Study on Yield Mechanical Properties of High Availability Materials before and after Aging for Intelligent Measurement Equipment

Angang Zheng¹, Xiangyu Yuan¹, Yifan Wang², Huaiying Shang¹, Yan Liu¹, Wulei Zhang³

¹China Electric Power Research Institute, Beijing, China
²North China Electric Power University, Beijing, China
³State Grid Henan Electric Power Co., Ltd., Henan, China

shanghuaiyingip@163.com

Abstract. One of the key technical research points in the field of smart grid measurement is to make a breakthrough in the detection and evaluation of high availability materials in intelligent measurement equipment. The comprehensive cross-action of multi-environmental stress brings a lot of data, how to find the key parameters in it, and how to analyze the complex environment into the characteristic combination of multiple single environmental factors, and the mathematical model of nonlinear evolution and service life of material aging based on the characteristic expression of the combination, all of the above are the key points and difficulties of the research. On the basis of the service life model, the research on differential protection measures and the study of life evaluation technology for smart grid measurement equipment can enable the equipment to realize wide-area application and high availability under more harsh conditions, which is one of the key points to improve the quality control in NQI system.

1. Introduction

The research of detection and evaluation of high availability materials of intelligent measurement equipment is an important link of the National Quality Infrastructure system. On the one hand, it can provide basic technical support and technical reserve for the wide-area reliable application of equipment in the field of measurement of smart grid, on the other hand, it can provide the corresponding technical standards, testing technology, evaluation technology, life control and so on for the quality control of equipment in the field of measurement, so as to make a positive push for the continuous improvement and leading development of NQI system in the field of smart grid measurement. [1-3]

Relying on the experimental base to design the aging test, the key index test data of the material in the typical environment of high cold, high dry heat, high altitude, high salt spray and high humidity heat are studied, and the nonlinear evolution and service life model of material aging under the comprehensive cross action of multi-environmental stress are abstracted, and the anti-aging and service life evaluation technology of the measurement equipment is studied.

According to the test data in extreme environment, the test design and testing technology optimization supplement or revise the corresponding technical standards, and based on the service life evaluation technology of the measurement equipment, the quality standard system covering the quality
control of the measurement equipment is constructed, so as to achieve the NQI four elements of high availability to support the smart grid measurement equipment technology reserves. [4-6]

2. Test Overview

2.1. Test materials subsection
This test is for the aging test of two materials used in the metering box: polycarbonate resin and acrylbutylene-styrene resin (PC-ABS) and glass fiber-reinforced unsaturated polyester mold plastic (SMC) under GB/T 23641.

(1) Polycarbonate resin and a butyl triamcine-styrene restyrene (PC-ABS) is a combination of polycarbonate resin (PC) and acrylonitril dipen-styrene (ABS) plastic, overcoming the original shortcomings of the two raw materials, to play their own advantages, that is, to enhance ABS heat resistance, impact and tensile strength. It also reduces the melt viscosity of polycarbonate, improves the stress cracking condition of THE PC, has good heat resistance, anti-impact, flame retardant properties, and has good mechanical properties in the ordinary temperature.

(2) Glass fiber enhanced unsaturated polyester mold plastic (SMC) has good strength, corrosion resistance, impact resistance, arc and smooth flat and other advantages, is widely used to replace metal materials.

2.2. Sample design
This test piece refers to the national standard "GBT 1043.1-2008 plastic simple beam impact performance determination" and the national standard "GBT 9341-2008 plastic bending performance determination" related content production, test type and size as shown in the figure.

2.3. Pilot scheme
Samples are collected from the metering box equidistant collection, each metering box collects about 28 samples, respectively, refers to the relevant standards described in the previous section for impact test and bending test, and records the impact performance before aging, pre-aging bending performance, post-aging impact performance and aging after bending performance.

2.3.1. Sample grouping
(1) Impact Group. A total of 3200 samples participated in the impact test, according to whether the aging is divided into 2 groups, each group is subdivided according to the intercepted box source, in order to avoid the accident of the test, each 7 for a group to test related performance, each group to remove the maximum and minimum value, the remaining 5 spline as the team's record value.

Impact strength \( a_{cu} \) is calculated as:

\[
a_{cu} = \frac{E_c}{h} \times 10^3 \tag{1}
\]

In the formula: \( a_{cu} \) for the impact strength of the specimen, \( E_c \) for the repaired specimen damage absorption of energy, \( h \) for the pattern thickness, \( b \) for the pattern width.

(2) Bending group. A total of 3200 samples participated in the impact test, according to whether the aging is divided into 2 groups, each group is subdivided according to the intercepted box source, in order to avoid the accident of the test, each 7 for a group to test related performance, each group to remove the maximum and minimum value, the remaining 5 spline as the team's record value.

Impact strength \( a_{cu} \) is calculated as:

\[
\sigma_b = \frac{3PL}{2bh^2} \tag{2}
\]

In the formula: \( \sigma_b \) for the specimen bending strength, \( P \) for the specimen destruction load, \( L \) for the span, \( b, h \) are the width and thickness of the specimen.
2.4. Test equipment

(1) Material aging equipment

The equipment used in the aging of the test parts is the Q-sun xenon lamp aging test machine produced by Q-Lab, the model is xe-3-H, according to GB/T 16422.2-2014, the aging environment in this test is set to: wavelength 290 to 800 nm, choose 550 W/m2 Temperature 65°C, humidity 65%, each spray 18 min, no water 102 min, cycle 500 hours.

![Material aging equipment](image1)

Figure 1. Material aging equipment.

(2) Impact equipment

Test impact using Chengde Jinhe Instrument Manufacturing Co., Ltd. production of XCJD-5 type micro-controlled simple beam impact test machine, model XCJD-5, in line with the GBT 1043.1-2008 plastic simple beam impact performance determination Part 1: non-instrumental impact test, BS EN ISO179-1 : 2001 Plastics-Kry of Charpy impact properties -Part 1: Non-instrumented impact test, GBT 21189-2007 Plastic simple girders, cantilevers Beam and stretch impact test with the hammer impact test machine test, JB/T 8762-1998 plastic simple beam impact test machine and other standards, impact speed 2.9 m/s, swing hammer angle 150 degrees, the strike center distance of 230 mm, the test used in the 5 J swing hammer torque PL =2.6795 N·m.

(3) Bending equipment

The test piece bending is made by Chengde Jinhe Instrument Manufacturing Co., Ltd. of the WDW-2 type microcomputer-controlled electronic universal test machine, which can produce a maximum test force of 2 kN, test force accuracy of 0.1%, test force measurement range of 2%-100% Fs, displacement measurement accuracy of 0.1%, speed range 0.01 mm/min- 500 mm/min; speed accuracy of up to 1%, resulting in a maximum compression travel of 600 mm, the loading speed of 2 mm/min was used in this test.

![Impact equipment](image2)

Figure 2. Impact equipment.

![Bending equipment](image3)

Figure 3. Bending equipment.

3. Test results and analysis

3.1. Experimental physical phenomena and characteristics
In the course of the impact test, due to polycarbonate resin and a butyl triene-styrene resin relative to glass fiber-enhanced unsaturated polyester mold plastic has better toughness, the spline in the absorption of pendulum fall kinetic energy, the production of about 20 degrees of small plastic deformation; The sample breaks quickly and only a small part is connected.

In the process of bending test, glass fiber enhanced unsaturated polyester mold plastic due to higher strength, load increase early, the appearance of the sample no significant change, no significant change in the loading process, with the increase in deflection, the sample produces local fracture, the end of the test. Polycarbonate resin and a butyl triene-styrene resin in the test process to produce a more obvious bending, reached the specified deflection after the load disappeared, the sample shape recovered, did not break.

3.2. Related data analysis
Calculate the impact strength before and after the sample aging based on the absorption energy of the sample shock process collected by the impact test equipment, as well as the pre-measured sample size and span, and calculate the bending strength before and after the sample aging according to the maximum load of the sample collected by the equipment and the sample size and span. The average impact strength and average bending strength of each batch of samples are calculated according to the results. [7-9]

3.2.1. Impact. After the aging of the two materials, the impact strength of most of the impact strength has a certain degree of impact intensity decay. Among them, polycarbonate resin and a butyl-butylene-styrene resin (PC-ABS) impact strength decreased by an average of 2.36%, and glass fiber-enhanced unsaturated polyester mold plastic (SMC) impact strength decreased by an average of 8.23%. [10-11]

![Figure 4. Impact Intensity Attenuation of PC-ABS](image1)

![Figure 5. Impact Intensity Attenuation of SMC](image2)

3.2.2. Bending. After UV aging, the fiberglass-enhanced unsaturated polyester mold plastic (SMC) has a more obvious bending strength attenuation, the average bending strength attenuation of 8.25%, polycarbonate resin and acrylbutene-styrene resin (PC-ABS) bending strength attenuation is not obvious, about half of the samples have a small performance enhancement, Approximately 52.5% of the sample review, the average bending strength of the sample increased by 0.3%. [11-13]
By using Pearson, Spearman and Kendall, the correlation between the impact performance and bending performance before and after aging of the two materials was analyzed, and the impact strength and bending intensity of the two materials were not correlated. That is, high availability materials do not have the correlation of aging resistance in different directions. [14-15]

| Correlation coefficient | p         |
|-------------------------|-----------|
| Pearson                 | 0.06748   |
| Spearman                | -0.00156  |
| Kendall                 | 0.0069    |

4. Conclusion

(1) After the test set UV aging process, polycarbonate resin and butene-styrene resin (PC-ABS) can still maintain good bending strength. In contrast, UV aging has a more obvious impact on the material performance of fiberglass-enhanced unsaturated polyester mold plastic (SMC), which reduces the impact strength and bending strength of the material, and the elastic mode has a certain increase, indicating that the external aging environment will reduce the material’s extreme deformation rate. It is recommended to pay attention to the adverse effects of the external environment when designing glass fiber-reinforced unsaturated polyester mold plastics that are exposed to the external environment for a long time.

(2) After the experimental application of the UV aging process, there is no definite relationship between the bending strength and impact strength of the two materials. That is, when the impact strength performance of the two materials with aging significantly reduced, it can not be concluded that its bending strength performance will be reduced at the same time, the opposite is the same. Whether this correlation will change with the change of aging time and the change of aging process has yet to be further experimentally verified.

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