Additive manufacturing process may lead to tougher, heat-resistant components for aerospace

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(PhysOrg.com) -- A new additive manufacturing process for mixing tough metals with ceramic materials and depositing, layer by layer, the mixed materials in the form of pastes could lead to stronger, heat-resistant, three-dimensional components for future space exploration, says a researcher at Missouri University of Science and Technology.

The research involves a process that is also less harmful to the environment because it uses water to reduce the amount of polymer needed to bind the metal and ceramic materials, says Dr. Ming Leu, who is leading the research.

Leu and his colleagues in Missouri S&T's Center for Aerospace Manufacturing Technologies (CAMT) are developing a way to create "functionally graded" material components that could be used for hypersonic aircraft or as parts of ultra-high-temperature engines and rocket boosters.

The research combines the metal and ceramic through the process of extrusion, which is similar to squeezing toothpaste through a tube but is precisely controlled. The result of squeezing the pastes of metal, ceramic and binder (the polymer and water) is a blended material that combines the toughness of the metal with the heat resistance of the ceramic. But the true value of the process, says Leu, is that it allows manufacturers to create customized parts for aircraft, spacecraft or other products.

"By controlling the extrusion forces, we can customize the percentage composition of each of the materials in the final product," says Leu, who is the Keith and Pat Bailey Missouri Distinguished Professor of Integrated Product Manufacturing.

With this process, a paste of ceramic material -- zirconium carbide, which is used to manufacture cutting tools -- is pushed through one tube, while the metal tungsten is pushed through a second. From a third tube comes a mixture of materials that is converted into zirconium carbide and tungsten after reaction sintering. From there, the functionally graded material is freeze-dried in a vacuum, the binder removed, and the final component reaction-sintered.

"In order to create high-performance combustion components or high-performance hypersonic vehicles that can sustain extreme heat and minimize thermal stresses, these types of functionally graded materials will be needed," says Leu.

Leu and his colleagues at S&T are developing a prototype of the system. Working with Leu are Dr. Greg Hilmas, a professor of materials science and engineering, and Dr. Robert G. Landers, an associate professor of mechanical and aerospace engineering.

The effort is funded through a two-year, $300,000 grant from the National Science Foundation's GOALI program (Grant Opportunities for Academic Liaison with Industry). Working with S&T on the project is Boeing, which is a member of the CAMT consortium. Boeing provides $60,000 plus an in-kind contribution toward the project.

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