

Machining under the microscope

With the increasing trend towards miniaturisation, reliable, cost-effective micro-machining processes are in high demand. Steed Webzell reports

The miniaturisation trends of the past 50 years have been nothing short of astonishing. In the 1950s, radios boasted five transistors, while computers were vacuum-tube-filled rooms. Today we have inexpensive, 100-million-transistor computer chips in our homes that we replace not because they have failed, but because technology has moved on.

The 'shrinking' of electronic devices has a knock-on effect for associated mechanical components, such as connectors and moulds for plastic parts and housings which similarly continue to get smaller.

It is this very trend that in the early 1980s prompted computer giant IBM to approach German machine tool builder Kern Micro-und Feinwerktechnik. With nowhere else to go and no manufacturer capable of producing a machine to the accuracy levels required, Kern was persuaded to produce its first desktop machining centre in 1982 for IBM.

Commissioned to drill 1,700 holes of 0.1 mm diameter in 'computer probe cards', the explosion in the PC industry soon saw one machine become a bank of more than 10. Continued demand saw IBM rival Siemens knock on Kern's door requesting machines for its own manufacturing needs. Since then, Kern has delivered over 670 machines worldwide, with desktop machines being the mainstay of business until 1997 when the first full sized machining centre was delivered – the Kern MMP – now known as the Micro.

"With the global consumer market continually striving for the smallest possible mobile phone, iPod, PC and gadget, manufacturing industry is forced towards production of increasingly complex, accurate and small components to meet these needs," says managing director Rudolf Riedel. "It is this growing worldwide demand that has seen Kern expand exponentially in recent times. In 2007 we produced 55 machines with 72 scheduled for 2008 and potentially 100 machine sales in 2009."

CULTURE CHANGE

Avenue Mould Solutions of Sligo, Ireland, recently installed a Kern Pyramid Nano machining centre.

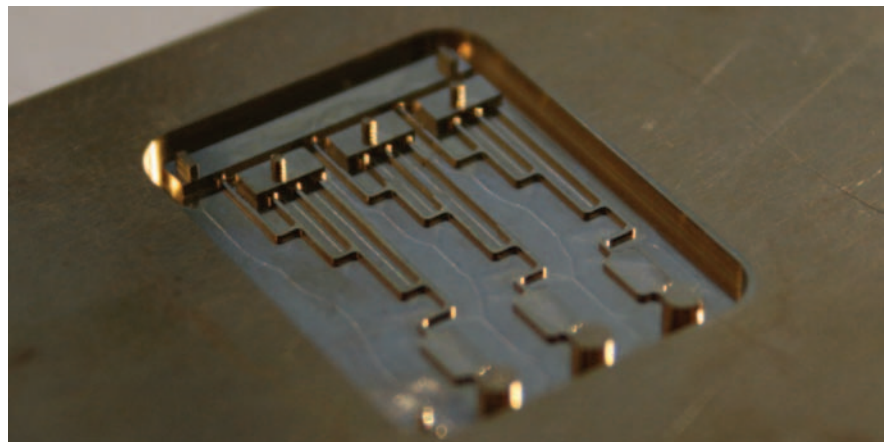
"The purpose of acquiring the Kern machine is two dimensional," explains the



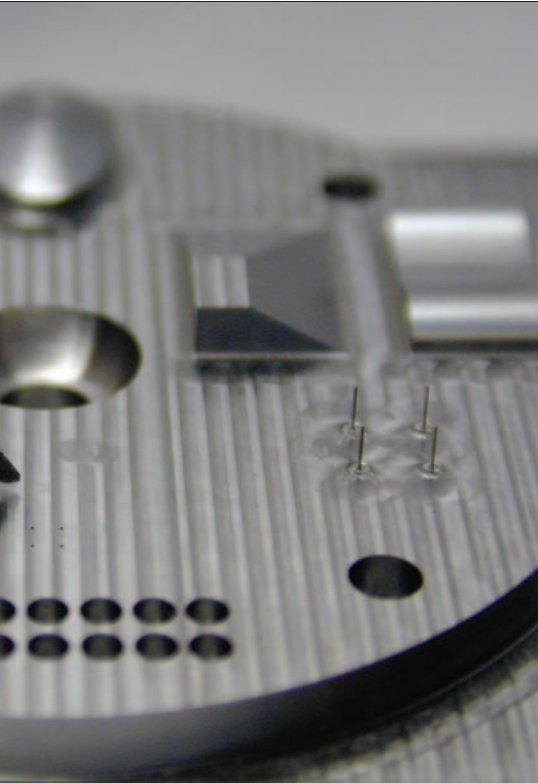
Avenue Mould Solutions is streets ahead on accuracy with its Kern Pyramid Nano

company's managing director Felim McNeela. "First, we want to improve the accuracy and surface finish on the multi-cavity mould components we currently manufacture and, second, we want to diversify into the growing micro-machining industry.

"This is a culture change for the whole company," he continues. "Our staff are undergoing training and our processes also have to change to meet the specialised micro-machining industry. To demonstrate the level of change required, our new Kern machine is more accurate



Cardiff University is working on microfluidic devices requiring moulded micro-channels



than our current CMM. The nature of our company is to continually drive forward, and as we take steps into the micro market the Kern Pyramid Nano will be central to our machining needs."

Unsurprisingly, academia is also showing much interest in micro-machining. A case in point is the Manufacturing Engineering Centre (MEC) at Cardiff University, which has a 5-axis HSPC micro-machining centre from Kern.

MicroBridge Services is a new company formed by the university with the remit of commercially exploiting the MEC micro-machining capability for the benefit of UK industry. MicroBridge works within the drug delivery, microsurgery and diagnostics area of medical engineering as well as the optic, lens, electronics and aerospace industries. This involves machining non-silicon materials, glass, polymers and a variety of metals.

The Kern HSPC has been supplied to the MEC with two spindles, a 42,000 rpm spindle as standard and an additional 90,000 rpm spindle to help solve specific customer issues. It has recently been employed to produce injection mould tools for microfluidic devices.

Microfluidic devices require micro-channels moulded on a surface that are created by free standing walls machined on the mould tool. A recent mould tool for

a device to examine drops of blood required channels machined at 20, 30 and 40 micron wall thickness.

"Using 0.6 mm diameter endmills we had to machine at the full 200 micron depth making small cuts on one side of the wall and then the other to gradually achieve the required thicknesses," says Dr Robert Hoyle, operations manager at MicroBridge. "The mould is produced from brass mainly for its ability to remain intact under such difficult machining conditions."

TINY TOOLS TOO

For most, the scale of micro-components is only eclipsed upon witnessing the size of the cutting tools used to machine such parts. Although small hole drilling is a common but far from straightforward micro-machining application, Rainford Precision of St Helens has recently held successful drilling trials with a number of customers. Supplying the Union Tool range of Super Micro Grain Carbide drills that start at 0.1 mm diameter and increment in 0.01 mm steps up to 2.0 mm diameter and then 0.05 mm steps up to

3.0 mm diameter, small hole drilling problems can now be a thing of the past.

For instance, one customer required 0.25 mm diameter holes to be drilled in 54 HRc tool steel to a depth of 3 mm; the target of 20 holes was achieved using a single Union Tool drill. The strength and rigidity of the drill eliminated the need for an EDM fast hole drilling machine, thereby saving its users considerable processing time and money.

"You can make significant savings by ensuring the drill is running true," says Rainford Precision's owner, Arthur Turner. "If you check the concentricity of the drill by clocking the 3 mm reinforced shank using a 0.001 or 0.002 mm clock, the hole size will be improved and drill breakage will be reduced. This will eliminate extra set-up time and the expense of using additional drills."

Continuing to share his drilling expertise Mr Turner adds: "Don't go too fast – get rid of heat by using the best spindle speed and feedrate for the material. Small drills have a proportionally bigger web compared to their larger counterparts and will produce more heat

Micro grinder

To meet the increasing demand for micro tooling, grinding machine manufacturers have been busy reviewing their product portfolio. A case in point is Walter, part of the Körber Schleifring group, which has recently introduced its 6-axis Helitronic Micro tool grinder.

The machine been designed from the ground up to meet increasing demands in the medical and electronics sectors for the production of micro tools of 0.1 to 12.7 mm diameter and the regrinding of

tools from 2 to 12.7 mm diameter.

As an example of cycle times, a drill of 0.4 mm diameter and 2 mm long can be produced in 3 min 20 sec, while a 0.4 mm diameter square endmill of 1.5 mm long can be ground in 4 min 30 sec.

The machine features an integrated Fanuc robot (double gripper) loading system for fast – less than 10 seconds – toolchange, in conjunction with a four-pallet loader.

by friction. Therefore it is important that the source of this heat is reduced to keep the web intact: consider slowing the spindle speed down. A major misconception with small drills is that they must be used at very high speeds."

Finally, Mr Turner says that customers need to consider drills with a 150° drill point. "This has a different cutting action when breaking through; the drill point doesn't tend to 'push' the material like sharper drill points and we've all seen 'flying saucer' swarf when drilling holes."

FREEZING TO HOLD

Beyond the actual machine and cutting tools, workholding presents further challenges for micro machining practitioners. To overcome the obvious difficulties, France-based AMCC has developed advanced technology for plate freezing small and delicate micro-components, and ongoing R&D has seen the company expand its product range with the new GFR series.

Birmingham-based Leader Chuck Systems is the UK agent for this unusual technology, which uses a film of ice to secure parts for grinding, milling and turning operations. "Most components that require traditional micro-machining operations, where material is removed from the part, are very fragile and therefore susceptible to damage. AMCC has answered this challenge with an

Laser cut solutions

Oxford Lasers is using Delcam's PowerMill CAM software to program its latest range of laser-based, 5-axis micro-machining systems.

The project leader responsible for micro-machining systems and applications at Oxford Lasers, Dr Dimitris Karnakis, says that micro-machining with lasers offers distinct advantages over conventional machining technology. He believes that, comparatively, lasers can machine very quickly, more accurately and give a better surface finish. Ra values well below 1 micron are achieved by running different passes of the laser over the surface at different angles.

"Using lasers avoids the problems associated with producing cutting tools that are small and robust enough to cut shapes at micron level," he says, adding that lasers can produce the smallest

shapes more effectively when compared with EDM.

A team at Aston University in Birmingham is using a system from Oxford Lasers programmed with PowerMILL to machine very narrow, high-aspect-ratio cavities into 125 micron diameter optical fibres to allow manufacturing of fully integrated in-line photonic devices for real-time sensing.

In another example, PowerMILL is used to support laser machining of microfluidic devices for biochemical analysis. These will allow biomedical researchers to manipulate fluids in networks of channels and monitor reactions requiring only small volume samples and reagents, producing little waste and offering rapid analysis times at relatively low cost.

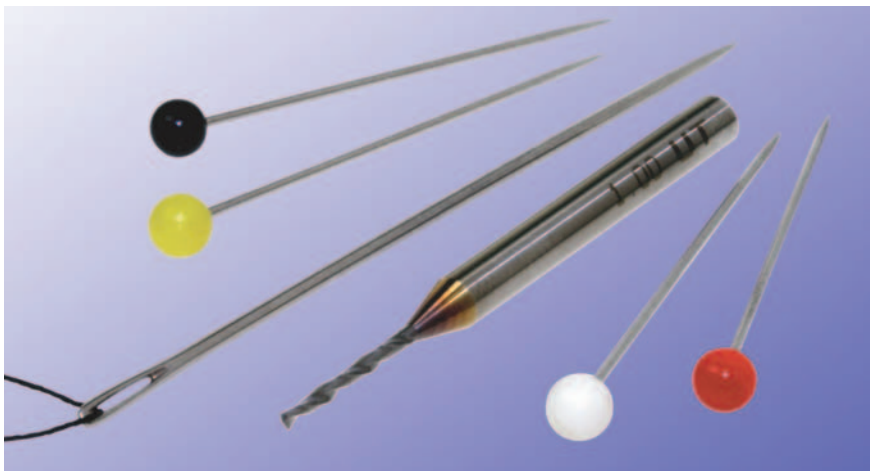
innovative solution that is quick and easy to use," says Leader Chuck's managing director Mark Jones.

Designed specifically for clamping via an ice film, delicate parts held with the GFR series are clamped without any distortion or mechanical stress being transferred to the part. This makes it suitable for grinding, milling and turning

electronic components, watch parts, medical implants and other finely detailed manufactured goods. The technology is also suited to applications where vacuum or magnetic fixtures cannot be applied: for instance, when components have through holes or the material is non-ferrous.

In operation, AMCC products are very simple to use. A fine spray of water is laid on the freezing plate and the component is positioned in a jig or specially designed top plate. The 'freeze' cycle is selected on the control unit and within seconds the film of water turns to ice, clamping the component ready for machining. Afterwards a thaw cycle is selected to release the part.

Although impressive to date, component miniaturisation will undoubtedly continue and even accelerate in the coming 50 years. By how much, is anyone's guess. Estimates are either too conservative, acknowledging the current limitations of technology and ignoring inevitable breakthroughs, or too fantastic, brushing aside real physical limitations. Somewhere between is a safer bet. □



The Union Tool range of Super Micro Grain Carbide drills start at 0.1 mm diameter