

台電工程月刊 849 期 (5 月號) 目錄

電力系統生態與綠能相關環保技術 專輯

永安濕地水深與水鳥群集之棲地經營管理研究.....	洪健恆.....	(1)
海洋牧場之溫排水道箱網養殖可行性研究	陳璽年 等	(26)
煙氣降溫減少石膏法生水用量評估	傅弼豐 等	(35)
電廠難處理廢水零排放處理可行性評估	曹志明 等	(44)
風力機葉片修護評估技術	鄭錦榮 等	(53)
電廠固體副產物資源化利用於全鈦氧化還原液流電池電解液研究.....	張書維 等	(75)
環保型木橫擔替代材料開發研究	吳成有 等	(84)
火力電廠SCR脫硝觸媒性能檢測與品質管理.....	曾志富 等	(91)
二氧化碳固態吸附劑改質性能研究	莊宗諭 等	(110)
二氧化碳吸收溶劑再生能耗與技術探討	張孟淳 等	(115)

永安濕地水深與水鳥群集之棲地經營管理研究

Effects of Water Level on Waterbirds in Yongan Wetland

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摘要

永安濕地於107年初經內政部核定並公告為地方級重要濕地，台電公司為濕地所有權人，基於生態保育的信念並落實環境宣言，維護濕地上的生物資源及棲地品質，期待興達電廠成為台灣第一座生態電廠，為工業發展與生態保育的平衡立下典範。本研究案全程由台電公司自主完成，研究成果除科學價值並彰顯生態保育的決心與能力。本研究標的為濕地的水鳥群集(Assemblage)，配合天然的水位波動調查各水位時的水鳥分布，從其分布點位得到偏好水深，評估以調控水位作為棲地經營管理手段的可行性。本研究發現鸕科、鶺鴒科及小水鴨分別使用水深12公分、7公分及10公分以內的區位，雁鴨科需要2種棲地類型，分別是水深12公分以內的裸露地及淺灘休息，以及12~30公分的深水區位覓食；鷺科的大白鷺、小白鷺平均地使用裸露地至水深40公分的區位，但大白鷺對周邊植被需求高、小白鷺使用更高比例的裸露地及淺灘；黑面琵鷺則偏好18至35公分深的區位，並用裸露地休息。研究指出當低水位(臺灣水準原點-35公分)提高至高水位(-25公分)時，將使水深12公分以內的面積從20%減少至10%，直接衝擊水鳥總量(減少20%)，其中對於鸕科、鶺鴒科水鳥衝擊最大，減少70%的個體。雁鴨科在中水位(-30公分)數量最多，提升至高水位時則減少20%的數量，顯示雁鴨科對裸露地及淺灘的需求。低中高水位皆保有足夠的深水區，故對黑面琵鷺的影響不大。建議永安濕地應以中水位(臺灣水準原點-30公分)為水位上限，以確保鳥類多樣性。

Abstract

In early 2018, Yongan Wetland was designated by Ministry of the Interior to be an important district wetland. As the land owner of the Yongan Wetland, Taiwan Power Company has been endeavoring to preserve its biological resources and natural habitats based on the belief that ecological conservation and putting environmental protection into practice are an essential part of the company's social responsibility. It is also the company's expectation that Hsinta Power Plant - located in close proximity to the wetland - will be built as an ecologically-friendly power plant in Taiwan and become a role model for harmonious coexistence of industrious development and ecological conservation. The study aims to assess the assemblage of water birds on Yongan wetland and evaluate feasibility of habitat management by properly controlling water levels in this area. In this study, we find the following facts: the family Scolopacidae usually prefer to reside in areas with water depths of less than 12 centimeters; the family Charadriidae usually prefer to reside in the areas with water depths of less than 7 centimeters; while the family Anatidae reside in two kind of habitats: one in the areas of less than 12 centimeter water depths for resting, the other

in the areas of 12 to 30 centimeter water depths for foraging. The *Anas crecca* usually like to live in the areas with water depths of less than 10 centimeters. The *Ardea alba* Linnaeus and *Egretta garzetta* prefer to reside – most of the time scattered across this area evenly - in the areas with water depths of less than 40 centimeters. The difference between them is that *Ardea alba* Linnaeus prefer locations nearby near vegetation plants, while the *Egretta garzetta* prefer exposed areas. The *Platalea minor* prefer locations of 12 to 30 centimeter depths for foraging, and exposed areas for resting. The study indicates that if the water levels rise from a low(-35cm below original bench marker) to a high(-25cm below original bench marker), the areas of less than 12 centimeter water depth will be down from 20% to 10%. This change will lead to a significant decrease of 20% in the number of water birds – especially with Family Charadriidae and family Scolopacidae dropping by 70% in number. When the water levels are in the middle range(-30cm below original bench marker), there are the largest number of water birds of Family Anatidae. As water levels rise to its highs, it will cause a 20% decrease in the number of water birds, indicating that the Family Anatidae need exposed and shallow wetland areas. Since wetland at any water levels could provide enough swathes of deep-water-level residence location for *Platalea minor*, the fluctuation of water levels at the wetland doesn't significantly influence *Platalea minor*. Finally, it is recommended that a middle water-level should be maintained as its maximum water level for Yongan Wetland to ensure the diversity of birds around this wetland.

關鍵詞(Key Words)：棲地經營管理(Habitat Management)、水鳥群集(Waterbirds Assemblage)、水深偏好(Water Depth Preference)、棲地選擇(Habitat Selection)。

海洋牧場之溫排水道箱網養殖可行性研究

A Feasibility Study of Marine Farming: Cage Culture in Thermal Discharge Channel

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摘要

林口電廠是台電公司近年更新改建的電廠之一，由於使用海水進行煙氣脫硫，因此排放出的脫硫溫排水除較高的水溫外，亦含有較高濃度的硫酸鹽及較低的 pH 值，為了評估林口電廠排放脫硫溫排水特性及發展海洋牧場可行性，本研究於脫硫溫排水道建置箱網進行養殖試驗。養殖物種包括三種魚類(龍膽石斑、七星鱸及黑鯛)、大型藻類及牡蠣，並同時進行水質參數的量測及比對。結果顯示脫硫溫排水之硫酸鹽濃度較原海水高約 100 ppm，平均水溫高約 5°C 到 6°C，pH 值平均約 7.1 左右；養殖結果顯示龍膽石斑在冬季時可能受益於脫硫溫排水道高溫成長快速，大型藻類及牡蠣則較不適合於脫硫溫排水道進行養殖。本研究初步釐清脫硫溫排水用於養殖之可行性，未來將針對箱網養殖魚隻進行食品安全衛生之相關檢測，以進一步證實脫硫溫排水用於養殖之可能性。

Abstract

Linkou power plant is one of the power plants that have been renewed in recent years. Since the power plant uses sea water for operation of flue gas desulfurization (FGD), the thermal water discharge of Linkou power plant features not only higher temperatures, but higher concentration of sulfate content and lower number in pH value. In order to evaluate the quality of the thermal water discharges and the feasibility of marine fish farming, a floating fish-farming cage was installed in the thermal water discharge channel for experiments of aquaculture. Three species of fish - including gentian grouper, Japanese seaperch and black seabream, seaweed and oyster - were selected for aquaculture. The results showed that the sulfate concentration and the temperature of thermal discharges were 100 ppm higher and 5~6°C than those of the normal sea water respectively - with pH value of the discharged water at about 7.1. The gentian grouper grew more rapidly in winter probably due to the higher temperatures in the thermal discharge channel.

關鍵詞(Key Words)：溫排水(Thermal Discharge)、海洋牧場(Marine Farming)、水產養殖(Aquaculture)、水溫(Water Temperature)、龍膽石斑(Gentian Grouper)。

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煙氣降溫減少石膏法生水用量評估

The Research of Reducing FGD Raw Water Consumption by Cooling Flue Gas

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摘要

本研究目的在於利用廢水預先降溫煙氣，減少濕式石灰石石膏法排煙脫硫(FGD)系統之生水使用量，同時降低排煙脫硫廢水量，以減少未來進行零排放時之負擔。以實際脫硫塔運轉參數進行之現場模廠試驗的結果如下：

- (1) 殼管式熱交換熱基礎試驗：無冷凝液體因此無效益。
- (2) 石膏法 FGD 之耗水量試驗：基礎實驗可知除霧器的捕捉效能占有極大之影響。
- (3) 以廢水間接冷卻後之煙氣進行石膏法 FGD 之耗水量試驗：無節水效益。
- (4) 以廢水直接冷卻後之煙氣進行石膏法 FGD 之耗水量試驗：具有節水效益，大多效益由廢水中之鹼度貢獻得來，原本設計之降溫來節水之課題比較下顯得較無進一步發展之效益。

應用 ASPEN PLUS 模擬液氣間接接觸的節水製程結果顯示，直接式效益較佳，且當廢水的入口溫度越高則會造成脫硫效率的下降，整體節水量(洗滌塔或噴淋塔+吸收塔)會隨廢水的液氣比之增加而增加，但當液氣比值增加超過 20 以後，則節水量增加趨勢趨於水平。以節水量而言，洗滌塔的模擬結果優於噴淋塔。

Abstract

The purpose of this study was to use FGD wastewater pre-cooling to reduce the amount of raw water evaporation, aiming to reduce raw water consumption of limestone FGD system. The pilot test results - through use of actual desulfurization tower operating parameters - are as follows:

- (1) Conduct shell and tube heat exchange heat basic test: no condensate liquid and no benefit.
- (2) Conduct gypsum FGD water consumption test: The basic experiment shows that the capture efficiency of demister has significant influence on water saving.
- (3) Conduct gypsum FGD water consumption test while undertaking flue gas cooling through wastewater indirect contact: no condensate liquid and no benefit.
- (4) Conduct gypsum FGD water consumption test while undertaking flue gas cooling through wastewater direct contact: There is a lot of condensate liquid - most of them being a contribution from the alkalinity in the wastewater, and very limited amount of them being a contribution from temperature cooling.

The contact simulation results show that the desulfurization efficiency would increase with the increase of the pH value and the ratio of liquid to gas. The higher the inlet temperature of seawater or waste water, the lower the desulfurization efficiency. The overall water saving will increase with the increase of the liquid-to-gas ratio of seawater or waste water; but when the liquid-to-gas ratio increases to more than 20, the trend of water saving tends to become flat. In terms of water saving, the simulation results of the scrubber are better than those of the spray tower.

關鍵詞(Key Words)：脫硫廢水 (FGD Wastewater)、二氧化硫(Sulphur Dioxide)、排煙脫硫(Flue Gas Desulfurization)、石灰石(Limestone)、模擬(Simulation)。

電廠難處理廢水零排放處理可行性評估

Feasibility Assessment of Zero Discharge Treatment of Refractory Wastewater in Power Plants

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摘 要

因應電廠排放水相關環保標準日趨嚴格的趨勢，對於排煙脫硫廢水及鍋爐鹼洗廢液等難處理廢水，如果使用傳統化學混凝和生物處理法，不但程序複雜且操作成本甚高，近年零排放相關技術已漸趨成熟且具環境友善特性。因應電廠排煙脫硫廢水處理之需求，本研究在現場進行零排放前處理評估，試驗結果顯示，為了改善傳統程序污泥過多及耗能等問題，零排放程序應結合薄膜軟化與濃縮功能，重金屬去除模組則應保留，薄膜軟化程序宜採多級設計，而薄膜濃縮程序可採多段或循環設計，最後階段的蒸發結晶階段應增設氨氣或氨水回收，程序過程的薄膜產水與蒸餾水可回收作為 FGD 補給水。另針對電廠鍋爐鹼洗廢液，使用減壓脫水乾燥裝置，在減壓狀態下將廢水蒸餾濃縮，處理後冷凝水之 pH 值仍然維持在鹼性範圍，而導電度則可降至 $266.8 \mu\text{s/cm}$ ，至於各種成分則都在微量範圍，在電廠應可充當補給水之用。

Abstract

In response to the increasingly strict requirement for desulfurization wastewater treatment in a power plant, this study conducted an on-site evaluation of zero liquid discharge (ZLD) pre-treatment. Regarding the pre-treatment evaluation, the test results showed that the process should consist of the membrane softening and concentrating function, with retention of the heavy metal removal module. The membrane softening procedure should be of multi-stage design, and the membrane concentration procedure can be of multi-stage or cyclic design. At the final stage of evaporation and crystallization, the ammonia recovery unit should be added. The product of membrane system and distilled water can be recycled for use as FGD feed water. For the wastewater treatment of boiler caustic cleaning, a vacuum dehydration drying device was used to distill the wastewater under reduced pressure. After treatment, the pH value of the condensed water remained in the designated alkaline range, while the conductivity decreased to $266.8 \mu\text{s/cm}$. The concentrations of other components were at the very low levels, and the distilled water thus could be used as the make-up water.

關鍵詞 (Key Words)：排煙脫硫(Flue Gas Desulfurization)、廢水(Waste Water)、零排放(Zero Liquid Discharge)、分析(Analysis)、前處理(Pre-treatment)。

風力機葉片修護評估技術

Wind Turbine Blade Repair Evaluation Technology

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摘要

目前台電公司一~五期及低碳島計畫共有169台大型風力發電機加入台電服勤機組，其中有76台為同型機組，風機安裝在海邊，面臨各種嚴酷的環境，二十年使用壽命內，葉片旋轉次數達 10^8 次的量級，葉片皆承受重力所造成的彎矩及振動，構成疲勞破壞的來源。其中葉片破損經歷了薔蜜颱風彰濱6支葉片損傷理賠處理分析；建立風機葉片使用報廢年限推算；彰工(I)風場23支風機葉片表面塗層損壞後續處理；觀園1.5 MW風機葉片破損肇因診斷分析等相關工作。因此本文由風力機葉片逆向工程建立修護評估技術，目標為建立2M風力機葉片之逆向工程，外型3D量測及模態測試、斷面結構量測、葉片積層分佈、葉片材料、機械及結構性質分析，建立各種破損修補對策及驗收基準。針對2M風機葉片逆向還原出玻璃纖維材料的積層、積層堆疊順序及纖維角度，再根據逆向工程所取得的積層結果進行6種案例模態分析、10種狀況的破壞分析。在模態分析中，以簡支梁的邊界條件設定，其結果與實驗數值較接近。在破壞分析中，需注意極端風速狀況下異常停機(例如：節矩轉動反應)，葉片有可能發生破壞，建立葉片模態及破壞分析能力，完成相關技術人才培育。

Abstract

At present, a total of 169 wind turbines – either installed under the Taipower Company's 1~5 Phase Project or under the Low-Carbon Island Project – have come to operational service. 76 of them are of the same type. Those wind turbines are installed at the seaside, inevitably confronting various harsh environments. During the expected service life of 20 years, the number of rotations of the blade will reach an order of 10^8 times, and the blades will be subject to bending moments and vibrations caused by the load of gravity, which constitute a source of fatigue damage. Among them, some blades have experienced the analysis for claiming damages done to six blades resulting from Toad typhoon that hit Changhua Coastal Industrial Park, leading to the establishment of the wind turbine blades retirement period calculation; and 23 wind turbine blades at the Changhua (1) wind farm have undertaken consequential treatment after having experienced surface-coating damages; and some turbine blades at Guanyuan 1.5 MW wind farm has undertaken related diagnostic analysis for finding the root causes of the blade break-up. Therefore, this paper aims to establish the repair evaluation technology on the basis of the reverse engineering of wind turbine blades. The goal is to establish the reverse engineering of 2M wind turbine blades, external 3D

measurement and modal test, sectional structure measurement, blade layer distribution, blade material, machinery and analysis of structural properties, establishment of various damage repair strategies and acceptance criteria. For the 2M wind turbine blades, the laminated materials, stacking order and fiber angle were reversely reduced, and then six kinds of case modal analysis and damage analysis of 10 conditions were performed according to the laminated results obtained by reverse engineering. In the modal analysis, the boundary conditions of the simply supported beam are set, and the results are found to be close to the experimental values. In the damage analysis, it is necessary to pay attention to abnormal shutdown under extreme wind speed conditions (for example, the pitch is too late to rotate), under which condition the blades may be damaged. This study also aims to establish blade modal and damage analysis capabilities, and complete the cultivation of relevant technical talents.

關鍵詞(Key Words)：風力機葉片(Wind Turbine Blades)、逆向工程(Reverse Engineering)、破壞分析(Damage Analysis)、模態分析(Modal Analysis)。

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電廠固體副產物資源化利用於全鈮氧化還原液流電池電解液研究

Study on the Utilization of Solid By-products in Power Plants in the Electrolyte
of Vanadium Redox Flow Battery

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摘 要

全鈮氧化還原電池作為儲能技術具有容量容易測量與控制、充放電次數高、極低的自放電率、電池容量易擴充、運轉維護成本低廉、無污染排放之環保問題也無起火或爆炸的風險等優點，經初步調查顯示本公司火力電廠的油灰與爐渣均含有可再利用的鈮元素，經適當的技術處理回收其中的鈮元素，便能將這些過去電廠需花費處理的廢棄物轉為具備高價值的關鍵能源材料。

本計畫將電廠固體副產物資源化利用於全鈮氧化還原液流電池電解液為目標，透過電廠固體副產物價值元素含量分析與調查、回收萃取鈮元素、萃取產物分析與電解液製備等研究項目，並進行包括電解液品質驗證、電池性能測試等驗證測試工作，最終針對技術可行性提出電廠資源化利用產量評估。

Abstract

As one of the energy storage technologies, the vanadium redox flow battery has many advantages, including ease in the measuring and controlling of battery capacity, higher number of electric charge and discharge cycles, lower self-discharging rate, better scalability of battery capacity, lower operation and maintenance costs, no environmental pollution caused by emissions, and no risk of being on fire and explosion. According to the preliminary investigations, it is discovered that some amounts of reusable vanadium resources are contained in the oil ash and slag of the thermal power plant. Using an appropriate treatment process, those vanadium resources could be recovered, which can be converted into one of valuable energy materials.

The goal of this project is to utilize power plant's solid byproducts in the electrolyte of vanadium redox flow battery. The research was conducted through the analysis and investigation of element compositions of power plants' solid byproducts, recovery and extraction of vanadium, extraction product analysis, electrolyte preparation, electrolyte quality verification, battery performance test, and evaluation of other related research work. Finally, we propose the production quantity assessment method for utilization of solid by-products in power plants in the electrolyte of vanadium redox flow battery.

關鍵詞(Key Words)：儲能(Energy Storage)、全鈮氧化還原電池(Vanadium Redox Flow Battery)、油灰(Oil ash)、資源化利用(Resource Utilization)、萃取(Extraction)。

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環保型木橫擔替代材料開發研究

A Study on Environmentally Friendly Materials Development for Replacement
of Chemicals Treated Wooden Cross-arms

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摘 要

本研究目的在於開發可以替代防腐木橫擔之環保材料，同時考量飛灰資源化再利用與其在重鹽害或污染地區之可應用性。進行不同基質之飛灰塑膠複合材製備與材料性質測試，包括機械性質、物理化學性質、電氣性質與耐候性質的測試等。此外也進行絕緣披覆型輕鋼橫擔的開發。研究結果發現ASA塑膠與飛灰相容性高，透過摻合玻璃纖維及內嵌金屬方管是具有潛力的複合材料。ASA+PBT+30%玻纖+10%的飛灰複合材料，具備相當不錯的高壓耐電痕性，且機械強度也符合橫擔材料之要求，可作為塑木橫擔的材料。

目前可商業化生產之飛灰塑木橫擔，不論是實心、中空或者內嵌金屬方管制品，其彎曲強度均無法達到台電材料規範中對於木橫擔機械強度之要求標準，無法做為木橫擔之替代材料。

輕鋼橫擔具有足夠的機械強度，但受限於抗蝕能力及無絕緣能力，若以輕鋼橫擔為骨幹，外面披覆絕緣塑料，除了可以克服塑木橫擔彎曲強度不足外，亦可作為因應蠕變的方案。本研究中所開發之HIPS+氟素樹脂塗層絕緣披覆型輕鋼橫擔在22kV電壓等級時特重汗損情形下仍可提供有效的洩漏距離，協助礙子不產生閃絡，可做為腐蝕及重污染環境之橫擔材料。

Abstract

The purpose of this study is to develop environmentally friendly materials that can replace chemicals treated wooden cross-arms and to consider the reutilization of fly ash as well as its applicability in serious salt damage or contaminated areas. In order to achieve this goal, different matrix of fly ash plastic composite material was prepared; and tests of material properties -including mechanical properties, physical and chemical properties, electrical properties and weathering properties - were conducted. In addition, insulation coated light steel cross arms were developed in this study. The results reveal that ASA plastic and fly ash has nice compatibility, and that it could be used as a potential composite material candidate through the enhancement of glass fiber and embedded metal tube. The composite material (containing ASA + PBT + 30% glass fiber + 10% fly ash) - with its characteristic of good resistance to high voltage tracking and satisfying the requirements of mechanical strength for crossarm material – could be another option.

At present, commercially available fly ash plastic crossarm, whether it is solid, hollow or embedded metal tube products, cannot be used as wood crossarm alternative material due to the

fact that flexural strength of its products cannot meet the specifications of TPC for wood crossarm material.

Light steel crossarm has sufficient mechanical strength; but has its limitations in use due to lack of the anti-corrosion ability and no insulation ability. To overcome the problem with bending strength and creep of plastic-wood crossarm, a solution was recommended, in which light steel crossarm acts as the backbone with plastic coating for electrical insulation. The HIPS coated with fluorocarbon resin insulation light steel crossarm developed in this study is a potential alternative crossarm material for use in corrosive and seriously polluted environment because it can provide effective leakage distance to resist insulator's flashover under 22 kV high voltage condition.

關鍵詞(Key Words)：環境友善材料(Environmentally Friendly Materials)、飛灰塑木橫擔(Fly Ash Plastic Crossarm)、HIPS+氟素樹脂塗層絕緣披覆型輕鋼橫擔(HIPS Coated With Fluorocarbon Resin Insulation Light Steel Crossarm)。

火力電廠 SCR 脫硝觸媒性能檢測與品質管理

SCR de-NO_x Catalyst Performance Tests and Quality Management in Thermal Power Plants

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摘要

選擇性觸媒還原法(Selective Catalyst Reduction, SCR)是目前工程實際應用最廣泛，也是技術最成熟的方法，其反應原理為在一定的溫度及O₂下，透過觸媒有選擇性的將煙氣中的NO_x還原為乾淨的N₂和H₂O。隨著環保法規加嚴，觸媒需求量逐年增加，而觸媒生產業者眾多且良莠不齊，新觸媒的採購及觸媒品質管理就顯得非常重要。本研究挑選5種台電公司曾使用或正在使用的觸媒廠牌，進行觸媒性能測試，同時也進行觸媒熱穩定性及抗化學中毒測試，用以模擬實際電廠使用可能觸媒失活情況。透過各觸媒廠牌性能比較，了解各觸媒廠牌優、缺點，可作為觸媒壽命評估及預測之判斷工具。最後，亦提出「觸媒性能檢測與品質管理指南」，供使用單位觸媒採購規範訂定及觸媒壽命評估之參考依據。

Abstract

Selective Catalyst Reduction (SCR) is currently among the most mature and widely used methods in engineering applications. The principle of reaction is to convert NO_x of flue gas into clean N₂ and H₂O – a chemical reduction reaction through reaction of catalysts under a certain temperature and O₂ concentration. Due to increasingly strict environmental regulations, the demand for those chemical catalyst products has been increasing every year. However, there are many catalyst producers and the qualities of their products are found to be uneven. As a result, the purchase of new catalysts and the management of catalyst quality are very important for effective power plant operation. This study selected five catalyst brands that have been used in Taiwan Power Company to conduct tests of catalyst performance. This study also conducts tests of catalyst thermal stability and chemical poison resistance to simulate possible catalyst deactivation in actual power plants. By comparing catalysts among different brands, we can know each brand's advantages and disadvantages. We can also use it as a tool to evaluate and predict the lifetime of the catalysts. Finally, this study also provided "Guideline for the testing of SCR catalyst and quality management" as a reference for users to set up purchase specifications and evaluate catalyst lifetime.

關鍵詞(Key Words)：觸媒活性(Catalyst Activity)、脫硝(De-NO_x)、壽命評估(Lifetime Assessment)、失活(Deactivation)。

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二氧化碳固態吸附劑改質性能研究

Research on Performance of CO₂ Solid Adsorbent with Property Modification

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摘要

由NOAA於2018年11月的報導中，大氣中平均二氧化碳濃度已升至408.16 ppm，近年來液態醇胺法為國際間主流捕碳之方法，固態吸附法則擁有無溶劑之優點，其於理論上可減少二氧化碳捕獲之能耗，本研究由傳統與微波水熱法合成MCM-41，並比較以不同矽源(Fumed Silica, TEOS, 水玻璃)與不同鹼液(TMAOH, NaOH)成之影響。

在本實驗內傳統水熱合成時，以Fumed silica為矽源、TMAOH作為鹼液來合成MCM-41較佳，其BET比表面積可達 $1174.38 \pm 10.20 \text{ m}^2/\text{g}$ ；而傳統水熱合成後擴孔，其擴孔較佳條件為120 °C、72Hr，孔徑分佈可由 $30.28 \pm 1.71 \text{ \AA}$ 提升至 82.17 \AA ，但其比表面積均下降約13.1~38.6 %。

最終嘗試以微波水熱之合成MCM-41，可降低反應時間至40~80 min，經改善試驗後，其BET比表面積最高可達 $1010.926 \pm 4.948 \text{ m}^2/\text{g}$ ，並於4 bar環境時，每公斤MCM-41可吸附至 $1.44 \pm 0.07 \text{ mol CO}_2$ ，並可由相關數據判斷，BET比表面積各因子影響程度為：微波水熱pH值>攪拌時間>微波溫度>微波時間。

Abstract

In the report of NOAA in November 2018, the average CO₂ concentration in the atmosphere has risen to 408.16 ppm. In recent years, the liquid MEA method has been the mainstream carbon capture method internationally, and the advantage of solid adsorption process is that it doesn't need the use of solvents, thus reducing the energy consumption in a CO₂ capture process theoretically. In this study, MCM-41 was synthesized by the traditional or microwave hydrothermal method, and compared with different Si sources (Fumed silica, TEOS, Sodium metasilicate), with different base (TMAOH, NaOH).

In the traditional hydrothermal synthesis, the optimum synthesis strategy is to use Fumed silica as Si sources – together with TMAOH as the base, and the BET specific surface area can reach $1174.38 \pm 10.20 \text{ m}^2/\text{g}$. In the pore expanding part, the synthesized condition is 120 °C, 72 Hr, which can increase pore size from $30.28 \pm 1.71 \text{ \AA}$ to 82.17 \AA , but the BET specific surface area may decrease to about 13.1~38.6%.

In order to reduce the hydrothermal synthesis time to 40~80 mins, this study synthesizes MCM-41 by the microwave hydrothermal method. After the improvement test, the BET specific surface area can reach up to $1010.926 \pm 4.948 \text{ m}^2/\text{g}$. In a 4 bar condition, MCM-41 per kg can adsorb $1.44 \pm 0.07 \text{ mol}$ of CO₂. The order of influence among various factors on BET specific surface area is: microwave hydrothermal pH value > stirring time > microwave temperature > microwave time.

關鍵詞(Key Words)：二氧化碳(Carbon Dioxide)、MCM-41(MCM-41)、水熱法(Hydrothermal Synthesis)、微波水熱法(Microwave Hydrothermal Synthesis)。

二氧化碳吸收溶劑再生能耗與技術探討

Study of Regeneration Technique of CO₂ Absorbent

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摘要

使用液態醇胺吸收劑經由化學反應吸收二氧化碳，為目前最主流之碳捕集方法。吸收二氧化碳後之富溶劑，需經氣提再生程序脫除二氧化碳後，方可繼續使用，此步驟需消耗大量熱能與蒸汽，為化學吸收法發展之瓶頸。本研究以通入CO₂後之MEA(Monoethanolamine)+AMP(2-amino-2-methyl-1-propanol)混和溶劑作為富溶劑，於氣提塔內進行再生實驗，計算CO₂脫除效率及再生能耗，尋找最佳操作條件，與基線之MEA溶劑比較，並探討氣提塔內之質傳現象。

混合溶劑之CO₂脫除，氣提塔操作在體積流率操作在0.3 L/min時有最低之熱負荷(Heat Duty, Q)，比採用MEA溶劑時降低20%以上；在蒸汽產生速率上，混合溶劑在提升濃度時，蒸汽產生速率增加不多，此表現亦優於MEA溶劑；評估蒸汽使用效率，發現較高濃度之混合溶劑，操作在較高再沸器溫度但較低之體積流率下，單位蒸汽量可脫除較多之CO₂量。

經熱力學及流力計算，可得整體質傳係數(KLa)受溶劑體積流率影響較大，而採用混合溶劑時，質傳係數亦為採用MEA溶劑時之2倍左右，顯示MEA+AMP混合溶劑之氣提特性更佳。

Abstract

The chemical absorption process is the most widely adopted approach of carbon dioxide capture. The rich solvent (solvent after CO₂ absorption) needs to be regenerated by stripping process for repeated usage. The large amount of energy and steam consumption during solvent stripping is a bottleneck for chemical absorption process development. In this study, a mix of MEA(monoethanolamine)+AMP(2-amino-2-methyl-1-propanol) blended amine solution is selected as the rich solvent to conduct the stripping test. Considering the stripping efficiency and heat duty, an optimized condition is proposed. The performance is compared with that of the baseline absorbent, MEA solvent. Also, the mass transfer phenomena in the packed-bed stripping column is discussed.

A minimum heat duty for stripping CO₂ from MEA+AMP solvent is obtained under the condition of liquid volumetric flow rate at 0.3 L/min. The heat duty is reduced by more than 20% by replacing MEA with MEA+AMP solvent. The steam production rate does not rise significantly when the MEA+AMP concentration is increased. To operate at a higher concentration of MEA+AMP solvent at higher reboiler temperature and lower volumetric flow

rate, a higher β value is found, which means that more CO₂ can be stripped by the same amount of steam.

By the thermodynamic and fluid dynamic calculation, the overall mass transfer coefficient (KLa) of CO₂ from liquid to gas phase is primarily determined by the volumetric flow rate of solvent. The KLa in MEA+AMP solvent is two times that of adopting MEA as solvent, showing that the former has a better stripping characteristics.

關鍵詞(Key Words)：二氧化碳(Carbon Dioxide)、吸收劑(Absorbent)、氣提(Stripping)、熱負荷(Heat Duty)、質傳(Mass Transfer)。

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