

# Rapid technology change

**Andrew Allcock went to visit a one-of-a-kind rapid prototyping/rapid manufacturing facility in the UK and heard how technology change is shaping its future direction more in favour of metal parts production**

**H**igh Wycombe's CRDM rapid prototyping/rapid tooling/rapid manufacturing facility has been growing steadily over these past few years; albeit in a pretty low profile way. Opened in 1994, with turnover today standing at £2.5 million, its ambitious plans envisage a 10-20 per cent/year growth rate over the next three years and payroll will rise from the current 40 to 100 people. The company recently moved to a new 22,000 ft<sup>2</sup> purpose-built facility.

CRDM is a spin-out from Buckinghamshire Chilterns University College, now Buckinghamshire New University. One hundred per cent owned by that institution, CRDM earns it keep in the commercial world without any public funding.

The company's business is split between rapid prototyping (RP) in plastics and resins using stereolithography (SLA), rapid mould tool making (taking in the rapid manufacture of laser-sintered tool inserts used in standard bolsters), injection moulding using those tools, plus, increasingly, the rapid manufacture of laser-sintered metal parts for fully functional prototypes or end use parts using German company EOS's Direct Metal Laser Sintering technology (see box). With this mix of activities, it is one of a kind in the UK and,

says director Graham Bennett: "We are one of the leaders in this field and have been doing this [laser metal sintering] longer in the UK than anybody else."

It is a measure of how the RP scene has changed when he describes plastics-based, stereolithography-type RP (SLA) as "traditional rapid prototyping"; increasingly the organisation is looking towards rapid mould tool making, moulding and, even more, to the rapid manufacturing of end use/production metal components.

## PERSONAL RP?

"We are still very interested in rapid prototyping, but as the market matures, there are more and more low-cost rapid prototyping machines coming into the market – in 2009 there will be a new machine coming out in the £2,000 to £3,000 range – so the bureau service will come under pressure from in-house facilities," Mr Bennett says, adding that RP machines will become like expensive photocopiers – "and most companies can afford these". Indeed, eventually "there will be one [RP machine] in every home," he offers.

So, the production of simple, small parts using RP will become increasingly unattractive for CRDM – and other RP

bureaux – although larger, more complex parts requiring finishing processes "will be around for quite a while". But while RP machines can be put on a desk, it isn't possible for companies to put a mould tool making facility on a desk, nor is rapid manufacturing in metal so easy or cheap, and these are the areas in which Mr Bennett sees CRDM growing.

To backtrack a little, CRDM was established with RP as its core service.

This then led to the creation of a service for the production of mould tooling on short lead times – rapid tooling – which also prompted the establishment of in-house moulding to support short batch runs in the required material of the parts initially designed via the RP process.

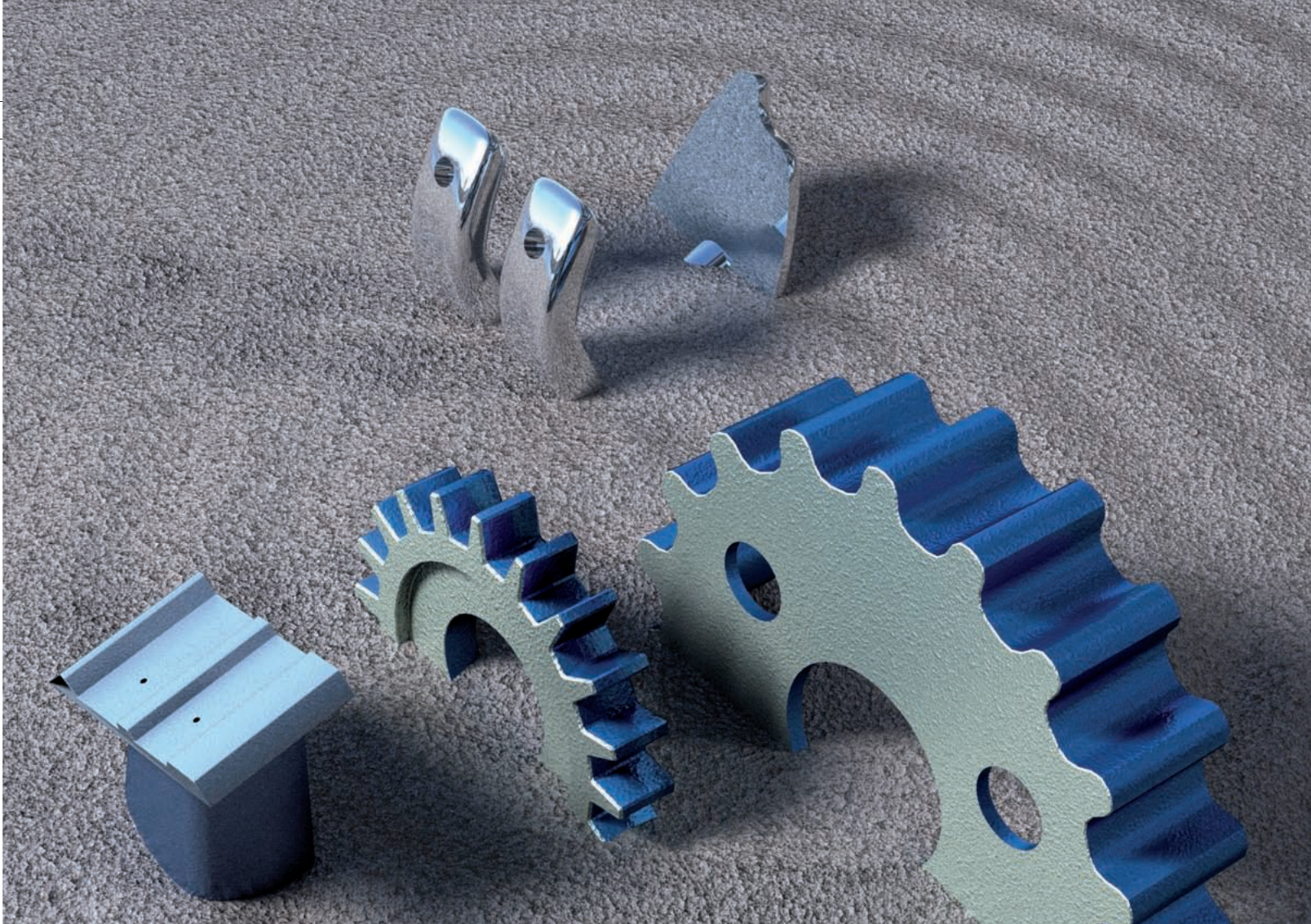
"We made the RP parts in a few days and were then told that it would take 10 weeks to make the mould tools," Mr Bennett explains. CNC machining was the first route applied to produce 'rapid tooling', but the company adopted the metal sintering process as soon as it could, taking on its first EOS machine in 1999 for the manufacture of nickel-bronze mould tool inserts.

In 2004 CRDM stepped up a gear, investing in an EOSINT M250 Xtended Direct Metal Laser Sintering machine. Prior to this investment, the company had made perhaps 80 tools in the preceding few years. It now makes some 300/year in nickel-bronze – indeed, this use of laser metal sintering is no longer considered novel, says Mr Bennett. Both customer confidence and CRDM experience have grown. Tool production



## EOS Direct Metal Laser Sintering

DMLS parts are built layer by layer, directly from 3D CAD data, fully automatically, in only a few hours and without any tooling. A laser melts metal powder, creating a fine, homogeneous structure. Parts are typically built up in layers of 20 micron. Multiple parts can be manufactured at the same time. (UK agent EOS UK, Warwick).



*Left, a titanium turbine blade; lower right, gears in stainless steel 17-4; top, a titanium knee implant*

can be as fast as two days, but is typically two to three weeks, with the tools used mostly to support in-house moulding.

However, recently (March 2007) the company acquired an EOSINT M270 and with this investment, both mould tool insert manufacture and rapid manufacture of end use metal parts have been positively affected.

#### **MORE MATERIALS**

The M270 now makes possible the processing of a wider range of more exotic materials. "This machine can manufacture parts in metals that we could not process before," Mr Bennett explains. "The M250 can process nickel-bronze and a version of steel, although it is very slow. The M270 can still process nickel-bronze but it can also process a whole raft of materials that weren't even available when we bought the M250. These include cobalt chrome MP1, stainless steel 17-4, Maraging steel (MS 1) and titanium, while during the next 12 months it is anticipated that

Inconel and Hastelloy will appear and, in the long term, maybe even aluminium."

The availability of hardenable Maraging steel will support the manufacture of mould tool inserts that can support runs of up to one million parts – nickel bronze can support runs of up to 100,000 (incidentally, CRDM's moulding capacity is 600 g maximum shot weight). This will

allow CRDM to address a different part of the market.

But, in addition, the availability of what Mr Bennett calls "more familiar materials", such as stainless steel 17/4, sees companies becoming more interested in the rapid manufacturing of components "because they understand this standard engineering material".

The result of installing the M270 has

### **Rapid manufacturing's future**

The RM market is growing. At last year's National Conference on Rapid Design, Prototyping & Manufacturing, RM specialist Econolyst highlighted that the global market for RM materials, machines, parts and services was put at just over \$100 million in 2006; just under \$140 million last year; and is predicted to be over \$160 million this year.

And consultant Wohlers Associates said last year in a major global report looking at the state of the 3D printing, additive fabrication, and rapid manufacturing industry, that RM is "the next frontier". Many companies in the aerospace, motor sports, medical, dental and consumer product industries are now using additive processes for custom and short-run production. Wohlers Associates believes that rapid manufacturing will eventually grow to become the largest application of additive fabrication.

## Rapid manufacturing – just what the doctor ordered

At the first Rapid Implant Manufacturing Forum held last September in Leuven, Belgium, DePuy Spine, Massachusetts said it had been relying on EOS Direct Metal Laser Sintering (DMLS) only since February 2007 and had already produced some 2,000 parts. So far these had mainly been used for evaluation purposes and sales samples. The company's Peter Ostiguy, staff team leader, said: "DMLS technology provides a new starting point for how we design our components. In the past we designed for manufacturability. Now, with laser-sintering, we can design for functionality. Geometric constraints have been reduced."

Using DMLS, DePuy has reduced lead times in some projects by up to 50 per cent, even if product iterations became necessary. DePuy also predicted a wider use of DMLS-manufactured instruments to be used in operating theatres once the new, hardenable material EOS Stainless Steel PH1 is commercially launched. The material fulfils the ASTM E8 specifications as built and complements the existing material EOS Stainless Steel 17-4.

indeed been that the business is not only able to make nickel-nickel-bronze mould tool inserts but increasingly is making metal parts, both as prototypes and end-use parts, within an envelope of 250 by 250 by 215 mm on the M270.

"The production of components is still quite a specialist requirement, but it is slowly becoming more interesting to other companies. We are able to offer solutions, in terms of geometries of parts in materials like stainless steel, which were not available to them previously. Indeed, this is a great strength, but the problem we have is to encourage designers to abandon the established CNC machining/EDM production route of multiple simple parts which are then assembled, in favour of a single, more complex item made via rapid manufacturing," explains Mr Bennett.

In fact, because rapid manufacture of metal parts is more costly than the established processes, this design-led approach is a shrewd initial angle of attack. However, as more and more laser metal sintering machines enter service and prices of the technology drop, things will change. Mr Bennett draws an analogy with RP for plastic parts: "Rapid manufacturing of metal parts is probably where RP for plastic parts was in 1993/4/5, and prices for stereolithography (SLA) since then have

plummeted as machines and materials have got cheaper. I think in five years' time metal sintering will be where SLA technology is now."

However, rapid manufacture of production parts is already attractive for 'legacy designs' where volumes of current parts are low, while sectors such as F1, medical (see box, top of page) and the defence industry are interested. In America, parts for rocket motors are one application area that CRDM's director cites. But companies are

becoming interested where annual part volumes are between 400 and 500, he offers. And it is the area of rapid manufacture that has most potential to support CRDM's growth ambition, for while the mould tool/moulding side of the business will grow, it will not be double-digit growth, Mr Bennett adds.

### PRODUCTIONISATION CHALLENGE

With rapid manufacture of metal parts as a production process becoming increasingly attractive, the challenge for CRDM is to build a production environment with its controls, processes and procedures that transform a method of prototyping into a production one.

Mr Bennett says: "When a client asks for a part, we need to have internal systems that will match standard production systems. So, for example, if we are making something from a piece of steel in a production environment there is



## DMLS service in the UK

Established In 1999, 3T of Newbury, Berkshire has two EOSINT M270 machines and can currently create parts in cobalt chrome (EOS CC MP1), stainless steel (EOS SS 17-4) and Maraging steel 1.2709 (EOS MS1). At the moment, the cobalt chrome Superalloy is probably the most attractive one for these markets as it offers very high strength and hardness, and can withstand high operating temperatures (up to 1,100 °C). The material could be used to produce accurate, complex exhaust manifold forms for example, and other options may include gearbox parts, suspension parts or complex fixings.

The introduction of titanium (Ti) and titanium 64 (TiAl6V4) powder is said to be an exciting opportunity for the 2008 F1 racing season and the development of new lightweight aerospace engine parts, according to the company.

traceability for the material, the material performance is well understood, and there are processes established governing manufacture.

"Because our technology has come from the rapid prototyping environment, these systems are not in place – not because they can't be, but because they haven't been required for one-off parts. But if a company wants regular quantities of the same part it will want a guarantee

that each batch will perform in the same way. We will have to take on board 'production customs'."

### PRODUCTIONISE JOURNEY

CRDM has already started its journey towards a production environment by gaining ISO9001 accreditation last year. "The first of many steps that we intend to take in terms of qualifications and approvals. Internally, we are developing

processes so that we do have traceability in the things that we make."

CRDM is also running in-house tests to qualify/characterise the performance of the new sintering materials. Again, in the case of plastic RP parts, the durability of the material has not been an issue since the part is for a prototype – now for metals people want to know a lot more about performance. The business is also working with customers to characterise materials in the formed state and also understand how properties are affected by, for example, raw material age or the way the powder is treated.

The companies that develop the materials, such as EOS, only go so far so in characterising them, says Mr Bennett, so it is up to users such as CRDM to take it and provide feedback.

Mr Bennett concludes thus: "I think that in time rapid manufacturing of metal parts will become an established manufacturing technique for particular geometries. But I think that the design liberation the process brings is the really exciting thing." □



*The medical sector is one of the lead examples for direct part production from metal powder*

## Third International RM conference

To be held on Wednesday and Thursday 9-10 July 2008, at the Sir Dennis Rooke Conference Centre, Holywell Park, Loughborough University, and now in its third year, the International Conference on Rapid Manufacturing (RM) is the world's only conference focused solely on 'end use parts' made using additive layer manufacturing technologies. The event provides a two-day platform for invited speakers, including the very best in both academic RM research activity and commercial RM applications.

The event also hosts a parallel technology and materials exhibition supported by leading RM systems vendors exclusively for conference delegates.

Visit: [www.rm-conference.com](http://www.rm-conference.com)