Design of Transformer Status Monitoring Device

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Abstract. According to actual needs of transformer on-line monitoring, this paper introduces IEC61850 to transformer on-line monitoring system, build reasonable modeling of data and logical devices. Based on IEC61850, the transformer on-line monitoring information model is established. Advanced embedded technology and communication technology are used to realize the monitoring device design, meanwhile, according to data attribute and failure mode to distinguish and finish maintenance strategy. It has certain reference significance to the improvement of transformer intelligent level and construction of intelligent substation.

Keywords: status monitoring, information model, transformer, maintenance strategy.

1. Introduction

Power transformer is key equipment of power system. Its stable operation is of great significance to safe and stable operation of power system. Development of intelligent substation construction is increasingly demand the intelligent level of substation, during the operation of substation, it needs more sensors and electronic devices installed in equipment's, to monitor and reflect the status information of equipment and realize self-status detection and diagnosis [1]. As key equipment of substation, the transformer needs a comprehensive monitoring and management system to avoid expensive replacement, cleaning cost, and unscheduled outages. And early monitoring of transformer's latent fault is of great significant to prolonging the life of the transformer. So the design of the transformer condition monitoring system has important application value.

2. Demand analysis of transformer status monitoring

To avoid transformer faults, it needs to comprehensively test transformer's running status, and catch the coming fault signal earlier. Largely depends on the operation of transformer condition, especially the electrical aging of transformer insulation aging, thermal aging, partial discharge aging, the high oil temperature greatly reduces insulation performance of transformer, at the same time, transformer oil quality cannot be achieved online monitoring and adaptive adjustment, and will intensifies transformer oil aging, then shorten the transformer life.

Expect monitoring parameters is few and operation is simple and reliable requires a detailed analysis of transformer fault form, and find the common features of faults, identify a specific characteristic parameter measurement. To sum up, it basically has following conditions:

The main monitoring objects are dissolved gas in transformer oil, dc resistance of winding, transformer oil temperature, sealing and leakage, winding deformation, partial discharge and body vibration. The specific status monitoring content and parts are set below

3. Analysis of on-line monitoring technology

3.1 The partial discharge on-line monitoring technology

When transformer internal fault occurs or running conditions are bad, it will partial discharge due to partial high field intensity, and then electrical information will appear and accompanied with sound and all kinds of non-electric information, therefore, in general the partial discharge detection can be

divided into electrical measurement method and the non-electric measurement method (including ultrasonic method, optical method, the decomposition method, etc.).

There are many interference sources and high strength to carry out partial discharge tests at substation site. Currently, the anti-jamming partial discharge detection methods are pulse polarity identification method, directional coupling method, ultrasonic positioning method, electric - ultrasonic joint positioning method. Electrical and ultrasonic joint positioning method takes electric pulse of partial discharge as the trigger reference signal, and records electric pulse signals and multi-channel ultrasonic signals, takes the time difference between electrical signal and the ultrasonic signals as travel time of partial discharge point reach to each sensor, and calculate the discharge location according to the equations.

With the development of digital signal processing technology, the software method is becoming a more effective method to eliminating interference. Application of adaptive filtering techniques can adjust their own parameters to meet the requirements of an optimum criterion when input sequence of unknown statistical characteristic and change, consequently achieve the discharge signal and limit interference.

3.2 The oil gas online analytical technology

Gas chromatography of oil gas composition and content has been an important mean to judge internal state of oil-immersed transformer for a long time.

Chinese guideline adopts three ratio methods, which is using relative ratio of collected gas concentration, infer cracking condition of oil or oil paper insulation. Currently, on-line monitoring device for oil gas content detection has been developed and applied at home and abroad. This device using gas chromatography detection principle, after degassing by automatic degasser, the dissolved gas in transformer oil automatically flow through the chromatographic column under the effect of carrier gas. Affinity effect of chromatographic column is different to fix different gas, different gas will flow out of the chromatographic column in different time, and component is separated. Semiconductor sensor could convert measured physical signals to electrical signals, and send to computer to do the quantitative analysis and calculation.

3.3 Infrared temperature measurement technology

Infrared thermal imaging technology is using infrared detector to accept the infrared radiation signal of the measured target, after amplification processing to a standard video signal, and then displayed infrared thermal image map on television screen or monitor. When the transformer lead is bad contacted, coil conductor joint virtual welding, overload running will cause overheating of partial conductive loop, iron core multipoint earthling can also cause core overheating. As infrared thermal image technology temperature measurement is precise, it can be used in the monitoring of transformer, by analysis of images to monitor each part temperature of transformer, by horizontal comparison to judge its status. By comprehensive monitoring of transformer oil to form an integrated system of online deoxidization, dewatering, degassing, cooling, filtering and early warning for transformer oil treatment system. By comprehensive judgment of test data, running data and history data to establish a perfect data warehouse, using intelligent control element such as artificial intelligence to choose different control strategies, according to the actual deviation change rule and controlled object characteristics, pure lag and disturbed factors, to solve the problem of nonlinear and linear system integration.

4. Monitor device hardware design

4.1 Monitor device hardware system design

Master IED of transformer plays an important role in the status monitoring system, it is not only used for processing and communication of subsystem data collected by status monitor, but also do simple analysis and diagnosis to the corresponding information. It also need to meet the digital communications functions requirements of IEC61850.

Status monitoring is for above performance parameters of the transformer. The whole hardware system is mainly composed of front signal acquisition unit (including smart sensors) and status handling units [4].Front signal acquisition unit is for acquisition of needed monitoring signals of circuit breaker, the early stage of the process, transformation, staging, and then realized in monitoring device internal condition analysis and diagnosis, the specific hardware structure is shown in figure 1, transfer to station control layer monitoring substation system. The station control layer monitoring substation is for the storage history data, data analysis and comparison, graphics processing and other functions. By doing this to ensure the front signal acquisition unit is concise and reliable under most severe environment, and also guarantees the function integrity and practicability of the monitoring system.

Hardware platform is the carrier to realize communication function. The master IED hardware system is divided into six modules by principles: master control minimum system, power supply module, switch input module, switch output module, communication module, analog input and output module and man-machine interface module. The structure schematic diagram is shown in figure 2. In Figure 2, A, B, C, D, E, F, is respectively as six interface connected port of IED and outside. A stands for communication interface between Ethernet interface that realized IEC61850 process layer communication and GOOSE communication interface; B stands for external input AC or DC power supply interface; C and D stands for switch value input and output interface of power grid, such as switch position, control signals, alarm and so on. He stands for current analog and 4 ~ 20 mA non-electricity current signal input/output interface after primary transformer voltage; F stands for online download debugging interface of man-machine interface board.

4.2 Intelligent transformer status monitoring master IED model

In IEC 61850 standard, logical nodes (LPHD) is used to describe basic device information. A logical node (LLN0) is used to describe the relevant attribute information. Extension node (SPTR) is mainly used to store the processed monitoring information. And other monitoring IED modeling is basically the same.

Table 2 LPHD logic node

Data name	Data type	instructions
PhyNam	DPL	IED nameplate
PhyHealth	ENS	IED healthy state
Proxy	SPS	Agent state

Table 3 LLN0 logic node

Data name	Data type	instructions
Mod	ENC	model
Beh	ENS	behavior
Health	ENS	Agent state
NamPlt	LPL	nameplate
brcbFltInfo	BRCB	Failure report: dsFltInfo

Uniform data object model ensures mutual understanding, information exchange and collaborative operation between different devices. After finish LN modeling, the measurement of transformer status monitoring device can correspondingly set the measurement, wave record information, parameter setting value to the corresponding logical node objects. Each LN consists of data with specific data attributes, data has structure and defined semantics include in specialized data attributes data table. The data object model is described by logical device name, logical node name, data names, data attributes.

Logical device. Information exchange mechanism mainly relies on accurate definition of information model. These information models and modeling methods is the core of the IEC61850 [7-9]. Whether it will exact and effective definite IED model is the key point to provide standard

service. Take the following transformer condition monitoring master IED data information model as an example to explain detailed process of modeling.

Master IED;

Table 4 SPTR logic node

Data name	Data type	instructions
Mod	ENC	model
Beh	ENS	behavior
Health	ENS	Agent state
NamPlt	LPL	nameplate
CoreFlt	SPS	Iron core fault
WindingFlt	SPS	Winding fault
TapFlt	SPS	On-load tap-changer fault
CoolingFlt	SPS	Cooling device failure
DschFlt	SPS	Discharge fault
OvTmpFlt	SPS	Overheating fault
DampFlt	SPS	damp fault
ElseFlt	SPS	Other fault
FltProb	MV	Probability of failure

4.3 software design

With status sensor, monitoring IED can real-time monitoring and record compaction status of transformer core and winding, displacement and deformation of the vibration, mechanical property of transformer on-load voltage regulating tap, oil gas, partial discharge, winding hotpot, micro water testing, transformer oil performance testing, leak testing, core testing, on-line infrared temperature measurement. Master will take data communication, control and management to slave IED, which is monitoring transformer status.

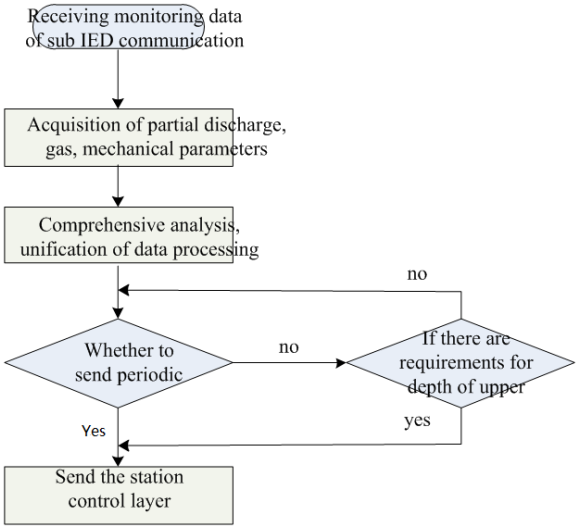

Figure 3 comprehensive analysis flow chart

Main IED regularly submits standard format monitoring data to control layer. It will immediately submit a message when fault probability detected by IED increase every 2%. When deep analysis is required, monitoring IED will answer the call to organize the required data files, by station control layer network submit to related analysis system and support parameters call and setting after physical isolation. The specific processes are as shown in figure 3.

Master station system of transformer on-line condition monitoring will provide real-time acquisition, monitoring, diagnosis and abnormal alarm, and other functions to transformer status information. By acquisition of real-time and management data of transformer, master station system will judge and forecast the transformer fault location, fault degree and development trend, realizes of transformer health status evaluation and judgment equipment condition.

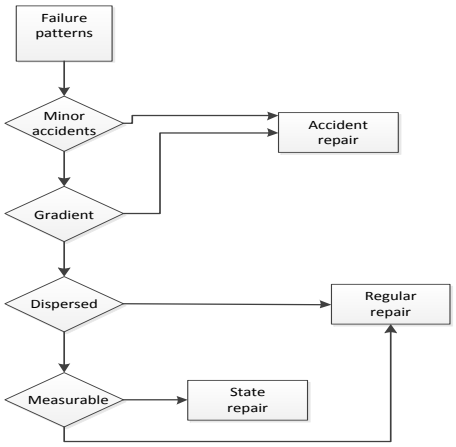

Fig6.The principle of transformer condition monitoring maintenance strategy

The purpose of transformer condition monitoring system is not only to status overhaul, and should analysis each according to fault type characters, formulate specific policies. As shown in figure 6, first determines the fault severity, and judge whether need accident repairs, and then judge whether preventive maintenance is needed. Finally, status overhaul to measurable fault types. Only in this way can offer a comprehensive service to transformer device.

5. Conclusion

The transformer operation status is related to the safe and stable operation of power system. This paper introduces the IEC61850 to transformer on-line monitoring system according to actual need. And model according to data classes and logical device. Establish transformer on-line monitoring information model based on IEC61850.

This paper has realized transformer online monitoring with advanced embedded technology and communication technology, at the same time, it uses substation automation information to realize information fusion in monitoring master station, and complete the maintenance strategy making according to the data properties and failure mode discrimination. It improves intelligent level of transformer and has certain reference significant to intelligent substation construction.

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