STUDY ON THE CHARACTERISTICS OF AEROSOL FOR GLAZE ICING MANUAL INTERVENTION

Song Tinglu, Li Xiaodong, Guo Xiaoyan, Yang Rongjie, Zhang Haoming
School of Materials science and Engineering, Beijing Institute of Technology Beijing, China
Email: song@bit.edu.cn

Abstract: Weather modification technology has been widely applied in social production and life, such as artificial rainfall and artificial hail dissipation. This paper introduces a new kind AgI aerosol formula. It can be used for specific manual interference operation to glaze icing aimed to the transmission line icing hazard, and it broadends the application field of weather modification. This new type aerosol is prepared by casting moulding and it has the feature of simple process. Through the test of the aerosol's ignition performance and combustion performance, we find that it is of great advantages in reliable ignition performance, stable combustion performance, appropriate burning rate and suitable burning rate pressure index at -20℃ and 0.2 standard atmospheric pressure. It not only has excellent coubustion performance, but also solve the problem that under low temperature and low pressure condition conventional aerosol isn't suitable for seeding operation by propellant rocket or airplane. In addition, we established an experimental device that evaluated the nucleation rate and icing efficiency of the aerosol particles. The undercooling catalysis effect of the aerosol is verified by the new experimental method. It has a higher nucleation efficiency and a better icing catalytic function. in laboratory simulation of atmospheric environment. At last, the icing catalysis principle of the aerosol and its engineering-oriented implementation are simply described and discussed.

1. INTRODUCTION

Weather modification technology has been widely applied in social production and life, such as artificial rainfall and artificial hail dissipation. It promotes the favorable and avoids the unfavorable by the method of seeding catalyst in the air. However, there is no specific mature manual interference operation aimed to state grid transmission lines icing now. South power grid was widely paralyzed because of frost disaster in 2008[1]. Huge amounts of AgI microparticles are released by burning the aerosol. The supercooled water in the air adhere to them as crystal nucleus and fall down in no-disaster form. Aerosol can be seeded by cannon , rockets or airplanes[2]. At this low temperature and atmospheric pressure of high cloud traditional aerosol can't be ignited reliably, even can't combust stably. Using the advantage of solid propellant we prepared a new type formula of AgI aerosol in order to overcome the drawbacks.

2. RESULTS AND DISCUSSION

The new kind AgI aerosol was prepared. Its combustion and ice nucleation performance was mainly tested by experiments. It had a reliable ignition under normal condition, even under low temperature and pressure. It had suitable burning rate and burning rate pressure index as figure 1. showed. The nucleation of the aerosol was tested by a new mothod. Table1. showed that the ice nucleation efficiency of the new aerosol was higher than traditional aerosol's. It also had a weaker temperature dependence of ice nucleation. It urged supercooled water become to snow or samll ice particles before glaze icing formed, eliminated or reduced the icing hazard to transmission lines.

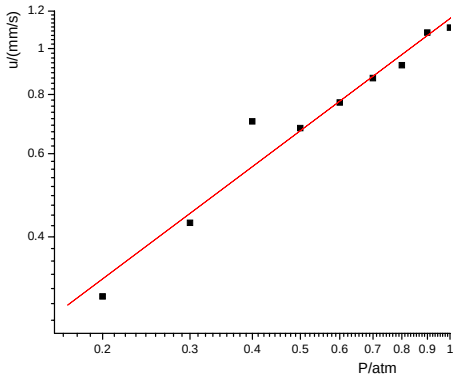

Figure 1: The burning rate pressure curve of the AgI aerosol

Table 1: Ice crystal mass of aerosal in ice nucleation test under different temperatures

Ice crystal mass/g	at -12℃	at -8℃
Traditional AgI aerosol	113.1	92.8
New type AgI aerosol	123.7	118．5

3. CONCLUSION

AgI aerosol formula were determined based on components of the solid propellant. AgI aerosol with nice processing property were prepared. It had a reliable ignition capability not only under normal temperature and pressure, but also under low temperature and low pressure. It had a suitable burning rate pressure index besides stable combustion. A new test method and an experimental equipment was designed to evaluate nucleation efficiency of the AgI aerosol. Ice nucleation tests were completed. The results showed that the ice nucleation efficiency of new type AgI aerosol was higher than the traditional AgI aerosals' under the simulated atmospheric environment. At the same time, the AgI aerosol has a certain engineering application prospect.

4. REFERENCES

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Study on the Characteristics of Aerosol for Glaze Icing Manual Intervention

Song Tinglu, Li Xiaodong, Guo Xiaoyan, Yang Rongjie, Zhang Haoming
School of Materials science and Engineering，Beijing Institute of Technology Beijing, China
E-mail: song@bit.edu.cn

***Abstract*—Weather modification technology has been widely applied in social production and life, such as artificial rainfall and artificial hail dissipation. This paper introduces a new kind AgI aerosol formula. It can be used for specific manual interference operation to glaze icing aimed to the transmission line icing hazard, and it broadends the application field of weather modification. This new type aerosol is prepared by casting moulding and it has the feature of simple process. Through the test of the aerosol's ignition performance and combustion performance, we find that it is of great advantages in reliable ignition performance, stable combustion performance, appropriate burning rate and suitable burning rate pressure index at -20℃ and 0.2 standard atmospheric pressure. It not only has excellent coubustion performance, but also solve the problem that under low temperature and low pressure condition conventional aerosol isn't suitable for seeding operation by propellant rocket or airplane. In addition, we established an experimental device that evaluated the nucleation rate and icing efficiency of the aerosol particles. The undercooling catalysis effect of the aerosol is verified by the new experimental method. It has a higher nucleation efficiency and a better icing catalytic function. in laboratory simulation of atmospheric environment. At last, the icing catalysis principle of the aerosol and its engineering-oriented implementation are simply described and discussed.**

Keywords-weather modification; aerosol; AgI; combustion; glaze icing; nucleation

I. INTRODUCTION

Weather modification technology has been widely applied in social production and life, such as artificial rainfall and artificial hail dissipation. Weather modification has been implemented in weather security of 2008 Olympics opening ceremonies and 2009 national day parade. At present,it mainly includes artificial rainfall and artificial hail dissipation. It promotes the favorable and avoids the unfavorable by the method of seeding catalyst in the air. It not only can reduces the loss of the disasters, but also has positive significance to social lives. However, there is no specific mature manual interference operation aimed to state grid transmission lines icing now. South power grid was widely paralyzed because of frost disaster in 2008. Direct economic loss was up to 22 billions. It brought great influence to social production and life[1,2]. So, developing glaze icing manual intervention technology and reducing transmission lines icing is an available way to state grid security.

AgI crystal has the most similar crystal structure to the ice. Huge amounts of AgI microparticles are released by burning the aerosol. The supercooled water in the air adhere to them as crystal nucleus and fall down in no-disaster form, such as snow or small ice particles. Aerosol can be seeded by cannon , rockets or airplanes[3]. At high cloud layer it's not only very cold, but also has a relatively lower atmospheric pressure, even less than 0.3 atm (standard atmospheric pressure). At this low temperature and atmospheric pressure traditional AgI aerosol can't be ignited reliably, even can't combust stably. Use the advantage of solid propellant for reference, we prepared a new type formula of AgI aerosol in order to overcome above drawbacks.

II. AEROSOL PREPARATION

Table 1 is the basal formula of AgI aerosol. We selected the adhesive and corresponding hardener as the polymer system, which produced by Beijing chemical reagent Co., Ltd. DOS was plasticizer. Oxidants were added discriminatively in accordance with the classification of their particles' size, and 5% AgI was extra added.

TABLE 1. BASAL FORMULA OF AGI AEROSOL

components	adhesive	hardener	plasticizer	oxidant
mass fraction %	17.1	1.85	2.55	78.5

We prepared raw materials by total mass of 50 grams. All of solid components needed to be screened and dried. All liquid components needed to dry in vacuum. Pre-mixed liquid components other than hardener first, and stirred evenly. Second, pre-mixed all of solid components, then mixed them evenly with liquid phase components that had been pre-mixed. Finally, added hardener and fully stirred for 15 minutes. Then vacuum casted and solidified in water oven at 50℃ for 5 days. Aerosol drug was cutted into drug strips of 5mm×5mm and preserved closed for use.

III. COMBUSTION CHARACTERISTICS OF AEROSOL

A. Ignition characteristic

Taken a drug strip, then cut one end of it into plane section and fixed an electric heating wire on the section tightly. Ignition characteristic of the aerosol was tested by energizing and igniting under normal temperature and pressure. It could be ignited reliably by repeated 10 times, so could it under -20℃ and normal atmospheric pressure. Then tested its ignition characteristic under -20℃ and decompression condition step by step for 0.1 atm each time until the pressure reduced to 0.1 atm, the drug strip couldn't be ignited reliably. That is the drug strips of AgI aerosol had reliable ignition under extreme -20℃ low-temperature and 0.2 atm low-pressure. They also had stable combustion, and

could meet the demands of seeding operation by airplanes in 7km high altitude.

B. Burning rate

We tested drug sticks' burning rate using CCD measuring method[4]. Tested for 5 groups and taken average value, we found that the burning rate of this aerosol u=2.07mm/s. It ascribed to the range of low burning rate propellants under the condition of 25℃, 1 atm. It could meet the requirement of engineering application of smoke agents or smoke bands. Figure 1 was the CCD burning gray graph of AgI aerosol under normal temperature and pressure.

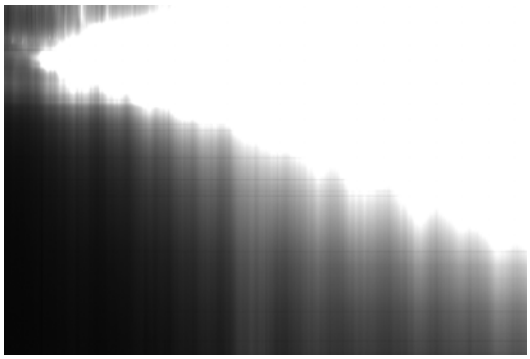

Figure 1. CCD burning gray graph of AgI aerosol under normal temperature and pressure

We used average burning rate test and chose 0.1 atm each step to test drug strips' burning rate under -20℃ temperature. Table 2 was the average burning rate data of AgI aerosol under -20℃ between 0.2 atm and 1.0 atm.

TABLE 2. THE AVERAGE BURNING RATE DATA OF AGI AEROSOL UNDER -20℃ BETWEEN 0.2 ATM AND 1.0 ATM

atmospheric pressure/atm	**1.0**	**0.9**	**0.8**	**0.7**	**0.6**
average burning rate/mm • s-1	1.11	1.08	0.92	0.87	0.77
atmospheric pressure/atm	**0.5**	**0.4**	**0.3**	**0.2**	**0.1**
average burning rate/mm • s-1	0.68	0.70	0.43	0.30	/

As show in the table, we found that the average burning rate of AgI aerosol was decreased as the pressure decreased step by step, which provided necessary data support for us to implement the manual intervention work and charge design. At the same time, we could choose different burning rate catalysts to control the burning rate of the AgI aerosol, and make series of AgI aerosol of different burning rate characters to satisfy many-sided demands[5].

C. Burning rate pressure index

Burning rate pressure index (n) is an important parameter between burning rate and pressure of solid propellant， which is related with the type and the components of solid propellant. And we can think to the sensitive level that burning rate to pressure. Its usual

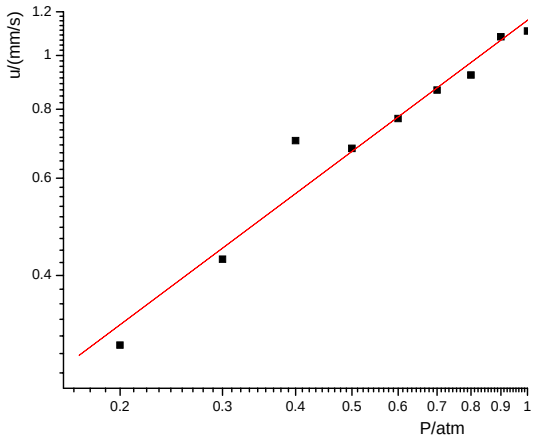

Figure 2. The burning rate pressure curve of AgI aerosol between 0.2 atm and 1.0 atm

formula： $u = u_0 P^n$. P is the pressure of burning chamber, u is burning rate and u_0 is burning rate index[6]. In order to make rocket engine work stably, n must be greater than 1. We linear fitted above data with the software origin, and got the burning rate index of AgI aerosol under the range of pressure between 0.2 atm and 1.0 atm: n=0.788, correlation coefficient R=0.9785. Figure 2 is the burning rate pressure curve of AgI aerosol under the pressure range between 0.2 atm and 1.0 atm. This AgI aerosol has an relatively suitable burning rate pressure index under the pressure range between 0.2 atm and 1.0 atm, which not only can be hung under the plane wings as smoke generator, but also adapt to rocket engine charge.

IV. NUCLEATION PERFORMANCE OF AEROSOL

We usually use the nucleation rate index to figure AgI aerosol's nucleation performance. That is the ice crystal number which each gram AgI burned formed. This method needs advanced electron microscopic observation and image recognition technology. It uses naked eyes' discrimination, and needs to take a sample to calculate nucleation rate. It's subjective. On this basis we designed a testing method more visual to measure the aerosol's ice nucleation efficiency, and designed a new experimental device independently.

This apparatus uses digital meters to control the temperature of the cloud chamber. Supercooled fog is made by ultrasonic wave. The catalysis of the AgI aerosol to the suprecooled water is simulated in the climate chamber. Directly use the mass of formed ice crystal (snow grains or small ice particles) in a given period to judge the ice nucleation efficiency of AgI aerosol. This way may express the aerosol particles catalyze supercooled water to snow grains or small ice particles more visible. This method needs more simple devices, makes less human errors and reflects more directly[7,8]. Figure 3 shows the cold fog after experiment and Figure 4 is the snow crystal grains on the test tray.

TABLE 3. ICE CRYSTAL MASS OF AEROSAL IN ICE NUCLEATION TEST UNDER DIFFERENT TEMPERATURES

Ice crystal mass/g	at -12℃	at -8℃
Traditional AgI aerosol	113.1	92.8
New type AgI aerosol	123.7	118．5

Figure 3. Cold fog after experiment

Figure 4. Snow crystal grains on the test tray

The ice nucleation capacity of this new type AgI aerosol was contrasted and verified compared with traditional AgI aerosol. 0.1g aerosol for each test, sprayed 200g fog each time and catalyzed 40 minutes. This test was repeated 5 times. Averaged data of the ice nucleation test under two different temperatures as table 3 showed.

As can be seen from the table 3, the ice nucleation mass of the new kind AgI aerosol was more than traditional aerosol's, not only under -12℃ but also under -8℃. That's the new aerosol had an excellent ice nucleation efficiency. The ice nucleation mass of the traditional AgI aerosol was 10.6g less than the new one under -12℃, but 25.7g less under -8℃. The new AgI aerosol had a weaker temperature dependence of ice nucleation. It had a better catalysis under higher temperatures, and broadened its range of application.

This new type AgI aerosol improved the efficiency that supercooled water into snow or samll ice particles. It urged supercooled water become to snow or samll ice particles before glaze icing formed, and eliminated or reduced the icing hazard to high voltage transmission lines. In addition, the new AgI aerosol was suitable for rockets and planes' seeding. We can select different operation methods according to the purpose of manual intervention and climate condition. It has some engineering application prospect.

V. CONCLUSION

(1) AgI aerosol formula were determined based on components of the solid propellant. AgI aerosol with nice processing property were prepared. It had a reliable ignition capability not only under normal temperature and pressure, but also under low temperature and low pressure. It had a suitable burning rate pressure index besides stable combustion.

(2) A new test method and an experimental equipment was designed to evaluate nucleation efficiency of the AgI aerosol. Ice nucleation tests were completed. The results showed that the ice nucleation efficiency of new type AgI aerosol was higher than the traditional AgI aerosals' under the simulated atmospheric environment. At the same time, the AgI aerosol has a certain engineering application prospect.

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