

EVALUATION OF INSULATION FAILURE IN POWER SYSTEM USING ARTIFICIAL INTELLIGENCE

¹Ugwu George Ani, ²Ifeagwu Emmanuel N. and ³Oji Charles Ifeanyi

¹Delta State University of Science and Technology, Ozoro

²Federal University Otuoke, Bayelsa

³Southern Delta University Ozoro

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Abstract: A power system is dynamic because the voltage and the current are not in phase, due to a phase angle difference. These occurrences led to instability, transient, and sub-transient conditions when power is wheeled from the generating station to the load centers. This tends to create undue stress on power machines, which leads to mechanical and electrical shifts from the machine's designed specification standard. This occurrence led to the burning of power facilities, faults in the power systems, the death of system operators, and insulation failures. Insulation failures of electrical machines are more pronounced in the distribution system than in the transmission system. Enugu Electricity Distribution Company (EEDC) was chosen, and the data on insulation failure of the power machine was gathered. EEDC comprises of 18 districts with 64 Injection. Through the secondary data, release by the protection, Control and Metering, 40 percent of the Injection Sub are losing insulation, which was gathered through preventive maintenance. Atani Injection Sub was chosen for investigation. Atani Injection Sub is made of 6 feeders: Housing, Iweka, Water Works, Iyiowa, Wharf, and Premier feeder. An insulation test was run using a megger, and the test result showed that the Iyiowa breaker failed the insulation test. Housing breaker, Iweka breaker, Water Works breaker, Wharf breaker, and Premier breaker are confirmed okay. Artificial intelligence was introduced to detect the insulation level in real time and was infused into EEDC networks in real time. The system was simulated, and the result showed that the artificial intelligence updated the system operator, the insulation level of the power machine, which reduced the rate of failure of the power machine to 10 percent.

Keywords: Artificial, Failure, Insulation, Intelligence, Power

1 Introduction

Power systems are designed with insulation design in view or protection purposes, both for the electrical machine and the machine operators. Transmission line voltages are varied ranges from low voltage, high voltage, extra high voltage, and ultra-high voltage. Each of the voltages is provided with the right insulation mechanism that it can be able to withstand. If the wrong insulation mechanisms are provided, it will lead to flashover.

2 Related Literature

Adejumobi [2007] presented the causes of insulation failure in transmission after collecting samples of transformer oils from different substations, but the study failed to present a technique for mitigation.

Bill [2022] presented that 56 percent of electric generators failures originate from electrical insulation damage. He characterizes insulation failure in power system without presenting a technique for mitigation.

Juam[2020] presented a method of insulation co- ordination by carrying out routing test of power system device but the problem is that, insulation failure might occur before the plan routine test.

Monem [2024] presented types of insulation failure and failure level detector for leakage current. The methods track leakage current but the system is not a smart system. The tracking is done manually, sometimes, before the manual tracking; insulation failure might have taken place.

Ifeagwu [2016], presented power flow analysis of electric transmission system in southern Nigeria. The study explores steady state of power transfer but did not deal with insulation failure in the system.

Ugwu [2024] , presented security intelligence improvement using power electronics technique, although the study deals on security of the system and networks but failed to address insulation failure in power system.

Armando [2020], presented an approach of detecting and predicting preventive failure, the approach fare than other approaches that characterize insulation but failed to present an algorithm for preventive detection. The algorithm fare well but the predictive detection of failure is not on real time. This is the problem this work wants to address, to characterize the failure, predict preventive detection and on real time, without human aiding, which is more efficient.

3. Methodology

The method adopted for this study is empirical and analytical approach. EEDC distribution networks were chosen for the test system and incorporation of artificial intelligence using Atani Road Injection Sub Station specifically for test and analysis. Atani Road Injection Sub Station comprises of six feeders which include: Housing Feeder, Iweka Feeder, Water Works Feeder, Iyiowa Feeder, Wharf Feeder and Premier Feeder. The failure spam's from silica gel, transformer oil, winding temperature, breaker conditions, relay co – ordination, battery bank and indoors and outdoors switch gear panel. The failure was characterize by secondary data from EEDC, where the failure of power transformer, breaker failure, and battery bank failure which are the factors contributed to the failure in operation. Loss of battery cells, high winding temperature, especially during heat wave period, nonfunctional silica, bad transformer oil and insulation failure of male and female contact of the circuit breaker, are the problems, the study wanted to solve. Based on maintenance log book, breaker insulation failure occurred two times at Atani Injection substation. One caused by mechanical contact of the breaker losing insulation which led to explosion. The other was caused by male and female contact of the breaker losing insulation, which led to explosion. In 33 Injection, the indoor panel exploded which endangered the life of the operator on duty. Army barrack substation lose two power transformer because of preventive maintenance, the winding temperature was too high, the silica gel which absolved moisture was nonfunctional and led to failure of two power transformer, this invariable led to the sack of operator on duty. At fegge Injection sub, the station was shut down due to DC power supply was below 40V which is not healthy for operation of the station. These were the physical assesment of four EEDC station evaluated. Other secondary data showed that EEDC lost 10 15MVA and 3 7.5MVA transformers, over fifty breakers, which seventy percent would have been averted through preventive maintenance. Artificial intelligence was incorporated with system networks of all the injection sub, the condition of all the breaker and power transformer, are updated every hour, in real time, and possible preventive

maintenance are noted and carried out, thereby mitigating failure of power facilities, especially, breaker and power transformer which is very expensive if they fail.

Mathematically

Using Power loss equation,

Power loss $P =$ Failure rate F

$$P = F \dots\dots\dots 1$$

$$P = I^2R \dots\dots\dots 2$$

$I^2 =$ Device useful Life D , $R =$ Artificial Intelligence

$$\text{Then, } F = I^2R \dots\dots\dots 3$$

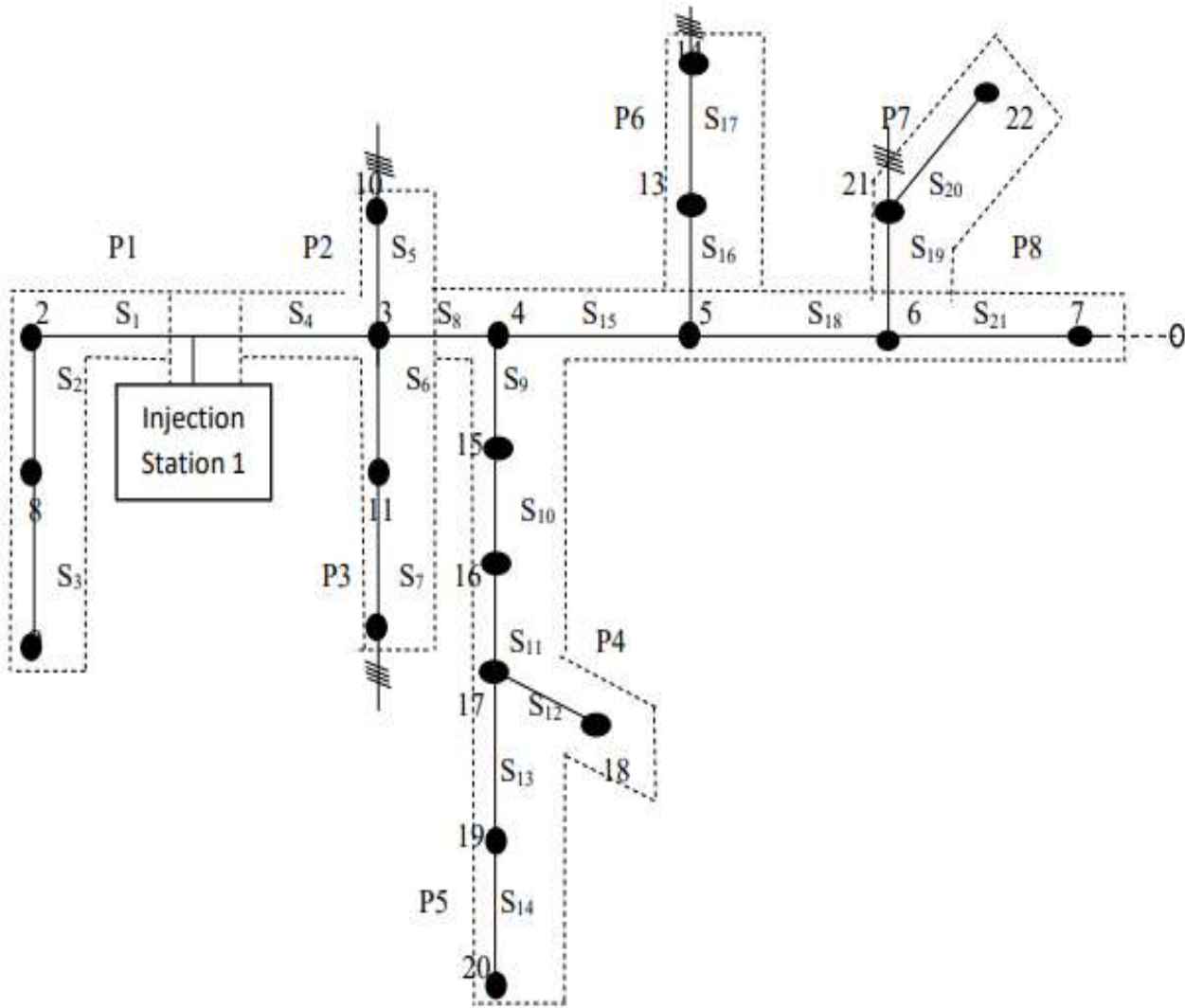


Fig 1; Franchise Network of EEDC

Fig 1 showed the franchise network of EEDC networks selected for the evaluation of insulation failure in power system network using artificial intelligence.

4. Result

Enugu Electricity Distribution Company (EEDC) was chosen, and the data of insulation failure of power machine was gathered. EEDC comprise of 18 districts with 64 Injection. Through the secondary data, release by the protection, Control and Metering, 40 percent of the Injection Sub are losing insulation, which was gathered through preventive maintenance. Atani Injection Sub was chosen for investigation and experiment. Atani Injection Sub is made of 6 feeders: Housing, Iweka, Water Works, Iyiowa, Wharf and Premier feeder. Insulation test was run using megger, which the test result showed that Iyiowa breaker failed insulation test, Housing breaker, Iweka breaker, Water Works breaker , Wharf breaker and Premier breaker are confirm okay. Artificial intelligence was introduced to detect the insulation level at all time on real time. The system was simulated and the end result showed that the artificial intelligence update the system insulation level of the power machine, which reduce the rate of failure of power machine to 10 percent.

			AY	AZ	
1					
2			FAULTCO UNTER (FT)	2024 PEAK (AMP)	2 AVE (A)
137	1F02	EMEKU	0.00	330	
138	1F01	AVUVU	0.00	159	
139		TR 1, 7	0		
140	33-33F	MBUTU	0.00	100	
141	1F02	HOUSING	0.00	177	
142	1F02	IWEKA	0.00	167	
143	1F03	ATANI V	0.00	212	
144		TR1, 15	0		
145	1F03	IYIOWA	1.00	226	
146	1F01	WHARF	0.00	48	
147	1F01	PREMIER	0.00	195	
148		TR2, 15	0		
149	1F04	BIDA 15	0.00	33	

Fig 2; Insulation level of Atani Injection Substation

Fig 2 showed the result of insulation test carried out using megger, and the result showed that Housing, Iweka, Waterworks, Wharf and Premier are okay, only Iyiowa that failed insulation test and it updated the information on the personal computer as shown in fig 2.

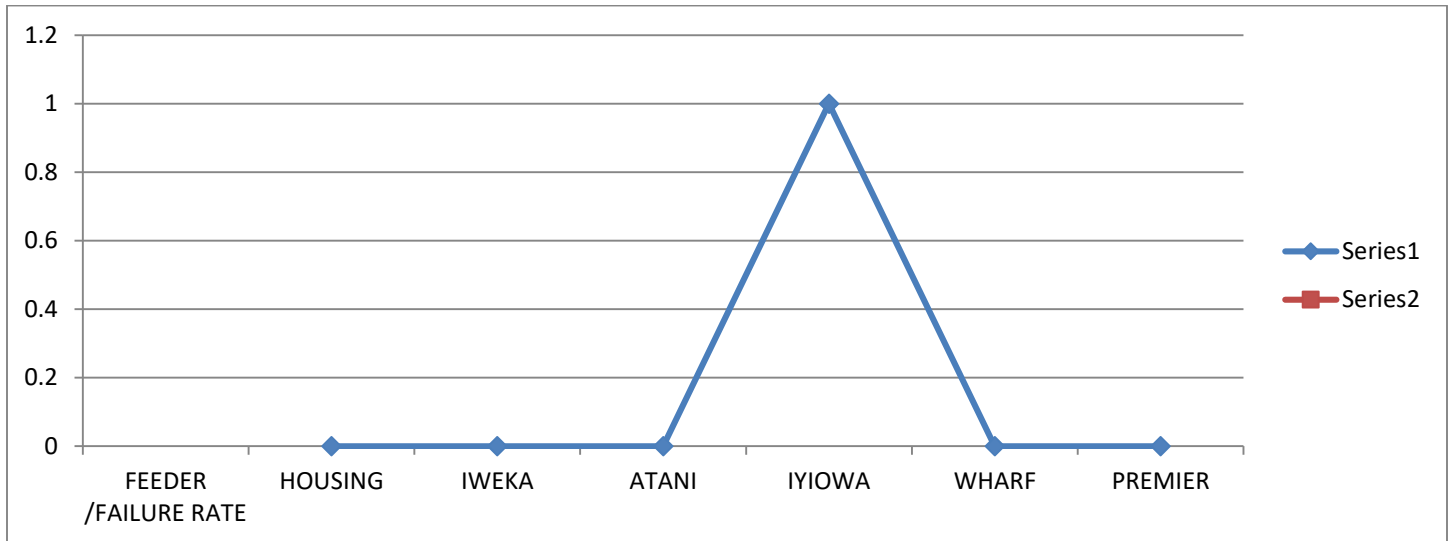


Fig 3; Insulation test result

Fig 3 showed the insulation test carried out at Atani Injection substation. The graph showed that it is only Iyiowa that failed the insulation test. The test result will guide the operator on duty not carry out operation on Iyiowa feeder. However, it will inform the management of preventive maintenance thereby safe guarding the equipment and the live of the operator on duty. Furthermore, it will reduce operational cost, because explosion incurs more operational cost.



Fig 4; Winding Temperature

Fig 4 showed the artificial intelligence embedded system of EEDC networks. It showed the winding temperature and the winding temperatures are within the acceptable limit of 50 to 60°C as shown in fig 4. Once it exceeds 75°C, it will display on the personal computer, thereby reminding the operator on duty to reduce load carrying capacity and activate force cooling of the power transformer. Since is on the real time, management can call the attention of operator on duty if he or she failed to take action when the winding temperature limit is exceeded.

5. Conclusion

The insulation failure in power system is a balance fault which occurrence is rare in power system. However, the recent failure in power system facilities is abnormal, which affected the reliability of power system devices, operations and inability to make a decent profit. The failure spam's from silica gel, transformer oil, winding temperature, breaker conditions, relay co – ordination, battery bank and indoors and outdoors switch gear panel. Artificial intelligence was interface with each devices, the readings, devices conditions was displays on the personal computer which predict the anticipated failure of each devices and preventive maintenance taken to mitigate possible device failure. The simulated possible device failure showed that possible balanced faults were reduced to 10 percent. This approached mitigated preventive failure of devices in power system networks and in transmission and distribution substation, especially in distribution substation.

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