New alloy could boost next generation jet fighter

January 5 2006

The next generation of jet fighter aircraft could fly farther and faster thanks to a new high-strength aluminum alloy prepared at the U.S. Department of Energy's Ames Laboratory. The new alloy is one material being developed for use in the F-35 Joint Strike Fighter, a cutting-edge aircraft that will see widespread use as the primary fighter for the U.S. Navy, Air Force, and Marines as well as U.S. allies abroad.

Researchers at Ames Laboratory's Materials Preparation Center will produce about 400 pounds of an aluminum-yttrium-nickel alloy over the next few months that will serve as a benchmark for testing and to help refine commercial production techniques. The material is being developed in conjunction with aircraft engine manufacturer Pratt & Whitney and a number of other public and private partners to replace heavier or costlier components in the "cool" sections of jet engines. The material also could be used in other parts of an aircraft such as wing spars.

"When it comes to aircraft design, you want the strongest and lightest materials to get the most efficiency," said MPC Director Larry Jones. "We (the MPC) have the expertise, processing capabilities and high purity raw materials to develop an alloy that performs up to the requirements for this project."

If the new material performs up to expectations, it could have a dramatic impact on the performance and efficiency of both commercial and military aircraft. Jones said that Pratt &Whitney engineers estimated that replacing various components in one particular jet engine with the Al-Y-Ni alloy could potentially lighten the engine by 350 pounds. That's an astronomical weight reduction in aircraft design, where engineers are typically happy to reduce the weight of components by a few pounds here or there.

"It means being able to carry significantly more fuel or payload," Jones said. "It could also mean lower production costs," pointing out that a bulkhead currently milled from a solid block of titanium for the JSF takes months to fabricate.

The alloy is produced using a process called high-pressure gas atomization. Pioneered at Ames Laboratory in the 1990's by metallurgist Iver Anderson, the HPGA process uses a special nozzle to blast a stream of molten alloy material with a pressurized gas such as helium or nitrogen. The result is powder-fine metal particles that are highly uniform in chemical composition and, because they cool so quickly, exhibit the amorphous structure of the liquid metal rather than the crystal structure normally found in bulk metals.

The powdered metal is currently vacuum hot-pressed and hot extruded, a process that bonds the particles together while retaining some of the amorphous structure. This partially amorphous, partially crystallized structure gives HPGA-produced materials improved properties, such as strength and ductility. Preliminary tests of the MPC's Al-Y-Ni alloy show it far exceeds anything commercially available. The top commercial aircraft-grade aluminum has a tensile strength of 70,000 pounds per square inch while this alloy has exceeded 100,000 psi in repeated preliminary tests.

Tests of the Al-Y-Ni alloy produced by a commercial manufacturer, however, have yielded less desirable results in the 90,000-92,000 psi range. While the basic "recipe" is the same, Jones said there are a number of inherent problems that ultimately affect the strength.

"Aluminum powders are used as rocket fuel so they're highly explosive," Jones said. "By using nitrogen gas in our process, it creates a nitride passivition layer so the powders are less likely to be explosive. This nitride layer breaks down during sintering, resulting in very strong bonds between the particles."

By contrast, Jones explained that the commercial process injects oxygen into the atomization gas stream to create a controlled oxidation of the powders. While the oxidation layer reduces the explosiveness, it remains during sintering, resulting in weaker bonds between particles.

"Purity of the materials going into the alloy also affects the overall strength," Jones said. "Any exogenous material will result in a weaker end product and that includes any oxidation that takes place."

To address this problem, the material being produced by the MPC will be kept in an inert environment until after the vacuum hot pressing process is completed. The MPC has modified its HPGA system to capture the powder in a container under an inert atmosphere. The powder will be sieved to less than 32 microns in size in an inert atmosphere glove box before being shipped in a sealed container to DWA Aluminum Composites, Los Angeles, where the vacuum hot pressing process will be completed. After vacuum hot pressing the pressed and sintered powder billet will be extruded. Only then will it be exposed to the normal atmosphere. The results will be studied to help modify and improve processing at the commercial level.

Funding for the production of the material – approximately $475,000 – comes from Pratt & Whitney and the Defense Advanced Research Projects Agency, the central research and development organization for the Department of Defense. DARPA manages and directs selected basic and applied research and development projects for DOD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions.

"This all came about as a result of basic materials research funded by the (DOE's) Office of Basic Energy Science," Jones said. "It's exciting to see the atomization process we developed advance to this point where it can make a real contribution to a project like the JSF and potentially the entire aviation and aerospace industry."

Source: Ames Laboratory

Citation: New alloy could boost next generation jet fighter (2006, January 5) retrieved 24 April 2024 from https://phys.org/news/2006-01-alloy-boost-jet-fighter.html