

Upper Stage Engine Composite Nozzle Extensions

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Carbon-carbon (C-C) composite nozzle extensions are of interest for use on a variety of launch vehicle upper stage engines and in-space propulsion systems. The C-C nozzle extension technology and test capabilities being developed are intended to support National Aeronautics and Space Administration (NASA) and United States Air Force (USAF) requirements, as well as broader industry needs.

Recent and on-going efforts at the Marshall Space Flight Center (MSFC) are aimed at both (a) further developing the technology and databases for nozzle extensions fabricated from specific C-C materials, and (b) developing and demonstrating low-cost capabilities for testing composite nozzle extensions. At present, materials development work is concentrating on developing a database for lyocell-based C-C that can be used for upper stage engine nozzle extension design, modeling, and analysis efforts. Lyocell-based C-C behaves in a manner similar to rayon-based C-C, but does not have the environmental issues associated with the use of rayon. Future work will also further investigate technology and database gaps and needs for more-established polyacrylonitrile- (PAN-) based C-C's.

As a low-cost means of being able to rapidly test and screen nozzle extension materials and structures, MSFC has recently established and demonstrated a test rig at MSFC's Test Stand (TS) 115 for testing subscale nozzle extensions with 3.5-inch inside diameters at the attachment plane. Test durations of up to 120 seconds have been demonstrated using oxygen/hydrogen propellants. Other propellant combinations, including the use of hydrocarbon fuels, can be used if desired. Another test capability being developed will allow the testing of larger nozzle extensions (13.5-inch inside diameters at the attachment plane) in environments more similar to those of actual oxygen/hydrogen upper stage engines. Two C-C nozzle extensions (one lyocell-based, one PAN-based) have been fabricated for testing with the larger-scale facility.