Experimental study on long-term aging of photovoltaic modules in plateau environment

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Abstract: There are some studies on the long-term aging power attenuation of components in China, but in Tibet, an area with high altitude and high ultraviolet intensity, there are no specific data and research materials on whether the attenuation factor of component power is the same as that in the mainland, whether the high altitude environment has an impact on the service life of components, and how the impact law is. The law and degree of aging attenuation of modules are an important basis for the maintenance of photovoltaic power stations. Therefore, it is very meaningful to study the long-term aging attenuation of photovoltaic modules in high-altitude areas.

Keywords: Photovoltaic modules; Plateau environment; Aging experiment

1. Introduction

Tibet Autonomous Region is located at the roof of the world, with high altitude and special geographical and climatic environment. The utilization of solar energy is a subject that needs to be seriously explored. With the large-scale promotion and application of photovoltaic power generation technology in Tibet, the factors affecting the power generation of photovoltaic modules have attracted more and more attention. At present, more and more attention has been paid to the power attenuation caused by natural aging and the reduction of power generation caused by dust on the surface of photovoltaic modules[1]. When photovoltaic modules are installed outdoors, dust will inevitably adhere to its surface. With the passage of time, it will accumulate more and more, which will have a certain impact on the power generation of modules. The factors affecting the dust falling on the surface of photovoltaic modules include wind speed, wind direction, air pressure, height, rain, snow and fog and many other factors[2]. Tibet is located in a mountainous area with high altitude. The wind direction changes frequently. The wind speed varies from high to low. Most areas can be divided into rainy season and dry season. In the rainy season, due to the scouring of rainwater, there is less dust residue on the surface of components, which has little impact on the power generation; However, in the dry season, due to the special climate environment in Tibet, such as dry, less vegetation, strong wind and more sand, it has a great impact on the power generation of components. Therefore, the study on the influence and law of dust on module power generation in plateau area has important guiding significance for the daily maintenance of photovoltaic electric field in Tibet.

2. Test methods and steps

Before carrying out relevant experiments, carry out pre experiments first. Conduct appearance inspection, determination of maximum power point and hidden crack test on all components in turn, as shown in Table 1.

Tab.1 Experimental steps

Steps	Test name	Test assembly
a	UV pretreatment	All PV modules
b	Appearance inspection	All PV modules
c	Determination of maximum power point	All PV modules
d	Crack test	All PV modules

2.1 Outdoor long-term aging test

The test method is based on the outdoor exposure test of photovoltaic modules, and the experimental steps are as follows.

(a) Place the pretreated photovoltaic module on the outdoor aging test platform, connect the resistive load with the module, and the resistance is R = Vmp / Imp.

(b) Open the test software related to the outdoor long-term aging test platform, so that the total radiation received by the component is 60kWh /m^2.

(c) The maximum power point determination test is carried out on the components, and the test results are compared with the previous test data.

(d) Continue to cycle outdoor exposure test and maximum

power point determination test. Until enough data is collected.
(e) During the test, the module can be subject to the hidden crack test periodically to check whether the crack of the battery inside the module changes with the outdoor exposure test. This item can appropriately adjust the test times and test interval according to the actual test data.

2.2 Effect of dust on power

In this paper, the influence of photovoltaic module surface covering on module power is mainly considered. The climate in Lhasa, Tibet is obviously divided into rainy season and dry season. Abundant rainfall in rainy season can well remove foreign matters on the surface of components, and dust has little impact on the power of components. However, in the dry season, without human intervention, a certain amount of dust will be attached to the surface of the module, which will have a certain impact on the power generation of the module after a long time of exposure and after rain, snow and strong wind[3]. The main research directions of this experiment are as follows:
(a) Impact of dust on component power in rainy season. Test method: the equipment connection is the same as the outdoor exposure test, and the maximum power point determination test shall be carried out on the components in different time periods. The time period can be 10 days, 20 days, 30 days, 40 days, 50 days and 60 days. The change of the time period can be adjusted according to the test data. Find the law through the test data. When the power changes little, the test at this stage can be stopped. During the periodic test, the component surface shall be kept in a natural state and shall not be wiped. According to the test data, adjust the test steps and carry out the corresponding verification test[4].
(b) Influence of dust on power in dry season. The test method is the same as the test method in rainy season. Appropriate modifications shall be made on its basis according to the actual situation.
(c) The impact of rain washing dust on power in dry season. In dry season, due to less rain, the rain can not completely wash the dust on the surface of the component, and there will be dust accumulation, which will have a great impact on the power of the component. In this experiment, when it rains in the dry season, the dust residue on the surface of the component is recorded in time by taking photos, and the maximum power point determination test is carried out. When the component is dusty and wiped clean, the power change is compared. Through many tests, the impact of rain washing dust on power in dry season is evaluated.
(d) In dry season, the influence of residual dust on power after snow melting. After snow melting, conduct the maximum power point determination test on the components in time, and compare the test data under the condition of dust and wiping clean. Through many experiments, find out its influence.
(e) In dry season, the change of component power after strong wind. After the strong wind, the maximum power point determination test shall be carried out in time to evaluate the impact of the strong wind on the component power. Repeat the experiment to find out the law.

3. Result analysis

3.1 Test result

From the following figures 1 to 3, it can be found that the power of the six 155 specification monocrystalline silicon modules working for 10 years has changed before and after wiping, and the power has increased after wiping, with a minimum of 8.0 watts and a maximum of 13.8 watts, with an average increase of 10.7 watts; According to the analysis, it is found that in the outdoor environment of Lhasa, the power attenuation of photovoltaic modules caused by dust will be 7.5% on average and 9.6% at most.

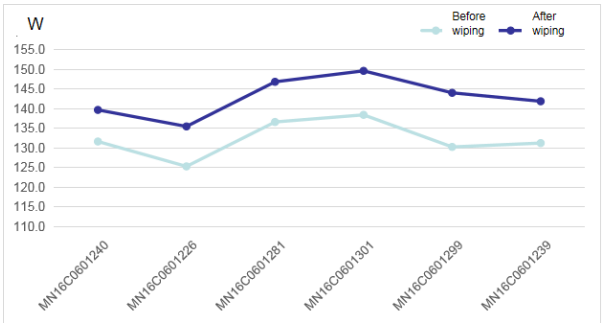

Fig. 1 Power curve of components before and after dust wiping after 10 years of operation

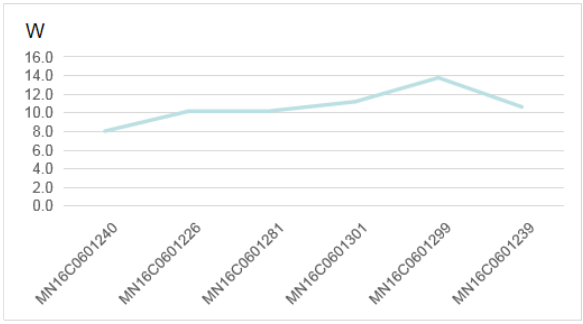

Fig. 2 Power attenuation curve of components before and after dust wiping after 10 years of operation

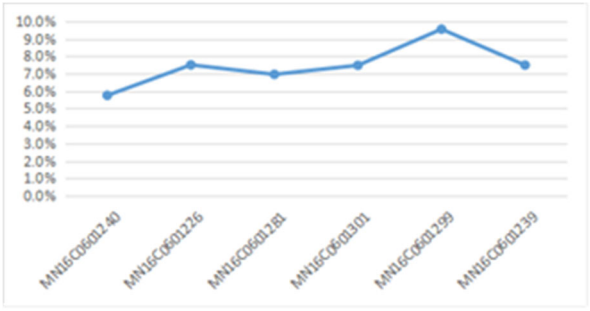

Fig.3 Power attenuation percentage of components before and after dust wiping after 10 years of operation

According to the following figures 4 to 8, it can be found that the dust on the surface of the module has a great

impact on the power of the module, which is 7.5%; Among them, it mainly has a great impact on the output current of photovoltaic modules, which is 7.5%, and has a small impact on the voltage, which is less than 0.5%.

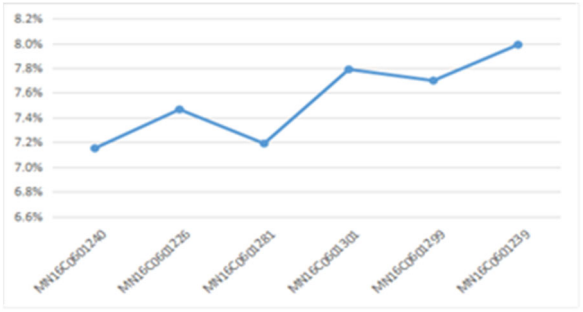

Fig.4 Short circuit current attenuation percentage

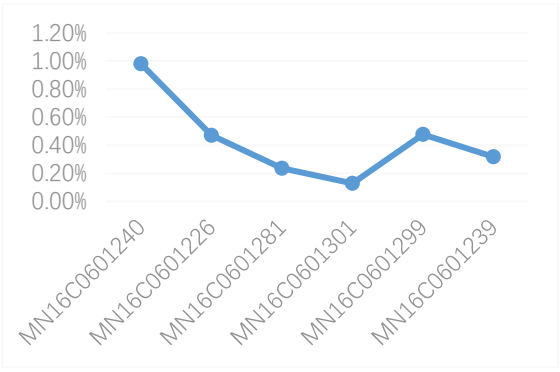

Fig.5 Percentage of open circuit voltage attenuation

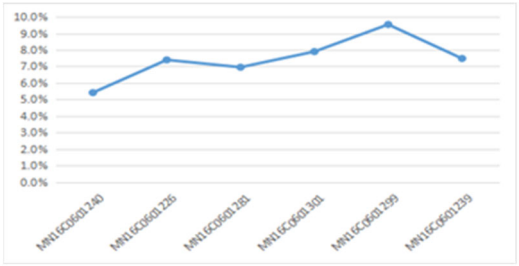

Fig.6 Current attenuation percentage at maximum power point

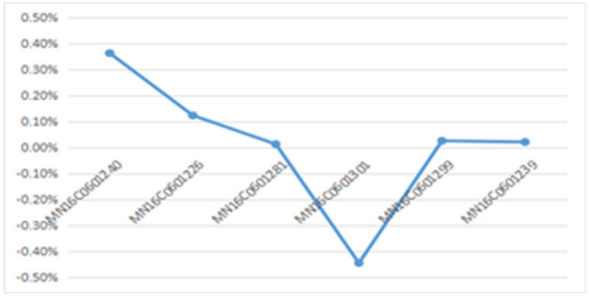

Fig.7 Maximum power attenuation point

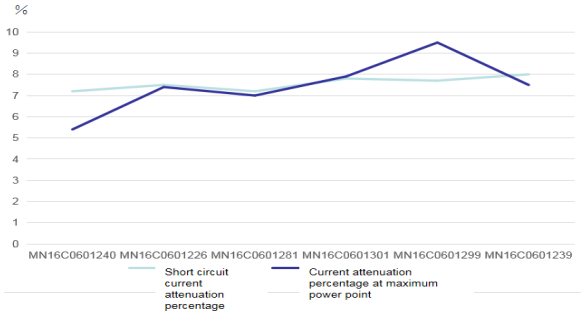

Fig. 8 Comparison of attenuation percentage of ISC and IPM

3.2 Influence of dust on component power in rainy season

The climate of Lhasa is obviously divided into dry season and rainy season. Generally, the rainy season is from May to October and the dry season is from November to April of the next year. It often rains in rainy season. The rain can wash the dust on the component surface, but there is some dust residue on the component surface. In order to test the impact of dust on module power in rainy season, four new single crystal modules and five polycrystalline modules are selected in this paper. After working outdoors for one month in Lhasa (July and August), the power change before and after module cleaning is tested. As shown in Figure 9 and figure 10.

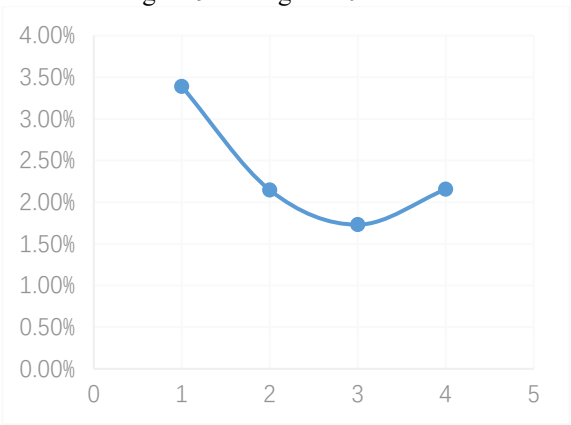

Fig.9 Power attenuation percentage of single crystal module before and after cleaning

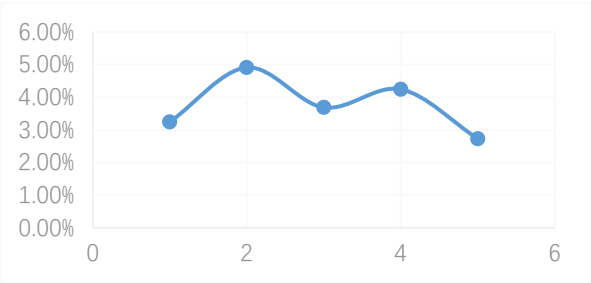

Fig.10 Power attenuation percentage of polycrystalline components before and after cleaning

According to the analysis of Fig. 9 and FIG. 10, during the rainy season in Lhasa (July and August), the impact of dust on the power of single crystal components after working outdoors for one month is 2.36% on average.

During the rainy season in Lhasa (July and August), when the polycrystalline module works outdoors for one month, the average impact of dust on its power is 3.76%. It is found that in the rainy season in Lhasa, the influence of dust on power is relatively small, and the power decreases by 2% - 4%, especially on polycrystalline components.

4. Conclusion

According to the above analysis, it is known that during the rainy season in Lhasa, rainwater can effectively clean the dust on the surface of components. Although there is some dust residue, it has little impact on the power of components, about 2-4%; In the dry season of Lhasa, dust has a great impact on the power of photovoltaic modules, more than 11%. For the photovoltaic modules that have been working in Lhasa for 10 years, we analyzed their test data and found that the power attenuation in 10 years is 9.93%, in which the voltage increases by about 1%, and the current decreases, especially the current attenuation at the maximum power point is 11.5%; In dry season, dust has a greater impact on its power, with an average of 7.5%, of which the impact on voltage is less than 0.5%, and the impact on current is greater, with an average of 7.5%.

According to the analysis of test data, it is found that in the dry season of Lhasa, the impact of dust on the power attenuation of modules working for 10 years is 7.5%, the impact of new photovoltaic modules is more than 11%, and the impact of dust on the power attenuation of old photovoltaic modules is less than that of new photovoltaic modules. It is found that the main reasons for this difference are that some stubborn stains on the surface of the old photovoltaic module are not easy to remove, and the glass on the surface of the module is related to the aging of the bottom texturing material.

To sum up, it is suggested that in Lhasa, Tibet, PV modules can be cleaned without manual cleaning in rainy season and once on the 15th-20th in dry season. In case of windy and sandy weather, it is recommended to clean them in time; The cleaning time interval of photovoltaic modules in other regions of Tibet should be cleaned according to the local climate characteristics. It is recommended to reduce the cleaning times when the rainfall is abundant, and once every half a month when the rainfall is scarce. In case of windy and sandy weather, it is recommended to clean them in time to ensure the power generation of photovoltaic modules.

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