Big small parts challenges

Producing and measuring micro-components or micro-features, 200 microns and below, poses challenges for engineering companies. Andrew Allcock reveals some of the solutions employed

Rutherford Appleton Laboratory (RAL), Didcot, Oxfordshire, is at the cutting edge of technology, supporting the work of over 10,000 scientists and engineers from the university and research community. As a government agency that conducts micro-machining, RAL turned to Kern (Deckel Grinders) when it needed to meet component accuracies of 1 micron.

One example is a backlight component for the Laser Department. This originally consisted of three parts that complete an

Left, a Kern Micro as employed by Rutherton Appleton Laboratory. Above, a Hexagon Global CMM at Reliance Precision which, through performace verification, delivers better-than-standard performance

assembly with an overall dimension of 4.5 by 2.5 mm. The intricacy and size meant that prior to the Kern Micro's arrival, the backlight parts were painstakingly machined and assembled manually under a microscope.

The Laser Department initially wanted four backlighters but this soon increased to 40. Such quantities represented a long process, so the responsible Millimeter Wave Group redesigned the assembly for 5-axis, one-hit machining.

Originally, the three-part backlighters took a working day to produce with an additional 2-3 hours for assembly. But the combination of Kern machine and the re-design now sees one complete backlighter finished in a little over 30 minutes. Just as well as the backlighter is now manufactured in batches of 120-140 on a regular basis.

The largest cutter used on the backlighter is a 2 mm diameter slot drill used to mill the external form. From this point a 0.2 mm diameter ballnose cutter is used to machine an optical form, then a 0.1 mm wide slitting saw is used to cut 1 mm deep at 70°. This is followed by further milling operations of similar scale to micron tolerances.

Adding to the difficulty of machining this part is the material – pure silver,


The Zeiss F25 is used by Kern in Germany to support its sub-contract operation. Uncertainty of measurement is 250 nm; resolution 0.25 nm

which demands exceptionally sharp cutters at all times to prevent swarf accumulation.

And a component recently manufactured at RAL for a space launch project to measure ozone depletion has overall dimensions of 0.023 by 0.090 mm. With the average human hair measuring 0.080 mm, this particular job can be compared to machining a rectangle on the end of a human hair.

SMALL MEASURES

Precision machine tool maker Kern, Germany, not only makes machines targeted directly at micro-machining, but also uses them to provide a sub-contract service. Among its customers are many well-respected watchmakers. The details on these parts are so small that measurement cannot be undertaken on standard CMMs – until, that is, Kern installed a Zeiss F25 machine.

Prior to this, products had to be measured using manual measuring equipment. An image-processing measuring machine only provided information on the position of the features. Obtaining information on the diameter of bores required additional test probes, so an accurate statement was extremely difficult. A final statement on bore depths was only achievable using a time-consuming measuring method. This was practically impossible for workpieces with up to 200 inspection features.

Manual trial-and-error inspection processes using the widest variety of test probes were not uncommon and often took up to 5 hours per workpiece. The influence of the operator on these manual measurements is also a consideration. Constantly changing workpieces in small batches required increased manpower, and drawn out start-up procedures and the generation of initial sample reports further delayed the manufacturing process.

However, with the F25, statements about size, form and position on micro-components can now be delivered in a single measuring run on the F25. The measuring volume of the 3D co-ordinate measuring machine is one cubic decimetre (10 cm^3). Measuring uncertainty for this volume is 250 nm with a measuring system resolution of 0.25 nm. Using minimal probe forces, this resolution, along with optimum control of the linear drives, enables contact measurements even in bores with diameters of less than 1 mm.

The 3D microprobe is designed for stylus diameters of 50-500 micron and stylus tip diameters of 120-700 micron with a free shaft length of up to 4 mm. The probe forces have also been minimised to less than 0.5 mN/μm. In addition to contact measuring, an optical sensor, whose optics were taken from Zeiss microscopes and specially optimised for the F25, is used for 2D measurements.

In conjunction with CAD-based Calypso measuring software, the measuring time for the bottom plate of a watch with 200 inspection features was reduced by 93 per cent from 5 hours to just 21 minutes. In-depth graphic measuring logs convinced customers and verified the consistently high quality.

The use of Calypso planner also drastically reduced the start-up time as the complete measuring program is created and simulated offline on a computer before the first workpiece undergoes a quality assurance check. The initial sampling reports are available in a few minutes after the first workpieces of a new series are produced. Waiting times, in which production had to wait for the results, are a thing of the past.

Additionally, since the deployment of the F25 to monitor production at Kern, the company has taken a significant step towards its goal of zero-error deliveries to

Photo-chemical etching scores over laser

Precision Micro, the Birmingham based specialist precision component manufacturer, claims to be 'raising the bar' for photo-chemical etching by setting new precision standards in the production of ultra-fine filter components for the medical market.

Precision Micro recently took up a challenge from a medical device manufacturer to produce a microfilter by the photo etch process following the failure of several other companies to deliver a successful solution.

The mesh had previously been manufactured by a laser process that was time-consuming, prohibitively expensive and left burrs on the underside of the component.

The challenge was to pierce a 78 mm diameter, 50 micron-thick stainless steel disc with 136,187 holes. Each hole is 100 microns in diameter (approximately the diameter of a human hair) on a staggered pitch of 200 microns. A general tolerance for these features of ± 10 micron was achieved as a result of Precision Micro pushing the boundaries of the process and achieving results previously considered impossible.

By etching all the holes at one time in a single process, the customer received a burr-free, stress-free component at an affordable price.

Lasers in medicine

Rofin-Baasel, Daventry, has been perfecting the fine cutting of micro-tubes, which are used for the production of stents and medical implants, for some 10 years. A result of this ongoing development is StarCut Tube, a high precision laser cutting system which is compact, self-contained and up to 10 times faster than the first generation systems.

The significant increase in performance and capability of this latest generation of StarCut Tube can be attributed to a state-of-the-art motion system. Linear motor technology together with directly driven rotary axes, provide enhanced speed and accuracy. The addition of a sophisticated laser control system allows the laser cutting parameters to be optimised to match the travel speed of the various axes, enabling complex geometries including cutting small radii to be easily achieved.

Today, StarCut Tube can process tubes with diameters of less than 200 microns with kerf widths of less than 15 micron. Radial and non-radial cutting angles can be achieved without any damage to the opposite wall thus making it possible to open tubes laterally or to cut hollow needle points. New and unusual cutting geometries are also possible; for example, spiral cuts or interlinked structures in just one process and operation (for flexible instruments).

The system can produce a coronary stent (above), 8.0 mm in length in less than 60 sec. Accuracies of only a few microns can be achieved repeatedly, thanks to the stability of the granite mounting platform.

StarCut Tube is available with a choice of laser sources including the proven StarCut 18 which has a power range of 7 to 25 W and achieves kerf widths of 18-20 micron. Additional laser options include the new StarCut 12fm, a 12 W fundamental mode laser and the StarCut Tube Fibre which has 20 W maximum power. These lasers offer kerf widths of less than 15 micron.

its watch component customers.

Measurement of micro-features is also a major issue for Reliance Precision (previously Reliance Gear), Huddersfield, where many components have micro features. "If we can't measure a component, or a feature of a component, then we wouldn't try to manufacture it. It's that simple, " says chief quality inspector Roy Mawhinney. But it is using standard CMMs in a novel manner to maintain its accuracy credentials.

The company's output includes sub-assemblies for mass spectrometers; potentiometer and encoder drive units; stainless steel leadscrews and super-standard components for medical equipment; and fine pitch gears for actuation gearboxes. The work involves a high degree of micro-machining. Rigorous inspection and tight quality control are crucial.

The company employs CMMs from Hexagon – two Brown & Sharpe Chameleons and a Global Image at Huddersfield, plus a Global Performance machine for its plant in Cork. These are used both for manufacturing process support and within its R&D facilities.

The company typically manufactures components with extremely small features and geometry within the tightest of tolerances. In some cases minute holes have to be measured with styli-to-bore clearances of less than 0.2 mm.

BETTER THAN STANDARD

Reliance regularly verifies the performance of its CMMs and can measure, with a high degree of certainty, positional tolerances that are beyond the CMM manufacturer's tolerances.

This 'above and beyond' process – developed by Hexagon specifically for Reliance – allows manufacturing tolerances to be verified on the Global CMM that would otherwise require an ultra high accuracy machine such as a Leitz PMM at twice the cost.

EDM wire-cut turning pioneered by workholding specialist Hirschmann – the turning of parts down to 10 micron diameter – is still novel but is already being improved by the same company following the launch of its second generation high speed rotary spindle (H80R.MAC). Its predecessor, launched two years ago, is already widely used throughout the world of micro-machining, it is claimed.

The new generation spindle has the additional benefits of positional indexing and servo controlled erosion using the rotary axis. This is in response to requests from, in particular, the medical, micro technology and aerospace industries to combine EDM turning of small parts with indexing and servo controlled erosion. Developed and tested in conjunction with the Institute of Micro Technology in Mainz, Germany, it is suitable for high speed applications.

Parts which have traditionally been both difficult and expensive to manufacture can be produced cost-effectively without compromising accuracy. Dental drills, medical implants and instruments, minimised assembly groups, micro-moulds for plastic injection and micro-tools can be manufactured more economically and without the traditional problems associated with the form/cylindrical grinding of small detailed parts.

Free from lateral side forces, geometries can be created without the influences of grinding wheel wear and form error. By rotating the component accurately at high speed, the surface is comparable with that of grinding. Set up is much faster using the high speed rotary spindle than with grinding. Metal removal rates are also better compared with grinding.□