Durability evaluation of insulator and internal pressure analysis during ground fault for 500 kV outdoor termination

TOMITA Yudai, **MORI** Hiroki, **YAGI** Masashi**;** Furukawa Electric Co., Ltd., (Japan), yudai.yt.tomita@furukawaelectric.com, hiroki.hm.mori@furukawaelectric.com, masashi.yagi@furukawaelectric.com

☒ **Young Researcher** (Proven full-time engineering and science university researchers and PhD students under 35)

ABSTRACT

In the case of a ground fault inside a termination, there is a risk of damage and the rupture of the insulator. In order to estimate the increase in pressure at the termination, a durability evaluation in the insulator test using explosive and numerical analyses of the internal arc in the termination was conducted. In the durability evaluation part of the insulator test, the maximum pressure was 12.0 MPa, but no breakage was observed in the insulator. In the numerical analysis of the 500 kV termination with the rupture disks model, the pressure increase and decrease were balanced, and the internal pressure remained constant at 6.2 MPa.

KEYWORDS

Outdoor cable termination, 500 kV, ground fault, internal arc, numerical analysis

INTRODUCTION

There is growing demand to increase the capacity of power cables to reduce transmission losses. On the other hand, the increased capacity of power cables requires an increase in the size of terminations. The larger size of the terminations may lead to more damage to peripheral equipment and longer restoration time in the event of an accident, especially if a ground fault occurs inside the insulator. A ground fault caused by an internal arc results in a sudden increase in pressure inside the insulator, which is expected to cause damage from flying debris due to ruptured insulators and environmental pollution from leaking oil and gas [1, 2]. In order to reduce damage, it is necessary to decrease pressure at the termination by installing pressure release structures [3, 4]. However, in order to obtain the proper pressure release effect, the pressure increase must be accurately estimated through experiments and numerical analyses. Ground fault tests using actual equipment are necessary for product evaluations, but it is difficult to study the optimum structure at the termination because of the high cost of safety measures and environmental pollution countermeasures. Therefore, if the internal pressure could be estimated by numerical analyses, the number of experiments could be reduced, and the cost of developing the optimal structure could be greatly reduced. In order to estimate the increase in pressure during internal arcing, it is necessary to reproduce the dynamic behavior inside the insulator for a short period of time and to understand the relationship between arc energy and the increase in pressure.

In this paper, a scaled-down experiment was conducted using explosives to simulate the increase in pressure during a ground fault, and the results obtained were used to estimate the increase in pressure inside the 500 kV outdoor termination.

DURABILITY EVALUATION OF INSULATOR TEST

In order to understand the relationship between the arc energy and the increase in pressure, as well as to investigate whether or not to consider the damage to the insulator under the conditions of the analysis, a durability evaluation as part of the insulator test was conducted on a simulated arc inside an insulator.

In the durability evaluation test, explosives were used to generate pressure in order to simplify the relationship between the input energy and the increase in pressure. The sample is shown in Fig. 1. This is an insulator made of FRP pipe with a silicone rubber outer sheath and is used in 110 kV cable terminations. The internal pressure was measured with a pressure transducer connected to the upper flange of the insulator in Fig. 2(a). As a pressure source, four cartridges containing explosives were connected to the bottom flange of the insulator in Fig. 2(b), the explosives were burned inside each, and the combustion gas was applied to the inside of the insulator. The amount of explosives was calculated from the first peak value of the energy of the internal arc when a ground fault occurred. Each cartridge was charged with 1.5 g of black powder and 5.0 g of smokeless powder, and the four cartridges were ignited simultaneously. In this test, water was filled instead of insulating oil for safety reasons, and no power cables were installed.

Fig. 1: Sample of durability evaluation of insulators test

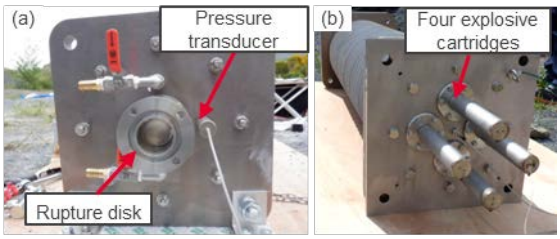

Fig. 2: Equipment of the sample (a) upper side, (b) bottom side