Researchers develop groundbreaking new rocket-propulsion system

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A University of Central Florida researcher and his team have developed an advanced new rocket-propulsion system once thought to be impossible.

The system, known as a rotating detonation rocket engine, will allow upper stage rockets for space missions to become lighter, travel farther, and burn more cleanly.

The result were published this month in the journal *Combustion and Flame*.

"The study presents, for the first time, experimental evidence of a safe and functioning hydrogen and oxygen propellant detonation in a rotating detonation rocket engine," said Kareem Ahmed, an assistant professor in UCF's Department of Mechanical and Aerospace Engineering who led the research.

The rotating detonations are continuous, Mach 5 explosions that rotate around the inside of a rocket engine, and the explosions are sustained by feeding hydrogen and oxygen propellant into the system at just the right amounts.

This system improves rocket-engine efficiency so that more power is generated while using less fuel than traditional rocket energies, thus lightening the rocket's load and reducing its costs and emissions.

Mach 5 explosions create bursts of energy that travel 4,500 to 5,600 miles per hour, which is more than five times the speed of sound. They are contained within a durable engine body constructed of copper and brass.

The technology has been studied since the 1960s but had not been successful due to the chemical propellants used or the ways they were mixed.

Ahmed's group made it work by carefully balancing the rate of the propellants, hydrogen and oxygen, released into the engine.

"We have to tune the sizes of the jets releasing the propellants to enhance the mixing for a local hydrogen-oxygen mixture," Ahmed said. "So, when the rotating explosion comes by for this fresh mixture, it's still sustained. Because if you have your composition mixture slightly off, it will tend to deflagrate, or burn slowly instead of detonating."

Ahmed's team also had to capture evidence of their finding. They did this by injecting a tracer in the hydrogen fuel flow and quantifying the detonation waves using a high-speed camera.

"You need the tracer to actually see that explosion that is happening inside and track its motion," he said. "Developing this method to characterize the detonation wave dynamics is another contribution of this article."

William Hargus, lead of the Air Force Research Laboratory's Rotating Detonation Rocket Engine Program, is a co-author of the study and began working with Ahmed on the project last summer.

"As an advanced propulsion spectroscopist, I recognized some of the unique challenges in the observation of hydrogen-detonation structures," Hargus said. "After consulting with Professor Ahmed, we were able to formulate a slightly modified experimental apparatus that significantly increased the relevant signal strength."

"These research results already are having repercussions across the international research community," Hargus said. "Several projects are now re-examining hydrogen detonation combustion within rotating detonation rocket engines because of these results. I am very proud to be associated with this high-quality research."

More information: Jonathan Sosa et al, Experimental evidence of H2/O2 propellants powered rotating detonation waves, *Combustion and*

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