Background Information: The 3D printed Aerospike Rocket Engine

Quick facts

- A joint Monash University/Amaero team of engineers successfully designed, built, and tested a rocket engine in just four months
- The engine is a complex multi-chamber aerospike design
- Additively manufactured with selective laser melting on an EOS M280
- Built from Hasteloy X; a high strength nickel based superalloy
- Fuel: compressed natural gas (methane); oxidiser: compressed oxygen
- Design thrust of 4kN or about 1,000 pounds. This is enough to hover the equivalent of five people (around 400 kg)

The 3D printed or Additive Manufactured aerospike rocket engine is the result of a collaboration between a group of Monash University engineers and Amaero Engineering, supported by Woodside Energy and Monash University.

Engineers at Amaero approached a team of Monash engineering PhD students, giving them the opportunity to create a new rocket design that could fully utilise the near limitless geometric complexity of 3D printing.

The team accepted the challenge and designed one of the most complicated but efficient rocket engines of all, the aerospike nozzle. Amaero printed the design, then the team test-fired their engine on a remote location in rural Victoria. The rapid manufacturing process allowed them to go from concept to physical testing in only four months.

The Monash engineers have now created a company, NextAero, to take their concepts to the global aerospace industry, starting with the International Astronautical Congress in Adelaide on 25-29 September

The aerospike rocket engine

The bell of conventional rocket engines directs the rocket exhaust in one direction. Atmospheric pressure also plays a part in directing the exhaust, so the engine only works with peak efficiency at one altitude, for example at launch. As the rocket climbs the flame spreads out, reducing thrust.

The aerospike design works by firing the gases along a spike and using atmospheric pressure to create a virtual bell. The shape of the spike allows the engine to maintain high efficiency over a wider range of altitude/air pressure. It's a much more complex design challenge and is difficult to build using traditional technology.

The team have created a novel three-chamber aerospike engine, which also allows for *thrust vectoring* without gimbaling systems. This means that instead of tilting the engine, which is done to control a vehicle's flight path, the engine can be firmly mounted to the chassis and instead vary the direction of the thrust via the pressure in the combustion chambers. This offers weight and cost savings, which the team hope to investigate in the future.

The rocket engine the team have created is an initial demonstrator. It is not intended for flight, but rather to show the possibilities if traditional manufacturing constraints are removed. The opportunity for researchers working in aerodynamics and combustion to work with Amaero's experts in 3D printing enabled some of the key problems associated with the aerospike nozzle to be solved. Once the design team were unshackled from the usual constraints of traditional manufacturing, curves and shapes ideally suited to optimising fluid flows and combustion gases could be brought to life.

Amaero Engineering

Amaero is a leader in additive manufacturing (metal 3D printing). From aerospace and defence, to automotive and general manufacturing, Amaero caters to a wide range of industry sectors. Amaero focuses on laser-based metal additive manufacturing technology production methods. Its team have combined experience of over 25 years in additive manufacturing in a broad range of materials including titanium, aluminium, stainless steel, tooling steel and nickel based alloys. Amaero is the only company in the Asia-Pacific region to offer extra-large metallic additive manufacturing capacity in powder bed fusion and direct laser deposition. Amaero provide their clients a wide range of services, from collaborative design through to manufacturing, or remanufacture and repair.

Amaero was created in March 2013 as a spin-off company from Monash University. Amaero now prototypes and manufactures components for a range of global companies and SME's in North America, Europe, Asia and Australia. Their technology is also now operating in a manufacturing facility in Toulouse with their partner Safran - the French-based global aerospace and defence company. More at www.amaero.com.au.

NextAero

NextAero is a company created by the Monash engineers who designed and tested their rocket engine. They comprise of 6 Ph.D. students in aerospace engineering currently studying at the Laboratory for Turbulence Research in Aerospace and Combustion (LTRAC) in the Department of Mechanical and Aerospace Engineering at Monash University. NextAero team will present the aerospike rocket engine to international aerospace companies and they intend to investigate future applications of 3D printed propulsion devices.

More at www.nextaero.com.au.

Project Sponsors: Woodside Energy and Monash University

Support for the project has kindly been provided by Woodside Energy and the Woodside Innovation Centre at Monash University.

Woodside is Australia's largest independent oil and gas company with a global portfolio, recognised for its world-class capabilities as an explorer, developer, producer and supplier of energy. Woodside's assets are renowned for their safety, reliability and efficiency, and we are Australia's most experienced LNG operator. Woodside believes technology and innovation are essential to bringing down costs and unlocking future growth. Today, the company is pioneering remote support and the application of artificial intelligence and advanced analytics across its operations.

The Woodside Innovation Centre at Monash, which forms part of Woodside's FutureLab network, is a transformational hub for technological innovation located at Monash University's Clayton campus (https://woodside-innovation-centre.monash.edu).

Monash University is a leader in metal 3D printing (Additive Manufacturing). In 2015 Monash led a team that created the world's first 3D printed jet engine. As part of a project supported by the Science and Industry Endowment Fund (SIEF) Safran, Monash University and Amaero, in collaboration with Deakin University and the CSIRO, took a Safran gas turbine power unit from a Falcon executive jet, scanned it and created two copies using their customised 3D metal printers. This research is now being extended further through the support of Australian Research Council's (ARC) strategic initiative "Industry Transformation Research Hub" and several industrial partners including Safran and Amaero.

For further detail, access to project media, and enquires please contact Marten Jurg at Amaero Engineering.

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