Precitech Solutions for the Automotive Industry - An Interview with Jeff Roblee and Ed Freyenhagen

Precitech 針對車載市場提出的全方位解決方案-Jeff Roblee 和 Ed Freyenhagen 獨家專訪

In this interview, Jeff Roblee, VP of Technology, and Ed Freyenhagen, Director of Engineering, talk about key applications for ultra precision machining in the automotive industry and the enabling technologies that make realizing them possible.

此專訪，技術副總 Jeff Roblee，與工程總監 Ed Freyenhagen，分享在車載市場超精密加工之關鍵應用，以及如何運用工程技術讓客戶達成目標應用。

WS: Why are your customers starting to use ultra precision manufacturing techniques more these days for automotive applications?

WS:為什麼近期您的顧客們越來越多選擇超精密加工技術運用於車載產品?

JR: There are many new features that automobile companies are developing into their products to enhance them and add functionality. Many of these new features require or can be made better by using ultra precision manufacturing techniques.

JR: 車載廠商為了產品研發，進行強化並增加其功能性，因此產生新的產品特性。許多新產品特性需透過超精密加工技術加以提升。

WS: What are some of these new applications and how does ultra precision bring value to them?

WS:有哪些是新銳應用例子?超精加工如何帶給他們新價值?

JR: The most interesting automotive applications that we commonly see are for head up displays (HUDs). Newer applications include ones such as infrared optics for LIDAR (light detection and ranging) systems for self-driving vehicles and animal and people detection systems. Also cars are now coming with cameras for backup and parking assistance which require imaging optics. Still other applications are being improved with ultra precision manufacturing techniques such as LEDs for enhanced interior illumination, signal lamp bezels, and head lamp optics.

JR:最有趣且常見的車載應用是抬頭顯示器(HUD)。較新穎的應用層面，例如:紅外光學，無人駕駛車、動物/人的感測系統應用的光感雷達(LIDAR)(光探測與測距)。此外，現今汽車裝配行車記錄器與倒車顯示器的鏡頭，皆為成像光學件。甚至有其他應用透過超精加工持續進行改善與精進，例如:強化內部照明的LED燈、警示燈板與頭燈光學品。

WS: What are some challenges that arise in making these types of parts using ultra precision manufacturing techniques versus making them with conventional machining methods?

WS:與傳統加工方法相比，使用超精密加工技術製造這類產品時，會面臨哪些挑戰?

JR: For more common ultra precision applications such as infrared and imaging optics the first challenge is cost. Competitiveness in the automotive market requires lower cost lenses, which means they need to be made faster. This can make programming a challenge. Additionally, with ultra precision we program our tools to 1 nm and most CAD systems do not create programs to this accuracy. For freeform applications, for which the surfaces to be made cannot be defined by a formula, CAD models are needed. The freeform shape of many LED lighting and signal lamp bezel applications push the limits of existing CAD tools. For these reasons advanced methods must be developed.

JR: 若是較一般的超精密應用，如紅外和成像光學品，首要面臨的挑戰是成本。在車載市場的競爭中，往往需要更低成本的Lenses，這表示他們需要生產的更加快速，這使編程成為一個挑戰。此外，透過超精密，我們編程刀具達1nm精度，這是大部分CAD系統所無法達到的編程精度。就自

由曲面應用而言，對於那些無法被公式所定義的加工表面，CAD模組是有必要的。許多LED照明與警示燈板應用所需的自由曲面面型，都將現有的CAD工具推至應用極限。因此，必須研發出更進階的加工方法。

WS: What ultra precision manufacturing techniques can be used to make parts faster?

WS:哪些超精加工技術可以幫助製程加速?

JR: Turning processes are much faster than milling processes and two technologies come to mind that that can benefit the turning of freeform surfaces. The first is called fast tool servo (FTS). This method of manufacturing rapidly moves the tool in coordinated motion with the spindle and axis positions allowing parts to be manufactured faster. Second is software called Adaptive Control Technology (ACT). Anytime you are moving the axis of a machine tool in a coordinated way to manufacturer a freeform (non-rotationally symmetric) part the dynamic errors of the machine contribute to deviations from the ideal shape of the final part. ACT is a learning algorithm that detects and eliminates repeatable errors in this type of manufacturing method. Both the Precitech FTS and ACT software help make parts faster than with traditional techniques.

JR:車削製程遠比銑削製程快上許多，主要有兩項技術有利於車削自由曲面。第一項是快刀伺服系統(FTS)，此加工方法是搭配主軸與軸位移，快速移動刀具，使工件得以快速被加工。第二項是自我調整分析軟體ACT。當你移動機台工具軸配合加工自由曲面(非旋轉對稱)工件時，機台動態誤差會影響最終工件理想形狀的偏差量。ACT是一個學習型演算法，可在這類加工方法中，偵測並消弭重複性誤差。比起傳統技術，Precitech FTS和ACT軟體兩者皆利於達成更快的製程。

WS: How can the programming challenges associated with the CAD system accuracy be overcome in the applications you mentioned above?

WS:關於CAD系統精度的編程挑戰，何以在您上述的應用中被克服?

JR: DIFFSYS software which has historically been used to create tool paths for all brands of ultra precision machine tools has made several advances in the area of freeforms. One of these is with the integration of tools that allow programmers to use a cloud of points from a surface defined in a CAD model to create tool paths. This is critical for freeform surfaces that cannot be defined easily by optical equations.

JR: Diffsys軟體，長久以來被各個超精密加工機品牌用以產出刀具路徑，在自由曲面應用上有做出許多突破。其中一項進步是整合各項工具使得編程者可以透過定義於CAD檔案中的表面投影點產出刀具路徑。對於無法輕易被光學式定義的自由曲面，此功能是一大關鍵。

WS: What types of material are typically used to create molds for automotive applications and can steel be used?

WS: 有哪些常見材質會用來製造車載相關模仁?可使用鋼材?

JR: Traditionally, since steel is a ferrous metal, it cannot be machined with a diamond. However, there are many reasons why one would want to use steel due to its hardness, which makes it resistant to damage during the molding process. Typically nickel plated steel or aluminum are used, which are not as robust. On the other hand, there have been advancements recently in ultra-sonic assisted machining that have started to change the traditional rule that only non-ferrous metals can be diamond turned.

JR: 傳統上，由於鋼材是含鐵金屬，因此無法用鑽石加工。然而，有許多原因會使大家考慮使用鋼材，主因是其鋼性，可以使之在成型製程中不易損耗。一般而言，鍍鎳鋼材與鋁材是普遍被使用的，但並非一樣耐用。另一方面，近期技術革新，運用超音波輔助進行加工，開始改變非鐵性材質才可進行鑽石車削的傳統規則。

WS: What key technologies enable ultra precision machine tools to be used for automotive applications?

WS:有哪些關鍵技術使得超精密加工機被用於車載應用?

EF: As Jeff mentioned two key technologies for turning operations are fast tool servo (FTS) and adaptive control technology (ACT). One that Jeff did not mention is ultra precision milling which is another method to make freeform shapes on molds required for head lamp optics. For some mold patterns due to physical limitation in the shape of diamond tools, milling may be required instead of the faster turning process.

EF:如同Jeff先前所提，在車削加工中有兩個關鍵技術分別為快刀伺服(FTS)和自我調整分析軟體(ACT)。有一項Jeff沒有提到的是超精密銑削，這是另一個製作頭燈自由曲面的加工方法。有些模仁設計，因鑽石刀具形狀的物理限制之故，就會選擇使用銑削，而非使用較快的車削製程。

WS: With regards to fast tool servo (FTS) and milling technologies what are the key considerations one should be aware of when manufacturing head lamp molds?

WS:關於快刀伺服(FTS)和銑削技術，當製造頭燈模仁時，有哪些關鍵考慮因素是使用者需知曉的?

EF: For FTS applications it is all about speed and accuracy. With a peak acceleration of 30 Gs and a fully integrated programming and operating interface the Precitech fast tool servo with Fastcom III control has benefits in both these areas. The story for milling is the same, speed and accuracy are critical considerations. The Levicron milling spindle has a top speed of 80,000 rpm which is faster than other ultra precision milling spindles. It is extremely thermally stable and has low error motions, making it accurate.

EF: 在快刀伺服的應用中，關鍵就是速度與精準性。透過峰值加速度達30Gs、一套完整的編程與操作介面，Precitech快刀伺服搭配Fastcom III控制系統，已經在速度與精準性上大有助益。在銑銷方

面也一樣，速度與精確性都是關鍵的考量因素。Levicron铣銷主軸擁有領先業界的最高轉速80,000rpm，遠比其他超精密铣銷主軸快上許多。且其主軸具備極佳的溫度穩定性與極低運動誤差，使加工更加精準。

WS: How does Adaptive Control Technology (ACT) enable better manufacturing of head-up display molds?

WS: 自我調整控制軟體(ACT)如何利於抬頭顯示器模仁的生產?

EF: In XZC turning, which is often referred to as slow tool or slow slide servo, the dynamic errors of the machine can be significant. By going slower these errors are reduced. However, going slower decreases productivity which increases cost. Also thermal errors can be introduced as temperature cycles effect the accuracy of the machine. This is more predominant on parts that take a long time to make such as freeforms. Ultimately ACT reduces the dynamic errors of the machine in XZC turning applications allowing you to go faster than you could without ACT, which has obvious benefits. This is one of the reasons we refer to this method as XZC turning instead of using the word slow. With ACT it does not need to be slow.

EF:在XZC車削中，經常被指為慢刀/慢導軌伺服，機台動態誤差可能很大。藉由降低速度，誤差可相應降低。但是，減緩速率也相對降低生產性，就會增加成本。此外，溫控誤差也就是指溫度週期影響機台精度。這些狀況會更加顯現在長時間加工的工件上，例如自由曲面產品。ACT根本上減少機台在XZC車銷中的動態誤差，允許加工者可以比沒有使用ACT時加工更快，這是一個很大的優勢效益。這也是我們為什麼指稱為XZC車削加工方法，而非使用"慢"這個字彙。搭配ACT，就無須減速加工。

WS: Most people in the precision manufacturing field are aware of automated tool changing when it comes to milling precision components. How has this concept been applied to ultra precision machining and what have been some of the challenges?

WS:談及铣削精密零件，超精加工產業中多數人都知曉自動換刀系統。如何使這個概念實踐於超精密加工中?會面臨哪些挑戰?

EF: Like everything in ultra precision it comes down to the sub-micron level. With automated tool changing the challenges are making tool holders that are balanced enough for ultra precision applications and a tool changing system that is repeatable enough so that the new tool is in the same place as the previous one. Levicron has solved both of these challenges with their milling spindle and custom build HSK tool holders.

EF:在超精密超精密的世界中，所有皆終歸至亞微米等級。使用自動換刀系統，製作可適用於超精密應用且有足夠平衡性的刀座成為一大挑戰，且刀具更換系統需具備足夠的重現性，使所更換上的刀與被更換的刀具，兩者位置一致。Levicron已經以其铣削主軸與客制HSK刀座徹底解決這兩個挑戰。

WS: How does automated tool changing help with the ultra precision manufacturing of automotive components?

WS:自動換刀系統在車載零件的超精密加工上有何助益?

EF: Specifically for corner cube applications used for signal lamp bezels and reflector molds. In order to make these productively and also finish them with an optical surface and sharp corners several tools are required. Using a milling system that allows for tools to be changed quickly without multiple tool setups makes the process viable for automotive applications.

EF: 特別適用於警示燈板與反射器模仁的角隅稜鏡應用。為了使之具有生產性且製作出光學表面和銳利轉角，需要多個刀具。使用允許刀具快速更換的銑削系統，免除多個刀具設置，大幅提升車載應用製程的可能性 。

WS: What's in store for the future of Precitech?

WS: Preitech的未來展望目標為何?

EF: We are always working on exciting new things. Specific to automotive applications, we plan to continue to make enhancements to DIFFSYS that make programming the tool path for complicated freeforms more accurate. We also plan to further integrate the operation of our fast tool servo system to speed up the process of making some of the molds used in automotive applications.

EF:我們總是研發激勵人心的新事物。特別針對車載應用，我們計畫持續強化DIFFSYS，在複雜自由曲面的刀具路徑編程上，可以更加精確。我們也更近一步計畫整合我們的快刀伺服系統來提升車載相關應用模仁的製程。

WS: Where can our readers go to find out more?

WS: 從哪裡讀者可以取得更多資訊?

EF: We have applications notes, videos, and brochures dealing with many automotive applications. These are all available on our website. www.precitech.com. Or come see us at the Photonics West show in San Francisco, CA from 31 Jan-2 Feb 2017. Booth 2035C.

EF: 我們有車載產品應用的資料、影片和型錄。這些都公開於我們的網站上www.precitech.com 。或是於2017/01/31-02/02前來舊金山Photonics West展會，攤位2035C，與我們見面。