Wired for speed

Steed Webzell details the strides made by wire-cut EDM researchers in their quest for ever-faster speeds and the latest machines that are the result. What is practically achievable and who is set to benefit?

Generating interest

Agie has developed an improved generator – its Intelligent Power Generator featuring eCut technology.

The company claims this not only to be fast, but also economical, eco-friendly and easy to use. It comes as standard on Agie's latest range of wire-cut EDM machines – the AgieCut Progress and AgieCut Vertex series. Cutting speeds of up to 500 mm^2/min can be achieved on most cutting heights, using standard wires. Also, a surface finish of 0.8 micron, through one precision cut, can be achieved twice as fast as machines with main and trim cut machining operations. This reduction in machining cycles means less power, wire, filter and resin consumption – a particular advantage for companies looking for ISO:14001 certification.

"There has been a lot of fuss and hype in recent months about the cutting speeds of wire-cut EDM machines," says Agie UK's sales and marketing manager, Chris Hewitson. "But we know we have something more than the fastest machine on the market – a real win:win scenario for our customers – high cutting speeds, a reduction in non-productive time and significant reductions in consumables expenditure."

Wire-cut EDM has come a long way from its commercial origins in the early 1970s, when top speeds of 10 mm^2/min were employed almost exclusively for the manufacture of stamping dies and punches. Speed increased to approximately 30 mm^2/min by the mid-70s, before surging rapidly to reach 300 mm^2/min by the mid-90s. Some of today's machines specify nominal speeds in excess of 500 mm^2/min, and while actual average cutting cycle times are less than nominal speeds, these have also witnessed tremendous gains.

Advances in technology are behind these impressive gains. Fast solid-state power generator circuitry, optimisation of current pulse shapes, high-performance control systems, automatic wire path generation, high flushing pressure, wire electrode quality and the increased availability of special wire alloys, have all contributed to the overall increase in cutting speed. In association with speed developments, machine designers have also introduced automatic threading systems, multi-axis simultaneous operation, wire breakage prevention strategies and automated component loading and unloading. All of this adds up to high-speed, high-performance production machines that are approaching the point where they can compete with more conventional machining methods such as milling, in terms of the achievable metal removal rates.

Wire-cut EDM has many traditional advantages such as: the elimination of secondary operations thanks to its ability to cut hard metals; the subsequent dramatic reduction in floor-to-floor times; excellent surface finish; the ability to machine complex profiles;

enhanced accuracy; no requirement for special tooling or high clamping forces; and the elimination of deburring operations – which is of particular importance to the medical sector where a missed burr becoming detached can have disastrous consequences. The only piece absent from the jigsaw that will promote EDM to the premier league of production processes is speed, but this is now changing.

While wire-cut EDM will always be a favourite for tooling, prototype and small batch work, production environments are where increased speed is taking this process. Launched a little over a year ago, the Charmilles CleanCut range of wire-cut EDM machines achieve speeds of 400 mm^2/min thanks to their powerful digital generators that create high-intensity sparks. This reduces erosion times, particularly for thicker parts, while also achieving the desired surface finish in fewer passes.

Several UK companies have invested in these machines. One is Tamworth-based Spark & Wire Erosion, which replaced its entire shop with Charmilles Robofil 240 and 440 CleanCut wire-cut EDM machines. The company is now running 24 hours/day, seven days/week unattended operations and has since secured new contracts for the supply of aerospace components. New work has also been the result for XL EDM, located in Stockton-on-Tees, which purchased a Robofil 440 CleanCut, helping it win profitable contracts in the medical sector for parts such as key-hole, liver transplant and sports injury equipment.

So what type of component will specifically benefit from these high speeds? For real advantages, the answer predominantly lies with complex or 'tricky to machine' parts. Involute gears, splines and cams all spring to mind, as do components featuring tall, thin slots or holes, as well as features that require very small internal corner radii – down to 0.02 mm – appearing sharp to the naked eye.

FABRICATING ENTERPRISE

One growth area, however, is in the fabricating sector, where enterprising companies are using wire-cut EDM to cut nested parts from a stack of blanks – often up to 50 at a time. This process is proving ideal in meeting component designs that require high accuracy blanks and is deemed by many to be superior to laser cutting by orders of magnitude, mainly due to its high quality edge generation that avoids the edge curl damage often prevalent with heat from a laser source. As for the future, speeds are such that it is conceivable that wire-cut EDM will be used for 'blocking out'

processes, reducing the need for sawing or machining to size operations.

In terms of achievable speeds in practice, all of the major suppliers claim that the nominal speeds specified are genuinely achievable, although this is clearly dependent on the complexity of feature, as well as the size and type of wire. At high speeds, thin wire can rupture, mainly caused by high-power density along the wire, which is regarded as the ratio of sparking frequency to spark distribution length. Thicker or coated wires tend to avoid frequent rupture at higher speeds, although this represents an obvious increase in cost of consumables.

At the most recent EMO exhibition in Milan, Sodick claimed to have set a new world record for EDM cutting using practical diameter wire. The combination of Sodick's new LQ33W high-speed generator and one of its AQ-L linear drive machines produced a solid 260 mm^2/min removal performance using normal brass wire measuring just 0.25 mm in diameter (the most commonly used wire diameter in industry) – or up to 340 mm^2/min with the coated equivalent.

Which materials...?

The modern generators offered by forward-looking machine manufacturers can cope with a wide range of materials including steel, tungsten carbide, boron carbide, titanium and aluminium. According to Thomas Schreiber at Mitsubishi, the 500 mm^2/min capability of its recently introduced FA-V series wire EDM also generates big improvements in cutting graphite as the particle size can now be much larger – up to 10 micron, whereas previously only 3 micron was achievable. He goes on to add that the performance of the machine also lends itself to awkward features where effective flushing is not possible. The Mitsubishi FA-V series is marketed in the UK through HK Technologies (see page 16).

PG Technology's seven-figure EDM centre

Surrey-based PG Technology has installed several Charmilles wire EDM machines, including 240 and 440 CleanCut high-speed models and several Charmilles 2030 SI twin-wire machines, helping it to produce high-volume, complex parts in materials ranging from aluminium alloys to more 'exotic' metals. "The machines give us a fast, accurate and cost-effective means of manufacturing, especially for complex parts," says PG's owner, Vincent Bootes. "We run our EDM centre 24 hours a day, seven days a week – lights out – which means we can meet very tight turnaround times."

The success of these machines is proven by their sales record, as highlighted by Peter Capp, managing director of Sodi-Tech EDM: "All production machines were sold during the launch and Sodick has a full order book of machines for China, Japan and the Far East. The earliest delivery on new orders is anticipated to be June 2004." Mr Capp adds that the machines are proving particularly popular with 'high-end' activities such as aerospace and Formula One, and that the speeds suit notoriously troublesome materials such as titanium.

Much research is taking place to determine methods of making machines faster. To sum it up in a general statement would be near impossible and demeaning to the effort involved, but there are some common threads that are leading to improved cutting speed results. One area is better control of the wire in terms of how it is transported from the supply reel, passed through upper and lower guides and energised by the electrical contacts. Another is better control of the wire properties in terms of stronger cores and in higher cooling efficiencies of coatings such as zinc alloys – it appears that the surface properties of the wire are a major factor in the metal removal capability of the wire electrode.

Control strategies are another area constantly under review. With research and comparison between adaptive control, non-linear control, robust control, measurement-based optimisation, two-degree-of-freedom controllers and fuzzy logic control, taking place at various research institutions. This work is proving a challenge, with the goal being effective controllers that can handle the complex physics of the EDM process, the complex mechanics of the machines and the complex electronics of the power generators, which deliver controlled and maximized energy to the spark gap for greater metal removal.

OPTIMUM CONDITIONS

So what are the optimum conditions for high-speed wire-cut EDM operations? Firstly, the nozzles that enclose the wire at the top and bottom should be as close to the job as possible. It is also important to create a blank that is approximately 3 mm bigger around its profile than the desired finished size. This allows the flushing pressure to be concentrated around the cut, rather than flowing over the edge of the blank, rendering it ineffective.

The limitations of wire-cut EDM are slowly being crossed-off one by one. And though the technological and commercial limits for this innovative process are not yet in sight (for instance there is still much to learn about spark formation and the microscopic removal of material at the workpiece surface), the evidence suggests that wire EDM is ready to make its debut in high-volume production machining shops, primarily due to faster cutting.

Attitudes are changing – no longer is wire-cut EDM seen as a last resort. Progressive production engineers are instead applying the ethos: 'how can I wire-cut EDM this part?' M