PROPULSION DIRECTORATE

Monthly Accomplishment Report
October 2001

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LEAP FORWARD FOR TURBINE TESTING CAPABILITY: A team of Propulsion Directorate researchers recently completed successful testing of the uncooled high pressure turbine (HPT) for the F119 engine used in the F-22 air superiority fighter. A total of 50 runs were made in PR's Turbine Research Facility (TRF) to create a complete operating map of the F119 HPT. A variety of parameters were evaluated, and detailed surface pressure and heat flux measurements were obtained in addition to overall aero performance data. This data is being compared with design predictions to help analyze F119 turbine performance and provide a benchmark aerothermal data set for CFD code calibration. This testing represents the first true performance test of a turbine stage in the TRF, and establishes it as an accurate, reliable, and cost-effective facility for testing real turbine hardware. The aero performance maps, pressure analysis, and heat flux data provided by the TRF will help substantiate the Integrated High Performance Turbine Engine Technology (IHPTET) and Versatile Affordable Advanced Turbine Engines (VAATE) goals. This new testing capability also provides the Air Force with the ability to verify turbine designs for the warfighter. This project was honored by being named PR's In-House Project of the Quarter for the 3rd Quarter of FY01. The award-winning team consists of Marc Polanka, Matt Meininger, Mike Kobelak, and Bob VanHook of the Turbine Engine Division (AFRL/PRT) and Curt Rice of Wyle Laboratories. (M. Meininger, AFRL/PRTT, (937) 255-3150)

In-House Project of the Quarter winning team

Turbine Research Facility

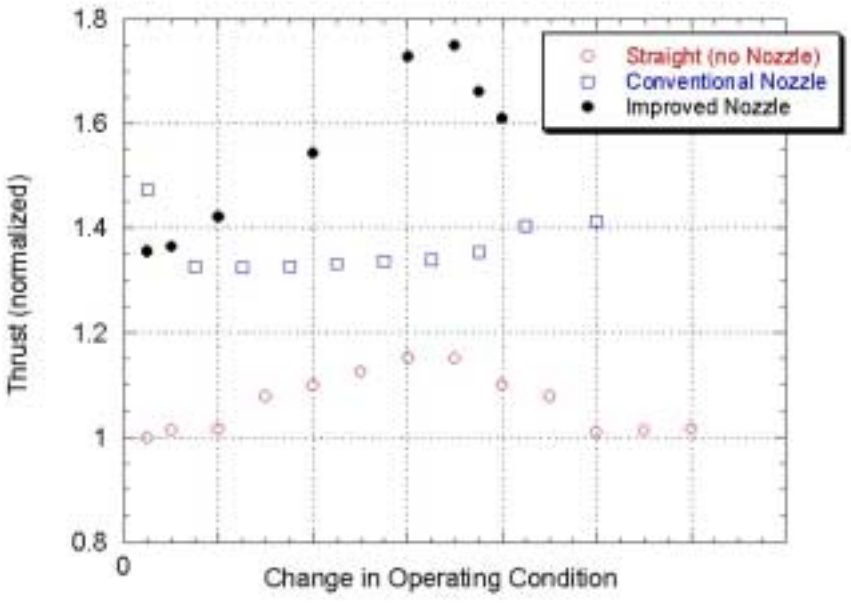
MATERIALS TECHNOLOGY FEATURED BY CNN: An article that appeared on CNN.com on 10 September 2001 features technologies being developed by the Propulsion Directorate's Polymer Working Group at Edwards AFB, California. The article, titled "Nanotech gets in your pants, and soon, your plane," discusses developments made in POSS (polyhedral oligomeric silsesquioxanes) nanotechnology. POSS materials are being considered as replacements for the metal bodies of missiles and satellite launch rockets. POSS nanomaterials are attractive for these applications because they offer effective protection from collisions with space debris and the extreme thermal environments of deep space and atmospheric re-entry. Another application of POSS nanotechnology under development is a new high temperature lubricant. This new nanolubricant could be effective at temperatures up to 500°F, which is 100°F greater than

conventional lubricants. The article also mentions an ongoing experiment on the International Space Station to examine the long-term effect of the space environment, specifically atomic oxygen and vacuum ultraviolet (UV) radiation, on POSS materials. An ongoing collaboration exists between the Polymer Working Group and Hybrid Plastics, a company that was spun off from the Polymer Working Group. Hybrid Plastics is poised to manufacture these nanomaterials large (ton) scale, and thus POSS might be viable for incorporation of nanotechnology into a variety of products. (R. Adams, AFRL Public Affairs - Edwards Research Site, (661) 275-5465)

Want more information?

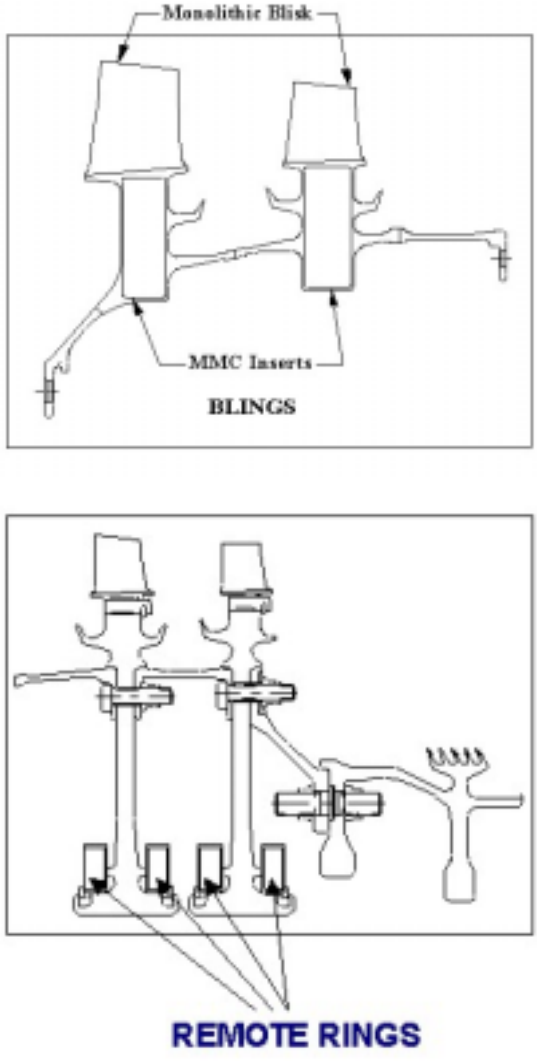
- Visit the Hybrid Plastics website by clicking here.

PDE PERFORMANCE BOOST MECHANISM DEMONSTRATED: The Propulsion Directorate's in-house research Pulsed Detonation Engine (PDE) was recently used to demonstrate significant increases in both thrust and efficiency without increasing cycle time. Performance improvements previously obtained with conventional nozzles had come at the expense of longer detonator tube blow down times, which limit cycle frequencies and peak attainable thrust. Conventional nozzles had also produced higher thrust levels per cycle at zero change in operating conditions. However, by taking advantage of dynamic compression effects in the unsteady detonation cycle, it was demonstrated that the performance of a different nozzle design could surpass that of the conventional nozzle design. As a result, significant improvements in thrust, fuel efficiency, and specific thrust (thrust per unit air flow through the engine) were realized without impacting blow down times. The physics responsible for this phenomenon had not been included in existing computational fluid dynamics (CFD) and analytic models of PDE cycles. Now that performance improvements of up to 75% have been demonstrated experimentally, the necessary physics is being added to models in order to facilitate optimization of detonator tube shapes and operating conditions. The PDE concept is of interest because it holds the promise of outstanding propulsion performance from an engine that is relatively simple and cheap to manufacture. The in-house PDE team is working to demonstrate that PDEs are realistic propulsion system options for missiles, unmanned aerial vehicles (UAVs), and even manned aircraft. (F. Schauer, AFRL/PRTS, (937) 255-1554)



Results showing PDE performance improvements

FIRST MMC REMOTE RING COMPRESSOR ROTOR TESTS A SUCCESS: Proof of concept testing of a metal matrix composite (MMC) remote ring compressor rotor was successfully completed by the Propulsion Directorate in October 2001. During the proof of concept testing, the remote ring compressor rotor was run up to 19,100 rpm at 700°F, which demonstrated the feasibility of the remote ring concept. Historically, a major emphasis in the gas turbine engine industry has been to improve engine performance through advanced component designs with higher temperature capability and reduced weight. This approach led to a more extensive use of advanced materials throughout the engine, and the application of advanced materials in complex, innovative component designs. The emphasis today has shifted towards meeting increased performance goals in an affordable manner. AFRL has conducted several research projects looking into the applicability of fiber reinforced MMCs to a variety of components including blades, spacers, shafts, ducts, and disks. In 1991, an Integrated High Performance Turbine Engine Technology (IHPTET) demonstrator engine validated an MMC bling design made of Ti-6-4 rotors that encapsulated Ti-6-4/SCS-6 MMC inserts. Although successful, the bling configuration was difficult to manufacture and was expensive. Recent efforts between AFRL and Allison Advanced Development Company have concentrated on remote ring MMC rotor configurations for the compressor. These allow two MMC rings to be used at the bore without being embedded into the monolithic rotor material. This concept has numerous advantages: (1) it has improved material properties and minimal residual stresses; (2) it removes the difficulties faced in the manufacture of the blings; and (3) it leads to the potential of using the same size rings on several stages in the engine, thus enabling further cost reductions for production. Work on the remote ring designs, which are using higher temperature orthorhombic titanium alloys with Ultra-SCS fiber, has been continuous since 1998. The recent proof of concept testing was the first step towards clearing the design to run in the Advanced Turbine Engine Gas Generator (ATEGG) 76/3 core test in November 2001. The next step will be to put this rotor through a low cycle fatigue test for further risk reduction. (K. Sargent, AFRL/PRTC, (937) 255-2081)



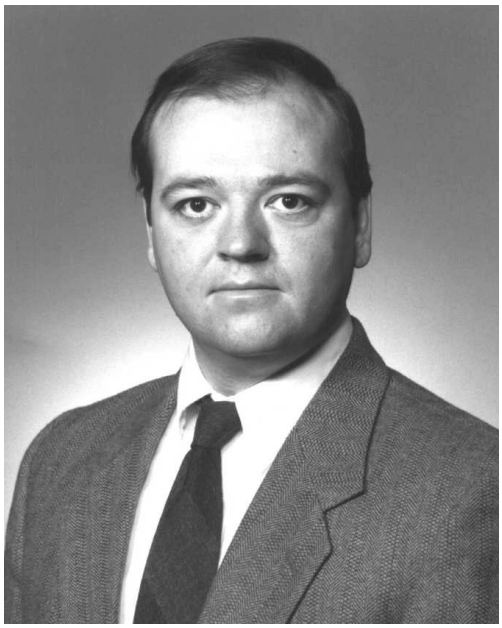
Conceptual designs: blings (top) and remote rings (bottom)

CAPT LAKE HONORED FOR RESEARCH ON SPACECRAFT PROPULSION: Capt James P. Lake has been named a recipient of the 2001 US Air Force Research and Development Award. Capt Lake, a researcher in the Propulsion Directorate's Spacecraft Branch (AFRL/PRSS) at Edwards AFB, California, was one of only five individuals Air Force wide chosen to receive this honor. He distinguished himself by co-inventing the world's first fully controllable solid rocket motor and by creating a wide range of fully automated spacecraft thruster test facilities. The controllable solid rocket motor he co-invented will enable satellites to perform the many complicated, high-g operations required for future on-orbit servicing missions. The automated test facilities he developed support the development of systems such as the micro-Pulsed Plasma Thruster and the High Power Hall Thruster. The automated micro-Pulsed Plasma Thruster test stand he developed provides the AF with a unique capability for the next century. Major modifications he made to an existing test stand improved the accuracy of measurements by three orders of magnitude, allowing significantly enhanced precision in the calibration of pulsed micro-Newtons of thrust. This capability is a "World's First" and enables many future AF micro-satellite missions. As a result, the micro-Pulsed Plasma Thruster has now earned its way onto an AFRL satellite, TechSat 21, to demonstrate the major benefits of these new lightweight thrusters in space. His work also supports the development of the High Power Hall Thruster, which is a system that will provide next-generation AF satellites with a new and incredibly efficient means of providing thrust for extended orbital maneuvers. Capt Lake's achievements have already saved thousands of developmental man-hours and millions of dollars, and through his innovative research, many future AF space visions become realizable. (R. Adams, AFRL Public Affairs - Edwards Research Site, (661) 275-5465)


Capt James Lake

FORSTER RECOGNIZED FOR DEVELOPMENT OF BEARING CAGES: Dr. Nelson H. Forster has been named the recipient of the 2001 US Air Force Science & Engineering Award for Manufacturing Technology. Dr. Forster is the senior engineer responsible for the technical direction of research and development in the Propulsion Directorate's Mechanical Systems Branch (AFRL/PRTM). In this capacity, he provides technical and programmatic guidance to ten scientists and technicians to understand and improve the mechanical design of advanced high temperature bearing systems. This understanding is used to develop innovative materials and processing techniques for better mechanical components in demonstrator engines for the Integrated High Performance Turbine Engine Technology (IHPTET) Program, Uninhabited Air Vehicles (UAVs), and high speed missiles. Dr. Forster applied his expertise in mechanical systems design to lead a research team to invent a process for developing high-strength/high-temperature carbon-carbon (C-C) bearing cages for use in advanced gas turbine engines. This material provides low density for reduced centrifugal loading, high thermal conductivity, low

friction, and essentially no wear. The end product now available is both affordable (only 10% of the total bearing cost) and robust, being the only material that can survive uncooled conditions of a Mach 3 demonstrator engine. C-C cages are targeted for two IHPTET demonstrator engines in 2004, and Williams International is testing them for a UAV application where it has been shown that C-C cages offer a 10X improvement in bearing life for fuel lubricated bearings. C-C cages are also in exploratory research for high-speed control moment gyros for military satellites. The combined total development costs for DoD systems that C-C cages will directly impact exceed $100 million, and all of these applications were directly tied to this initial program which developed C-C cage technology and manufacturing processes. (R. Wright, AFRL/PRTM, (937) 255-5568)



Dr. Nelson Forster

McNAMEE PRAISED FOR LEADERSHIP IN RESEARCH MANAGEMENT: Lt Col Joseph W. McNamee, PhD, has been named the recipient of the 2001 US Air Force Science & Engineering Award for Research Management. Lt Col McNamee, a Major during the rating period for this award, distinguished himself as an Air Force laboratory manager while serving as the Deputy Chief of the Propulsion Directorate's Power Division (AFRL/PRP). He demonstrated tremendous leadership and technical skills as well as an intense enthusiasm for his work. He also displayed an unparalleled ability to inspire passion for his vision in others. He led PRP in recovering from a major budget cut while refocusing the division's research objectives to target space and weapons power requirements as well as aircraft power needs. During this crucial period, Lt Col McNamee was the single source for detailed technical and programmatic information on every one of the division's 150 research programs. He led the way in developing key partnerships with Air Force users, product centers, and DoD and national laboratories to jointly define future aircraft, space, and directed energy weapon system requirements. As a result of his leadership, unproductive research efforts were eliminated which freed up resources for high payoff technologies and an aerospace power research and development program tightly focused on key enabling technologies. Largely due to the efforts of Lt Col McNamee, PRP now has a program that is coordinated with government and industry partners to maximize the return on technology investments. (Col C. Kimberlin, AFRL/PRP, (937) 255-6226)

Lt Col Joseph McNamee

AIR FORCE HONORS SPYKER FOR ENGINEERING ACHIEVEMENT: Dr. Russell L. Spyker has been named the recipient of the 2001 US Air Force Science & Engineering Award for Engineering Achievement. Dr. Spyker leads the Propulsion Directorate's Power Electronics in-house research team of five engineers and two technicians to identify and evaluate solutions for a wide range of aerospace power electronic design and applied research problems. Over the past year his team successfully developed and tested original and inventive solutions to several aerospace electrical power system problems. He collaborated with industry partners to develop new affordable capacitor packaging methods and a novel compact ratiometric current transformer. The new capacitor modules are 1/6th the cost of conventional sealed capacitors and offer a weight and volume savings of 30%. They will save millions of dollars as the Air Force and DoD move towards "more electric" systems, and this technology is transitioning to several military and commercial systems. The ratiometric current transformer saves 70% of the weight and volume over current state-of-the-art sensors, and it will transition into many Air Force and commercial power electronic subsystems. Dr. Spyker also exploited the astonishing energy density of ultracapacitors, a new high energy density storage device, by developing an advanced power electronic system to provide "battery-like" performance with 100X cycle life improvement over existing battery systems. Making a capacitor look "battery-like" resulted in several innovative circuit designs, which are presently being pursued for patent protection. "Battery-like" capacitor technology has the potential to replace thousands of low discharge rate batteries saving millions of dollars for the Air Force and industry while solving a serious aircraft safety issue. The astonishing results produced by Dr. Spyker and his team solving power related problems over the past year make him well deserving of this honor. (J. Weimer, AFRL/PRPE, (937) 255-6016)


Dr. Russell L. Spyker

THORNBURG NAMED CGO OF THE QUARTER: Capt Jeffery T. Thornburg has been named the Propulsion Directorate's Company Grade Officer of the Quarter for the 2nd Quarter of 2001. Capt Thornburg serves as the program manager for the Integrated Powerhead Demonstration (IPD) engine, which is a critical technology demonstrator for the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program. The IPD Program has two main technical goals: (1) to increase turbine life by using a full flow cycle staged combustion design, and (2) to increase bearing lifetime and reduce wear by incorporating hydrostatic bearing technology in both the hydrogen and oxygen turbopumps. The IPD Program contributes to IHPRPT goals of doubling cryogenic booster thrust-to-weight, achieving Mean-Time-Between-Overhauls of 100 missions, and reducing hardware costs by 35%. In his capacity as IPD program manager, Capt Thornburg coordinated and executed recent testing of the IPD oxygen turbopump at NASA's Stennis Space Center. He was also hand-picked to lead the recent IHPRPT Phase II PRDA effort for the entire

Space and Missile Propulsion Division (AFRL/PRS). He is a key contributor to the IHPRPT Materials Working Group, and is recognized as an expert in computational fluid dynamics. This summer, he sponsored two Air Force Academy cadets, motivating one to pursue a career in rockets. Capt Thornburg has also made significant contributions to the community. He was selected to be an adjunct professor at the Antelope Valley College, and he also volunteers at the Antelope Valley Children's Center. Capt Thornburg is a deserving recipient of this honor. (R. Adams, AFRL Public Affairs - Edwards Research Site, (661) 275-5465)

Capt Jeffery T. Thornburg