

TITLE OF THE INVENTION

VACUUM SWITCHGEAR

FIELD OF THE INVENTION

5 The present invention relates to a vacuum switchgear and more particularly to a vacuum switchgear having a function for diagnosing the soundness of the vacuum pressure during the normal operation.

10 BACKGROUND OF THE INVENTION

 The withstand voltage performance and interruption performance of the vacuum switchgear depend on the internal pressure (vacuum pressure) of a vacuum container. Fig. 9 shows the discharge characteristic in a vacuum, that is, the so-called Paschen curve indicating the correlation of the product of pressure and distance with the discharge voltage. As shown in the drawing, when the vacuum pressure rises to a certain value or higher, the insulation performance is lowered suddenly. In the vacuum switchgear, there are possibilities that the vacuum pressure may be deteriorated due to not only breakage and failures but also long-term transmission of atmospheric gas, so that a periodic inspection is required.

25 Generally, in the soundness check of vacuum pressure, a method for carrying out the vacuum switchgear from the

receiving power board, then impressing a predetermined high voltage between the poles, and judging the soundness by existence of flashover is adopted. In this case, problems arise that the service must be interrupted at
5 time of inspection and a high voltage power source is necessary additionally. To respond to maintenance conservation needs such as simplification of the inspection work or labor saving by continuous monitoring, a method capable of diagnosing during the normal
10 operation is desired and various methods are proposed. For example, in Japanese Patent Laid-open No. Hei 7 (1995)-65676, a method for arranging a detection electrode around a vacuum valve and detecting a discharge pulse generated at time of deterioration of the vacuum
15 pressure is proposed.

However, in this diagnostic method, the discharge pulse used for diagnosis is a high frequency signal, so that the detection circuit is complicated and moreover, a discrimination function for radio wave noise from the
20 surrounding environment is required, thus the cost is increased inevitably.

SUMMARY OF THE INVENTION

In the prior art aforementioned, the high frequency
25 pulse is used for the vacuum pressure diagnosis, so that a problem arises that complicated signal processing

function and circuit such as a pulse detection circuit and a discrimination function from external noise must be installed additionally.

5 An object of the present invention is to solve the aforementioned problem and to provide a vacuum switchgear having a function for diagnosing the soundness of the vacuum pressure during the normal operation.

10 The first invention of the present invention is a vacuum switchgear with a vacuum pressure diagnostic device attached including a metallic container at a floating potential, a vacuum container composed of an insulating bushing fixed to the metallic container, and at least one pair of connectable electrodes in the vacuum container, wherein a measuring terminal for vacuum
15 pressure diagnosis is arranged opposite to the metallic container, and the metallic container and measuring terminal are molded by an insulator such as epoxy, and a grounding layer is installed on the outer peripheral part of the insulator, and the grounding layer and measuring
20 terminal are insulated electrically, and the soundness of the vacuum pressure is judged by measuring a voltage generated at the measuring terminal.

25 The second invention is a vacuum switchgear including a metallic container at a floating potential, a vacuum container composed of an insulating bushing fixed to the metallic container, and at least one pair of connectable

electrodes in the vacuum container, wherein the metallic container is molded by an insulator such as epoxy, and a grounding layer is installed on the outer peripheral part of the insulator excluding a part of area, and a

5 measuring terminal for vacuum pressure diagnosis is arranged opposite to the one part of area, and the soundness of the vacuum pressure is judged by measuring a voltage generated at the measuring terminal.

According to the present invention, the ground
10 capacity of the metallic container is increased by the grounding layer of the outer peripheral part of the insulator, so that the potential of the metallic container during the normal operation (during current supply) approaches the ground potential. When
15 electricity is discharged between the main circuit and the metallic container when the vacuum pressure is deteriorated, the potential of the metallic container becomes equal to the system potential. Namely, by a potential rise at the system frequency (50 Hz or 60 Hz)
20 generated in the metallic container, deterioration of the vacuum pressure can be detected, and a vacuum switchgear with a vacuum pressure diagnostic device attached in which the detection circuit and diagnostic circuit are simplified extremely can be provided at a low cost.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross sectional view showing an embodiment of the vacuum switchgear of the present invention.

Fig. 2 is a cross sectional view showing the
5 conventional vacuum switchgear.

Fig. 3 is a characteristic diagram for explaining the potential of the metallic container when the vacuum pressure is sound.

Fig. 4 is an illustration for various electrostatic
10 capacities affecting the potential of the metallic container.

Fig. 5 is an illustration for an equivalent circuit used to obtain the potential of the metallic container.

Fig. 6 is an illustration for potential variations of
15 the metallic container when the vacuum pressure is deteriorated in the prior art.

Fig. 7 is an illustration for potential variations of the metallic container when the vacuum pressure is deteriorated in the vacuum switchgear of the present
20 invention.

Fig. 8 is a cross sectional view of the vacuum switchgear of another embodiment of the present invention.

Fig. 9 is a characteristic diagram showing the relationship between pressure and discharge start voltage.

Fig. 10 is a cross sectional view of the vacuum
25 switchgear of the third embodiment of the present

invention.

Fig. 11 is a cross sectional view of the vacuum switchgear of still another embodiment of the present invention.

5 Fig. 12 is a circuit block diagram showing the diagnostic device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 Fig. 1 is a side cross sectional view showing an embodiment of the vacuum switchgear of the present invention.

As shown in the drawing, the vacuum valve 1 is composed of a fixing-side insulating bushing composed of a ceramic cylinder 2, a terminal plate 3, and a fixed conductor 4 and a moving-side insulating bushing composed of a metallic container 12 at a floating potential, a ceramic cylinder 6, a terminal plate 7, a moving conductor 8, and a bellows 9. At the ends of the fixed conductor 4 and moving conductor 8, a fixed electrode 11 and moving electrode 10 are fixed respectively. The moving electrode 10 can operate by keeping the vacuum tightness by the bellows 9 and makes contact with or separates from the fixed electrode 11 to play a role as a switchgear. Further, the units are joined by brazing in a high-temperature vacuum oven.

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The periphery of the metallic container 12 is molded

by an insulator 20 such as epoxy. The outer periphery of the insulator 20 is coated with conductive paint 21 (the two-dot chain line portion) and the painted surface is grounded E. Further, for the insulator 20, a measuring
5 terminal 50 for vacuum pressure diagnosis is molded simultaneously and the measuring terminal 50 and conductive paint 21 are electrically insulated.

The measuring terminal 50 is connected to a pressure diagnostic device 51 and the pressure diagnostic device
10 51 is composed of a capacitor C0 and a voltmeter 52 for measuring voltage output Vout. One end of the measuring terminal 50 is connected to the capacitor C0 grounded, and voltages generated at both ends of the capacitor C0 are measured by the voltmeter 52, and the soundness of
15 the vacuum pressure is diagnosed by the voltages.

Hereinafter, the vacuum pressure diagnostic method of the present invention will be explained.

Fig. 2 shows the prior art indicated for comparison and existence of the insulator 20 with the periphery
20 thereof fixed at the ground potential is a main difference from the present invention. The actual potential of the metallic container 12 during current supply, that is, when the vacuum valve 1 is charged will be explained. For the vacuum valve 1, to satisfy the
25 ground insulation performance, an insulation distance between it and the receiving power board for storing the

operation mechanism or switchgear (both are not drawn) is reserved. Further, also for the measuring terminal 50, to satisfy the insulation performance with the system, actually, an interval between it and the vacuum valve 1 must be preserved sufficiently. Therefore, generally, an electrostatic capacity C_m between the metallic container 12 and the main circuit is very large compared with an electrostatic capacity C_g between the metallic container 12 and the ground. An actual potential E_f of the metallic container 12 is decided by the formula indicated below on the basis of C_m and C_g for a system potential E_p :

$$E_f = E_p \times C_m / (C_m + C_g) \approx E_p,$$

so that from $C_m \gg C_g$, it becomes almost the same potential as the system potential E_p . On the other hand, in the embodiment (Fig. 1) of the present invention, around the metallic container 12, there exists the insulator 20 having a ground layer on the outer peripheral part, so that the ground capacity C_g of the metallic container 12 increases. Therefore, the actual potential E_f of the metallic container 12 is shifted from the system potential E_p to the ground potential side (Fig. 3).

The potential of the measuring terminal 50, that is, the measuring voltage V_m is decided, in addition to the electrostatic capacities C_p and C_m , by the ground

capacity C1 of the measuring terminal 50, the electrostatic capacity C2 between the metallic container 12 and the measuring terminal 50, and the capacitor capacity C0 in the pressure diagnostic device 51. Each electrostatic capacity is explained in Fig. 4 and the measuring voltage Vm can be obtained by the equivalent circuit shown in Fig. 5. The electrostatic capacities Cp, Cm, C1, and C2 are decided by the structure and size and needless to say, the measuring voltage Vm is a proportional value to the potential Ef of the metallic container 12.

Further, to ensure the safety, the measuring voltage Vm must be a sufficiently small value for the system voltage Ep. It is desirable to set the capacitor capacity C0 in the pressure diagnostic device 51 to a sufficiently large value for C2, and for example, in the 6.6 kV system, the ground voltage 5.4 kVp thereof is equivalent to the system potential Ep, and assuming the electrostatic capacity C2 between the metallic container 12 and the measuring terminal 50 as 10 pF, by setting C0 = 10000 pF, the measuring voltage Vm can be suppressed to about 5 V.

Next, a case that the vacuum pressure is deteriorated will be explained. As shown in the Paschen curve shown in Fig. 9, when the pressure rises to 10^{-2} Torr or higher, the insulation performance lowers. In this case,

electricity is discharged between the main circuit and the metallic container 12 and the potential E_f of the metallic container 12 is put into the state that a discharge pulse is superimposed to the system voltage.

5 As shown in Fig. 6, in the prior art, the potential E_f of the metallic container 12, even if sound, is almost equal to the system potential E_p , so that the variation in correspondence with deterioration is only the high frequency discharge pulse and the pressure can be
10 diagnosed by detection of the high frequency discharge pulse. On the other hand, according to the present invention, by the insulator 20 having a grounding layer in the periphery, the potential E_f of the metallic container 12 is shifted on the ground potential side, so
15 that when the vacuum pressure is deteriorated, not only the high frequency discharge pulse is generated but also the potential at the system frequency rises. Namely, instead of the high frequency discharge pulse, by taking up a rise of the potential at the system frequency, the
20 deterioration may be diagnosed.

Here, the effects of this embodiment will be explained. In the prior art, the deterioration of the vacuum pressure is diagnosed by detection of the discharge pulse, so that a countermeasure for
25 electromagnetic wave noise from the surrounding environment such as a high frequency detection circuit

and a portable telephone is necessary and the cost of the pressure diagnostic device 51 is increased inevitably. A circuit 53 shown in Fig. 2 plays this role. On the other hand, according to the present invention shown in Fig. 1, it is desirable to detect a rise of the potential at a system frequency of 50 Hz or 60 Hz. For example, using the voltmeter 52 as a tester and a judgment means 500 as an inspector, when the voltage rises to a preset threshold value or higher, the inspector can detect easily deterioration of the vacuum pressure. Further, the judgment means 500, as shown in Fig. 12, may be composed of a comparator 501 for comparing the voltages at both ends of the capacitor C0 with a preset threshold value, a relay contact 502 for operating by output of the comparator 501, and an alarm lamp 503 (or buzzer) which is turned on or off by the relay contact 502. Also in this case, the comparator 501 may take up the voltage at the system frequency, so that it is simplified extremely compared with a circuit for handling the high frequency pulse. Further, the vacuum pressure diagnostic method by the system frequency voltage of the present invention can ignore an influence of external electromagnetic wave noise, so that the reliability of diagnostic results is improved.

Further, in this embodiment, an example of the vacuum valve 1 having two insulating bushings of the metallic

container 12 at a floating potential is explained.

However, the vacuum valve 1 may have an arc shield 201 at a floating potential in a ceramic cylinder 200 as shown in Fig. 11. The conductive paint 21 installed on the

5 outer peripheral part of the insulator 20 is grounded, so that the ground capacity of the arc shield 201 is

increased and the potential of the arc shield 201 during operation is shifted from the system potential to the

ground potential side. When the vacuum pressure in the

10 vacuum valve 1 is deteriorated, the potential of the arc shield 201 becomes equal to the system potential, so that

in the measuring terminal 50, the potential at the system frequency rises. Therefore, also in this case, the

deterioration of the vacuum pressure can be detected by

15 the simple pressure diagnostic device 51 aforementioned.

Next, the second embodiment will be explained by referring to Fig. 8. The structure of the vacuum valve 1 is the same as that of the first embodiment, so that the explanation thereof will be omitted. The metallic

20 container 12 is molded by the insulator 20 having a ground layer on its periphery and in this embodiment, the

measuring terminal 50 is arranged separately. At a part of the surface of the insulator 20, a part 55 which is

not coated with the conductive paint 21 is installed and

25 the part 55 and measuring terminal 50 face each other.

Further, the connection relationship between the

measuring terminal 50 and the pressure diagnostic device 51 is the same as that of the first embodiment.

The effects of this embodiment will be explained hereunder. The measuring terminal 50 is shielded in the electric field from the main circuit by the conductive paint 21 at the ground potential, so that the ground capacity C1 of the measuring terminal 50 is increased. As a result, even if the capacitor C0 in the pressure diagnostic device 51 is damaged or the connected line is disconnected, the potential of the measuring terminal 50 is lowered sufficiently compared with the system potential Ep, so that the safety for a maintenance and inspection is improved.

Meanwhile, although it is a common matter between Embodiments 1 and 2, during the input and interruption operation, there are possibilities that an arc generated between the electrodes may touch the metallic container 12 and in this case, the potential Ef of the metallic container 12 becomes equal to the system potential Ep. This is a phenomenon generated regardless of the soundness of the vacuum pressure, so that it is adequate to exclude diagnostic results when an operation instruction is given.

Hereinafter, the third embodiment of the present invention will be explained by referring to Fig. 10.

A vacuum switchgear 100 includes a vacuum valve 101

having an interruption and a disconnection function and a vacuum valve 102 for ground switching and both are molded by the insulator 20 having the grounded conductive paint 21 around. The vacuum valve 101 has the disconnection
5 function, so that to ensure the safety for the maintenance and inspection person, it is desirable for it to have a diagnostic function for the vacuum pressure.

The vacuum valve 101 is composed of two insulating bushings 104 and 105 and the metallic container 12 at a
10 floating potential and stores contact electrodes in the respective insulating bushings. In the insulating bushing 104 on the left of the drawing, a fixed electrode 110 is connected to a conductor 112 via a fixed conductor 111 and is connected to the bus by a bushing 113. On the
15 other hand, in the insulating bushing 105, a fixed electrode 114 is connected to a conductor 116 via a fixed conductor 115 and is connected to the load by a bushing 117. Further, moving contacts 120 and 121 are respectively fixed to moving conductors 122 and 123 and
20 both moving conductors are connected by a conductor 124. Namely, in the vacuum switchgear 100, a current is supplied through the route of the bushing 113, conductor 112, fixed conductor 111,, fixed electrode 110, moving electrode 120, moving conductor 122, conductor 124,
25 moving conductor 123, moving electrode 121, fixed electrode 114, fixed conductor 115, conductor 116, and

bushing 117. Further, an arc shield 119 around the contact electrode is used to prevent metallic particles emitted from the electrode at time of input and interruption from adhering to the inner surface of a ceramic cylinder 118, thus the insulation performance is prevented from deterioration.

The conductor 124 for connecting the two moving conductors 120 and 121 is connected to an operation rod 126 via a ceramic rod 125 and the operation rod 126 is connected to an insulating rod 127. The insulating rod 127 is driven by an operation mechanism (not drawn) installed individually and the contact electrodes in the insulating bushings 104 and 105 make contact with or separate from each other. Further, a bellows 130 is installed between the operation rod 126 and the metallic container 12, so that they can operate by keeping the vacuum tightness. By the operation mechanism, the moving electrodes 120 and 121 move to three positions of an on position Y1, an off position Y2, and a disconnection position Y3 and realize the interruption function by an operation between the on position Y1 and the off position Y2 and the disconnection function by an operation between the off position Y2 and the disconnection position Y3.

On the other hand, the vacuum valve 102 for ground switching is composed of a bellows 148, a ceramic cylinder 140, terminal plates 141 and 142 at both ends

thereof, a fixed conductor 143, a moving conductor 144,
and a fixed electrode 145 and a moving electrode 146
which are fixed to both conductors and these units are
mutually joined by brazing. The moving conductor 144,
5 outside the vacuum valve 102, is connected to a
connection conductor 149 for mutually connecting three
phase parts. Further, the moving conductor 146 is
connected to an insulating rod 151 via a metal fitting
150. The insulating rod 151 is driven by an operation
10 mechanism (not drawn) separately installed to open or
close the contact. Further, the fixed conductor 143 is
connected to the conductor 116 connected to the load, so
that the load is grounded by the input operation of the
vacuum valve 102. Further, on the insulator 20, a
15 capacitor 152 for voltage measurement is molded and
existence of a voltage on the load side is discriminated.

The measuring terminal 50 for vacuum pressure
diagnosis is molded inside the insulator 20 together with
the vacuum valves 101 and 102 and is arranged opposite to
20 the metallic container 12 of the vacuum valve 101. The
measuring terminal 50, through a connection line 160, is
connected to the pressure diagnostic device 51 similar to
that of Embodiment 1 or 2. In the metallic container 12
at a floating potential, by the conductive paint 21
25 grounded around the insulator 20, the actual potential
thereof is shifted from the system potential E_p to the

ground potential side. When the vacuum pressure is deteriorated similarly to the previous embodiment, electricity is discharged between the main circuit and the metallic container 12, and the potential of the metallic container 12 rises up to the system potential E_p , so that on the basis of this potential rise, the deterioration of the vacuum pressure can be diagnosed. As mentioned above, even in the vacuum switchgear 100 having the disconnection function, when the insulator 20 having the grounded conductive paint 21 around is installed, a highly reliable vacuum pressure diagnostic device can be installed easily.

According to the present invention, the inner pressure can be diagnosed by a potential rise of the metallic container at a floating potential, so that a vacuum pressure switchgear in which the deterioration diagnostic device is simplified and the diagnostic reliability is improved can be provided.

WHAT IS CLAIMED IS:

1. A vacuum switchgear comprising a metallic
container at a floating potential, a vacuum container
composed of an insulating bushing fixed to said metallic
5 container, and at least one pair of connectable
electrodes in said vacuum container, wherein a measuring
terminal for vacuum pressure diagnosis is arranged
opposite to said metallic container, and said metallic
container and said measuring terminal are molded by an
10 insulator, and a grounding layer is installed on an outer
peripheral part of said insulator, and said grounding
layer and said measuring terminal are insulated
electrically.

2. A vacuum switchgear comprising a metallic
15 container at a floating potential, a vacuum container
composed of an insulating bushing fixed to said metallic
container, and at least one pair of connectable
electrodes in said vacuum container, wherein said
metallic container is molded by an insulator, and a
20 grounding layer is installed on an outer peripheral part
of said insulator excluding a part of area, and a
measuring terminal for vacuum pressure diagnosis is
arranged opposite to said one part of area of said outer
peripheral part of said insulator.

25 3. A vacuum switchgear according to either of Claims
1 and 2, further comprising a diagnostic device for

measuring or continuously monitoring an AC voltage at a system frequency generated at said measuring terminal, wherein said diagnostic device, when a voltage rise higher than a threshold value occurs, decides it as a vacuum defective.

4. A vacuum switchgear according to any of claims 1 to 3, wherein said outer periphery of said insulator is coated with conductive paint and said grounding layer is formed by grounding said conductive paint.

10 5. A vacuum switchgear according to Claim 3, wherein said diagnostic device, when no operation instruction is given to said vacuum switchgear, measures a voltage generated at said measuring terminal and when a voltage rise higher than a threshold value occurs, decides it as
15 a vacuum defective.