Based on the rainfall system platform raindrops research and analysis of pressure loss

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Abstract. With the rapid development of China’s military career, land, sea and air force all services and equipment of modern equipment need to be in the rain test, and verify its might suffer during transportation, storage or use a different environment temperature lower water or use underwater, the water is derived from the heavy rain, the wind and rain, sprinkler system, splash water, water wheel, a violent shock waves or use underwater, etc Test the product performance and quality, under the condition of rainfall system platform in the process of development, how to control the raindrops pressure loss becomes the key to whether the system can simulate the real rainfall [1], this paper is according to the rainfall intensity, nozzle flow resistance, meet water flow of rain pressure loss calculation and analysis, and system arrangement of the optimal solution of rainfall is obtained [2].

1. Introduction
This article in view of the different types of rainfall shower nozzle, through comparing the experimental data, choose this rainfall system is the most suitable nozzle [3]. Through the different types of nozzle experiment, with the aid of computer optimization technique, the optimization design of nozzle layout, brings forward the laboratory artificial rainfall shower space layout of the optimal solution.

2. Rainfall system composition and the function
By the n * m nozzle, n, n root branch line of speed regulating valve, n, n flow meter pressure gauge, n * m electromagnetic switch valve and n * m a manual throttle valve. Its main function is to achieve uniform rainfall rainfall l is continuously adjustable [4].

3. Nozzle area computation
3 the nozzle diameter, respectively \(d_1=0.95\text{mm}\), \(d_2=1.5\text{mm}\), \(d_3=2.1\text{mm}\)

\[
S_n = S_1 + S_2 + S_3 = \pi \left( \frac{d_1^2}{2} + \frac{d_2^2}{2} + \frac{d_3^2}{2} \right) = 5.93 \times 10^{-3} \text{m}^2
\]

(1)

So, a list of nozzle (10) of the pipe diameter d1 finance content [5]:

\[
d_1 \geq 2 \sqrt{\frac{10S}{\pi}} = 8.7 \text{mm}
\]

(2)
Diameter $d_2$ points should satisfy large area in charge of the road [6]:

$$d_2 \geq 2\sqrt{\frac{10 \times 19 S}{\pi}} \approx 3.8 \text{ m}$$

(3)

Small diameter $d$ points should satisfy area in charge of the road [7]:

$$d_3 \geq 2\sqrt{\frac{10 \times 7S}{\pi}} \approx 23 \text{ mm}$$

(4)

Nozzle spray process and the rain to Competent road calculation, As shown in Figure 1. Take outlet pipe diameter $d = 125 \text{ mm}$ (line allows velocity can be chosen as: import $v = 1.5 \text{ m/s}$, export $v = 2.5 \text{ m/s}$), so Inlet pipe (large pump) $d = 150 \text{ mm}$ in diameter [8]:

Figure 1. Nozzle spray process and the rain to Competent road calculation.

$$V_{in} = \frac{Q_s}{\pi (d_2)^2} = 1.6 \text{ m/s}$$

(5)

All the main routine Reynolds number, $\text{Re} = \frac{v d}{\nu} = 2.26 \times 10^4 / 1.007 \times 10^{-6} = 2.8 \times 10^4$

The tube running Cheng Liu resistance calculation formula:

$$\Delta p = \lambda \frac{1}{2} \frac{v^4}{d^2} \rho$$

(6)

The turbulent flow along the Cheng Liu resistance coefficient:

$$\lambda = 0.032 + 0.221 \text{ Re}^{0.237} = 0.043$$

$$\Delta p = \lambda \frac{1}{2} \frac{v^4}{d^2} \rho = 0.043 \times \frac{2.26^4}{100} \times 1000 = 888 \text{ Pa}$$

(7)

If line calculated at 100 m, the path loss is 0.09 Mpa.

4. In charge of the way to calculate

By the assigned to each branch of the main road, shunt $d = 125 \text{ mm}$. Water enter the shunt into three road, all the way to the corresponding branch, the other two road on both sides of the flow. To one
side of the flow rate is 100/19 (100 -) / 2 = 47.4 m³ / h, each column, through traffic 100/19 = 5.3 m³ / h.

After the first column, Q=47.4 m³/h

\[ V_1 = \frac{Q}{\pi d^2} = 1.07 \text{ m} \]  

(8)

Along the Cheng Liu shunt resistance  \( \text{Re} = \frac{v d}{\nu} = 1.07 \times 0.125 / 1.007 \times 10^6 = 1.33 \times 10^5 \)

The tube running Cheng Liu resistance calculation formula:

\[ \Delta p = \lambda \frac{L \cdot v^2}{d^2} \rho \]  

(9)

The turbulent flow along the Cheng Liu resistance coefficient

\[ \lambda = 0.032 + 0.221 \text{Re}^{-0.237} = 0.045 \]  

(10)

\[ \Delta p_i = \lambda \frac{L \cdot v^2}{d^2} \rho = 0.045 \frac{1.2}{0.125} \frac{1.07^2}{2} \times 1000 = 252 \text{ Pa} \]  

(11)

After the second column Q= (47.4 -5.3) m³/h=42.1 m³/h

\[ V_2 = \frac{Q}{\pi d^2} = 0.95 \text{ m} \]  

(12)

Along the Cheng Liu shunt resistance,  \( \text{Re} = \frac{v d}{\nu} = 0.95 \times 0.125 / 1.007 \times 10^6 = 1.18 \times 10^5 \)

The tube running Cheng Liu resistance calculation formula:

\[ \Delta p = \lambda \frac{L \cdot v^2}{d^2} \rho \]  

(13)

The turbulent flow along the Cheng Liu resistance coefficient

\[ \lambda = 0.032 + 0.221 \text{Re}^{-0.237} = 0.045 \]  

\[ \Delta p_i = \lambda \frac{L \cdot v^2}{d^2} \rho = 0.045 \frac{1.2}{0.125} \frac{0.95^2}{2} \times 1000 = 200 \text{ Pa} \]  

(14)

After the third column Q= (47.4 -5.3*2) m³/h=36.8m³/h

\[ V_3 = \frac{Q}{\pi d^2} = 0.83 \text{ m} \]  

(15)

Along the Cheng Liu shunt resistance,  \( \text{Re} = \frac{v d}{\nu} = 0.83 \times 0.125 / 1.007 \times 10^6 = 1.03 \times 10^5 \)

The tube running Cheng Liu resistance calculation formula:

\[ \Delta p = \lambda \frac{L \cdot v^2}{d^2} \rho \]  

(16)

The turbulent flow along the Cheng Liu resistance coefficient

\[ \lambda = 0.032 + 0.221 \text{Re}^{-0.237} = 0.045 \]  

\[ \Delta p_i = \lambda \frac{L \cdot v^2}{d^2} \rho = 0.045 \frac{1.2}{0.125} \frac{0.83^2}{2} \times 1000 = 154 \text{ Pa} \]  

(18)

Is for the end of the frictional pressure loss
\[ \Delta p = \Delta p_1 + \Delta p_2 + \Delta p_3 = 606 Pa \] 

5. Nozzle control algorithm
Two-dimensional rainfall distribution expectations by analog computer is given, and the actual measurement of rainfall, rainfall intensity data for two-dimensional rainfall error values, through the error diffusion algorithm, nozzle control of quantity, and then control the two-dimensional rainfall distribution. Distributed rainfall sensor measurement of rainfall data continuous rainfall distribution is obtained by interpolation calculation, for the use of closed loop control of rainfall [9].

Error diffusion algorithm: control the amount of each nozzle, Its control algorithm is as follows:

\[ p_4 = W_1 \times \text{pid}(e_1) + W_2 \times \text{pid}(e_2) + W_3 \times \text{pid}(e_3) + W_4 \times \text{pid}(e_4) \]

Among them, \( W_1, W_2, W_3, W_4 \), For the weight, \( \text{pid}(\bullet) \) is PID operation.

6. Rainfall intensity uniformity simulation
In order to simulate different aperture of nozzle in different pressure, we make a simulation software which simulate the artificial rainfall, it can set the value, such as nozzle pressure, nozzle diameter, nozzle center distance, nozzle in distance. And then we can look at the combination figure clearly, a three-dimensional figure of a single nozzle rain intensity distribution, a three-dimensional figure of all areas rainfall intensity distribution, a section figure of all areas rainfall intensity distribution, a 85% section figure of rainfall intensity distribution, and rainfall intensity distribution of the contour [10].

The operation panel of simulation software interface is shown in Figure 2.

![Software analysis](image)

Figure 2. Software analysis.

7. The rain intensity distribution calculation and analysis
Nozzle diameter is small, the Reynolds number is larger, so the shower nozzle model for the round hole turbulent jet model. The rainfall intensity distribution accord with normal distribution, satisfy:

\[ u = u_{\text{max}} \exp\left(-\frac{r^2}{b_{\text{e}}^2}\right) \]

Among them: Be as strong rain when \( r = b_{\text{e}} \) in equal, is proportional to the jet distance, of the relationship between the radius and jet as follows:

\[ b_{\text{e}} \propto \text{actg} 60^\circ x_{\text{max}} \]

Based on the constant flow are:
\[
Q = \int_0^{x_{\text{max}}} 2\pi ur \, dr = 2\pi u_{\text{max}} \int_0^{x_{\text{max}}} re^{ \left( \frac{r^2}{be^2} \right) } \, dr
\]

\[
Q = \pi b_e^2 u_{\text{max}} \left[ 1 - e^{ \left( \frac{-x_{\text{max}}^2}{be^2} \right) } \right]
\]

\[
u_{\text{max}} = \frac{Q}{\pi b_e^2 \left[ 1 - e^{ \left( \frac{-x_{\text{max}}^2}{be^2} \right) } \right]}
\]

8. Conclusion

In the process of rainfall realize the change of rainfall intensity, the pressure with the additional requirements for water supply, need water supply pipeline pressure adjustment is done in a very short period of time, to make changes in rainfall intensity steady rainfall process can in the shortest time. In view of this, in view of the water supply pipeline pressure control stability and uniformity of rainfall influence research. Through experimental study and theoretical calculation, put forward in the artificial rainfall rainfall intensity changes to ensure that the nozzle discharge pressure constant solution.

9. References

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