Molten metals in spin cycle on ESA's centrifuge

October 16 2014

Housed at ESA's ESTEC technical centre in Noordwijk, the Netherlands, the Large Diameter Centrifuge (LDC) is not designed for astronaut training but specifically for research. Jointly financed by ESA and the Dutch government, it is available for a wide variety of applications. The 8 m-diameter LDC can operate at up to 20 g, with four gondolas able to accommodate up to 80 kg of payloads, with a central gondola as a control. Two additional gondolas can be attached to mid-arm to provide different g-levels simultaneously. Experiments can be spun for up to six months non-stop. Credit: ESA–A. Le Floc'h

The experimenters stared through bulletproof glass at the whirling 8 m-diameter centrifuge. Never mind the shaking or stirring of drink cocktails – what happens when you spin a cocktail of molten metal?

ESA's Large Diameter Centrifuge provides research teams with easy access to hypergravity. Based at ESA's technical centre in Noordwijk, the Netherlands, it can spin at up to 67 revolutions per minute, producing gravity levels of up to 20 times Earth normal in the gondolas at the end of its four arms.

This time around, one of the gondolas contained a special furnace filled with a molten combination of titanium and aluminium. After around an hour's spinning, the alloy was allowed to cool and solidify over 15 minutes.

Afterwards, the titanium aluminide was removed to see how the newly formed metal's microstructure had been affected by a gravity level eight times stronger than Jupiter's.

"While lightweight, titanium aluminide is strong and corrosion-resistant," explained Laszlo Sturz of the Access company, a spin-off of Technical University of Aachen in Germany, taking part in the research.

"In particular, its strength increases with temperature, making it particularly promising for building aerospace and automotive engine elements as well as other moving parts.

A furnace for the solidification of titanium aluminide (TiAl) alloy ready to be placed into its Large Diameter Centrifuge gondola. The furnace chamber at the cylinder's core is surrounded by ceramic heatshields and buffered by inert argon gas, with telemetry systems and external water-cooling pipes seen wrapped around the cylinder. Credit: ESA–A. Le Floc'h

"Right now, titanium aluminide parts are cast in various ways, including centrifugal, where a ceramic mould is spun as the alloy cools. But such manufacturing follows a trial-and-error approach.

"Our project aims at creating a detailed mathematical model of how solidification is influenced by changing gravity levels, to help in optimising future casting technology."

Gravity-driven convection in the molten metal influences the solidification: change the level of gravity and the microscopic alloy grains should change their size, too.

While differing levels of hypergravity can been accessed through the ESA's centrifuge, microgravity casting will be tested next year during the 10–15 minutes of weightlessness available on the flight of a suborbital rocket.

A quartet of casting furnaces will be flown on the Maxus rocket.

The ESA-led GRADECET project (Gravity Dependence of Columnar to equiaxed transition in peritectic TiAl alloys) involves researchers from Germany, Ireland, Slovakia, France and Hungary. Data for the GRADECET model are being gathered by solidifying TiAl across a spectrum of gravity levels. Gravity drives convection flows in the molten metal that influence the solidification process; change the level of gravity and the microscopic grain size of the alloy

should change too. A quartet of casting furnaces will be flown on an ESA Maxus suborbital rocket in 2015. A previous furnace design flew on Maxus-8 in 2010, seen here with four cylindrical furnaces. Credit: ESA

"This centrifuge campaign is also serving to qualify them for flight," said ESA's Antonio Verga.

The challenge was to design a self-contained furnace that can heat up to the 1700°C required on the inside while its outermost skin remains at no more than 70°C.

The chamber where electrical heaters melt the alloy is surrounded by ceramic heatshielding and buffeted by inert argon gas, with water coolant pipes threaded around the cylinder's exterior.

Temperature sensors will relay realtime data to eager researchers throughout the process.

Provided by European Space Agency