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고압 가공배전선의 노화된 ACSR-OC 도체에 대한 열화검출시스템 설계

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Development of Deterioration Detecting System for Aged ACSR-OC Conductors in HV Overhead Distribution Lines

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Abstract

Design and experiments of a nondestructive testi system to inspect deterioration of ACSR-OC (ACSR Outdoor Cross-linked Polyethylene Insulated Wire usually used in HV overhead distribution lines presented in this paper. ACSR-OC conductor built to t pollutants air for a long period would be easily progress to corrode so that it may lead to the reducti of the effective cross section area of conductors.

A fault diagnosis system consisting of a solenoid c sensor, a constant current source with RF frequency signal processing unit and a motor driver/controller designed and implemented. This instrument can det the sensor output variation due to deterioration corrosion, continuously. As a result, it was shown t such corrosion detector can readily be utilized estimating the diameter change due to deterioration overhead distribution lines and in giving an ea warning or inform before severe aged conductor m lead to fail.

1. Introduction

There are several kinds of conductors used in H distribution lines in domestic areas, but m conductors, i.e., 22.9[kV] lines, have been use ACSR-OC (ACSR Outdoor Cross-linked Polyethylene Insulated Wires). Overhead power lines exposed to t atmosphere for a long period may be slow deteriorated by such corrosion factors as chlorid sulfur, soot or dust in the air[1]. Corrosion cause reduce the mechanical performance and to incre power loss. Severe local corrosion on the overhe power lines sometimes leads to result in weakening the conductors, overheating and eventually failu Although most troubles or accidents in distributi lines may occurred by contacting other conducti materials with the live conductors or by impulsi energy such as strokes or lightning, it may be one of main factors that the conductors exposed to the atmosphere for a long period deteriorates slowly with age. In general, ACSR-OC used to HV overhead distribution lines may be easily attacked by atmospheric corrosion as well as sometimes galvanic corrosion[2,3]

According to the regulations[4] in KEPCO (Kore Electric Power Corporation), the useful life of t overhead power lines regardless of types of conducto is given about 30 years. HV distribut- ion conducto built in an industrial region may be rapidly deteriora by pollutants. Therefore, it is necessary to asse corrosion degree of the aged conductors in service a to determine the replacement period of them befo they may lead to failure.

The overhead distribution lines are periodica inspected to visual inspection method. Inspector c often find any serious fault such as broken wire b it is impossible to detect the internal corrosion in aged conductor. In addition, this method always ta much labor and expense to inspect all spans of conductors precisely and further, its inspection res shows a little reliability. In particular, it is har possible for ACSR-OC to inspect the corrosion becaus of its polyethylene insulated coating. Hence, it necessary to develop any nondestructive test syste in order to detect internal or serious local corrosion ACSR or ACSR-OC conductors.

This paper deals with a basic research result f design of a nondestructive detecting system to inspe and diagnose deterioration of distribution conducto Structural properties of corrosion detector a corrosion detecting methods will be discussed.

2. Deterioration of ACSR-OC

2.1 Deterioration Mechanism

As shown in Fig. 2.1, ACSR-OC consists of hot-di galvanized steel strands in the inner layer, hard-dra aluminum conductors in the outer layer a polyethylene insulator coating. Aluminum strands used to conductors to transfer power current, wh steel strands take charge of the most tensile streng of ACSR-OC. The surface of steel strand is galvanize in order to prevent atmospheric corrosion and t galvanizing layer also presents iron-zinc alloy becau it is made to hot-dip.

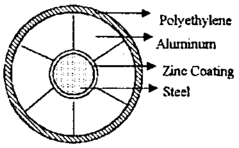

Fig. 2.1 Cross section area of ACSR-OC

In HV distribution lines built in domestic area overhead power lines are about above 90[%]. Hen most conductors are always exposed to the polluta atmosphere easily to corrode[1]. Corrosion a deterioration mechanism is mainly determined material components contained in ACSR-OC an exposed environmental index. Therefore these facto play a main role to diagnose the remaining life of pow lines.

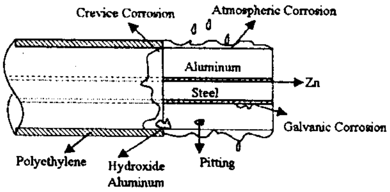

Fig. 2.2 Corrosion mechanism

Once aluminum strands of ACSR-OC or ACSR ar exposed in the atmosphere, they begin to be direc corroded by pollution air, shown in Fig. 2.2. Ev through aluminum is an active metal with high affin to oxygen, it has high corrosion resistance in the because a film oxide formed on its surface protects t aluminum strands. In any cases, however, its r decreases with the elapse of time. Hence, alumin appears a high corrosion resistance.

Galvanizing on the surface of steel strand modera the rate of corrosion as the ferrous may be directly exposed in air or moisture because it has strong chemical affinity with oxide irons. If zinc coating has been corroded, aluminum strands are in contacting with galvanized steel strands and then, they would be attacked by galvanic corrosion, especially in coastal areas where salt is carried by wind.

2.2 Detection of Deterioration

Local and global corrosion caused by atmosphe and galvanic corrosion may appear all the spans conductors exposed to the similar regions. To dete these corrosions to any quantified data, there have b several attempts. One of them is to detect the chang of cross section area in aged aluminum strands[5] the zinc loss of the galvanized steel strands in the in layer[6]. In addition, an infrared camera can be u but it may be less sensitive and give low accuracy[

Eddy current method using a probe coil or encircling coil has been widely applied nondestructive test (NDT) of conductive materials [An important advantage of eddy current testin compared with other testing methods is that there no need for physical contact with the surface of t object under testing and further its measurement sp is rapid.

3. Fault Detecting System Design

3.1 Solenoid Coil Sensor

A solenoid having a conducting material at t longitudinal axis such as ACSR conductor, as show in Fig. 3.1, is excited by an alternating current. In sensor, thus, the electromagnetic performance of material would appear as the impedance variation the coil itself. In practice, it can be used to detect cross section area of conductors inside the solenoid c by measuring impedance variations compared to t of reference conductors. For the simplicity of discu impedance analysis for eddy current sensor is omit here.

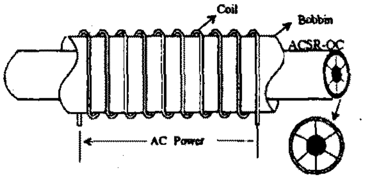

Fig. 3.1 Solenoid coil and test conductor

3.2 Detecting System Design

An encircling coil as shown in Fig. 3.1 can not applied to realistic corrosion detector system becau of limiting its structure. Since the sensing coil cou be clipped around strung conductors to be able to det corrosion along the conductors, it has to be split i two parts.

In this research, we propose a different type sensing head that can be easily implemented by o one connector. For the purpose of this, the coil designed to a PCB flexible cable. Its electric performance always keeps stable and there occu hardly any mechanical fault because it is protected a laminated cable.

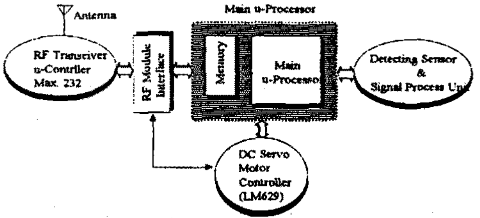

Fig. 3.2 Schematic diagram for corrosion detector

The detector system consists of a corrosion detect to the air and a control unit operated by inspector the ground. The corrosion detector has the capabilit such as detecting sensor output, transforming it digital data, driving a servo motor, counting distan and transmitting measurement data to the control u and so on. Fig. 3.2 shows the block diagram corrosion detector unit in the designed corrosi detector.

Sensor coil is excited by a constant current sour with RF sinusoidal signal. As the output changes corrosion of conductors are usually very small, it necessary to amplify it to a suitable level in sign processing unit. Measured data is transmitted to master processor and this data including distance d send to the ground control unit by a UHF R transceiver. The corrosion detector moves along t conductor by a small size servo motor which can giv forward and reverse direction and speed control. T detector unit operates by the power supplied batteries. Control unit at the ground comprises lap-top(notebook) computer and a RF transceiver. T computer has the capability of controlling the corros detector, receiving measurement data continuously and analyzing data.

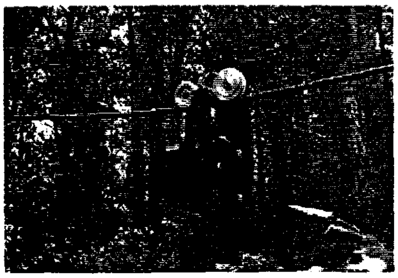

Fig. 3.3 Implemented detector System

It is necessary to design suitable programs in t corrosion detector system operated in practice field. master processor, an assembly program is designed order to measure sensor outputs, to control a communicate the detector system. Furthermore, control the detector on the ground, a control a measurement program, which is designed by usi Visual C^{++}, is also given.

4. Experiments and Discussions

4.1 Performance for Corrosive Conductors

To verify the utility of the implemented detector, artificial conductor was tested. First, the prepa conductor was sample under new condition which h several faults on the surface of aluminum strands the outer layer. Such faults are several broken wi (a~e), corroded parts(f~j) by hydrochloric a solution and abrasions(k~o).

Fig. 4.1 shows the output characteristic to measured by the implemented system. As a result, can be easily seen that the output of corrosion detec is nearly proportional to the degree of corrosion.

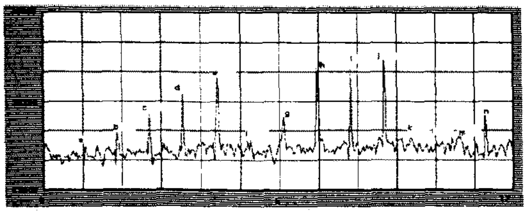

Fig. 4.1 Conductor with artifitial faults

In general, the response of the zinc layer on the st core may not appear to the eddy current variation the sensor coil. As mentioned above, ACSR-OC comprises aluminum strands with smooth body and then, the zinc loss of steel core may be hardly affected to the output of corrosion detector despite of its serious status. However, it may not be a crucial issue provided that the detector could give a suitable output for aluminum strand corrosion. Although aluminum strand inside begins to corrode after all zinc layer would be removed off, the corrosion detector can present a response corresponding to the corrosion of aluminum strands at that time.

4.2 Field Tests

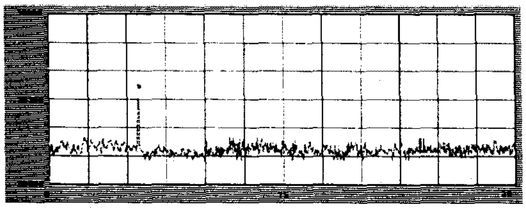

Fig. 4.2 Measurement data for an aged ACSR-OC

Based on the experimental results obtained in t laboratory, an aged ACSR-OC conductors in the fie have been examined. It is seemed that the conduc and its polyethylene coating may not be any corros or faults before measuring it by the detecting syste Fig. 4.5 illustrates the detecting data for one conduc In this result, there exists one location where its outp appears higher than any other outputs for the t conductor. It means that these points may progressed more serious or lead to some faults. As t result from visual inspection, it is verified that th exists any damage on the polyethylene coating a aluminum strands in the inner layer of ACSR-OC m be somewhat deformed.

5. Conclusions

This research deals with a design of nondestructi test system to diagnose deterioration of HV overhea distribution lines and some experimental results. M of aged conductors lead to local corrosion or chan of cross section area of the conductors. A detecti system with a solenoid eddy current sensor is design and examined to detect the change of cross secti area. Through some experiments for several artificia corroded conductors and aged conductors, the output variation properties of aluminum and steel strands were tested and discussed. As a result, it was shown that the proposed system could be effectively applied to detect severe faults caused by any local and global corrosion.

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