

出國報告(出國類別：考察)

煉製能效暨相關節能技術考察報告

服務機關：台灣中油公司環保處

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煉製能效暨相關節能技術考察報告

洪克銘

摘要

COP21 會議將於 11 月底開始於法國巴黎召開。本次會議預期將制定抑制全球氣候暖化具全面約束力之相關規範及機制，以接替將到期之「京都議定書」。會議前碳排佔全球 95% 之 183 個國家提交了各自的減排溫室氣體之承諾(INDCs)，也帶給以外貿導向之我國莫大之減碳壓力。

本公司從 2005 年起為因應京都議定書生效，即致力於推動生產工場之能源管理與節能計畫推動並獲成效。惟煉製結構複雜，從進料、製程、精煉度 以及聯產品特性等均影響節能之成效，且亦感後續節能推動面臨瓶頸，亟需尋求新的節能方案與能源效率管理技術。本計畫目的即藉由考察蒐集美國煉油、石化相關產業之節能技術發展與運用實例，以協助公司各廠進一步之能效改善，達成公司節能減碳之目標。

本項計畫共考察 EcoTechnol 公司薄膜之 CO₂ 分離捕獲與廢水處理回收相關節能減碳技術；Aspen Tech.製程模擬之節能運用與管理，以及 HoerBiger 之 HydroCom 大型壓縮機無段節能技術。此次考察顯示部分技術具有甚高之運用潛力，如 HydroCom 及 Aspen 相關技術若能落實於製程應用將有助公司達成能源局之能源大用戶五年 5%之節電計畫管控與本公司持續推動之生產工場節能目標。另薄膜之廢水處理回用，以及煙道氣之 CO₂ 捕獲技術經驗，亦有助研擬後續推動之水資源回用以及配合碳捕獲封存(CCS)之低能耗碳捕獲技術建立。

煉製能效暨相關節能技術考察報告

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煉製能效暨相關節能技術考察報告

洪克銘

壹、目的：

COP21 會議將於 11 月 30 日至 12 月 10 日於法國巴黎召開。本次會議延續去年里約會議，將朝制定抑制全球氣候暖化具全面約束力之相關規範及具體量化做法等機制，以接替將到期之「京都議定書」。在此次會議前已經有 183 個國家提交了各自的減少排放溫室氣體之預期貢獻承諾(INDCs)，這些國家的排碳量占了全球的 95%，這也顯示各國對這次高峰會的重視程度。但也帶給以外貿導向之我國莫大之減碳壓力。

本公司從 2005 年起為因應京都議定書生效，即致力於推動生產工場之能源管理與節能計畫推動並獲成效，累計 10 年來之減碳成效超過 200 萬噸佔總排碳量之 20%。惟煉製結構複雜，從進料、製程、精煉度以及聯產品特性等均影響節能之成效，且亦感後續節能推動面臨瓶頸，亟需尋求新的節能方案與能源效率管理技術。另經濟部於 2014 年針對全國用契約容量達 800 千瓦以上之用電戶，公告「能源用戶訂定節約能源目標及執行計畫規定」，要求 4 年達成 4% 以上之節電管控措施。這都將影響本公司各廠處節能之壓力與減碳目標達成。

本計畫目的即藉由考察蒐集美國煉油、石化相關產業之節能技術發展與運用實例，以協助公司各廠進一步之能效改善，達成公司節能減碳之目標。本項計畫規劃考察 EcoTechnol 公司之低能耗 CO₂ 薄膜分離捕獲與廢水處理回收等相關節能技術；Aspen Tech. 製程模擬在節能與能源管理之運用，以及 HoerBiger 之 HydroCom 大型壓縮機無段節能技術。

貳、考察行程：

11月4日起程前往美國，於當地時間同日抵洛杉磯入宿飯店。11月5日晨即起程前往 Ecotechnol 公司，位於接近洛杉磯與聖地牙哥鄰接處 Escondido 之辦公室拜會，由 Ecotechnol 公司技術總監 Larry Lien 等接待，並就 Ecotechnol 公司薄膜分離之技術、相關薄膜產品，以及應用實例聽取簡報。尤其介紹該公司特殊薄膜在廢水之純化回用應用技術實例，以及海水淡化等相關技術與工程經驗。另針對薄膜在 CO₂ 捕獲分離技術，近期在澳洲之尾氣實廠捕獲 CO₂ 之測試結果。接著由 Larry Lien 陪同前往位於 Fountain Valley 之奧蘭治縣水務局 (Orange County Water District, OCWD) 之地下水補給系統 (Groundwater Replenishment System, GWRS) 參觀。

OCWD 負責管理龐大的地下水盆地，提供奧蘭治縣北部和中部的飲用水。該局使用世界上最先進的含水層補給系統，取代部分屬於當地水利部門、都市和其他用戶的地下井水，作為其管理的地下水源。



OCWD 使用三種主要工程管理方式保護地下水：

- 1) 補充系統：從各方面截流捕集地表水，補充到地下水盆。水從地表向下移動滲入地下水盆地，並藉自然地過濾和提純以補充蓄水層。該局並利用充氣橡膠水壩、堤防和閘門等補充水導流設施、過濾系統，並設置屏障井將水泵入地下水盆地以避免海水污染。
- 2) 監測系統：監測和保護水的質和量。始終保持水盆在可持續水位，阻止海水入侵以避免地下水被污染。此外，檢測在水盆地中和將進入的水，檢查是否有有害化學物，並調查地下水污染。該局還設置監測井監測供水壓力，並採樣送往先進質量保證實驗室檢測飲用水的質量。



3) 淨化：除地表水補充系統浸透注入外，還使用一部分的再生水。該局地下水補給系統（GWRS），使用處理過的廢水，加以淨化來補充飲用水供應。並利用植被的淺水池塘濕地自然淨化水質。

OCWD之廢水回收係使用Hollow Fiber薄膜作為前處理，再經由Ultrafiltration及高效率之逆滲透薄膜之後段純化處理後，最後經UV光殺菌後作為飲用水。

11月6日則一早起程前往洛杉磯北方文圖拉郡 (Ventura County)奧克斯納德市 (Oxnard)的一處採油礦區，參觀該礦區之蒸汽注入場(Steam Injection Plant)。



該工場將蒸汽注入油井加熱以幫助重質原油之採收。原油採收後之生產水 (Production water) 經CPI油水分離後之熱排水，先經Ultrafiltration前處理後再經 Ecotechnol公司特殊之高溫薄膜加以純化得到之高溫回收純水，並直接回用作蒸汽工場之進料。此項技術不但減少達8成以上之廢水排放，並直接利用此高溫回收水生產蒸汽，減少蒸汽生產之能耗。隨後與Larry Lien 及相關技術人員就此項廢水純化及高溫薄膜相關技術應用交換意見。隨後搭機離開洛杉磯前往休士頓繼續後續之考察行程。11月7,8日適逢星期例假，得以一覽休士頓市街景與市郊風光。

11月9日首先前往本公司海外石油 OPIC HOUSTON INC.拜會。進公司30多年以來首次踏上本公司在北美之海外據點。隨後前往 HOERBIGER 美國公司拜訪。



Hoerbiger(賀爾碧格)是全球最大的獨立從事氣體壓縮機氣閥及其他空氣及冷凍壓縮機配件研究開發和生產的企業。公司從1895年創立至今，已有118年的歷史，Hoerbiger已成為在壓縮機技術、自動化和傳動技術等三大技術領域世界領先的跨國公司。其事業領域目前涵蓋：往復式壓縮機、燃氣發動機、螺桿壓縮機、工業防爆、機械工程、醫療技術、客用車與輕型商用車、商用車、船舶、飛機製造業、遊樂設施、閥門自動化及汽車測試系統等領域。在壓縮機產業方面，賀爾碧格專門生產往復式壓縮機、螺桿空氣和氣體壓縮機等之關鍵零組件並提供相關服務，包括壓縮機閥、填料環、填料夾、氣缸、襯裡、活塞、騎手頻帶、活塞環、連桿，及十字頭和曲軸等維修、再生，和改造服務。其閥門產品包括：吸氣閥，

排氣閥，止回閥，平板閥，環閥和提升閥。壓縮機活塞桿密封包括：壓力包裝，包裝油，戒指，和包裝箱等。此外，該公司也提供交通工具的氣動和液壓系統。本次考察任務主要了解賀爾碧格公司獨特之大型往復式壓縮機節能技術(HydroCome)及相關應用實例經驗。當天由賀爾碧格公司壓縮機部門經理 Alberto Vargas P.與資深技術經理 Jack Schwaller 負責接待，除就煉油廠大型往復式壓縮機之節能基本原理；閥件、軸封及環套等之節能設計；Hydrocom 之往復式壓縮機容量控制系統，以及逆止閥解決逆流問題之機械安全方案，等相關節能技術，及應用實例廣泛加換意見與討論。



Kobelco / Refining / Residue desulfurization (RDS)

11月10日則在本公司 OPIC 陳總經理雄茂陪同下，一同拜訪 Aspen Tech 公司位於休士頓之分公司。Aspen Tech 公司係國際知名之製程模擬與程控技術之技術服務公司。其 Aspen Plus 軟體是化工業普遍使用之著名製程模擬設計軟體。本公司亦租用其軟體提供公司研究所及各廠處使用。基於公司 10 年來戮力推動節能之管控，傳統之設備更新改善、操作之最適化、蒸汽與油氣等能資源之回收利用等之節能空間已受到大幅壓縮，必須尋求較新之節能技術以協助生產製程之節能推動。此行旨在蒐集 Aspen 在煉廠操作之排程、製程之整合與高階程控技術等近幾年之發展與應用經驗。



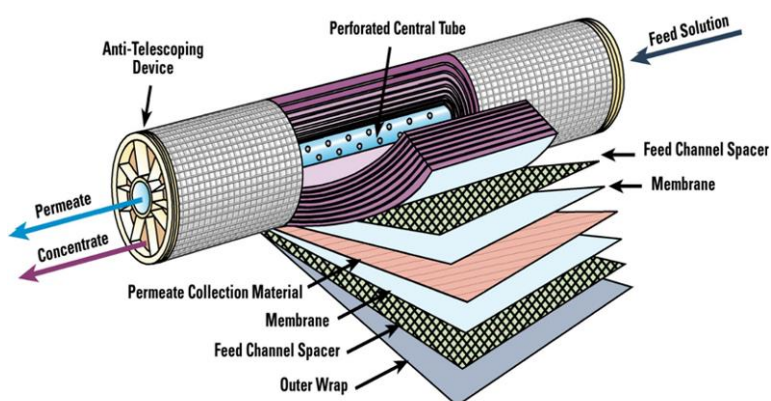
本次參訪由 Aspen Tech.公司技術諮詢部門副總裁 (VP Global Business Consultants) 與負責全球技術服務之副總裁 (VP Global Services) **Michael Leung** 兩位先生負責接待。**Michael Catt** 主持會議，資深高級業務顧問 (Sr. Principal Business Consultant) **James Li**、能管之產品經理 (Product Manager – Energy Management) **Jack Zhang**，以及資深高級顧問/工程師 (Sr. Principal Consultant/Engineer) **Hongwei (Davy) Li** 等三位先生一齊全程參與此項會議。**Michael Catt** 先就此行訪問致意並簡介該公司相關業務。其餘各位分別針對 Aspen 公用系統、煉廠排程、高階程控等技術發展分別簡報，其中 Jack Zhang 遠從波士頓以視訊方式全程參與。最後並由 Michael Catt 主持共同探討可以幫助本公司節能推動之相關對策方案。

參、考察心得：

本次考察任務在蒐集美國煉油石化相關節能技術發展與運用實例，以協助公司各廠進一步之能效改善，達成公司節能減碳之目標。本次分別拜訪 EcoTechnol Inc., Hoerbiger American Inc.,與 Aspen Tech. Co.,等三家公司，分別就薄膜之廢水處理新技術與海水淡化技術、薄膜CO₂捕獲技術、壓縮機節能設計與無段式控制節能技術，以及製程模擬應用於製程節能、排程、與高階程控等技術進行交流與討論。並參訪加州奧蘭治縣水務局 (Orange County Water District , OCWD) 之地下水補給系統 (GWRS)，與文圖拉郡 (Ventura County) 奧克斯納德市一處採油礦區之蒸汽注入場之熱廢水回收系統。對上述幾種主要技術發展分述如下：

薄膜之廢水處理技術

Ecotechnol 自行生產各種特殊需求之薄膜濾材及模組，尤其針對耐高溫、高壓之高黏度條件之膜材。該公司採用商用薄膜基材，再自行表面處理修飾，與捲繞加工。右圖係其螺旋捲繞之典型 RO 薄膜結構圖。



Hollow Fiber Microfiltration (MF)	.1 to 1 micron	Bacteria
Ultrafiltration (UF)	6K to 100K MWCO	Proteins
Thin Film UF	500, 1K, 2K & 3K MWCO	Rejects Ferric Iron, Dyes & Small Colloids
Nanofiltration (NF)	150 to 500 MWCO	Divalent salts rejected 99% but transmits salts or acids
RO / EMS®	50 to 150 MWCO	Rejects all salts and acids 99+%

EcoTechnol之薄膜分離技術，包含：飲用水、無菌水及超純水等水質純化，工業及生活廢水、薄膜生物反應器及垃圾滲濾液等廢水處理，生技、製藥及食品飲料工業之分離，以及水之回用以及零廢液排放等技術。其主要應用產業包含，飲用水相關之海水與微鹽水之淡化、地下水與地表水處理；傳統及膜生物反應器汙水處理，及垃圾掩埋場滲濾液處理等之民生產業，以及油氣、採礦與冶金、環工、製藥、生技、化工，及食品飲料等工業。Ecotechnol公司之專業服務含水及廢液處理、薄膜之應用技術、工程與建造、專案管理，以及技術之研發與顧問。目前主要之業務有：

- 水/廢水處理之貨櫃廠 (移動式水和污水處理系統)
- 污水處理及水之回用 (污水處理水之純水淨化及沉入式膜生物反應)
- 採礦冶金 (製程和廢液之酸性和金屬回收、酸性礦山廢水處理、氧化鋁/鋁製程開發，以及黃金尾礦之氰化物回收與礦石(金)之微波處理)
- 製藥/生物技術 (MBR技術在廢水和製程之應用)
- 石油與天然氣(生產水處理、污水處理)

EcoTechnol可供應處理量75m³~1200m³ /天組裝式貨櫃水處理廠，採全自動化系統、遠程監控、完全絕緣且具照明、空調及機電系統，可隨時啟用。採模組化設計運送、安裝維護成本低。



EcoTechnol公司具有相當多海水淡化廠之實績。下圖係分別位於及義大利ENEL之10,000 m³/day逆滲透膜海水淡化廠。





The Ultrafiltration system is equipped with SS-TiO₂ Tubular membranes treated water is suitable for Reuse, eg. Agriculture

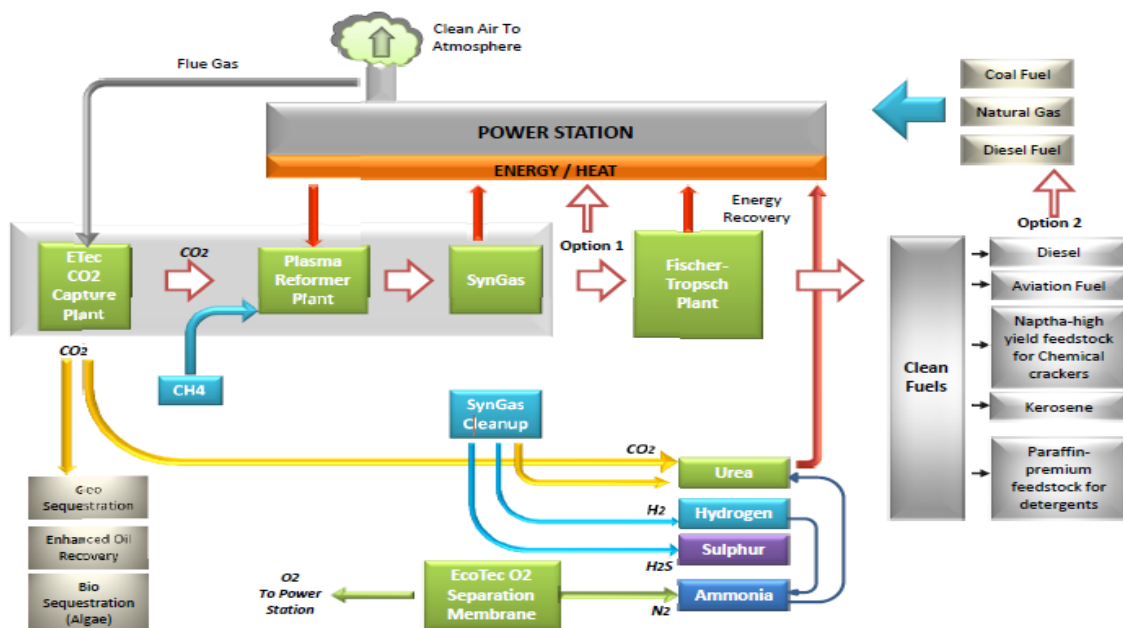
上圖則係採用 TiO₂ 薄膜之 Ultrafiltration 系統處理之農業回用水。製程水或公用系統水之回用系統則如下圖。它經由一段或兩段之奈米過濾 / 逆滲透 (NF / RO)，即可得到所需之超純水。

為配合廢水零排放需要，通常經由奈米過濾 / 逆滲透系統截流之濃縮液，可再進一步以蒸發、結晶或乾燥成半固態殘渣廢棄物。



薄膜 CO₂ 捕獲技術

EcoTechnol 以其薄膜分離之技術，開發出薄膜二氧化碳捕獲之技術，並試圖進一步發展以捕獲之 CO₂ 進行 Synthetic Fuel 生產之 IC4F 製程，如下圖。



該公司並與本公司簽訂合作意向書，就其 CO2 捕獲技術合作進行評估。EcoTechnol 並以貨櫃組裝一套移動式薄膜 CO2 捕獲設備，以便進行烟道氣之實場 CO2 捕獲測試。



由於雙方對於捕或測試之場址，以及煉研所對於 EcoTechnol 所提出之初步性能測試資料，雙方仍有些歧見。本計畫因此一直未能進行本公司實廠之測試。EcoTechnol 另尋得澳洲進行相關之測試。本次考察特意就此項計畫之進展與 EcoTechnol 之技術總監 Larry Lien 進行討論。

Larry Lien 表示，該計畫以原 2-Stage 薄膜分離管設計進行烟道氣之 CO2 捕獲測試，CO2 約可提高至 80% 以上，惟無法達到本公司當時設定之 90% 純度要求。後來另該計畫考慮 CO2 捕獲後之運輸問題，決定加入第三段之冷凍回收技術設計。原設計之二段薄膜僅負責將 CO2 提濃至 80% 以上，再經由第三段之冷凍法將 CO2 冷凍並提高純度至 90% 以上。該公司並邀請本公司可以前往澳洲之測試廠參訪。將請該公司提供進一步之測試數據進行評估。

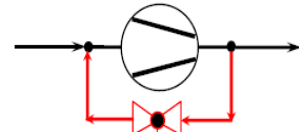
氣候變遷議題持續發燒，COP21 在各國陸續提出自主減碳貢獻(INDC)，及各方協商下終於達成巴黎協定。面對強制性之國際減碳壓力下，CCS 不排除在未來扮演相當角色。本計畫若能顯示較目前商業化之胺吸收法具較佳經濟效益，將加強雙方之合作開發。

往復壓縮機節能與無段式控制技術

傳統往復式壓縮機之氣量調解法共可分下列幾種，其優劣點分述如下：

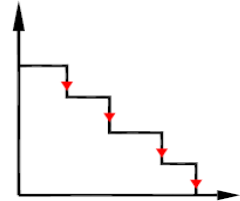
(1) 旁通回流調節

- 調節靈活，方便易行
- 運行經濟性差
- 適用於偶爾調節或調節幅度小的場合



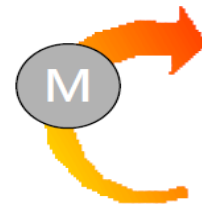
(2) 逐級氣量調節

- 全程壓開進氣閥調節
- 階梯形控制
- 潛在的連杆負荷和潤滑問題
- 適用於粗調節



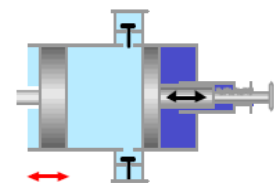
(3) 驅動機轉速調節

- 用於驅動機為內燃機或汽輪機的壓縮機或驅動電動機功率較小的壓縮機
- 可能對壓縮機工作產生不良影響，如氣閥R&P、潤滑、振動等



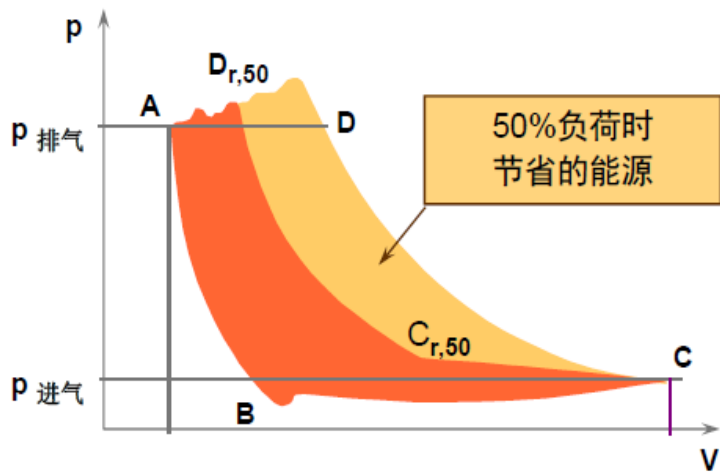
(4) 氣腔餘隙調節

- 通常手動調節，也有用自動液壓調節系統
- 調節速度較緩慢
- 通常不適用於已有設備改造



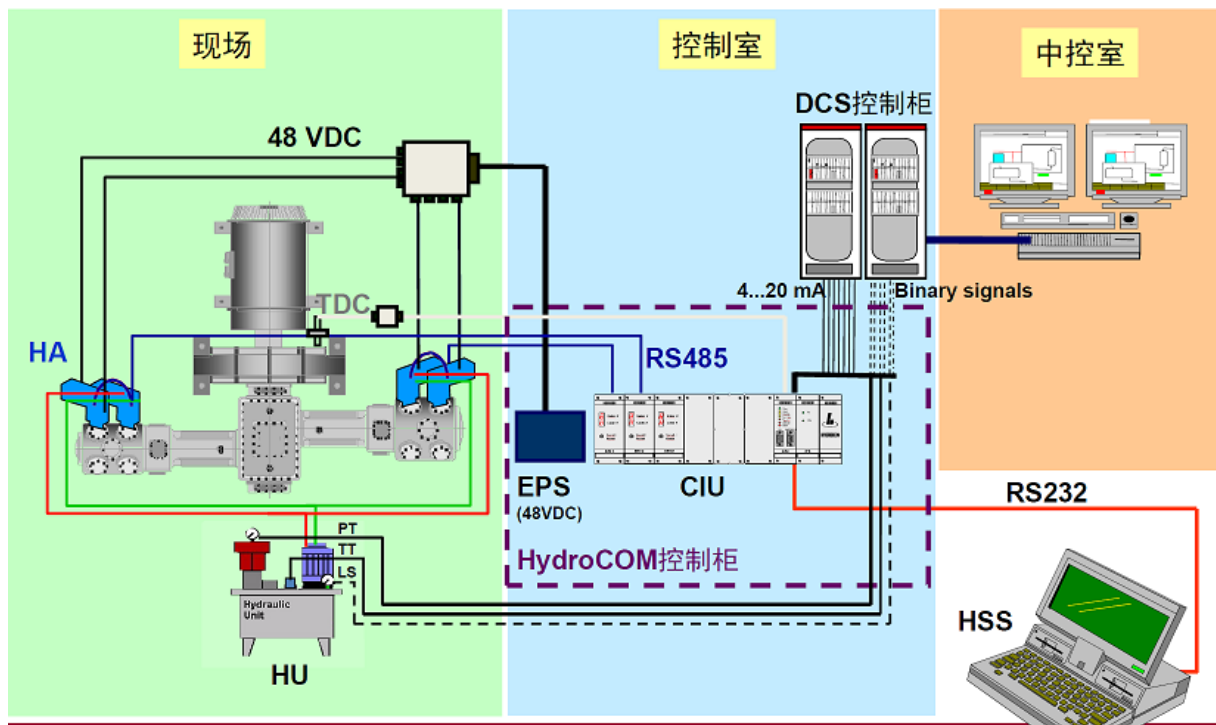
對於氣量調解要求，通常須盡量自動化、最大可調解範圍，以及達到最大節能目的。對於典型之旁通閥調解，若以平均 60% 負載，一座 2,000kW 壓縮機，一年損失之電費，以每度 2.5 元計算即達 1360 萬元 (2,000 x 0.85 x 40% x 8,000 x 2.5)。

HydroCome 的基本原理是只對需要之氣體量進行壓縮，剩下之氣體在壓縮行程開始之際，即已回流至氣腔內。亦即其整體作功僅及於實際之氣體負載量。因此幾乎不會造成能耗之浪費。下圖表示 50% 負載下壓縮作功所節省之能耗。



惟要確實達成上述之要求，HydroCome 除了採用其獨特之控制閥門，並使用全自動液壓控制系統執行進氣閥之穩定調控。除具有本身之控制系統外，並可直接由中控室之 DCS 執行製程之穩定需量控制。

由於節能成效甚佳，Hoerbiger 幾乎席捲全球往復式壓縮機市場，累計安裝之壓縮機台數超過一千兩百座以上。其中全球主要煉油大廠安裝之台數亦達一百多套，如附件。



以國內而言，台塑石化於 2006 年首先於其煉二廠之 RDS 工場進行兩套功率 11,500kW 壓縮機改裝，又接著改裝潤滑油基礎油廠兩套功率 11,000kW 之壓縮機。及至目前整個台塑系統已累計改裝了 9 組壓縮機，其應用範圍亦涵蓋至 RDS、基礎油氫化、芳香烴工場、VGO 工場與 CCR 工場等。至於中國大陸，及至目前安裝之壓縮機數已近 200 台，其應用亦以煉製、探採及石化為主，煉廠部分如：煤組、加氫(裂化、精製、改質與脫硫處理)、氫氣工場、焦化工場，以及天然氣輸送、儲氣及採氣。石化則如：乙炔、HDPE、聚丙烯、合成氣、化肥、空氣分離...等，如下圖例所示。



目前適值政府大力推動節電計畫。煉製廠電力大都應用在製程及公用系統之轉動機械，但現場一向對製程設施之節能較趨保守。本公司煉製事業部主要之煉製製程，如 RDS、RFCC、煤組(Reforming)...等不乏大型往復式壓縮機，其節能之潛力不容忽視。目前已知大林廠第三 RDS 正規劃引進一套氫氣壓縮機之 HydroCome 氣量調節系統。本公司將協助各廠加強推動相關之節能改善。

製程模擬在製程節能、排程、與高階程控等應用

此行拜訪 AspenTech，Aspen 特別針對在煉油能源管理方面相關之製程設計模組，包含：公用系統優化（Aspen Utilities Planner™）、Aspen Petroleum Scheduler，以及 aspenONE Advanced Process Control，進行簡報及討論。

Aspen 的公用系統之節能管理分成公用系統離線優化與線上優化，其分述如下：

1) 公用工程離線優化（Aspen Utilities Planner™）

離線優化是基於 Aspen Utilities Planner™ 的公用系統嚴格機理離線模型。其中，製程用能需求預測是由工廠生產計畫決定的，是由 PIMS 計算的結果。模型用於優化公用系統的生產、燃料選擇與採購以及設備的生產負荷，從而提高能源效率。還可以利用模型進行多種業務過程相關的能量和公用系統管理，如報表、工況分析、採購合約評價等等。

1) 公用系統線上優化

線上優化是公用系統的線上開環優化。通過 Aspen Online 將 IP.21 的資料導入到 Aspen Utilities 模型，並將計算的結果寫回到 IP.21。線上優化模型用於優化公用工程的生產優化，並為熱力廠操作工提供建議，包括：

- 每台鍋爐的最優產汽量
- 每台蒸汽輪機最優發電量
- 每台鍋爐的最優燃料
- 最優的購電量

汽電廠可以根據模型的建議調整設備操作，從而獲得最大限度減少能耗。

本公司大林廠，日前亦已啟動公用系統之改善計畫，充分使用 RFCC 等工場 Flare 排出的 FG、增加高壓鍋爐之蒸汽產量，以增加 TG 之發電及中壓蒸汽抽氣量，減少外購蒸汽。本公司林園廠、桃廠公用系統均甚為龐大，若能確實推動系統整合優化，對提升整廠之能耗降低應具相當成效。

另外在石油調度排程方面，今天的煉油調度須處理以更少的員工，面對日益複雜、靈活的供應鏈動態環境。藉由調度自動化，應是提供最佳方案和業務執行之間的溝通橋樑，在尊重煉油廠的限制下獲取計畫的效益。Aspen Tech 的石油調度排程(Aspen

Petroleum Scheduler)是整合全面支援調度、煉油活動，並加入碼頭調度優化的新集成系統。自 1995 年以來，Aspen 石油調度程式幫助全球各地的客戶規劃出好的業務調整的計畫，防止在波動的市場中造成利潤損失，似乎獲得不少迴響。

AspenTech 公司的解決方案是在一個平臺管理的所有活動，它是以事件基礎，建構全煉油廠的單混合優化解決方案。目前全球有 45% 以上煉油廠，使用 Aspen 的 PIMS 之 LP 軟體進行整合，從精確計畫與排程獲得更大的利潤。為摻配之最適化，Aspen Petroleum Scheduler 整合了煉廠多元摻配優化系統 (Aspen Refinery Multi-Blend Optimizer)。Aspen Petroleum Scheduler 並以實現煉油廠調度更全面的看法，將排程延伸出煉油廠大門，包括碼頭運營和管線調度。Aspen Petroleum Scheduler 的碼頭調度功能，負責管理所有進出之貨量，一直到碼頭，同時自動產生及更新所有煉油廠排程中事件。新的管線調度功能則容許更精確追蹤進出之傳輸動作，及包括影響業務調度之關鍵配套碼頭。為優化管線灌裝管理，Aspen Petroleum Scheduler 可輕易管理多個，平行和具注入點之雙向管線段。

Aspen 宣稱，通過協調調度所有煉油廠活動，Aspen Petroleum Scheduler 可以幫助企業達成下列之效益：

- 提高生產效率
- 減少白贈的品質、庫存和滯期費
- 縮短停機和啟動週期
- 更好的評估機會
- 縮小規劃和調度之間的差距
- 減少跳車和非計畫性事故

肆、建議事項：

煉製結構複雜，從進料、製程、精煉度 以及聯產品特性等均影響節能之成效，因感後續節能推動面臨瓶頸，亟需尋求新的節能方案與能源效率管理技術。本計畫共考察 EcoTechnol 公司薄膜之 CO₂ 分離捕獲與廢水處理回收相關節能減碳技術；Aspen Tech.製程模擬之節能運用與管理，以及 HoerBiger 之 HydroCom 大型壓縮機無段節能技術。上述技術大多不同本公司過去執行之節能改善計畫，過去節能計畫較偏向於設施的改善、操作管理之加強與能資源之整體充分應用。

於此次考察顯示部分技術具有甚高之運用潛力。如 HydroCom 技術，雖碰觸製程較核心大型壓縮機之氣體需量調控，惟其造成之節能效果亦顯而易見，而國內外亦不乏成功先例。建議可全面性了解本公司各廠處相關設施，擇其較具效益之項目檢討逐步更新改善。

今日之煉油調度，面對日益複雜、靈活的供應鏈動態環境。藉由製程之模擬與調度自動化，可以幫助管理掌握充分之資訊，對原油採購評估、煉製之排程、操作設施之選擇、操作策略之擬定、最佳產品之組合及品質，以及配合市場作最有效之調度等，提供即時即準確之資訊。應是提供最佳方案和業務執行之間的溝通橋樑，在尊重煉油廠的限制下獲取公司最大效益。Aspen 煉油之規劃與調度排程係全方位規劃與調度決策系統，有別於本公司現有 LP 系統較偏於原油採購評估，且已被許多國際大型煉油廠所採用，相關技術若能落實於製程應用，將有助公司達成節能之推展，且增進公司經營之績效。另外，公用系統之能源優化管理系統，對於煉油廠之能效改善似仍有甚大空間，亦值得進一步推展。

水資源發展條例即將完成立法，對於 EcoTechnol 薄膜之廢水處理回用與薄膜相關技術對於煉廠之減廢及水資源利用，另煙道氣 CO₂ 之薄膜捕獲技術經驗，對於發展溫室氣體減量技術等，均有助於本公司研擬後續推動之水資源回用以及配合碳捕獲封存(CCS) 之低能耗碳捕獲技術建立。

伍、附錄：

附錄一、出國預計行程表

預定起迄日期	天數	到達地點	地區等級	詳細工作內容
104.11.4~104.11.5	2	洛杉磯	285	起程
104.11.6~104.11.7 洛杉磯時間 104.11.5~104.11.6	2	洛杉磯	285	前往San Diego北邊之Escondido 拜訪EcoTechnol公司，討論薄膜水資源回用及高能效薄膜二氧化碳捕獲技術，並前往北洛杉磯Fountain Valley汗水處理場址與Oxnard蒸汽注入廠之處理場，以及位於Carlsbad之南半球最大海水淡化廠- San Diego水務局參訪。
104.11.8~104.11.9 休斯頓時間 104.11.7~104.11.8	2	洛杉磯-休斯頓	233	交通及例假
104.11.10~104.11.12 休斯頓時間 104.11.9~104.11.11	3	休斯頓	233	1.考察 HydroCon 之壓縮機節能技術，及其在煉油石化產業支應用案例 2.拜訪 AspenTech.與其相關技術人員就製程模擬技術在節能管理與製程整合節能技術應用進行討論。
104.11.12~104.11.13 休斯頓時間 104.11.11~104.11.12	2	台北	233	返程

附錄二、EcoTechnol 公司介紹

EcoTechnol 主要專業在應用膜技術來解決採礦、石油和天然氣、製程、能源、廢物管理、供水和污水處理等工業的問題。其經驗涵蓋了研發，諮詢，測試工作的管理，設計，規劃，施工，調試，營運和項目管理，以及商業和財務管理。EcoTechnol 是一個標榜活力和創新的清潔技術公司，專注於提供開發實用的解決方案，以幫助更有效利用全球日益減少的自然資源，同時降低排放與減少廢棄物。

EcoTechnol 通過廣泛的研發項目，開發了包括海水淡化，污水處理和水的循環利用，淨煤及 CO2 捕獲技術等智財權之多元化產品組合。EcoTechnol 不僅提供設計和建造的膜的應用系統，並可以針對特定應用開發新的薄膜。EcoTechnol 標榜能針對最困難的問題，選擇和提出最佳成本效益的解決方案。EcoTechnol 的知識和技術專長可以應用到廣泛的行業之先導試驗與開發新的工藝，以幫助提高性能、增加利潤並減少對環境的影響。

Business Overview



- 30+ Years of Project Achievements
- Global Applications
- +250,000 m³ H₂O Filtered Per Day
- +90 Gigalitres Filtered Per Annum

Specialists in advanced membrane technology for unique water and industrial process applications worldwide.

Ecotechnol is a socially responsible company striving to make tomorrow's technology, today's solutions.

With products and services to some of the world's most complex environmental challenges, we aim to achieve lasting global impact for a better world. Our applications include;

- Water Purification & Recycling
- CO₂ Capture & Treatment
- Mineral Processing Optimisation
- Industrial Chemical Capture

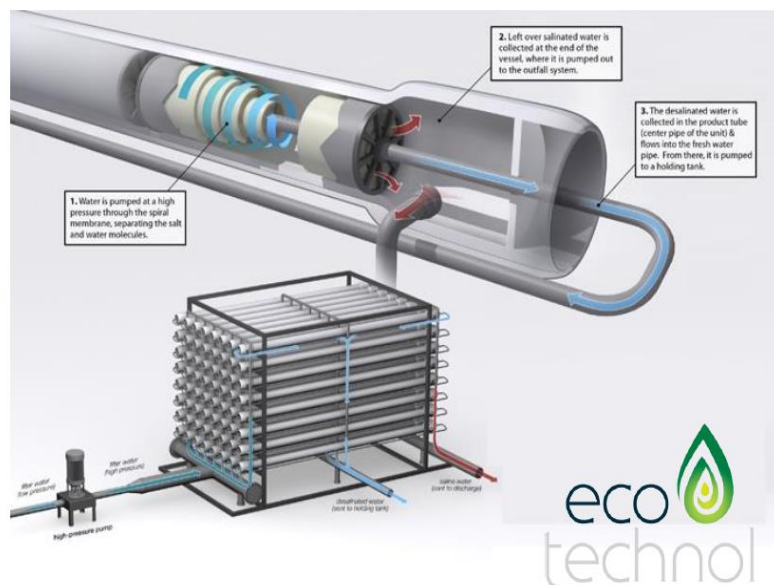
Our Global Reach & Major Projects



Reverse Osmosis

RO systems are the most commonly used desalination technology.

Ongoing development has made membranes the most cost effective and environmentally friendly proven process for seawater desalination.



Our Global Reach & Major Projects



Eco technol-OsmoAsiaPacific / AsianTec

Partial User List

Sea Water Reverse Osmosis (SWRO)

Installed Plants

CUSTOMER	EQUIPMENT	DESCRIPTION
Indonesia PT. Putra Submer	720 M ³ /D SWRO	Power Plant
Indonesia PT. Navatani Persada	500 M ³ /D SWRO	Power Plant
Indonesia PT. Wijaya	1,200 M ³ /D SWRO	Power Plant
Indonesia GT Petrochem	2,000 M ³ /D SWRO	Chemical Factory
Indonesia PT. Budi	2,000 M ³ /D SWRO	Power Plant
Indonesia PT. Nagama	15,000 M ³ /D SWRO	Power Plant
Indonesia PLN	3,000 M ³ /D SWRO	Power Plant
Malaysia Shanyang Plywood 1, Miri	500 M ³ /D SWRO	Power Plant
Malaysia Shanyang Plywood 2, Miri	1,500 M ³ /D SWRO	Power Plant
Malaysia Shanyang Plywood 3, Miri	1,000 M ³ /D SWRO	Power Plant
Malaysia Bitulu Foscom Plywood 1	2 x 500 M ³ /D SWRO	Power Plant
Malaysia Bitulu Foscom Plywood 2	500 M ³ /D SWRO	Power Plant
China Lee & Man Paper Dongguan	24,000 M ³ /D SWRO	Pulp and Paper Factory
China Guangzhou Paper	20,000 M ³ /D SWRO	Pulp and Paper Factory
Iran Aronab Co	3 x 15,000 M ³ /D SWRO	Refinery
Iran Fari Niroy	400 M ³ /D SWRO	Power Plant
Indonesia Hydro Hitech Optima	2 x 1,400 M ³ /D SWRO	Power Plant
Indonesia Pt. Jaya Benja Machine	2,400 M ³ /D SWRO	Power Plant
Iran Avin Palayesh Niroy	570 M ³ /D SWRO	Power Plant
Indonesia Hydro Hitech Optima	2 x 360 M ³ /D SWRO	Power Plant
Indonesia Hydro Hitech Optima	2 x 1400 M ³ /D SWRO	Electronic Plant

CO₂ Capture

Eco Technol has developed an economic process for capturing carbon dioxide from exhaust gases produced in the burning of a wide range of carbon based fuels including coal, oil, natural gas or biomass. The process can be retrofitted to existing combustion processes, including power stations, furnaces, boilers, incinerators etc, and does not require high concentrations of CO₂ in the exhaust gas, e.g. the process can be used to treat exhaust gases containing <10% (vol) CO₂.

The Eco Technol membrane system is compact and simple to operate making it ideal to be retrofitted to existing plant infrastructure.

The membrane system can capture more than 90% of the CO₂ in the flue/exhaust gas and concentrate it into a volume of approximately 10% of the original feed gas volume.

One of the main advantages of this process is its simplicity compared to other processes currently being considered for CO₂ capture such as amine absorption. There is no need to use chemicals or to regenerate or replace absorbents.

Eco Technol CO₂ Capture Process Advantages

- Capital and operating costs are significantly lower than competing processes e.g. Amine Absorption
- Less energy consumption than competing processes
- Can be retrofitted to any existing power plant infrastructure
- Modular design allows scale-up of process using multi-stage operations
- Low maintenance requirements because there are no moving parts in the membrane system
- No corrosion issues or complications related to chemical consumption or regeneration
- Compact and lightweight and can be positioned either horizontally or vertically, ideal for retrofitting to existing plants

Examples of Eco Technol's Gas Treatment Applications:

- **Algae Production** - Eco Technol membranes were used to process flue gas from a gas fired power plant (250 MW) to capture CO₂ which was then used to grow algae for production of nutritional supplements. The Eco Technol membrane system operated successfully for 4 years; produced 60% CO₂ from flue gas to enhance the growth of *Dundenella* and *Spirulina* Algae.
- **Fermentation Process** - CO₂ was sequestered using Eco Technol membranes from an ethanol fermentation process and delivered to a green house growing

roses. Water and Ethanol were removed using Eco Technol membranes and returned to fermentation tank

- **Solvent Gas Capture Process** - To comply with Air Pollution requirements a thermal oxidizer was installed to remove organic solvent vapours that were evaporated from a manufacturing process. Eco Technol gas membranes were installed to concentrate the organic solvent vapours into a smaller volume reducing the CAPEX (smaller foot print due to smaller volume to process) and OPEX (less volume for thermal oxidation) of the air pollution equipment
- **CO₂ Removal from Methane** - Eco Technol gas membrane were successfully used to remove excess CO₂ from a natural gas formation upgrading the natural gas to (<2% CO₂). Viable alternative to amine scrubbing
- **Treatment of Landfill Gas** - Eco Technol gas membrane was tested to remove contaminants from landfill gas. Viable alternative to scrubbing/absorption processes
- **O₂ enrichment of combustion air** – increasing the O₂ concentration leads to improved combustion efficiency, reduced fuel consumption and reduced emissions

Oil & Gas

Eco Technol can provide specialised membrane treatment systems for the wide range of oil and gas industry applications:

Produced Water treatment

- Small footprint (80% less than current best available technology)
- Ideal for off-shore platforms where space is very limited
- Very high treatment capacity compared to existing plants
- Exceeds current environmental discharge limits

Refinery Effluent treatment

- Technology to handle heavily polluted streams
- Treatment of sour water & desalter water
- Heavy metal removal from effluent streams
- Spent caustic treatment and recycling

Mining

Membrane technology can be used in a wide variety of mining applications, including the fractionation of pregnant leach solutions (PLS) in hydrometallurgical leaching circuits, fractionation and concentration of metals and acids in refineries, as well as water balance management and wastewater treatment.

Membranes have been developed that will purify, fractionate or concentrate copper,

zinc, nickel, uranium, gold or silver. Applications have been developed across the pH spectrum from 0 to 14. Membrane systems have been constructed that operate on feed streams from 200° C to 3000 centipoise. Membrane systems have treated slurries containing up to 60 wt% solids. Membrane processes have also been developed and tested to successfully purify solvents, like LIX.

Membrane technology can be used to separate metals from large volume leach mining solutions containing copper, zinc, iron, nickel, gold or silver. Incorporating membrane technologies into current mining operations has the potential to increase production because the membrane technology can be used to pre-concentrate leach solutions, and increase utilisation of existing extraction and refinery capabilities.

Membrane technologies are ideally suited to fractionations that add value to processing fluids from refineries like separating metals from acids or concentrating acids and producing high quality process fluids. Because of the unique selectivity of membranes, permeate streams can be produced containing purified acid free of metals or purified high pH cyanide solution free of metal impurities like copper.

Environmental applications of membrane technology ranges from treating Acid Mine Drainage (AMD) to cost effectively meet surface discharge standards, management of process plant water balances, and treatment of process wastewaters to recover heavy metals and/or reagents while also producing clean water which can be discharged to the environment.

Eco Technol has broad experience in the application of membrane technology covering the development of processes and treatment plants which improve process yields and operating profits as well as reducing environmental impact.

Eco Technol has developed a number of specific processes for the mining industry, including:

Cyanide Recovery Process

The Eco Technol process offers a cost effective and environmentally friendly means of extracting gold using a conventional cyanide leaching circuit. It is especially effective for treating those gold ore bodies which have previously been considered uneconomic because of high concentrations of cyanide soluble base metals. There are added benefits including: recovering and selling the cyanide-soluble base metals (copper, zinc, nickel, etc); recovering additional gold; minimising environmental issues associated with using cyanide by recovering and reusing the cyanide back in the process, reducing cyanide consumption, reducing chemicals required for cyanide destruction, reducing transport of chemicals to site; and discharging water which meets environmental and health regulation standards.

[Download Eco Technol Cyanide Recovery Brochure here](#)

Spent Acid Recovery

Eco Technol can separate and recover leach acid from hydrometallurgical operations. Benefits include: reduced lime consumption for neutralisation; concentrated metal fractions allowing reduction in equipment size in downstream extraction/purification processes; effluent can be treated to recover acid, metals and recycle water producing discharge meeting environmental regulations

Acid Mine Drainage

Eco Technol can treat environmentally sensitive waste streams from mining operations allowing recovery of metals (Cu, Ni, Zn, etc) as well as producing a treated effluent which meets environmental discharge regulations. The Eco Technol process incorporates special treatment steps for dealing with high scaling environments, eg gypsum. Depending on solution compositions up to 90% water recovery can be achieved and lime reductions between 50-90% compared to conventional treatment processes

Caustic Recovery

Eco Technol can provide systems to recover caustic and sodium aluminate from Bayer process streams, with resultant benefits of reducing caustic consumption, increasing alumina recovery, reuse of water and minimising losses from the process

Further examples of Eco Technol's applications include:

- Acid recovery and purification – Sulfuric/Hydrochloric/Hydrofluoric/Nitric/Phosphoric
- Alkaline recovery and purification – Caustic/Potassium Hydroxide/Cyanide
- Water balance management, including recovery and purification of water for reuse
- Removal of process contaminants/poisons to improve process yields
- Concentration of metals to improve yields in downstream processes
- Effluent treatment for recovery of metals and reagents for reuse

Additional treatment processes developed by Eco Technol include:

- Nickel Metal Hydride Battery Reclamation
- Solar Panel Reclamation

附件三、Hoerbiger America Inc.公司簡介

Hoerbiger，奧地利著名的天文學家和數學家，是 Hoerbiger 公司的創始人。他於 1894 年研製出了世界上第一個使用金屬網狀閥片作為密封元件的壓縮機氣閥，並且申請取得了該技術的專利權，並於 1895 年在奧地利維也納創立了 Hoerbiger 公司。

Hoerbiger 是全球最大的獨立從事氣體壓縮機氣閥及其他空氣及冷凍壓縮機配件研究開發和生產的企業。公司從 1895 年創立至今，已有 118 年的歷史，Hoerbiger 已成為在壓縮機技術、自動化和傳動技術 三大技術領域世界領先的跨國公司。集團公司總部設在奧地利和瑞士，在歐洲、亞洲和美洲分別設有地區總部。到 2013 年，在全球 e 各洲的國家和地區經營著一百多家獨立的生產或業務營運之子公司及代表處，全球擁有員工四千多位。其主要產品則包含：

Valve 氣閥

Ring & Packing 環與填料

HydroCOM Control System 節能控制系統

RecipCOM Monitoring System 線上控制系統

Serial Product 系列空壓機之零配件

Lubriquip 精密潤滑注油系統

Safety Product / Check Valve & EV 安全產品（逆止閥與防爆閥）

台灣霍爾比格股份有限公司是 Hoerbiger 集團於 1993 年於台灣成立之獨資分公司，進行壓縮機零配件的銷售，主要客戶涵蓋煉油、石化、化工、氣體、鋼鐵等行業。

Experience real capacity control and energy savings with HydroCOM



How much control do you really have when it comes to capacity control?

You have many options available to you for controlling capacity for your reciprocating compressor. HydroCOM, however, achieves best results in terms of speed, energy savings and accuracy.

Some questions you should ask yourself about your existing control system:

■ **Economical aspects**

Does my control system waste energy like a bypass valve?

■ **Control range**

Does my control system have large control range for highest flexibility?
Is it efficient on all loads?

■ **Process issues**

Does my control system react quickly enough and does it precisely control all required pressure levels, flow rates or other parameters unlike step control or bypass valves?

■ **Automation requirements**

Can my control system be fully integrated into the DCS to allow remote control unlike pockets and manual operation?
Does it provide any kind of self-diagnosis functions?

■ **Environmental restrictions**

Does my system help to fulfill stringent environmental conditions unlike control-flares?

HydroCOM: A wise investment for efficient capacity control

HydroCOM is an efficient, stepless, dynamic and fully-automated control system.

It saves money due to excellent controllability and by significantly improving performance and pays for itself within a short period of time.

Is HydroCOM right for my compressor?

- **Yes, if you want to lower your energy and capital costs.**

HydroCOM capacity control follows an intelligent concept: just the required amount of gas needed is being compressed, unlike other control systems like bypass valves that recirculate compressed gas, or stepped control that compresses more gas than you need.

HydroCOM lowers capital costs of efficient multistage compressors. Capital costs of a compressor with HydroCOM are lower compared to a compressor with 50%, 75% and 100% stepped control.

- **Yes, if you want a stepless control range and stable process parameters.** Fork unloaders installed on the suc-

tion valves are actuated hydraulically resulting in a stable stepless control over a broad control range from (0) 10%* to 100%. Any capacity variation is bumpless in comparison to stepped control.

- **Yes, if you need immediate capacity control response and highest control dynamics.**

HydroCOM is very fast and precise much faster than bypass valves or variable clearance pockets. The capacity can be changed within three revolutions of the crankshaft.

- **Yes, if you want a fully automated capacity control system.**

HydroCOM interfaces to your DCS or PLC for automatic actuation. Therefore, a minimum of intervention is required for operation.

- **Yes, if you are concerned about gas flaring and complying with environmental regulations.**

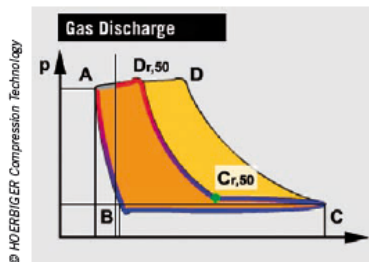
Based on the intelligent concept of HydroCOM, it reduces CO₂ emission costs since energy savings are realized. HydroCOM reduces the need for gas flaring since it only compresses the volume of gas required by the process. Thus, it reduces environmental impact and helps to comply with environmental regulations.

Proven success

HydroCOM is used in a variety of applications. Basically nearly every reciprocating compressor installation can be equipped with HydroCOM.



The heart of HydroCOM: smart actuators



How HydroCOM works:

At full load gas is compressed during the entire compression stroke.

At partload HydroCOM holds the suction valve open at the start of the compression stroke and automatically closes the valve when the desired volume of gas is in the cylinder. Only the gas required is compressed to discharge pressure.

1

Electric housing

Microprocessors inside the electric housings handle the fast and precise actuator timing. When installing the actuator only power supply and bus cables have to be electrically connected.

2

Valve housing

The valve housing is the “hydraulic heart” of the HydroCOM actuator. Oil pressure (connection on top) is applied to the hydraulic piston to push the unloader down when needed. The solenoid valve (similar to those in common rail diesel injection systems) is the fast switching element giving the HydroCOM its high dynamics.

3

Seal housing

The seal housing fits directly to the suction valve cover. It separates the oil-section of the valve housing and the gas-section of the compressor. A temperature sensor measures continuously the valve cover temperature and makes this value available for indication in the process control system. This temperature is used to monitor the condition of the suction valve.

4

HydroCOM unloader

The motion of the HydroCOM unloader is controlled by the hydraulic pressure applied in the valve housing.

5

Suction valve

The HOERBIGER plate or ring type suction valve with non-metallic sealing elements ensures long life time and best efficiency.

HydroCOM supports complete systems integration

Clear system interfaces allow easy and straight forward integration of compressor and HydroCOM.

Modular system design

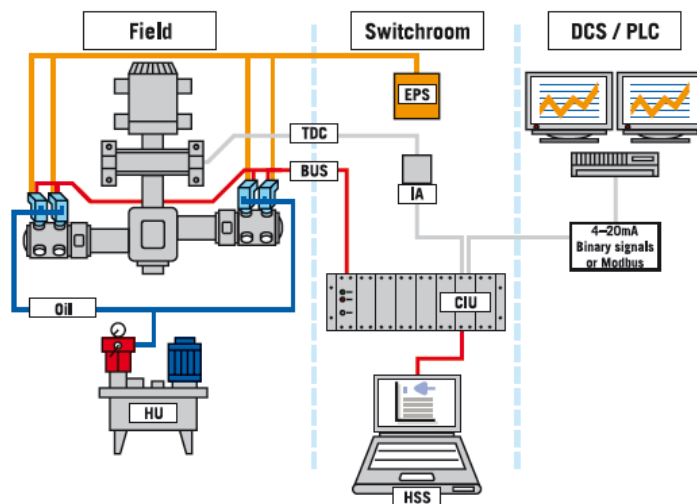
Due to its modular design HydroCOM is easy to integrate into both existing and new compressor installations. Process control tasks are implemented in a DCS or a loop controller.

In a control panel the HydroCOM "Compressor Interface Unit" (CIU) carries out data exchange between DCS and HydroCOM.

Monitoring with HydroCOM

Embedded temperature monitoring of suction valve covers allows insight into compressor conditions such as leaking valves.

Monitor and protect your compressor with RecipCOM, our machinery protection and online monitoring system. RecipCOM is certified according to IEC 61508 / 61511 and complies with API 670.



© HOERBIGER Compression Technology

HydroCOM's many success stories

Many users worldwide take advantage of the outstanding performance of HydroCOM.

Over 660 HydroCOM installations are achieving significant advantages over other systems.

HydroCOM installations are found in many industrial applications including:

- Chemical plants
- Refineries
- Gas transport and storages
- Gas turbine plants

HydroCOM's leading edge technology, optimal integration and excellent maintenance features have proven to be the ideal choice for customized process control systems.

Not only does HOERBIGER lead the way in compressor controls, it also provide local support from the largest service network in the world.



Neuman & Esser / Chemical / Chlorine electrolysis



Ariel / Gas turbine plant



Dresser Rand / Refining / Hydrodesulfurization (HDS)



Borsig / Natural gas storage



Kobelco / Refining / Residue desulfurization (RDS)



Thomassen / Refining / Hydrotreating

This compressor is the largest API machine ever built.

The benefits of HydroCOM at a glance

- ✓ Reduce energy and CO₂ emission costs
- ✓ Reduces capital costs for multistage compressors
- ✓ Control capacity with fast, stepless precision from 10%* to 100%
- ✓ Stabilize line conditions under dynamic control
- ✓ Standardised components for highest reliability
- ✓ Integrate easily into your plant control system
- ✓ Upgrade your existing compressors easily

**) depends on application*

More than 660 HydroCOMs have been successfully installed – benefit from our experience

compressor-mechatronics@hoerbiger.com

Technical data of HydroCOM		
Control range	(0...) 10*...100%	*depends on application
Max. suction pressure	160 bar / 2320 psi	
Max. suction valve temperature	120° C / 220° F	
Max. compressor speed	1200 rpm	
Suited for corrosive environment?	yes	
Suited for non-lube applications?	yes	
Suction valve	non-metallic plate or ring	
Max. number of actuators	48	
Ex-certification	EU (ATEX), US (FM), Canada (CSA), Japan	

www.hoerbiger.com



HOERBIGER
because performance counts

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HOERBIGER Compression Technology is a business unit of HOERBIGER Holding AG, Zug / Switzerland. HOERBIGER is active throughout the world as a leading player in the fields of compression technology, automation technology and drive technology. In 2009, its 6,500 employees achieved sales of 772 million Euro. The focal points of its business activities include key components and services for compressors, gas engines and turbomachines, hydraulic systems and piezo technology for vehicles and machine tools, as well as components and systems for shift and clutch operations in vehicle drive trains of all kinds. Through innovations in attractive technological niche markets, the HOERBIGER Group sets standards and delivers cutting-edge solutions for the benefit of its customers.

This product brochure contains product specifications based on research and development on the one hand and on manufacturing on the other hand. Dependent on place of installation, operating conditions and specifications, several parameters of the described product may change. Thus, Hoerbiger assumes no liability or warranty for the accuracy and completeness of information covered in this brochure.

附件四、Aspen Tech 公司簡介



Welcome Dr. Horng

CPC visit to AspenTech's Houston office

Date: November 10, 2015



Introductions



- Michael Catt, Houston, VP Global Business Consultants
- Michael Leung, Houston, VP Global Services
- James Li, Houston, Sr. Principal Business Consultant
- Jack Zhang, Boston, Product Management – Energy Management
- Hongwei (Davy) Li, Houston, Sr. Principal Consultant/Engineer (Services)

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Agenda



• Welcome and Introductions	9:45-9:55	Michael Catt
• Agenda and Meeting Objectives	9:55-10:05	Dr. Horng
• CPC Snap Shot	10:05-10:20	
• Aspen Utilities	10:20-12:00	Jack Zhang
• Lunch (brought in)	12:00-12:30	all
• Planning & Scheduling	12:30-14:00	James Li
• Aspen Advanced Process Design	14:00-14:30	Hongwei (Davy) Li
• Follow-on Action Items and Close	14:30-14:45	all

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AspenTech Company Overview

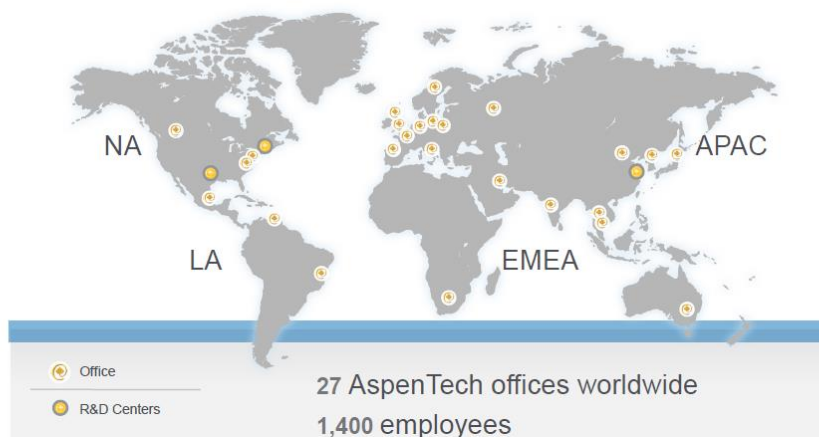
- Thirty years of technology leadership in the process manufacturing industries
- The leading provider of engineering, manufacturing and supply chain solutions
- Our mission-critical solutions enhance capital efficiency and reduce operating costs
- Blue-chip customer base of over 1,500 process industry companies rely on AspenTech to help them achieve operational excellence goals

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Global Presence



5

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AspenTech - Optimizing Process Manufacturing

Reduce costs, improve margins, increase return on capital



6

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Blue Chip Customer Base

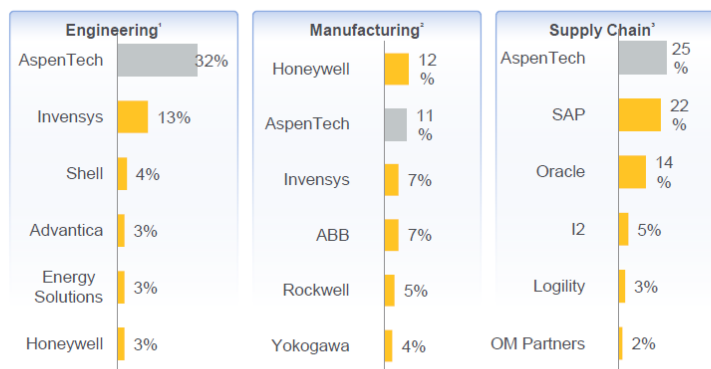


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Market Leadership



Source: ARC Advisory Group 2008, management estimates
 Note: Revenue from software licenses and maintenance, training, software configuration and customization services
 (1) Energy and Chemical Industries (2) Energy, Chemical and Pharma Industries, excluding operator training services (3) Energy, Chemicals and Pharma Industries

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A Significant Eco-System In Place

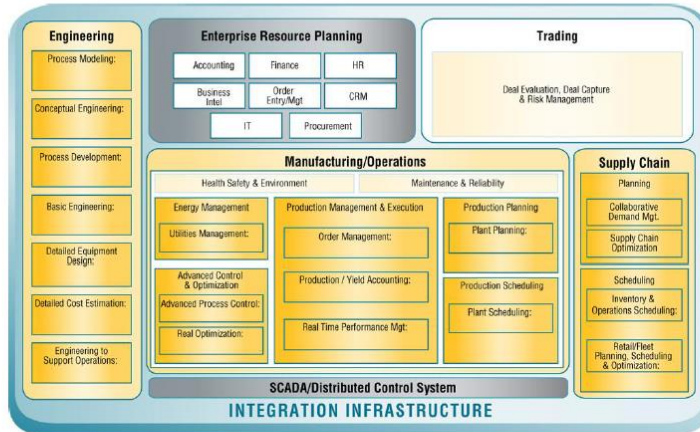
- Aspen software is used to design **70%** of all E&P / Midstream surface assets in the world
- For more than **30 years**, Aspen has been helping facilities operations achieve best in class performance by providing solutions for:
 - managing real-time data
 - optimizing hydrocarbon processes with simulation models
- Over **800** Universities and **30,000** Chemical Engineering students are exposed to AspenTech Simulation applications annually
- Over **12,000** Registered AspenTech Engineering Suite Users globally

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aspenONE Solution Map



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AspenTech Has Helped Create Value with Our Point Solutions (Basis: A 200kbpd Refining System)

AspenTech Point Solution	Individual Benefits (Dollars/Year)
Aspen HYSYS®	\$2M-\$5M
Aspen DMCplus®	\$3M-\$10M
Aspen PIMS®	\$5M-\$20M
Aspen Orion™	\$2M-\$8M
Aspen Advisor™	\$1M-\$2M
Aspen DPO™	\$2M-\$10M
Aspen Retail™	\$3M-\$5M
Total (Not Inclusive of all Point Solutions)	\$17M-\$57M

...but to achieve the highest value, business issues today require a move from point solutions to integrated solutions and their associated work processes.

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Why aspenONE Advanced Process Control

- Increase Production Rate
- Decrease energy costs
- Improve quality
- Increase yields
- Sustainable benefits at a lower cost
- Better utilization of skilled resources

Advanced Process Control
**Increases throughput,
 decreases costs and improves
 quality**

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