Surge Arresters for Gas Insulated Switchgear (GIS)

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Abstract

Until the mid-1990s, we had been realizing the compact design of surge arresters for Gas Insulated Switchgear (GIS) with a three-column structure design electrically connected in series. Since then, we realized a simple and compact surge arrester design through the development of high gradient blocks.

There are many Metal Oxide (MO) block suppliers in the world, however, only a few suppliers can produce high gradient blocks. Such blocks are essential in making compact and light-weight surge arrester units.

Currently, we are manufacturing and selling a variety of surge arresters, both units with high gradient blocks and surge arresters (tank type) for GIS. More than 20,000 of surge arrester units have been delivered at home and abroad.

1 Preface

Surge arresters are used to protect electric equipment such as power transformers and switchgears against an overvoltage in power network systems. Surge arresters play an important role in maintaining a stable power supply. Metal Oxide (MO) surge arresters are currently the mainstream in the field of surge arresters used in power network systems worldwide. We developed and commercialized such an MO surge arrester without series gaps for the first time in the world. The MO surge arrester employs MO blocks. It demonstrates excellent non-linear voltage-current (V-I) characteristics.

With the advent of the MO surge arrester, power outage incidents caused by overvoltage, like lightning strikes, are drastically reduced. In addition, since overvoltages can be suppressed by the excellent non-linear V-I characteristics, it is possible to have a lower level insulation design for power network systems. As a result, substation equipment can be a compact design with big economic benefits.

Meanwhile, the Gas Insulated Switchgear (GIS) is increasing because it can operate with a smaller footprint (compact space) than a conventional air-insulated substation. This paper introduces the surge arresters for GIS (GIS surge arrester).

2 History of Meiden GIS Surge Arresters

In 1975, we developed and commercialized the world's first porcelain-housing type MO surge arrester without series gaps. One year later, we developed and released GIS surge arresters. In 1979, the Japan's first 500kV GIS surge arresters were developed and delivered.

In the early days, our GIS surge arrester was produced in a single-column structure. This unit was, however, subject to increasing the total length when the rated voltage became higher. As a result, we developed a design of a three-column structure system where the conducting pass is connected in series. Fig. 1 shows a conducting pass and external appearance of the arrester unit in the three-column structure.

In this case, however, this three-column structure has an intricate internal construction compared with the single-column structure. To resolve this issue, we embarked on the development of high gradient blocks.

3 Development of High Gradient Blocks

The high gradient block has a high reference voltage per thickness. For this reason, it is possible

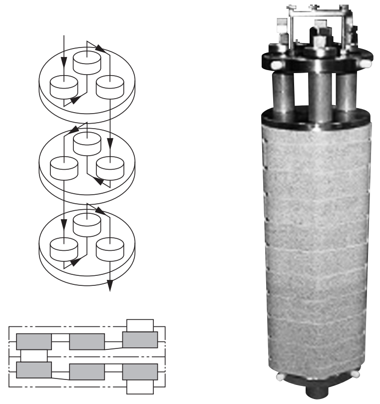

Fig. 1 **Conducting Pass and External Appearance of the Arrester Unit in Three-Column Structure**

In a three-column structure, the conducting pass is kept in the single-column structure. In this manner, the GIS surge arrester unit became compact.

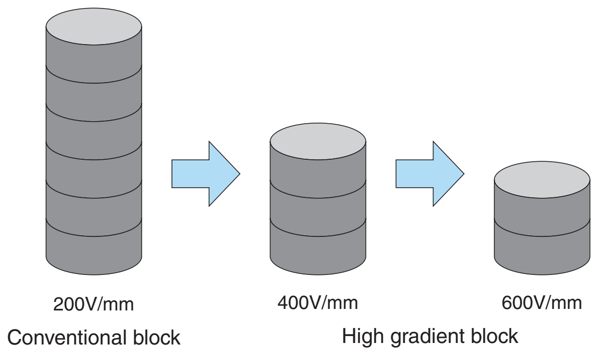

Fig. 2 **Image of Block Use between Conventional Blocks and High Gradient Blocks**

Compared with conventional blocks (200V/mm), the number of blocks can be reduced to half in the case of 400V/mm and to one third for 600V/mm when high gradient blocks are used.

to decrease the number of blocks and design a compact surge arrester. Fig. 2 shows image of block use between conventional blocks and the high gradient blocks.

The MO block is composed of ZnO grains of about 10μm and grain boundary layers that surround ZnO grains. The reference voltage of the MO block is in proportion to the number of grain boundary layers between electrodes of both ends. Accordingly, to get a high gradient to the block, it is necessary to reduce the ZnO grain size and increase the number of grain boundary layers. Fig. 3 shows the microstructure models of a conventional block and the high gradient block.

To obtain high gradient blocks, we improved the composition compound and sintering processes as described below.

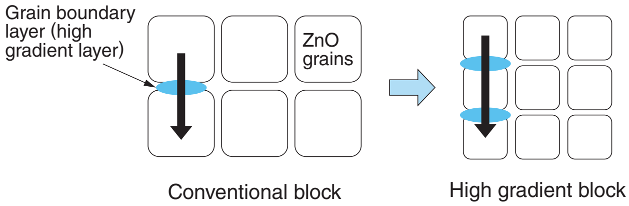

Fig. 3 **Microstructure Models of Conventional Block and High Gradient Block**

As the number of grain boundaries increases as the ZnO grains are miniaturized, the resistance of the element can be increased.

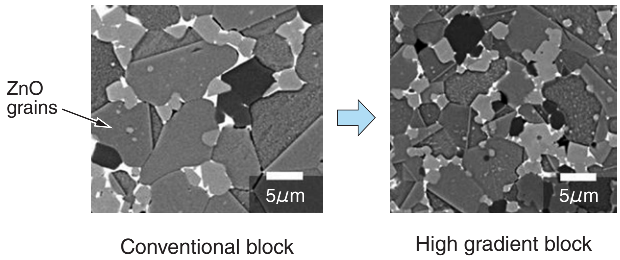

Fig. 4 **Microstructure of Conventional Blocks and High Gradient Blocks**

Compared with conventional blocks, we recognize that the ZnO grains of the high gradient block became more smaller sizes.

(1) Composition compound

Selection of materials and its optimum composition compound of materials

(2) Sintering

Suppression of grain growth and control of grain boundary layers

In order to increase the energy withstand capability, we analyzed the breakdown mode and primarily improved the side insulation.

As a result of these improvements, we finally developed high gradient blocks with high reliability. Fig. 4 shows microstructure of conventional blocks and high gradient blocks.

There are many companies that manufacture MO blocks globally. But most of them only produce conventional blocks. To develop high gradient blocks, it is necessary to have high technologies such as suppression of grain growth, advanced control of grain boundary layers, improvement of energy withstand capability, and technologies for the reinforcement of side insulation. For this reason, there are few companies that can manufacture high gradient MO blocks.

Table 1 shows a comparison of arrester units for 500kV systems between the three-column structure with conventional blocks and a single-column

Table 1 Comparison of Surge Arrester Units between Using Conventional Blocks and High Gradient Blocks

The table below shows comparison of the GIS units for the 500kV system between the three-column structure with conventional blocks and single-column structure with high gradient blocks. When high gradient blocks are used, the number of blocks is reduced by 50% and total mass is reduced to 70%.

Items \ Type of SORESTER		ZSE-C3FT (Conventional block)	ZSE-G4FT (High gradient block)
No. of blocks (pcs.)		138	69 (50% reduction)
MO block unit	Total length of unit (mm)	2000	1830 (10% reduction)
	Unit mass (kg)	390	130 (70% reduction)
Structure of MO block unit		Three-column structure	Single-column structure
External appearance of unit			

structure with high gradient blocks. Due to the high gradient blocks, the number of blocks used has been reduced by 50%, and this has resulted in the simplification of structures, a decrease in the number of parts used, and a reduction of total mass to about 70%.

4 Introduction of Meiden GIS Surge Arresters

We manufacture GIS surge arresters at our SORESTER Factory in Japan and MEIDEN ZHENGZHOU ELECTRIC CO. LTD. (MZE) in China.

4.1 GIS Surge Arresters Manufactured by MEIDEN for Japanese Market

Table 2 shows the major ratings of the ZS-D Series delivered to the Japanese market. This series involves surge arrester units in a single-column structures with high gradient blocks covering up to the rated voltage of 280kV (power system voltage 275kV). Some are used as a built-in unit for Meiden switchgears and are also delivered to GIS manufacturers in Japan. Surge arrester units equipped with

Table 2 Major Ratings of the ZS-D Series

The ZS-D Series is composed of surge arrester units in a single-column structure with high gradient blocks.

Items	Ratings			
Arrester type	Standard	High performance	High performance	High performance
Rated voltage (kV)	28~42	84~140	84~196	182~280
Nominal discharge current (kA)	10			
Switching surge current withstand capability class	D	C	BB	B
Discharge current withstand capability (High current impulse)	65kA, 2 times (4/10μs wave)			

Table 3 Major Ratings of GIS Surge Arrester Units for Overseas Markets

For the rated voltage range of 60kV to 468kV.

Items \ Type of SORESTER	ZSE-G2FT	ZSE-G3FT	ZSE-G4FT
Rated voltage: Ur (kV)	60~288	90~216	360~468
Max. continuous operating voltage: MCOV (kV)	0.8Ur	0.8Ur	0.8Ur
Nominal discharge current (kA)	10	20	20
Line discharge class	3	4	5
Discharge current withstand capability (kA)	100	100	100
Energy absorption capability (kJ/KV-arrester rating, Within one minute)	7.9	13	16.5

disconnecting devices are also released so that the arrester unit can be disconnected from a power network system during withstand voltage test at the site. Since the release in 1998, we have delivered more than 4000 units of ZS-D series surge arresters in Japan.

4.2 GIS Surge Arresters Manufactured by MEIDEN for Overseas Markets

For overseas versions of our product, we manufacture a series of surge arrester units with the rated voltages of 60kV to 468kV in accordance with IEC 60099-4. Table 3 shows the major ratings of GIS surge arrester units for overseas markets. These surge arrester employ higher gradient blocks compared to Japanese market. Since the release in 2011, we delivered more than 1000 units of ZSE-G Series surge arresters.

Fig. 5 GIS Surge Arrester for the 500kV System

A GIS surge arrester for the 500kV system (single-phase type) manufactured by MZE in China is shown.

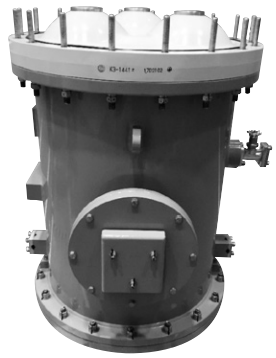

Fig. 7 GIS Surge Arrester for 150kV System

A GIS surge arrester for the 150kV system (three-phase type) is shown. This type has been developed this year.

(a) 220kV (b) 110kV

Fig. 6 GIS Surge Arresters for the 220kV and 110kV Systems

GIS surge arresters for the 220kV system (single-phase type) and for the 110kV system (three-phase type) manufactured by the MZE in China are shown.

MZE in China began to manufacture high gradient blocks early on and developed the tank type GIS surge arresters in accordance with the IEC Standards and GB Standards – (China National Standards). These products are designed to realize the compact and light-weight surge arrester.

Fig. 5 shows a GIS surge arrester for the 500kV system, Fig. 6 shows GIS surge arresters for the 220kV and 110kV systems, and Fig. 7 shows a GIS surge arrester for the 150kV system. Regarding the supply records, 37 pieces (single-phase type) for the 500kV system, 4400 pieces (single-phase type) for the 220kV, and 3500 pieces (three-phase type) for the 110kV system (total surge arrester 10,500 units) have been delivered.

5 Postscript

This paper introduced a history and the features of Meiden GIS surge arresters with high gradient blocks. It realized a remarkable compact design in size and mass.

We will continue to make every effort to realize higher gradient for the arrester blocks so that GIS surge arresters can become more compact to reduce environmental impact.

We will also realize the compact design in our line-ups of all type such as porcelain housing and polymer housing type surge arresters. In so doing, we will continue to offer a wide variety of compact surge arresters for markets worldwide, contribute to the safety and stability of power facilities, and work towards global environmental conservation.