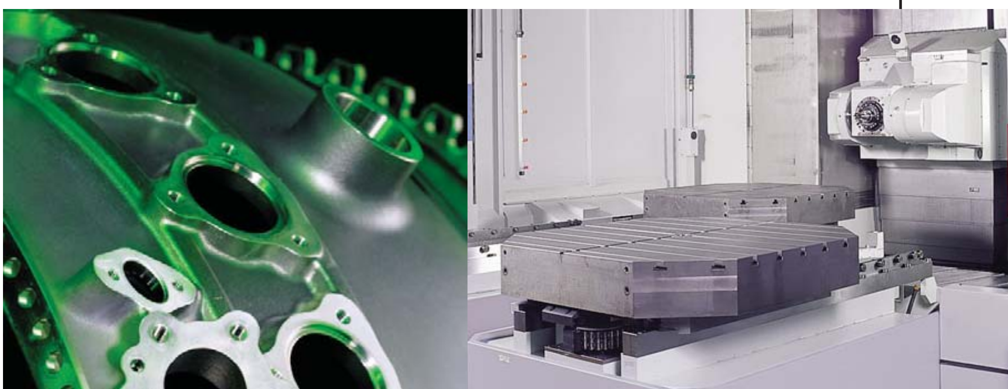
Metalcutting 'omelette'

University of Sheffield's new Advanced Manufacturing Research Centre (AMRC) is set on a course to test and extend metalcutting boundaries. But it might involve 'breaking a few eggs'

Dedicated to pushing the boundaries of all aspects of machining difficult and exotic materials used in aerospace, airframe structures, turbine, power generation, medical, F1 and certain areas of the automotive sector, is the University of Sheffield's new Advanced Manufacturing Research Centre (AMRC). The Centre is setting out its stall at its new facility with equipment and support services that will enable it to set about defining how far production metalcutting processes can economically be driven.

"It has taken us five years to bring this global research centre together but as a result, we have benefited from the care in establishing the right equipment and facilities with key collaborating partners," says Dr Rab Scott, project manager. "This will enable UK manufacturing to have a better understanding of metal cutting, to be more effective and hence competitive, particularly in the aerospace but also in related sectors of industry.

"With the equipment we have installed and support of strategic partners, we are able to push the boundaries of machining processes that industry cannot or would never be prepared to chase. Although it is not the objective, we can even break things to determine the limits of acceptance."



Testing aerospace component machining boundaries with the ZT 1000

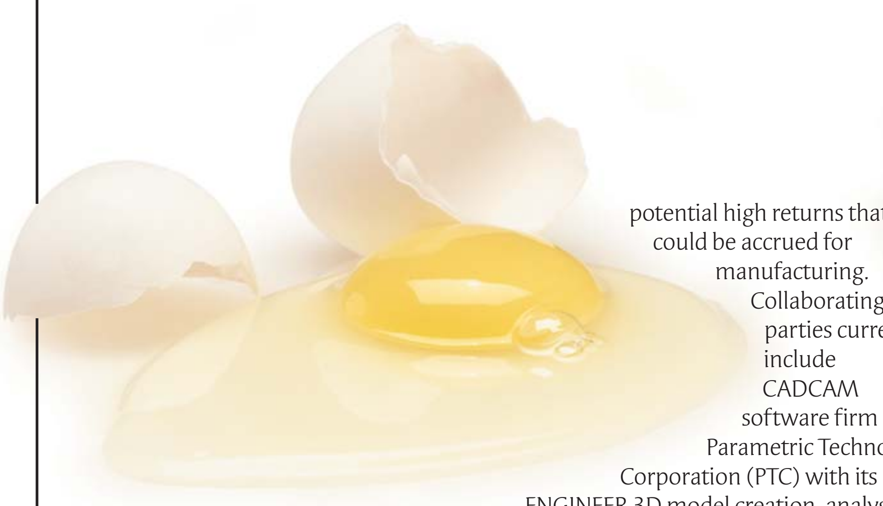
Dr Scott cites the machining of a pair of wing flap ribs in 10 hours rather than the normal 36. The AMRC is targeting to reduce the time further to six hours with a 50 per cent reduction in the number of cutting tools used. And when it is understood that there are 50 flaps on each wing of the aircraft, the cost savings begin to repay the research effort, even without the spin-off of any transfer of technology.

METALCUTTING SUPPORT

To help in the investigation of machining, process modelling through simulation of metalcutting plus the investigation of thermal changes, chip formation, residual stresses, tool wear, together with the effects of coolant will run concurrently with actual metalcutting processes bringing what Rab Scott describes as: "Changing the physical into a virtual world of research without actually having to make and test everything."

As part of the initial investment of £20 million generated from industrial contributions and DTI support, this high technology hub has just installed a £1.1 million, 37-tonne StarragHeckert ZT 1000 head-changing horizontal machining centre. A Cincinnati H8-8000XT horizontal machining centre, a Cincinnati V5-2000 vertical machining centre and Mitsubishi electro-discharge machine supplied by collaboration partners, are also now installed.

Funding of generic projects of interest to all partners are drawn from central coffers, with AMRC taking ownership of the intellectual property that the Centre can use to generate revenue in the future. However, specific projects will be partner-funded with



those projects involving several partners – already there are around 40 projects underway.

Behind the concept of AMRC is the quest by the world's aerospace companies to cut weight and develop higher performing, more economical aircraft by maximising the benefits gained from using high performance materials. The downsides are that materials such as titanium and heat-resistant super-alloys and modern composites are very difficult to machine, so the trade-off between material advantage against cost-to-produce, has never before been such a key issue.

The problem is not simply to cut faster or develop new tooling solutions to run at optimised metal removal rates; processes have to be realisable, reliable and most important, repeatable. As ever in aerospace matters, factors to be taken into the equation are cost effectiveness plus any detrimental effect that any high-performance production process may have on the part, the structure of the material, internal stresses and ultimate fatigue.

CLUSTER CAMP

The AMRC is next to Sheffield Airport on a 40-hectare Advanced Manufacturing Park owned by UK Coal. Previously an open cast mining area, the park was established to create 4,500 jobs by 2007 from a cluster of high-technology companies.

The growing list of collaborating companies is described by Dr Scott as "a critical resource of expertise and having considerable practical experience". He also describes it as demonstrating the serious nature of the projects and potential high returns that could be accrued for manufacturing.

Collaborating parties currently include CADCAM software firm Parametric Technology Corporation (PTC) with its Pro-ENGINEER 3D model creation, analysis and up to 5-axis machine programming software. StarragHeckert of Switzerland, one of the world leaders in multi-axis machining of difficult materials, is also sharing its R&D engineering and technical knowledge and sending graduate engineers to the UK to be closely involved with project work.

Cincinnati and Mitsubishi are supplying specialist machine tools; highly critical advanced tooling comes from Sandvik and Technicut, both of which are working with StarragHeckert on high-speed machining strategies for blisks as well as hard metal cutting techniques.

These projects are not only backed by Boeing but aerospace specialists and suppliers in the UK such as Messier-Dowty, Callender Aeroport, Hamble Structures and Reliance Gear Company. In addition, a specialist Microscopy laboratory with key equipment supplied by non-destructive testing specialist Johnson & Allen is also supported, while there's access to the University of Sheffield's advanced onsite facilities such as electron microscopes.

The StarragHeckert ZT1000 is the largest acquisition and a prime example of how the AMRC has identified the importance of equipment to provide the criteria for not only eliminating as many variables as possible before its research starts, but providing the capability from using advanced machine tool technology to ensure credible results.

The twin-pallet machine will accept parts weighing up to six tonnes, has two exchangeable heads, weighing one tonne each, which sit on their own pallet for automatic exchange. One head is a gear-driven 37 kW spindle giving 6,000 rpm but able to develop a massive 940 Nm of torque enabling deep, aggressive roughing; the other is a 24,000 rpm, 40 kW spindle with 43 Nm of torque for high-speed machining tasks.

According to Dr Scott, much of the research and development will be focusing on the optimisation of cutting conditions for a certain material without degrading the quality of the part or the material. He describes how the machine, component and material all have natural frequencies which lead to different levels of vibration under cutting conditions. One of the targets of AMRC is to optimise the process then take any vibration created beyond the current limiting frequencies by dampening out the dominant vibration elements, similar to driving though a wheel balance problem at certain speeds in a car.

BREAKING BARRIERS

Once achieved, and this is where the comment about breaking things is relevant, it enables the rates of metal removal to be enhanced considerably. He talks of increasing the cutting rates for titanium by an unbelievable factor of 10. "We are already reducing cutting times by a third," he says, "but of critical importance is that we do not set up stress or defects within the internal structure of the material that influence behavioural fatigue. And this is where our material testing capability runs hand in glove with machining optimisation."

Long-term benefits, however, are not just faster removal of metal. To simplify aerospace assembly, for instance, and stock control, larger monolithic parts with bigger surfaces and thinner wall sections will need to be machined effectively, hence the size, capability and precision of the StarragHeckert ZT 1000.

"Research will also significantly influence the future design of components and even the machine tools and production concepts that are needed to make them," Dr Scott adds.

"You can't make an omelette without breaking a few eggs, and that's what we are going to be doing here, with the security of being away from the production environment." M