ATF Researchers Address Potential For Bismaleimide Composite Degradation

MICHAEL A. DORNHEIM/LOS ANGELES

An urgent research effort is under way to ensure that the bismaleimide resin material planned for extensive use in the advanced tactical fighter can be protected from corrosion, following the results of an accidental discovery at General Dynamics this March.

An experiment, which has been repeated in other laboratories, discovered that the resin can decompose in a salt water environment due to products formed by galvanic corrosion.

Materials officials believe the problem will likely not occur outside of the laboratory, and that standard methods of protection against galvanic corrosion will be effective. These methods have been tested in the laboratory and appear to work, according to officials of both airframe and materials companies.

However, the results of the March experiment were unexpected and sufficiently counter to the notion that "composites don't corrode" that its shock value caused the ATF community to scramble to find the cause and develop solutions. "It's been out of control—all politics, and very few people knew the facts," one industry engineer said.

Bismaleimide (BMI) is a member of the polyimide resin family, and is favored because it offers greater toughness and higher operating temperatures—up to 350-400F—than the conventional epoxy resins currently used in aircraft composites. Some believe it also simplifies parts fabrication.

ATF full-scale development proposals are due in to the Air Force on Dec. 31, and this threat to a basic ATF material has caused a last-minute reevaluation of plans. "I think we have a way around it," Thomas R. Rooney, Northrop/McDonnell Douglas ATF program manager, told a meeting of the Society for the Advancement of Material and Process Engineering on Nov. 14. "But right now, we have to make a decision: do we propose that we're going to solve it and stay with our current system, or do we propose a system we know is alright and say we'll conduct a study to try and develop a safe BMI system?"

Referring to previous perceived problems with composites, Rooney said, "I may be overly optimistic, but I think we're facing another ghost."

Officials on the competing Lockheed/Boeing/General Dynamics team say they have a solution in hand, and plan to use BMI in their proposal. The corrosion discovery at General Dynamics' laboratory came at a time when the Lockheed team was selecting materials for its ATF proposal and "obviously had an impact on the design," an official said.

The Navy would be the most affected by any corrosion problem because of its salt water operating environment. The Navy plans to buy a version of the ATF with a different airframe, and its program is 3-4 years behind the Air Force.

Favored composite resins have changed over the ATF program. In the early to mid-1980s the Air Force pushed thermo-

Taiwanese IDF Flight Test Work Advances; Airframe Production May Begin Next Year

HONG KONG

Three of four Indigenous Defense Fighter prototypes sit on the ramp at Taichung, Taiwan. The IDF, also known as the Ching-kuo fighter, is designed and configured as a fast-climbing, lightweight defense interceptor for the Taiwanese air force. It can also carry antiship missiles (AW&ST July 3, 1989, p. 30).

The four prototypes have completed almost 30 test flights. Three of the prototypes are single-seat versions with the fourth a two-seat trainer. The test flight program is based at the government-backed Aero Industry Development Centre in Taichung.

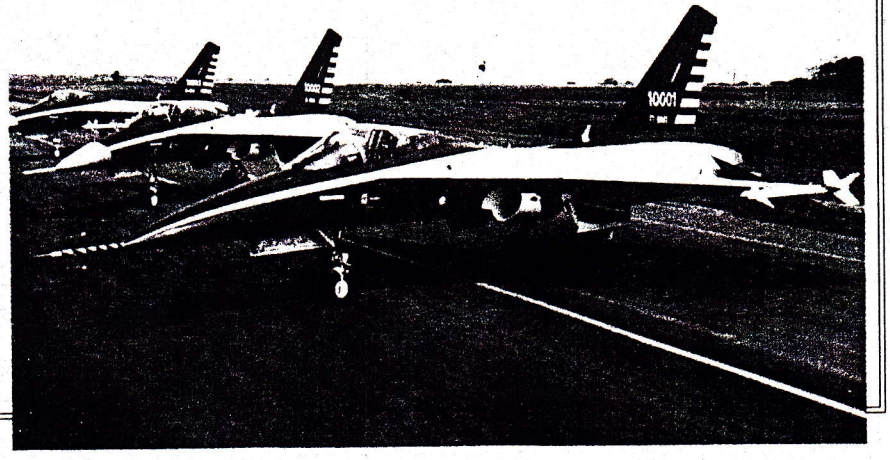
Production of about 250 IDF airframes will likely start in 1991. The manufacturing rate will increase to as high as 30 a year. About 45 of the two-seat versions will be built as trainers with a backup antishipping role.

The IDF is distinguished by main landing gear that cant slightly forward, a single-vertical stabilizer and an all-moving horizontal stabilizer. It is smaller than the General Dynamics F-16, which it resembles.

Prototype cockpit configuration included a head-up display and a pilot's seat with 15-30-deg. tiltback, similar to the F-16. Two square cathode ray tube displays at knee-height on the underside of the central console were surrounded by multiple analog gauges, according to a Western observer. Some cockpit switches were hard to reach.

The cockpit's sidestick controller and throttle were designed to hands-on-throttle-and-stick (Hotas) philosophy. Aircraft flight control surfaces are operated electronically. Allied Signal provided the cockpit environmental control system.

The Ching-kuo is powered by two Garrett TFE1042-70 engines, which provide 8,400 lb. of thrust each with afterburner. Western analysts believe the aircraft is underpowered. A follow-on engine will provide up to 14,000-lb. thrust. □



plastic resins which can be reheated and reformed, but hoped-for improvements in high operating temperatures did not occur as expected, and the costs remained high. Bismaleimides are now favored for critical applications, with toughened epoxies as an "adequate" backup. In hot conditions, the BMI can be 15% lighter than epoxy, according to Robert C. Wingfield, general manager of BASF Structural Materials' Anaheim Div., a major supplier of BMI to the ATF program.

The corrosion concern arose when Michael C. Faudree, a General Dynamics composite materials and process engineer, could not find a large enough glass jar to test a BMI-carbon fiber sample in a salt water and jet fuel mix. He used a tin can instead, and was surprised to find several days later that the BMI had dissolved at the water/fuel interface.

Subsequent analysis showed that the conductive carbon fiber in contact with the tin and the salt water electrolyte had formed a battery, creating hydroxyl (OH-) ions. These ions were collected on the composite and bunched in sufficient density at the fuel/water interface to form a highly basic solution, estimated to have a pH of 13 or 14.

Base solutions are known to degrade BMI, and the surprise was that such an intense base was formed. Stagnant conditions are required to prevent the hydroxyl ions from dissipating, and later tests have shown that it can occur at the air/water interface without fuel present, and with aluminum instead of tin forming the battery. Epoxy is more sensitive to acid solutions than base solutions.

All of the following conditions appear to be necessary for BMI decomposition: a conductive fiber, in contact with a metal, in an electrolyte solution, with oxygen present, and stagnant conditions at the water interface to prevent dissipation. Higher temperatures speed the process.

The Lockheed team promptly informed the Air Force, and in June an industry meeting was held to brief the problem to the Air Force, the Navy, the two contractor teams and BASF.

Researchers have applied standard galvanic corrosion protection methods to prevent BMI decomposition, with encouraging results. Standard techniques include breaking electrical continuity with a fiberglass scrim or polysulfide sealant, or using a noncorroding titanium interface.

Research is still under way to better understand the phenomenon and whether it is a real operational concern, since it has not been seen on actual aircraft, Wingfield said. The General Dynamics F-16XL BMI wing box was inspected and showed no sign of corrosion, he said. □

Garrett Auxiliary Power Units to Equip Northrop ATF, Black Hawk Helicopter

LOS ANGELES

Northrop has selected the Garrett GTCP36-F23 auxiliary power unit to equip production versions of its YF-23 advanced tactical fighter, should Northrop win the ATF full-scale development contract next April.

A unique feature of the Garrett APU is that it provides emergency power as well as auxiliary power, Steven R. Loranger, Garrett Auxiliary Power Div. sales and marketing vice president, said. This means that if primary power fails in any part of the ATF's flight envelope, the APU can be started quickly enough to provide hydraulic and electrical power to save the aircraft. The GTCP36-F23 provides this power from its own gearbox, as well as bleed air from a load compressor.

Particularly challenging starting conditions are at high altitude and low airspeed after a cold soak, and company research on high-altitude combustion and rapid starting has solved this problem, Loranger said. The APU is air-breathing and does not have oxygen bottles or hydrazine propellant like some emergency power units (EPUs).

The two YF-23A prototypes are now fitted with Garrett GTCP36-200A APUs that provide bleed air only. Emergency power comes from an AiResearch hydrazine EPU used on the F-16. The GTCP36-200A and the 400-hp.-class GTCP36-F23 are derivatives of the GTCP36-200 APU on the McDonnell Douglas F/A-18 and the GTCP36-280/300 APU on the Boeing 737, Airbus Industrie A320 and McDonnell Douglas MD-80 transports.

The Lockheed ATF team does not plan to select an APU for production versions of its YF-22 fighter until after the full-scale development award, and both Garrett and Sundstrand would be contenders. The YF-22A prototypes use a modified Sundstrand Titan APU.

A different member of the Garrett GTCP36 APU family performed its first starting test on an Army/Sikorsky UH-60 Black Hawk helicopter last month. The GTCP36-150[BH] is to equip new Black Hawks starting in July, 1991, and also will become part of the spares inventory. The aircraft currently are equipped with Sundstrand Titan APUs. In Fiscal 1990 the buy was competed for the first time since the start of the program, and Garrett won a contract for one year of production with fixed-price options for the following four years in a winner-take-all contract. □

Aerospatiale General Aviation Negotiating Purchase of Piper

EDWARD H. PHILLIPS/WASHINGTON

Aerospatiale General Aviation is negotiating to purchase Piper Aircraft Corp. following a letter of intent signed by both companies on Oct. 24.

"We are encouraged by the tone and pace of the discussions, and they are moving in a very favorable way," Kevin T. Tracey, vice president, marketing for Piper, told AVIATION WEEK & SPACE TECHNOLOGY. He said if Aerospatiale acquires Piper, the purchase "would benefit both companies" and the general aviation industry.

Piper owner M. Stuart Millar has been holding discussions with potential investors and buyers for about a year. The due diligence period between Piper and Aerospatiale will expire on Jan. 15, Etienne LeFort, chairman and chief executive officer for Aerospatiale General Aviation, said.

Aerospatiale General Aviation, based in Grand Prairie, Tex., sold 50 new aircraft in the U. S. in 1990 and expects to sell 70-80 in 1991. The company builds aircraft in Tarbes, France, then disassembles them for shipment and reassembly in Texas.

Piper, which is plagued by financial problems, has drastically reduced production and laid off large numbers of workers this year. Piper expects to build only 166 aircraft in 1990, a number significantly lower than the 300-400 units projected by senior company officials earlier this year (AW&ST Apr. 23, p. 30).

Millar is selling Piper's Lakeland, Fla., factory as well as type certificates for certain Piper aircraft to help generate additional money.

"Cash flow continues to be a problem for us," Tracey said. "We can't buy as many parts as we want, which means we can't build as many airplanes as we would like to," he said. The Vero Beach, Fla.-based company "is paying in advance for parts as cash flow permits," Tracey said.

"We may have lost an order or two, but most customers are being very patient with us for their aircraft," Tracey said. Currently, a buyer must wait about a year before taking delivery of an aircraft ordered this month.

Piper is concentrating its resources on building high-revenue aircraft such as the Malibu Mirage and the Cheyenne 3A and Cheyenne 400. A small number of trainers are being built to meet contractual commitments, but production is proceeding "at a very reduced rate," Tracey said. Piper has a production backlog worth about $176 million and employs about 630 people. □