重庆大学 CHONGQING UNIVERSITY

SKL-PES 输配电装备及系统安全与新技术国家重点实验室 State Key Laboratory of Power Transmission Equipment and System Security

Study on Icing Characteristics of Bundle Conductors Based on Xuefeng Mountain Natural Icing Station

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CONTENTS

1 Background

- China is one of the countries in the world that has the most serious icing on transmission line.
- Icing can damage mechanical and electrical properties of transmission line, which cause the ice accidents and have a strong impact on the security and reliability of power network。

1 Background

Icing disaster of power network at home and abroad

- The most serious ice rain and ice storm attacked the eastern Canada and northeastern America in January of 1998.About 4.7 million people from Canada and 500 thousand people from America were affected for some time.
- Ice Storm for three days happened in December of 1998. 38 main transmission lines were taken offline.500 MV electricity couldn't deliver so that more than 3.5 million families suffered from power failure.
- In November of 2005,snow and ice disaster which happened in German leaded to collapse of overhead line structures and massive power failure.
- In the period between January of 2006 and June of 2007 in China, the number of 500kv line tripping caused by icing is 13, which is accounting for 8.84% of total line tripping. The number of no-plan outage of 500kv line caused by icing is 4, which is accounting for 11.11% of total outage.

1 Background

***Why** we study Icing Characteristics of Bundle Conductors*

- With the accelerating pace of economic development and increasing of power requirement, bundled conductor has been a main style of erection in order to restrain corona development and reduce the line impedance, especially in the EHV and UHV.

- Research on icing characteristic of Bundle Conductors are a very important theoretical value for mechanism study of bundle conductor in rime and buildup of forecast model.

2 Test platform

Panorama of Xuefeng Mountain Natural Icing Station

Altitude: 1400 meters high
Period ice: Between November and March in next year

Max wind speed: 25m/s
Annual precipitation: over 1800mm

2 Test platform

Measuring Equipment

Automatic meteorology

Electronic scales

3 Sample and Methods

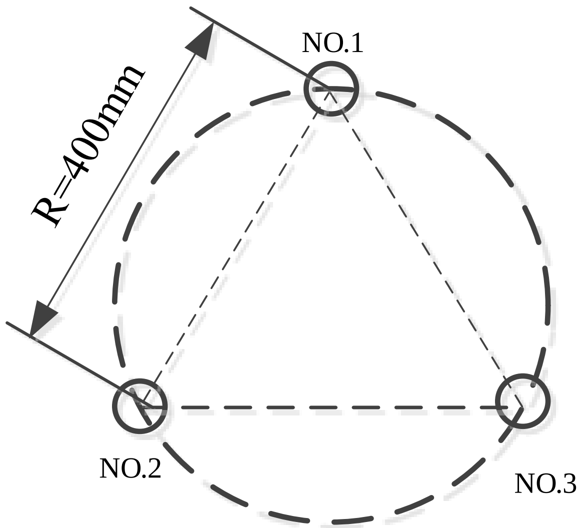
Basic parameters of conductors

No	Types of wire	Diameter of wire(mm)	Material	Bundle spacing(mm)
)1	single conductor	16.36	ACSR	
2	3-bundle conductor	18.88	ACSR	400
3	4-bundle conductor	24.26	ACSR	450

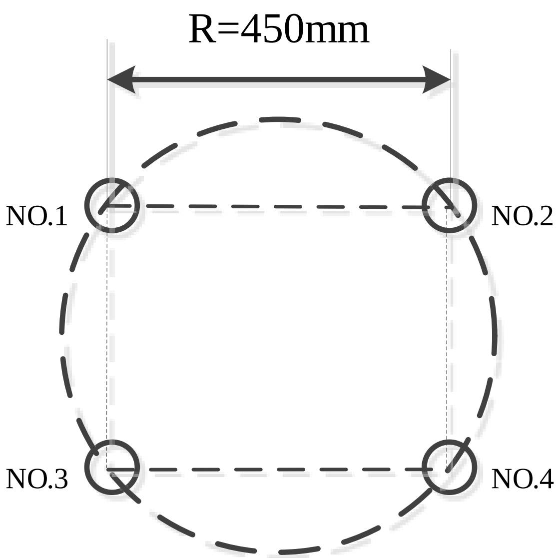
ACSR: aluminium conductor steel reinforced

3 Sample and Methods

Structure diagram of conductors



3-bundle conductor



4-bundle conductor

3 Sample and Methods

Measuring Method of Shape:

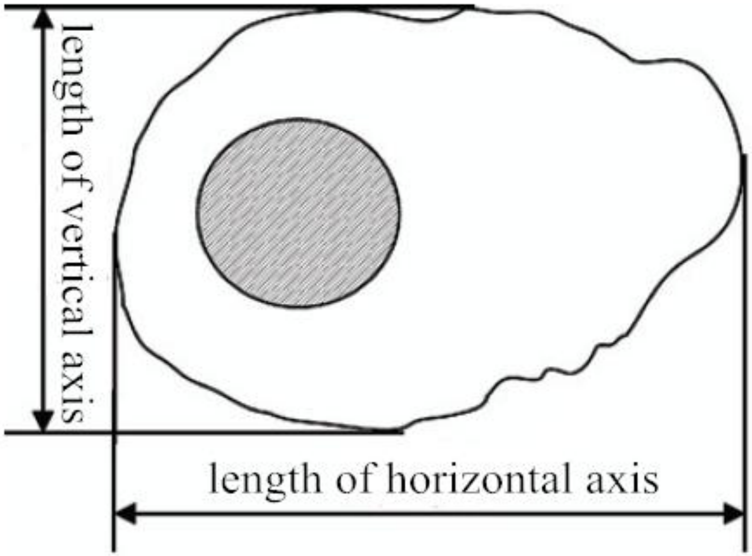
(a)

(b)

- Firstly, an incision on the ice layer should be made
- Secondly, a hole with the same diameter as the conductor on the paper should be taken. And then, a channel from the edge of the paper toward the hole should be cut.
- The ice conductor through the hole on the paper should be inserted.
- Thirdly, sketch the outline of the ice layer on the paper.
- Finally, the area of the ice layer can be easily obtained using AutoCAD software based on the sketch.

3 Sample and Methods

Measuring Method of Thickness:

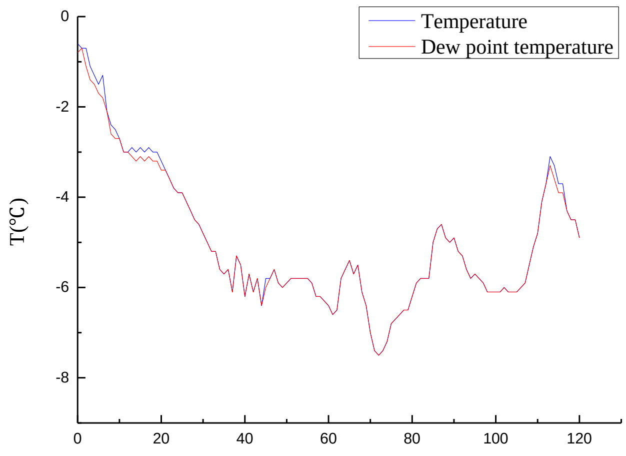


Length of horizontal axis: the length of ice at windward side.

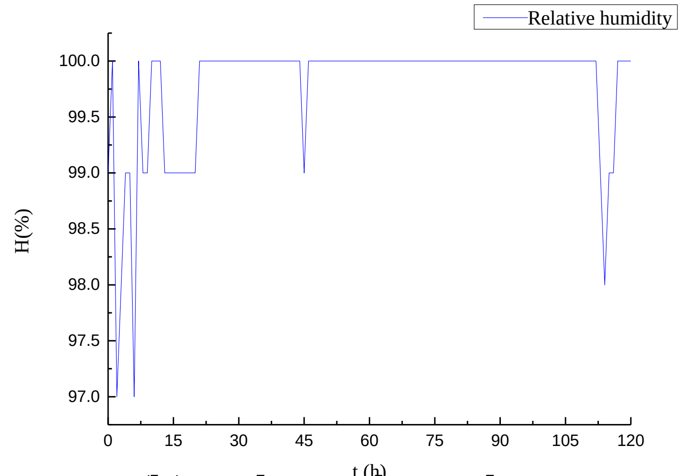
Length of vertical : the length of ice at the direction which was perpendicular to the wind

4 Results and Analysis

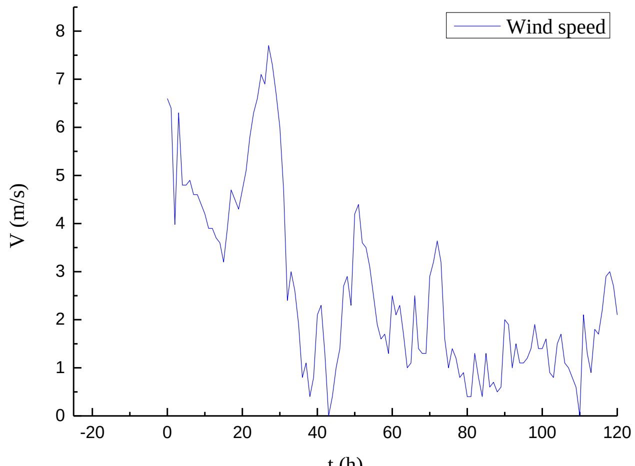
4.1 Meteorological condition



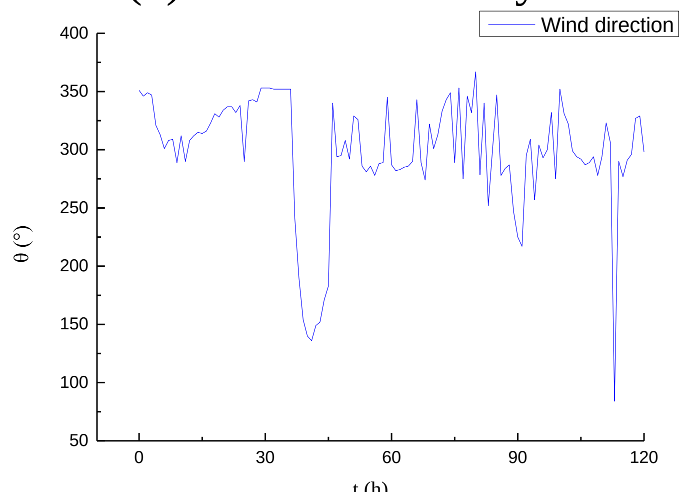
(a) Temperature



(b) Relative humidity



(c) Wind speed



(d) Wind direction

4 Results and Analysis

4.2 Ice thickness of Bundle Conductors

Relationship between icing thickness of **single conductor** and time

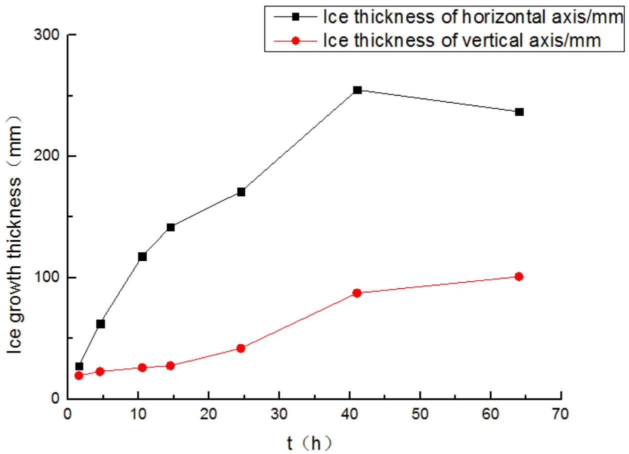
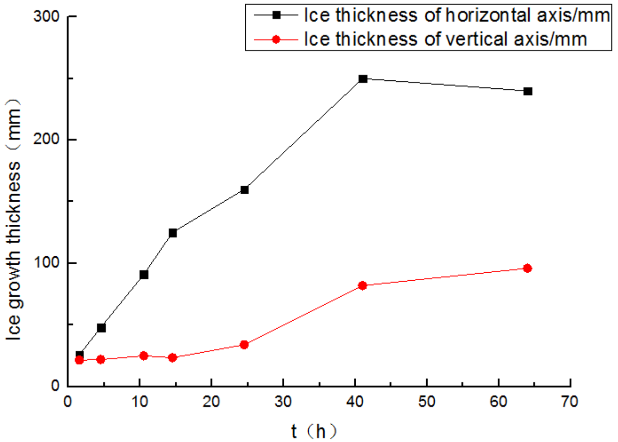
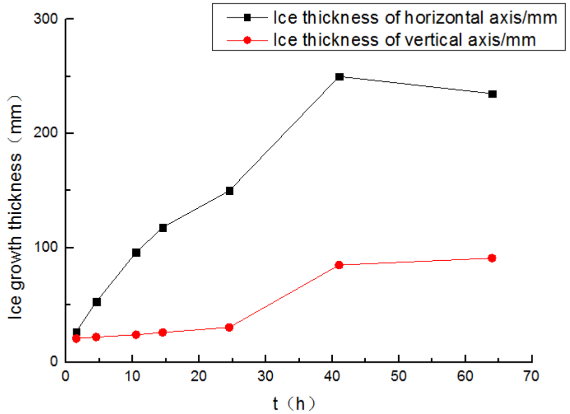


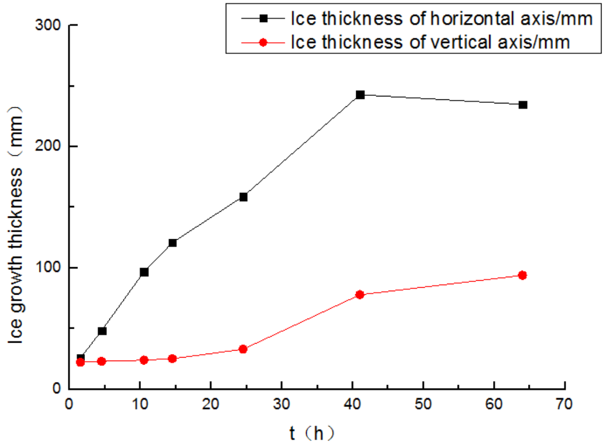
Fig. 5 Relationship between icing thickness of **3-bundle conductor** and time



(a) No.1 sub-conductor



(b) No.2 sub-conductor

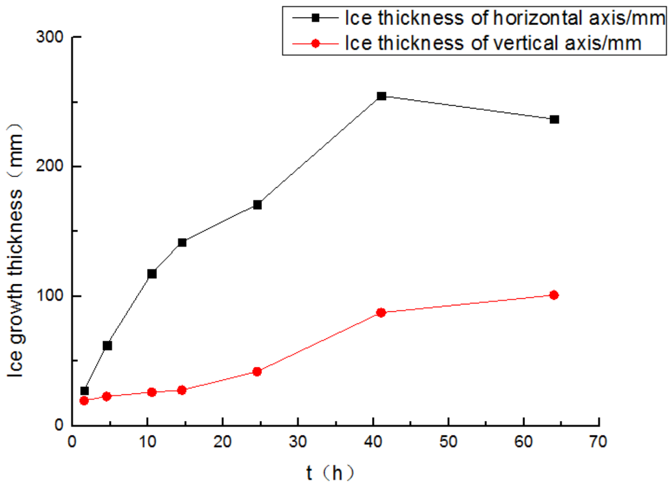


(c) No.3 sub-conductor

4 Results and Analysis

4.2 Ice thickness of Bundle Conductors

Relationship between icing thickness of **single conductor** and time



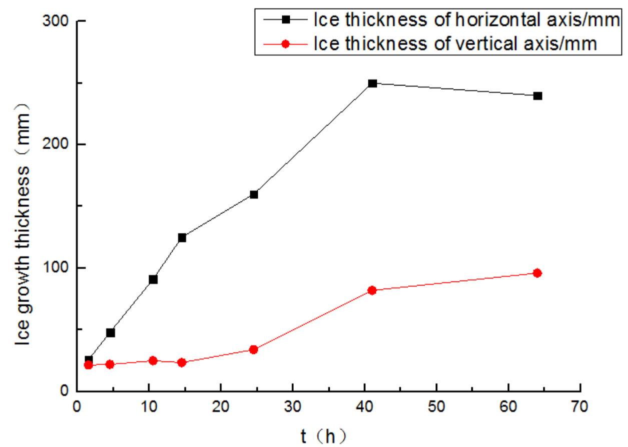
- Growth speed of horizontal axis is distinctly different with which of vertical axis for both 3-bundle conductor and single conductor in the process of ice.
- The growth of ice thickness is a nonlinear process.
- Ice growth on single conductor is faster than any other two kinds of conductor due to smaller diameter of conductor.
- The max specific value of ice thickness between horizontal and vertical axis is above 5. The value in saturation is about 2.5.

4 Results and Analysis

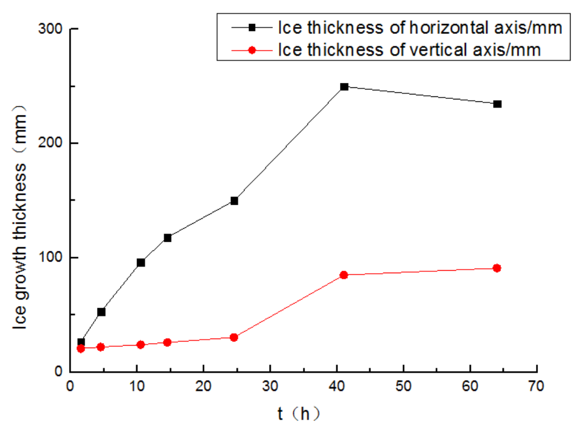
4.2 Ice thickness of Bundle Conductors

- No.1 and No.2 sub-conductor which in vertical direction had almost no difference. However, the max thickness of No.3 sub-conductor located in lee side was slightly lower than that of No.2 sub-conductor located in windward from the horizontal direction.
- Compared with single conductor, the max thickness of sub-conductor which is located in lee side of horizontal direction is less.

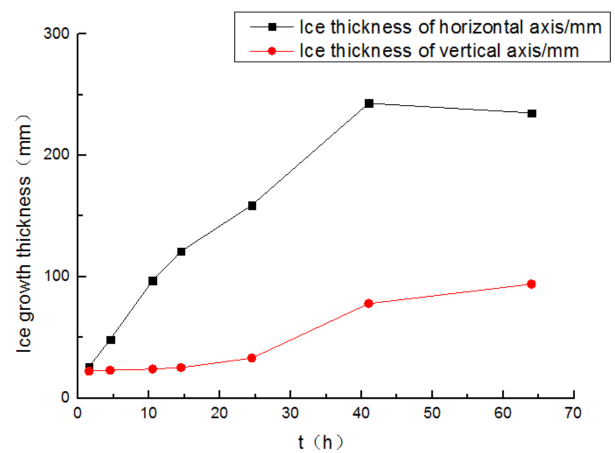
Relationship between icing thickness of **3-bundle conductor** and time



(a) No.1 sub-conductor



(b) No.2 sub-conductor



(c) No.3 sub-conductor

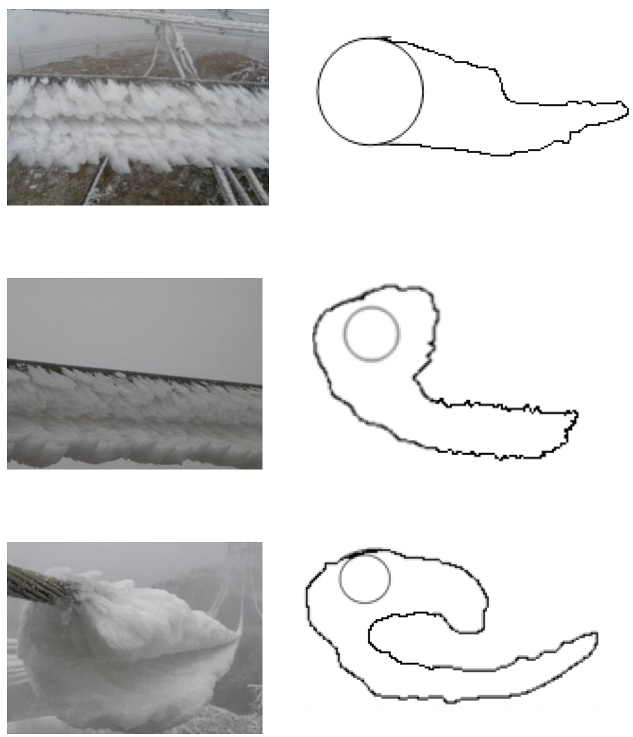
4 Results and Analysis

4.3 Ice shape of bundle conductor

17h

38h

64h

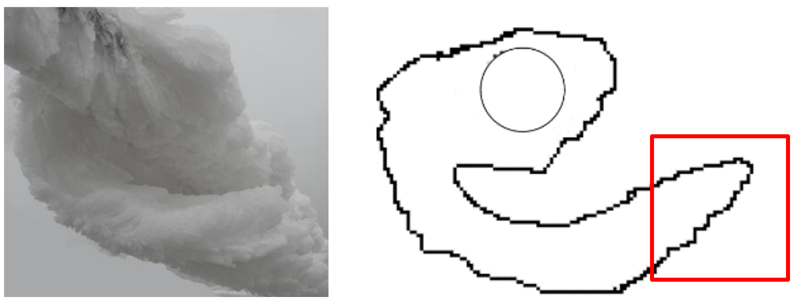


Single Conductor

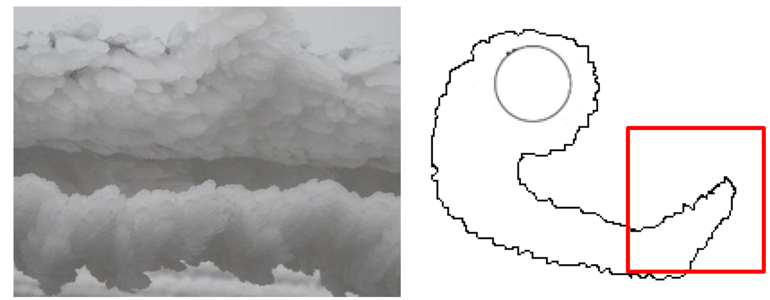
- In initial stage, icing on windward of conductor was relatively uniform, but icing on lee side of conductor was rare, which was thin and nonuniform and even without ice in some places.
- Ice period from seventeen hours, ice on windward of conductor grows rapidly. There is layered phenomenon in ice, the length of which under layer is 3 times longer than that of upper layer.
- Ice period over sixty-fourth hour, both ice under layer and ice on upper layer was thickened, and the dent of stratification was much deeper than before.

4 Results and Analysis

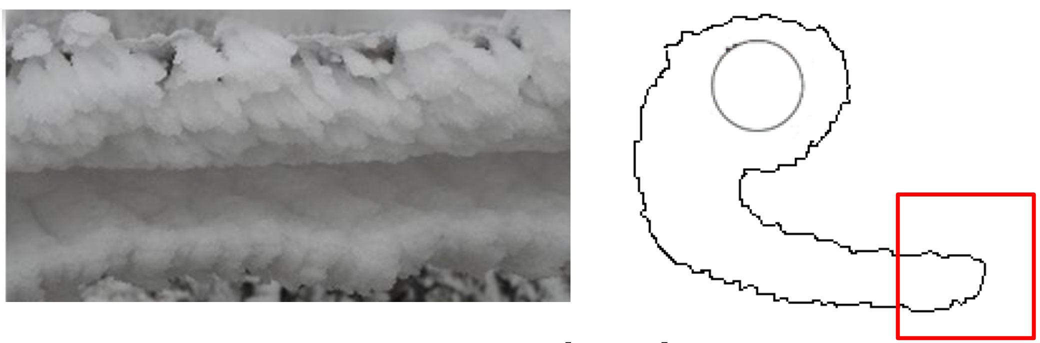
4.3 Ice shape of bundle conductor



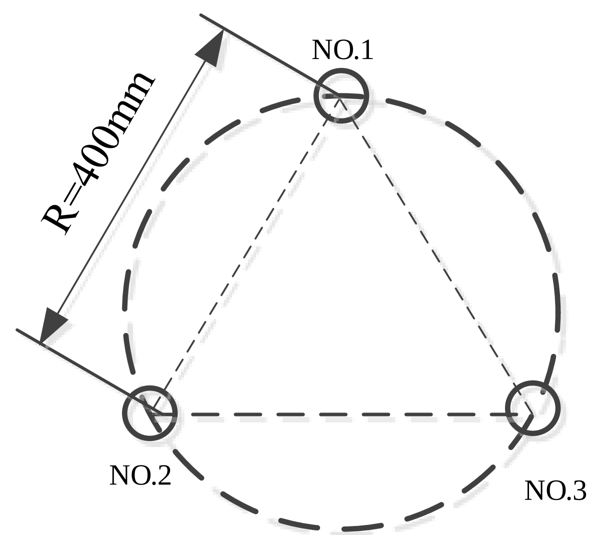
NO.1 sub-conductor



NO.2 sub-conductor



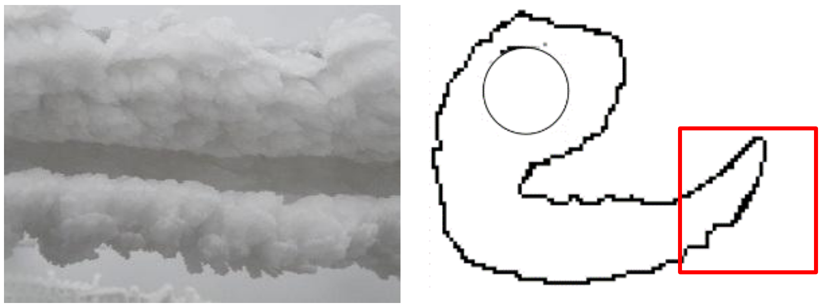
NO.3 sub-conductor



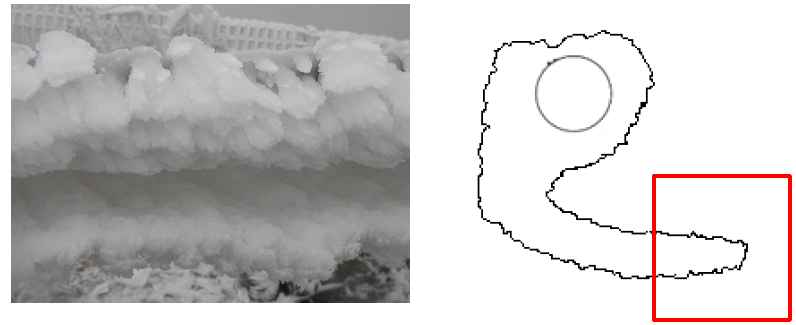
3-boundle Conductor in Saturation

4 Results and Analysis

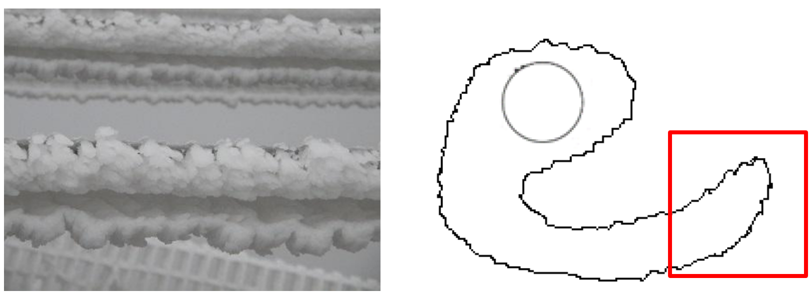
4.3 Ice shape of bundle conductor



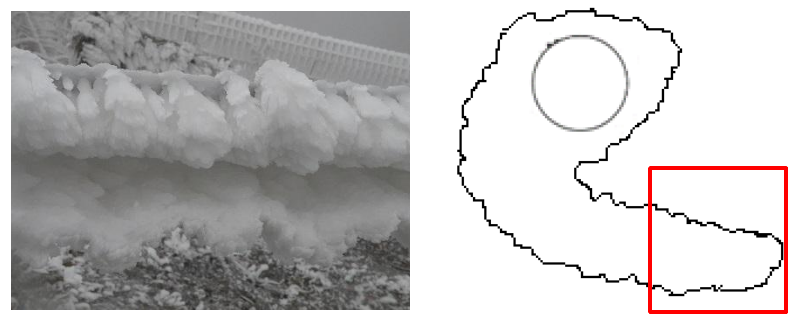
NO.1 sub-conductor



NO.2 sub-conductor

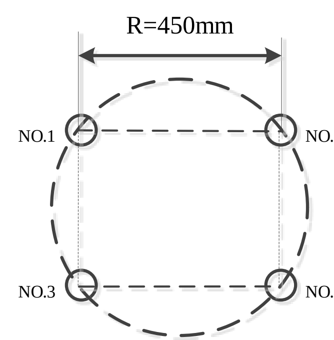


NO.3 sub-conductor



NO.4 sub-conductor

4-boundle Conductor in Saturation



4 Results and Analysis

4.4 Ice weight of bundle conductor

Ice Weight in Saturation

Types	Single conductor	3-bundle conductor	4-bundle conductor
ice weight (kg/m)	5.8	5.83/5.81/5.61	5.93/5.63 5.79/5.59

- Compared with single conductor, the total amount of ice on multiconductor bundles is far more ,but the average ice weight on single conductor is more than that on 3- bundle and 4-bundle conductor .
- The sub-conductor on lee side has less weight than that on weather side, because wake flow may affect the icing of sub-conductor on lee side .

5 Conclusion

- (1) Growth speed of horizontal axis is distinctly different with which of vertical axis for bundle conductor in the process of ice. The specific value of ice thickness between vertical and horizontal axis is above 5. The value in saturation is about 2.5.
- (2) The growth of ice thickness is a nonlinear process. Icing on conductor at the initial stages and metaphase grew fast, while it tended to saturation in later period. Ice growth on single conductor is faster than any other two kinds of conductor due to smaller diameter of conductor.
- (3) When ice reached some thickness, the weight of ice was able to make the conductor twist, the phenomenon of stratification was found. While short conductor used for simulation in laboratory didn't have stratification in ice environment.
- (4) Compared with single conductor, the total amount of ice on multiconductor bundles is far more, but the average ice weight on single conductor is more than that on 3- bundle and 4-bundle conductor.

Thank You!