Research on cleaning scheme of photovoltaic power plant based on pollutant composition analysis

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Abstract. Solar photovoltaic (PV) modules, as an important component of the photovoltaic conversion process within a PV system, are closely related to the efficiency and service life of the PV system's overall work performance. Dust in the atmosphere is affected by rainfall, electrostatic forces, van der Waals forces and gravity, and will gather together and settle on the surface of the PV module to form dust accumulation, which reduces the amount of radiation and light energy absorption. Therefore, it is really necessary to carry out the research on the pollutant composition and treatment measures program of the surface pollution index of PV modules.

1 Introduction

Since photovoltaic (PV) modules are usually placed in natural environments, dust particles continue to accumulate on the surface of the modules as the environmental conditions change, thus interfering with their normal operation and affecting their efficiency[1,2]. In the process of photovoltaic systems for solar thermal utilization and solar power generation, PV modules, as the important components for absorbing and converting light energy, have a photoelectric conversion efficiency that is closely related to the condition of the surface ash accumulation and a variety of meteorological parameters[3-5]. The ash accumulation particles under the electron microscope are shown in figure 1~2.

Therefore , this article studies the component surface pollution index of the pollutant composition and content, according to the pollutant physical and chemical properties, the development of different component pollutant management measures different components, with different components of the washing reagent to clean the pollutants of different characteristics, detection of photovoltaic components of the surface pollution of the governance effect or also can be carried out to the scene of the different power stations for experimentation, to get the actual governance effect[6-8].

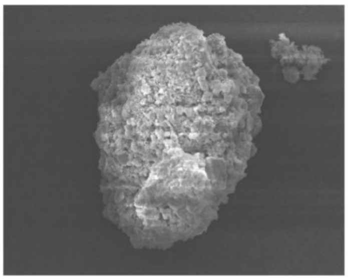

Figure 1. Cone and agglomerate ash accumulation particulate matter map

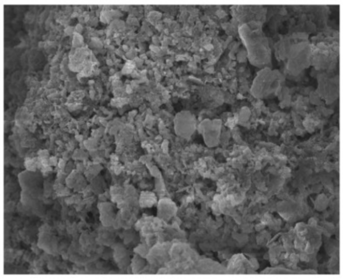

Figure. 2. Aggregate ash particles

2 Reports on the analysis of contaminant samples from different regions

Three typical test areas were selected in a PV power plant, and three typical samples were found, namely the roadside area, the edge of the mine and the middle area, which were sent to a professional analyzer for testing.

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2.1 Dust particle size detection results in each experimental area of photovoltaic power plant

Table 1. Detection results of dust particle size in each experimental area of photovoltaic power plant

Sample No.	Test area	No. of tests	Average particle size (nm)	D10 (nm)	D50 (nm)
1	roadside area	1	325.5	208.3	331.6
		2	338.5	205.6	348.7
		averages	332	206.95	340.15
2	mining area	1	343.9	214.4	346.6
		2	340.5	190.9	345.5
		averages	342.2	202.65	346.05
3	other areas	1	331.9	235	328
		2	334.5	226.3	339.7
		averages	333.2	230.65	333.85

Conclusion: The mining area has the largest dust particle size, followed by other areas, and the roadside area has the smallest particle size. The mining area may have inputs of larger dust particles from the mine, and the roadside is mainly dust with smaller particle sizes.

2.2 Dust morphology and elemental analysis results for each experimental area

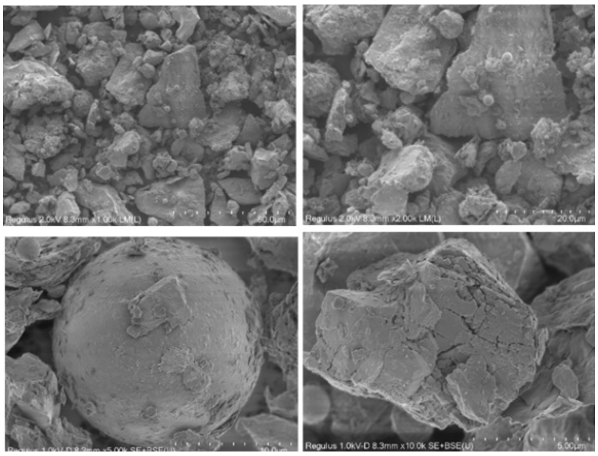

Figure. 3. SEM analysis results of dust in the roadside area

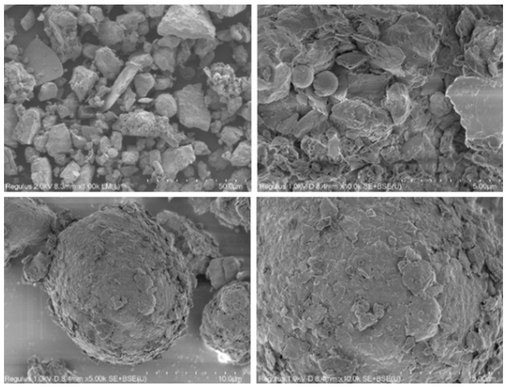

Figure.4. Results of SEM analysis of dust in the mining area

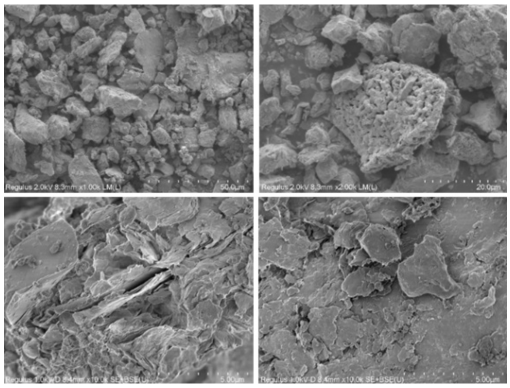

Figure.5. Results of SEM analysis of dust in other regions

Table 2. Analysis results of dust elements in each area of PV power plant

Sample No.	Test area	No. of tests	Si (%)		Ca (%)		Mg (%)		Fe (%)	
			weight ratio	atomic ratio	weight ratio	atomic ratio	weight ratio	atomic ratio	weight ratio	atomic ratio
1	roadside area	1	51	58.51	31.19	25.07	8.22	10.89	9.59	5.53
		2	43.37	56.67	39.36	33	3.02	4.17	10.26	6.17
		3	31.03	41.53	29.87	28.02	4.74	7.33	34.36	23.13
		averages	41.80	52.24	33.47	28.70	5.33	7.46	18.07	11.61
2	mining area	1	38.68	51.31	9.29	8.64	6.18	9.47	45.85	30.59
		2	51.48	61.60	15.29	12.82	7.16	9.90	26.06	15.68
		3	38.51	48.82	33.03	29.34	4.47	6.54	23.99	15.29
		averages	42.89	53.91	19.20	16.93	5.94	8.64	31.97	20.52
3	other areas	1	47.47	59.89	17.03	15.05	3.08	4.49	32.42	20.57
		2	45.22	58.84	6.91	6.30	4.16	6.25	43.71	28.60
		3	48.11	59.71	14.76	12.83	5.29	7.58	31.84	19.88
		averages	46.93	59.48	12.90	11.39	4.18	6.11	35.99	23.02

Conclusion: Analyzing the results of tables 1~2 and figures 3-5, we can see that: The main components of PV plant dust are Si, Ca, Mg and Fe. From the results of elemental analysis, it can be seen that the main component of the dust in each area is Si, and the roadside area has the highest content of Ca in addition to Si; the mining area and other areas have the highest content of Fe in addition to Si.

2.3 Dust contact angle test results for each experimental area of PV power plant

Table 3. Contact angle test results for each region of the PV plant

Sample No.	Test area	First time	Second time	Third time	Fourth time
1	roadside area	4.4	5.2	3.8	4.5
2	mining area	5.3	6.7	7.3	6.4
3	other area	6.8	5.7	7.6	6.7

Conclusion: Analyzing the results of Table 3 shows that: Generally the smaller the contact angle, the greater the adhesion. From the test results, it can be seen that the roadside area has the smallest contact angle and other areas have the largest contact angle. This means that the roadside area has the greatest adhesion of dust to the PV panels and is the least easy to clean. Other areas of the dust on the PV panel adhesion force is the smallest, easier to clean. As show in figure 6.

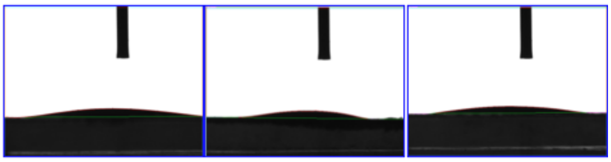

Figure. 6. Contact angle of different areas

3 Analysis of contaminant samples from different regions

3.1 R&D process

According to the physical and chemical characteristics of pollutants in different regions of PV power stations, we formulate targeted component pollutant management measures, and ensure the reasonableness and effectiveness of pollutant management by analyzing the pollutant composition and content before and after the laboratory management and testing the power of the components. Harmful substances in the air can be adsorbed on their surfaces, which are acidic or alkaline. Dust often contains clay and other substances, which will absorb the moisture in the air or in the material, making it undergo hydrolysis reaction and decompose the gelatinous aluminum hydroxide, which is alkaline. The different acidity and alkalinity of the dust on the corrosion of photovoltaic panels is different, the stronger the corrosion effect, the more serious the damage to the photovoltaic panel surface cover, there is also an impact on the efficiency of power generation, so from the chemical nature of the accumulated dust can be divided into: acidic accumulated dust, neutral accumulated dust and alkaline accumulated dust[9-11].

3.2 Usage

Pollutants on the surface of photovoltaic panels have a significant impact on their power generation efficiency. Surface pollutants not only affect the transmittance of light, which in turn affects the amount of radiation received by the component surface; pollutants adhering to the surface of the panel will also form a shadow, which produces a hot spot effect in the localization of photovoltaic modules, which causes damage to the photovoltaic panels, affecting the power generation rate and shortening the service life of the photovoltaic panels at the same time.

In order to verify the effect of the three detergents, three PV panel panels were taken, and the types of dust on the panels were as follows: the dust on the first one was dried and knotted dusty clay, the dust on the second one was alkaline oil, and the third one was acidic bird droppings. With three kinds of detergent will be three panels cleaned once, found that No. 1 detergent is suitable for scrubbing neutral pollutants; No. 2 detergent is suitable for scrubbing the weakly acidic exhaust oil stained panels; No. 3 detergent is suitable for scrubbing the bird droppings stains presenting a weakly acidic effect is very good. The specific experimental process is shown in Figs. 7-12.

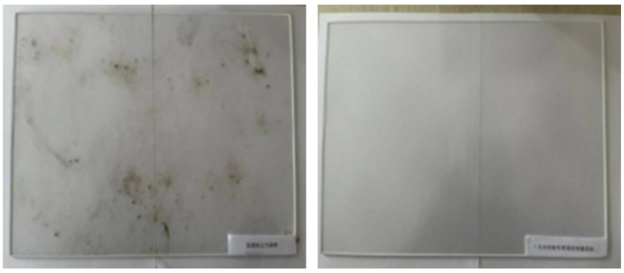

Figure.7. Neutral clay stains and after washing with detergent No. 1

Figure.8. Neutral clay stains and after washing with detergent No. 2

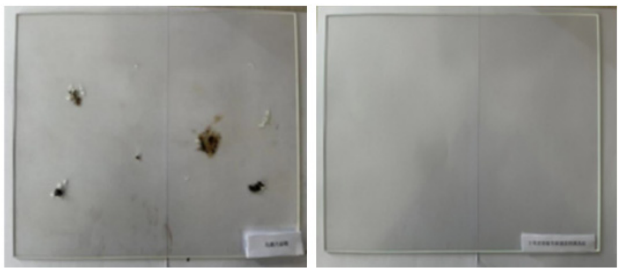

Figure.9. Neutral clay stains and after washing with detergent No. 3

From the experimental process and experimental results, it can be seen that the special No. 1, No. 2, No. 3 targeted special detergent for photovoltaic panels, no cost detergent, saving water resources, the cleaning effect is very good, and will not damage the surface of the panels at all. Therefore, in the future, it can be popularized and applied in the cleaning project of photovoltaic power station.

Figure. 10. Comparison of cleaning effect of cleaning agent No. 1

Figure. 11. Comparison of cleaning effect of cleaning agent No. 2

According to the in-depth observation and precise analysis of the on-site cleaning effect, No. 1 cleaning agent is effective in cleaning PV panels with dried dust, No. 2 cleaning agent is effective in cleaning PV panels stained with oil, and No. 3 cleaning agent is effective in removing PV panels stained with bird droppings. In order to meet the cleaning needs of different types of stained PV panels in the power station, the laboratory research has a targeted three cleaning agents. In the actual cleaning process, the cleaning agent is easy and convenient to operate, with excellent cleaning effect, high cleaning strength, without hurting the surface of PV panels, which greatly shortens the cleaning time, improves the cleaning efficiency, and at the same time prolongs the service life of PV panels, and contributes to the sustained development of photovoltaic power generation business.

Figure.12. Comparison of cleaning effect of cleaning agent No. 3

4 Conclusion

This paper investigates the analysis of pollutant composition and the development of cleaning reagents. First of all, for an agricultural photovoltaic complementary project three areas with typicality, take pollutant samples, after testing and analysis: in the roadside area, the pollutant contact angle is the smallest, indicating that the roadside dust on the photovoltaic panels has the strongest adhesion, cleaning difficulty is high; in contrast, the pollutants in other areas have a larger contact angle, the dust on the photovoltaic panels has less adhesion, the cleaning difficulty is relatively small, and the cleaning process is relatively easy. For the characteristics of different pollutants, several experimental reagents that can achieve the best results were developed. Developed three cleaning agents, in the laboratory and photovoltaic power station site, carried out a number of experiments to compare. The experimental results show that the cleaning effect of the three cleaning agents on different pollutants meets the expected standard, and can effectively clean the pollutants on the PV panels to ensure the stable operation of the PV power plant.

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