Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Application of OIT Method for aging evaluation of NPP cable

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1. Introduction

In the condition monitoring of cable aging, oxidation induction time(OIT) testing is particularly useful for materials like XLPE and PE, for which no confident results can be obtained from indenter or elongation measurements. OIT is a technique that can be used to evaluate aging of organic materials. OIT testing can be used as a life assessment technique for electric cable used in electric power plants, control, instrumentation, and power cables. Polymers age by means of chemical reactions with oxygen. Antioxidants are chemicals added to polymers in order to inhibit oxidative reactions. As long as antioxidants remain in an insulation polymer, the properties of the cable insulation do not degrade significantly. The OIT is related to the amount of antioxidant remaining in a polymer, and thus to the age, or remaining life, of the polymer. In an OIT test, a small sample of material is placed in a differential scanning calorimeter (DSC) and subjected to a constant temperature of approximately 180℃ to 220℃ in an oxygen atmosphere until a strong exothermic reaction occurs in the material. The strong exothermic reaction begins when the antioxidant is consumed. The period from the start of the test until the strong exothermic reaction begins is the OIT. This time is indicative of the amount of remaining life of the insulation material. The shorter the OIT, the closer is the material to its end of life. Figure 1 shows DSC schematic with enlarged view of head assembly

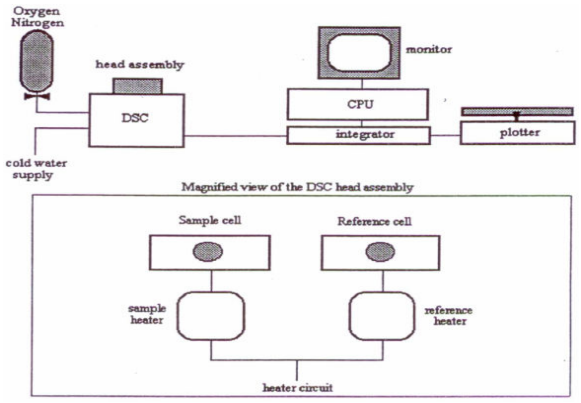

Figure 1. DSC schematic with enlarged view of head assembly

2. Method and Result

2.1 Theory of OIT test

The DSC(differential scanning calorimeter) unit consists of a central cylinder that contains two cells with individual heaters. The amount of sample need is small, for example, 5 milligrams. A sample is placed on a small aluminum pan and covered with a stainless steel screen, which is crimped over the pan. The sample is then placed in one of the two cells, called the sample cell. An identical pan and screen are placed in the other cell, called the reference cell. The heat capacities of the two pans and screens are equal. Power is supplied to both the sample and the reference cell to raise their temperatures to a preset level. While the temperature is being raised to the desired level, the sample is immersed in a nitrogen atmosphere to prevent premature or partial oxidation before reaching the desired temperature. The sample cell and reference cell are maintained at the same temperature, and the difference in the power needed to keep them at the same temperature is recorded on a thermogram. When the preset DSC temperature is reached, the purge gas is switched to oxygen. The sample cell is maintained in a pure oxygen environment to allow the insulation material being tested to react chemically with oxygen. These reactions, however, produce little heat, so the difference in power to keep the two cells at the same temperature is small. After the antioxidant is consumed, the polymers begin strong exothermic reaction. This difference becomes large and is very obvious on the thermogram. The line is constant until the antioxidant is consumed. At this time, the strong exothermic reaction between oxygen and polymer causes a reduction in power to the sample cell in order to maintain the same temperature as the reference cell, and the thermogram departs from the baseline. An exothermic slope line can be drawn on the thermogram and the baseline can be extended. The OIT is then defined as the time between the introduction of oxygen and the intersection of the baseline extension and the exothermic slope line. Figure 2 and figure 3 shows a picture of DSC(Differential scanning calorimeter) machine and sample cell & reference cell.

Figure 2. DSC

Figure 3. sample cell & reference cell

2.2 OIT test result of NPP cables

Figure 4 shows a general DSC graph of OIT measurement. Isothermal OIT time in the figure 4 is the data that we want to obtain through this experiment.

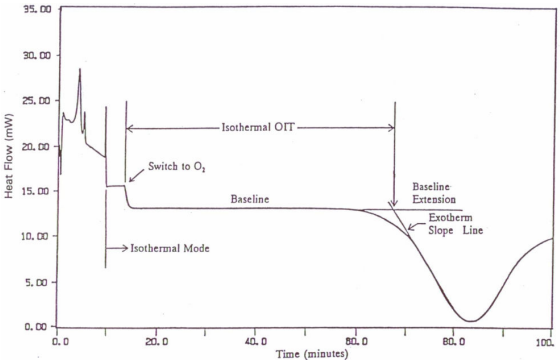

Figure 4. DSC thermogram of OIT measurement

Figure 5, figure 6, and figure7 shows an OIT test result of XLPE insulation, CSP cable and CR cable of NPP cable. XLPE insulation cable showed typical OIT graph and 11.3 minutes OIT time. And CSP cable showed typical OIT graph and 16.5 minutes OIT time. But OIT graph of CR cable was very different from the graph of typical OIT, so it was impossible to calculate the OIT time for CR cable.

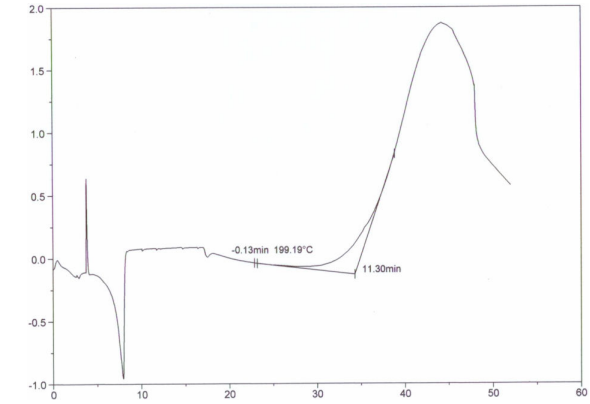

Figure 5. OIT test result of XLPE insulation cable

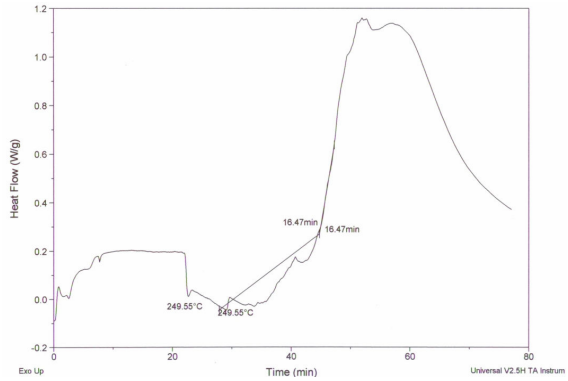

Figure 6. OIT testing of CSP cable in NPP

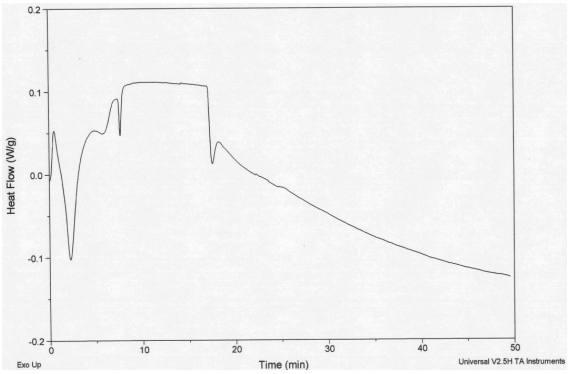

Figure 7. OIT testing of CR cable in NPP

3. Conclusion

Oxidation Induction Time(OIT) test was implemented for the CR, CSP and XLPE cables to find the possiblity of life evaluation by using OIT method. XLPE and CSP cable OIT test showed a typical OIT graph and OIT time. It was verified that the evaluation of XLPE and CSP cable life can be evaluated by using OIT Method. But CR cable OIT test showed different shape of graph and OIT time. It was verified that the evaluation of CR cable life by using OIT Method was impractical.

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