'Lighting a match in a tornado' is 1 of multiple feats for propulsion center

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When Walter O'Brien was a young boy, he recalls a moment of complete exhilaration when he was able to design and build a balsa wood airplane model that actually flew from his parents' front porch, across the street, and landed on the neighbor's deck. That boy of 10 is now in his early 70s, but he remains as excited about his engineering prowess now as he was then.

Only today, he is celebrating the award of his most recent patent on a significantly more sophisticated design ¬¬?? a novel ignitor for combustion and supersonic flows, a device that may prove useful in Mach 5 or hypersonic speed vehicles.

O'Brien, director of Virginia Tech's Center for Turbomachinery and Propulsion Research (CTRP), explained the difficulty of designing such an ignitor. "It is like trying to light a match in a tornado," he smiled.

Aerojet, an internationally recognized aerospace and defense leader specializing in missile and space propulsion, found the ignitor's possibilities so interesting it donated $50,000 to support students in the design and building of a scramjet combustion simulator that will be tested at Mach 2.4 in the company's facilities. An undergraduate student team is completing the design.

Aerojet is just one of many such companies interested in the CTRP. O'Brien and the collaborative partners working in the center, some of whom have been there more than three decades, have grown the research and education program into one of the leading centers of its kind in the country. Pratt & Whitney attested to this fact when it established a strategic partnership with Virginia Tech in 2008.

Previously, Pratt & Whitney had dozens of contracts with various universities that focused on propulsion. The world leader in the design and manufacturing of aircraft engines, space propulsion systems and industrial gas turbines decided to instead concentrate its resources, and named Virginia Tech one of its first three Centers of Excellence to support fundamental research initiatives in gas turbine propulsion systems.

Since the partnership started in January 2008, Pratt & Whitney has provided major support for Virginia Tech's research in turbomachinery and propulsion. O'Brien said, "Pratt & Whitney recognized the research capabilities we have, not just in mechanical engineering (ME), but in aerospace engineering, materials science, and engineering science and mechanics, and even outside the college in the statistics department." In a news release, Pratt and Whitney's Senior Vice President for

Engineering Paul Adams said, "Virginia Tech has outstanding technical capabilities that complement our fundamental research needs and we are excited about expanding our partnerships with these institutions. Pratt & Whitney has invested significantly in engineering capability and is committed to differentiating our technologies through investment in fundamental research and development."

The CTRP history began in 1970 when O'Brien and his colleague, Hal Moses were among the first investigators to apply high response transducers on the rotors in axial flow compressors, producing research that contributed valuable insights to reasons why compressors became unstable.

O'Brien, a Roanoke native, had earned his ME undergraduate degree from Virginia Tech in 1960. After receiving his master's at Purdue University in 1961, he returned to his hometown to work for the Aerospace Research Corporation for three years until he left to pursue his Ph.D. in ME at Virginia Tech. From 1967 until 1970 he worked at Blacksburg's Poly Scientific office and served on the ME faculty in a part-time capacity.

With O'Brien's doctorate attached to his name, J.B. Jones, the ME department head at the time, convinced the propulsion engineer to leave his position in industry where he had worked on measurement techniques for jet and rocket engines and join the ME faculty full-time. "The U.S. had just finished the Apollo project," O'Brien recalled, and the ME department wanted to expand its research in propulsion. "JB told me to establish a research program. He believed in research and discovery, and the combination would make one a better teacher."

O'Brien laughed about the subject of his first Virginia Tech proposal. "It was on the measurement of solid propellant burning; simply stated, the art of controlling hot, fast gas," he quipped. Later, his research on compressors and measurement was supported by Project Squid of the Office of Naval Research. O'Brien said the program turned into eight years of research support for the University. Explaining why the Navy used the word squid as a name, O'Brien said, "the Squid is nature's jet propulsion device, and much propulsion technology is inspired by nature's engineering." His work led to the improved stability of compressors and showed how air flow separation occurred, leading to compressor instability.

During the 1970s, O'Brien made a number of long-term relationships with professional colleagues in the propulsion industry. By the end of that decade he was bringing in about a quarter of a million dollars a year in research contracts, a significant number for that time.

Larry Taylor, Hal Moses, Tom Diller, and eventually Wing Ng, all ME professors, as well as Joe Schetz of aerospace and ocean engineering (AOE), were now working together on the turbomachinery and propulsion research. "Around 1980 we realized that we were growing to a point where we did not know what each other was doing. So we put together some internal reviews. After about three years, we realized that the folks supporting us ¬¬? like Wright Patterson Air Force Base, the Navy, General Electric, Pratt Whitney ? would also want to hear about our work," O'Brien said. This led to the founding of the CTPR in 1987. One year later, O'Brien was awarded a

chaired professorship, the J. B. Jones Professorship of Mechanical Engineering.

Today, the group has upwards of $3 million in annual research expenditures. It has expanded to include additional members of AOE, as well as faculty from the electrical and computer engineering, engineering science and mechanics, and materials science and engineering departments.

Beyond its on-campus research success, CTRP's reputation was instrumental in Rolls Royce's decision in 2008 to locate one of its new facilities in the Commonwealth. Company officials lauded the engineering brainpower of both Virginia Tech and the University of Virginia when Rolls Royce announced Virginia had secured the highly competitive deal. The impact of the Rolls Royce decision on economic development has the potential of investing some $500 million in the state and employ as many as 500 people when its new facility is completed.

Among CTPR's projects that interest companies like Pratt & Whitney, Aerojet, and Rolls Royce are the design of hydrogen fuel injectors for gas turbines, measurement of turbine temperatures and heat transfer, determination of combustion stability in afterburners and dry-low nitrogen dioxide burners, reduction of turbomachinery noise, testing of supersonic combustion, and the development and licensing of high temperature heat flux sensors. These projects are carried out in laboratories on and off campus, and include the operation of gas turbines and high-pressure combustion experiments. CTPR maintains a unique gas turbine research laboratory for full scale testing and research. It houses PT6, JT15D, and F109 turbine engines outfitted for research needs. At the lab, they conduct jet flow studies, high temperature sensor testing, and hydrogen-fueled gas turbine research. O'Brien also conducted a portion of his ignitor research for supersonic uses at this facility near the Virginia Tech Airport.

On campus, the gas turbine heat transfer lab is used to model detailed internal flow in cooled turbine blades and other original flow predictions. The lab is the home of 80 parallel computer processors that are used in simulation and modeling experiments.

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