Experimental Investigation of Insulators' Icing Based on XMNIT

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1 Introduction

Background

- China is one of the countries which are frequently attacked by icing and icing accidents have reached up to thousands of times.
- Icing is a serious threat to the operation of power system.
- In early 2008, the freezing rain, rare in the history, attacked the south of China. This disaster brought great economic losses.

1 Introduction

- **Icing Environmental Conditions in Nature**
  - **Air temperature**
  - **Wind velocity and wind direction**
  - **Water droplet diameter**
  - **Liquid water content**

1 Introduction

Test Environments

Artificial climate chamber

- ✓ Easy to control environmental parameters
- ✓ Not limited by the season
- ✓ Repeat test

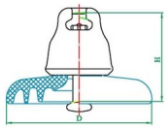
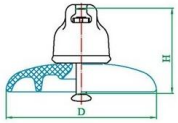
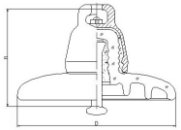
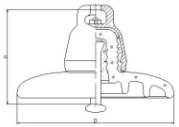
Natural environment

- ✓ Complicated and varied
- ✓ Weak repeatability
- ✓ Time-consumption

2 Tested Insulators

Tested Insulators

Tab.1 Dimensions of insulators

Types	*D*	*H*	*L*	Profile
XP-300	320	195	370	
XP-70	255	146	295	
LXY-300	320	195	485	
LXY-160	280	170	400	

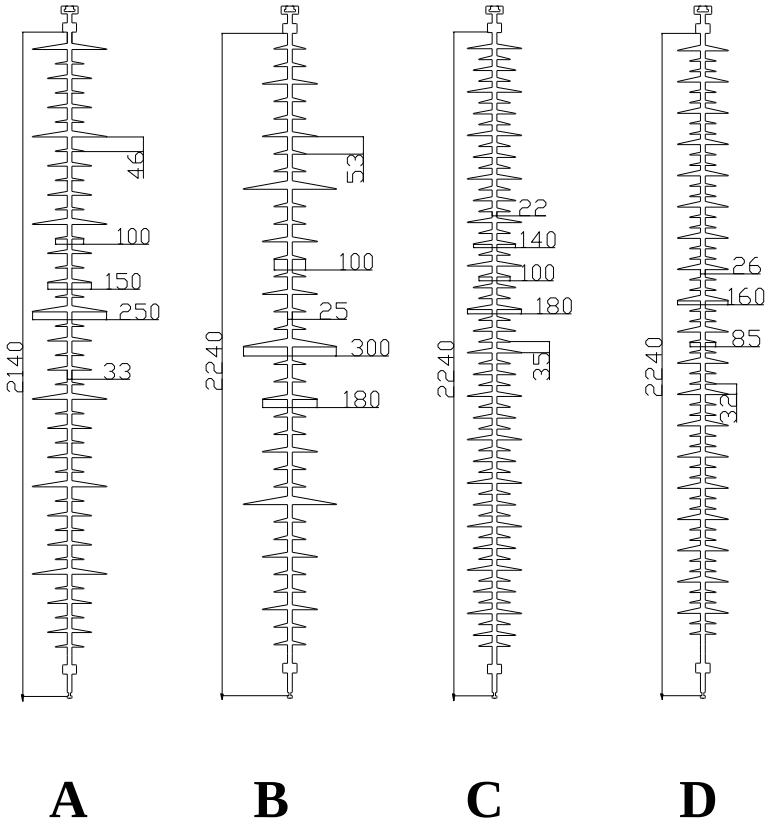


Fig.1 Profiles of composite insulators

3 Simulation and Analysis

Meteorological parameters

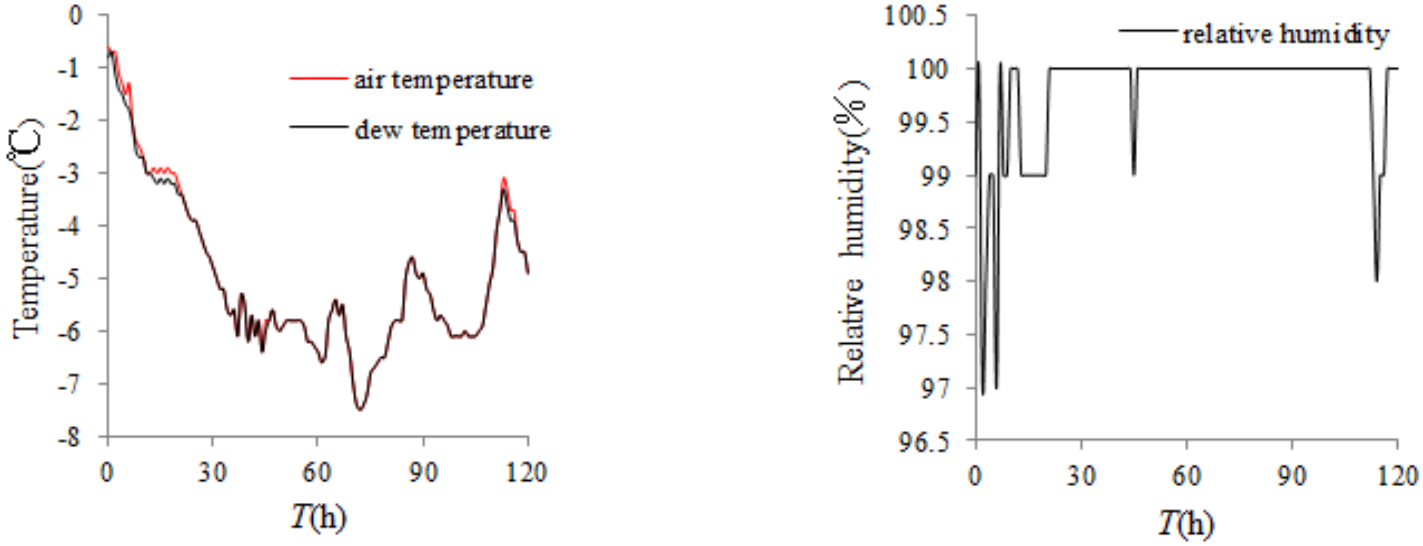


Fig.2 Ambient temperature and relative humidity

- ✓ **Air temperature was always below 0 ℃. Due to effect of wind, it declines linearly at early stage.**
- ✓ **Relative humidity remained at 100 % during the icing period, and it provided sufficient super-cooled water droplets for atmospheric structure icing.**

3 Simulation and Analysis

Meteorological parameters

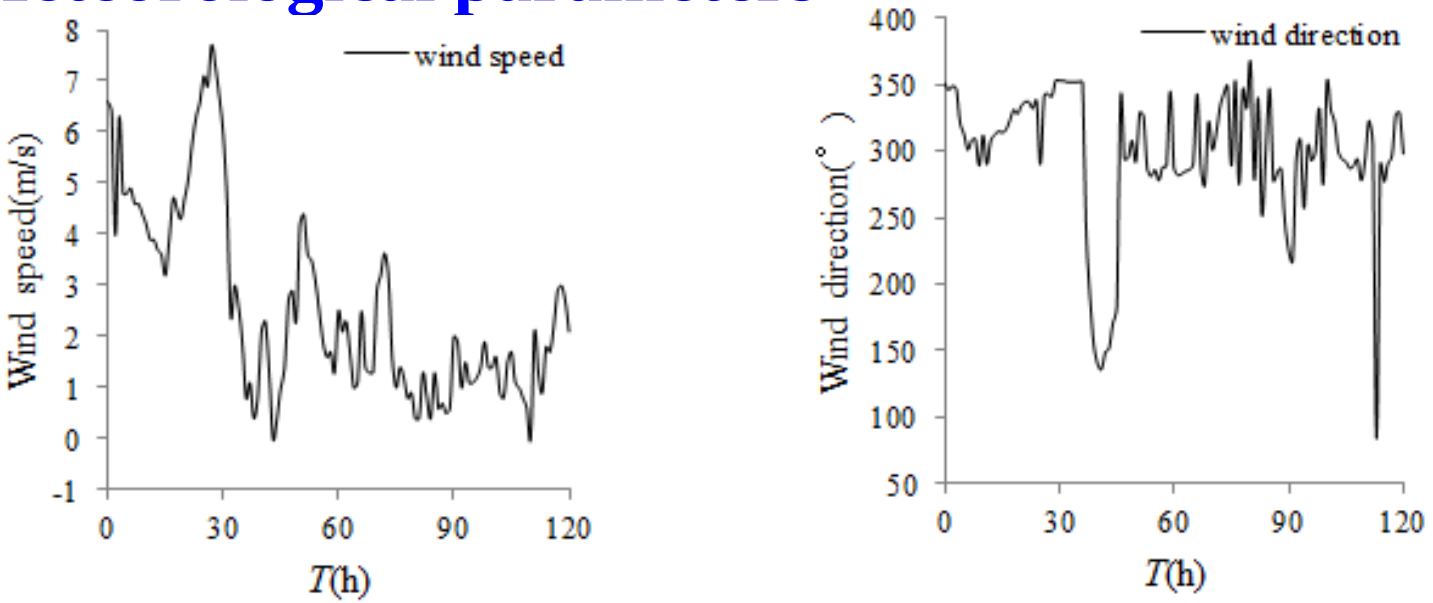


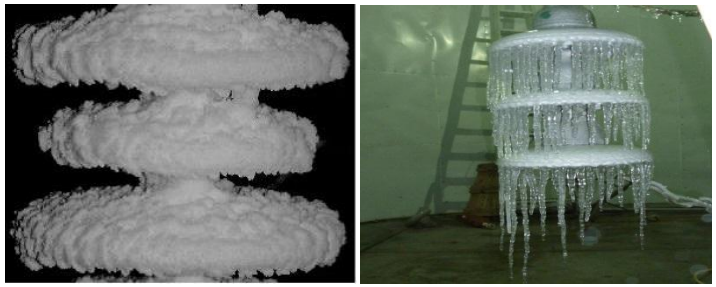
Fig.3 Wind velocity and wind direction

- ✓ **Wind velocity was high at the early stage and then fluctuated with alternative day and night.**
- ✓ **During most time of the ice period, wind blew from the northwest and north.**

3 Test Results and Analysis

Icing appearance

Test environments have a great influence on the icing appearance.



- ✓ **in the artificial climate chamber, two types of ice (glaze and rime) are uniform.**

- ✓ **However, in field test, it is totally different. Ice mainly exists on windward side of insulator and there is almost no ice on leeward side.**

Fig.4 Icing appearance

3 Test Results and Analysis

Growth of ice mass

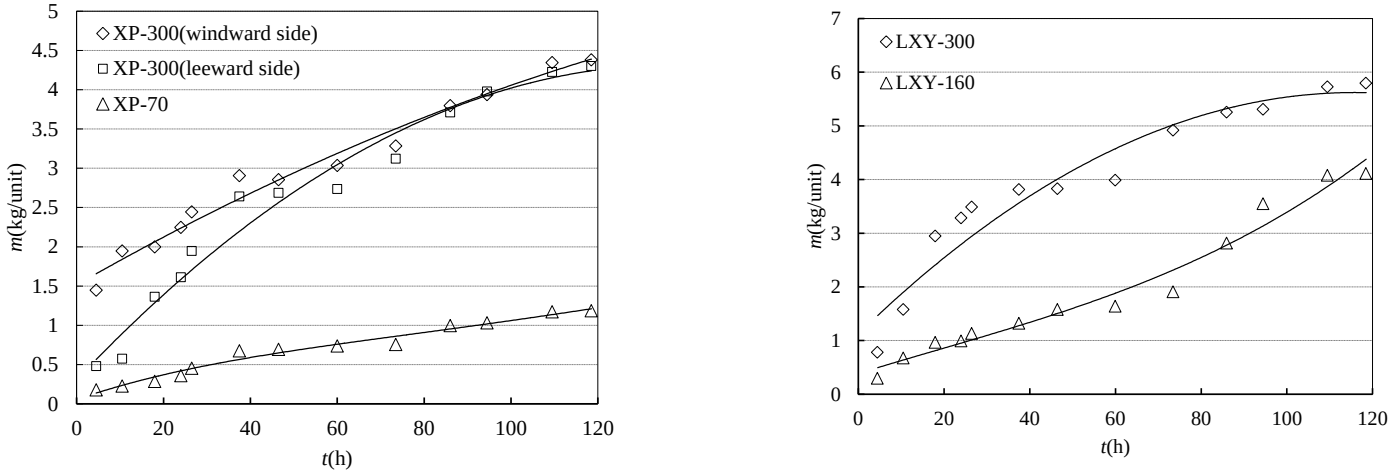


Fig.5 The growth of ice mass of insulator strings

- ✓ **The ice mass grows nonlinearly, while the growing degree is varied with the increasing of time**
- ✓ **The larger diameter of the sheds of XP-300 and LXY-300 with the larger windward area could capture more super-cooled water droplets leading to more severe icing.**

3 Test Results and Analysis

- **Schematic diagram of experimental measurement**

Fig.6 The schematic diagram

This paper selects the extended length of icicle attached on the surface of insulator (l), ice thickness of the shed (d_0) and ice thickness of insulator's leeward side (d_1) as ice characteristics of ice-covered insulator.

3 Test Results and Analysis

- **Relationship between ice characteristics of ice-covered insulators and icing time**

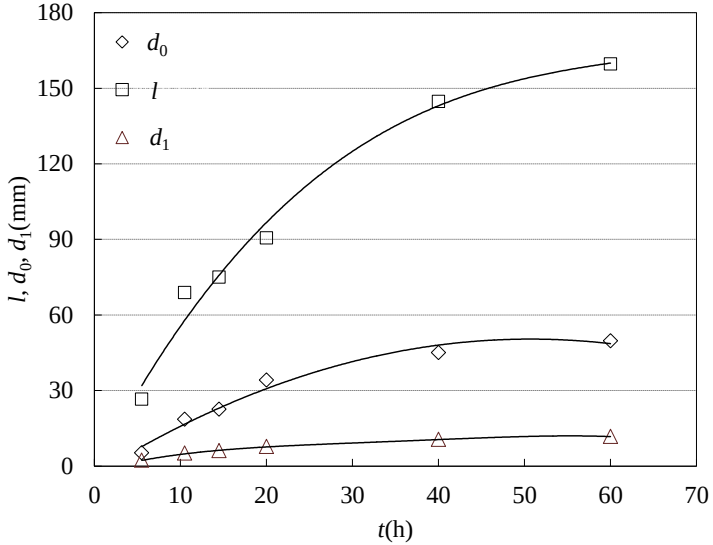


Fig.7 Relationship between ice characteristics and icing time

It is obvious that the ice growth rate of d_0 is significantly faster than that of d_1 and then both grow slowly. This can be explained by the fact that the shape of insulators is changed by ice, which results in E reducing.

3 Test Results and Analysis

- **Relationship between *l* and icing time**

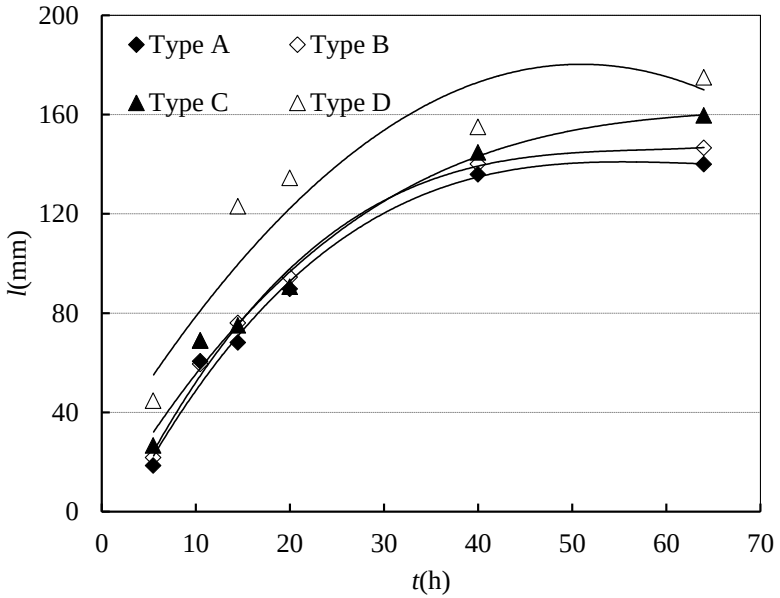
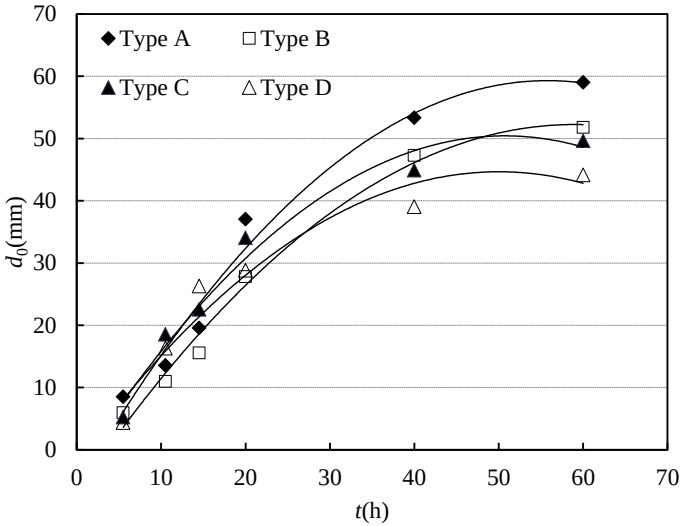


Fig.8 Relationship between *l* and icing time

l grows nonlinearly with time increasing. As icing continues, the shape of insulator has been changed and the equivalent diameter of insulator is larger. Thus, *E* further reduces. Then, *l* tends to be saturated, which is also affected by the decrease of wind speed in the later stage.

3 Test Results and Analysis

Relationship between d_0 and icing time



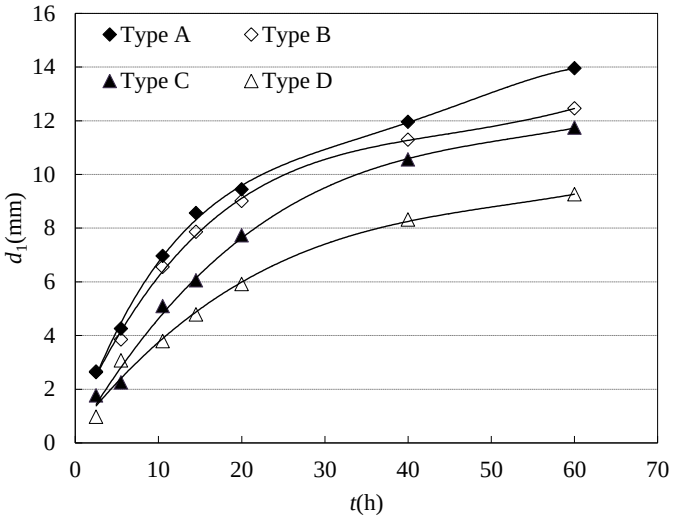
d_0 will first increase with an increase in the icing time, and then change very slowly.

Fig.9 Relationship between d_0 and icing time

- ✓ **Water droplets obtain larger kinetic energy and more likely to collide with the insulator.**
- ✓ **The increase of wind velocity accelerates the process of heat exchange of water droplets.**

3 Test Results and Analysis

Relationship between d_1 and icing time



The ice thickness of icing on the surface of leeward side (d_1) demonstrates a nonlinear growth with the increase of time, but the growth degree will slow down along with the increase of time.

Fig.10 Relationship between d_1 and icing time

- ✓ when water droplets carried by wind bypass the rod of insulator, the velocity dramatically drops leading to the decrease of collision coefficient, thus there is little ice existed on the leeward side.

3 Test Results and Analysis

Ice mass

Tab.2 Ice mass

Types	A	B	C	D
Ice mass (kg)	16.15	16.94	17.32	17.09

- The ice mass of Type C and D is heavier than that of other two insulators.
- The number of shed of Type C and D is bigger.
- The diameter of the maximum shed of Type A and B is larger, which reduces the ice.

4 Conclusions

(1) There are considerable differences between the icing formed under artificial environment and that formed under natural environment.

(2) With the increase of time, the ice mass will grow nonlinearly, while the grow degree slows down. Icing of insulators arranged on the windward side is somewhat more serious than that arranged on the leeward side.

(3) The increase of the length of windward side shows a nonlinearly growth with the increase of time. The growth degree at the first stage is rapid, while it slows down at other two stages.

Thanks For Your Attention!