Dynamic Analysis on the Closing Resistors of Gas Insulated Switchgear

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GIS (Gas Insulated Switchgear) is used in electric power system to insure non conductivity, breaking capacity and operating reliability. In the present study, dynamic analysis on the closing resistors of the GIS has been carried out by the commercial dynamic analysis code COSMOS MOTION and 3-D modeling program SOLID WORKS. In order to find the minimum value of chatter vibration of closing resistors, the motion of moving and fixed resistor parts of closing resistors were simulated by varying the spring constant, the damping coefficient and the mass of moving and fixed resistor parts. The simulated results were compared with experimental results. The application of the results could reduce chatter vibration of closing resistors of the GIS. These data are also useful on the development of future model GIS with minimum chatter vibration for the determinations of the spring constant, the damping coefficient and mass of a moving part.

Key Words: Gas Insulated Switchgear, Dynamic Analysis, Chatter Vibration, Closing Resistors

1. Introduction

The gas insulated switchgear (GIS), which is filled with SF6 insulating gas in the closed metallic pressure vessel, consists of circuit breaker, current transformer, disconnecting switch, and earthing switch. The GIS system is widely applied to the electric power system because of its excellent breaking and closing capabilities. GIS system ensures the security of the electric power system by closing abnormal current during the operation. After the breaking operation the GIS system has to return to the normal position for the normal operation of the electric power system. During the opening and closing operation the GIS system may have input surge due to chatter vibration of the closing resistor and the input surge makes the system unstable. In order to reduce the surge due to re-closing of circuit breaker and to get stability of the system, the input surge is suppressed by application of additional resistor that has identical phase with the circuit breaker.

Closing resistors are generally attached to the circuit breaker either internally or externally, and are classified into two types by the operation mechanism: the resistor has identical operating mechanism with the circuit breaker, and that has independent operation mechanism. The closing resistor may be inserted into the circuit breaker by tulip type contact or butt contact. The closing resistor with butt contact consists of the moving part that has opening and closing movements, and

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the fixed resistor part. The fixed resistor part are composed of the spring that absorbs the impact energy originated from the moving part, the case that envelopes the spring, and the resistor for the reduction of surge. If chatter vibration occurs at the spring during the operation, the fixed resistor can not reduce the surge at the closing resistor.


The present study has been carried out to reduce the electrical surge caused by the chatter vibration due to collision of the fixed resistor part and moving part of the butt contact circuit breaker. Analyses on the spring constants of moving part and fixed resistor part, damping coefficient, gravity of moving part of the resistor have been carried out in conjunction with experiments on the dynamic characteristics.

2. Dynamic Analysis

The behavior of the moving part and fixed resistor part of the closing resistor during collision of these two parts has been carried out through COSMOS MOTION (Solid Works Corporation) which is a commercial software for the dynamic characteristic analysis. For dynamic analysis of closing resistor, solution of constitutive equations is constructed by

\[ x(t) = C_1 e^{\omega_1 t} + C_2 e^{\omega_2 t} \]

\[ = C_1 e^{\left(\frac{c}{m} \sqrt{\frac{k}{m}} \right) t} + C_2 e^{\left(\frac{c}{m} \sqrt{\frac{k}{m}} \right) t} \]

(1)

here \( m \) is mass, \( c \) is damping coefficient, \( k \) is spring constant and \( C_1, C_2 \) are optional constants from initial conditions.

The behavior of solution is depended upon dimensions of damping. Critical damping constant, \( c_c \) is defined by damping constant, \( c \). The relation of \( c_c \) and \( c \) is expressed by

\[ \zeta = \frac{c}{c_c} \]

(2)

here \( \zeta \) is damping ratio.

In case of under damped system, the solution at condition of \( \zeta < 1 \), \( c < c_c \) becomes

\[ x(t) = e^{-\omega_d t} \left\{ \frac{\omega_d}{\sqrt{1 - \omega_d^2}} \cos \left( \sqrt{1 - \omega_d^2} \omega_d t \right) + \frac{\omega_d^2}{\sqrt{1 - \omega_d^2}} \sin \left( \sqrt{1 - \omega_d^2} \omega_d t \right) \right\} \]

(3)

In case of critically damped system, the solution at condition of \( \zeta = 1 \), \( c = c_c \) becomes.

For collision analysis of closing resistor, the analysis is made of converting impact load of the collision to static load. The Value of impact factor, \((1 + \sqrt{1 + 2h/\delta_{st}})\) multiplied by static load, \( P \) is used for the analysis.

Various values of the spring constant, damping coefficient and weight of each part have been applied for the analysis to reduce chatter vibration. The analysis has been carried out with the initial condition that the moving part collide to the fixed resistor part with the speed of 9.8 m/s under the assumption of rigid body of the moving part and the fixed resistor part.

Analyses were carried out successively for each case as shown in Fig. 1. The damping coefficients were 0.6 N·s/mm for the fixed resistor part, and 5 N·s/mm for the moving part respectively. The input data were changed for each spring constant in the analysis.

Damping coefficients were varied as same as spring constant 0.5 N·s/mm, 0.6 N·s/mm for the fixed resistor part, and 0.05 N·s/mm, 0.1 N·s/mm, 0.5 N·s/mm, 1 N·s/mm, 2 N·s/mm, 5 N·s/mm for the moving part.

Weight values of the moving part for the analysis were 3.31 kg, 3.41 kg, 3.60kg, 3.69 kg, 3.86 kg,