PROPULSION DIRECTORATE

Monthly Accomplishment Report
September 2003

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CAPACITOR TECHNOLOGY SUCCESSFULLY TRANSFERRED TO INDUSTRY: The Propulsion Directorate recently developed fluorene polyester (FPE) dielectric capacitor technology. This technology increases the temperature capability over the state-of-the-art by 75°C (135°F) and greatly improves reliability and maintainability. Dearborn Electronics, Inc of Longwood, Florida, a major capacitor supplier to the DoD, has adopted this technology and now offers high temperature (200°C), metallized FPE capacitor devices for commercial and defense sales. FPE is critical to maintaining a defense industrial base in robust capacitors since the previous state-of-the-art capacitor technology, polycarbonate dielectric, is no longer available. FPE capacitors are excellent in timing and integrating circuitry applications, high frequency coupling applications, and where severe military environments require robust materials. (Lt Col J. Erno, AFRL/PRP, (937) 255-6178)

High temperature, metallized FPE capacitor devices are now available from Dearborn Electronics

ULTRA COMPACT COMBUSTOR TESTING COMPLETED: The Propulsion Directorate recently completed high pressure testing of an Ultra Compact Combustor (UCC) developed under a joint program with Williams International. The goal of the program was to develop and investigate a UCC system that could perform as well or better than a conventional turbine engine combustor system in terms of combustion efficiency, stability, and ignition without sacrificing performance. As part of this program, PR and Williams collaboratively developed a UCC for use in an existing Williams engine system, in this case the F415, which powers the Tomahawk missile.


Williams' Ultra Compact Combustor in operation

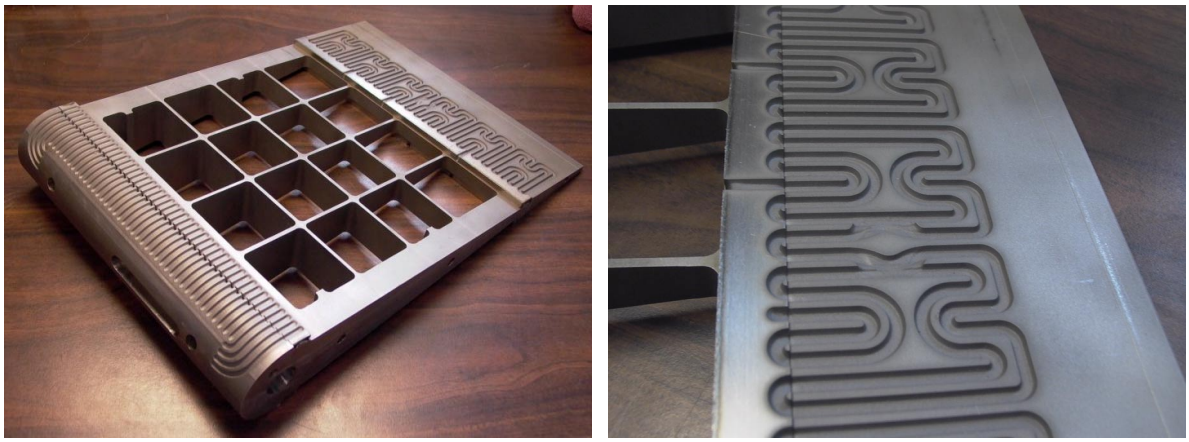
The UCC turned out to have 69% less volume than the original F415 combustion system. Testing was conducted in PR's High Pressure Combustor Research Facility (HPCRF), and the results show that the UCC performs as well as, or in some cases better than, the F415 combustor in terms of combustion efficiency. The UCC also demonstrated an 89% increase in Lean Blow-Out (LBO) operability compared to the F415 with ignition occurring well below the LBO limits of the original F415 engine system. Further tests will be performed to extend the database

as well as to investigate several optimization opportunities, and an engine test is currently being considered for late 2004. This technology could result in a substantial increase in the range and speed of the missile system by reducing specific fuel consumption and decreasing the weight of the engine. (Mr. D. T. Shouse, Mr. C. Frayne, Dr. W. M. Roquemore, and Dr. J. Zelina, AFRL/PRTS, (937) 255-4636)

VIJ RECOGNIZED FOR ACHIEVEMENTS IN POLYNITROGEN CHEMISTRY: The Propulsion Directorate's Dr. Ashwani Vij was recently selected for Honorable Mention for the 2003 Air Force Basic Research Award. Dr. Vij was recognized for his groundbreaking work in the area of polynitrogen chemistry. He is credited with creating the pentazolate anion (N_5^-), which offers the possibility of forming the ionic salt $N_5^+N_5^-$. Computational chemistry has shown that this species is stable if it can be synthesized, yet it would be incredibly energetic and useful as a future rocket propellant. As a rocket propellant, $N_5^+N_5^-$ would have a specific impulse far better than any existing mono- or bipropellant, but it would have ordinary nitrogen as its only exhaust product. The exhaust would be environmentally benign and the exhaust plume would be virtually indistinguishable from the surrounding nitrogen gas of the atmosphere. This would result in a missile system that would be environmentally responsible and have good handling characteristics, but would be quite difficult for a potential adversary to detect. (Dr. R. Channell, AFRL/PRSP, (661) 275-5762)

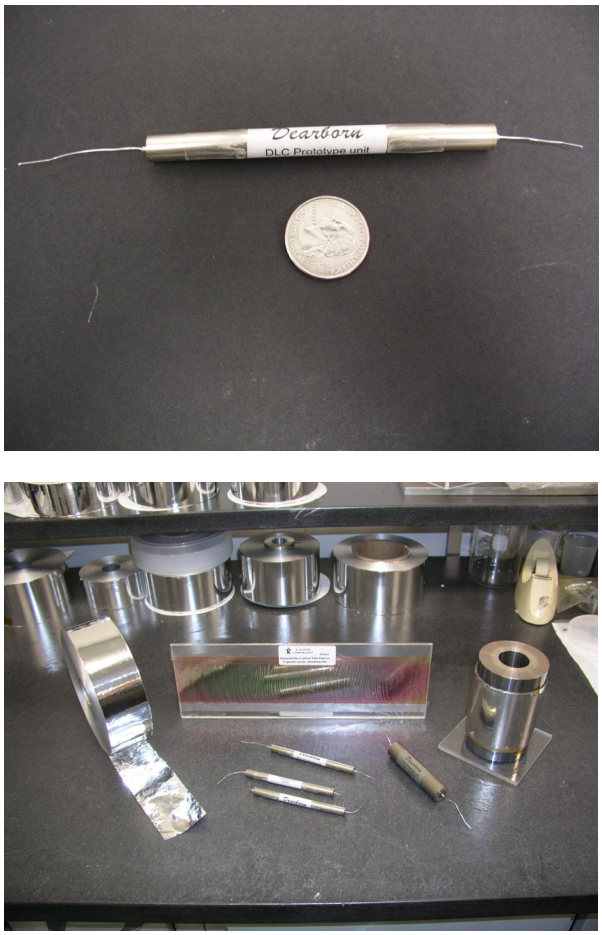
Dr. Ashwani Vij was selected for Honorable Mention for the 2003 Air Force Basic Research Award

SBIR EFFORTS PAYOFF FOR SCRAMJET DEMO ENGINE: The Propulsion Directorate's Aerospace Propulsion Division (AFRL/PRA) is benefiting from technology developed by Ormond LLC of Kent, Washington, under the Small Business Innovation Research (SBIR) Program. Ormond developed abrasive water-jet machining technology that made it feasible to fabricate a unique part for an AFRL/PRA scramjet demonstration engine. Using abrasive water-jet machining technology, Ormond successfully fabricated a monolithic flap structure for the second generation Ground Demonstration Engine, known as GDE-2. The use of waterjet machining made it possible to change this structure from a multi-piece weldment to a more robust monolithic design. Consequently, the success of the SBIR Program with Ormond has had a direct and immediate impact on the push to develop the technology needed to develop engines in support of the X-43C hypersonic flight vehicle and other programs. (Lt A. Fink, AFRL/PRAS, (937) 255-7328)



Abrasive water-jet machining was used to create this flap for the GDE-2 scramjet demonstrator

DIAMOND-LIKE CAPACITOR PROGRAM OFF TO A RUNNING START: Just two months into the project, the K Systems/Diamonex Diamond-Like Carbon (DLC) Capacitor project team has produced the first DLC dielectric films with excellent characteristics. These films were sent to Dearborn Electronics, Inc for device fabrication and testing. Four 30-nF devices were manufactured and packaged, and thermal testing of these four devices has begun at Dearborn Electronics. A new web-handling system at Diamonex will be operational by January 2004, which will allow long lengths (i.e., thousands of feet) of dielectric films to be deposited. Larger, high voltage devices will then be fabricated and analyzed. DLC generally consists of hydrocarbon structures that exhibit physical properties similar to those of diamonds. DLC materials exhibit a low coefficient of friction, high wear resistance, extreme hardness, extreme corrosion resistance, and exceptional scratch resistance. DLC films have a high direct current resistance, high thermal conductivity, and high voltage breakdown strength which makes them excellent candidates for pulse power capacitors. Furthermore, these properties do not degrade over a wide temperature range (-55°C to 200°C). Compared to conventional pulse power capacitors, DLC capacitors offer reduced size, weight, and volume, increased temperature capability, and greater than two times the energy storage density. DLC capacitors also have numerous commercial applications in domestic utilities and appliances, oil well drilling equipment, power supplies, aircraft, trains, automobiles, and medical devices. (Ms. S. Fries Carr, AFRL/PRPE, (937) 255-4101)



DLC capacitors and capacitor films

Want more information?

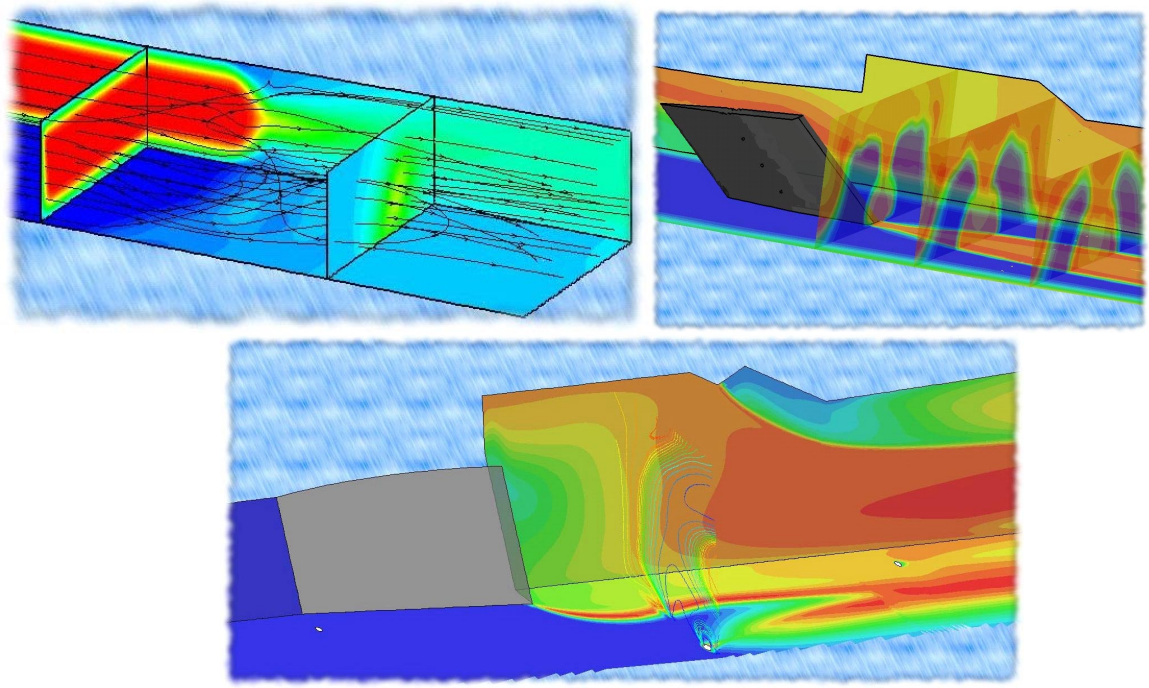
- More information on DLC capacitor technology is available at both the K Systems and Diamonex websites.

WHEELER HONORED AT WOMEN OF COLOR CONFERENCE: The Propulsion Directorate's Maj Mona D. Wheeler was honored at the Women of Color Research Sciences and Technology Conference held 12-13 September 2003 in Nashville, Tennessee. At the conference, Maj Wheeler was presented with the Women of Color Research Sciences and Technology Professional Achievement Award. This award is presented to a highly experienced, mid-career professional who has made significant achievements in her chosen career path in science or technology with emphasis on her achievements as a role model and leader for others in her field. Maj Wheeler was recognized for her outstanding work as PR's Assistant Chief Scientist, a role that she has held since August 2002. In this role, she is responsible for managing the science programs for PR's Space and Missile Propulsion Division (AFRL/PRS) at Edwards AFB, California. (Col M. Heil, AFRL/PR, (937) 255-2520)

Maj Mona Wheeler (right) receives the Women of Color Research Sciences and Technology Professional Achievement Award from Phyllis Allen, Director of Strategic Marketing and Planning for Dupont

ANALYSIS PLAYS KEY ROLE IN SCRAMJET ENGINE DEVELOPMENT: A team of researchers in the Propulsion Directorate's Aerospace Propulsion Division (AFRL/PRA) recently completed an intensive computational fluid dynamics (CFD) study of 34 alternative flame holder configurations. These analyses were performed in support of two scramjet engine development efforts: the joint Air Force/NASA X-43C program and the Air Force Single Engine Demonstration program. A computational approach was pursued because the time and expense associated with fabricating and testing this many configurations were prohibitive. As a result of these analyses, the three most promising flame holder configurations were selected, and they will be examined experimentally before the engine lines are frozen in the two flight test programs. These analyses are particularly critical, because the design of the flame holder can have a profound effect on the operation of a scramjet engine, and this is likely to be the last major configuration change to the engine prior to flight testing. The researchers responsible for these analyses, Drs. Doug Davis, Dean Eklund, and Dan Risha of AFRL/PRA and Dr. Susan Cox-Stouffer of Taitech, Inc, were recognized as PR's In-House Project of the Quarter for their efforts. (Mr. A. Boudreau, AFRL/PRAT, (937) 255-1237 and Capt B. McDonald, AFRL/PRAS, (937) 255-5210)

The PRA Analysis Team (from L to R): Dr. Susan Cox-Stouffer, Dr. Doug Davis, Dr. Dean Eklund, and Dr. Dan Risha.

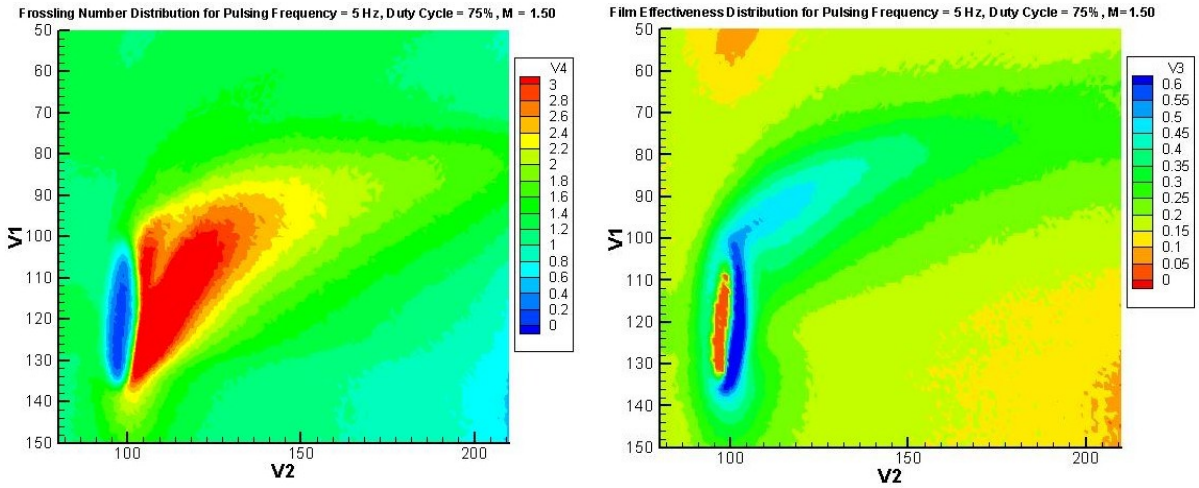


A sample of the CFD analysis results

ERBACHER WINS SAE'S McFARLAND AWARD: The Propulsion Directorate's Dr. John Erbacher was recently selected to receive the prestigious Forest R. McFarland Award from the Society of Automotive Engineers (SAE). The McFarland Award is presented annually to recognize outstanding contributions toward the work of the SAE Engineering Meetings Board in the planning, development, and dissemination of technical information through technical meetings, conferences and professional development programs, or outstanding contributions to Engineering Meetings Board operations in facilitating or enhancing the interchanges of technical information. Dr. Erbacher was honored for his distinguished support and leadership as Technical Program Chair for both the 1999 and 2002 SAE Power Systems Conferences. His outstanding leadership played a critical role in ensuring that all technical aspects for both conferences were successfully completed and all schedules met. Dr. Erbacher will receive the McFarland Award at the next SAE Power Systems Conference to be held in 2004. (Lt Col J. Erno, AFRL/PRP, (937) 255-6178)

Dr. John Erbacher was selected to receive SAE's prestigious Forest R. McFarland Award

NEW METHOD OF TURBINE BLADE COOLING INVESTIGATED: The Propulsion Directorate has recently been conducting research on turbine blade leading edge film cooling with pulsed coolant flow. In the past, continuous coolant flow has been used for turbine blade/vane film cooling. The major objective of this study was to evaluate if it was possible to obtain comparable film effectiveness and/or heat transfer coefficients using pulsed coolant flow. The results show that, when compared with the continuous coolant method, pulsed coolant flow improves the film effectiveness in most cases studied, which is beneficial for turbine blades/vanes. Pulsed coolant flow also decreases the heat transfer coefficients in many cases studied, which is again beneficial to turbine blades/vanes. As an added benefit, the transient infrared (IR) thermography technique used for this study was found to be superior to the transient liquid crystal technique previously used in two key ways. First, the transient IR technique requires only one test instead of the two required for transient liquid crystals, and second, the transient IR technique is not limited to a specific temperature range. This new measurement technique was exclusively developed in PR's laboratories, and this pioneering effort is proving to be time and cost effective. (Dr. S. Ou, AFRL/PRTT, (937) 255-6043)



The figures above show the heat transfer coefficient in terms of Frossling number distribution (left) and film effectiveness distribution (right), for coolant pulsing frequency = 5 Hz, duty cycle = 75%, and blowing ratio = 1.5.

FRIES CARR HONORED FOR EFFORTS TO ADVANCE CAPACITOR TECHNOLOGY: The Propulsion Directorate's Ms. Sandra Fries Carr was recently selected to receive the Meritorious Civilian Service Award. Ms. Fries Carr was recognized for her distinguished performance over the 10-year period from May 1992 to October 2002. During this time, she demonstrated outstanding leadership, management skill, and technical expertise as she spearheaded the design, construction, and activation of a one-of-a-kind capacitor research and development facility. This facility, which includes a state-of-the-art Diamond-Like Carbon Dielectric research facility, is the only facility of its type in the world. Ms. Fries Carr also performed groundbreaking work on a new dielectric called FPE, which represents the greatest advancement in high temperature dielectric materials in decades. Largely due to her efforts, this material is being commercially manufactured by a US firm, and it will give a competitive edge to present and future high performance military systems. Ms. Fries Carr is also a recognized international expert in the area of dielectric and capacitor technology, and she is regularly sought out for consultation on a broad range of technical issues related to capacitor devices. (Mr. J. Weimer, AFRL/PRPE, (937) 255-6236)

Ms. Sandra Fries Carr was selected to receive the Meritorious Civilian Service Award

HOJNACKI RETIRES AFTER 42 YEARS OF SERVICE: A ceremony was held on 7 October 2003 to honor the Propulsion Directorate's Mr. John Hojnacki on the occasion of his retirement. His retirement marks the culmination of more than 42 years of dedicated service; he concluded his distinguished Air Force career as PR's Corporate Development Officer. Mr. Hojnacki served in many other roles during his career. Early in his career, he performed in-house research in the area of high speed propulsion, and went on to be a program manager, branch chief, and senior staff engineer. Over the years he received numerous Wright Laboratory (now AFRL) and Propulsion Directorate Awards, and he is also the recipient of both the Silver and Gold Knight of Management Awards from the National Management Association. Mr. Hojnacki was a key member of the Propulsion Directorate team for many years, and he will be missed by his many friends and associates. (Col M. Heil, AFRL/PR, (937) 255-2520)

Mr. John Hojnacki retired after 42 years of Government service