue stars line represents the actual value. The figure in the order is the serial number of inspection data, and the ordinate instructed the size of leakage gas diffusion density Combined with figure 1-4 you can see, When diffusion concentration is greater than 1.765 kg/m<sup>3</sup>, Model predicted value and actual value have a slightly larger difference; This may be due to leakage gas diffusion time is short, the early trend of diffusion caused by unstable; When the concentration of diffusion in 1.4 ~ 1.764 kg/m<sup>3</sup>.The model predicted value and actual value is closer, the forecast effect is better.

#### IV. CONCLUSION

In this paper, Firstly through the calculation results in the same experiment conditions compared with calculation results of fluid dynamics model. The multivariate regression model based on univariate regression, can forecast the diffusion of the gas concentration within the error range in a certain degree, Moreover, with the spreading of the gas. The diffusion of the gas is more and more far distance, the diffusion of the gas concentration is more and more small. Wind speed directly affect the spread of leakage gas concentration, And the greater the wind speed, the smaller the diffusion of the gas concentration is. Finally, their simulation results show the effectiveness of the proposed model.

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