QMISOLUTIONS

Additive Manufacturing

White Paper

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Connecting expertise.

ADDITIVE MANUFACTURING

Additive Manufacturing (AM) has been attracting a significant amount of attention both in Australia and globally, in terms of research activity, new system acquisition and its repeated citation in the press as a major opportunity for manufacturers. New initiatives such as the Advanced Manufacturing Precinct at RMIT, which is heavily focussed on AM processes, the Victorian Centre for Direct Manufacturing, based on a cold spray deposition process, and the increasing activity in laser additive manufacturing at Monash University are providing Australia with a diverse and unprecedented portfolio of AM equipment, services and expertise. These facilities span the range of materials, processes and systems available and provide Australian manufacturers with the ideal environment in which to investigate the relevance of AM to their business.

Additive (AM), rapid (RM) or direct manufacturing (DM) has emerged as a direct development from the Rapid Prototyping (RP) technologies that revolutionised 3D model preparation. Where RP was used to produce replicas or models of parts for evaluation purposes only, AM can produce not only prototypes but fully functional parts in a variety of materials, including metals, and hence can be used as a primary manufacturing process, providing the economic criteria are met.

The advantages afforded by AM are cited as:

- minimal or no tooling required
- minimal or no material wastage
- freedom of design
- reduced lead time
- no cost penalty for feature complexity

Systems available range from ultra-low cost open-source DIY systems such as RepRap (www.reprap.org) through systems aimed at the personal user and hobbyist (www.pp3dp.com) costing only a few thousand dollars, into lower cost commercial systems (www.uprint3dprinting.com) to high end systems capable of producing functional metal parts for applications in demanding environments such as aerospace and automotive (www.eos.info).

The most high profile project around AM in Queensland is the planned acquisition of an electron beam freeform fabrication (EBF^3) system by Ferra Engineering from Sciaky for use on Titanium production parts for the Joint Strike Fighter. This system is capable of depositing up to 7kg per hour of material but requires a significant amount of machining to produce the final desired shape.

Ferra to build F-35 parts[1]

Ferra Engineering has signed a Memorandum of Agreement with Lockheed Martin to establish the world's first facility for the direct manufacture of titanium parts for the vertical fins on the F-35 JSF. The Brisbane, Queensland, company will use new technology to fabricate titanium aerospace components which will give significant cost advantages over traditional methods.

Two hundred new jobs will be added at the Ferra factory as it builds up production. Lockheed Martin and Ferra have worked for 18 months on the direct manufacturing process which will be integrated into a new facility. The new process has the potential to save between 30 and 50% of the cost of machining aerospace titanium components which are some of the most expensive components in the F-35 airframe. Production is expected to start in 2012 with first deliveries three years later."

In selecting the EBF^3 process, the capabilities of the AM system have been matched to the specific requirements of the component being manufactured, and this is a process that should be carefully adhered to by any manufacturer considering a transition to AM from conventional manufacturing.

When considering which process is most appropriate for a particular design a number of factors need to be taken into account including the required material, the mechanical properties, part accuracy, the surface finish quality needed and the level of functionality required. The cost of each AM part is greatly influenced by the build time but if multiple parts are required, this may reduce the individual part cost if they are manufactured in the same batch. Thus, batch size and part volume will also influence the cost justification.

Whilst these considerations are all highly influential in the economics of utilising an AM approach, perhaps the greatest opportunity lies in the area of "design freedom". Rarely does the direct substitution of AM for traditional manufacturing processes result in an economically feasible case.

AM processes are not restricted by the rules which dictate that certain features must be included or modified to ensure that the part can be physically manufactured. Examples of this are the need to include draft angles and eliminate overhangs on parts which are to be injection moulded to ensure that they can be removed from the mould. Access for cutting tools in downstream machining operations also leads to compromises in the design. Throwing away the "design for manufacture" rulebook allows completely new structures to be realised which are only possible using AM techniques. This can lead to huge benefits if fully exploited and the boundaries surrounding this design freedom are still being explored and defined.

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[1] AIDN Newsletter August 2010

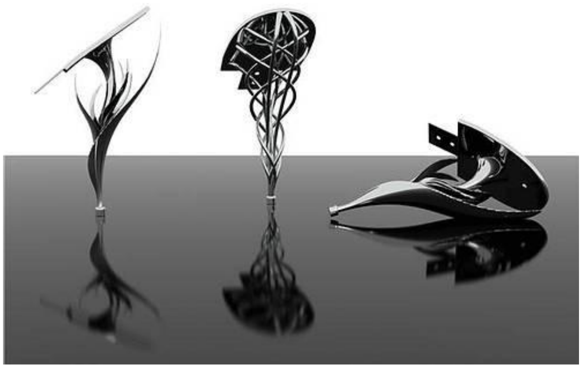
A metal door bracket from the A350 was completely redesigned and by utilising an internal 'bamboo' structure, reproducible only using AM manufacturing processes, it met its functional targets whilst shedding 80% of its weight.

Airbus bracket before (left) and after design optimisation for additive manufacturing (right)

www.lzn-hamburg.com

It is this iterative approach, whereby components are completely redesigned to do the same job, but look radically different, even borrowing their structures from nature, where huge advantages are possible.

The creative industries have embraced this already, with jewellery, hat, shoe and even dress designers utilising AM as a means to realise their products – a new ethos of "manufacture for design".



Structural metal heels for shoes

www.kerrieluft.com

The challenge in educating designers and engineers about the advantages and constraints offered by AM is a significant one, but there are a number of organisations including Universities, CRCs and State and Federal governments who are educating companies and exploring the benefits and limitations of AM. Dr Jennifer Loy at Griffith University teaches young designers how to design and make parts using AM techniques before they learn the traditional manufacturing rules. This increased level of freedom manifests itself in highly imaginative and creative designs for their first year projects.

The proliferation of AM machines, projects, grants and research activity around AM in Australia illustrates the growing interest in this technology to produce lower volume, complex engineered parts for highly specialised applications. But, despite this huge increase in activity in the research community, there is still limited industrial take-up, particularly of the higher end systems, as opposed to the hobbyist machines. Greater awareness of the possibilities afforded by AM, either discretely or in combination with traditional processes, will enable Queensland's manufacturing companies to determine the real relevance of AM to their business and may lead to new innovative products that offer competitive advantage in specific applications.

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