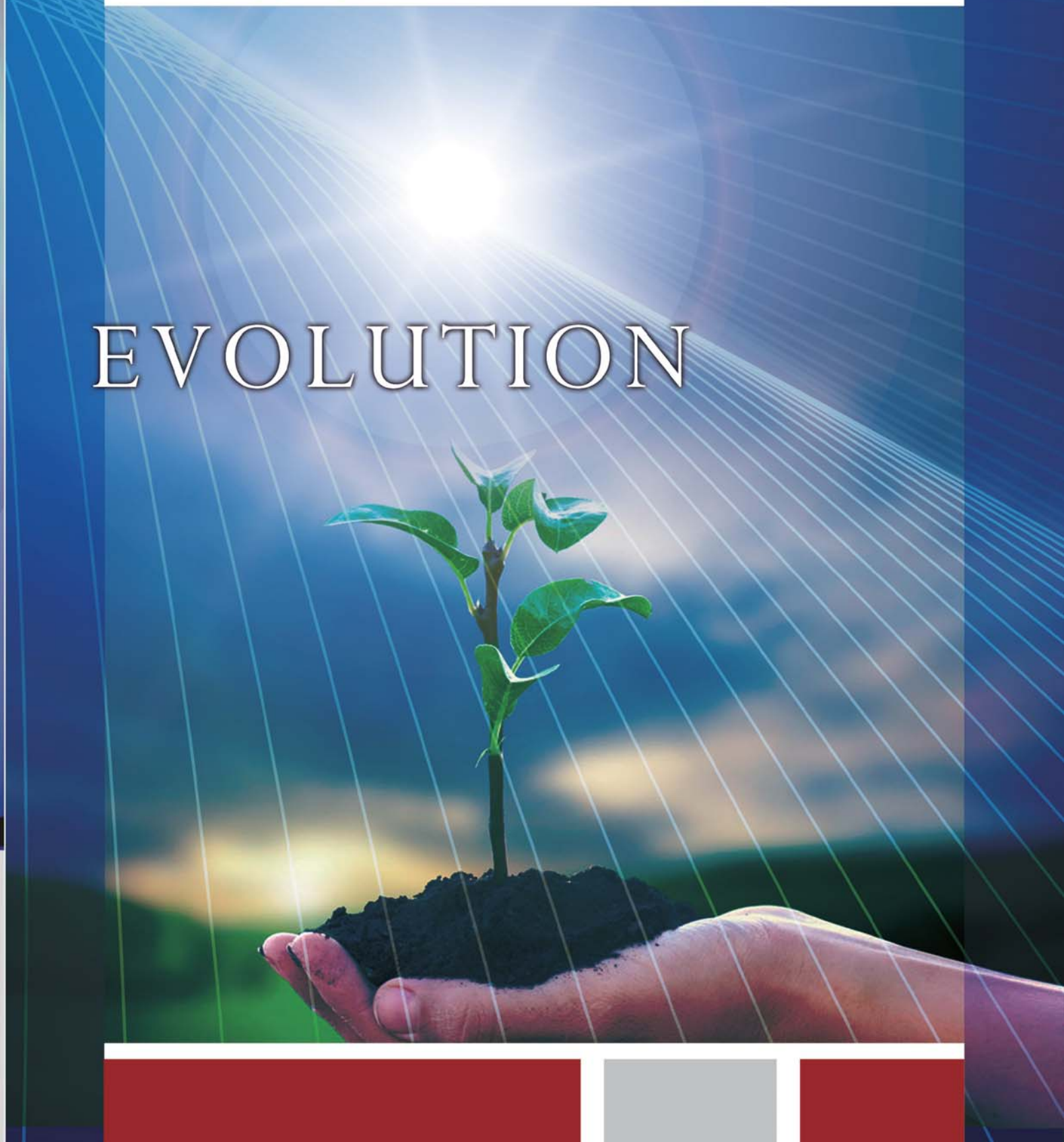
ANDERSON COMPASS

2013.10

EVOLUTION



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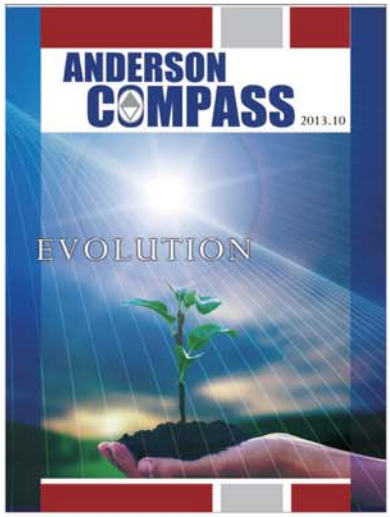

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慢 活 休 閒 LOHAS

總編輯的話 Editor's Note

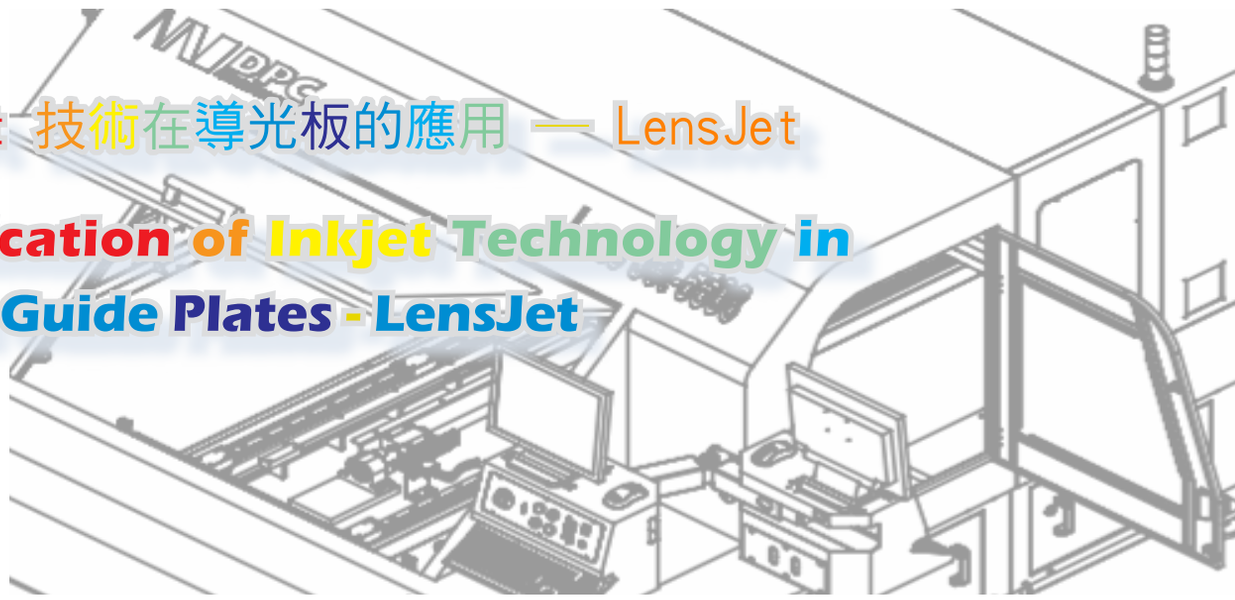
總經理 王元男 Jason Wang

無論是從產品的角度或從管理的看法，當我們要面對「蛻變」的議題時，其核心的關鍵都是「人」；只有「人」才能使產品創新、進化，只有「人」才能使管理更有效率、更有競爭。但針對這千古不變的道理，人們又經常因墨守成規、故步自封，導致企業無法迎向改變，提早在競爭淘汰的洪流中一個個的消失。這幾年在南歐所引發的全球經濟危機，其實就是在安逸下墮落的結果。安逸平穩的企業，員工總是在不自覺中喪失原本戒慎恐懼的危機意識，多數大鍋飯不想改變的心態，淹沒了滿懷雄心壯志進入職場的新血輪，轉眼間昔日「放眼天下，捨我其誰」的豪情壯志，已不知為何物;反而是「天下本無事 庸人自擾之」的消極作為變成主流價值。

本期的諸多文章，不論是技術、市場或管理，處處彰顯恩德公司企圖改變的脈動，但不可諱言，公司的想法或計劃，其成功與否的關鍵還是要有多數同仁的支持與共識。我們希望藉由本期的主題「蛻變」，喚醒哪些曾經立志想讓世界看得到以及還沒完全被安逸所腐蝕的同仁，一起攜手，一起跟隨公司改變的腳步，來改變恩德公司。

No matter whether we are thinking from a product or management perspective, when facing change, people are critical. Only people can innovate and improve the product ; only people can make the management more efficient and competitive. However, despite this this time-tested principle, people grow complacent, becoming a stick-in-the-mud, with the result that enterprises are unable to adapt and then disappear from the stream of competition, one after another, like natural selection. In recent years, the global economic crisis in southern Europe is the result of depravation after too much ease and comfort. In an easy, comfortable and stable enterprise, the employee unwittingly loses the original crisis consciousness of fear. The status quo swallows up the new blood with ambition and initiative. In the twinkling of an eye, the grand ideal of “scan the world widely, who but myself can do it?” is gone, and the negative attitude of “Never trouble trouble, until trouble troubles you!” becomes the mainstream ethos.

In several articles in this journal, Anderson Group’s pursuit of evolution is highlighted everywhere, no matter whether with regard to the technology, market or management. However, it goes without saying that the key to success for the company’s ideas and plans is the support and common sense of a majority of our colleagues. We wish to wake up those colleagues who once made up their minds to be seen by the world and who have not yet been completely devoured by ease and comfort; let us change Anderson Group together by following the changing direction of the company.



Inkjet 技術在導光板的應用 — LensJet

Application of Inkjet Technology in Light Guide Plates - LensJet

戴己二 Ryan Thay from AIC

隨著科技的日新月異，平面顯示器已經成為日常中不可或缺的產品之一，從電視、電腦、相機到智慧型手機或是平板電腦等，都包含在其應用範圍中，而薄膜電晶體液晶顯示器(Thin Film Transistor Liquid Crystal Display，TFT - LCD)為目前市場上之主流產品，其主要的結構包括了背光模組、偏光板、玻璃基板、液晶、彩色濾光玻璃、彩色濾光片等零組件(圖1)，「導光板」則是背光模組中最關鍵的零組件，其主要原因為液晶面板本身並不具有發光的特性，因此需要透過背光模組提供光源，而導光板正好是左右輝度、均勻度等最重要的組件之一，透過導光板上所具有的光學特徵，將點光源或是線光源轉換成為面光源，並將光線均勻的分散至面板的各個位置，達到提供光源之目的。

導光板主要原料為壓克力(PMMA)、聚碳酸樹酯(PC)或新世代工程塑膠(COC)，目前則以壓克力(PMMA)為主流產品，在製程的部份主要可分為印刷式導光版、非印刷式導光版以及擴散式導光版三種主要製程。印刷式導光版主要是透過網版印刷的方式將二氧化鈦或二氧化矽這類具有高散射效果的材料印刷於導光板表面，藉由不同的光學佈點方式所形成的光學特徵，讓光線能夠在導光板內部傳播，使光源能夠均勻的分布於板材上的各個位置，此方式雖然具有快速生產的優勢，但也因為需先經過製版的動作，因此整體的製程時間會較長。非印刷式的導光板主要是透過銑削、鉋削、蝕刻或是壓模等方式設計出具有幾何圖型的模具，經過射出成型機將這些特徵轉移至導光板上，因此能夠直接產出具有光學特徵的導光板，此方式雖然也具有快速生產的優勢，但也因需針對模具進行開發，因此前製的成本會較高。擴散式導光板則是直接於材料中加入不同成

As technology advances, flat panel displays (FPD) have become an integral part of everyday electronics products. Televisions, computers, cameras, smart phones, and tablet PCs are all included in their scope of application. Thin film transistor liquid crystal display (TFT-LCD) is the mainstream product in the current market; its main structure comprises component parts such as backlight modules, polarizers, glass substrates, liquid crystal, color filter glasses, color filters and so on (as shown in Figure 1). The “light guide plate (LGP)” is the most crucial component of the backlight module. The main reason is that the LCD panel itself does not produce luminance and so requires a backlight module to act as a light source. The LGP is one of the most important components for controlring the brightness and evenness ratio of the

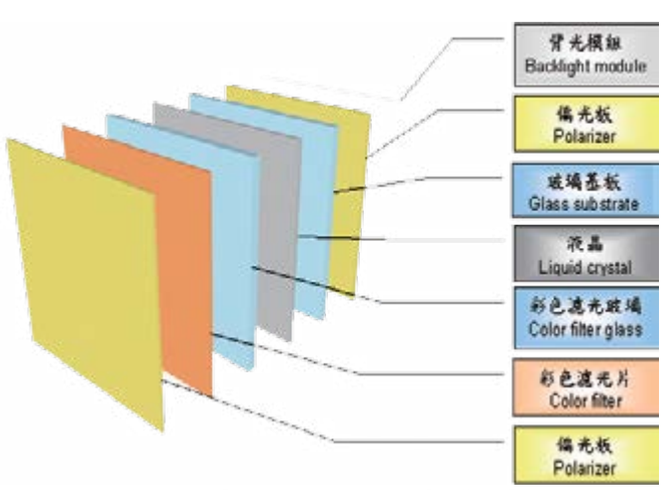


Figure 1 Component Parts of TFT-LCD

份的高分子聚合物，讓導光板內部因有不同折射率的材料進而引發光漫射的現象，但此一技術尚未成熟且均齊性不易調整，目前此技術仍尚未普及。

而為了在導光板的製程上能有所創新與突破，恩德嘗試將Inkjet的技術導入導光板的製程中，透過數位噴印的方式將特殊墨水噴印於導光板表面進而形成微透鏡，並藉由這些微透鏡影響光的折射，達到讓光線均勻分布於導光板各處的目的。Inkjet技術在此製程上的應用可以彌補過去製程的缺點，例如前期製版所需耗費的大量時間及成本、修改光學設計所耗費的時間，也因數位噴印的關係，工程師可針對光學佈點的結果進行快速的調整，因此整體的製程時間可由原本所需的6~7周縮短為2天左右(圖2)，加速了產品上線量產的時間。

illumination. With the optical properties of an LGP, point light or line light is transformed into area light, evenly spreading the light to each part of the plate, thus achieving the purpose of providing a light source.

The primary materials used for LGPs is acrylic (PMMA), polycarbonate resin (PC) or cyclic olefin copolymer (COC), with acrylic (PMMA) as the most widely used. The production process of LGPs can be divided into three primary types, printed LGPs, non-printed LGPs and diffusion. Printed LGP processing utilizes screen printing to print material that has a high scattering effect, such as titanium dioxide or silicon dioxide, on the surface of the LGP. With the optical properties produced by different optical dot distributions, light scatters inside the LGP and evenly distributes to each part

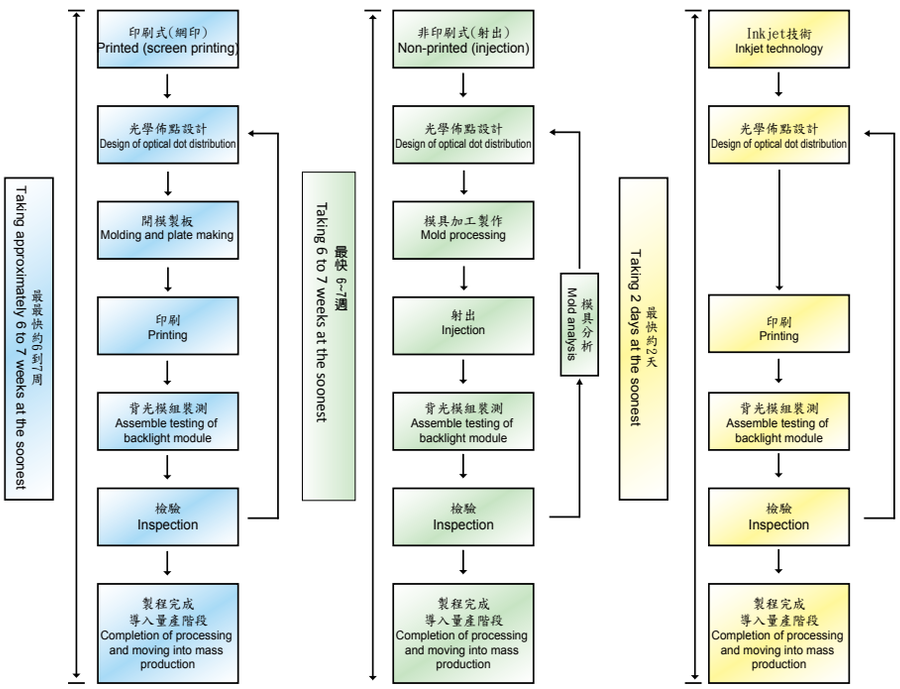


圖2 導光板製程差異比較 Fig. 2 Comparison of Different Kinds of LGP Processing

傳統導光板的材料厚度約為4mm左右，多以射出、網印等為主要製作方式，而17吋以下的導光板材料厚度則為1~2mm左右，一些高階的產品像是筆電或是平板電腦等甚至已要求使用到0.55mm的導光板。可預見的是未來平面顯示器的走向勢必朝更輕更薄的目標前進，在此情況下傳統的非印刷(射出等)製程會面臨到材料翹曲、噴痕、溢料或是毛邊等瓶頸而無法突破，而印刷(網版)製程的方式則會因點徑的尺寸無法再變小或是光學佈點的均勻性等問題而

of the plate. Although this process has the advantage of fast production, the plate must be made before processing, so the overall processing time is actually longer. Non-printed LGP processing mainly uses milling, planing, etching or die molding to design and produce geometric-patterned molds. These specially designed features are transferred onto an LGP through injection molding machines, and therefore the LGPs possess optical properties. Even though this approach also has the advantage of fast production, molds require pre-processing and the cost for developing molds is comparatively

無法提升導光板的輝度，因此inkjet技術所具有的優勢正好可以針對現有製程所產生的問題，提供一個完善的解決方案(表1)。

製程技術	生產方式	優點	缺點
印刷式	將射出成型後的導光板，透過網版印刷的方式將光學特徵轉印至導光板表面。	開發成本低 產能高	前置時間長 網印點徑較大 光學變更耗時
非印刷式	利用精密模具技術，設計出具有光學特徵之模具，再透過射出成型機射出導光板。	減少導光板製程 產能高	前置時間長 光學變更耗時
擴散式	直接將高分子聚合物加入壓克力材料內，使其因密度不同而達到光漫射的效果。	光利用率高 製造方便	技術尚未成熟 均齊性不易調整
Inkjet 技術	透過光學佈點軟體將座標資料轉出至LensJet，再用inkjet技術將資料噴印於導光板表面進而形成光學特徵。	無需製版 墨滴點徑小 光學改版快速 產線易彈性調整	導光板需前製程處理 產能低於網印與射出方式

表1 導光板製程優缺點比較表

恩德針對導光板製程所開發的微透鏡噴墨機—LensJet，主要是將過去累積多年的彩色噴繪機製造經驗與inkjet相關技術移植至此機台，並透過強化機台結構與提升機台精度等方式，來達到導光板製程所需要的高精度標準。在機台結構部份，從組裝階段開始便設定了嚴苛的誤差容許範圍，包括各組件的平面度、垂直度、直線度及平行度等皆需不斷的進行細部的調整與修正，以確保機台完成後仍保有高水準的精度表現。在噴繪系統的部份，目前LensJet使用墨滴大小10pl的噴頭，並透過噴頭錯位排列的方式可提供300dpi及400dpi的噴印架構，而噴印解析度可依光學佈點的設計方式以及光源的入光方式而進行調整。未來也會嘗試使用更小墨滴規格的噴頭，除了滿足市場上對於導光板輝度上的要求外，也希望可以透過不同的噴頭類型滿足市場上多樣化的導光板應用。

LensJet噴印範圍為1,240mmx710mm，從小尺寸的手機面板到55吋的大型電視螢幕用導光板皆可進行噴印，而也因為數位噴印所具有的優勢，讓產線上的排程更具有彈性，不同的尺寸的訂單不再需要耗費冗長的時間進行製版、測試與調整，而僅需要透過光學佈點的改變即可達到不同尺寸所需要的光學特徵，除

higher. Diffusion processing directly adds different components of polymers into the materials of the LGP, triggering light diffusion because different materials have different refractive indexes. However, the technology is not yet mature and homogeneity is difficult to achieve; thus the technology is not yet universal.

Seeking an innovative breakthrough in current LGP processing, we are trying to apply inkjet technology to the process. Using digital inkjet printing technology, inks are printed on the surface of the LGPs and thus form a micro lens; these micro lenses affect light refraction, achieving the goal of distributing light evenly on the LGP. Application of inkjet technology to this process can make up for past shortcomings, such as the large amount of time and cost required for making plates, or the time needed for optical design and adjustment of previous processing. Digital inkjet printing also allows engineers to proceed with quick adjustments based on the resulting optical dot distribution; therefore the overall processing time can be shortened from the original six to seven weeks to around two days (as shown in Figure 2). This greatly speeds up the time for products to be ready for mass production.

The thickness of traditional LGP material, mainly produced by injection or screen-printing processing, is approximately 4mm. The thickness of the material for a 17'' or smaller LGP is approximately 1 to 2 mm. Some high-end products such as notebooks or tablet PCs even require an LGP of 0.55 mm. It is foreseeable that the future trend of FPDs is for them to become lighter and thinner; in this case, the traditional non-printed (injection) processing will face the bottlenecks related to material warping, jetting, overflow or flash. As for printed (screen printing) processing, issues such as difficulty further reducing the size of spot diameter and homogeneity of optical dot distribution hinder efforts to enhance the brightness of LGPs. Inkjet technology has the exact advantages for overcoming problems with current processes and provides a complete solution (refer to Table 1).

了免去傳統製版所需耗費的時間與成本外，也能夠提升機台的生產效益。目前LensJet已研發至第二代機種，除了保有機台原本的特性外，也另外新增噴頭獨立溫度控制系統以及防撞機構。獨立溫控系統的目的除了是希望減少噴頭預熱所耗費的時間外，也避免在長時間的溫度變化下因熱漲冷縮所產生的變形。而防撞機構則是為了避免噴印過程中材料產生翹曲的現象，或是因人為作業疏忽所產生的噴印條件設定錯誤，則此安全機制會自動啟動並保護噴頭。在工作檯面的設計上則可進行客制化的修改，像是真空吸著孔徑的大小、位置、型式甚至是真空區域的劃分等，皆可依客戶的使用習慣或是治具的尺寸進行設計。另外包括供墨系統、負壓系統以

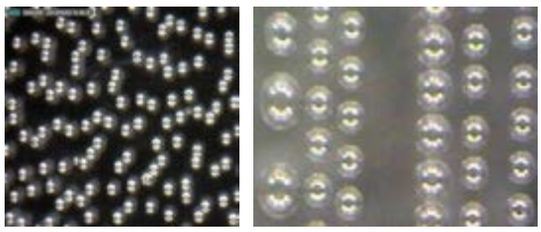


圖3 Lens於導光板上之噴印結果
Fig.3 Printing Result of the Lens on an LGP

及電子電路系統等，在二代機的部份也進行了小幅度的設計變更與韌體升級，除了希望能夠持續提升機台的穩定性與良率外，也能夠將inkjet技術普及於市場，並掌握此核心技術。

未來導光板在市場上的趨勢必然會朝向更輕更薄的方向前進，inkjet技術的導入無非是希望針對現有製程所無法突破的困境提供更佳的解決方案，儘管目前此製程技術尚未普及於市場，但恩德仍希望透過對inkjet技術不斷的投入並拉攏市場上導光板製造的領導廠商使用此一技術，展現LensJet本身所具有的優勢，並期望能夠滿足未來市場上對於更小的透鏡點徑、更高的產能以及良率提升的嚴苛要求。

Processing Technology	Method of Production	Advantages	Disadvantages
printed	Screen printing to transfer optical properties onto the surface of injection molded LGPs	Low development cost High productivity	Long lead-time point diameter is larger for screen printing Optical change is time-consuming
Non-printed	Using precision mold technology to design molds with optical properties and then injecting an LGP via injection molding machines.	Reducing LGP processing High productivity	Long lead-time Optical change is time-consuming
Diffusion	Directly adding polymers to acrylic material so that an LGP produces a light-diffusing effect due to different densities	High light utilization Ease of manufacture	Technology is not yet mature Homogeneity is difficult to adjust
Inkjet technology	Coordination data is transferred onto LensJet via optical dot distribution software; then information is further printed onto the surface of an LGP via inkjet technology to form optical properties.	Requiring no plate making Small diameter of ink droplets Quick optical revision Flexible production line adjustment	Requiring pre-processing of LGP Productivity is less than that of screen printing and injection

Table 1 Comparison Table of Pros and Cons of Different Kinds of LGP Processing

LensJet, the micro lens inkjet machine we developed for LGP processing, is a product of our years of accumulated experience manufacturing color inkjet printers and inkjet-related technology. The high standard of precision required for LGP processing attained by strengthening the machine structure and enhancing the precision of the machines. To ensure that the machine retains its high precision performance, we set stringent error tolerance range for the machine structure in the assembly stage; planeness, perpendicularity, straightness and parallelism of each compartment are constantly adjusted and modified. Our current LensJet inkjet system utilizes nozzles for ink droplets of 10pl and provides 300 dpi and 400 dpi inkjet printing via staggered arrangement of the nozzles. The inkjet printing resolution can be adjusted by the design of optical dot distribution and the way the light entering from the light source. In the future, we will try to adapt nozzles to produce ink droplets of smaller sizes. In addition, to meet market requirements of LGP brightness, we hope we can satisfy the requirements for diverse LGP applications using nozzles of different sizes.

The printing range of LensJet is 1,240mm x 710mm and thus it is applicable for products from small-sized mobile phone panels to LGPs for 55” TV screens. The production line schedule can be more flexible because of the advantages of digital inkjet printing; orders for LGPs of different sizes no longer require long lead-time for making plates, testing and tuning, and merely require changing the optical dot distribution to attain the demanded optical properties for different LGP sizes. In addition to eliminating the time and cost of traditional plate making, the production efficiency of the machines is enhanced. Currently LensJet has been developed into a second-generation model. In addition to the original features, a nozzle-independent temperature control system and collision prevention structure are added. The purpose of the independent temperature control system is to reduce the time required for nozzle preheating and prevent deforming of the nozzle due to thermal expansion and contraction due to long-term temperature changes. The collision prevention structure prevents material from warping during the printing process; also, when there is a printing setting error due to human negligence during operation, the collision prevention mechanism automatically activates and protects the nozzle. The design of the working platform, such as the size, location, and type of vacuum absorption opening, or even the division of the vacuum area, can be customized in accordance with the customer’s work practices or the size of fixtures. Moreover, the ink supply system, negative pressure system, and electrical circuit system of the second-generation model are slightly modified and the firmware has been upgraded. In addition to constantly enhancing the stability and yield rate of the machine, we hope to make inkjet technology universal in the market and to master this core technology.

The future trend in LGPs is clearly lighter and thinner ones. The introduction of inject technology provides a better solution for overcoming the bottlenecks of the current production processes. Although this production technology is currently not yet popular in the market, we hope that through continuous improvement in inkjet technology, we will draw leading manufacturers of LGPs to use the inkjet process. Eventually, the advantages of LensJet will become evident and we expect to be able to meet stringent requirements for smaller lens diameter, higher productivity and yield enhancement that we expect to see in the future market.

如何達成平台式噴繪機噴印精度達到小於0.1mm的絕對誤差

Attaining Less Than 0.1 mm Absolute Deviation Printing Precision for Flatbed Inkjet Printer

紀明昇 Ming-Sheng Chi from AIC
陳博勳 Po-Hsun Chen from AIC

前言

平台式噴繪機可經由噴印車在工件上來回的相對運動以完成工件的噴印加工；因此要達成準確的噴印精度，除了平台的定位機構以及台面真空吸著系統外，噴印車穩定的移動速度，乃是決定噴印品質的重要因素。由於噴墨頭的設計，通常是以固定的發射頻率進行油墨噴射的動作，因此噴印車的移動速度，必需滿足噴墨頭發射頻率以及噴印解析度之設定。在目前市面上的噴墨頭中，以6pl、14pl及42pl為常見的設計規格，其相對應之解析度分別為1440dpi、720dpi及360dpi，因此若選用14pl之噴墨頭，該噴墨頭在正常應用下，其噴印解析度即為720dpi，若該噴墨頭設定之噴射頻率為12.8KHz，則噴印車水平的移動速度必需接近於 451mm/s，才可滿足噴印解析度720dpi之噴印需求。

一般噴印車的傳動系統，可藉由伺服馬達控制系統加以實現，其傳動方式可經由馬達藉著齒輪帶動皮帶，皮帶再拉動噴印車，使噴印車在軌道上直線運動。然而伺服馬達帶動皮帶的傳動方式，在平台式定位的架構下，其精準度無法滿足精密機械加工的應用需求，因此利用外加光學尺達成精密量測定位是常見的設計方法。為達成所需要之噴印精度，可藉由光學尺編碼器取得噴印車相對位置的回授訊號，同時產生噴射信號給噴頭噴印墨水，如此即可達成高精度噴繪機的實現。

Introduction

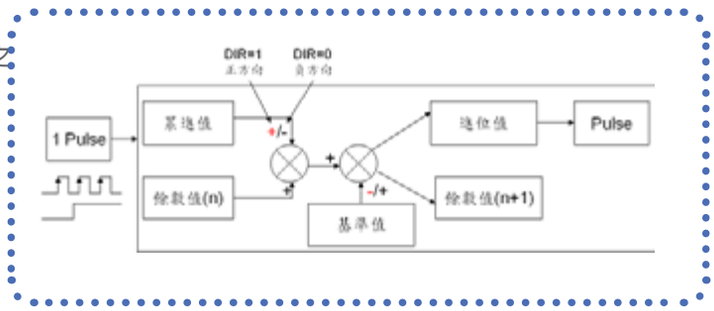
A flatbed inkjet printer completes a print through the jetting process via back and forth relative movement of the carriage over the item being printing. To achieve jetting precision, the platform positioning mechanism and ,table vacuum system, and steady moving speed of the carriage are all important factor that determine the printing quality. Since printing heads are designed to jetting at fixed jetting frequency, the moving speed of the carriage must satisfy the settings for printing heads jetting frequency and printing resolution. Among the printing heads in the current market, the common design specifications are 6pl, 14pl and 42pl, with corresponding resolutions of 1440 dpi, 720 dpi and 360 dpi. Therefore, if one chooses the14pl print head for normal applications, the printing resolution will be 720dpi. When the jetting frequency of the print head is set to 12.8 KHz jetting frequency, to achieve 720 dpi printing resolution, the horizontal moving speed of the inkjet vehicle must be close to 451 mm/s.

Generally,print carriage is driven by servo motor controlled system that drives pulley and belt to move the carriage on linear guide rails to perform lateral movements. The accuracy of motor-driven belt transmission under platform-type positioning usually cannot meet the requirements for precision printing. Thus, the use of an external linear scale to attain precise positioning is a common design approach. In order to achieve the levels of printing precision required for a high-precision inkjet printer, the linear scale encoder can be used to obtain feedback signal of the carriage relative positions, threrefore system generates signals for the nozzle to jet out ink.

控制演算法

恩德的噴印車是透過皮帶拉動，皮帶具有傳動平穩、無噪音等優點，但也容易發生打滑、伸縮，造成精度不易控制的缺點。因此恩德在橫梁上外加單位為1μm的光學尺，再經由下列演算法將訊號換算成符合720dpi解析度的觸發訊號。其產生方式是藉由一計數器，於光學尺編碼器每回授一次觸發信號時，將該計數器累加一次設定之累進值，直到發生溢位時即產生噴射信號。

1. 基準值設定為10000000
2. 累進值設定為283465



透過此演算法，在噴印距離為1000mm時，所產生之噴印誤差計算如下：

Standard Pitch(720dpi下理想的佈點間距)

(25.4÷720)×1000=35.277777778μm

Trigger Pitch(此演算法計算後的佈點間距)

10000000÷283465=35.27772μm

1000mm Jetting counter(一公尺所需佈點數)

int(1000000÷35.277777778)=28346

噴印距離

(28346×35.27772μm)÷1000=999.98mm

噴印誤差

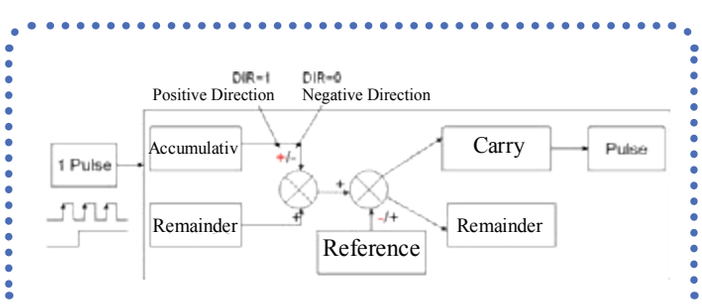
999.98-1000=-0.02mm

由上述可知，使用單位為1μm的光學尺，在此控制方法下，可達成噴印精度小於0.1mm絕對誤差的目標，即使光學尺在安裝上造成誤差，亦可藉由調整累進值加以修正。

Control algorithm

The Anderson printing vehicle is driven by a belt. The belt has the advantage of smooth transmission and low noise, but the slipperiness, contraction and expansion problems which lead to precision control difficulty are its weak points. Anderson adds a 1μm spec optical linear scale on the gantry. Through an algorithm, as shown below, it converts signals into 720 dpi-resolution trigger signals. It generates these through a counter. Each time the linear scale encoder feeds back a trigger signal, the counter increments its preset accumulative value until overflow occurs and an inkjet signal is generated..

1. Reference value is set to 10,000,000.
2. Accumulative value is set to 283,465.



Through this algorithm, for a jet printing distance of 1,000 mm, the generated printing deviation is calculated as follows:

Standard Pitch (ideal point spacing for 720 dpi)

(25.4÷720) × 1000 = 35.277777778μm

Trigger Pitch (point spacing after algorithm calculation)

10,000,000 ÷ 283,465 = 35.27772μm

1,000 mm Jetting counter (required points in 1 meter)

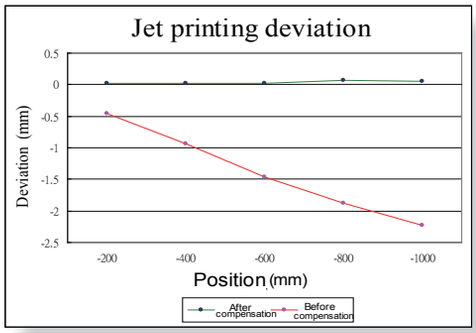
int (1,000,000 ÷ 35.277777778) = 28,346

Jet printing distance

(28,346×35.27772μm) ÷1,000 = 999.98mm

Jet printing deviation

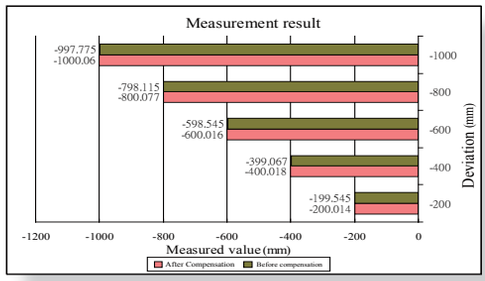
999.98-1,000=-0.02 mm



From the above, through using a 1μm spec optical linear scale and this method of control, we can achieve the target for jet printing precision of absolute deviation less than 0.1mm. Even if the installation of a linear scale causes error, it can be corrected by adjusting the accumulative value.

測試與討論

本實驗噴印一1×5的方塊圖，每個方塊間隔200mm，利用CCD對位，並使用雷射干涉儀測量方塊間隔，其測量結果顯示，每個方塊間隔與期望值200mm相差約0.445mm，噴印1000mm所累積之誤差為2.225mm。藉由調整累進值，修正每次佈點之間距，使噴印1000mm之後可補償2.225mm之累積誤差，利用雷射干涉儀測量每200mm之噴印誤差如圖所示。



Testing and Discussion

This experiment printed a 1 × 5 box diagram. The spacing of each box was nominally 200 mm, using CCD alignment and laser interferometer to measure the box intervals. The measurement results showed that the difference between box spacing and the expected value of 200 mm was approximately 0.445 mm. The accumulated deviation of 1,000 mm printing was 2.225 mm. We compensated for the accumulative 2.225 mm deviation of 1,000 mm printing by adjusting for the accumulative values and correcting the point spacing. The 200 mm printing errors via laser interferometer measurements are shown in the figures.

結論

本計畫以累進的方式將原本單位為1μm的光學尺換算成720dpi解析度的觸發訊號，且透過調整累進值可改善光學尺在安裝上造成的誤差，從實驗結果可看出在未補償前每200mm誤差約為0.445mm，補償後每200mm誤差可降至0.1mm以下。此精度之噴繪機型搭配抗侵蝕墨水噴印在製作蝕刻製程用的鋼鈑上，經蝕刻後所留下的圖形配合AEC(Anderson Europe GmbH)生產的高精密CNC雕刻機，將可加工成具有高優質刀鋒的刀模。

Conclusion

This project used an accumulative method to convert a 1μm-unit linear scale into 720 dpi resolution trigger signals; and improved the errors in installation via adjustment of nominal accumulative values. The experimental results showed that prior to compensation, the deviation was about 0.445 mm per 200 mm. The deviation could be reduced to less than 0.1 mm per 200 mm after compensation. Incorporating anti-erosion ink, this precision inkjet model printed on steel sheets for the etching process.Through the use of high precision CNC engraving machines manufactured by AEC (Anderson Europe GmbH), the graphics remaining after etching would be processed into dies with high quality cutlery blades.

幾何誤差補償研究
RESEARCH ON GEOMETRIC ERROR COMPENSATION

李明哲 Tommy Lee from AIC

前言

由於產業的進步趨勢，製造業對精度的要求也日漸提高，對於CNC機台的應用越來越廣泛。而零件的加工精度主要取決於機台本身的精度，所以若能提高機台的精度也就能提高加工工件的精度。有關提高機台精度的方法基本上可分誤差預防及誤差補償的兩種做法，誤差預防即提高機台零件精度、組裝精度方式進行，以減少機台誤差量；誤差補償依即時性則可分為離線量測後補償及線上量測補償（如熱誤差、切削力），本文將對機台的誤差種類進行大致介紹，並對目前商用控制器所能提供的誤差補償功能進行概述。

機台誤差討論

一部CNC機台其誤差大致可分準靜態誤差、動態誤差及工件與刀具誤差。準靜態誤差又包含了幾何誤差、運動誤差、熱誤差、重力造成的誤差等。動態誤差包含了機台結構震動、主軸偏擺、控制器誤差等。工件與刀具誤差包含了夾具誤差、工件挾持變形、刀具磨耗誤差等。以誤差補償的觀點來看唯有穩定可預測的誤差才能以低成本的方式進行補償，對隨機不可預測的誤差則無法進行有效誤差補償。在諸多的誤差中，幾何誤差屬於穩定可被量測者且其佔總誤差量不小的比例，其可先行進行離線誤差值量測，故是各家控制器廠商優先處理的誤差補償項。

依據ISO230規劃，幾何誤差依其特性可分為兩類，一為位置誤差(Location Error)及元件誤差(Component Error)，其定義如下：

位置誤差(Location Error)為不隨元件移動而改變的誤差，即各部件組裝完成則已確定。元件誤差(Component Error)則隨著元件位置不同而有所不同的誤差，即表現運動元件之全行程誤差狀態。

Preface

With progress in the industry, manufacturers have also gradually enhanced their accuracy requirements and the application of CNC machines is increasingly extensive. The accuracy of parts produced mainly depends on the accuracy of the machine itself. Therefore, once the precision of the machine improves, the accuracy of the products made can also be increased. Basically there are two practices for enhancing the accuracy of a machine; they are error prevention and error compensation. Error prevention involves enhancing the accuracy of the machine parts and assembly precision in order to reduce the amount of error of a machine. Error compensation can be divided into compensation after offline measurement and online measurement compensation (such as thermal error and cutting force) instantaneously. This paper will roughly introduce the types of errors associated with machines and summarize the error compensation functions provided by current commercial controllers.

Discussion of Machine Error

The errors of a CNC machine can be divided into several types: quasi-static errors, dynamic errors and workpiece and tool errors. Quasi-static error includes geometric error, motion error, thermal error and error caused by gravity. Dynamic error includes

位置誤差　　元件誤差

A0Y　　EYZ

誤差方向　軸線方向　　誤差方向　軸線方向

一直線軸的元件誤差(Component Error)可表達為1項位置偏差(EXX)、2項直線偏差(EYX,EZX)及3項角度誤差(EBX Pitch,ECX Yaw,EAX Roll)，所以XYZ三軸的狀況下共有18項元件誤差，再加上位置誤差(Location Error)，即三軸系間的3項直角度誤差 (A0Y,B0Z,C0Y)共有21項誤差。另在五軸機的情況下，一旋轉軸會包含五項位置誤差(X0C,Y0C,A0C,B0C,C0C)及6項元件誤差(EXC,EYC,EZC,EAC,EBC,ECC)，所以基本上一部五軸CNC機台共有43項幾何誤差。對於設備製造商的巨大挑戰便是如何將誤差來源加以量測且拆解分析，最後補入相對應之補正參數。而控制器廠商則是如何發展有效的補償運算法，即時將補償量算出並修正加工路徑。

有關不同誤差項，需使用適合的量測設備，再配合適當的量測方式規劃，才能將該單項誤差量出。由於量測設備種類繁多，在此不對此議題進行太多探討。但目前較常使用於位置偏差(Position error of linear motion)量測的儀器雷射干涉儀；直線偏差(Straightness error

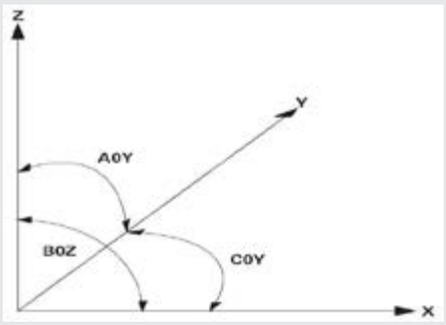


Fig. 1 直線軸位置誤差 Location Error of Linear Axis

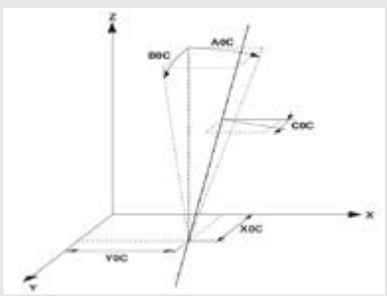


Fig. 3 旋轉軸位置誤差
Location Error of Rotation Axis

the structure vibration of the machine, spindle tilt and controller error. Workpiece and tool error includes errors of fixture, clamping deformation of the workpiece and tool-wear error. Error compensation can only be accomplished in a low-cost way in the case of stable and predictable errors. Effective error compensation cannot be done against stochastic and unpredictable errors. Of the many possible errors, geometric error is stable and predicable and accounts for a significant percentage of the total error amount. As it can be addressed by offline measurement of the error amount in advance, it is the error compensation each controller vendor handles preferentially.

According to the ISO230 planning, geometric errors can be divided into two types according to their characteristics. One is location errors and one is component errors, with the definitions below.

Location Error　　Component Error

A0Y　　EYZ

Direction of Error　Axial Direction　　Direction of Error　Axial Direction

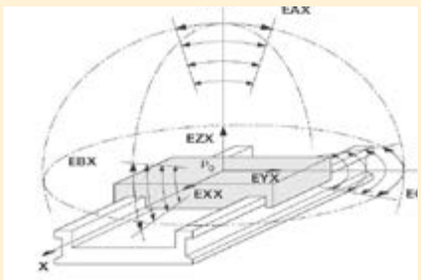


Fig. 2 直線軸元件誤差 Component Error of Linear Axis

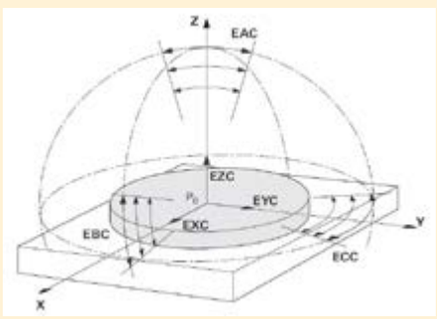


Fig. 4 旋轉軸元件誤差
Component Error of RotationAxis)

of linear motion)有雷射干涉儀、自動視準儀；角度誤差(Angle error of linear motion)有電子水平儀、雷射干涉儀、自動視準儀等。有關旋轉軸的誤差量測則有R-test、雷射干涉儀加角度模組等。另由於技術的進步目前使用Laser Tracer進行空間誤差的量測方式，也日趨常見

Fig.5 RENISHAW XL80
雷射干涉儀
RENISHAW XL80
Laser Interferometer

Fig.6 FARO Laser Tracer

控制器補償功能簡介

如控制器廠商重複提起的概念：控制器只能讓好的機器變更好但無法使壞機器真正改善。其 精神在於，若機台本身有良好的重複性則誤差補償為可行，若其不穩定則補償不可執行。另一重要觀點則是應利用機構直接修正方式將精度盡量做好，再將剩下的微小誤差量交於控制器補正。由於市面上控制器廠商眾多，現只就恩德較常使用的FANUC及SIEMENS控制器的提供幾何誤差補償功能進行介紹。

- 在三軸機台情況下，FANUC&SIEMENS提供的基本的補償項有背隙補償(Backlash compensation)&節距補償(Pitch error compensation)。另直線度補償(Straightness error compensation)為機台提高精度須嘗試的方式。
- 在五軸機台情況下，首要的為旋轉機構鍊設定及誤差量補償功能由於五軸機台的重要功能之一就是刀尖控制功能(TCP)，其基本的架構便是控制器建立機台合適旋轉機構鍊，在此同時亦將旋轉中心偏移值補入，讓機台進行補償。圖7即FANUC的示意圖。

近來一些控制器亦針對如何幫助客戶快速完成旋轉機構鍊設定議題，開發了一些整合量測功能如SIEMENS的cycle996或HEIDENHAIN cycle451，可透過執行控制器規劃的程式結合量測儀器，將設定參數計算出並自動填入。

在大型機台中，可使用空間誤差補償功能(Volumetric Error Compensation) 以克服機台大型化時所累積龐大的誤差。

其原理是使用量測儀器將機台行程空間依規劃的空

Location error is an error which will not be changed by component movement, meaning it is confirmed when the assembly of each part is done. Component error will be changed by different component location, meaning it is the expression of the full travel error status of the motion component. The component error on a linear axis can be presented by one positioning error (EXX), two straightness errors of linear motion (EYX, EZX) and three angle errors of linear motion (EBX Pitch, ECX Yaw, EAX Roll). Therefore, there are a total of 18 component errors under condition of three axes of XYZ; if the location error is added, it means there are a total of 21 errors for three angle errors (A0Y, B0Z, C0Y) among three axes. Furthermore, in the case of a five-axis machine, a rotation axis can include five location errors (X0C, Y0C, A0C, B0C, C0C) and six component errors (EXC, EYC, EZC, EAC, EBC, ECC). Therefore, there are basically a total of 43 geometric errors for a five-axis CNC machine. The grand challenge for the manufacturer is how to measure,bresk down and analyze the error source and then interpolate the corresponding compensating parameter. For controller vendors, the grand challenge is how to develop an effective method for compensating operations in order to figure out the compensation amount immediately and correct the processing path.

With regard to different error terms, it is necessary to use proper measuring instruments suited to appropriate measure planning in order to measure out the error of that single term. Since types of measuring instruments vary, we will not investigate this topic too deeply. However, the most widely used measuring instrument for identifying position error of linear motion is a laser interferometer. For straightness errors of linear motion, there are laser interferometers and auto-collimators, and for angle errors of linear motion, electronic level meters, laser interferometers and auto-collimators can be used. As to the error measurement of the rotation axis, there are R-tests, laser interferometers, angle modules and so on. Due to the improvement of technology, it is becoming increasingly common to use laser tracers in the measurement of volumetric error.

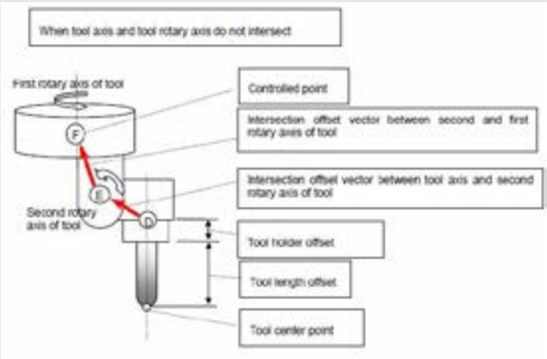


Fig. 7 FANUC龍門刀具迴轉型旋轉中心誤差補償示意
Diagram of Error Compensation of ANUC Gantry Tool Revolving Rotation Center)

間格點量出每一點的誤差值，接下將其輸入控制器補償參數表中，控制器依據行進位置參考空間格點誤差值進行補償值內插計算。其名稱於FANUC稱為3次元誤差補正(Three dimensional error compensation)，在SIEMENS稱為 VCS (Volumetric Compensation

結論

隨著技術的演進，控制器能即時處理的資料量不斷的提升，可提供補償功能也不斷的增加。如何透過對各種誤差項深入了解並進行確實可靠的量測，並透過軟性的誤差補償方式優化機台，同時也思索硬性的誤差預防方式的可行性(機械設計優化、零件及組立流程精度提升等)，以提供客戶高精度且長期穩定的機台，是做為設備供應商須面對的嚴肅課題，也是恩德集團努力不懈的目標及使命。

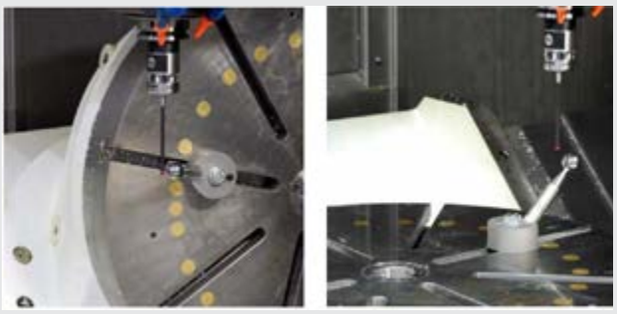


Fig 8 SIEMENS使用cycle996功能配合量測儀器進行旋轉機構設定
Rotation Mechanism Setting by SIEMENS Using cycle996 Function with Measuring Instrument

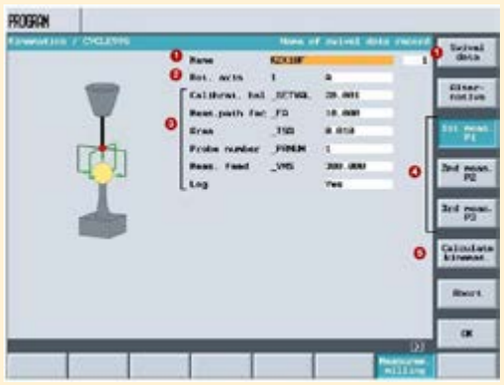


Fig.9 SIEMENS使用cycle996功能設定畫面
Setting screen of SIEMENS using cycle996 function

Introduction of Compensation Function of Controller

One concept mentioned repeatedly by controller vendors is that a controller can only enable a good machine to become better, but it cannot make a bad machine good. Essentially, if a machine itself has good repetitiveness, error compensation is workable; however, if it is unstable, compensation can not be executed. Another important viewpoint is first make the good precision well by the direct correction method of the mechanism, and the remaining minor errors can be compensated for by the controller. As there are numerous controller vendors on the market, here we are only introducing the geometric error compensation functions provided by FANUC and SIEMENS controllers commonly used by Anderson.

•In a three-axis machine, the basic types of compensation provided by FANUC and SIEMENS controllers are backlash compensation and pitch error compensation. In addition, compensation for errors of straightness is a method that should be attempted to enhance precision.

•In a five-axis machine, the setting of the rotation mechanism chain and the amount of error compensation are primary. One of the important functions of a five-axis machine is its tool center pnint control function (TCP), and its basic structure involves the controller providing an appropriate rotation mechanism chain for the machine. At the same time,

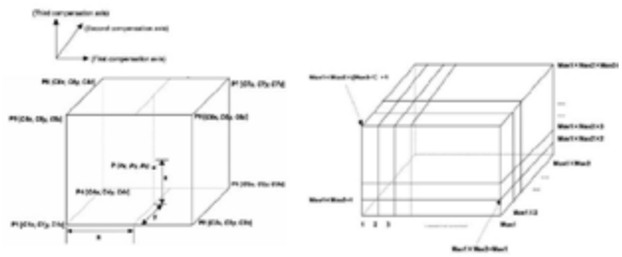


Fig.10 FANUC 3次元誤差補正示意
Diagram of Error Compensation of ANUC Gantry Tool Revolving Rotation Center

the offset value of the rotation center is brought in to facilitate the compensation of the machine. Figure 7 is a diagram of FANUC.

Recently some controllers have integrated measurement functions, such as the SIEMENS cycle996 or the HEIDENHAIN cycle451. These have been developed to help the customer quickly complete the setting of the rotation mechanism chain. The setting parameters can be figured out and entered automatically through the planning program of the controller with measuring instruments.

For big machines, volumetric error compensation can be used to overcome the huge errors that accumulate with big machines.

The principle is to use a measuring instrument to measure the error value of each point of the planned spatial grid in travel volume. After that, you must enter these values into the compensation parameter table of the controller, and the controller will carry out the interpolation operation to determine compensation values according to the promenade position and referring to the spatial grid. FANUC's name for this is Three Dimensional Error Compensation and SIEMENS calls it VCS (Volumetric Compensation System)

Conclusion

As the technology evolves, the controller can immediately handle the amount of data constantly upgrading providing compensation function also constantly rising. The way to supply a machine with high precision and long-term stability requires deeply understanding each error term and carrying out practical and reliable measurements, optimizing the machine based on error compensation and thinking about the practicability of error prevention (optimization of machine design, improvement of part and assembly flow precision, and so on).The goal of providing customers with high precision machines that possess long-term stability is a serious task that an equipment suppliers must face. Meanwhile it should also be Anderson Group's goal and mission.

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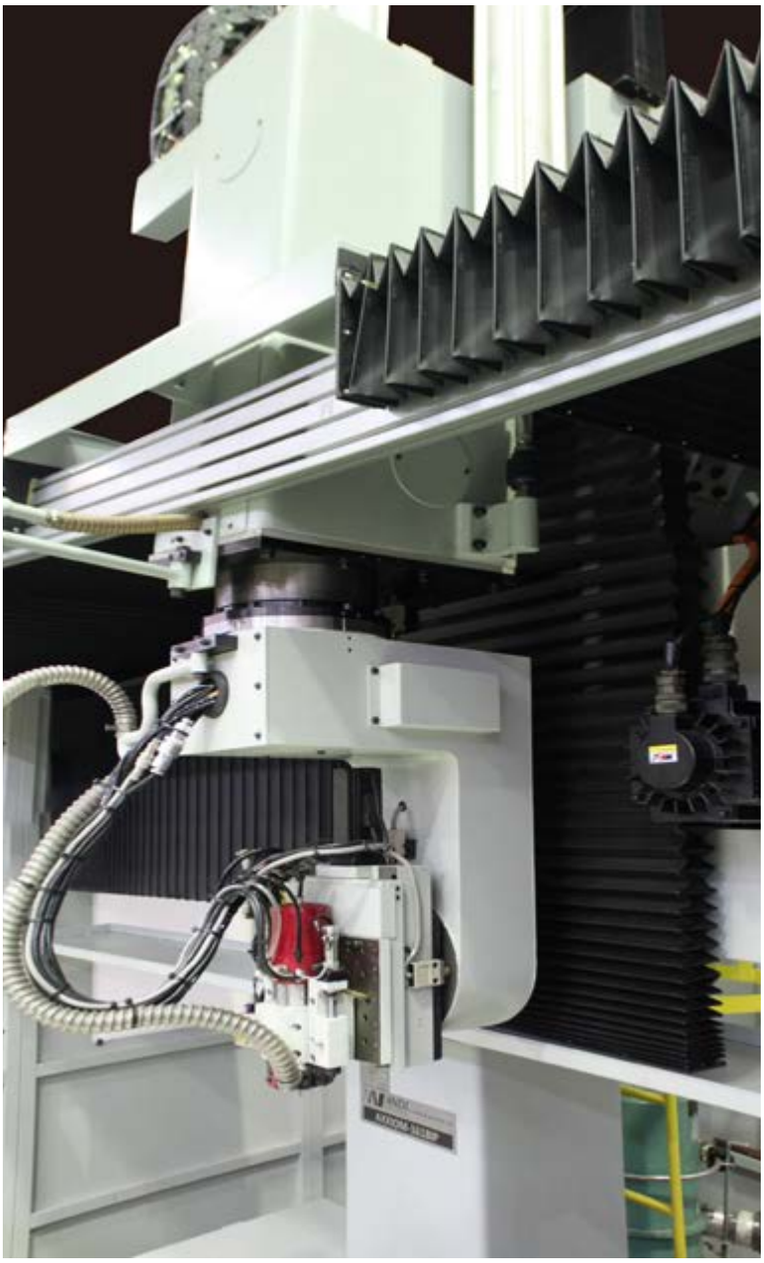


黃政義 Cheng-Yi Huang from AIC

五軸機的特殊應用 –碳纖維板鑽孔 Special Applications of 5-axis Machines — Drilling Carbon Fiber Plate

碳纖複合材料具有很多優點：強度高、重量輕、抗疲勞、耐高溫、耐腐蝕、等特性，使其在國防工業、汽車醫藥航太、運輸、電子及運動器材等工業產品上被廣泛應用。在航空製造業，複合材料被廣泛應用在機翼、機身、尾翼、推動裝置及著陸裝置。目前複合材料種類繁多，其中以碳纖維材料應用最為廣泛，其加工性能也極為苛刻，普通刀具難以對其進行高質量加工。因此需要一些特殊夾持方式及刀具來駕馭這種材料。

複合材料鑽削加工時，影響鑽削加工品質的因素有三：

1. 加工過程：如工件夾持方式、切削進給量、加工主軸的轉速…等。
2. 工件材質：複合材料本身的基材是屬於碳纖維或玻璃纖維等等…類型。
3. 加工刀具：包含刀具材質、刀具外型幾何形狀、刀具是否有塗層、刀具磨耗性…等。
4. 如前所述，複合材料鑽削加工是一複雜的工序，其影響因素繁多。

The advantages of carbon fiber composites include high strength, light weight, fatigue resistance, high temperature resistance, corrosion resistance, and more. These features explain their wide use in industries such as defense, automotive, pharmaceutical, aerospace, transportation, electronics, and sports equipment. In the aviation industry, composite materials are widely used in the wings, fuselages, tails, pushing devices and landing devices. Currently, a wide range of composite materials exists and the most widely used is carbon fiber materials. Yet carbon fiber materials are difficult to handle. Since it is difficult to process carbon materials for high quality products and manufacture them with ordinary tools, special clamping methods and tools are needed to manage

this kind of material.

When performing drilling work on composite materials, there are three factors that will affect the quality of drilling.

1. Process of work: The methods used for workpiece clamping, cutting feed rates, machining spindle speeds, and so on.
2. Workpiece materials: Whether the substrate of the composite materials is carbon fiber or glass fiber, etc.
3. Processing tools: Tool materials, geometry of tool shape, coated or uncoated tools, tool abrasion, etc.

The drilling of composite materials is a complex process and is influenced by various factors.

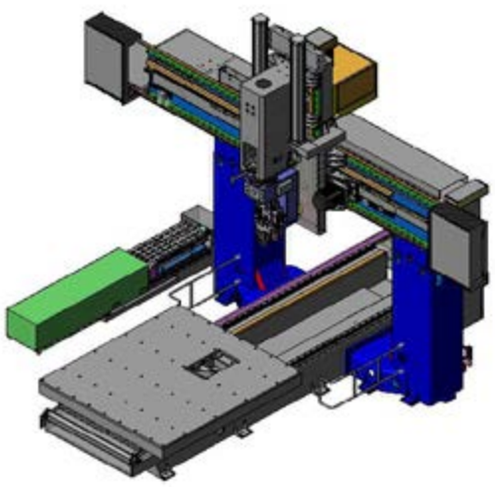


Fig.1

然而運用於飛機上會有許多的碳纖維板需要鑽很多小消音孔，往往在一片材料上會有數千孔，甚至上萬孔需靠鑽削加工來完成。而運用在此處上大部份的碳纖維板都是曲面外觀，要在曲面上鑽削垂直孔，品質要好(不可有毛邊)速度要快，實是一件不容易的技術。

恩德較其他同業佔絕對優勢的地方在於：恩德擁有精密機械的五軸加工機技術及PCB鑽孔技術，恩德只需整合此兩項技術，便可快速在曲面碳纖薄板上完成快速加工鑽孔動作(圖1)。

Nevertheless, carbon fiber used in aircrafts often needs to be drilled to produce many small silencer holes. Usually, there will be thousands or even tens of thousands of holes in one piece of material. These holes must be created by drilling. Since most carbon fibers used for aircraft are bent, it is not easy to drill vertical holes on bent surfaces with good quality (no flash) and at fast speeds.

The Anderson Group stands out among its competitors in the industry because we possess five-axis machining technology and PCB drilling technology, and produce precision machinery . The Anderson Group can rapidly complete drilling work on bent carbon fiber sheets (Figure 1) by simply integrating these two technologies.

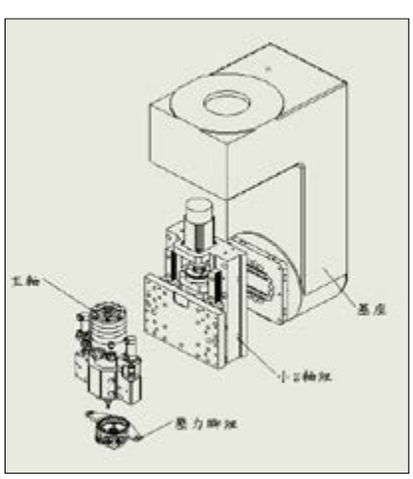


Fig.2 WoodCAM-複合式刀具在任一平面加工/
WoodCAM-Compound tool Processing on
Arbitrary Plane

恩德的五軸加工機機械座標定義是包含：三個直線座標(X,Y,Z)構成右手直角座標系，而兩個旋轉座標則是繞著Y,Z軸旋轉分別定義B,C軸。實際的五軸同動為X,Y,Z軸配合B,C軸，使主軸刀尖快速沿著曲面移動，並垂直於工件曲面。

在B軸上固定一組小Z軸，小Z軸的滑座上裝置一高速主軸，主軸頭組下方固定一組壓力腳裝置(圖2)，並在壓力腳下方裝上一片壓力墊耐磨環，利用五軸(X,Y,Z,B,C軸)動作將主軸移動至與加工物垂直處時，由氣壓控制壓力腳組下降，並壓置在工作物的曲面上。

當壓力腳上之耐磨環緊壓在工作物後，小Z軸由伺服馬達控制快速下降，完成快速鑽孔動作，也因耐磨環有壓住材料上方，讓材料與治具面緊貼一起,所以不會產生毛邊，當需連續快速加工鑽孔時，壓力墊只需沿工作物曲面作移動，單靠小Z軸快速下降鑽孔，同時此壓力腳搭配集塵系統可提供良好排屑效果，且具有冷卻鑽頭功能。

For Anderson's five-axis machining, machine coordinates are defined by three linear coordinates (X, Y, Z) which constitute a right-handed vertical coordinate system and two rotating coordinates moving around axis Y and Z which are defined as axis B and C. The actual simultaneous movement of five axes functions in a way that axes X, Y,

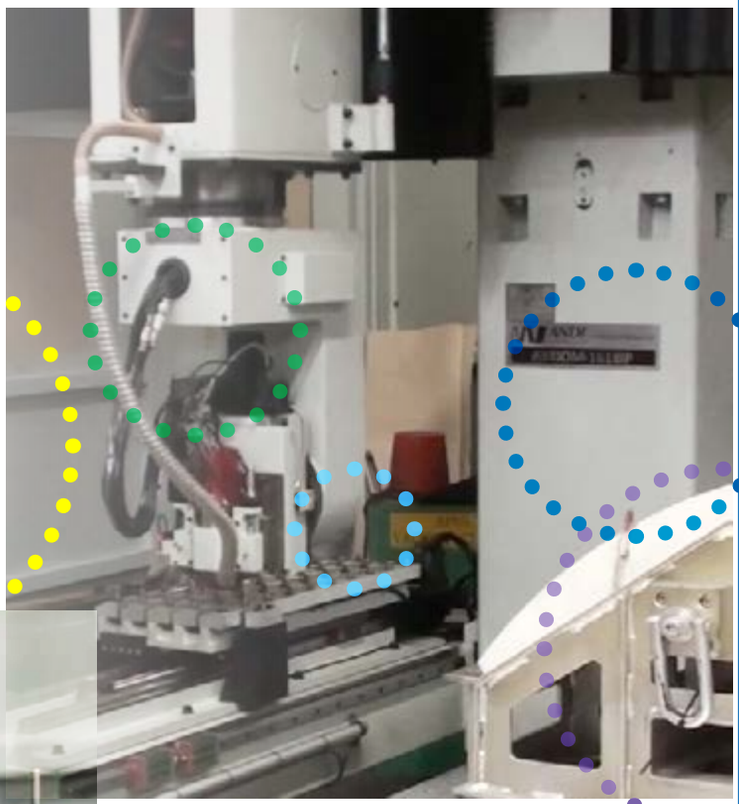
and Z coordinate with axes B and C, so that the spindle tip can quickly move along the bent surface and keep perpendicular to the surface of the workpiece.

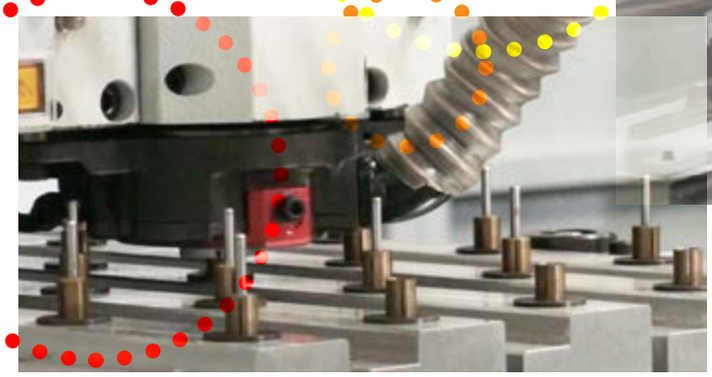
A small axis Z is fixed on axis B. A high-speed spindle is installed on the guiding saddle of axis Z. A pressure foot device (Figure 2) is mounted below the head group of the spindle and a pressure pad wear ring is mounted under the pressure foot. By using the motions of five-axes (X, Y, Z, B, C), the spindle is moved to the position where it is perpendicular to the workpiece. The pressure foot set is lowered by pressure and is pressed on the bent surface of the workpiece.

When the wear ring on the pressure foot is pressed against the workpiece, the small axis Z will be rapidly lowered by the servo motor to swiftly complete the drilling operation. Since the wear ring is pressed against the material, the materials and the surface of the tools are closely packed together. As a result, there will be no burrs. When fast successive drilling is required, the pressure pad just moves along the surface of the workpiece and the small axis Z will be rapidly lowered to drill holes. At the same time, the pressure foot and the dust collection system can work together to remove chips effectively and cool the drill bits as well.

近年來複合材料的高速發展，已幾乎取代鋁合金成為飛機製造第一應用材料的趨勢，同時也衍伸很多新加工技術的需求。恩德應用五軸加工技術結合高速鑽孔的功能，幫助客戶解決了此一技術的瓶頸，展現恩德在機械開發和加工應用的能力與實力。

The rapid development of composite materials in recent years has led to a trend of replacing aluminum alloys with composite materials in manufacturing aircraft. Various new processing technologies are needed as a result. Anderson Group combines five-axis machining technology with high-speed drilling to help customers solve this technology bottleneck, demonstrating that Anderson has the ability and strength for developing and applying machines in industry.





WoodCAM-複合式刀具在任一平面加工
WoodCAM-Aggregate tool Processing on Arbitrary Plane

江邵華 Sha-Hua Jiang from AIC

前言

WoodCAM為一對話視窗之軟體，在市場不斷的改變下，我們不斷新增功能。WoodCAM在數控加工中直接利用對話式的設計，特別是電腦與數控機床的聯接，使得設計、工藝規劃及編程和加工的整個過程全部在電腦上即時完成。

為了市場的需求，我們在這次功能新增功能上做了讓複合式刀具可以在任意平面加工的功能，為了對付在傳統的鑽孔機需要做製具才可以完成的加工法，經由WoodCAM簡單的設定就可以達到客戶需要的目的。

介紹

WoodCAM之任意平面，只需要三個步驟就可以完成，如下圖所示：

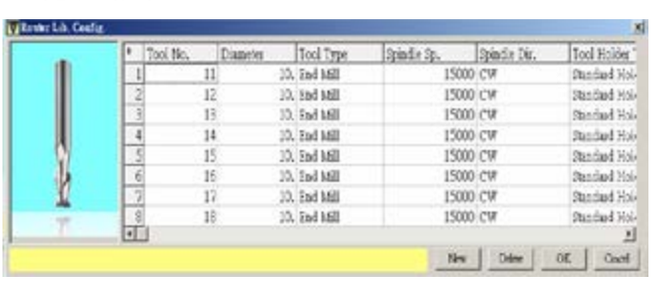


Fig.1

1. 刀具庫設定
2. 建立任意平面
3. 參數式加工數值設定

Preface

WoodCAM is a set of software with dialog boxes. To meet the demand of this constantly changing market, we continue to append new functions. During digital control processing, WoodCAM uses a direct dialogic design, especially for the connection between the computer and the digitally controlled machine. This makes it possible to complete the design, process planning, programming and the entire processing at once on a computer.

In response to market demand, we have appended a new function which enables the compound tool to process material on an arbitrary plane. In order to deal with situations where the processing method requires a fixture on a traditional drilling machine, a simple setting of WoodCAM satisfies the customer's needs.

Introduction

Only three steps are needed for an arbitrary plane using WoodCAM, as shown below:

1. Tool magazine setting
2. Create arbitrary plane
3. Parametric processing numeric value setting

第一步(刀具庫設定)

由WoodCAM主畫面進入刨花刀刀具庫之設定畫面，如下圖所示。

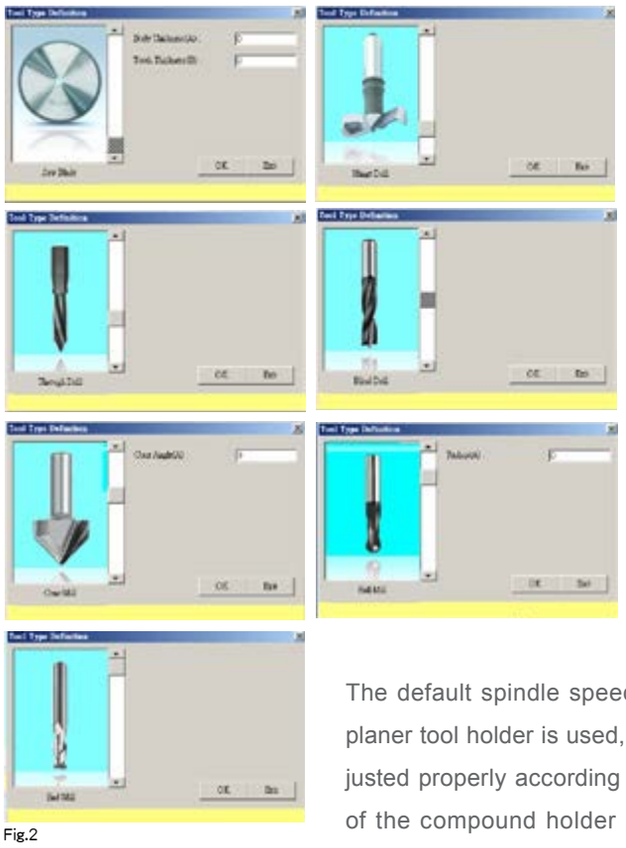


Fig.2

刀具型式

選所須修改之刀具型式時，會有另一畫面供其選擇，有端銑刀、球型銑刀、雕刻刀、盲孔鑽、穿孔鑽、鉸孔鑽，以及鋸片，共七種刀具型式，其中以端銑刀、球型銑刀，及鋸片最常使用之。如下圖所示。

轉速

主軸之旋轉轉速，其預設值為15000，單位為rpm。如使用複合式刨刀刀把時，根據複合式刀把之轉速比與切削時之狀況，適時調整其主軸轉速，建議值為6000~8000rpm。如使用複合式鋸片刀把時，主軸轉速建議值為3000~6000rpm。

主軸正逆轉

CW與CCW可供選擇。使用複合式刀把時，一般為逆轉(CCW)，其需根據刀把與刀具正逆螺旋判斷其轉向。

刀把型式

點選欲更改之刀把型式時，亦會有另一畫面供其選擇，有一般常用刀把、水平固定式複合刨刀刀把、水平固定式複合鋸片刀把、可調整式複合刨刀刀把，以及可調整式複合鋸片刀把，共五種刀把型式。如下圖3所示。

平面

於A軸0度時，刀具之指向。如刀具指向板材上平面時，其平面為0，指向板材左、右、前、後、下之平面時分別為1、2、3、4，以及5等。

刀具長度

其為刀具安裝於刀把時，刀把至刀具端面之長度。如刀具為鋸片時，請忽略此刀具長度。

First step (tool magazine setting)

From the main menu of WoodCAM, enter the setting screen for planner a shaving knife tool magazine, as shown in Figure 1:

Tool Type

Click the tool type you wish to modify and there will be another screen with options, with seven tool types, including the end milling cutter, ball type milling cutter, engraving cutter, blind hole drill, piercing drill, reaming drill and saw blade. Of these, the end milling cutter, ball type milling cutter and saw blade are used most often, as shown in Figure 2.

Spindle Speed

The default spindle speed is 15,000 rpm. If a compound planer tool holder is used, the spindle speed should be adjusted properly according to the ratio of the spindle speed of the compound holder and the condition upon cutting. The recommended value is 6,000 to 8,000rpm. If a compound saw blade holder is used, the recommended setting for the spindle speed is 3,000 to 6,000 rpm.

Spindle CW/CCW

CW and CCW are optional. When using a compound holder, in general it should be CCW. The direction of rotation is determined against the forward and reverse screw of the holder and tool.

Tool Holder Type

Click the tool holder type that requires modifying, and another screen with options will appear, withfive tool holder types, including the commonly used holder, fixed level compound planer tool holder, fixed level compound saw blade holder, adjustable compound planer tool holder and adjustable compound saw blade holder, as shown in the figure 3 below.

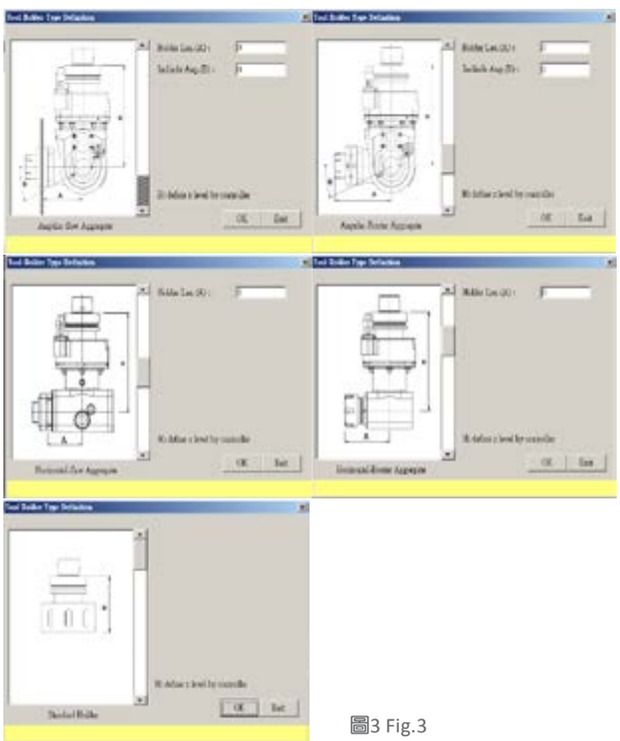


圖3 Fig.3

切削進給(Feed Rate)： 加工時之進給速度
下刀進給(Down Feed)：刀具向下切削之進給速度
安全高度(Safe Level)
於快速位移時，刀尖與板材表面之高度距離。如刀把為水平複合刨刀刀把(水平複合鋸片刀把)時，其安全高度從刨刀中心(鋸片底端)至材料表面之距離，建議值為60mm(鋸片直徑為180mm時為30mm)。如刀把為可調整式複合刨刀(可調整式複合鋸片刀把)，並調整一角度時，其安全高度分別從刨刀之刀具中心(鋸片之底端中心)至材料表面之距離。

以上為刀具的參數，若沒有一直更換刀具座，原則上，只輸要輸入一次皆可。
當第二次操作時軟體會記錄上次所設定的參數。

第二步(設定任意平面)

WoodCAM產生任意平面時，需要一直線與一角度來建立所須之平面，而其一角度旋轉方向係以右手定則(拇指為直線之方向，而四指為角度旋轉之方向，為欲加工之方向)為基準旋轉所建之平面，如此即可得任意平面。於WoodCAM主畫面之右下角附近有一立方體圖示，如此圖  所示。點選此按鈕，即可進入建立任意平面之畫面，如下圖所示。

Xs, Ys：一直線之起始點為第一點。
Xe, Ye：一直線之終點為第二點。
Angle(角度)：平面旋轉角度(0° <Angle<=90°)，其0° 為水平面，而90° 為垂直面。如下圖所示。

Plane

The pointing direction of the tool when A axle is 0 degree. If the tool points at the upper plane of the panel, the plane is 0;

if it points to the left, right, front, rear and lower plane, it is 1, 2, 3, 4, and 5, respectively.

Tool Length

Tool length is the length from the holder to the tool end face when the tool is installed in the holder. If the tool is a saw blade, please ignore the tool length.

Feed Rate

Feed rate upon processing.

Down Feed

Feed rate upon down cutting.

Safe Level

The safe level indicates the height distance from the nose of the tool to the surface of the panel upon rapid displacement. If the holder is a level compound planer tool holder (level compound saw blade holder), the rec-

Fig.4

ommended value of the safe level distance from the planer tool center (bottom of saw blade) to the surface of the panel is 60 mm (30 mm when the diameter of the saw blade is 180 mm). If the holder is an adjustable compound planning knife (an adjustable compound saw blade holder), and the angle is adjusted, the safe level is the distance from the center of the planer tool (bottom center of saw blade) to the surface of the panel.
Above is the tool parameters. If the tool base is not changed often, in principle, it is only required to enter it once.The software will record the previous setting parameters upon the second operation.

Second step (arbitrary plane setting)

When an arbitrary plane is generated by the WoodCAM, the required plane should be created based on a line and

Fig.5

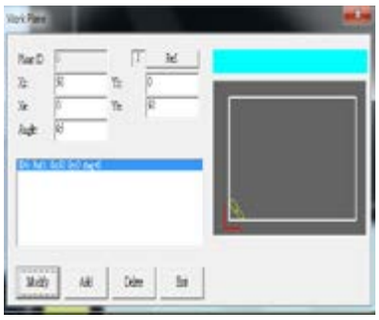


Fig.6

設定完成就可以產生為如上圖所示斜面的平面。

第三步(參數式加工數值設定)

參數式加工畫面，如下圖所示。

選擇完刀具即可在設定的平面上進行想要的加工圖元進行加工。

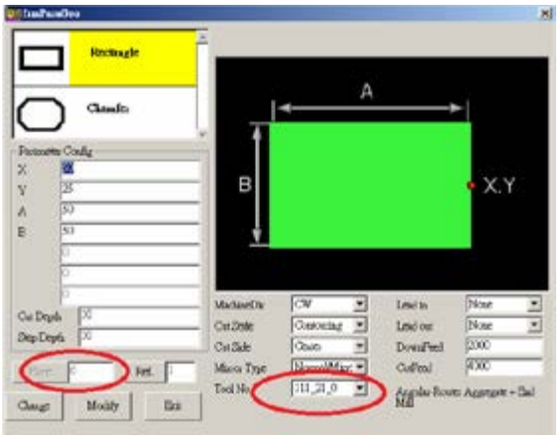


Fig.7

結論

WoodCAM複合式刀具之任意平面設定，可以容易快速的在任意平面上操作。不僅可以讓使用者在四軸的機器上，利用複合式刀具在任意平面加工，並減少前置時間，增加市場競爭力。在未來，WoodCAM軟體亦會隨者市場的變動而增加新功能，讓使用者不斷增加在市場上的競爭力。

angle. The direction of the angle's turn may follow the right-hand rule (the thumb providing the line's direction and the four fingers are the direction of the angle turn, meaning the direction of processing required) as a standard to turn the created plane, so an arbitrary plane can be obtained. There is a cubic icon at the bottom right corner of the main menu of WoodCAM, appearing as  .

The screen for arbitrary plane creation can be entered by clicking on this button, as shown in the figure below.

Xs, Ys: the starting point of the line is the first point.

Xe, Ye: the end point of the line is the second point.

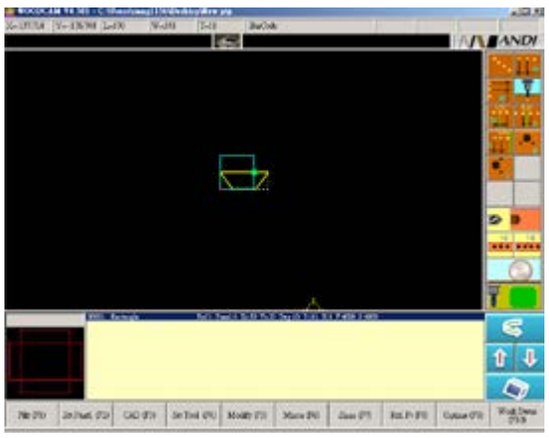
Angle: the rotation angle of the plane (0°<Angle<=90°), in which 0° is the horizontal plane and 90° is the vertical plane, as shown in the figure below.

The inclined plane shown above can be generated when the setting is completed.

Third step (parametric processing numeric value setting)

The Parametric processing screen is shown below.

When the tool is selected, iIt is able to process on the desired processing pixel of the setting plane.



Conclusion

The WoodCAM compound tool can be easily and quickly operated on arbitrary plane. This enables the user to use compound tool to process an arbitrary plane on a four-axis machine, which can not only reduce lead time but also enhance market competitiveness. In the future, new functions may be added to WoodCAM software in response to the changing needs of the market. This enables the user to constantly enhance their market competitiveness.

PCB鑽孔機控制人機介面
Machine Interface of PCB Drilling Machine

張焜俊 Kage Chang from AIC

前言

現今的CNC機械市場，多數仍存在以文字指令的介面，來指導操作者操作機械，但由於不同國籍的使用者對於文字未必有相同的認知，而圖形能縮小設計者與使用者認知之差異，增加對操作介面的直覺感。因此，在人機介面的設計以圖形化取代大量的文字命令，以及簡化複雜的操作流程，讓初學的使用者能在很短的時間內就能獨立操作。因此人機介面的好壞，也漸成為是產品競爭的關鍵因數。

Introduction

In today's CNC machinery market, many machines still use text instruction interfaces to guide the operator on how to use the machine. However, users from different cultures may not have the same cognitive response to the texts. Graphics can reduce the difference in perceptions between the designer and user, enhancing the user's ability to use intuition when using the operating interface. Therefore, designing human-machine interfaces with graphics is an excellent alternative to large amounts of text; it can help simplify complicated operation processes to allow novices to operate the machine independently within a very short time. For many products, the quality of the human-machine interface has emerged as a key competitive advantage.

系統架構

為使鑽孔機的人機介面能擴大應用的範圍，並適應於各種控制器或運動控制卡，讓控制器或運動控制卡能夠減少動程規畫以外的計算，如前處理的部份或座標象限的轉換。為了讓控制器可以減少在前處理的部份浪費效能，人機需先處理程式解譯的部份，並直接將它翻譯成控制器所能直接執行的巨集，此部份也同時能讓人機適用於各式各樣的控制器或運動控制卡，人機只需要將解譯出來的程式翻譯成對應控制器或運動控制卡所需要的格式即可。

為了讓控制器減少動程規畫以外的計算，所有的象限轉換，座標偏移全部由人機做計算，送到控制器或運動控制卡皆為機械座標，讓控制器或運動控制卡可以直接做加工，不需要再額外做轉換及計算，能使控制的效能更加提升。在程式的傳輸方面，採用DNC直接控制，由人機直接將加工程式寫入到控制器做加工。

System Structure

One strategy for expanding the scope of applications of a human-machine interface for drilling machines is to adapt it to a variety of controllers or motion control cards. This can reduce the amount of computing in addition to the dynamic process planning that the controller must perform, for example, pre-processing or conversion of coordinate quadrants. To reduce pre-processing waste of controller efficiency, the human-machine interface should first process the program interpretation and then translate it directly into marco which the controller can execute directly. This approach produces a human-machine interface suitable for a wide range of controllers or motion control cards; the interface only needs to translate the interpreted

program into the format required for the corresponding controller or motion control card.

All quadrant conversion and coordinate offsets should be computed by the interface, which then sends the mechanical coordinates to the controller or motion control card. With these mechanical coordinates, the controller or motion control card can process directly without further conversion and computing, greatly enhancing the efficiency of its control performance. Program transmission is directly controlled by DNC, and the human-machine interface directly writes the processing program onto the controller for processing.

Fig.1

功能

一個加工程式從載入到開始加工有許多的步驟，如何以簡單清晰的思維讓使用者在很短的時間內就能完成自己的需求是很重要的，最好的方式無疑是圖形的模擬。為使用者在做任何一個設定時，即可清楚的知道自己的設定會產生的結果，

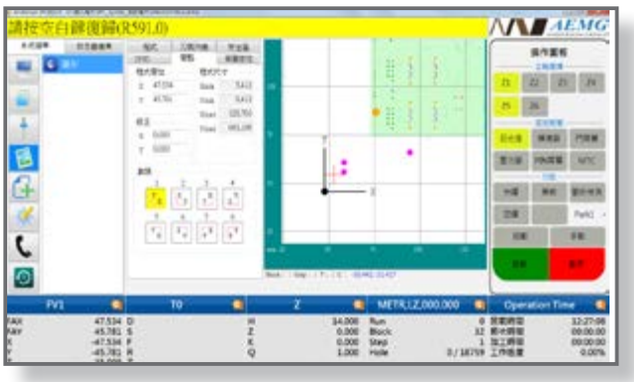


Fig.2

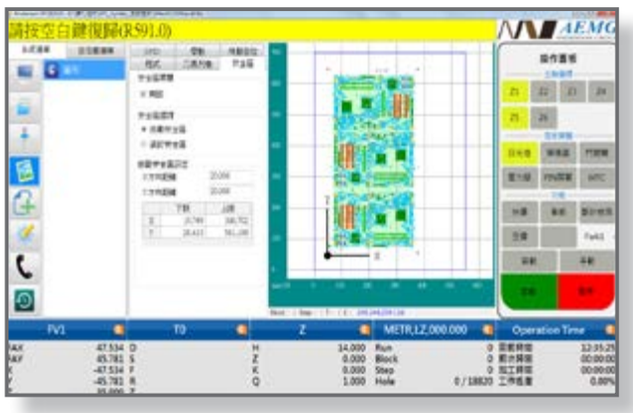


Fig.3

Fig.4

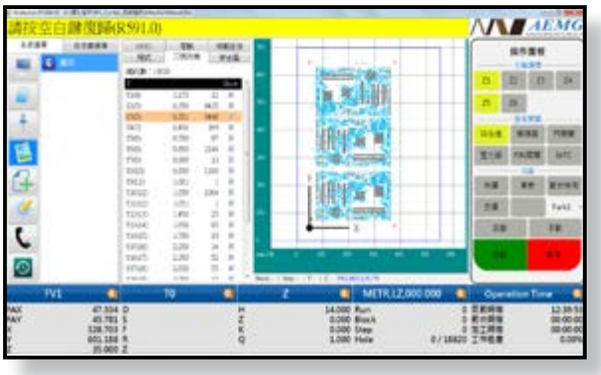


Fig.5

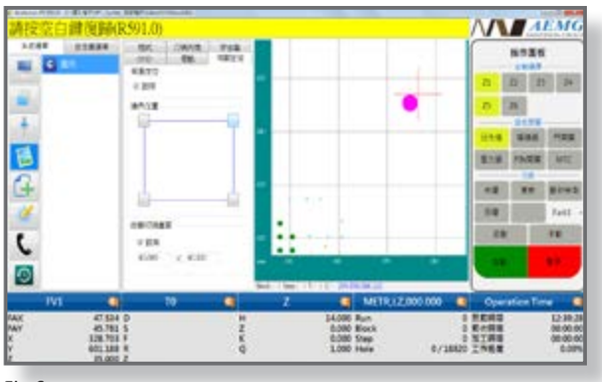


Fig.6

因此我們在PCB的人機設計，就依此概念設計了很多重要的圖形介面。

以上圖示皆是重要的圖形介面，編輯器（圖1）、象限轉換（圖2）、OPID設定（圖3）、安全區（圖4）、刀具清單（圖5）和伺服定位（圖6）。前四項皆可以立即做圖形模擬。伺服定位可以讓使用者快速的將加工程式的位置定位在檯面上，以及提供快速邊界定位。

Features

There are numerous steps in any processing program, from loading to process start. It's important to employ simple yet clear concepts that allow users to meet their own demands in a very short period of time; graphic simulation is undoubtedly the best approach. When designing any setting, the outcome is clearly known in advance, so many important graphic interfaces are designed in accordance with this concept.

The following are all important graphic interfaces for HMI: editor (Figure 1), quadrant conversion (Figure 2), OPID setting (Figure 3), safety zone (Figure 4), tool list (Figure 5), and servo positioning (Figure 6). The first four are immediately ready for graphic simulation. Servo positioning allows users to quickly locate the position of the processing program on the table and provides fast boundary positioning.

結論

控制型人機介面容易擴增應用範圍，並縮短開發的時間，對於新功能的增加也更加容易，機械製造商能自己掌握此技術時，產品的差異性和精緻性就有機會更勝於競爭對手。由於控制器或運動控制卡只做單純的運動規畫，減少一些額外的處理及計算，更可以讓性能充份發揮，對於機台產生的一些錯誤結果，也可以更容易的去偵錯及找出問題所在。而人機的重點在於直覺操作，及簡化複雜的流程，讓使用者可以更容易學習和操作。

Conclusion

It is easy to expand the application scope of control human-machine interfaces and to shorten development time for other controller or motion control card; also it is easier to add new features. When the machinery manufacturers can master the technology easily, they have a better chance of succeeding against their competitors through product differentiation and sophistication. Since the controller or motion control card can only process simple dynamic planning the fact that this approach reduces additional processing and computing, allows it to make full use of its features. It also makes it easier for the controller or motion control card to debug and identify problems when there are errors. The key goal of human-machine interfaces is intuitive operation; the interface should simplify complicated processes so that users can learn to operate the machine with ease.

Full Line & Campro Nesting

李琬琪 Claudine Lee from AIC

前言

隨著生活品質精進,現代人對於居家環境的設備、裝潢越來越講究,在裝潢時除了要思考功能性、美觀及價格之外,還要能突顯主人對整個家的品味跟生活的態度。也因為這樣,廚房已經不再只是煮飯的空間,還要跟整個家的調性相輔相成,更進一步具備畫龍點睛的功能。而不論是大家庭、小家庭亦或是單身,只要是有人住的地方,就一定有廚房,換言之,不管科技再怎麼發達,廚房仍然是個永遠不會被淘汰的空間。

無論客戶喜歡的是量身訂做的個人化產品或是整齊且有設計感的系統廚櫃,龐大的需求不斷的刺激著這個產業,也因為客戶對品質要求的提高,使得競爭更趨激烈。現在的廚櫃門板、系統傢俱廠商們無不思考如何在同樣的工時裡將產能提高,並達到最好的材料利用率為目標。而整線的作業方式已經成為必然的趨勢。

Preface

As quality of life improves, people pay more attention to appliances and decorations in their home environment. They consider not only functionality, appearance, and price during decorating, but the taste and values of the owner must be taken into account with regards to the entire home. Therefore, a kitchen is no longer just a space for cooking; it has to be coherent with the tone of the entire house to add a finishing touch. Whether it is a big or small family, or a single person household does not matter; wherever someone lives, there is always a kitchen. In other words, the kitchen is a space that will never be eliminated.

Whether customers prefer custom-made personalized products or neat cabinet systems with a sense of design, the huge demand constantly stimulates competition and innovation in the cabinet industry, with fierce competition because of the rising expectations as to quality among customers. Kitchen cabinets, door panels, and furniture systems manufacturers these days are all trying to raise the yield within the same number of working hours and trying to reach the goal of the best material utilization rate; full-line operations have become an inevitable trend.

整線概念

我們的概念是建立一個SERVER端，掌管所有排版出來所產生的程式，包括NC程式、貼標程式及所有需要使用到的資料庫，在辦公室的人員將排版資料輸出後，現場工作人員可以透過網路存取，獲得工作清單及程式以進行加工。以下為Full Line的硬體設備，大略以A、B、C簡稱來描述整個設備的作業流程。

A. 板材自動貼標系統，搭配一台WIN 7主機(a)及TSC標籤機，控制Labeling Control自動貼標程序。

B. GENESIS/2713 with Mul ti-Boring 10x，搭配PC Front 控制器(b)，並且以Campro DNC系統管理所有NC程式及貼標LAB程式

C. 推料台，搭配一台WIN 7 主機(c)及TSC標籤機，主要工作為Labeling Manager補貼標籤，或是進行手動貼標。

The Full Line Concept

Our concept is to build a server end to control all programs produced along with layout, including NC programs, labeling programs and all required databases. After the staff in the office exports layout data, on-site staff can access it via the Internet, obtain the working list and programs, and begin machining. Below is the Full Line hardware equipment, with a rough description of the processing of the entire set of equipment.

A. An automatic board labeling system, equipped with a WIN 7 host (a) and a TSC labeling machine, to control the automatic labeling procedure.

B. This example shows GENESIS/2713 with Multi-Boring 10 x 7, equipped with a PC Front controller (b) and it is managed by a Campro DNC system for all NC programs and labeling LAB programs.

C. A material feeding platform, equipped with a WIN 7 host and TSC labeling machine. The main task is to supplement labeling with the Labeling Manager or to label manually.

以下提供了三種不同的組合，目的都是達成貼標切削的整線目標：

1. A+B+C：當Campro DNC載入工作清單後，機器A開始做自動貼標動作，當貼標完成，將板材推到B，(a)並且通知(b)對應的加工程式，當B加工完成，成品推到C時，(b)會通知(c)現在已經進行的貼標程式，(c)會自動開啟排版示意圖做檢查是否有損壞而需補印的標籤。

2. A+B：當Campro DNC載入工作清單後，機器A開始做自動貼標動作，當貼標完成，將板材推到B，(a)並且通知(b)對應的加工程式，當加工完成，成品推到C時便完成。

3. B+C：當Campro DNC載入工作清單後，機器B開始加工程式，當加工完成，成品推到C時，(b)通知(c)進行的貼標程式，(c)自動開啟排版示意圖讓使用者做手動標籤。

Below we offer three different combinations for reaching the full-line goal of labeling cutting.

1. A+B+C: After Campro DNC loads the working list, machine A starts auto labeling. After labeling is complete, A pushes boards to B, (a) and informs its (b) corresponding machining program. When B completes machining, finished products are pushed to C and (b) will inform (c) the currently working labeling program, and then (c) will open the layout diagram automatically to check whether there are damaged labels which need to be reprinted.
2. A+B: After Campro DNC loads the working list, machine A starts auto labeling. After labeling is complete, A pushes boards to B, (a) and informs its (b) corresponding machining program. When machining is complete, finished products are pushed to C and it ends.
3. B+C: After Campro DNC loads the working list, machine B starts the machining program. When machining is complete, finished products are pushed to C, and (b) will inform (c) the currently required labeling program, and then (c) will open layout diagram automatically for users to label manually.

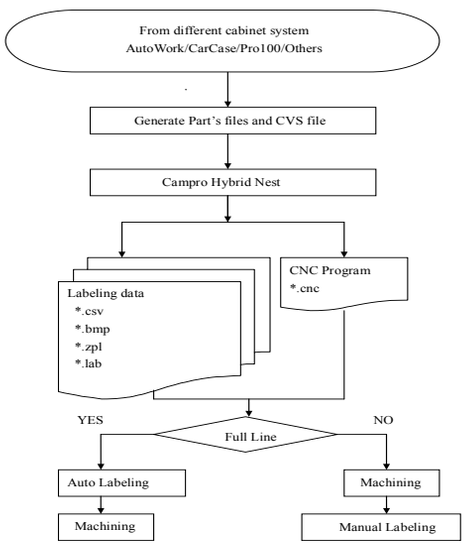


Fig.1 Campro Hybrid Nest 整合排版的概念/
Campro Hybrid Nest Integrated Layout

Campro Hybrid Nest整合排版

整線的管理系統，除了要有良好的硬體設備之外，軟體的整合扮演一個相當重要的角色。透過軟體、韌體、與硬體的溝通，業者可以減少許多在設計、拆料、加工、出貨的過程中產生的不必要的人為錯誤。因為前端設計軟體如過江之鯽，在此不再累述它們的功能。對於生產業者而言，其重點在於思考如何將前端資料轉換成加工程式，做出成品，而Campro Hybrid Nest就提供了這樣的解決方案。

以下是我們對於廚櫃門板及系統傢俱業者所提出的方案:

Model A.針對整體設計的個人化商品

業者拿到設計端拆好的工作清單(CSV)，例如：AutoWork/Pro100->進入Campro Hybrid Nest 排版->轉換為NC(CNC檔)及貼標程式(Lab檔)。生產端只要載入貼標程式做自動貼標，並以相對應的NC程式切削，當成品推到出料台時，業者可以繼續下一塊版材的貼標及切削，如此便可以達到持續加工生產的整線管理。

Model B.針對已經有制式尺寸的櫃體或廚櫃門板

業者利用已經建立的Macro程式庫(Campro內建或自己建立的)，利用Campro的介面挑選適用的macro，使用者只要輸入尺寸、厚度、數量等參數->Campro會自動建立一個CSV資料庫->進入Campro Hybrid Nest 排版->轉換為NC(CNC檔)及貼標程式(Lab檔)。使用者利用自己既有的標籤樣版套上Campro產生的示意圖，經過標籤列印後便可以對照排板示意圖的位置，以手動方式貼標。

下列僅以流程圖來描述Campro Hybrid Nest和廚櫃設計軟體的資料庫的溝通方式，大致如圖1所示。

Campro Hybrid Nest Integrated Layout

A full line management system not only requires good hardware; software integration also plays an important role. Through the communication between software and firmware and hardware, manufacturers can avoid many unnecessary human errors during the processes of design, splitting, machining, and shipping. Because there are already numerous front-end design software products, here we skip the description of their functions. For manufacturers, the key is to consider how to convert front-end data to machining programs and produce finished products. Campro Hybrid Nest provides exactly such a solution.

Below is our solution for kitchen cabinets, door panels, and system furniture manufacturers

Model A. for Personalized Products with Integrated Design

Manufacturers obtain the working list (CSV) split at the design end. For example: AutoWork/Pro100->enter Campro Hybrid Nest layout ->convert to NC (CNC file) and labeling program (Lab file). The production end only needs to load programs for auto labeling and use the corresponding NC programs for cutting. When the finished products are pushed to the output platform, manufacturers can continue labeling and cutting the next board, to achieve full line management of continuous machining production.

Model B. for Standard-Sized Cabinet Body or Door Panels

Manufacturers use a pre-built Macro database (Campro built-in or self-built) and choose a suitable macro via the Campro interface. Users only have to enter the parameters, such as size, thickness, and quantity. ->Campro will build a CSV database automatically. ->enter Campro Hybrid Nest layout->convert to NC (CNC file) and labeling program (Lab file). Users apply their existing label templates to the diagram generated by Campro. After label printing, they should refer to the positions of the layout diagram and label manually.

The communication between the Campro Hybrid Nest and cabinet design software is described in the diagrams below:(figure 1.)

整合排版的概念

簡言之，Campro需要的資料僅是前端拆料之後所生成的資料清單，也就是CSV檔案。一個完整的廚櫃CSV檔案，至少含有板件的長度、寬度、厚度、數量、顏色、封邊資料、以及相對應的加工程式或是圖檔，透過這些訊息，軟體會自動產生圖檔並且使用業者所選取的刀具做排版加工程式，若是應用在廚櫃門板，則可以依照業者所定義的macro巨集，依照所輸入的變量來產生圖檔，並且使用業者所定義選取的刀具做排版加工程式。現在，先來介紹Campro排版軟體的應用介面。

The Campro Hybrid Nest Integrated Layout

In a word, Campro only needs the data list generated after front-end material is split, which is a CSV file. A complete cabinet CSV file contains at a minimum the length, width, thickness, quantity, color, and edge sealing data of boards, and corresponding machining programs or graphic files. Using all the information, our software will generate graphic files automatically and use cutters selected by the manufacturer for layout machining programs. If Campro is applied to cabinet door panels, it complies with the macros defined by the manufacturer and generates graphic files according to the variables they enter. Then it uses the cutters defined and selected by the manufacturer for the layout machining program.

Below we introduce the application interface of Campro layout software.

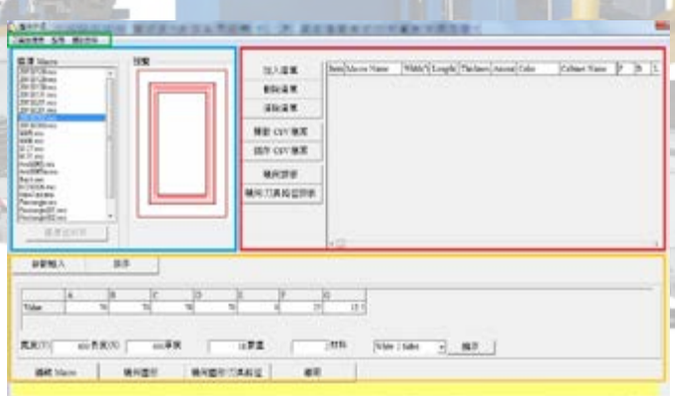


Fig. 2

▬▬ 一、Campro Hybrid Nest 介面(圖二)

左側藍色方框：圖檔對應的資料夾，可以是Macro巨集、XML、或DXF

左下黃色部份：參數輸入處，針對Macro可輸入變量，產生不同尺寸的圖形。

右側紅色部份：CSV清單的顯示區

左上綠色方框：下拉式選單，控制所有刀具定義對應、鑽孔深度、NC程式輸出的象限、以及標籤列印所需資料選項

▬▬ I. Campro Hybrid Nest Interface(Fig.2)

The blue box on the left side is the corresponding folder for graphic files. It can be macro, XML, or DXF.

The yellow part on the lower left is for parameter entry; variables for macros can be entered to generate graphs of different sizes.

The red part on the right side shows the CSV list.

The green drop-down menu on the upper left controls all cutter default correspondence, drill hole depth, output quadrants of the NC program, and the options for label printing information.

▬▬■ 二·定義CSV欄位

CSV就是一般EXCEL的資料庫，在欄位中間以逗點”,”分隔，Campro Hybrid Nest可支援3種不同圖形格式(MRO/XML/DXF)。

A. MRO為macro巨集程式，呼叫編撰好的macro程式時可依使用者輸入的參數自動縮放，經過Campro的解譯，自動產生CAW圖檔並且排版。

B. XML為特定格式，使用者可使用其前端設計軟體(目前支援AutoWork)設計並拆圖，產生Campro已定義的XML格式，經過Campro的解譯，自動產生CAW圖檔並且排版。

C. DXF為一般通用的圖檔格式，一般而言只有幾何圖形，若要帶入加工資料，則必須要有已定義的資料來做描述，經過Campro的解譯，自動產生CAW圖檔並排版。

D. Campro本身具備產生CSV的基本功能，我們當作內定型態，如果業者完全沒有使用前端拆圖軟體，仍然可以透過我們的介面產生基本版的CSV資料，但因應每家應用的前端軟體不同，我們可以支援不同欄位定義，使用者只需指定他們的欄位給Campro，並且新增一個型態即可。

▬▬■ II. Defining CSV Field

CSV is the database of general EXCEL; “,” is used to separate fields. In Campro Hybrid Nest, we support 3 different graphic formats (MRO/XML/DXF).

A. MRO is a macro program, calling edited macro programs and auto-zoom according to parameters entered by users. After decoded by Campro, it generates CAW graphic file and conducts layout.

B. XML is a specific format. Users can use their front-end design software (currently supports AutoWork) to design and split diagrams to generate a Campro defined XML format. After decoded by Campro, it generates CAW graphic file and conducts layout.

C. DXF is a general graphic format. Usually there are only geometric graphs. If machining data need to be processed, defined data must be used to describe them. After decoded by Campro, it generates CAW graphic file and conducts layout.

Campro has a basic function of generating CSV and we regard it as default types. If manufacturers have no front-end diagram split software, they can still generate basic CSV data via our interface. But we support different field default for different front-end software products. Users only need to designate their fields for Campro and add a new type.

▬▬■三·排版

選取CSV並填入所有加工排版參數後，即可進行排版並做最佳化，系統可以計算出板材利用率，提供業者參考並輸出所有加工NC資料。

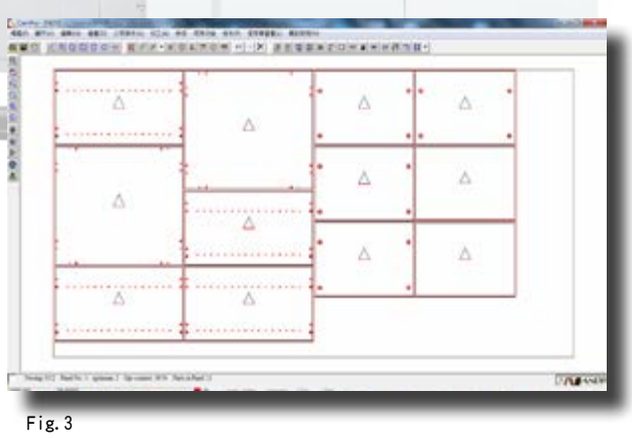


Fig. 3

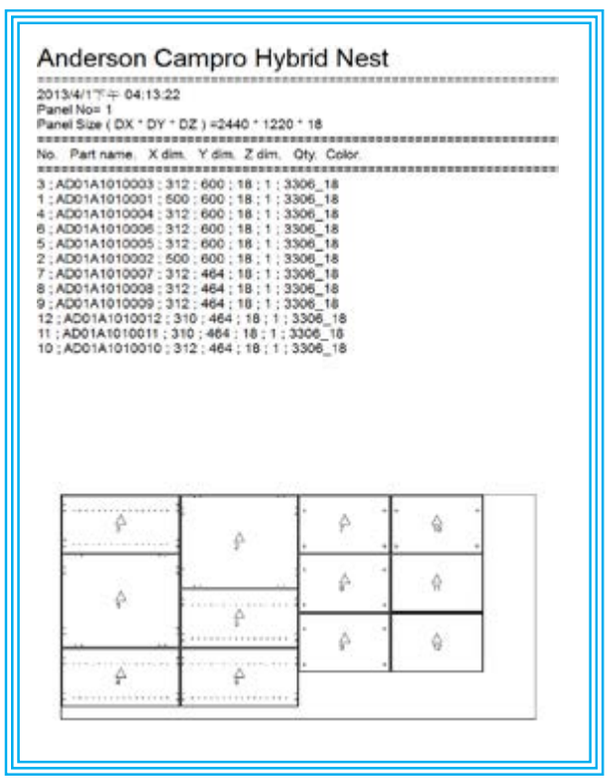


圖4/ Fig. 4

▬▬▬四. 顯示排版結果(圖3)

▬▬▬III. Layout

After CSV is selected and all machining layout parameters are filled in, layout and optimization can be conducted. The system can calculate the utilization rates of boards for manufacture's reference and export all machining NC data.

▬▬▬IV. Displaying Layout Results(Fig.3)

▬▬▬五.產生貼標程式 - BMP 及ZPL程式

▬▬▬六.排版結果示意圖(圖4)

▬▬▬七.整線作業的標籤列印

透過整線標籤的列印，業者可以使用觸控螢幕做單張標籤列印，或是使用列印所有標籤的按鈕，做所有的列印。(圖五)

▬▬▬V. Generating Labeling Programs – BMP and ZPL Program

▬▬▬VI. Layout Result Diagram (Figure 4)

▬▬▬VII. Label Printing of Full Line Operation (Figure5)

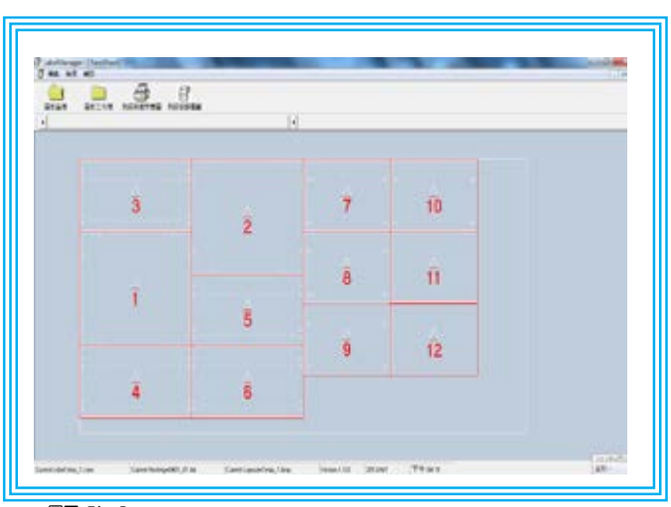
Through the printing of full line label, manufacturers can use the touch screen for single label printing, or use the button for printing all labels to print all labels.

結論

因為市面上軟體種類非常多,現在業者在採購硬體的同時,通常也會詢問我們能否提供一些軟體方案,尤其在國外含有排版功能的軟體,單價相對的也高, 而現在,透過幾個自行研發的軟體跟機器的溝通合作,我們達到一個整線的解決方案, 在此提供給大家參考.

Conclusion

Because there are many different types of software in the market, manufacturers often consult us for software solutions when purchasing hardware, especially with the software with layout functions, the prices of which abroad are often relatively higher. Now, through the communication between several of our own R&D software solutions and the machines, we achieve a full-line solution for your reference.

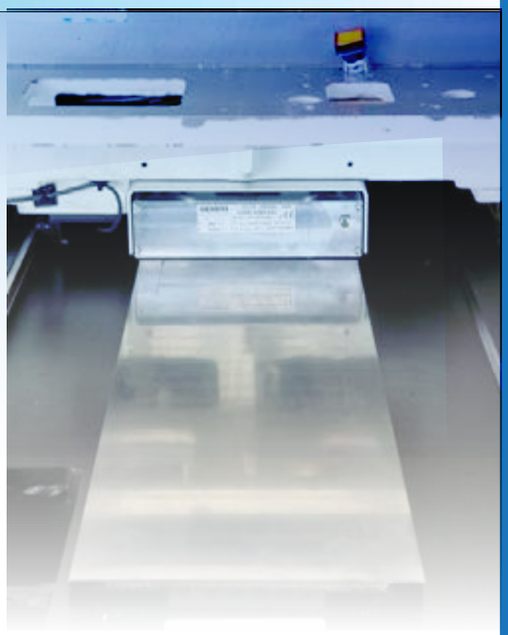


圖五 Fig. 5

線性永磁同步馬達之探討

Permanent Magnet Linear Synchronous Motors

蔣繼緯 Chi-Wei Chiang from AIC



前言

觀察近年來的國際知名工具機大展，不少知名大廠將線性馬達驅動之高速工具機視為是主流機種之一，由此可見線性馬達在工具機產業逐漸佔有一席之地。礙於國內對於線性馬達這領域的熟悉度及成本因素考量等問題，僅有少數的研究機構及幾家業界公司願意投入人力與經費去研發線性馬達與相關產品開發。有鑑於此，投入研發線性馬達這塊領域，相信會在市場競爭中更具有優勢，因此本文要針對平板式線性馬達來探討其設計概要。

Background

Looking over the renowned international machine and tool exhibitions in recent years, it's clear that many well-known manufacturers have been promoting high-speed machines driven by linear motors as their mainstream models. This phenomenon shows that linear motors have gradually taken its space in the machine tools industry. However, few research institutes and companies in Taiwan are willing to invest in the development of linear motors and related products, due to their lack of familiarity with the technology and concerns about cost. Under these circumstances, a company that invests in the research and development of linear motors can gain a competitive advantage in the market. Thererefore, this article introduces the design concept of flat linear motors.

線性馬達簡介

近年來，我國工具機產業跟自動化工業，在線性傳動中使用線性馬達來取代傳統旋轉馬達的比例有日漸趨升的傾向。線性傳動最傳統的方式是使用旋轉馬達加上滾珠螺的傳動裝置，這種方式要透過聯軸器、滾珠螺桿、齒輪、齒條等這些中間環節，此種間接的輸出直線運動，限制了馬達的速度響應，而滾珠螺桿會產生間隙、摩擦等問題，因此在定位精準度上會有誤差。

相較之下線性馬達為直接驅動之致動器，無需機械式傳動件，所以馬達和負載間無減速比、無背隙與磨耗問題且整體剛性佳、可靠度佳(不需要滾珠導螺桿，不受限材料之彈性係數)，線性馬達允許多個動子在同一滑軌上、因此行程無上限且不失其位置精度。此外，線性馬達擁有良好的動態響應，可獲得高速、高加速度及頻寬、高定位精度、高伺服剛性(抗干擾性)、較低之速度漣波及較小之安定時間。

基本上線性馬達的優缺點如下：

優點為：

(1) 馬達直接驅動負載，因此速度與加速度高。
(2) 構造簡單、結構堅固、可靠度高
(3) 高精密定位控制
(4) 無行程上限
(5) 有較佳的動態響應（Dynamic Response）
(6) 磨損小，使用壽命高

缺點為：

(1) 線馬為開放結構，因此容易產生漏磁效應。
(2) 負載容易受到線性馬達產生的推力漣波或震動的影響。
(3) 所使用的感測元件(光學尺)為開放性結構，較容易損壞。
(4) 當傳遞過程中所產生能量損耗，會有效應產生，容易直接反應到負載端。

線性馬達的結構其實是由旋轉馬達變化來的。以感應馬達為例，將一台旋轉馬達沿著徑向切開，然後將旋轉馬達的周圍展開成直線，如圖1所示。如此可得到由旋轉馬達演變成最原始的線性馬達。圖1中，由旋轉馬達之定子演變成線性馬達的部分可稱為一次側，由旋轉馬達之轉子演變成線性馬達的部分可稱為二次側。

Introduction of Linear Motors

In recent years, the machine tools and automation industry in Taiwan shows a clear trend toward replacing traditional rotary motors with linear motors. The most traditional approach to designing a linear drive is to use a rotary motor plus a ball screw rod transmission device. Using this approach, intermediate links such as stock shafts, ball screws, gears, racks and many other parts are needed. Such indirect linear output motion limits the response speed of motors. In addition, gaps and friction will occur among ball screws. As a result, there are errors in positioning accuracy.

In contrast, linear motors belong to the type of actuators that are directly driven, so no mechanical transmission parts are needed. It meets that linear motors doesn't need ball screws and unrestricted by elasticity of materials .Therefore, there is no reduction ratio, backlash, or wear problems between the motor and the load. In addition, overall rigidity and reliability are good. In addition, since linear motors allow multiple forcers on the same slide, there will be no limit on travel, and position precision will not be lost. Moreover, linear motors have good dynamic response, high speed, high acceleration and bandwidth, high positioning accuracy, high servo stiffness (immunity), lower ripple and low speed of settling time.

Advantages and disadvantages of linear motors are as follows:

Advantages are:

(1) Load is directly driven by the motor. Speed and acceleration is high.

(2) Simple structure, strong construction and high reliability.

(3) High-precision positioning control.

(4)No stroke limit.

(5)Better dynamic response

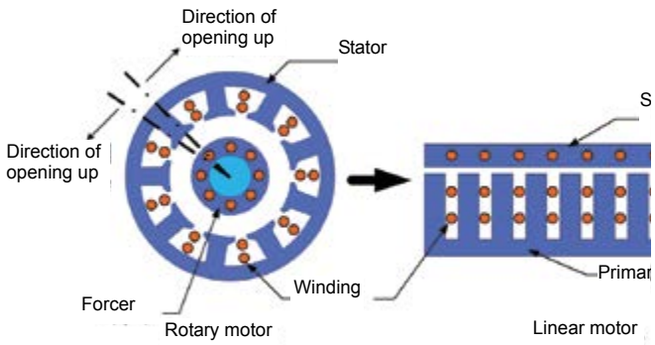


Fig. 1 旋轉馬達演變成線性馬達之過程/
Evolution process of rotary motors into linear motors

(6)Little wear, long life.

Disadvantages are:

(1)Linear motors have an open structure so they are prone to magnetic leakage.

(2)Loads are vulnerable to the thrust ripple or vibration generated by a linear motor.

(3)The sensing elements (linear scale) used have an open structure, so they are easily damaged.

(4)The energy loss generated during the transmission process will result in rising temperature. Such a temperature rise will be easily directed to the load end.

The structure of linear motors is actually derived from that of rotary motors. Take an induction motor as an example: if we cut open a rotary motor along its radial direction, and then open up the rotary motor into a straight line as shown in Figure 1, we will have a primitive linear motor derived from a rotary motor. In Figure 1, the part of a linear motor that is derived from the stator of the rotary motor is called the primary part. The part of a linear motor that is derived from the rotor of the rotary motor is called the secondary part.

線性馬達之分類

線性馬達在不同的情況下有不同的分類方式，最主要有兩種分類方式：依照結構型式分類與依照動作原理分類。

如果依照結構型式分類，主要可分為平板型線性馬達、圓柱型線性馬達、圓盤型線性馬達與圓弧型線性馬達，如圖2所示。

若依照動作原理分類，一般來說可分為五大類：線性直流馬達（Linear DC Motors, LDM）、線性感應馬達（Linear Induction Motors, LIM）、線性同步馬達（Linear Synchronous Motors, LSM）、線性脈衝馬達（Linear Pulse Motors, LPM）與線性混合式馬達（Linear Hybirid Motors, LHM），如圖3所示。

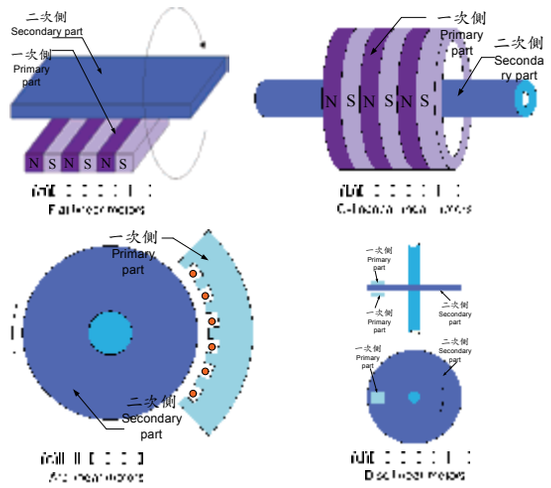


Fig.2 線性馬達結構分類/Categories of Linear Motors

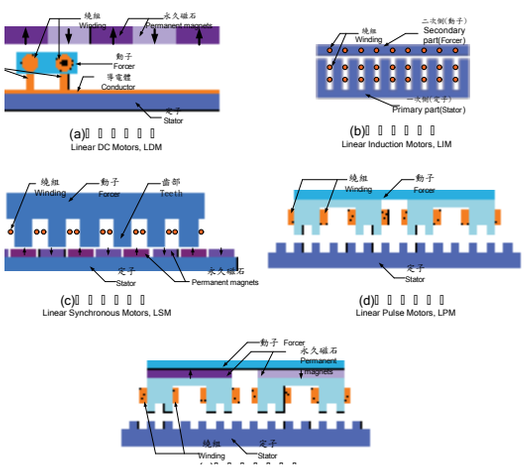


Fig.3 線性馬達動作分類/Operation classification of linear motors

根據不同的應用場合選用不同的線性馬達是非常重要的，由於恩德是將線性馬達應用於鑽孔機平台來回傳動，根據此需求線馬必須要有極大的推力、極快的加減速且推力漣波要小，因此選用平板式線性同步馬達為開發主軸。本文將會針對平板式線性同步馬達做說明。

Categories of Linear Motors

Linear motors are classified according to different principles. The two main classification principles are structure type and theory of motion .

If basing classification on structure type, we can divide motors into flat linear motors, cylindrical linear motors, disc linear motors and arc linear motors, as shown in Figure 2.

If motors are classified according to motion theory, in general, there will be five major types of motors: linear DC motors (LDM), linear induction motors (LIM), linear synchronous motors (LSM), linear pulse motors (LPM) and linear hybrid motors (LHM), as shown in Figure 3.

It is essential to use different linear motors for different applications. Since the Anderson Group uses linear motors to drive drilling machines back and forth, linear motors must have great thrust, fast acceleration and deceleration, and small thrust ripple waves. Therefore, we have chosen flat linear synchronous motors as our focus of development. This article will further describe flat linear synchronous motors.

線性同步馬達的結構介紹

一般線性永磁同步馬達分成兩大結構：動子(Forcer)與定子(Stator) 。動子顧名思義就是移動的部份又稱之為一次測，一般動子是由三相繞阻組成的，可分為有鐵心式(Core)和無鐵心式(Coreless)，如圖4所示。

有鐵心式

有鐵心式動子是由繞阻纏繞在矽鋼片齒部上所組成的，其結構如圖4(a)所示。有齒式同步馬達在結構上非常堅固，而且推力也比較高，但是因為有齒部的關係，所以

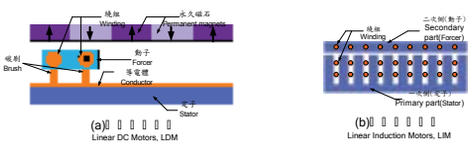


Fig.4 動子結構差異/Structural difference of forcers

在磁石和線圈之間會產生高的吸引力，此吸引力稱為頓力(Cogging Force)。若氣隙寬度有些許不同時，便會產生頓力導致系統不穩。

無鐵心式

無鐵心式馬達在繞線上是無齒部結構，故不會產生頓力和磁阻力，其繞組可分成集中繞與分佈繞。當需要高加速和低推力特性時，設計上會把繞組黏在軛鐵上，盡可能減輕動子重量來達到高加速特性。圖4(b)為短動子雙側式馬達，其具有高加速特性和高推力密度之特性，但是需要使用較多的磁石，會有增加成本的缺點。

Introduction to the Structure of Linear Synchronous Motors

Generally, permanent magnet linear synchronous motors contain two major structures: the forcer and the stator. As the name suggests, the forcer is the part that will move. It is also known as a primary part. General forcers are composed of three-phase armature windings and can be divided into core types and coreless types, as shown in Figure 4

Core

A core forcer is formed by winding around the teeth of silicon steel sheets. The structure is shown in Figure 4(a). Toothed synchronous motors are structurally strong and have high thrust, so there will be strong attraction between the magnet and the coil. Such attraction is called cogging force. If the gap width is slightly different, cogging force will be generated, resulting in instability of the system.

Coreless

Coreless motors have no teeth in winding, so cogging force and magnetic resistance will not develop. Winding can be divided into centralized winding and distributed winding. When high-speed and low-thrust are required, designers will fix the winding to the yoke to minimize the weight of the forcer in order to achieve high acceleration. Figure 4(b) shows double-sided motors with short forcers. This type of motor is characterized by high acceleration and high thrust. But since more magnets are required, the disadvantage is that the cost will be increased.

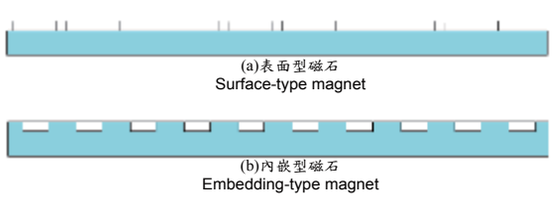


Fig.5 不同的定子磁石排列方式/Different arrangements of stator magnets

定子，顧名思義就是線性馬達固定的部分也可以稱為2次側，主要是由鐵芯與永久磁石構成。根據永久磁石配置方式可分為兩種類型，一種是永久磁石配置於定子鐵芯表面，稱之為表面型磁石排列，另外一種是在定子鐵芯嵌入永久磁石，稱之為內嵌型磁石排列，如圖5所示。

由於線性馬達的一次側或二次側的長　是有限制的，因此線性馬達的定子與動子會有邊緣末端。在動子側移動時，定子側會對動子產生一負向推　，因為末端磁場的改變在定子側感應出一電壓與一電　，此感應電　稱為邊際效應電，這種現象稱為邊際效應(end-effect)，此效應會　低線性馬達的動　且造成能　額外損失。此外邊際效應也會使線性馬達的頓力增加。

The stator, by definition, is the fixed part of a linear motor. It can also be called the secondary part and is mainly constituted by the iron core and the permanent magnet. There are two types of permanent magnet configurations: permanent magnets placed on the surface of the stator core, also called the surface-type magnet arrangement, and permanent magnets embedded in the stator core, also called the embedded-type magnet arrangement. These two types are illustrated in Figure 5.

Since the length of primary or secondary parts of linear motors have their limits, the stator and the forcer of linear motors have ends. When the forcer moves, the stator will produce a negative thrust of the forcer, because change of the end magnetic field can be induced with voltage and electric current by the stator. The induced current is called the end-effected current. Such a phenomenon is known as an end-effect, and this effect will reduce the power of a linear motor and result in additional loss of energy. Moreover, the end effect will also increase the cogging force of a linear motor.

線性同步馬達的動作原理

線性馬達的動作原理簡單來說是對一次側三相繞組通以三相交流電，此時一次側會產生一移動磁場，有如會移動的N極與S極，此移動磁場與二次側永久磁石所形成的磁場相互作

用而得馬達的推力，利用磁石與磁石間同極相斥極相吸的原理，讓馬達動子能隨著移動磁場同步的運動。如圖六所示，當動子位於Point A位置時，此時驅動器會給予動子三相繞阻對應的電流來產生磁場，此磁場會跟定子磁場相互排斥，因此動子會移動，當動子跑到Point B時，三相電流也要提供相對應的值，從這裡可以看到電流跟磁場都是時變的，因此動子可以任意的前進或是後退。

Theory of Linear Synchronous Motor Operation

Simply put, the operation theory of linear motors consists of providing three-phase AC current to a primary part with three-phase winding. A moving magnetic field will be generated on the primary part, just like the N-pole and S-pole. The moving magnetic field will interact with the magnetic field generated by the permanent magnet of the secondary part, and thus produce the thrust for the motor. By applying the theory that magnets with the same polarity will repulse each other and those with different polarities will attract each other, the motor forcer will move synchronously along with the magnetic field. Figure 6 shows that when the forcer is in the position of Point A, the driver will give the three-phase winding a responsive current to the stator to generate a corresponding magnetic field. At this point, the magnetic field and the stator are mutually exclusive, so the forcer will move. When the forcer moves to Point B, the three-phase current will have to provide a corresponding value. From here, we can see that the current and the magnetic field are time-varied, so the forcer can move forward or backward arbitrarily.

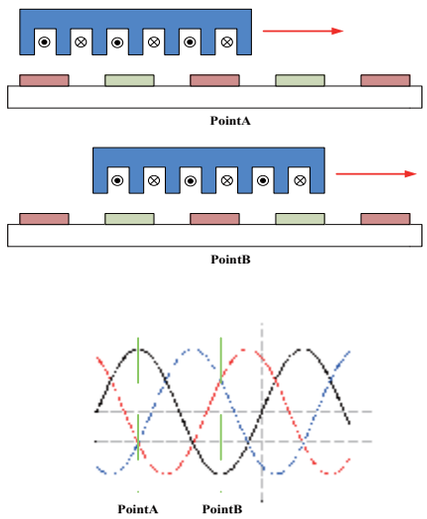


Fig6. 線性馬達位置與電流關係圖/
Diagram of relationship between linear motor position and current

線性同步馬達的設計概要

大致上說明完線性同步馬達的工作原理後，這邊要來談談線性同步馬達的設計概要，基本上涵蓋電機、機械和熱傳這三大領域，這邊主要針對電機部份設計說明。

Design Concept of Linear Synchronous Motors

After explaining the theory of how linear synchronous motors operate, we now move on to the design concepts of linear synchronous motors. Basically, three major areas will be covered—electrics, mechanics and thermal transmission. Here, we will mainly focus on the design of the electrical parts

[a]槽極數組合

在上述結構介紹中提到線性同步馬達主要是由一次側動子和二次側定子組成，所以動子和定子的搭配必須選擇合適的槽極數組合，槽極數組合會影響整個線性馬達的性能，例如推力跟頓力。因此槽極數的搭配是很重要的；此外，線性同步馬達跟旋轉馬達有個很不一樣的地方是線性同步馬達的極數不一定是要為偶數，旋轉馬達則是一定要為偶數。

[b]繞線的選擇

槽極數的搭配決定後，接著會影響的是繞線的配置，線性馬達的繞線方式主要分為兩種：集中繞與分布繞，要使用何種繞線方式主要是根據選用的槽極數來決定。由於分佈繞比集中繞需要較高的齒部來容納繞組，而且集中繞的末端繞組長度較短，可以減少銅損，使馬達的效能提高，因此有鐵心式的線性同步馬達通常會使用集中繞。

[c]頓力(cogging force)的影響

有鐵心式的線性同步馬達本身會有一個Y軸方向的阻力，可以簡稱為頓力，頓力是在沒有入電流下，由永久磁石與鐵芯槽齒間所產生的吸引力，頓力大致上由兩個成分所構成：槽效應與末端效應。由於頓力會使馬達在運作時產生震動且導致定位不準，因此，如何降低頓力成為每個線性馬達設計者需要克服的困難點之一。

藉由選擇適當的槽極數組合、磁石斜型(skew)或齒部削角可以降低由槽效應所產生的頓力，如圖7所示，而藉由

增加輔助極可以降低由末端效應所產生的頓力。以上這些方式是最普通降低頓力的方式，至於要選擇何種槽極數組合、磁石斜幾度或齒部削多大，就依據每個設計者的經驗了。

[d]磁性材料的選擇

一般在製作一台馬達時，所選的磁性材料通常可以區分如下：軟磁材料（Soft Magnetic Materials）與硬磁材料（Hard Magnetic Materials）。

馬達所使用的鐵芯導磁材料通常稱為軟磁材料，或稱為電磁鋼片，其因具有窄的磁滯迴路（Hysteresis Loop）、高的導磁率等特性，才能達到易著磁要求。在電磁鋼片中加入矽元素後又稱為矽鋼片。目前鐵芯都會使用矽鋼片薄片（厚度0.12 mm到0.64 mm之間）堆疊而成，用來截斷渦電流的路徑，以降低渦流損。

硬磁材料的部份指的是永久磁石，比起一般軟磁材料，永久磁石具有一個較寬的磁滯迴路，因而被稱為硬磁材料。由於永久磁石具有相當高的能量密度，因此被用來取代傳統的繞線線圈(excitation winding)。

永久磁石材料發展至今，一般常用的有鋁鎳鈷（Alnico）、氧化鐵（Ferrite）、釤鈷（SmCo）、及釹鐵硼（NdFeB）。其中鋁鎳鈷因為低矯頑力（coercive force, Hc），故磁能積(magnetic energy product)較低，一般常用氧化鐵，其因價格低廉，而在高性能的場合中通常使用釤鈷與釹鐵硼，但是因為釹鐵硼比釤鈷便宜很多，故偏愛使用釹鐵硼。

[e] 性能要求

在設計線馬之前，要先了解線馬所應用的場合，以恩德為例，線馬主要是應用在鑽孔機的Z軸來回移動進行鑽孔加工，為了達到高速加工的要求，必需先推估線馬所需的推力，以Z軸來說，由於Z軸線馬必須背負主軸跟一些機械零件進行加工(總重約為12 kg)且來回的加減速必須達到3G(1G=9.8m/s2)，根據公式F=ma，當加減速欲達到3G時，線馬必需提供353N的推力。

[a] Lot/pole number combination

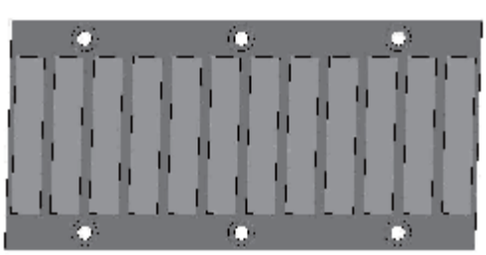
In the previous introduction of its structure, we mentioned that linear synchronous motors are composed of primary parts and secondary parts. Therefore, an appropriate slot/pole number combination must be chosen for the forcer and the stator. The slot/pole number combination will influence the performance of a linear motor, such as its thrust and cogging force. Therefore, the slot/pole number combination is very important. In addition, a linear synchronous motor is different from a rotary motor in that the pole number of the former doesn't have to be an even number, while the pole number of the latter has to be an even number.

b] Choice of winding

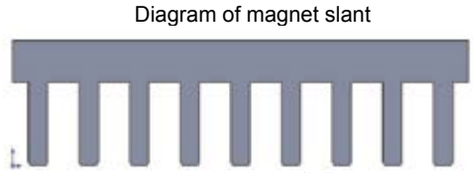
Once the slot/pole number is decided, the following step is to consider the winding configuration. Winding for linear motors is mainly divided into two categories: centralized and distributed winding. The choice of winding method depends on the slot/pole number selected. Since distributed winding requires higher teeth to accommodate the winding, and centralized winding has a shorter length of winding at the end, which can reduce copper loss and improve the performance of motors; therefore, centralized winding is commonly used for core linear synchronous motors.

[c] Impact of cogging force

Linear synchronous motors with iron-cores have resistance in the Y-axis direction, which can be referred to as cogging force. Cogging force is the attraction formed between permanent magnets and the slot and teeth of the iron core in the absence of electric current. Cogging force is mainly conposed of the slot effect and the end effect. Since cogging force will cause motors to vibrate during operation and thus result in inaccurate positioning, reducing cogging force has become one of the obstacles every linear motor designer must overcome.



(a)磁石斜型示意圖
Diagram of magnet slant



(b)齒部削角示意圖
Diagram of teeth cutting angle

Fig.7 結構示意圖/Structural diagram

The cogging force caused by the slot effect can be reduced by selecting appropriate slot/pole combinations, skew or cutting angle tooth, as shown in Figure 7. By adding the auxiliary pole, the cogging force generated by the end effect may be lowered. These are the most common ways to reduce cogging force. Each designer must decide the number of slot/pole combination, degree of skew angle, or the angle of teeth, based on their experience.

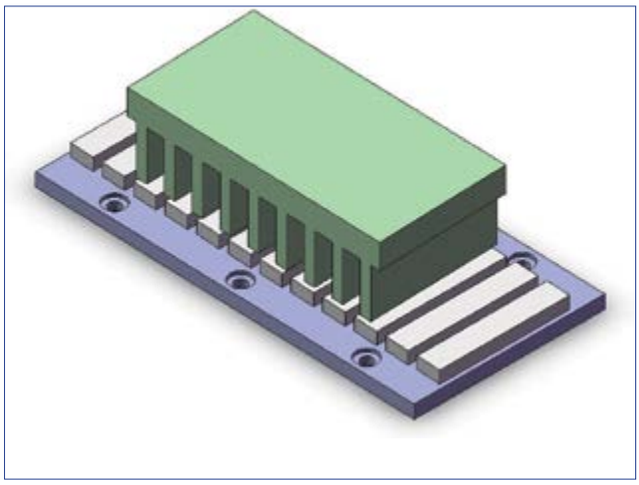


Fig. 8 恩德線性馬達架構圖/Structural diagram of Anderson Group's linear motors

[d] Choice of magnetic materials

Generally, when a motor is manufactured, the magnetic materials to be chosen include soft magnetic materials and hard magnetic materials.

Iron core magnetic materials used in a motor are usually soft magnetic material, or electromagnetic steel sheets. They have the characteristics of narrow hysteresis loop and high permeability, so they can meet the requirement of easy magnetization. Silicon steel is produced by adding silicon in an electromagnetic steel sheet. Currently, iron cores are made by stacking thin silicon steel sheets (with thickness between 0.12 mm to 0.64 mm). This way, the path of eddy currents can be cut off in order to reduce electrical current loss.

Hard magnetic materials refer to permanent magnets. Compared to soft magnetic materials, permanent magnets generally have a wider hysteresis loop; that is why they are called hard magnetic materials. Since permanent magnets have a rather high energy density, they are used to replace traditional excitation winding.

Common permanent magnetic materials that have been developed include alnico, ferrite, SmCo, and NdFeB. Of these, alnico has low coercive force (Hc), so its magnetic energy product is low. Generally, iron oxide is used due to its low cost. In high-performance situations, SmCo and NdFeB are commonly used. However, since NdFeB is a lot cheaper than SmCo, NdFeB is more commonly used.

[e] Performance requirements

Before designing motors, it is essential to understand the circumstances in which the motors will be used. Anderson Group linear motors, for example, are mainly used with the Z-axis for drilling machines that conduct drilling back and forth. In order to meet the requirement of high-speed processing, it is essential to estimate the thrust needed by linear motors. Since the Z-axis linear motors must carry the spindle and some mechanical parts to perform processing (with total weight of about 12 kg), and the round-trip acceleration and deceleration must reach 3G (1G = 9.8 m/s2) according to the formula that F = ma, linear motors must provide 353 N thrust if the acceleration and deceleration speed of 3G is to be reached.

恩德線性馬達的發展與應用

根據前述所提出來的一些應用的需求與設計概要，恩德致力開發應用於鑽孔機Z軸的平板式線性永磁同步馬達，其架構如圖8所示，表一為恩德Z軸平板式線性馬達之規格表。目前Z軸加減速已經能夠達到3G的需求。

國內工具機業者能夠自己開發機台跟線性馬達的公司少之又少，主要原因在於一般機械廠所具備的電機機械專業知識比較不足，恩德投入電機設計領域已經有段時間，目前主要是針對Z軸線性同步馬達和主軸馬達進行開發，未來希望可以開發X跟Y軸線性同步馬達，讓廠內機台都能應用恩德自己所生產的線性馬達，這樣成本會更加有優勢，因此，機械跟電機能夠達到上下垂直整合的話，這樣恩德工具機在業界會更具有競爭力。

Development and Application of Anderson Linear Motors

Based on application needs and design concepts, the Anderson Group is committed to the development of flat permanent magnet linear synchronous motors used for Z-axis drilling machines. The structure is shown in Figure 8. Table 1 shows the specifications for Anderson flat permanent magnet linear synchronous motors used in Z-axis drilling machines. Currently, the Z-axis acceleration and deceleration have been able to achieve 3G requirements. Very few machine tool manufacturers in Taiwan are able to develop their own machines and linear motors. One of the main reasons is that most machinery plants lack electrical and mechanical expertise. The Anderson Group has been working in the field of motor design for some time, and its current focus is developing Z-axis linear synchronous motors and spindle motors. In the future, the company also aims to develop X and Y axis linear synchronous motors so that all the machines in a factory can be run by linear motors produced by the Anderson Group. In this way, Anderson Group will gain an advantage in machine's cost. In conclusion, with vertical integration of electrical and machinery tools, the Anderson Group will be more competitive in the machine tool industry

Table 1. Z軸平板式線性馬達之規格 / Specifications of Z-axis flat linear motors

連續推力[N] Continuous thrust	372
電流[A] Current	3
推力常數[N/A_{rms}] Thrust constant	124
反電動勢常數[$V_{rms}/(m/s)$] Back EMF constant	73.88
散熱系統Cooling System	Water Cooling

PCB盲Router技術探討
PCB Depth Routing Technology

鄧金安 Jin-An Teng from AIC

近年來PCB產業的盲撈應用越來越多，恩德為因應客戶的不同需求而著手開發相對應機種以滿足PCB產業，另來盲撈深度的精度要求也不斷提高，為此恩德進行多項實驗測試企圖找出影響盲撈精度的問題點並加以改善。以下將針對恩德公司的盲撈機種說明。

In recent years, there are an increasing number of applications for depth routing in the PCB industry. In response to the different needs of customers, Anderson began developing models to satisfy the requirements of the PCB industry. Moreover, recently the requirement for precision in depth routing depth has been increasing. Anderson conducts multiple experimental tests to find out the factors affecting the precision of depth routing and to improve the problems. Below are descriptions of Anderson's depth routing models.

壓力腳上加裝光學尺型盲撈機

適用於從加工板面往下控制深度的加工，盲撈精度可控制在+/-0.05mm內。此型式盲撈機提供了三種偵測工件板面高度模式：

a)．只在每次M15下刀時同步偵測工件板面高度。

b)．執行程式中的每個單節的起始點偵測工件板面高度。

c)．動態即時偵測工件板面高度。

經測試後發現模式a是此型盲撈機控制深度是最穩定的，而模式b與模式c偵測工件板面方式會受到壓力腳與工件磨擦而讓壓力腳傾斜，進而影響到偵測板面高度的數值。若PCB工件表面不允許有刮痕時，可先放置一片FR4板在材料上方，再執行盲撈動作。

Depth Routing with Linear Scale Equipped on Pressure Foot

This depth router with linear scale on pressure foot can be applied to processing that controls depth downward from the processing board surface. The depth routing accuracy can be controlled within +/-0.05 mm. This type of depth router provides three modes of detection of board height for the workpiece:

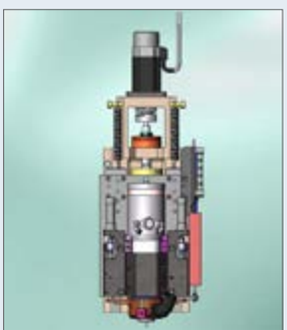
a) Synchronized detection of board height of a workpiece only when Z axes move down command M15 steps-down.

b) Detection of board height of a workpiece at the start point of each single section in program execution.

c) Dynamic real-time detection of the board height of a workpiece.

After testing, we found that depth-control was most stable under the first mode described above. Using modes b and c for board detection of the workpiece, the pressure foot tilts due to the friction between the pressure foot and the workpiece. The value of the detected board face height is therefore affected. When scratches are not allowed on the surface of a PCB workpiece, place one piece of FR4 board on top of the material and then proceed with depth routing.

光學尺探針式盲撈機



光學尺/Linear scale
Resolution 0.001mm

應用上分成兩種：

1. TOP Mode：探針偵測加工件板面高度後，依程式定義的深度從PCB板面往下計算控制深度。

a). 自動探測加工板面高度模式

執行加工程式時，機台先使用探針自動探測工件板面上的每一個M15的加工下刀點的板面高度，接下來再執行盲撈動作。

b). 多點探測工件板面高度後取平均值模式.

工程人員可以在加工程式中定義每個加工區多個量測點，並取每一區的平均值當作加工件的板面高度。

盲撈程式指令M18Z1.0（Z 正值表示殘厚加工 1.0mm, M18 開啟盲撈加工）

2. Buttom Mode：必須先使用探針探測檯面加工區域的平面度，控制器會建構一個虛擬曲面，然後置放工件於電木板上進行盲撈，且控制器會依曲面的高低變化數值而改變Z軸高度，此盲撈模式的深度是從PCB板子底面往上計算深度，一般稱為殘厚加工。

盲撈程式指令M18Z-1.5(Z負值表示殘厚加工 1.5mm, M18 開啟盲撈加工)

操作流程：

a). 讀取探測檯面的程式並執行探測動作。

b). 儲存探測檯面的數據於檔案中。

c). 讀取殘厚盲撈加工程式，並執行盲撈動作。

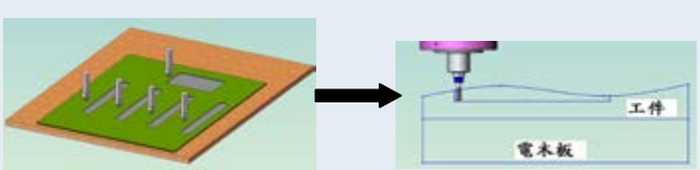


Fig.1

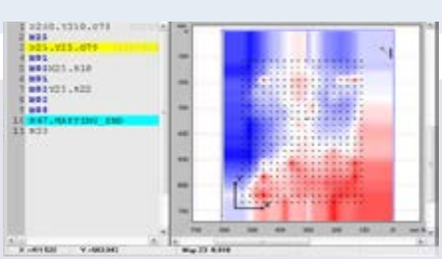


Fig.2 探測檯面平面度結果示意圖
Schematic Diagram for Result of Detected Table Flatness
紅色區表示比參考點高
Red zone indicates the values are higher than reference point.
藍色區表示比參考點低
Blue zone indicates the values are lower than reference point.

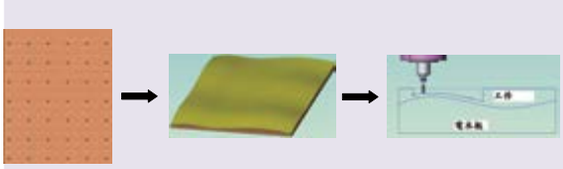


Fig.3

電流偵測式盲撈機(接觸式盲撈機)

偵測盲撈深度的基準為PCB的內層銅，在電路板製程中必須將盲撈基準的銅層布線到電路板外側邊緣，以方便將信號連接電流偵測模組，此種型式的盲撈機的主軸與機台必須要做到完全隔離，其中關鍵在於主軸，其軸心與外殼必須是可以導電的結構，否則無法達成此功能。(Fig.4)

Depth Router with Linear Scale Probe

1. TOP Mode: After the probe detects board height of the processing workpiece, the controlled depth is calculated in accordance with depth as defined by the program downward from the PCB board face.

a) Auto Detection Mode of Processing Board Surface Height .When the processing program is running, the machine automatically detects the board surface at each Z axes move down position(command M15)by using the probe.Then runs the depth routing action.

b) Average Value Mode after Multiple Detections of Board Surface Height for a Workpiece.

Engineers can define multiple measuring points at each processing area in the processing program. The average value of each area is then used as the board surface height of the workpiece being processed.

Engineers can define multiple measuring points at each processing area in the processing program. The average value of each area is then used as the

改善盲撈精度項目

除上述的不同的盲撈機構或原理會影響精度外，另外還有一些相關的週邊設施也會直接或間接影響精度結果，以下分別說明探討。

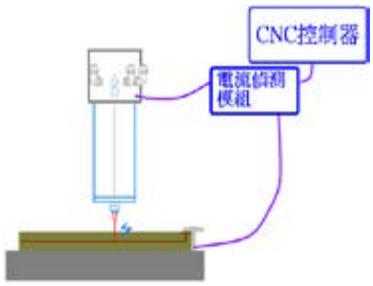


Fig.4

1. 安裝Z軸光學尺（解析度0.001mm），可達到Z軸全閉迴路控制：消除機械傳動系統中的各種誤差與間隙。
2. 電木板增加固定螺絲孔，降低電木板板翹問題：舊版本的電木板只有在週圍有固定螺絲，中間的板翹問題嚴重，使用千分錶探測並用手壓電木板時，數值變化有些會超過150um以上，這個現象會嚴重影響盲撈深度的穩定性，因此增加電木板中間的螺絲固定孔，降低電木板板翹問題。(Fig.5)
3. 使用高精度量刀器（OMRON, D5A-8511 High precision switch)，校正量刀器平面。(Fig.6)

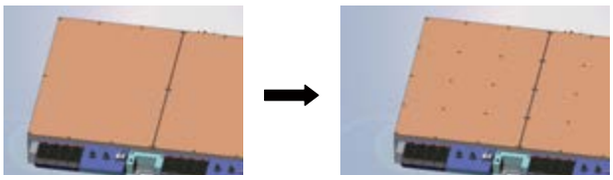


Fig.5

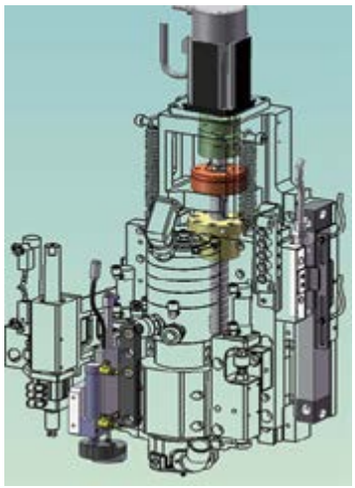



Fig.6

電流偵測式盲撈機
Blind Router with Linear Scale Probe

board surface height of processing workpiece.

Depth Routing Program Instruction M18Z1.0 <- Z positive value indicates remaining thickness processing of 1.0mm, M18 activates depth routing processing (Fig.1)

2. Bottom Mode: Must use the probe to detect the flatness of the table processing area first. The controller will then establish a virtual curve. Next, place the workpiece on the template to proceed blind routing. The controller will change the Z-axial height according to the change in values of the curve surface. The depth of this type of depth routing mode is calculated upward from the bottom surface of a PCB plate, and is generally referred to as remaining thickness processing.

Deooth Routing Program Instruction M18Z-1.5 <- Z the negative value indicates a remaining thickness processing of 1.5mm; M18 activates depth routing processing

Operation Process:

a) Read the program of “Detective Table” and run the detective action.

b) Save the data of table detection on file.

c) Read the production program of “Remaining Thickness ” and run the depth routing action. (Fig.2 &Fig.3)

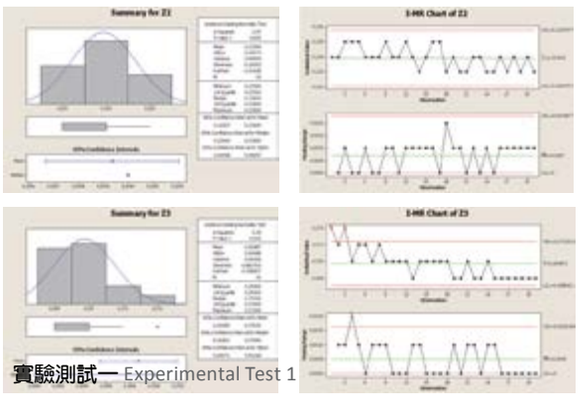
Depth Router with Current Sensing (Contact Depth)

The inner copper layer of PCB provides the basis for depth routing detection. During circuit board manufacture, it is necessary to wire a basis for blind routing, the copper layer, to the outside edge of the circuit board in order to facilitate the connection between the signal and current sensing module. The spindle and machine of this type of depth router must be completely separate. The key to the separation is on the spindle. The axle center and outer case must be the conductive structure, or this function cannot be achieved.

(Fig.4)

Improvements on Depth Routing Precision

In addition to ways the depth routing mechanisms or principles mentioned above may affect precision, there are some other related peripheral devices that may



實驗測試一 Experimental Test 1

directly or indirectly affect the precision results.

1. Installing a Z-axis linear scale (resolution of 0.001mm) to achieve Z-axial full closed loop control eliminates of a variety of errors and gaps in the mechanical drive system.

2. Add fixed screw holes on template to reduce warp, or on older version template, the fixed screws are only on the edges. In this case, the gap between the template and the table is most serious in the middle area. When a dial indicator is used for detection and press down the template by hand, the gap between the table and the template can be measured values more than 150um. This phenomenon seriously affects the stability of depth routing . Hence the solution is to add fixed screw holes in the middle of the template to reduce the problem of warp.(Fig.5)

3.Use the high-precision tool measure (OMRON, D5A-8511 High precision switch) to calibrate the plane of tool measurement. (Fig.6)

實驗測試一

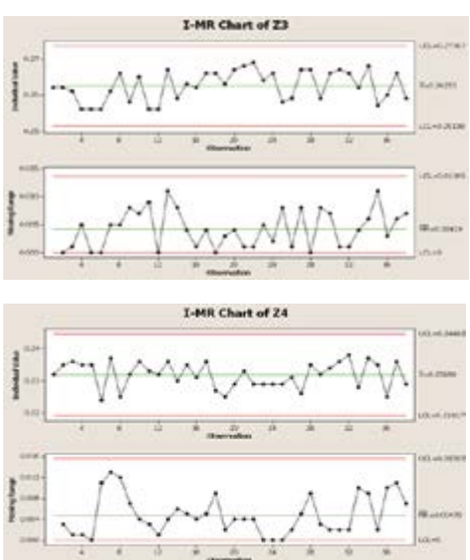
同一把刀具在主軸不旋轉的條件下測試，使用此量刀器的重覆精度3~4um左右。

實驗測試二

條件1：沒有按正量刀器平面。

條件2：主軸有旋轉，於停止後測量刀長。

結果：每次量測刀長的變化最大為11~13um。

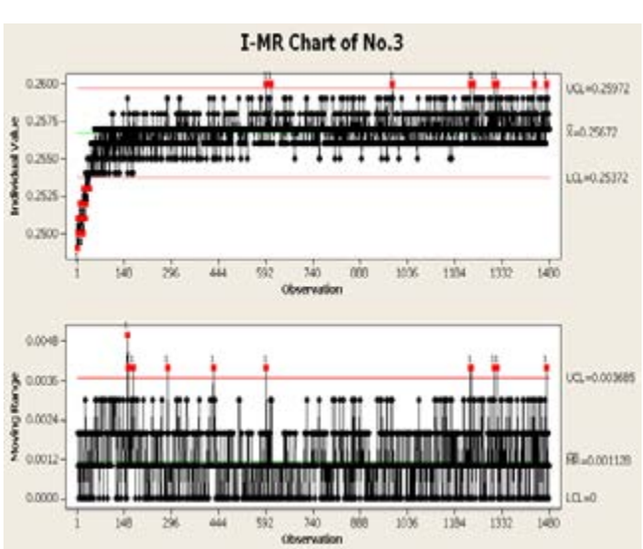


實驗測試二 Experimental Test 2

實驗測試三

條件1：按正量刀器平面於5um左右。 .

條件2：主軸有旋轉，於停止後測量刀長。



實驗測試三-1 Experimental Test 3-1

Experimental Test 1

Test the same tool under the condition of the spindle not rotating. The repeatability of this tool measure is around 3~4um.

Experimental Test 2

Condition 1: No calibration on tool measure plane.

Condition 2: Spindle rotates. Measure tool length after the spindle stops rotating.

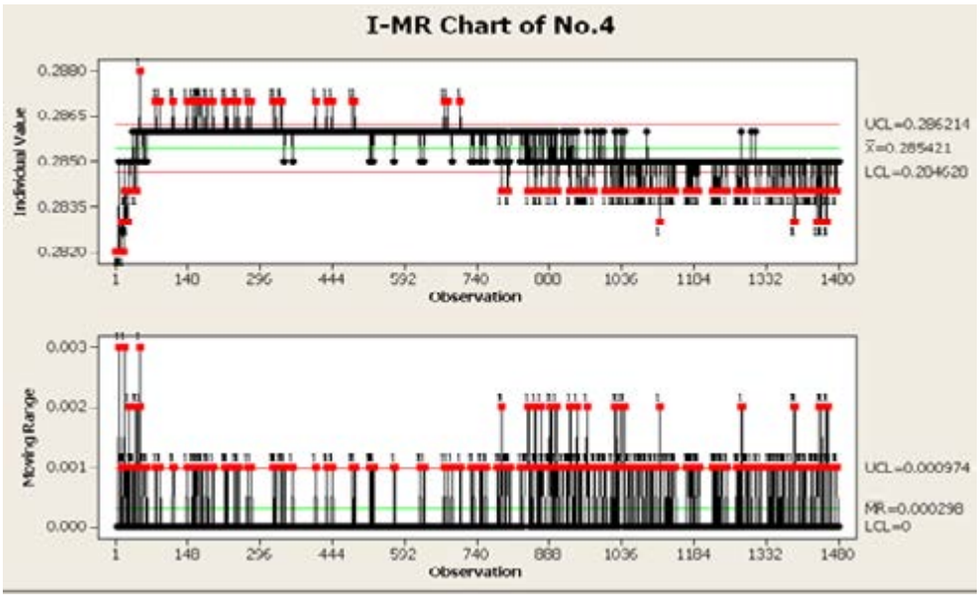
Result: the maximum change in measured tool length is 11~13 um.

Experimental Test 3

Condition 1: Calibrate the tool measure plane around 5um.

Condition 2: The spindle rotates. Measure tool length after the spindle stops rotating.

Result: the maximum change in measured tool length is 3~5 um.



實驗測試三-2 Experimental Test 3-2

結果：每次量測刀長的最大變化為3~5um。

除上述的實驗，使用白色塑膠材質壓力腳墊，以及主軸的壓力腳氣缸壓力調於2kg/cm時的盲撈精度較穩定，因為主軸壓力腳可以確實將PCB電路板確實壓平於檯面上。

最近在客戶端執行恩德的光學尺探針式盲撈機實驗中，程式中定義的殘厚為0.25mm，單趟五個主軸加工結果殘厚落在0.23~0.25mm，這個結果客戶非常滿意，此客戶的公差需求為0.25+/-0.03mm；當然這個結果只是一個參考數據，因為此數據尚未包含測刀誤差及主軸溫升所導致的誤差；克服主軸溫升問題方面，可思考主軸結構是否有改善的空間，應用方面可增加主軸暖機功能或於盲撈加工一段時間後，以重新量測刀長方式克服。

Apart from the above experiments, blind routing precision is more stable when the pressure pad uses white plastic material and the cylinder pressure of the spindle pressure foot is set at 2kg/cm². The reason is that a spindle pressure foot can securely press the PCB circuit board flat on the table.

In a recent experiment at a customer's end facility we executed Anderson's depth router with a linear scale probe. The program defined the remaining thickness of workpiece as 0.25 mm and the single trip processing result of five spindles were within 0.23~0.25 mm. The customer was very satisfied with the result, as the demanded tolerance was between 0.25+/-0.03 mm. Of course this result provides only reference data because it does not include tool measurement deviation and deviation caused by the rise in spindle temperature. As for overcoming the problem with a rise in spindle temperature, we can consider room for improvement on the spindle structure. In terms of application, we may strengthen the warm-up feature of spindle. Another way to overcome the problem is to measure the tool length again after the blind routing processing runs for a period of time.

雷射軟板切割機之應用與簡介
Application and Introduction of Laser FPC Cutters

方思巽 Arnors Fang From SOGOTEC/ 施逸廷 Shi Yiting From DPC/ 劉致奚 Kai Liu From DPC

前言

60~70 年代時，軟板最主要被美國用於軍事、航太方面，後因冷戰結束，美國國防經費大幅刪減後，才使得大量用於民生工業；而我國和日本最早是應用於計算機、照相機等消費性產品，後因近十年來資訊及電子產業的蓬勃發展，逐漸將應用範圍擴及於電腦、電子週邊、通訊等領域。對於一般的消費性電子產品來說，以單價較低且兼具傳輸電性及可撓性的單雙層軟板為主；而較為複雜的大型機具，則以多層板應用居多。以下為各層軟板的應用範圍(表一)，目前公司在PCB硬板的生產設備如成型機及鑽孔機已非常成熟，且之前各家從事硬板生產之廠商由於競爭及毛利率下降，產業轉型升級、客戶要求等因素，有些也想轉型來生產軟板，有鑑於此開發軟板切割及鑽孔設備，已成為公司未來研究發展方向。

Background

In the 1960s and 1970s, flexible printed circuit (FPC) boards were mainly used by the military and aerospace industries in the United States. After the end of the Cold War, a significant reduction in the U.S. defense budget shifted applications of FPC boards to industries related to people's livelihood. Taiwan and Japan are the countries that first used FPC boards in consumer products such as calculators and cameras. With the rapid development in the information and electronics industries over the past decade, FPC boards have gradually come to be used in many fields, such as computers, electronics and communication. Due to their low unit price and transmission capacity and flexibility, single and double layer FPC boards are widely used in general consumer electronic products. More complex, large-scale equipment, mostly uses multilayer FPC boards. The application scope for different layers of FPCs is shown below in Table 1.

Our company already has highly developed equipment, such as molding machines and drilling machines, for producing printed circuit boards (PCBs). In addition,the manufacturers that are engaged in the production of PCBs also want to switch to the production of FPC boards as a strategy to deal with severe competition, declining gross profit margins, transformation and upgrading of industry, customer requirements and many other factors. As a result, the development of FPC board cutting and drilling equipment has become a focus of the company's future research and development.

軟板的定義

軟性印刷電路板又稱為軟板，軟性印刷電路板(Flexible Printed Circuit Board；FPC)英文縮寫為FPC將一可撓式銅箔基板，經蝕刻等加工工程，最後留下所需的線路，以作為電子產品訊號傳輸的媒介。FPC主要用以搭載電子零件，如積

體電路晶片、電阻、電容、連結器等元件，以使電子產品能發揮既定的功能。由於FPC具有折撓性及可三度空間配線等特性，在科技化電子產品強調輕薄短小、可折撓性的趨勢後，FPC將有很大的成長空間，而它的發展並能使相關電子產業更加蓬勃。[1]

採用軟板的優點包含使產品依照空間改變形狀做成立體配線，因此能夠縮減體積，也同時能減少重量。而且軟板本身，除了原有的載台的功能外，也能應用在PCB硬板間，或者是與其它模組之間的連結，例如在LCD的領域中，驅動IC可採用COF(Chip on Film)的方式打在軟板上，然後再與玻璃面板之間的電路相連結，大家可以想見講求輕薄的LCD產品，是非常的講究側面厚度的縮減，如果不是使用軟板，幾乎是不可能達成這樣的效果。但是這樣的設計也不是沒有缺點，軟板的生產成本較高、必須客製化生產、甚至不容易採取全自動化生產線，在接合上也不適合較重的元件，甚至還有容易產生靜電效應等因此軟板在使用上也是有一定的限制。

軟板種類 Category of FPC	應用範圍 Applications
單層板 Single layer	碟機、行動電話、DSC、STN-LCD Hard drives, mobile phones, DSC, STN-LCD
雙層板 Double layer	PDP、LCD-TV、LCD Monitor
多層板 Multilayer	大型機具 Large machinery

Table 1. 各層軟板的應用範圍 /
The Application Scope of Various Layers of FPC
資料來源Source: IT IS

Definition of Flexible Printed Circuits

Flexible printed circuit boards, also known as FPCs, are made from FCCL (flexible copper clad laminate) through etching and other processes. The circuits are then created on the FCCL to serve as a medium for signal transmissions in electronic products. FPC boards are mainly used to carry electronic components such as integrated circuit chips, resistors, capacitors, connectors and other components so that electronic products can function properly. Since FPC boards have the features of flexibility and three-dimensional wiring, they have great potential in a modern world that demands lightweight, thin, and compact electronic products. Their development will also trigger the vigorous growth of related electronics industries. [1]

One of the advantages of FPC boards is that three-dimensional wiring is possible for to accommodate different shaped products, allowing product volume and weight to be reduced. In addition to their original function as a stage, FPC boards can also be used in PCBs, or as a connection with other modules. For example, in the field of LCDs, driver ICs can be printed to FPC boards using the COF (chip-on-film) method, and can then be connected with the circuits between the glass panels. Since LCD products are lightweight and thin, it is essential to reduce the thickness of the side. Without FPC boards, it is almost impossible to achieve this effect. However, such a design is not without its drawbacks. The product cost of FPC boards is high, production must be customized, it is not easy to implement fully automated production lines, heavy elements are not suitable for connecting, and it is even prone to static electricity effect. As a result, FPC boards have their limit in terms of applications.

軟板材料及結構

軟板主要應用材料為FCCL （軟性銅箔基板），是以銅箔與絕緣基材組合而成。銅箔使用壓延銅箔或是電解銅為主，但以壓延銅的延展性比較好；作為絕緣基材的材料主要是PET或PI（聚亞醯胺樹酯），至於接著劑則以壓克力膠、或環氧樹酯為主。FCCL製造流程中，以精密塗布與壓合之控制最為關鍵，對潔淨度要求相當嚴格，而就成本而言，PI與壓延銅箔大概就佔了七成以上，製程掌握的難度又比硬板高出許多。軟板也可依層數區分為2 Layer FCCL的無膠系軟板基板，和3 Layer FCCL的有膠系軟板基板。兩者最大差異在於銅箔和PI膜之間有無接著膠劑。而2L FCCL具有耐熱性高、耐撓折性好、尺寸安定性良好等優點，但成本相對較高，因此大部份軟板主要使用3L FCCL，只有較高階軟板才會用到2L FCCL。一般軟板結構，如圖一所示。

Material and Structure of FPC Boards

The main material used in FPC boards is FCCL (flexible copper clad laminate), which is composed of copper foil and insulating substrates. Copper foil is mainly rolled annealed copper or electrodeposited copper. Yet rolled annealed copper has better ductility; materials used as insulating substrate are PET or PI (polyimide resin). Acrylic or epoxy resin is used for the adhesive. In the process of manufacturing FCCL, precision casting and lamination are the critical key points. Cleanliness requirements are stringent. In terms of cost, PI and rolled annealed copper account for more than 70% of the total cost. The production process is more difficult than that of PCBs. According to the number of layers, FPC boards can be divided into two-layer FCCL without adhesive and three-layer FCCL with adhesive. The biggest difference between them is whether there is adhesive between the copper foil and PI film. Two-layer FCCL possesses heat resistance, high flexibility and good dimensional stability, but its cost is relatively high. Therefore, the majority of FPC boards used are three-layer FCCL. Two-layer FCCL is used only in higher scale FPC boards. The structure of a regular FPC board is shown in

Figure 1:

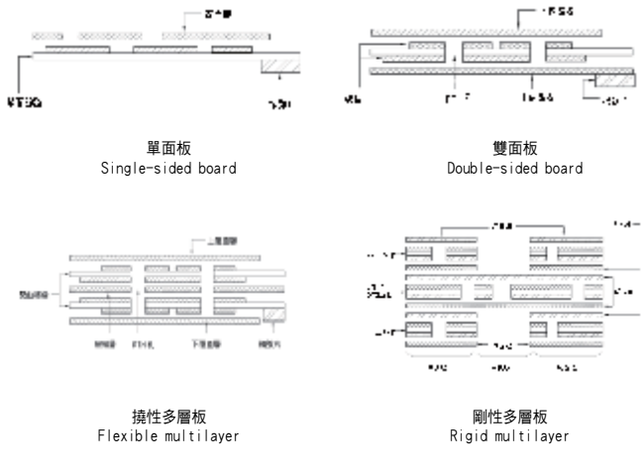


Fig. 1 軟板結構圖 / Structure Diagram of FPC

軟板切割機功能規格要求

目前開發的軟板切割機設備屬第一代的產品，未來還會針對客戶製程需求，開發新功能及整合性的上下料系統(Roll to roll、Sheet to sheet)，此設備目前搭配355波長的UV Laser及同軸CCD輔助定位系統並配有蜂巢式真空台面，及鑽孔用治具。適用於一般軟性電路板(單層、雙層、多層)外型切割及孔型穿孔加工，並配有程式轉檔軟體，可經由轉檔讀取Gerber及DXF檔案進行轉檔加工使用，其機台外觀及功能規格如附圖二及附表二所示：

Fig.2 軟板切割機(FBL-D15W)外觀圖 / Appearance of FPC Cutters (FBL-D15W)

項目/Item	規格描述/Specification
雷射腔體/UV Laser	(1) Laser Wavelength : 355 nm (2) Avg. Power @30kHz: 15W (3) Pulse Width @30kHz: 20ns (4) Pulse Energy @30kHz: 0.5mj (5) Long- term Instability(8h +/- 3c):+/- 2%2
掃描頭組/ Scanner head	(1) Working wavelength: 355nm (2) Field size: 54 x 54mm
擴速鏡/Beam Expander	2~10x
聚焦鏡/F- θ Lens	(1) EFL: 100mm (2) Field size: 54x 54mm
XY軸平台/XY Table	(1) Driving mode: linear motor (2) The table size: 533 x 633mm (3) X-axis travel: 550mm (4) Y-axis travel: 650mm (5) Maximum speed: 30m/min (6) Linear scale resolution: 0.2um (7) Positioning precision: + / - 2um
操作軟體/Software	(1) Compatible format: Gerber & DXF file conversion (2) Laser parameter adjustment (3) Automatic alignment and calibration
視覺系統/CCD System	(1) Image capturing components: CCD (2) Coaxial CCD image capturing and positioning CCD
冷卻系統/ Chiller System	(1) Inner circulation, use of laser cooling (2) Cooling capacity: 570W at 20C water/35C (3) Water tank capacity: 5 liter
製程能力/Process Capability	(1) Appearance accuracy: + / - 25um (2) The minimum cutting diameter: 50um

Table 2. 軟板切割機功能規格表 / Functions and Specifications of FPC Cutters

Functions and Specifications of FPC Cutters

The current FPC cutters are first generation products. In the future, integrated loading and unloading systems (roll-to-roll, sheet-to-sheet) with new features will be developed in accordance with customers' needs. This device is currently equipped with UV Lasers with a wavelength of 355 nm, a coaxial CCD assisted positioning system, a cellular vacuum table, and drilling tools. It is applicable to regular FPC board (single layer, double layer, multilayer) exterior cutting and hole perforation processing. It is also equipped with program file conversion software. Through file conversion, Gerber and DXF files can be read and used in processing. The appearance, functions, and specifications of the machine are shown in Figure 2 and Table 2 below:

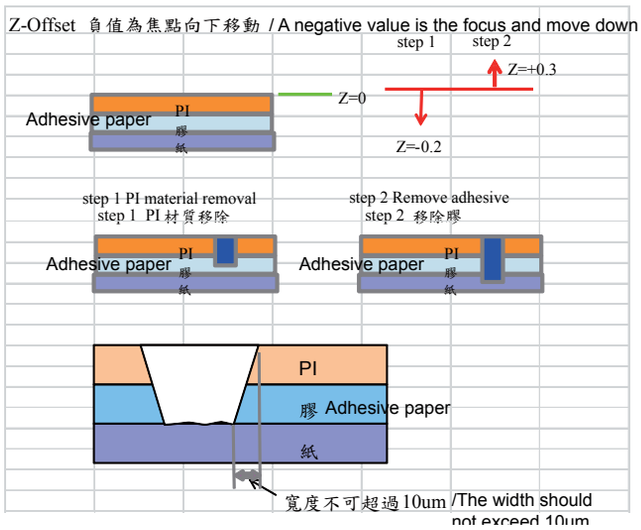


Fig. 3 軟板切割示意圖 / Diagram of FPC Cutting

軟板外型切割

軟板切割機製程能力要求，膠層的移除是軟板切割的關鍵，且切割度不可超過10u，且軟板不能放至超過3個月膠層會硬化需保持密封，在撕PI時必需要壓住紙不能同時撕，這在於雷射在切割時功率的控制及焦距高度調整和台面平整的穩定性都有相對關係，當然膠的材質也會有影響。目前比較常用的PI軟板有兩間廠商HANWHA與INNOX，HANWHA公司出產的軟板膠層品質比較好，雷射切割加工容易，但材料較貴只需一次加工即可完成，但相對的INNOX公司出產的軟板膠層品質較差較會有壓合後的微小氣泡產生，雷射切割加工較不易，需要二次加工才可完成，但在成本的考量之下，還是有比較多廠商使用價格便宜的軟板，所以在軟板切割加工方面也必需要，克服因為不同軟板材質所造成加工參數的影響。這也是目前我們機台必需要努力及加強的地方。其軟板切割示意圖如圖三所示:[2]

Exterior Cutting of FPC Boards

For the production capability requirements of FPC cutters, the key to FPC cutting is the removal of the adhesive layer. The cutting width also cannot exceed 10u. In addition, FPC boards cannot be stored for more than three months since the adhesive layer will become hardened. Therefore, it is necessary to keep the adhesive layer sealed. When PI is being torn, it is necessary to press and hold the paper rather than tearing them at the same time. There is a corresponding relationship between the laser power control, cutting focus and height adjustment, and the stability of the working table. Of course, the materials of the adhesive will also have an impact. Currently, the most commonly used PI FPC boards are provided by two manufacturers, Hanwha and Innox. Hanwha Company produces FPC boards with a better quality adhesive layer, so it is easier to implement laser cutting. However, the material is more expensive, even though it takes only single processing to complete the cutting work. In contrast, the adhesive layer of FPC

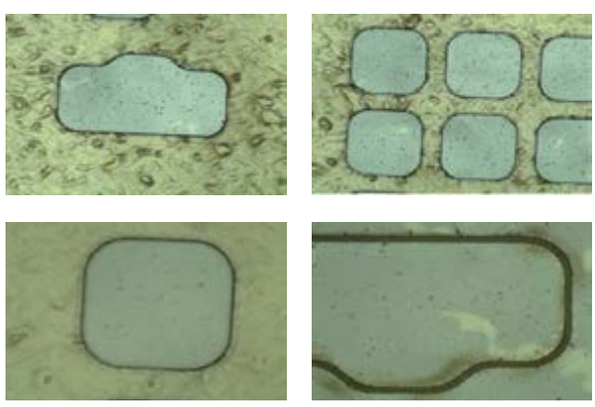


Fig4. 符合客戶要求的切割品質 / Cutting Quality which Meets Customers' Requirements

boards produced by Innox is of poor quality. There will be tiny bubbles after lamination and it is not easy to implement laser cutting. Therefore, secondary processing is needed. However, after taking cost into consideration, more manufacturers still choose cheaper FPC boards. Therefore, in FPC cutting, it is necessary to overcome the impact of different FPC materials on processing parameters. This is also where we need to strengthen and improve our machines. FPC cutting is as shown in Figure 3: [2]

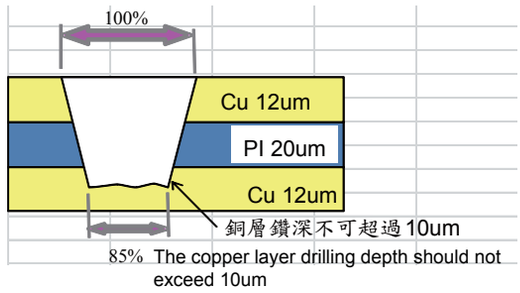


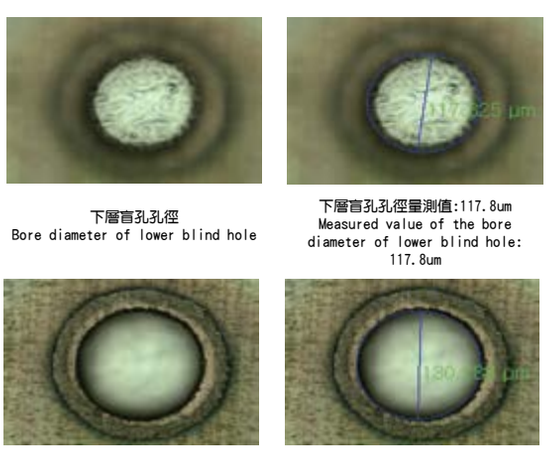
Fig.5 穿孔上下孔徑示意圖/
Diagram of Perforated Upper and Lower Bore Diameters

軟板外型切割品質要求

(a)切割後的PI軟板內部不能有雜質。
(b)材質設定參數要一致，不能過切而造成外型焦黑。
(c)切邊　度不能大於10u，線　要均勻一致。
(d)切圓角 時，切角要一致且不能有雜質存在。
(e)雷射功率調整不能過大，不然會造成溢膠及粉塵雜質大多。

Quality Requirements for the Exterior Cutting of FPC boards

(a) There cannot be impurities in the interior of PI FPC after cutting.
(b) Set consistent parameters for materials. Do not overcut and char the appearance.
(c) The width of the cutting side cannot be greater than 10u. The line width must be consistent.
(d) When cutting fillets, the cutting angles must be consistent and no impurities are allowed.
(e) Laser power adjustment cannot be too large, or it will cause excessive adhesive and too many dust impurities.



下層盲孔孔徑
Bore diameter of lower blind hole

下層盲孔孔徑量測值:117.8um
Measured value of the bore diameter of lower blind hole: 117.8um

上層盲孔孔徑
Bore diameter of upper blind hole

上層盲孔孔徑量測值:130um
Measured value of the bore diameter of upper blind hole: 130um

Fig6. 盲孔上下孔徑量測圖 /
Measurement Diagram of Upper and Lower Bore Diameters of Blind Holes

軟板穿孔

軟板穿孔主要是用於多層板的加工，而多層板是由單面板或雙面板所組成，並且透過鑽通孔使導電層相通或是利用功率控制鑽盲孔連接不同導電層，增加線路密度和提升可靠度，但有時因層數增多，會使的可撓性變差，其應用領域較有限。但也有客戶利用穿通孔去做軟板定位的基準孔，各材料製程端看客戶要如何應用，一般客戶要求穿孔時上下孔徑的誤差不能大於15%，舉例來說若客戶要求要鑽一個130um的孔徑，130x0.85=110.5um，也就是說在130~110.5um的上下孔徑是符合要求的。且可以過切底層銅箔，但深度不能超過10um。如附圖五、圖六、圖七所示:[2]

Perforation of FPC

FPC board perforation is mainly used for processing multilayer boards. Multilayer boards are composed of single-sided or double-sided boards, and different conductive layers are connected through the through holes or by controlling the blind holes through power. The density of circuits is increased and reliability is enhanced. But sometimes flexibility will deteriorate with an increase in the number of layers. Its field of application is also limited. However, there are also clients who use through holes to function as positioning reference holes for FPC boards.

Whether or not one can take this approach depends on how clients will apply the material in production. Generally, customers will require that the perforation error of the upper and lower bore diameters cannot be greater than 15%. For example, if customers request to drill a bore diameter of 130 um, 130 x 0.85 = 110.5 um, it means that the upper and lower bore diameters between 130 to 110.5 um are in line with the requirements. The underlying copper foil can be cut a little larger, but the depth cannot be more than 10 um as shown in Figures 5, 6, and 7: [2]

雷射軟板切割機的推廣

軟板產業最初應用於硬碟(HDD)和光驅領域，基本上被日本廠家壟斷。2003年照相手機的興起，催生一大批中國大陸和台灣以及韓國廠家進入，打破日本廠家的壟斷局面。2005到2006年，FPC市場達到第一個高潮，2007年開始殺價流血競爭。2007到2009年連續3年FPC平均價格持續下降，累積降幅超過50%，近百家小企業倒閉，軟板行業開始變得很健康。軟板的下游市場也在不斷擴大，擴展到手機、筆記本電腦、LED Light Bar等，最終軟板行業在2010年徹底翻身，2010年軟板市場達到81.91億美元，比2009年增加21%。

對手機而言，其功能模塊之間大多是用軟板連接，每增加一個功能模塊基本上就需要增加一片軟板。智慧型手機內部結構復雜，功能眾多，軟板使用量大增。尤其是2011年觸控屏成為智慧型手機標準配置，觸控屏的連接軟板具備一定難度，單價較高。追求超薄的電子產品都是軟板市場增長的動力，平板電腦也是軟板市場增長的驅動因素，英特爾2012年力推的Ultrabook同樣將促進軟板市場發展。2011年軟板市場繼續快速增長，達到95.69億美元，增幅17%，預計2012年將達到106.80億美元，增幅12%。[3]

有鑑於此，目前公司所生產製造的雷射軟板切割機，正在和韓國軟板生產製造商合作，進入產品製程驗證期，配合客戶的生產製程做機台修正，並了解製程的應用，雖然進入市場的時間點有點晚起步，但現在正好是軟板產業最蓬勃發展的時候，只要追求超薄的電子產品都是軟板市場增長的動力，且亞洲又是生產消費性電子裝置，最多的國家。所以只要機台能通過製程精度的驗證，後續的市場是可期的，也可以為集團帶來更高的利潤及成長。

Promotion of FPC Laser Cutters

FPC technology was originally applied in the fields of hard disk drives (HDD) and optical drives. Basically, FPC technology was monopolized by Japanese manufacturers. With the rise of camera phones in 2003, a large number of Chinese, Taiwanese, and South Korean manufacturers also entered the industry, thus breaking the monopoly of Japanese manufacturers. From 2005 to 2006, the FPC market reached its first climax. Cutthroat competition began in 2007. In three consecutive years from 2007 to 2009, the average price of FPC boards continued to decline, with an accumulative drop in price of more than 50%. Hundreds of small companies closed their businesses as a result. However, the FPC industry also became healthier and the downstream market of FPCs started to expand, spreading the trend to mobile phones, laptops, LED light bars, etc. Ultimately, the FPC industry saw a complete revival in 2010. The market value of FPCs in 2010 reached $ 8.191 billion, a 21% increase compared to the value in 2009.

For mobile phones, the functional modules are mostly connected by FPC boards. Basically, for every extra functional module, one FPC is required. The internal structure of smart phones is very complex. Since they come with many functions, the demand for using FPC technology has increased. The situation reached a climax in 2011, when the touch screen became a standard device for smart phones. The connecting FPC boards for touch screens are difficult and expensive to produce. The pursuit of ultra-thin electronic products has been driving growth in the PFC market. Tablets are also a source of momentum for FPC market growth. In 2012, Ultrabook promoted by Intel also promoted the development of the FPC market. In 2011, the FPC market continued to grow rapidly, reaching $9.569 billion, an increase of 17%. It is expected that in 2012, it will reach $10.68 billion, an increase of 12%. [3]

In view of this, the company is now cooperating with Korean manufacturers of FPC boards to test the production

ability of our laser FPC cutters. To explore the applications of our machines in production, Anderson will modify machines based on customers' production process needs. Although the company is still new to the market, it is entering the market at a good time when the FPC industry is booming. Since all electronic products that pursue ultra-thinness are providing the growth momentum for the FPC market, and Asia has the most countries that produce consumer electronics devices, the future of this market is huge. As long as our FPC cutting machines pass precision verification, they will without doubt bring profits and growth to the Group.

結論

2013年美通社PR Newswire/Reportlinker.com在全球軟性印刷電路板(FPC)行業研究報告指出，對軟性印刷電路板製造商來說，2012年是一個豐收年，FPC使用在幾乎所有流行的電子產品，特別是平板電腦和智慧型手機，它有力地促進了FPC市場。全球FPC市場規模達到USD 10,680 million，在2012年與2011年相比，同期相比增加了15.2%。2012年，FPC實現了強勁的增長在所有電子零件和部件，並在2013年將繼續保持強勁的增長勢頭。全球FPC市場規模在2013年預計將達到USD 11,628 million，與2012年相較將會成長8.9%。[4]

由上述的軟板產業趨勢探討可知，台灣貴為全球消費性電子裝置代工龍頭特別是在觸控面板、智慧型手機、超薄筆記型電腦、平板電腦及遊戲機等個人消費性電子產品的應用上貢獻卓著。根據韓國代理商所述，韓國一年的軟板設備採購量約為200多台，更不用說台廠如台郡、嘉聯益、毅嘉、鴻勝等大廠所採購的設備量，若能夠更了解客戶所需的生產製程，進而改善機台的功能及性能提升客戶產品良率及品質，若能如此，此設備後續的效益是可預期的。也可使軟板版圖移動重演硬板的軌跡向上提升，也希望公司可利用此機會踏入軟板的市場，讓公司可以進一步的成長。

Conclusion

The 2013 research report from PR Newswire/Reportlinker.com on the global FPC industry pointed out that 2012 was a prosperous year for FPC manufacturers. FPC is used in almost all popular electronic products, especially tablets and smart phones, which effectively expanded the FPC market. The global FPC market size reached USD 10,680 million. Compared with the same period in 2011, an increase of 15.2% was seen in 2012. In 2012, use of FPC boards sharply increased in all electronic parts and components and will continue to maintain strong growth momentum in 2013. The global FPC market scale is expected to reach USD 11,628 million in 2013, with an increase of 8.9% compared to that in 2012. [4]

As this discussion of FPC industry trends shows, with Taiwan as the OEM leader in global consumer electronic devices, especially in touch panels, smart phones, ultra-thin laptops, tablets, game consoles and other personal consumer electronic devices, Taiwan has made outstanding contributions to these devices. According to one South Korean agency, Korea purchases approximately 200 units of FPC equipment every year. The amount does not include procurement from Taiwanese manufacturers such as Flexium, Career, Ichia, and Foxconn. If we can better understand customers' production processes, and thus improve the function and performance of our machines to further enhance customers' product yields and quality, the subsequent profits from this device and the shift of FPC market share can be expected to follow the pattern of the PCB market. We hope that our company can make good use of this opportunity to enter the FPC market, so it can grow further.

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The Latin American Market

拉丁美洲市場

Raymond from AGA

Latin America comprises of the countries from Mexico, Central America and South America. A total of about 1 billion people call Latin America home and the predominant language spoken is Spanish, with the exception of Brazil, where the language is Portuguese. English is widely spoken by the well-educated and the business communities.

Over the past 15-20 years, the entire Latin American market underwent a major transition, from being a purely natural resources driven economy, to include a large variety of natural resources, including agricultural commodities, to an emerging manufacturing hub, utilizing the abundance in natural resources found to add value to their natural products, creating jobs and opportunities.
Standing out from the crowd are Mexico and Brazil, both highly populated countries, with high birth rates, increasing life expectancy of its citizens and a growing, better educated middle class. Based on both their geographical locations, Mexico being in close proximity to the huge USA market and Brazil with cultural ties to both Europe and Asia, these 2 countries will be the locomotives, also driving economic expansion in other Latin American markets.

Mexico will strongly influence the markets of Central America, who traditionally have kept in close connection with Mexico and Brazils increasing economic power will drive development in larger South American countries such as Argentina, Chile, Colombia and Peru.
It is widely believed that the economic growth in Latin America will continue for the foreseeable future. Politically most countries have friendly and expanding ties, there are no political or religious tensions and having a common language (Spanish) helps with communication and commercial relations.

拉丁美洲包括墨西哥以及中美洲和南美洲各國，拉丁美洲人口總共約10億人，主要語言為西班牙語，但巴西除外，當地語言為葡萄牙語。受過良好教育的人士和企業界則廣泛使用英語。

過去15-20年間，整個拉美市場經歷重大轉變，從一個純然天然資源供應經濟，包括各式各樣自然資源相關產業例如農產品，轉為新興的製造業樞紐，運用豐富的自然資源為其自然產品增加價值，創造就業和機會。

其中尤以墨西哥和巴西表現特別亮眼，兩國皆人口稠密、出生率高、人民壽命延長，同時也擁有越來越多受過良好教育的中產階級。就地理位置而言，墨西哥鄰近美國此一龐大市場，而巴西則與歐洲和亞洲有文化聯繫，這兩國將成為帶動其他拉美市場經濟擴張的主要動力來源。

墨西哥未來將對中美洲市場的影響力甚大，後者傳統上一直與墨西哥保持著密切的聯繫，而巴西日益強大的經濟力量將推動南美洲幾個大國的發展，例如阿根廷、智利、哥倫比亞和秘魯。一般認為在可預見的將來，拉丁美洲的經濟將持續成長。政治上，這裡大多數國家皆享有友好擴展的關係，也沒有任何政治或宗教緊張局勢，並且擁有一個共同的語言（西班牙語），有助於溝通和商業交流。

For the Anderson Group and its partners in Latin America, this means solid opportunities to grow their business and develop stronger market penetration for their diversified product range. In particular the sales potential for ANDERSONS CNC router line will develop, as demands for manufacturing and finishing machinery increases and volume demand for manufactured goods increases as disposable income increases proportionally to the growing middle class.

Recent sales success in Brazil, Mexico, El Salvador, Guatemala, Peru and Panama are examples that until recent many of these a CNC sales would not have been possible, due to lack of demand. Anderson has now emerged as a serious supplier of high tech, high quality CNC equipment with an increasing branding and market recognition.

Having been able to develop a strong and well educated technical support force in Mexico, Anderson can now offer, Spanish speaking technicians to cover the demand in Latin America, with no cultural or language barriers impeding our working relationship with our customer base in this market.

The outlook for Anderson in this growing market is strong and will most definitely lead to added sales and market share in the future.

The main challenges Anderson will face is that as many companies are expanding at a fast rate, they are outgrowing their needs in human resources and finding qualified, well trained staff to operate and maintain CNC Routers will be a challenge for many of our present and future customers.

Working in manufacturing still carries a stigma in many Latin countries and many young people, graduating from school and colleges, prefer to seek a career in different industries and will want to avoid a position in manufacturing. There is now a certain migration shaping, where citizens of impoverished countries in Central America are trying to access Mexico, a country which has no immigration system or lobby and finding it difficult to assimilate with industrial migration.

However, the overall perspective of “doing business in Latin America” is bright and Anderson is positioning itself well in a market promising solid potential.

對於恩德集團和其在拉丁美洲的合作夥伴而言，這是推展多元化產品業務及擴大市場的絕佳機會。其中，因為製造及精加工機械的需求量增加，恩德 CNC 鉋花機產品的銷售潛力更是看好，，且由於日益壯大的中產階級及其可支配收入同等增加，因此大量製成品的需求也隨之增加。

近來在巴西、墨西哥、薩爾瓦多、瓜地馬拉、秘魯和巴拿馬銷售成功的狀況是最佳例證，由於過去對於 CNC 並無需求，因此這些銷售狀況以往是不可能出現的。恩德現在已成為重要的高科技高品質 CNC 設備供應商，其品牌和市場認可度也日益提升。

恩德已在墨西哥建立一個強大且受過良好教育訓練的技術支援團隊，現在可以提供講西班牙語的技術人員以符合拉丁美洲的需求，沒有任何文化或語言上的障礙可以阻礙我們與這個市場的客戶群之間的工作關係。

恩德在這個逐漸茁壯的市場前景看好，未來銷售量和市場佔有率勢必提高。恩德即將面臨的主要挑戰是，由於許多公司快速擴展，導致他們人力資源短缺且找不到合格、訓練有素的工作人員來操作和維護 CNC 鉋花機，這對許多我們現在和未來的客戶而言將是一大挑戰。

在許多拉美國家，從事製造業仍然是不太光彩的事，許多剛從學校或大學畢業的年輕人寧願尋求不同行業的就業機會，也不願意從事製造業。現在出現某種移民現象，中美洲貧困國家的公民試圖遷移至墨西哥，這裡沒有移民系統或遊說團，他們也發現很難融入當地產業。

但是，整體而言，「在拉丁美洲做生意」前景依然看好，恩德集團也在這個潛力雄厚的市場占有一席之地。

電子機械-韓國市場未來展望及機會
ELECTRONIC MACHINERY - FUTURE PROSPECTS AND OPPORTUNITIES IN THE KOREAN MARKET

侯建富 Jeffrey Hou from AIC

自恩德進入韓國市場15年以來，銷售到此市場的機台數已超過500台以上，單單2012年銷售台數就達70台之多，僅次於大陸市場。 為何近幾年來韓國市場如此蓬勃發展，本人以多年來經營此市場經驗願與公司同仁及業界分享。主要原因依個人淺見，大概可區分為以下兩大項：

Smart Phone發明

新創科技產業及3C產品如雨後春筍般大放異彩，自從iPhone問世以來，相關衍生產品紛紛出籠，小筆電、平板甚至未來可預見的穿戴式產品如Google Glass、 iWatch等體積小、功能性齊全的產品，絕對是未來3C市場產品主流。然而體積小、功能性強，正好符合軟性電路板(Flexible Printed Circuit ; FPC)特性，也因此造就韓國這幾年來電路板產業的版圖遷移。過去幾年由於在硬式電路板(Printed Circuit Board)，韓國不敵台灣及中國以量大及低價在市場競爭。在經過2008年金融風暴侵襲，韓國業者轉而投入軟硬結合板(Rigid-Flex board)及軟板的開發與量產，短短幾年內韓國已悄悄追上日本成為軟板產量及產值世界第二的國家。也正因為韓國軟板產量增加，進而幫助恩德這幾年在韓國市場銷售迅速倍增。

品牌崛起

提到韓國3C品牌，大家馬上就會想起Samsung(三星)及LG。Samsung 2012年更以黑馬姿態一舉超越Apple拿下智慧型手機市佔第一的位置。

Since Anderson Group entered the Korean market 15 years ago, the number of machines sold there has exceeded 500 units. Seventy units were sold in 2012 alone, a number second only to our sales in the Chinese market. From my years of experience in charge of the Korean market, I would like to share with my fellow colleagues the reasons why the Korean market has been booming rapidly in recent years. In my opinion, there are two major reasons:

Invention of Smartphones

New-tech industry and 3C products spring up like mushrooms and yield unusually brilliant results. Since the inception of the iPhone, many derivative products have emerged. Netbooks, tablet PCs, or even—in the foreseeable future—wearable products that are small in size and yet have full functionality such as Google Glass and iWatch, will undoubtedly be the mainstream of future 3C products. Flexible printed circuits (FPC) provide small size with a wide range of functions, and this technology has been shifting the direction of development of the circuit board industry in Korea in recent years.

Over the past few years, Korea has not been able to compete with Taiwan and China in the printed circuit board market in terms of the large capacity and low price they can provide. After the financial crisis hit in 2008, Korean enterprises turned to the development and mass production of rigid-flex boards and FPC boards. Within a few years, Korea caught up with Japan and became the second largest country in terms of FPCB output and output value. The increase of FPCB production in Korea has facilitated the rapid growth of Anderson Group in the Korean market.

The Rise of Brand

When it comes to Korean 3C brands, we immediately think of Samsung and LG. In 2012, Samsung even overtook Apple and achieved the largest market share in the smartphone category.

2012年全球智慧型手機市佔率 / Global Smartphone Market Share in 2012

原2011年Apple的高階機款出貨量是三星的2倍，2010年仍有60%，可見三星是全速追趕。為何三星能迅速崛起，除強力品牌行銷策略之外，依個人觀察三星本身企業文化也是造就今日產品及品牌壯大的主因。據私下瞭解，三星是韓國國內唯一無工會組織的跨國企業，在韓國工會力量運作非常強勢環境中，實不容易。公司彈性、強勢的作為，加上政府大力支持，三星自然成為韓國重要的國際品牌。除此之外，三星仍傳承以往嚴謹管理方式，相較於對手LG，三星對品質要求是高於對手。這由恩德目前在韓國的客戶群裡，就可顯現兩家公司對品質要求的差異，由這些小地方也不難窺見三星成功的關鍵。這幾年三星及LG的成功與成長，也印證在恩德近幾年於韓國的銷售佳績。

Source: Money DJ website; http://www.moneydj.com/

In 2011, Apple shipped twice as many high-end models as Samsung. In 2010 the shipment was still 60%, showing that Samsung is catching up at full speed. Based on my personal observations, other than its strong brand marketing strategy, the reason why Samsung could rise so rapidly is its corporate culture. Samsung is the only multinational enterprise in Korea without a labor union. In an environment where the power of labor unions is great, Samsung definitely struggles to stand out. The enterprise's flexible yet strong actions, together with government support, make Samsung one of the most important international brands in Korea.

In addition, Samsung follows a rigorous approach to management inherited from its past. Compared to its rival LG, Samsung has a higher standard of quality requirements. Reflecting on Anderson's existing customer base in Korea, it is easy to see the differences in quality required by these two companies. It is from such seemingly trivial details that we can see the key factors in Samsung's success. Samsung and LG's success and growth in recent years also attest to the good sales performance of Anderson in Korea.

而反觀台灣印刷電路板(PCB)廠多半為Apple供應鏈，儘管全球智慧型手機市場仍在成長，但三星在今年第一季底推出旗艦機種GALAXY S4，將有助其市佔率再成長，若未來Apple智慧型手機不能再展雄風，以前大啃蘋果訂單的台系軟板、HDI廠等營運成長動能恐將受擠壓。

說明至此，也將NTI統計2011年全球前五十大印刷電路板排行榜列於下表。由表中可清楚看出全球印刷電路板產業一年產值及規模。雖目前手上尚無最新2012年排名資料，但排名順序應無太大變化。唯軟板廠營收2012年有較大成長，後文將針對全球主要軟板廠商三年來營收數據來分析闡明。

前五十大印刷電路板廠商中，台灣業者共入榜16家，除欣興電子(第一名)之外，還包括臻鼎(第四名)及健鼎(第五名)，台灣電路板產業規模已成為世界第一，也因此帶動台灣印刷電路板設備廠家數及種類成為全球第一。五十名中，日本也有16家，大陸(含香港)5家，韓國才7家入榜。令人好奇為何韓國市場相較於台灣市場規模小很多，而韓國廠商又如何在全球競爭中取得先機，再則恩德又為何近兩年在此市場表現亮麗，只能解釋為韓國這幾年積極著力提昇軟板製造技術及擴充產能，再加上三星及LG加持，使得市場蓬勃發展造就需求不斷增加。

In contrast, Taiwan's PCB factories are mostly part of Apple's supply chain. Although the global smartphone market is still growing, given that Samsung will launch its flagship model GALAXY S4 at the end of Q1 this year and is expected to further expand its market share, Taiwan FPCB and HDI factories that depend heavily on Apple's orders will be greatly affected if Apple can no longer keep its share of the smartphone market.

The table below shows the top 50 PCB makers worldwide in 2011, with statistics produced by NTI. The annual output value and scale of the global PCB industry are presented clearly in the table. Even though there is no updated 2012 ranking, it is likely that the ranking order has not changed much. However, the revenue growth of FPBC factories in 2012 was substantial. It is worth analyzing the revenues of global major PCB manufacturers over the past three years

NTI-100 World Top PCB Makers in 2011 (US$ Million)					
Rank	Makers	Country	2010	2011	Comments
1	Unmicron (欣興電子)	Taiwan	2,179	2,453	Includes Subtron, Ruwel & Clover in full
2	Nippon Mektron	Japan	2,106	2,314	New plant under construction in Suzhou
3	Ibiden	Japan	2,110	2,149	2nd HDI plant under construction in Malay
4	Zhen Ding (臻鼎)	Taiwan	1,150	1,512	Aiming to be the world number one
5	Tripod (健鼎)	Taiwan	1,370	1,396	Plant in Xiantao under construction
6	HannStar Board(瀚宇彩晶)	Taiwan	1,148	1,391	Inlclucded GBM PCB Group
7	TTM Technologies	USA	1,366	1,390	Shanghai IC Substrate plant completed
8	SEMCO	Korea	1,282	1,385	Kunshan HDI started to contribute revenue
9	Nanya PCB (南亞)	Taiwan	1,158	1,324	Kunshan Phase III bldg almost completed
10	Young Poong Group	Korea	978	1,204	Interflex built a 8-story FPC plant in Ansan
11	KB PCB Group	HK/China	1,122	1,046	Slight set-back in 2011
12	Shinko Denki Ind	Japan	1,003	1,034	A new Flip-Chip plant under construction
13	CMK Corporation	Japan	968	1,010	Thailand plant running well
14	Daeduck Group	Korea	800	955	IC substrate business is doing well
15	Sumitomo Denko PC	Japan	700	927	45% of the works goes to Apple
16	Multek	USA	680	870	Striving to be a next $1 billion maker
17	Viasystems Group Inc	USA	806	866	Bought DDi in May, $1129M prorated
18	Mflex	USA	791	832	Apple seems to take 75% of output in "12Q1
19	Kinsus (景碩)	Taiwan	676	776	Suzhou IC Substrate plant will contribute
20	Meiko Electronics	Japan	833	774	3/11 Earthquake/tsunami affected FY2011
21	Compeq Mfg Co Ltd (華通)	Taiwan	738	754	Chongqing HDI plant to be operational "14Q1
22	Wus Group (楠梓電)	Taiwan	663	735	New plants almost completed in Kunshan
23	AT&S	Austria	676	715	New HDI plant in Chongqing operates Q4
24	Fujikura	Japan	778	601	Restructuring after disasterous Thai flooding
25	Gold Circuit (金像)	Taiwan	519	579	Fire at Changshu plant affecting 2012
26	Taiwan Techvest(志超)	Taiwan	482	570	Building a new plant in Chengdu
27	Simmtech	Korea	520	554	Built a new plant in Xian & is operational
28	Nitto Denko	Japan	573	546	Building a new plant in Ho Chi Minh
29	Chin Poon (敬鵬)	Taiwan	527	542	Automotive applications exceeded 50%
30	Unitech (耀華)	Taiwan	407	534	World Class HDI new plant in Ilan, Taiwan
31	PID (Panasonic)	Japan	456	528	Built two new ALIVH plants in TW & Vietnam
32	Hitachi Chemical	Japan	471	504	Singapore exports 80% to U.S. customers
33	Toppan NEC	Japan	396	484	New plant under consideration
34	LG Innotek	Korea	612	475	Quit high layer MLB, a supplier to iPhone
35	Ellington	HK/China	390	430	New plant has been discussed
36	Dynamic(定穎)	Taiwan	394	397	Emphasis on HDI
37	Career Technology(嘉聯益)	Taiwan	325	390	Apple job seems to be more than 20%
38	Kyoden	Japan	444	390	Thai subsidiary is expanding
39	MGC Group	Japan	340	390	JCI and Tai Hong Industry
40	Kyocera SLC	Japan	260	390	Some subconturcting with Shinko Denki
41	Sanmina-SCI	USA	380	366	2nd plant in Wuxi is ready
42	Fujitsu Interconnect	Japan	296	364	Vietnam is considering expansion
43	Isu Petasys	Korea	307	345	Bought 51% stake of HK-based Tat Chun
44	SI Flex	Korea	314	344	Expanding in China
45	Founder Technology	China	258	339	Built a new HDI plant & a QTA plant
46	ASE (日月宏)	Taiwan	320	320	Not much changes
47	Shennan Circuit	China	256	320	Into IC substrate business
48	CCTC	China	255	305	Expansion under consideration
49	3CEMS (三希科技)	Taiwan	368	288	Restarts in 2012
50	Shirai Denshi	Japan	256	286	Sold 450 Vespers (AVI) so far

NTI-50 World Top PCB Makers in 2011 (US$ Million)

(N.T. Information Ltd, July, 2012)

There are 16 Taiwanese enterprises among the top 50 PCB manufacturers. In addition to the No.1 ranked Unmicron, Zhen Ding and Tripod are ranked No. 4 and 5, respectively. The scale of Taiwan's PCB industry is

definitely at the top worldwide, and thus it has driven the number and types of PCB equipment manufacturers to become the greatest around the globe. Among the top 50 manufacturers, there are 16 Japanese enterprises, 5 Chinese (including Hong Kong) ones, and only 7 Korean enterprises. Thus it is curious that the Korean enterprises were able to seize the opportunity and preempt the global competition, when the scale of the Korean market, as compared to the Taiwanese market, is definitely smaller.

Also we cannot help wonder why Anderson has had such outstanding performance in the Korean market these two years. It can be understood by the fact that Korea has actively invested efforts in improving FPC manufacturing technology and capacity expansion. In addition, with the competitive performance of Samsung and LG, the market is booming and has created increasing market demand.

談到這裡，先來稍微解釋一下何謂軟板及市場規模，和產品運用。軟性印刷電路板又稱軟板(Flexible Print Circuit；FPC)是將軟性銅箔基板(FCCL)和軟性絕緣層使用接著劑貼附後壓合而成，並經過蝕刻等加工過程，最後留下所需的線路，作為電子訊號傳輸媒介，通常還會搭配積體電路晶片、電容、電阻等電子元件，才能使電子產品發揮更多功能。

軟板最初應用在硬碟（HDD）和光碟機（ODD）領域，行業發展相當穩健，基本上被日本廠家壟斷。2003年照相手機的興起，催生一大批中國大陸和臺灣以及韓國廠家進入，打破日本廠家的壟斷局面。2005到2006年，FPC市場達到第一個高峰，2007年開始殺價流血競爭，2007到2009年連續3年FPC平均價格持續下降，累積降幅超過50%，近百家小企業倒閉，但軟板行業反而變得更健康。

At this point, I shall explain a little what flexible printed circuit boards (FPCBs) are, as well as their market scale and product applications. FPCBs are the remaining required circuits produced by adhering flexible copper clad laminate (FCCL) to a flexible insulating layer and pressing them together before other processes such as etching. FPCBs serve as an electronic signal transmission medium and are usually equipped with integrated circuit chips, capacitors, resistors and other electronic components to enable the electronic products to serve more functions.

FPCB technology was initially applied in the fields of HDD and ODD. The development of these industries was quite steady and was basically monopolized by Japanese manufacturers. Then in 2003, the rise of camera phones induced a large number of Chinese, Taiwanese, and Korean manufacturers to enter the market and broke the monopoly of Japanese manufacturers. From 2005 to 2006, the FPC market reached its first peak; however, in 2007 competing enterprises began cut-throat competition. From 2007 to 2009, the average price of FPC boards continued to decline for three consecutive years, with a cumulative decline of more than 50%. Hundreds of small enterprises went out of business, but the FPC industry became healthier.

軟板優點包含使產品體積縮小、重量較輕薄、有可折撓性、可依照空間改變形狀做成立體配線、可提升系統的配線密度並減少配線錯誤等。缺點包含成本較高、容易因製造過程中掉落或碰撞而折損、不適合接較重的元件、容易因為靜電殘留而吸附灰塵等。

軟板可運用的範圍十分廣泛，包含電腦及週邊設備、通訊產品、消費性電子產品、汽車、軍事等領域，其中又以通訊產品佔的比重最重約三成，其次為Panel佔二成多，PC及週邊設備佔二成。

一般手機只需3到5片軟板、智能手機則是6到8片，而iPhone 4等配備雙鏡頭以及多種模組的智慧手機就需要12片軟板，iPad 2增加了前後鏡頭，就意味著增加兩片軟板，綜觀各產品對軟板的需求，智慧手機和平板電腦將繼續強力拉動FPC市場。

產品 / Product	使用數量 / Qty of Use
手機 / Mobile Phone	3~6 pieces
智慧型手機 / Smartphone	6~8 pieces
平板電腦 / Tablet PC	5~8 pieces
筆記型電腦 / Notebook PC	4~6 pieces
電子書 / EBook	5~10 pieces
數位相機 / Digital Camera	7~10 pieces

各產品使用軟板的數量 / The number of FPCB used for each product

The advantages of FPCBs are as follows: FPCB technology satisfies the need to make electronic products smaller in size and lighter in weight. In addition, they are flexible, so they can change shape to fit the required space; thus three-dimensional wiring is available. The use of FPCBs can also improve wiring density and reduce wiring errors. The disadvantages of FPCBs include their high cost and a tendency to be damaged if dropped or bumped during processing. Moreover, FPCBs are not suitable for connecting heavier components and dust easily adheres to them due to static electricity.

The range of FPCB applications is broad, including computers and peripherals, communication products, consumer electronics, the automotive industry, the defense industry, and so on. Communication products account for 30% of the market, followed by panels, which account for 20%, and PCs and peripherals, which account for 20%.

General mobile phones require 3 to 5 FPCBs; smartphones generally require 6 to 8 pieces, while other smartphones, such as iPhone 4, equipped with dual lenses and a variety of modules, require 12 pieces. iPad 2 is equipped with additional front and rear lenses so two additional FPCBs are required. Taking a broad view of the FPCB demand for each product, smartphones and tablet PCs will continue to drive the expansion of the FPC market..

軟板依產品結構可分為：

一、單面板(Single Side)：為最基本的軟板種類之一，組成方式將導體層塗上一層接著層，之後在再加上一層介電層，優點包含製程容易、價格較低等。

二、雙面板(Double Side)：組成的方式使用雙面板基材，於雙面電路成形後，分別各加上一層覆蓋膜，因為厚度增厚，因此可撓性降低，其應用領域較有限。

三、多層板(Multilayer):主要是使用單面板或雙面板所組成，並且透過鑽孔使導電層相通，增加線路密度和提升可靠度，但因層數增多，使的可撓性變差，其應用領域較有限。

四、軟硬板(Rigid-Flex):是由多層硬板加上單面軟板或雙面軟板所組成，分別利用硬板的支撐性和軟板的可撓性結合成。

FPCBs can be divided into the following types based on product structure:

I. Single-sided: One of the most basic types. It has a single conductor layer coated with an adhesive layer, and a dielectric layer is added. The advantages include easy process and low lost.

II. Double-sided: Double sided FPCBs consist of double-sided substrates. After the double-sided circuit is formed, a cover layer is added on both sides. Flexibility is reduced because is it thicker; therefore, its applications are limited.

III. Multilayered: It is mainly composed of single-sided or double-sided FPCBs. The conductor layers are interconnected by drilling holes, thus increasing wiring density and improving reliability. However, flexibility is reduced because of the additional layers, therefore, the range of applications is limited.

IV. Rigid-Flex: A hybrid construction circuit consisting of multilayer rigid boards and single-sided or double-sided flexible boards. It is made of rigid boards, which can support heavier components and flex boards, which possess flexibility.

軟板主要構成的原料為軟板基板(FCCL)，可依層數區分為無膠系軟板基板（2 Layer FCCL）和有膠系軟板基板（3 Layer FCCL），兩者最大差異在於銅箔和聚醯亞胺薄膜之間有無接著膠劑。而2L FCCL具有耐熱性高、耐撓折性好、尺寸安定性良好等優點，但成本相對較高，因此大部份軟板主要使用3L FCCL，只有較高階軟板才會用到2L FCCL。FCCL主要供

應的國家包含日本、美國、台灣等，2L FCCL供應廠商有Nippon Steel、Sumitomo Metal Mining、Nitto Denko等，3L FCCL有Nippon、Toray、Arisawa等。追求超薄的電子產品都是軟板市場增長的動力，平板電腦也是軟板市場增長的驅動因素，Intel 2012年力推的Ultrabook同樣將促進軟板市場發展。

2011年軟板市場繼續快速增長，達到95.69億美元，增幅17%，2012年更達到106.80億美元，增幅12%。技術層面上，2L FCCL已經成為主流，3L FCCL日漸沒落。軟板的下游市場也在不斷擴大，擴展到手機、筆記型電腦、LED Light Bar等。對手機而言，其功能模組之間大多是用軟板連接，每增加一個功能模組基本上就需要增加一片軟板。智慧手機內部結構複雜，功能多，軟板使用量大增，尤其是2011年觸控面板成為智慧手機標準配置，觸控面板的連接軟板具備一定難度，單價較高。

FPCBs are mainly composed of FCCL. FCCL can be divided into the non-adhesive-type FCCL (two-layer FCCL) and the adhesive-type FCCL (three-layer FCCL). The biggest difference between the two is whether there is adhesive material between the copper foil and polyimide film. The two-layer FCCL has the advantages of high heat resistance, high flexibility, and good dimensional stability. However, its cost is relatively higher. Thus, three-layer FCCL is used for most FPCBs, and only two-layer FCCL is used for high-end FPCBs. Major FCCL supply countries include Japan, the USA, and Taiwan. Examples of two-layer FCCL suppliers are Nippon Steel, Sumitomo Metal Mining, Nitto Denko, and so on. Three-layer FCCL suppliers include Nippon, Toray, Arisawa, and so on. The growth of the FPCB market is driven by the pursuit of ultra-thin electronic products. The tablet PC is another driving factor in the growth of the FPCB market. In addition, the Ultrabook promoted by Intel in 2012 has also boosted the development of the FPCB market.

In 2011 the FPCB market continued to grow rapidly and reached 9.569 billion dollars, an increase of 17%. In 2012, it reached 10.680 billion dollars, representing an increase of 12%. Technically two-layer FCCL has become the mainstream product, while three-layer FCCL gradually has fallen out of favor in the market. The FPCB downstream market is also continuously expanding to mobile phones, notebook computers, LED light bars, and other fields. The functional modules of mobile phones are interconnected by FPCBs; every additional functional module basically requires one additional piece of FPCB. The internal structure of smartphones is complicated with multiple functions, so the use of FPCBs has increased greatly. Particularly since 2011, a touch panel has become a standard feature of smartphones. The connecting FPCBs for touch panels are definitely not easy to make, so the cost is higher.

Company	Country	2010	2011	2012E
NOK(旗勝)	Japan	2071	2335	2480
SEI(住友電工)	Japan	700	934	980
FUJIKURA(藤倉)	Japan	777	901	1008
M-FLEX	US	803	831	960
ZDT(臻鼎)	TAIWAN	274	528	580
NITTODENKO(日東電工)	JAPAN	496	513	420
Interflex	KOREA	362	460	577
CAREER(嘉聯益)	TAIWAN	321	394	518
SI FLEX	KOREA	306	345	360
SONY CHMICAL	Japan	293	280	230
FLEXIUM(台郡)	Taiwan	144	260	367
ICHIA(毅嘉)	TAIWAN	152	211	279
Sumitomo Bakelite	Japan	214	188	130
FLEXCOM	KOREA	134	155	216
Bhflex	KOREA	96	133	181
MFS(維用)	SINGAPORE	137	125	80
PARLEX	US	69	70	70
NewFlex	KOREA	60	54	50
DAEDUCK GDS	KOREA	78	121	165

全球主要FPCB廠家2010-2012年收入及排名(單位:百萬美元)

Annual Revenue and Ranking of World's Major FPCB Suppliers in 2010-2012 (Unit: million USD)

日本企業仍然是FPC市場的龍頭，近20年來，一直壟斷HDD和ODD的軟板市場，日本廠家擁有穩定的品質、龐大的產能以及遍佈全球的生產基地。2010年，日本軟板廠家NipponMektron(旗勝)收入比2009年增長35%，達到22.2億美元，全球第一的位置愈加穩固。NipponMektron是Nokia、Apple和Sony的主要供應商，也是全球硬碟大廠西部資料(Western Digital)、東芝(Toshiba)的主要供應商。

M-FLEX是RIM和Apple的主要供應商，這兩家為M-FLEX貢獻了85%的收入。日本FUJIKURA（藤倉）則陷入價格苦戰，業績衰退；這家公司以光通信和連接器為核心業務，FPC領域沒投入太多心血，技術遜於NipponMektron，不得不進行價格戰。住友電工(SUMITOMO ELECTRIC)和住友電木都是FPC大廠，不過FPC業務對他們來說，都是非核心業務，客戶都是硬碟、光碟機、數位相機、DV廠家。2010年這些領域並沒有多大的增幅，同時還面臨臺灣業者的價格壓力，因此業績變化不大或甚至下滑，日本企業日東電工(NITTO DENKO)和索尼(SONY Chemical)也都是如此。儘管日本廠家遭遇311地震、泰國洪水、日元升值三重打擊，依然取得了非常優秀的成績，尤其NOK仍然保持全球霸主地位。除NOK外，FPC對日本企業而言都不是核心業務，FUJIKURA更一度欲縮減FPC業務規模，不過2011年iPad給了Fujikura更多信心。

Apple是全球最大的軟板採購商，2011年採購規模近20億美元，iPod、iTouch、iPad、iPhone、筆記型電腦都需要使用數量眾多的軟板。Apple認證的軟板供應商有6家，分別是日本的NIPPON MEKTRON、SUMITOMO ELECTRONICS、FUJIKURA、美國的M-FLEX，臺灣的FLEXIUM(台郡)、韓國的INTERFLEX。韓國FPCB 4強，INTERFLEX、SI FLEX、FLEXCOM、BHflex都有不錯的增長，INTERFLEX超過未上市的SI FLEX成為韓國第一大FPC廠家。當然這些客戶的主要客戶無一例外是三星(SAMSUNG)和LG，韓國廠家依靠三星和LG，其中LG雖然下滑，但三星的智慧手機和平板電腦都增長強勁，FPC廠家受益良多，Interflex產品還通過了Apple認證。

臺灣廠家中臻鼎（ZDT）是Apple主要供應商也是鴻海旗下一員，依靠鴻海集團，業績自然不俗。ZDT發展迅速，成立僅5年就進入全球前十大PCB廠家。Career 嘉聯益則依靠大陸廠家和HTC，Ichia毅嘉主要依靠諾基亞和HTC。新加坡企業控股，生產基地位於湖南長沙的MFS的大客戶是HGST，不過HGST被西部資料收購後，其大客戶極有可能轉移訂單。

中國大陸的FPC廠家規模都很小，技術水準也比較落後，還無法獲得國外大公司的認同，不過受益于中國龐大的手機產業，也有不錯的增幅。這其中比較大的有比亞迪電子、三德冠（Three Golds）、中興新宇（ZTE XINGYU FPC）、景旺（KINWONG）、精誠達（JINGCHENGDA）、奈電（NETRON SOFT-TECH）、嘉之宏（JIAZHIHONG）、珠海元盛 （ZHUHAI TOPSUN）。中國大陸最大的FPC廠家是湖南維勝，它是新加坡MFS控股企業。

Japanese enterprises are still the leaders in the FPC market. In the past 20 years, Japanese companies have monopolized the FPC market of HDD and ODD; they have stable quality, large capacity and worldwide production bases. In 2010, the Japanese FPC manufacturer, NipponMektron, had an increase of 35% in revenue compared to that in 2009, reaching 2.22 billion dollars, securing its place as No. 1 in the world

ranking. NipponMektron is the major supplier for Nokia, Apple and Sony, and it is also the major supplier for the world famous HDD brands, Western Digital and Toshiba.

M-FLEX is the major supplier for RIM and Apple; these two companies contribute 85% of M-FLEX's revenue. The Japanese enterprise FUJIKURA is struggling against price competition and its revenue is declining; the core business of FUJIKURA is optical communications and connectors. The company does not invest much effort in the FPC market, so its technique is inferior to NipponMektron and it has to wage a price war.

SUMITOMO ELECTRIC and SUMITOMO BAKELITE are both FPC manufacturers, but the FPC market is not their core business. Their major customers are HDD, ODD, digital camera, and DV manufacturers. In 2010, there was not much market expansion in these fields and the companies faced price pressure from Taiwanese enterprises, resulting in no change or even a decline of revenue. The same happened to the Japanese enterprises NITTO DENKO and SONY Chemical. Even so, despite encountering the triple whammy of the 311 earthquake, floods in Thailand, and the appreciation of the Japanese yen, Japanese manufacturers still obtained excellent results; particularly, NOK, which retained its place as a global conqueror. For Japanese enterprises other than NOK, FPC is not their core business. FUJIKURA even reduced the scale of its FPC business for a while, but in 2011, iPad gave FUJIKURA renewed confidence in the FPC business.

Currently, Apple is the world's largest FPCB buyer. In 2011, it made a purchase of nearly 2 billion dollars. Apple's iPod, iTouch, iPad, iPhone, notebooks all require the use of a large quantity of FPCBs. There are six Apple-certified FPCB suppliers, that is, NIPPON MEKTRON, SUMITOMO ELECTRONICS, FUJIKURA from Japan, M-FLEX from the USA, FLEXIUM from Taiwan, and INTERFLEX from Korea.

The top four leading Korean FPCB manufacturers, INTERFLEX, SI FLEX, FLEXCOM, and BHflex, all have shown quite steady growth. INTERFLEX overtook the unlisted SI FLEX and became the largest FPC manufacturers in Korea. Their main customers are SAMSUNG and LG. Korean manufacturers rely heavily on SAMSUNG and LG. Although the revenue of LG has declined, Samsung's smartphones and tablet PCs are growing strong in the market, which benefits FPC manufacturers. Interflex products even passed Apple's certification.

The Taiwanese manufacturer ZDT is a major supplier for Apple and also a member of the Hon Hai / Foxconn Technology Group. The company is known for its great sales performance. ZDT developed rapidly and entered the global Top 10 of PCB manufacturers only five years after its establishment. Career relies on mainland manufacturers and HTC; Ichia relies mainly on Nokia and HTC. MFS is a manufacturer with its production base located in Changsha, Hunan; its controlling company is a Singapore enterprise. The largest customer of MFS is HGST; however, after HGST is acquired by Western Digital, it is likely that HGST will transfer its orders to other suppliers.

FPC manufacturers in mainland China are small-scale; the technology level is relatively immature and they have not yet obtained recognition from large foreign companies. Nevertheless, these manufacturers still have good sales growth and are benefitting from China's powerful, huge mobile phone industry. Of these manufacturers, the relatively larger ones are BYD Electronics, Three Golds, ZTE XINGYU FPC, KINWONG, JINGCHENGDA, NETRON SOFT-TECH, JIAZHIHONG, and ZHUHAI TOPSUN. China's largest FPC manufacturer is MFS, whose controlling company is MFS Singapore.

瞭解過全球、韓國軟板產業規模及市場走向之後，不禁要回頭檢視恩德產品是否存在任何機會。其實在2010年電子機械部門早由韓國代理得知未來當地市場發展趨勢，也因此在2010年開始便積極尋找下一世代產品，適逢與翔德(DIGITAL PHOTONICS CORP.)現有雷射技術相結合，於今年四月份的KPCA(Korea Printed Circuit Association)展示會中，恩德集團展出第一台專用於軟板之UV雷射鑽孔成型機(如下圖)，使得電子機械部門在軟板設備產品線又增添生力軍。綜觀目前主要競爭對手，ESI是目前市占率第一品牌，粗略估計ESI銷售至韓國市場數量已超過300台以上，保守估計由2013年開始韓國每年至少需求量約100台左右，以單價每台美金44萬預估，即是每年美金4千4佰萬市場規模。此銷售總額決不低於當地機械鑽孔機一年需求，因此想在韓國市場更上層樓，UV雷射鑽孔成型機的推展絕不容小覷。

然而進入此產業門檻確實不低，初期投入雷射研發成本金額所費不貲，開發者除本身對UV雷射運用必須熟悉之外，更需對不同軟板材質特性相當瞭解，否則很容易就會事倍功半，前功盡棄。

Having just described the scale of the global and Korean FPCB industry and trends in the FPCB market, we need to review Anderson's products to see whether they have any chance of competing successfully in this market. As early as 2010, our electronic machinery department acquired information on local market trends from our Korean agent. Since then, they have been actively been looking for next generation products. Anderson Group presented the first UV laser drilling machine exclusively made for FPCB processing (as shown below) that combines current laser technology of DIGITAL PHOTONICS CORP at the KPCA (Korea Printed Circuit Association) exhibition this April. The electronic machinery department now has a new force in the FPCB equipment product line. Looking at our current main competitors, ESI holds the greatest share of the current market. A rough estimate shows that ESI has sold over 300 units into the Korean market. A conservative estimate is that, starting from the beginning of 2013, Korea's annual demand is approximately 100 units. With an approximate unit price of USD 440,000, the size of the market is around 44 million USD per year. This total sales amount is not lower than the annual local demand for drilling machines. Therefore, in order to push our performance in the Korean market, the promotion of UV laser drilling machines can not be overemphasized.
The barriers to entering this industry are not low. The initial investment cost is high; developers must be familiar with the use of UV lasers and at the same time fully understand the material properties of different FPCBs; otherwise you end up getting half the results for twice the effort, and what has been achieved will be spoiled.

總而言之，無論未來下一世代3C消費性產品發展為何，輕、薄、短、小，一定是最後市場需求主流。在未來「以量取勝」已不是致勝的關鍵趨勢，包括軟板等PCB業者只能往更高階製程發展，往「質量」方向邁進。然而，下一階段恩德該如何提供更符合市場需求產品，除精進現有產品線之外，更高精密機械與先進製程產品研發是刻不容緩課題。相信在全體電子機械部及相關單位、子公司等同仁努力之下，下一款俱備市場競爭力機種正積極進行中，請各位拭目以待！

All in all, regardless of the specific developments in the next generation of 3C consumer products, the mainstream market demand will be for lighter, thinner, shorter products with smaller features. In the future, "winning by quantity" is no longer going to be the key to success. PCB manufacturers as well as FPCB manufacturers have only one choice: pursue advanced process development and focus on "quality." One big question is how can Anderson provide products that conform more to market needs in the next stage. In addition to improvements along existing lines, developing higher precision machinery and advanced product processing are urgent issues. With the efforts and support of the electronic machinery department, related divisions, and fellow colleagues in our subsidiaries, the next competitive model is on its way to the market. We look forward to seeing it!

街頭藝人 Bucker

王元男 Jason Wang from AIC

法蘭克福的購物大道，人群接踵，商店、酒吧、餐廳、咖啡廳處處充滿活力，看不出有歐債金融風暴即將席捲的陰影。大道上各式各樣的街頭藝人，爭奇鬥艷，各各拿出看家本領，來吸引遊客目光。在各種街頭藝術表演中，最吸睛的表演是有一位神奇的傑克，表演神奇的空中懸浮。從物理的觀點，雖然大概可猜出其方式，但還是不得不佩服其用心的藝術創作。看到每個驚奇興奮的眼神，和充滿天真好奇的孩童表情，讓我不得不為他投下神聖的一歐元以資鼓勵。圍觀者和表演者兩者的街頭互動，何嘗不又構成另一種藝術的表演，或許戲如人生、人生如戲，才是街頭藝人想要傳達的精隨。

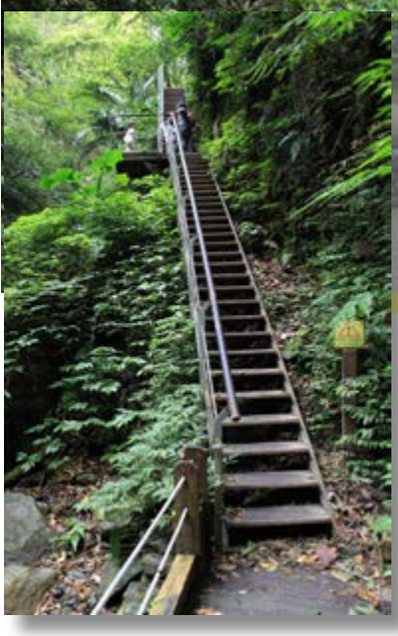
People come one after another along the bustling lane of a shopping district in Frankfurt. The shops, bars, restaurants and coffee shops are crowded and lively. Here, the looming shadow of the European financial crisis cannot be seen, except, perhaps, in an assortment of beggars vying with one another to draw the attention of passers-by with their creative performances. Each one performs some special feat or trick to attract the curiosity of spectators. The most popular and interesting of these street performers is “magic Jack,” who appears to be floating in the air. Upon careful examination, the method he employs to achieve this illusion can be guessed, but we still admire the attention that he has put into creating this artistic illusion. Seeing the amazed and excited expression in the eyes of curious children looking on, I have no choice but to drop him a single Euro as encouragement. Stepping back to take in the scene, one could view the interaction between the street performer and the onlookers as another artistic performance: maybe a play imitates life and life is like a play. Perhaps this is the essence of what the beggar wants to say.

PS:當你無意間在街頭，看到我坐在街旁的空中，請不要懷疑更不要猶豫，請投下NT100元

PS: If you some day catch sight of me levitating in the air on the street, please do not hesitate or doubt, just drop me an NT100 note..

春遊林美石磐步道

A Visit to Linmei Shihpan Trail in Spring



陳慧玲 Hui-Ling Chen from AIC

蟄伏沉寂的冬天過後，春暖花開的季節就該出去走走！之前就曾多次耳聞林美石磐步道之美，今年趁著春遊宜蘭之際，安排至這個頗負盛名的步道一遊。

林美石磐步位在溫泉勝地-礁溪的林美村，沿著山路前進並不易迷路，但入口處較為隱密，一不小心可能就錯過！還好假日時有不少遊客，入口處停了不少的車輛，方才不至於錯過入口。在進入林美石磐步道前，會先經一段碎石步道，沿途可見一片綠草如茵的高爾夫球場與景色優美的湖景。

似乎為了維護步道環境的關係，步道的入口處設有管制站進行人數管制，同一時間內只放行固定的人數進入步道。林美石磐步道是一環狀步道，走完全程即可回到入口處，不需再原路折回，不致降低遊興。步道採最低人為干涉的生態工法施設，步道沿途可見最多人工雕琢的部份就僅只木棧道、卵石步道及木梯，充份保留原始的自然生態之美。

步道沿著山谷而設，全程不長且平緩，慢步悠遊其中不需一個小時，步道中林木成蔭，溪流、瀑布夾道，即便炎炎夏日走在其中應該也絲毫不覺得熱，是一絕佳的避暑勝地。家中二個溫室中豢養的小傢伙也都可以輕鬆地自行走完全程。沿途的自然風光更是個極佳的自然生態教室，哥哥甚至脫口而出：「這是課本有提到的昭和草耶！」、「唉唷！有蜥蜴！」、「啊！標示牌說小心有蛇！」

拜入口處實施人數管制不致一時湧入大量的人潮，身處其中可完全感受遠離城市的喧囂，讓身心靈獲得充份的放鬆。下回若有機會到礁溪時，不妨安排個生態步道之旅，好好享受一下芬多精的洗禮，也可順便就近在礁溪泡個美人湯喔～

After a long winter, I was eager for some hiking in this warm spring with flowers blooming everywhere. I had long heard about the beauty of Linmei Shihpan Trail, and had the chance to visit this famous trail during my trip to I-lan this year.

Shihpan Trail is located in Linmei Village of Jiaoxi, a town known for its hot springs. The way is not hard to follow along the mountain trail, but the entrance to the trail is remote and can easily be missed if you're not paying attention. I was lucky and did not miss it, as it was a holiday and there were many tourists and cars were parked outside the entrance. A pebble trail led the way to the main trail and a green golf course and some gorgeous scenery with lakes.

To maintain the environment along the trail, there is a control station at the entrance, and only a limited number of guests are allowed onto the trail at one time. Linmei Shihpan Trail forms a loop, so traveling the complete length of the trail brings you back to the entrance. Thus there is no need to backtrack and one needn't be bored by going back the way one came The trail was designed to have a minimal impact on the ecology, with the only artificial elements being wooden paths, pebble trails and wooden ladders. The original beauty of nature has thus been maintained.

The trail is constructed along a valley, which is not long and has no steep slopes. Walking its length takes less than one hour. A stream with waterfalls winds its way through the green forest, so you do not feel hot even when walking the trail in summer. In fact, this is a perfect place to get away from the summer heat. My two children who are city-born and city-raised could complete the journey with ease. The scenery was like a living lecture in ecology, with my older son excitedly remarking, "Hey, this is the fireweed that I saw in my textbook!" "Look, a lizard!" "Wow, the sign says be careful of snakes"!

Thanks to the limitation of visitors at the entrance, there isn't too much of a crowd. Thus we can enjoy seclusion from the noisy and hectic lifestyle of the city and completely relax body and mind. If you have the chance to visit Jiaoxi, why not visit this ecological trail? Bathe yourself in the fragrance of the Pythoncidere and enjoy a relaxing moment. You can also enjoy the hot springs of Jiaoxi!

夏日南投之旅
My Summer Tour of Nantou

黃淑君 Joey Huang From AIC

趁著假期大學時代的好友遠從墨西哥回來，規劃了兩天一夜的南投之旅。
A friend from my college days came back from Mexico for vacation and we planned a two-day trip to Nantou.

第一天行程規劃到現在很夯的中部景點－妖怪村，園區範圍並不大，內有多棟主題特色松林町商圈。來妖怪村逛逛完全不需收費，it's free!
On the first day, we visited one of the more popular tourist spots in central Taiwan: the Monster Village. The village, also named Song-Lin, is not very large and contains several theme shops. You don't need a ticket to tour the monster village; it's free!

自從妖怪村爆紅後，不管平日或假日，常常是塞滿人海的狀態，這個新興景點讓我覺得跟以往去溪頭旅遊的感覺不同，多了一份新鮮感。整體的規劃很有趣，很有日本風味，妖怪都變得很可愛親切，中間還安排吉祥物『枯麻』跟『巴豆妖』跳舞節目歡迎觀光客的到來，圓圓胖胖的身體跳起舞來很可愛，逗得大人小朋友哈哈大笑，真的很有趣。外圍店家賣的東西也配合妖怪主題，讓人一眼看到還不知是賣甚麼。其實都是平常耳熟能詳的小吃，很推薦大家來這裡參觀！
As Monster Village has experienced a boom in popularity, it is often crowded on weekends and weekdays. This new spot has a different feel than any of my past visits to Xitou, introducing something new. The overall theme of the area is interesting and rich in Japanese flavor, and the monsters are cute and kind. During our visit, the mascots "Kumar" and "Badou" performed a dance, their chubby, round bodies making the dance even cuter, and all the children and adults had a laugh and enjoyed a fun time. The souvenirs in the shops also reflect the monster theme—you really have to explore some of these shops firsthand to see what is sold! Among other things, there are many famous Taiwanese snacks. I strongly recommend Monster Village as a place to visit if you're ever in Nantou.

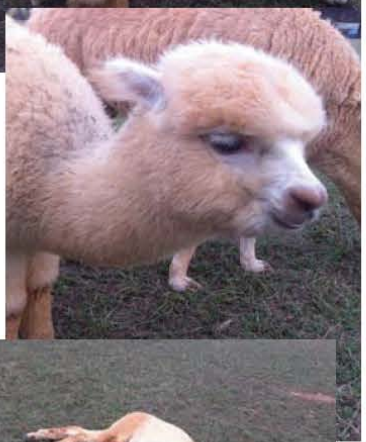
在民宿稍作休息後，我們前往猴探井天空之橋挑戰。其實猴探井是指地形像一口井，井的旁邊有一座山像猴子，是名為猴探井的風水寶地，後來沿用風水寶地的名稱當地名，並不是說這邊真的有猴子。既然是風水寶地，當然會有夜總會，看到的時候不要太驚訝，最古老的墓年代都很久遠了。
After a rest at our guest house, we went on to a new challenge: the Sky Bridge of Houtanjing. The name Houtanjing comes from an interesting feature of the landscape; a nearby mountain shaped like a monkey. It has a reputation as an auspicious site according to the art of Fengshui (Chinese geomancy). Of course, we didn't see any real monkeys. Since

it is a great spot that is believed to have positive influence on a family's future, we were bound to see some tombs. No need to be scared—some of these tombs could even be called ancient.

這景點觀光客好多，到入口還要排隊才能夠走到天空之橋，走在橋上非常的平穩，橋面很寬，只是風比想像中的大，難怪禁止拿傘上橋。走在橋上可以感受到懸空時，風從四面八方吹過的感覺，還可以遠眺地平線，如果是黃昏時段還可以觀看近180度的夕陽美景，當然，前提是遊客人數不多，不會被催著走的情況下。橋上遠眺的風景非常宜人，叢林之中又有小河流穿梭，欣賞起來格外精神氣爽。第一次來猴探井的朋友，建議先逛完猴探井遊憩區後再走天空之橋，因為天空之橋目前是單行道，如果先走到對面的話，必需繞一大圈才能再回到猴探井遊憩區，所以不妨先逛完猴探井遊息區再走天空之橋。後面有規劃攤販區可以稍作休息，也有小吃飲料可以品嚐，整個行程非常悠閒自在。回程的路上還買了當地有名的鳳梨酥當伴手禮，這也是非常推薦一定要買的。

There is another very popular spot to visit, with a line from the entrance to the Sky Bridge. The bridge is wide and stable to walk on, but the wind was stronger than expected. Maybe that is why walking on the bridge with an umbrella is prohibited. On the bridge, it felt like we were airborne, with wind blowing from every direction, and the horizon visible in the distance. In the evening, one can see the glorious sunset with a wide view of almost 180 degrees, provided the place is not too crowded. The scenery was spectacular and with rivers flowing through the forest, we felt refreshed and relaxed. For those visiting Houtanjing for the first time, you should walk around the area before crossing the sky bridge. This is because the sky bridge is one-way only, so once you have crossed, you have to take the long way around to get back to the Houtanjing rest area. So tour around the rest area before you go on the bridge. There are food stands, places to take a rest, or enjoy snacks and beverages. It could be a truly relaxing moment. Before we left, we bought some pineapple cakes, which the area is famous for. They are also strongly recommended as a souvenir.

當日行程我們最後規劃到天馬牧場近距離目睹草泥馬的風采，牧場規劃一區很廣闊的草原專為草泥馬放牧，讓他們盡情的奔跑，也讓遊客自由在牧場內跟草泥馬互動，真的很溫馴又可愛，不管是餵食或拍照都乖乖的配合，殺了不少記憶卡；最後，接近閉園時間，園區人員也讓我們參與把草泥馬趕回柵欄內，牠們都會乖乖的聽著指示回家。我們就像牧羊犬一樣拉成一條長長的線，讓他們隨著方向回到窩裡，很有趣的體驗！



Our last stop was Tianma Farm where we went to see alpacas up close. On the farm, there is a wide grassland area for alpacas only, where they can run frolick at will, and visitors are free to interact with the animals. Alpacas are extraordinarily friendly and cute, and they cooperated fully when we fed them and took their pictures, eating up a great portion of my camera's memory card. As the farm's closing time drew near, the staff let us take part in herding the alpacas back into their resting area, and the alpacas followed us as we formed a long line for leading them back to their home. It was a unique and interesting experience.

這次的行程安排很豐富難忘，希望很快有機會再規劃下一次的旅行，讓自己放鬆一下！

Our tour this time was rich in flavor and one to remember. I hope that I will have a chance to plan another delightful trip like this one soon.

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