technology today

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The Aerospike Engine

It is important for our students to realize that many technological breakthroughs only come after repeated laboratory or prototype failures. As teachers we all know this, but many of our students are too quick to give up when a project they are working on first doesn't go as planned. In this column I selected an emerging technology that aeronautics engineers have been struggling to bring to fruition for many years.

Seventeen years ago NASA released a fact sheet about a new type of rocket engine they were trying to develop with Lockheed Martin. This engine could eliminate the need to use booster rockets to launch satellites and people into space. NASA's aerospike engine, which they described in August 2000, was actually an engine concept first proposed in the 1960s by Rocketdyne, then a Boeing division.

Aeronautical engineers have now spent at least 67 years trying to perfect this technology. The engine is finally ready for its first test launch early next year.

Actually, some early NASA designs of the space shuttle showed an exhaust flume that would have been created by an aerospike engine, but I could not find any NASA records that showed they proceeded past ground testing before their plans to use an aerospike on the Space Shuttle were shelved. You can read NASA's original document on this engine online at https://www.nasa.gov/centers/marshall/news/background/facts/aerospike.html

It looks like ARCA Space Corp. (arcaspace.com/en/news.htm) has finally carried this rocket concept to the finish line. Sounds kind of simple as I write it, but all that is left for them to do is complete ground testing of the engine shown on the stand (Photo 1); move their test rocket (shown on a flat bed truck in Photo 2) to the launch pad; do all the pre-flight checks, and finally launch the Haas 2CA, the world's first SSTO (Single Stage To Orbit) rocket, into space.

The ARCA Space Corp. artistic rendering (Photo 3) shows an exhaust-shaped nozzle that looks nothing like what we are used to seeing on a rocket launched into space. Instead of confining the exhaust gases by a conventional bell-shaped nozzle, an aerospike uses the changing air pressure of our atmosphere, from the ground to space, to partially control the shape of the expanding gases that push the rocket forward.

Today the different stages of a rocket have different shaped bell nozzles to help them get the most forward push through the atmosphere that they are going through. The bell-shaped nozzle designed

Photos courtesy ARCA Space Corp.

Photo 1—The aerospike demonstrator test engine on the test stand. Within the next few months it should be cleared for a test flight.

Photo 2—The rocket on the flat bed has the aerospike engine on board, ready to be taken to the launch site. If all goes as planned, it will perform a suborbital space flight. Its sea level thrust will be 4.2 tons from a low-energy propellant. It can reach space because the aerospike engine design lets its nozzle conform to be most efficient for the atmospheric pressure it is flying through.

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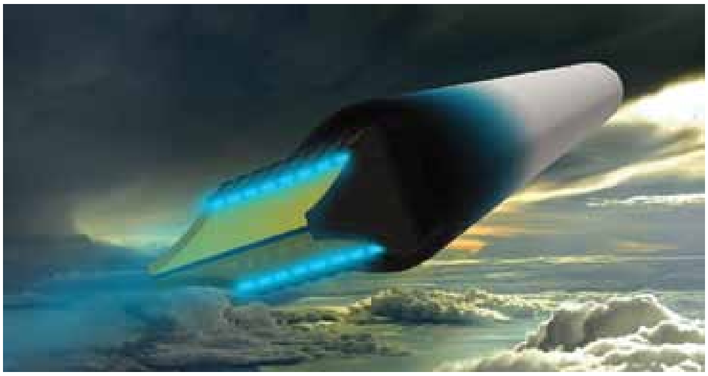

Photo 3—Artistic rendering of how different an aerospike engine nozzle is from the bell-shaped nozzle found on all past rockets.

for the first stage grows significantly less efficient as the rocket climbs toward outer space, so the higher it goes the less pushing force you get from the fuel that you are burning. This happens with each stage until finally the rocket enters orbit. With a conventional system, each consecutive stage has a bell-shaped nozzle most effective for the air pressure that it will encounter once it is ignited, to further push the rocket away from our planet.

This NASA quote best describes why ARCA's aerospike engine could significantly change, and speed up, our ventures to other planets: "The initial stage of the Saturn rocket which carried the Apollo astronauts to the moon featured a narrow nozzle to produce an ideal straight-edged column of exhaust at sea level. However, the command module which orbited the moon featured a much wider bell nozzle better suited for controlling the combustion gasses in the vacuum of space."

NASA's point was, if an aerospike engine could be successfully developed, it would be an SSTO rocket engine that could perform at sea level just as efficiently as it could perform in space on a trip to the moon or Mars. This video (youtube.com/watch?v=EWf4iOMSPNc) shows a test firing of an aerospike engine. It also uses animation to show how an aerospike engine works, and why its nozzle design could get the best propulsion at sea level or even in the vacuum of outer space.

Taking It a Step Further

1. With the power of the internet at your fingertips it is not difficult to research the history of most technological developments. Select 5 technologies that interest you and document how long it took to develop them.

2. Most technology labs include a rocket building activity. When you test fire the rocket project that you build, is the efficiency of its rocket engine affected by a change in air pressure during its flight? Why?