

A Study on Partial Discharge Pattern Analysis for HVDC MI-PPLP Cables

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ABSTRACT

This paper describes the partial discharge pattern analysis for HVDC MI-PPLP cables. PPLP insulation has higher insulation strength and lower permittivity. It can also increase the allowable temperature to 80 – 85 °C, enabling large capacity transmission. The MI-PPLP cable was firstly applied to ±600kV Western Link project. In addition, HVDC MI-PPLP cable is being applied to ±500kV Bukdangjin-Goduk HVDC cable project in South Korea. For reliable operation of MI-PPLP cable, it needs to develop the insulation diagnosis technology. Therefore, in this paper, the partial discharge characteristics during the loading cycle voltage test are analysed as a basic research for the development of MI-cable diagnosis technology.

KEYWORDS

HVDC cable, MI-PPLP, Partial discharge, Pattern analysis

INTRODUCTION

The HVDC cable is not affected by capacitive charging current, so long-distance transmission is possible. The large capacity transmission is also possible because there is no influence by dielectric loss, sheath loss and so on. In addition, there are advantages in that the conductor resistance is low, the transmission loss is reduced, the power flow and the load control are easy, and the utilization ratio is increased [1].

Types of HVDC cables include MI cable, MI-PPLP (Mass Impregnated Polypropylene Laminated Paper) cable, OF cable, LCC XLPE cable and VSC XLPE cable. The characteristics of the MI-PPLP cable are as follows.

MI-PPLP is a non-draining cable impregnated with insulating oil in insulation paper laminated with a thin polypropylene film between Kraft papers. The MI-PPLP cable was firstly applied to ±600kV Western Link (Scotland-England) project and began monopole operating in December 2017. In addition, HVDC MI-PPLP cable is being applied to ±500kV Bukdangjin-Goduk HVDC cable project in South Korea. It will be completed in March 2020. The MI-PPLP cable has higher DC as well as impulse dielectric strengths compared to conventional MI cables and can increase the conductor temperature to 80 – 85 °C. Therefore, it can reduce the insulation thickness at the same voltage[1-2].

However, in terms of cable reliability, it is necessary to verify the partial discharge condition of HVDC cables. It is urgent to develop the real-time insulation condition monitoring and diagnosis technology.

Therefore, in this paper, the partial discharge characteristics of real HVDC MI-PPLP cable during the loading cycle voltage test are measured and analyzed as a basic research for the development of ±500kV MI-PPLP cable diagnosis technology.

CHARACTERISTICS OF MI-PPLP CABLE

MI-PPLP cable enhances insulation performance by laminating polypropylene between Kraft papers. The manufacturing process is similar to the conventional MI cable, but the paper winding tension and impregnation conditions may be different from the MI cable.

Compared with Kraft paper, the PPLP insulating paper has higher insulation strength and lower permittivity. It can also increase the allowable temperature to 80 – 85 °C, enabling large capacity transmission. In addition, polypropylene has a high resistivity compared to MI Kraft paper, but has a high electric field. However, polypropylene has an advantage of being able to operate at higher voltage than Kraft paper because of its excellent dielectric strength [3-5].

As a result, the developed highest voltage level of the MI-PPLP cable is currently ±700kV.

Polypropylene of MI-PPLP cable is closely related to DC insulation breakdown strength as well as impulse insulation breakdown strength. That is, as the PP content is increased as compared with conventional Kraft insulating paper, the dielectric strength becomes better and the breakdown strength linearly increases. However, the higher the PP content, the more vulnerable to mechanical stress. Therefore, the PPLP cable with PP content of 40 to 60% is generally used [3-5].

The MI-PPLP cable can operate up to 1,000kV in theory due to the improved DC and impulse dielectric strengths. It has a high operating temperature and is capable of large-capacity transmission and can produce compact cables compared to MI cables. That is, it is a very economical cable suitable for high voltage and large capacity. The insulation thickness can be reduced, capacity of 25 ~ 50% can be increased at the same insulation thickness because of better DC and impulse insulation strength. Therefore, the reduced weight of 20% can be manufactured.

HVDC CABLE PARTIAL DISCHARGE MEASUREMENT HARDWARE SYSTEM

In this paper, the partial discharge measurement hardware is developed for HVDC cables. It has 3 analysis modes with frequency analysis mode, pulse analysis mode, and time difference analysis mode. It can simultaneously measure 8 channels in each mode. Hardware has independent trigger function and noise gating function for each channel. The number of simultaneous measurement channels in each mode can vary depending on the state of the measured HVDC cable. Finally, HVDC cable partial discharge signals measured by the measurement device are transmitted to the analysis device through the signal processing.