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電力變壓器絕緣油診斷案例剖析
Part 1：概論

Case Study of Power Transformer Insulating Oil Diagnosis

Part 1：Introduction

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摘　要

本研究對電力變壓器之異常案例進行剖析，除本篇概論以外，另依異常型態類別分述為絕緣紙老化診斷、溶解性氫氣成長、鐵心的過熱與放電、過熱、放電之個別專題，本篇為全6則專題中第1則專題。本篇概論簡要說明對須注意或異常的變壓器，如何利用台電綜研所自行開發之「油中氣體案例診斷法」進行關鍵氣體與氣體成長模式辨識，並執行綜合診斷以評估可能的異常部位，提供作為後續追蹤與內檢之規劃參考。

Abstract

This study aims to analyze the fault cases of power transformers through 6 special topics. In addition to this introduction, topics such as ageing diagnosis of insulation paper, growth of dissolved hydrogen, core overheating and discharge, overheating, and discharge will also be discussed based on the type of faults. This article of introduction briefly explains how to identify key gases and gas growth patterns in transformers that require attention or are abnormal, and how to perform comprehensive diagnosis to evaluate possible fault locations to serve as reference for follow-up action and internal inspection planning.

關鍵詞(Key Words)：電力變壓器(Power Transformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、變壓器故障診斷(Transformer Fault Diagnosis)。

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電力變壓器絕緣油診斷案例剖析
Part 2：絕緣紙老化診斷

Case Study of Power Transformer Insulating Oil Diagnosis

Part 2：Insulating Paper Ageing Diagnosis

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摘　要

國際上目前最廣為使用的三種變壓器絕緣紙老化指標為油中溶解性二氧化碳、糠醛、甲醇，本文針對三種指標進行介紹與比較，對油溫校正公式與各種油處理對甲醇濃度的影響性進行評估，並對三種老化指標在台電公司設備之測試結果進行實地普查及數據分析後，挑選數台已達使用年限之變壓器進行拆解取絕緣紙樣品，對三種老化指標測試準確性作驗證。研究結果發現台電公司絕緣紙老化情形分為熱老化、酸催化水解老化與區域性絕緣油散熱不良之三種主要老化態樣，而使用甲醇作為絕緣紙老化評估時，在拆解變壓器驗證之案例中為三種指標中最能反映實際老化程度者，研究成果並引入作為台電公司評估絕緣紙老化之例行試驗項目。

Abstract

The three most widely used ageing indicators of transformer insulation paper in the world are dissolved carbon dioxide, furfural, and methanol in oil analysis. In addition to introducing and comparing the above three indicators, this article also evaluates the influences of the oil temperature correction formula and various oil treatments on methanol concentration. After conducting afield study and data analysis on the test results of the three ageing indicators on Taipower's equipment, several transformers that had reached their service life were selected for disassembly and insulating paper samples were taken to verify the accuracy of the tests for the three ageing indicators. The research results found that the ageing of Taipower's insulating paper is divided into three main ageing states: thermal ageing, acid-catalyzed hydrolysis ageing and regional poor heat dissipation of insulating oil. When methanol is used to evaluate the ageing of insulating paper, in the case of dismantling the transformer for verification, it is the one that best reflects the actual ageing degree among the three indicators. The aforementioned research results have been introduced as a routine test item for Taipower to evaluate the ageing of insulating paper.

關鍵詞(Key Words)：電力變壓器(Power Transformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、絕緣紙老化(Insulating Paper Ageing)、糠醛(Furfural)、平均聚合度(Average Degree of Polymerization)、甲醇(Methanol)、乙醇(Ethanol)。

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電力變壓器絕緣油診斷案例剖析
Part 3：溶解性氫氣成長

Case Study of Power Transformer Insulating Oil Diagnosis

Part 3：Dissolved Hydrogen Growth

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摘　要

台電公司為強化變壓器油中溶解性氫氣成長之相關風險管控措施，除修訂電力變壓器油中氣體分析診斷用參考文件以外，並進一步調查氫氣濃度測試結果較高之變壓器的氣體產出原因作為經驗參考。本文就變壓器中溶解性氫氣之來源與其對變壓器之危害進行文獻整理，並將台電公司高氫氣濃度案例調查結果加以釐清，並分類為電暈引發氫氣成長、材料釋放氫氣、樣品不均勻性等，以供後續綜合診斷之參考。

Abstract

In order to strengthen the risk management and control measures related to the growth of dissolved hydrogen in transformer oil, Taipower has not only revised the reference document for dissolved gas analysis and diagnosis in power transformer oil, but also further investigated the reasons for the gas production in transformers with high hydrogen concentration test results as a reference. This article compiles literature on the sources of dissolved hydrogen in transformers and its harm to transformers, and clarifies the investigation results of Taipower's high hydrogen concentration cases, and classifies them into hydrogen growth caused by corona, hydrogen release from materials, sample inhomogeneity, etc., to serve as reference for subsequent comprehensive diagnosis.

關鍵詞(Key Words)：電力變壓器(Power Transformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、氫氣(Hydrogen)、部分放電(Partial Discharge)、絕緣油(Insulating Oil)。

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電力變壓器絕緣油診斷案例剖析
Part 4：鐵心的過熱與放電

Case Study of Power Transformer Insulating Oil Diagnosis

Part 4：Core Overheating and Discharge

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摘　要

電力變壓器鐵心常見的異常型態包含過熱與低能量放電，本文對鐵心常見的結構設計進行說明，並以案例詳述鐵心多點接地、塊間短路與片間短路情形引起異常的原因，分析異常發生時油中溶解性氣體分析(以下簡稱油中氣體分析)的特徵與成長模式，油中氣體成長情形與負載之關聯性，以及電氣試驗辨識方式與量測之限制性。期待未來透過油中氣體與電氣試驗結果之綜合診斷，可有效提升異常設備風險評估精準度，並進行更適宜之運轉與維修方式規劃，有效提升電網韌性。

Abstract

Common fault types of power transformer cores include overheating and low-energy discharge. This study not only describes the common structural design of the core, but also uses cases to detail the causes of faults due to multi-point grounding, short links between core steel blocks or laminations. In addition, this study focuses on the characteristics and growth pattern of dissolved gas analysis in oil (DGA) when faults occur, the correlation between gas growth conditions in oil and load, and the limitations of electrical test identification methods and measurements. It is expected that in the future, through comprehensive diagnosis of gas in oil and electrical test results, the accuracy of risk assessment of fault equipment can be effectively improved, more appropriate operation and maintenance method planning can be carried out, and the resilience of the power grid can be effectively improved.

關鍵詞(Key Words)：電力變壓器(PowerTransformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、變壓器故障診斷(Transformer Fault Diagnosis)、鐵心(Core)。

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電力變壓器絕緣油診斷案例剖析
Part 5：過熱

Case Study of Power Transformer Insulating Oil Diagnosis

Part 5：Overheating

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摘　要

以絕緣油中溶解性氣體分析(以下簡稱油中氣體分析)進行電力變壓器的預知故障診斷時，在過熱型異常的診斷效益最為顯著，特別對負載電流通路部位的中高溫過熱情形，搭配電氣試驗進行早期診斷時，可有效避免其惡化為高能量電弧放電，降低變壓器事故風險。鐵心相關的過熱異常診斷已於本專題 Part 4 說明[1]，本文針對鐵心以外的其他部位發生異常銅損、鐵損與雜散損產生過熱的案例進行說明，並分析其油中氣體特徵，以及異常情形與負載和電氣試驗間的關聯性。

Abstract

When using dissolved gas analysis (DGA) in insulting oil for predictive fault diagnosis of power transformers, the benefit is most significant in the diagnosis of thermal fault, especially for medium and high temperature overheating in the load current path. When combined with electrical testing, early diagnosis can effectively prevent it from deteriorating into high-energy arc discharge and reduce the risk of transformer accidents. The diagnosis of core-related thermal fault has been described in Part 4. This article explains the cases of overheating due to abnormal copper loss, iron loss, and stray loss in parts other than the core, and the dissolved gas characteristics in the oil, as well as the relationship between abnormal conditions and load and electrical tests.

關鍵詞(Key Words)：電力變壓器(Power Transformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、變壓器故障診斷(Transformer Fault Diagnosis)、過熱(Overheating)、熱故障(Thermal Fault)。

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電力變壓器絕緣油診斷案例剖析
Part 6：放電

Case Study of Power Transformer Insulating Oil Diagnosis

Part 6: Discharge

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摘　要

引起變壓器異常跳脫之內部故障型態通常為高能量電弧放電，致力於避免其發生以維繫供電穩定，為變壓器預防性診斷的第一目標。本文針對變壓器中的放電型態進行介紹，分析引起各式放電的原因，並說明絕緣油中溶解性氣體分析(以下簡稱油中氣體分析)如何應用於放電診斷。

Abstract

The internal fault type that causes tripping of a transformer is usually a high-energy discharge. Avoiding the occurrence of the above situation to maintain the stability of the power supply is the first goal of preventive diagnosis of transformers. This article introduces the discharge types in transformers, analyzes the causes of various discharges, and explains how dissolved gas analysis (DGA) in insulating oil may be used in discharge diagnosis.

關鍵詞(Key Words)：電力變壓器(Power Transformer)、油中溶解性氣體分析(Dissolved Gas Analysis, DGA)、變壓器故障診斷(Transformer Fault Diagnosis)、放電(Discharge)、電弧(Arc)。

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以局部放電量測技術發掘異狀及完成改善以轄區某變電所之#1 配電變壓器為例

Use Partial Discharge Measurement Technology to Discover Anomalies and Complete Improvements - Taking #1 DTR of a Substation as an Example

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摘　要

目前高壓設備運轉時若有異常情形發生，常利用 UHF[1]或 AE 的方法來進行檢測，在且其為相當有效益的偵測技術。本篇報告以本課轄區某變電所之#1 配電變壓器發生異音情形時，透過符合 IEC60270 標準[2]之局部放電量測的兩種儀器檢測，並且交叉比對驗證找變壓器異常位置。局部放電量測結果顯示於該變壓器二次側接頭處有明顯的震動訊號，但無明顯的放電訊號；而油中氣體分析結果，並未發現乙炔。為了釐清問題，確保變壓器送電安全，本所隨後安排開蓋檢查，進一步確認及解決異音之發生原因，預防及降低發生事故之風險機率。

Abstract

When high voltage equipment operates abnormally, ultra-high frequency (UHF) or acoustical emission (AE) methods are often used for detection, which is a very cost-effective detection technique in practice. In this report, we use two instruments that meet the IEC 60270 standards for partial discharge (PD) to detect and analyze the abnormal noise which occurs in #1DTR, and cross-compare and verify the abnormal location in the transformer. The PD measurement results show that there is an obvious vibration signal at the secondary side joint of the transformer, but there is no obvious discharge signal. In addition, the results of the total combustible gas (TCG) analysis meet the standard and no acetylene is found. In order to clarify the problem and ensure the safety of the power transformer, we then arranged to open the cove for internal inspection to further confirm and solve the cause of the abnormal noise, and to prevent and reduce the risk of accidents.

關鍵詞(Key Words)：超高頻 (Ultra-high Frequency)、聲發射(Acoustical Emission)、可燃性氣體總量(Total Combustible Gas)、局部放電 (Partial Discharge)。

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以外部量測數據分析變壓器內部異常位置

Use External Measurement Data to Analyze Abnormal Locations Inside a Transformer

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摘 要

有關本處轄下一台 60/(30+30)MVA 變壓器，民國 91 年 7 月 25 日加入系統，運轉迄今約 21 年，經安排變壓器 TCG 送試，發現絕緣油中乙烯突升伴隨乙炔產生，研判變壓器內部有中溫過熱及微小放電情形，且後續轉變為高溫過熱及放電情形。

以往變壓器內部出現異常狀況時，須於開蓋內檢後方可找出異常位置，本案於開蓋內檢前進行外部線圈回路電阻量測，先行找出異常位置，且與開蓋內檢結果不謀而合，後續若發生絕緣油中氣體異常案例，乙烯(C_2H_4)、乙炔(C_2H_2)被視為關鍵氣體，且乙烯、乙炔上升速率與變壓器負載利用率呈現正相關，可能為 OLTC 或 NVTC 金屬接點接觸不良所致，可於開蓋內檢前進行外部線圈回路電阻量測，以利找出異常位置。

Abstract

There is a 60/(30+30) MVA transformer under the jurisdiction of our department. It was added to the system on July 25, 2002, and has been in operation for about 21 years. After arranging for the transformer TCG test, it was found that the ethylene in the insulting oil suddenly increased and acetylene was produced. It is determined that there is medium-temperature overheating with slight discharge inside the transformer, which subsequently turn into high-temperature overheating and discharge.

In the past, when an abnormal condition occurred inside a transformer, the abnormal location could only be found after opening the cover for internal inspection. In this case, the external coil loop resistance was measured before opening the cover for internal inspection to find the abnormal location first, and the measurement results were consistent with the results of the internal inspection results after opening the cover. Coincidentally, if there is a subsequent case of abnormal gas in the insulating oil, ethylene (C_2H_4) and acetylene (C_2H_2) are regarded as key gases, and the rising rate of ethylene and acetylene is positively correlated with the load utilization of the transformer, which may be caused by poor contact of the OLTC or NVTC metal contacts. Therefore, the external coil loop resistance can be measured before opening the cover for internal inspection to facilitate finding the abnormal location.

關鍵詞(Key Words)：乙烯(Ethylene)、乙炔(Acetylene)、可燃性氣體(Combustible Gas)、中溫過熱(Medium-Temperature Overheating)、高溫過熱(High-Temperature Overheating)。

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改善電力變壓器局部放電圖譜辨識之研究

Study on Improving Partial Discharge Pattern Identification of Power Transformers

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摘 要

為改善電力變壓器局部放電圖譜辨識，本研究旨在針對電力變壓器局部放電(PD)圖譜辨識提出改善的方法。我們都知道局部放電相位分析圖譜(PRPD)模式和脈衝序列分佈圖譜(PRPS)，用於診斷局部放電訊號並判斷為電暈放電、表面放電、外部放電和雜訊。局部放電的模式識別在應用產業和學術界具有多種益處。首先，根據建議的測量資料收集和分析流程圖，應用高頻比流器(HFCT)來抑制測量訊號的雜訊。其次，採用局部放電脈衝的特性參數來提高電力變壓器的局部放電模式辨識。局部放電的脈衝持續時間和脈衝頻率兩個脈衝的特徵參數被作為抑制測量訊號的雜訊的因數。最後，透過現場測試應用此方法可以提高局部放電相位分析圖譜的診斷效果。

Abstract

This study aims to propose an improved method for partial discharge (PD) pattern identification of power transformers. We know that the phase resolved partial discharge (PRPD) and the phase resolved pulse sequence (PRPS) are commonly used to diagnosis PD signals and determine whether they are corona, surface discharge, external discharge or noise. PD pattern identification has various benefitscial for industrial applications and academic research. In this study, we first apply a high-frequency current transformer (HFCT) to suppress the noise of measured signals according to the proposed data collection and analysis process. Secondly, the characteristic parameters of PD pulse are used to improve the partial discharge pattern identification of power transformers. Two pulse characteristic parameters, namely the pulse duration and the pulse frequency of the discharge, are used as factors for suppressing noise in the measured signals. Finally, field test applications prove that the aforementioned method may improve the diagnostic performance of PRPD.

關鍵詞(Key Words)：局部放電(Partial Discharge, PD)、高頻比流器(High-Frequency Current Transformer, HFCT)、局部放電相位分析圖譜(Phase Resolved Partial Discharge, PRPD)、脈衝序列分佈圖譜(Phase Resolved Pulse Sequence, PRPS)。

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變壓器故障模式對掃瞄頻率響應分析影響簡介

The Impact of Transformer Failure Modes on Sweep Frequency Response Analysis

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摘　要

現今針對變壓器鐵芯及繞組做診斷，最常見的是掃瞄頻率響應分析(Sweep Frequency Response Analysis, SFRA)，即一般所稱之繞組變形試驗，現已列入台灣電力公司及各大電力變壓器製造廠的例行測試項目。

本文為利用一變壓器模擬器做模擬，先取得正常狀態的基準值(Baseline)後，再模擬其低壓側匝數損失(Loss of Turns)及鐵芯移位(Core Shifts)。本文期望利用已知故障對測試結果造成的影響，能再拓展到大型電力變壓器上，以增加診斷的準確率。

Abstract

Nowadays, the most common diagnostic method for transformer cores and windings is Sweep Frequency Response Analysis (SFRA), also known as the winding deformation test, which has been adopted by Taipower and various power transformer manufacturers in Taiwan as a routine test.

This article uses a transformer simulator for fault simulation. After obtaining the baseline value of the normal state, the low-voltage side loss of turns and core shifts are then simulated. We hope to utilize the impact of known faults on test results and extend it to large power transformers to increase the accuracy of diagnosis.

關鍵詞(Key Words)：掃瞄頻率響應分析(Sweep Frequency Response Analysis, SFRA)、匝間短路(Shorted Turns)、匝數損失(Loss of Turns)、鐵芯移位(Core Shifts)。

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電力變壓器油中氫氣成長與雜散氣體相關性研討

Study on the Correlation between Dissolved Hydrogen and Stray Gassing in Power Transformer Oil

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摘 要

110 年 12 月 12 日台灣電力公司(以下簡稱台電)某變電所內變壓器故障，透過 9 分量油中氣體檢測裝置即時紀錄發現事故油中氫氣快速上升現象。為提升早期預警覺察，台電參考國際標準規範[1-2]下修氫氣須注意基準並增加氫氣增量標準。鑒於事故發生，全面盤點供電系統運轉中變壓器狀態，列管有運轉風險設備，並挑選氫氣偏高之高風險設備開蓋檢查，然而，卻沒有發現異狀，深入研究發現造成油中氫氣上升因素很多，不是所有原因都會影響設備運轉，部分原因如雜散氣體或者其他非電氣現象的反應都有可能在設備運轉期間導致氫氣上升，且在氣體產生速率穩定前提下不會危及設備運轉安全，為更詳細瞭解設備內部狀態，本篇挑選氫氣偏高之高風險變壓器內絕緣油送相關檢驗機構檢測確認油中氫氣偏高原因是否為雜散氣體所致。

Abstract

On December 12, 2021, a transformer in a substation of Taipower failed. Through the real-time recording of the Calisto 9 oil gas detection device, it was discovered that hydrogen gas in the accident oil increased rapidly. In order to improve early warning and awareness, Taipower has revised down the hydrogen required attention standards and increased hydrogen increment standards with reference to international standards[1-2]. In view of the aforementioned accident, Taipower conducted a comprehensive inventory of the status of all of the transformers in operation, listed equipment at risk of operation, and selected high-risk equipment with high levels of hydrogen for inspection. However, no anomalies were found. After in-depth research, it was found that there are many factors causing the rise of hydrogen in the oil. Not all factors will affect the operation of the equipment. Some factors, such as stray gassing or other non-electrical phenomena, may lead to the rise of hydrogen in oil during the operation of the equipment. And when the gas is generated under the premise of stable speed, it will not endanger the safety of equipment operation. In order to understand the internal status of the equipment in more detail, this article selects the insulating oil in high-risk transformers with high hydrogen content and sends it to relevant inspection agencies for testing to confirm whether the high hydrogen content in the oil is caused by stray gassing.

關鍵詞(Key Words)：電力變壓器(PowerTransformer)、油中氣體分析(Dissolved Gas Analysis, DGA)、氫氣(Hydrogen)、雜散氣體(Stray Gassing)。

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變壓器本體乙炔氣體含量異常處理

The Process of Handling Abnormal Acetylene Gas in the Insulating Oil of a Distribution Transfomer

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摘　要

配電變壓器(DTr)的絕緣油中可燃性氣體數值異常，乙炔氣體含量從 0.08ppmv 突增至35ppmv，依據「綜合研究所變壓器故障診斷基準」之「電力變壓器/電抗器故障：油中氣體分析診斷基準」將變壓器列異常狀態，後續按「供電單位變壓器絕緣油處理後加壓復電作業規範」所述程序進行檢修處理。

分析油中氣體含量變化，低壓側 R 相線圈直流電組值數據偏高，NVTC 雙電壓切換裝置附近檢測出異常放電圖譜…等，這些外部診斷數據與開蓋內檢結果相吻合，有助於預先找出變壓器的異狀點，本文以電力變壓器#4DTr 為例，分享電力變壓器本體油中氣體異常的處理過程。

Abstract

When an abnormal value of flammable gas in the insulating oil of a distribution transformer (DTR) was detected, and the acetylene gas content suddenly increased from 0.08ppmv to 35ppmv, according to the specifications of the “Transformer Fault Diagnosis Standards of Taiwan Power Research Institute (TPRI)” and the “Power Transformer/Reactor Failure: Diagnostic Indicators for Gas Analysis in Oil”, the transformer was classified as abnormal and was inspected and repaired in accordance with the procedures described in the “Specifications for Pressurization and Power Restoration Operations after Transformer Insulating Oil Treatment of Power Supply Units”.

After analyzing the changes of gas content in the oil, it was found that the data of the DC group value of the R-phase coil on the low-voltage side was too high, and abnormal discharge patterns were detected near the NVTC dual-voltage switching device. These external diagnostic data are consistent with the internal inspection results after opening the cover, which helps to find out the abnormal points of the transformer in advance. This article takes X E/S #4DTR as an example to share the process of handling abnormal gas in the oil of the power transformer body.

關鍵詞(Key Words)：油浸式電力變壓器(Oil-Immersed Power Transformer)、局部放電(Partial Discharge, PD)、電弧(Arcing)、乙炔氣體(Acetylene Gas)、無電壓分接頭切換器(No-Voltage Tap Changer, NVTC)。

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電力變壓器油中氣體分析及絕緣材料老化故障之研究

Research on Power Transformer Dissolved Gas Analysis and Aging Fault of Insulating Materials

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摘 要

本公司某配電變電所配電變壓器(DTR)於 109 年 01 月發生故障跳脫，並由本公司電力修護處、綜合研究所及供電處委託電力修護處召開「電力變壓器故障鑑定研討會議」，確認故障原因。

變壓器油中氣體分析(DGA)可有效偵測變壓器故障之初始狀態，並進行變壓器狀態分析；若能在運轉中(不停機)發現變壓器內部初期異常，評估繼續運轉安全性與立即檢修之必要性，以延長設備平均故障間隔時間(Mean Time Between Failure, MTBF)，提升供電安全。

相關文獻中說明，固態絕緣材料受熱會分解成一氧化碳(CO)和二氧化碳(CO_2)，本文章針對固態絕緣材料劣化(本案事故主因)，分析變壓器故障期間放電路徑、故障材料及歷年油中氣體分析(CO 和 CO_2 之比值，氧氣及氮氣)，可發現若 CO 和 CO_2 之比值與氮氣濃度急速增加，即可判定固態絕緣材料有異常現象產生，需密切注意(實施部分放電量測、縮短取油送試間隔時間或停電檢修)，本文章依實例利用油中氣體分析，落實變電設備狀態基準維護(Condition-based Maintenance, CBM)，進而提昇事故防範之能力。

Abstract

A distribution transformer (DTR) in one of Taipower's distribution substation experienced a fault trip in January 2020. Soon after, the company held a "Power Transformer Fault Identification Seminar Meeting" to confirm the cause of the fault.

Dissolved gas analysis (DGA) can effectively detect the initial state of transformer failure and perform transformer status analysis. If initial abnormalities of a transformer can be discovered during operation (without shutting down), it will help evaluate the safety of continued operation and the necessity of immediate maintenance, and help extend the mean time between failures (MTBF) of the equipment and improve the security of power supply. Safety.

The literature points out that solid insulating materials will decompose into carbon monoxide (CO) and carbon dioxide (CO_2) when heated. This article focuses on the deterioration of solid insulating materials (the main cause of this case), analyzes the discharge path during transformer failure, fault materials and gas analysis in oil over the years (the ratio of CO and CO_2, oxygen and nitrogen). If the ratio of CO and CO_2 and the nitrogen concentration increase rapidly, it can be determined that there is an abnormal phenomenon in the solid insulation material, and close attention is required (implement partial discharge measurement, shorten the interval between oil extraction and test time or power outage for maintenance).

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This article uses gas analysis in oil to implement condition-based maintenance (CBM) of substation equipment based on examples, thereby improving the ability to prevent accidents.

This article uses the aforementioned real case and DGA to implement Condition-based Maintenance (CBM) of substation equipment, thereby improving the company's accident prevention capabilities.

關鍵詞(Key Words)：油中氣體分析(Dissolved Gas Analysis, DGA)、平均故障間隔時間(Mean Time between Failure, MTBF)、狀態基準維護(Condition-Based Maintenance, CBM)。

化學與材料分析應用於變壓器故障鑑定

Chemical and Material Analysis Applied to Transformer Forensic Analysis

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摘 要

本文針對常見化學與材料分析技術應用於變壓器故障鑑定之工具，包含光學顯微鏡、X射線螢光光譜儀、掃描式電子顯微鏡與能量分散式 X 射線光譜儀、傅立葉轉換紅外線光譜儀進行原理、功能與應用案例之介紹。並以變壓器 D12087 發生引線相間短路之原因鑑定為例，說明進行變壓器異常鑑定時，如何整合化學、機械、物理、材料、電力等跨領域之檢測技術剖析設備異常原因。

Abstract

This article introduces the principles, functions and application cases of common chemical and material analysis techniques used in transformer fault identification tools, including optical microscopes, X-ray fluorescence spectrometers, scanning electron microscopes and energy dispersive X-ray spectroscopy, and Fourier transform infrared spectrometers. In addition, this article also takes the identification of the cause of short circuit between different phase-leads in transformer D12087 as an example to explain how to integrate cross-field detection technologies such as chemistry, mechanics, physics, materials, and electricity to analyze the causes of equipment fault when conducting transformer forensic analysis (TFA).

關鍵詞(Key Words)：電力變壓器(Power Transformer)、變壓器故障診斷(Transformer Fault Diagnosis)、變壓器故障鑑定(Transformer Forensic Analysis, TFA)。

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