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RAPOLAC readies weld-based production for the real world

SMD process offers significant savings in cost and time

The RAPOLAC international research project has successfully brought a new manufacturing technique for the aerospace industry to the brink of commercialisation.

Eight academic and industrial partners from four countries collaborated on RAPOLAC (Rapid Production of Large Aerospace Components). The three-year project has developed the shaped metal deposition (SMD) process from an experimental proof of concept, to an automated manufacturing technology ready for use by a range of companies.

SMD produces components by welding a continuous metal wire into the desired shape. This reduces the wastage involved in machining parts from a larger block, and removes the need for the expensive tooling used in forging. Using SMD, the time required to design and produce a large aerospace component such as an engine casing can be reduced from nine months to a few weeks.

The SMD technology was initially developed by Rolls-Royce plc, but was not widely adopted for commercial production for several reasons. The TIG welding process had to be manually controlled by a skilled technician, and there was little understanding of the material properties of the parts produced by such an innovative process.

Rolls-Royce licenced the technology to the University of Sheffield Advanced Manufacturing Research Centre with Boeing (AMRC), the lead research partner in RAPOLAC, to move SMD towards commercialisation.

Rosemary Gault, RAPOLAC project manager, says:
"SMD was a very promising technology when it came us, but companies weren't interested because it was very labour intensive and we didn't understand the material properties. Thanks to the funding from the EU Framework Programme and the hard work of all our partners, it's now been fully modelled and automated. It's ready to go into wider production, and we're talking to a number of companies from aerospace and other sectors."

Automation

The movements of the robot welding arm within the SMD cell were automated early in the project, but the welding torch itself had to be manually controlled by a skilled technician.

For the technician, this was a tedious job – and for the firm, it is an expensive waste of staff resources. Developing an automated control system, so that the cell can run itself without the need for continual supervision, was vital for the commercial viability of the technology.

Researchers at the Università degli Studi di Catania, Sicily, developed a fully automated control system – initially on a simplified version of the SMD cell in their own laboratory, then integrated into the primary SMD cell at the AMRC.

The control system was based on analysis of measurements from a range of sensors. These data are processed in real time, to compute the exact amount of material needed at each process cycle while guaranteeing the stability of the process.

Professor Giovanni Muscato of the Università degli Studi di Catania, says:
"Developing an automatic control system for SMD was very challenging. At the beginning, the process was not simple to understand and the measurement of the welding parameters was rather difficult. With extensive tests, conducted in parallel with the theoretical study of the process, we were able to find a stable control law that was also robust. The controller developed in the Catania cell was then easily transferred to the cell at the AMRC and, with a minimal amount of final tuning, worked perfectly."

The Catania team has applied for a patent on their work. The automated control was integrated with process models developed by Samtech, an engineering software company based in Liège, Belgium.

Optimisation

Researchers at the AMRC focused on optimising the SMD process, ensuring that parts are produced with the best achievable material properties in the most efficient way.

The researchers proved the empirical relationships between weld parameters (such as travel speed, wire speed and welding current) and the material outputs (including bead thickness, shrinkage and hardness). This knowledge was then used to develop a stable parameter window with known mechanical properties for the desired part size.

Researchers at Intec, part of the Universidad Nacional del Litoral in Santa Fe, Argentina, meanwhile studied the behaviour of the metal weld during the SMD process, and can predict the effect of thermal effects on residual stresses and on microstructure.

Gustavo Escobar of the AMRC says: *"We now understand how the key process factors affect the system's outputs. We are able to predict part geometry and customise the microstructure of parts to achieve the required mechanical properties. Industries using SMD will benefit from a well-understood process where parts are produced right first time, to very high standards."*

Proven properties

The team at the Katholieke Universiteit Leuven, Belgium, studied the microstructure and mechanical properties of the components produced by SMD, and demonstrated that they are at least as strong as parts produced by established processes.

The material strength and ductility of parts produced by SMD exceed the standards for cast material (ASTM F1108), can compete with the standards for wrought material (ASTM F1472), and can meet the current AMS4999A aerospace quality standard for additive layer manufacturing.

Bernd Baufeld of the Katholieke Universiteit Leuven says: *"The unique fabrication conditions of additive layer manufacturing techniques such as SMD lead to a very fine microstructure which is usually not achievable by other techniques. These microstructures are responsible for the excellent mechanical properties and can, to a certain extent, be tuned by the SMD parameters."*

The next step

RAPOLAC consortium members are now seeing keen interest in the SMD technology from industry. They have already produced test parts for six different aerospace companies, and have also been approached by companies from other sectors including medical and motorsports.

Footprint Sheffield, the leading industrial partner in RAPOLAC, aims to adopt the technology in its own factory to help the company expand its markets and offer higher-value services.

Richard Jewitt, director of Footprint Sheffield, says: *"Footprint's involvement in the RAPOLAC project has been an essential part of developing our future strategy. To survive and prosper we must move up the technology ladder in what we manufacture and enhance the skills level of our staff. Being part of the Rapolac project has enabled us to assess a new manufacturing method, while our staff have been working closely with experienced and highly capable partners."*

EDITORS NOTES

About RAPOLAC

RAPOLAC (Rapid Production of Large Aerospace Components) is a three-year research and development projected funded by Priority 4 (Aeronautics and Space) of the EC Sixth Framework Programme (FP6). The project aimed to demonstrate that the shaped metal deposition (SMD) process is a technically and commercially valid technique for producing large parts for aerospace and other industries.

The project is co-ordinated by the University of Sheffield Advanced Manufacturing Research Centre with Boeing (AMRC). Partners include Università degli Studi di Catania, Sicily; Katholieke Universiteit Leuven, Belgium; Intec, part of the Universidad Nacional del Litoral in Santa Fe, Argentina; manufacturing SME Footprint Sheffield Ltd (formerly Footprint Tools), UK; engineering software group Samtech, Belgium; environmental consultancy Diad, Italy; and project management specialist Metec, Italy.

For more information, see http://www.rapolac.eu/

About SMD

Shaped metal deposition (SMD) is a manufacturing technology patented by Rolls-Royce plc and licensed to the University of Sheffield.

The system manufactures components by building them up from welded wire – typically titanium alloy or aerospace-grade steel. RAPOLAC concentrated on a widely-used titanium alloy, Ti-6Al-4V. The system involves a robot arm carrying a TIG welding head, operating in a sealed cell filled with a neutral gas. The automated system can produce parts from a computer-aided design (CAD) model.

Parts made by SMD are near-net shape and require minimal machining to finish. The technique can substantially reduce the cost and lead time of producing prototypes and short-run manufacturing. The technique can also be used to produce hybrid components by adding complex structures onto large cast or forged parts.

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