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電業環境友善技術　專輯
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以固態吸附技術捕捉煙氣中二氧化碳之程序分析

Applying Solid Adsorption-desorption Technology to Conduct Carbon Dioxide Capture Tests

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摘 要

近年來，大氣中的二氧化碳濃度持續上升。根據 NOAA 的報告，全球大氣中二氧化碳的平均濃度截至 2024 年 11 月已達 423.64 ppm。為因應此趨勢，我國於 111 年 4 月 21 日修正相關法規，將《溫室氣體減量及管理法》更名為《氣候變遷因應法》，並於 112 年 1 月 10 日完成三讀，正式將國家長期減碳目標調整為「2050 年淨零排放」，進一步強化對溫室氣體排放的管控措施。

本研究應用固態吸脫附技術對電廠煙道氣進行二氧化碳捕捉測試。實驗首先採用水洗法去除煙道氣中的酸性氣體，隨後利用膜式除水器去除水分，最後依測試需求執行一階段或二階段的二氧化碳分離程序來進行測試。在研究過程中，透過實驗設計評估設備運作效能，並持續最佳化流程與改進製程，以提升捕捉技術的穩定性與整體效率。

Abstract

In recent years, the concentration of carbon dioxide in the atmosphere has continued to rise. According to a report published by the National Oceanic and Atmospheric Administration (NOAA), the average concentration of carbon dioxide in the atmosphere on a global scale has reached 423.64 ppm as of November 2024. In response to this trend, Taiwan renamed the “Greenhouse Gas Reduction and Management Act” as the “Climate Change Response Act” on April 21, 2011, and completed the third reading process of the Legislative Yuan on January 10, 2023, officially adjusting the national long-term carbon reduction target to “net-zero emissions by 2050” to further strengthen the control measures for greenhouse gas emissions.

This study applies solid adsorption-desorption technology to conduct carbon dioxide capture tests on power plant flue gases. The experiment first employs a water-washing method to remove acidic gases in the flue gases, then uses a membrane dehumidifier to eliminate moisture, and finally performs a one-stage or two-stage carbon dioxide separation procedure according to the test requirements. During the process of this study, we continue to evaluate the operating performance of the equipment through experiment design, and enhance the stability and overall efficiency of the capture technology through process optimization.

關鍵詞(Key Words)：碳捕捉與封存技術(Carbon Capture and Storage, CCS)、固態吸附劑(Solid Adsorbent)、真空變壓吸附(Vacuum Pressure Swing Adsorption)。

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化學吸收法溶劑氣提程序改良研究

A Study on Improved Solvent Stripping Process of Chemical Absorption Method

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摘 要

為減緩溫室效應，各國在 2024 年於聯合國氣候變化綱要公約第 29 次締約方大會(COP29)中亦積極討論目前巴黎協定內的碳市場合作機制與氣候融資等議題。我國同步也宣示訂下 2050 年淨零排放的總目標。期望能夠透過這些努力將全球的溫度升幅控制在 1.5℃ 以內。在減碳措施中，其中一種方法是在既有設施中增加碳捕捉設備，從煙氣中捕捉二氧化碳。

本研究測試化學吸收法碳捕捉技術，於台中發電廠設置 CABS 設備，並透過測試不同溶劑與再生程序的改良，以追求更高的能量使用效率。富液分流與多段式熱交換常見用於減少溶劑再生能耗，並同時減少產品氣體冷凝負擔。初步試驗的結果顯示，在 AMP /PZ 複合型溶劑流量比 2：1 時獲得最佳的再生能耗，溶劑降解產物 NH3 的排放也是最低值。化學溶劑吸收法為目前最成熟與廣泛使用的碳捕捉技術，可視為了解碳捕捉技術的起點。

Abstract

To mitigate the greenhouse effect, countries around the world actively discussed issues such as carbon market cooperation and climate financing within the Paris Agreement at the 29th Conference of the Parties (COP29) of the United Nations Framework Convention on Climate Change (UNFCCC) in 2024. In response to the aforementioned development trends, Taiwan has announced the establishment of an overall goal of net-zero emissions by 2050. It is hoped that through these efforts, the global temperature increase can be controlled within 1.5°C. Among various carbon reduction measures, one is to add carbon capture equipment to existing facilities to capture carbon dioxide from flue gases.

This study aims to evaluate chemical absorption carbon capture technology. To achieve the purpose, we set up a CABS system at Taichung Power Plant to pursue higher energy efficiency by testing improvements in different solvents and regeneration procedures. Rich solvent splitting and multi-stage heat exchange are commonly used to reduce solvent regeneration energy consumption and simultaneously reduce condensation burden. Preliminary test results show that the optimal regeneration energy consumption is obtained when the AMP/PZ composite solvent flow ratio is 2:1, and the emission of solvent degradation product NH3 is also the lowest in this case. The chemical absorption method is currently the most mature and widely used carbon capture technology and can be regarded as the starting point for understanding carbon capture technology.

關鍵詞(Key Words)：二氧化碳捕獲(Carbon Capture)、吸收法(Chemical Absorption)、氣提程序(Stripping Process)、醇胺(Amine)、程序改良(Process Modification)。

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螺旋藻養殖生物固碳與資源循環之應用

Application of Biological Carbon Sequestration and Resource Recycling in Spirulina Cultivation

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摘 要

近年來二氧化碳減量是每個企業都需要面臨的重要議題，尤以固碳最為關鍵。在許多固碳模式中，生物固碳是被認為最為環保的減碳方式之一。本研究目的為探討連續式螺旋藻養殖的效益，經由所設立的參數監測系統，收集各種相關養殖資料與訊息，以了解環境變化，並記錄微藻生長情況。螺旋藻養殖試驗包含短期養殖條件試驗與長期養殖作業。在螺旋藻資源循環應用之可行性研究方面，我們進行了螺旋藻作為農業用肥料試驗與螺旋藻循環資源應用模式之評估。研究結果顯示，在一個養殖期間內，很難能得到確切的最大收成量，可能會出現濃度下降的情況，可透過最大生長量進行評估比較準確。螺旋藻養殖過程水體中大部分組成變化不大，但磷酸根、矽、硝酸氮、氨氮都會隨時間改變，其中以氨氮最明顯。以現有的預測模式推估，營養鹽倒數的線性關係不太明顯，需選用更好的預測模式測試。螺旋藻作為農業用肥料試驗是以玉女小番茄苗進行觀察研究結果顯示螺旋藻肥料對小番茄結果生長有明顯助益，尤其在莖葉生長促進作用最為明顯，主莖長度增幅達 113%，對植物生長有益無害，螺旋藻可作為替代化學肥料的產品。此外，螺旋藻作為小番茄栽種肥料，其消耗係數為 0.006，可見當有充足的藻粉時可進行廣泛農業增肥補充，提升農作物的生產力。

Abstract

In recent years, how to achieve carbon dioxide reduction has become an important issue that every company needs to face, with carbon sequestration being the most critical issue. Among various carbon sequestration methods, biological carbon sequestration is considered one of the most environmentally friendly ways to reduce carbon emissions. The purpose of this study is to explore the benefits of continuous spirulina cultivation. Through an established parameter monitoring system, various relevant cultivation data and information are collected to understand environmental changes and to record the growth of microalgae. Spirulina cultivation trials include short-term cultivation condition tests, long-term cultivation operations. In terms of the feasibility study on the recycling application of spirulina resources, we conducted a trial of spirulina as an agricultural fertilizer and an evaluation of the application model of spirulina recycling resources. The results show that during a breeding period, it is difficult to obtain the maximum harvest volume, and the concentration may decrease. Nevertheless, it would be more accurate to evaluate through the maximum growth volume. During the cultivation of spirulina, most of the composition in the water does not change much, but phosphate, silicon, nitrate nitrogen, and ammonia nitrogen will all change over time, with ammonia nitrogen being the most obvious. It is estimated based on the existing prediction model that the linear relationship of the reciprocal of nutrients is not obvious, and a better prediction model needs to be selected for testing. A test using spirulina as an agricultural fertilizer was conducted on cherry tomato seedlings. The results showed that spirulina fertilizer has a significant benefit on the growth of cherry tomatoes, especially in promoting the growth of stems and leaves. The main stem length increased by 113%, which is beneficial to plant growth. In other words, spirulina can be used as a substitute for chemical fertilizers. In addition, the consumption coefficient of spirulina as a fertilizer for cherry tomatoes cultivation is 0.006. It can be seen that when there is sufficient algae powder, extensive agricultural fertilizer supplementation can be carried out to increase crop productivity.

關鍵詞(Key Words)：螺旋藻 (Spirulina)、養殖(Cultivation)、生物固碳(Biological Carbon Fixation)、循環經濟(Circular Economy)、肥料(Fertilizer)。

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低溫 SCR 脫硝觸媒技術介紹

Introdcution of Low-temperature SCR Denitration Catalyst Technology

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摘 要

選擇性觸媒還原(SCR)技術因其高效、穩定而被廣泛應用於煙氣脫硝。傳統 SCR 技術通常在高溫區間(300~400℃)運行，但低溫 SCR 技術可以在較低的溫度下(100~300℃)有效去除 NO_x，避免高能耗的煙氣再熱，具有顯著的節能降碳效益，且安裝於煙氣尾端，避免物理及化學的毒化，可有效提升觸媒壽命。錳氧化物(MnO_x)因具有多變的化學態和豐富的晶格缺陷，表現出優良的氧化還原性能，並具有極強的表面酸性，是目前新型低溫脫硝觸媒的主要研究對象。低溫 SCR 技術的應用領域相當廣泛，目前在非電業領域已有不少工程應用實績，特別是尾氣溫度較低的中小型鍋爐。而在發電業領域則處於萌芽階段，預估在特定場域具有較高的優勢並有機會被先行應用，包括：既有燃氣複循環機組、生質燃料發電機組、低負載燃煤機組及 CCS 結合燃煤機組等。

Abstract

Selective catalytic reduction (SCR) technology is widely used in flue gas denitration due to its high efficiency and stability. Traditional SCR technology usually operates in the high-temperature range (300~400℃), but low-temperature SCR technology can effectively remove NO_x at lower temperature (100~300℃), avoiding high-energy-consuming flue gas reheating, which has significant energy saving and carbon reduction benefits. It is installed at the end of the flue gas to avoid physical and chemical poisoning, which can effectively extend the catalyst lifetime. Manganese oxide (MnO_x) has a variety of chemical states and rich lattice defects, exhibits excellent redox properties, and has extremely strong surface acidity. It is currently the main research object of new type low-temperature denitration catalysts. Low-temperature SCR technology has a wide range of applications. At present, there are many engineering applications in fields other than the power industry, especially in small and medium-sized boilers with lower exhaust temperatures. In contrast, the application in the power generation sector is still in its infancy. It is expected to have advantages and the opportunity to be applied first in specific fields, such as existing gas-fired combined cycle units, biomass power generation units, low-load coal-fired units, and coal-fired units combined with CCS.

關鍵詞(Key Words)：脫硝(de-NO_x)、選擇性觸媒還原(Selective Catalyst Reduction)、低溫(Low Temperature)、錳基觸媒(MnO_x-based Catalysts)。

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電廠餘氫再利用於發電之技術可行性與初探

Preliminary Study on Technical Feasibility of Reusing the Power Plant By-product Hydrogen for Power Generation

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摘　要

氫能源與燃料電池技術同時兼具創能與儲能之特點，是一種可以實現零污染的發電技術。大潭發電廠複循環發電機組採用海水電解製氯方式以避免海生物於循環水渠道及設備上附生，由於目前海水電解衍生的氫氣直接釋放到大氣，如能有效利用排放的氫氣作為燃料，結合燃料電池發電技術，為一具潛力之能源利用與潔淨發電技術。本研究以大潭發電廠海水電解設備為主要研究標的，針對該廠之設備應用電廠餘氫再利用於發電之技術可行性進行研究，透過餘氫應用於發電之發展現況案例探討、實驗室模擬試驗、實場調查評估、實場小規模測試驗證，根據前述成果據以提出設計評估，並設計規劃一實場設備以驗證技術之可行性，根據現階段研究成果，認為該技術具備應用潛力，但仍需持續精進以擴大應用範圍。

Abstract

Hydrogen energy and fuel cell technology have the characteristics of both power generation and energy storage. At the same time, it is a power generation technology that can achieve zero pollution. The combined cycle generators of Datan Power Plant use seawater electrolysis to produce sodium hypochlorite to prevent marine organisms from growing on the circulating cooling water tubes and equipment. So far, the hydrogen derived from seawater electrolysis is directly released into the atmosphere. If the discharged hydrogen can be effectively used as a fuel source and combined with fuel cell power generation system, it will be a potential energy utilization and clean power generation technology. This project takes the seawater electrolysis equipment of Datan Power Plant as the main research subject, and studies the technical feasibility of reusing the by-product hydrogen for power generation. Through case studies on reusing the by-product hydrogen for power generation, laboratory simulation tests, on-site investigation/evaluation and small-scale test verification, a design evaluation was proposed based on the above results, and a real-site equipment was designed to verify the feasibility of the technology. Based on the current research results, it is believed that the technology has application potential but needs continuous improvement to expand its application scope.

關鍵詞(Key Words)：海水電解(Seawater Electrolysis)、燃料電池(Fuel Cell)、氫氣(Hydrogen)、氫能源(Hydrogen Energy)、餘氫(By-product Hydrogen)。

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回首頁

鋰電池正極材料回收再製造研究

Research on Recycling and Remanufacturing of Lithium-Ion Battery Cathode Materials

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摘 要

近年來鋰離子電池成為新興動力來源之一，其高能量密度的特性，目前被廣泛應用於便攜式電子產品、電動汽機車及各種儲能系統，使得鋰離子電池的需求量逐年上升，而在資源有限的情況下，若能將價值高且含稀有金屬的電池正極材料回收再製，不僅可以減少環境的迫害，亦能創造永續價值。

本研究採用濕式冶金方法回收廢棄的 $LiNi_{0.8}Co_{0.2}O_2$ (NC82)正極材料粉體，將其改製成更高電容量的 $LiNi_{0.9}Co_{0.1}O_2$(RC-NC91)下一代正極材料。實驗中透過加酸和還原劑對廢棄正極材料進行溶解及過濾後，利用 MP-AES 測定和 EDTA 錯合劑滴定確定回收金屬溶液濃度，經化學萃取去雜質後，接著以化學共沉澱法改製成新的正極材料前驅物 $Ni_{0.9}Co_{0.1}(OH)_2$，再混合單水合氫氧化鋰後，經高溫燒結，得到 $LiNi_{0.9}Co_{0.1}O_2$(RC-NC91)新的正極材料，並與使用單純化學原料合成的 $LiNi_{0.9}Co_{0.1}O_2$(NC91)進行物性與電性測試比較，結果兩者性能相當一致。

Abstract

In recent years, lithium-ion batteries have become one of the emerging power sources. Due to their high energy density, they are currently widely used in portable electronic products, electric vehicles and various energy storage systems, causing the demand for lithium-ion batteries to increase year by year. In the context of limited resources, if high-value cathode materials containing rare metals can be recycled and reused, it will not only reduce environmental damage, but also create sustainable value.

This study uses the hydrometallurgical method to recycle spent $LiNi_{0.8}Co_{0.2}O_2$ (NC82) cathode material and transform it into the next-generation cathode material of higher capacitance $LiNi_{0.9}Co_{0.1}O_2$ (RC-NC91). In the experiment, the waste cathode material was dissolved and filtered by adding acid and reducing agent, and the concentration of the recovered metal solution was determined by MP-AES and EDTA complexometric titration. After chemical extraction to remove impurities, it was then synthesized to a cathode precursor $Ni_{0.9}Co_{0.1}(OH)_2$ by a chemical co-precipitation method. After mixing with lithium hydroxide hydrate and sintering at high temperature, a new cathode material of $LiNi_{0.9}Co_{0.1}O_2$ (RC-NC91) cathode material was obtained. The physical and electrical properties of RC-NC91 were tested and compared with $LiNi_{0.9}Co_{0.1}O_2$ (NC91) synthesized using pure chemical raw materials. The results showed that the performance of the two was quite consistent.

關鍵詞(Key Words)：鋰離子電池(Lithium-ion Batteries)、回收(Recycling)、鋰鎳鈷氧化物($LiNi_xCo_{1-x}O_2$)、化學共沉澱(Chemical Co-precipitation)、永續(Sustainability)、濕式冶金法(Hydrometallurgical Method)。

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化學混凝除硼系統改善研究

Improvement of Chemical Coagulation Boron Removal System

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摘 要

本計畫目標為利用電廠既有、採用傳統化學混凝程序的廢水處理設施，達成廢水中硼汙染物的去除效益提昇。本文中探討兩種化學藥劑在不同處理條件下硼汙染物的去除成效，希望在不改變現有處理設備的情況下，改善硼汙染物的去除效益。以氫氧化鈣為處理劑是利用其與廢水中硼離子形成硼酸鈣沉澱，或是與硫酸鈣產生共沉澱效應來去除水中硼汙染物。且當水中同時存在硼與過氧化氫時，在適當的酸鹼值條件下則會進一步產生過硼酸根離子，可大幅度提升硼汙染物去除率。以螯合劑作為處理劑是基於螯合劑中的鈰化合物在特定結構下，和硼離子有較高親和力，相較於氫氧化鈣，在產生化學反應時具有較佳的選擇性，除了可減少額外的汙泥產生外，亦可將硼汙染物降至更低的濃度，可減少後段樹脂負擔。本計畫研究流程分三部分，首先於實驗室中利用杯瓶試驗探討不同藥劑及處理條件，接著再串接小型離子交換樹脂單元，以模擬現場實際處理程序，最後將試驗條件實際應用在現場既有處理單元進行測試，並找出最適化參數提供給電廠做為未來操作參考。實驗結果顯示相較於氫氧化鈣法，螯合劑法具有更佳的選擇性與硼去除效率，且相較於氫氧化鈣法產生之汙泥量更為減少，在考量整體藥劑成本與後段汙泥清運費情況下，螯合劑法為更適合的處理程序。

Abstract

The goal of this project is to utilize existing wastewater treatment facilities of power plants that adopt traditional chemical coagulation procedures to achieve improved boron contamination removal efficiency in wastewater. This article discusses the effectiveness of two types of reagents in removing boron contaminants under different treatment conditions, hoping to improve the removal efficiency without changing the existing treatment equipment.

Calcium hydroxide is used as a treatment agent to remove boron contaminants by using it to form calcium borate precipitation with boron ions in wastewater, or to produce a co-precipitation effect with calcium sulfate. When boron and hydrogen peroxide coexist in water, perborate ions will be further produced under appropriate pH conditions, which can greatly improve the removal rate of boron contaminants. The chelating agent method is based on the fact that the cerium compound in the chelating agent has a higher affinity for boron ions under a specific structure. Compared with calcium hydroxide, it has better selectivity when producing chemical reactions. In addition to reducing the production of additional sludge, it can also reduce boron contaminants to a lower concentration, which can reduce the burden on the resin in the later stage.

The process of this research project is divided into three parts. First, cup and bottle tests were used in the laboratory to explore different chemicals and treatment conditions. Then, small ion exchange resin units were connected in series to simulate the actual treatment procedures on site. Finally, the test conditions were actually applied to the existing treatment units on site for testing, and the optimal parameters were found and provided to serve as a reference for power plants' future operations. Experimental results show that compared to the calcium hydroxide method, the chelating agent method has better selectivity and boron removal efficiency, and the amount of sludge produced is lesser. Considering the overall chemical cost and the later sludge cleaning freight, the chelating agent method is a more suitable treatment process.

關鍵詞(Key Words)：排煙脫硫技術(Flue Gas Desulfurization)、廢水處理(Wastewater Treatment)、化學混凝法(Chemical Coagulation)、螯合劑(Chelating Agent)、離子交換樹脂(Ion Exchange Resin)。

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薄膜系統在電廠純水運用的新趨勢

New Trends in the Use of Membrane Systems for Ultrapure Water in Power Plants

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摘 要

水處理系統在發電廠中扮演著至關重要的角色，無論是冷卻系統、鍋爐用水還是廢水的部分，穩定的水質直接影響到發電效率、設備壽命及環境保護。發電廠運作過程中需要大量的水來冷卻和進行熱交換，若水質不當則可能會導致結垢、腐蝕及其他問題。新的電廠水處理系統由傳統的離子交換樹脂改成 RO 逆滲透與 CEDI 電去離子膜塊，不需使用化學品，即可確保穩定的水質，不僅能提高發電效率、提高工作環境安全、降低複雜性，亦可減少對環境的影響。總而言之，水處理系統的提升目前已成為推動發電部門可持續發展的重要因素。

Abstract

Water treatment systems play a vital role in power plants. Whether it is the cooling system, boiler water or wastewater, stable water quality directly affects power generation efficiency, equipment life and environmental protection. Power plants require large amounts of water for cooling and heat exchange. Improper water quality may lead to scaling, corrosion and other problems. The new power plant water treatment system has been changed from traditional ion exchange resin to Reverse Osmosis Membrane and CEDI electrodeionization membrane blocks, which can ensure stable water quality without the use of chemicals. It can not only improve power generation efficiency and the safety of working environment, but also reduce complexity and the impact on the environment. All in all, the improvement of water treatment systems has become an important factor in promoting the sustainable development of the power generation sector.

關鍵詞(Key Words)：水處理系統(Water Treatment System)、逆滲透膜(Reverse Osmosis Membrane)、連續式電去離子膜塊(Continuous Electrodeionization Products)、不含化學物質(Chemical Free)。

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地理資訊系統於生態檢核制度之應用潛力與挑戰分析：以台電永安濕地實務為例

Application Potential and Challenges of Geographical Information System (GIS) in Ecological Inspection System：Taking Taipower's Yongan Wetland Practice as an Example

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摘　要

在全球生物多樣性喪失與自然資本風險日益升高的情境下，生態檢核制度已成為開發行為中不可或缺之治理工具。其中地理資訊系統(GIS)因具備整合、分析與視覺化空間資訊之能力，逐漸被應用於生態敏感區之判釋、保育策略制定與開發衝擊評估中。本文從制度背景與技術應用兩大面向出發，探討 GIS 在台灣生態檢核實務中的潛力與挑戰，並以台電公司永安濕地長期自主研究為實例，分析其於資料建置、物種熱點分析、施工避讓設計與跨域整合等層面之實務經驗。研究發現，GIS 不僅為制度提供技術支撐，更在企業內部推動跨部門合作、知識內化與決策回饋中扮演關鍵角色。本研究進一步提出制度化、技術發展、人才培育與企業實踐等面向之建議，期盼為我國生態檢核制度之優化與國營企業永續治理能力之深化提供具體參考。

Abstract

In the context of global biodiversity loss and increasing nature-related risks, the ecological impact system has become an indispensable governance tool in development activities. Among various tools, Geographic Information System (GIS) has the ability to integrate, analyze, and visualize spatial information, and has been gradually used in the interpretation of ecologically sensitive areas, the formulation of conservation strategies and the assessment of development impacts. This study explores the potential and challenges of GIS in Taiwan's ecological inspection operations from two aspects: institutional background and technical application, and takes Taipower's long-term independent research on Yongan Wetland as an example to analyze its practical experience in data collection, habitat hotspot mapping, buffer analysis for construction avoidance, and interdisciplinary integration. The results show that GIS not only provides technical support for the system, but also plays a key role in promoting cross-departmental collaboration, knowledge institutionalization, and adaptive decision-making within the company. Based on the above efforts, this project puts forward opinions and suggestions on institutionalization, technology development, talent cultivation and enterprise practice, etc., hoping to provide reference for the optimization of Taiwan's ecological inspection system and the deepening of Taipower's sustainable governance capabilities.

關鍵詞(Key Words)：環境影響評估(Environmental Impact Assessment, EIA)、生物多樣性(Biodiversity)、地理資訊系統(Geographic Information System, GIS)、生態檢核(Ecological Inspection)、可持續發展(Sustainable Development)。

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以煤灰作為生物濾材之可行性初探

A Preliminary Study on the Feasibility of Using Coal Ash as Biofilter Media

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摘　要

煤灰是燃煤發電過程所產生之固體副產物，分為飛灰及底灰，其中底灰顆粒較粗，表面具多孔隙，雖可作為低強度粒料使用，但利用價值較低且大量去化不易，開發其他再利用途徑有其必要性。由於底灰本身屬於一種多孔性材料，本研究嘗試將底灰與一般商業販售火山岩濾材進行比較，探討以底灰作為生物濾材的可能性。實驗結果顯示，底灰作為生物濾材具有一定可行性，可作為培菌基質使硝化菌附著，進而分解魚類養殖過程產生之氨氮，保持水質穩定，效果與市售火山岩濾材相當。未來除了可以研究不同製程產生之底灰作為濾材之效果差異外，也可以與市面上其他濾材進行比較，更進一步釐清煤灰於水產養殖及觀賞水族之安全性及應用價值。

Abstract

Coal ash is a by-product produced during the coal-fired power generation process. It is divided into fly ash and bottom ash. The bottom ash has coarser particles and a porous surface. Although it can be used as low-strength pellets, its utilization value is comparatively low and it is not easy to remove in large quantities. Therefore, it is necessary to develop other reuse methods. Since bottom ash itself is a porous material, this study attempts to compare bottom ash with generally commercially available volcanic rock filter material to explore the possibility of using bottom ash as a biofilter media. Experimental results show that bottom ash has certain feasibility as a biofilter media. It can be used as a culture substrate to allow nitrifying bacteria to attach to decompose the ammonia nitrogen produced during fish farming and to maintain stable water quality. The effect is equivalent to that of commercially available volcanic rock filter material. In the future, in addition to studying the differences in the effectiveness of bottom ash produced by different processes as filter material, it can also be compared with other filter material on the market to further clarify the safety and application value of coal ash in aquaculture and ornamental aquariums.

關鍵詞(Key Words)：煤灰(Coal Ash)、底灰(Bottom Ash)、生物濾材(Biofilter Media)、硝化作用(Nitrification)、硝化菌(Nitrifying Bacteria)。

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研磨底灰作為混凝土礦物摻料之技術可行性研究

Technical Feasibility Study on Using Ground Bottom Ash as a Mineral Admixture for Concrete

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摘 要

本研究之目的在於探討台中電廠研磨底灰作為混凝土礦物摻料之適用性，期能提升底灰應用價值，並解決飛灰供應不足問題。首先參考台中飛灰粒徑值，訂定研磨後底灰的粒徑 D50 分別為 16.31 μm 與 11.56 μm，接著確認該研磨底灰是否能符合 CNS 3036 要求。結果發現，研磨底灰之表面呈不規則狀且多孔，需水量高於飛灰約 1%，活性指數超過 80%，兩種細度之研磨底灰皆符合 CNS 3036 F 級飛灰的物化性要求。

當研磨底灰比照飛灰部分取代水泥製作混凝土時，可發現研磨底灰試體之抗壓強度發展趨勢和飛灰一致，且試驗組相較於控制組試體有較高的強度增幅。本研究以熱重分析儀評估氫氧化鈣分解溫度，再以燒失法推估各試體之氫氧化鈣含量。結果發現，當試體養護齡期由 28 天增加到 91 天時，控制組有氫氧化鈣含量增加的趨勢，而含飛灰和底灰的試驗組反而下降，推測係因卜作嵐反應消耗氫氧化鈣所致。因此，研判底灰經適度研磨後於水泥基材料中可發生卜作嵐反應，可作為飛灰替代材料，且研磨後粒徑較小的材料，製成混凝土試體之強度較高。

Abstract

This study aims to explore the applicability of ground bottom ash (GBA) from Taichung Power Plant as a mineral admixture for concrete, with a view to improving the application value of dry bottom ash and solving the problem of insufficient fly ash supply. First, referring to the fly ash particle size value in Taichung, the particle sizes of the ground bottom ash (D50) were determined to be 16.31 μm and 11.56 μm respectively, and then it was confirmed whether the ground bottom ash could meet the requirements of CNS 3036. The results showed that the surface of the ground bottom ash is irregular and porous, requires about 1% more water than that of fly ash, and the activity index exceeds 80%. The fineness of both ground bottom ash met the physical and chemical requirements of CNS 3036 F-grade fly ash standards.

When ground bottom ash (compared to fly ash) is used to partially replace cement to make concrete, it can be found that the compressive strength development trend of the ground bottom ash specimens is consistent with that of fly ash, and the test group has a higher strength increase compared to the control group specimens. In this study, a thermogravimetric analyzer was used to evaluate the decomposition temperature of calcium hydroxide, and then the loss-on-ignition (LOI) method was used to estimate the calcium hydroxide content of each sample. The results showed that when the curing age of the specimen increased from 28 days to 91 days, the calcium hydroxide content in the control group tended to increase, while the test group containing fly ash and bottom ash decreased instead. It is speculated that this is due to the consumption of calcium hydroxide by the Pozzolanic Reaction. Therefore, it is determined that after moderate grinding, bottom ash can undergo the Pozzolanic Reaction in cement-based materials and can be used as a substitute material for fly ash. Moreover, materials with smaller particle sizes after grinding have higher strength in concrete specimens.

關鍵詞(Key Words)：飛灰(Fly Ash)、研磨底灰(Ground Bottom Ash)、卜作嵐反應(Pozzolanic Reaction)。

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結合廢液鹼的鹼活化爐石底灰混凝土應用研究

Research on the Application of Alkali-activated Slag-bottom Ash Concrete Incorporating Waste Alkali Liquid

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摘 要

本計畫以飛灰陳化結合水淬爐石粉的方式發展出低碳凝膠，並以底灰取代細粒料的方式來延緩混凝土的固化，最後製作出結合廢液鹼的鹼活化爐石底灰混凝土，並應用於高壓混凝土地磚的生產，送台灣檢驗科技公司(SGS)檢測。檢測結果顯示，地磚抗壓強度可達600kgf/cm^2(A 級磚標準為 320kgf/cm^2)，透水磚壓強度可達 300kgf/cm^2。將來可以進一步發展飛灰陳化品質控管技術，這樣就可以針來自不同電廠的飛灰或所需的混凝土性能，給予最適當的陳化條件。此外，只要是富含非晶態的鋁矽酸鹽類且低鈣含量的工業廢棄物，比如 FRP 和廢玻璃，都有機會透過這樣的模式去化掉。

Abstract

In this project we use fly ash aging combined with granulated blast furnace slag powder to develop a low-carbon gel, and use bottom ash to replace fine aggregates to slow down the setting of concrete. Then, the alkali-activated slag-bottom ash concrete incorporating waste alkali liquid was produced and used in the production of compressed concrete paving unit, and sent to Taiwan Inspection Technology Company (Taiwan SGS) for testing. The test results show that the compressive strength of the compressed concrete paving unit can reach 600 kgf/cm^2 (higher than the A-grade standard of 320 kgf/cm^2), and that of the permeable concrete paving unit can reach 300 kgf/cm^2.

In the future, fly ash aging quality control technology can be further developed, so that the most appropriate aging conditions can be given to fly ash from different power plants or according to the required concrete properties. Additionally, any industrial waste that is rich in amorphous aluminosilicates and has low calcium content, such as FRP and waste glass, can be processed in this way.

關鍵詞(Key Words)：飛灰陳化(Fly Ash Aging)、低碳凝膠(Low-carbon Gel)、結合廢液鹼的鹼活化爐石底灰混凝土(Alkali-activated Slag-Bottom Ash Concrete Incorporating Waste Alkali Liquid)、飛灰陳化品質控管技術(Quality Control Techniques for Fly Ash Aging)。

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