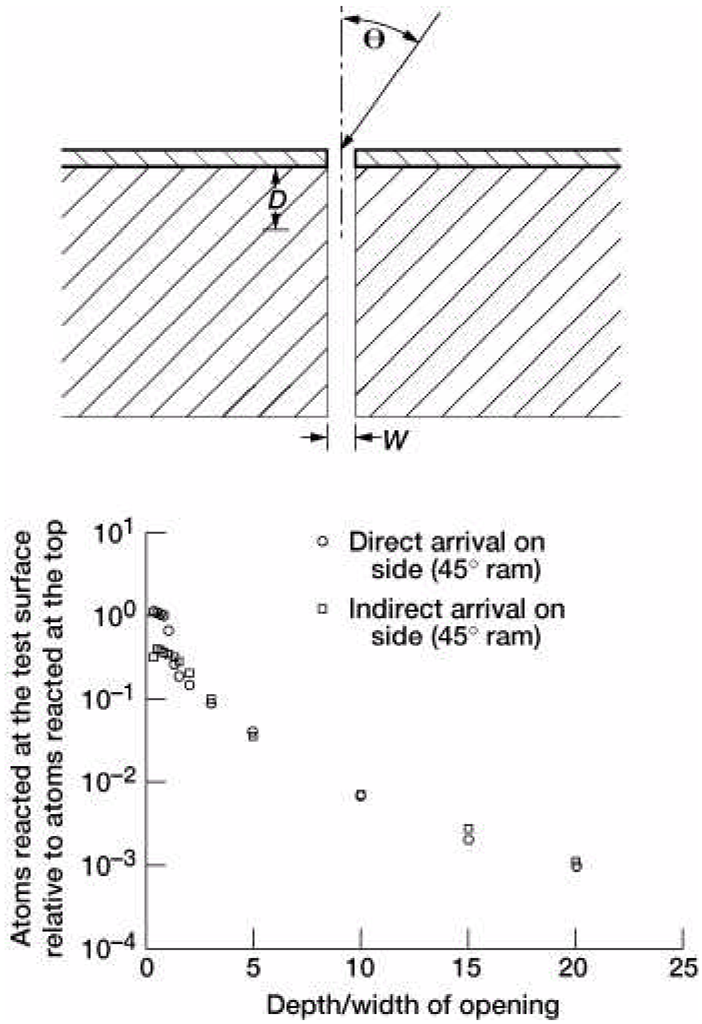
Monte Carlo Technique Used to Model the Degradation of Internal Spacecraft Surfaces by Atomic Oxygen

Atomic oxygen is one of the predominant constituents of Earth's upper atmosphere. It is created by the photodissociation of molecular oxygen (O_2) into single O atoms by ultraviolet radiation. It is chemically very reactive because a single O atom readily combines with another O atom or with other atoms or molecules that can form a stable oxide. The effects of atomic oxygen on the external surfaces of spacecraft in low Earth orbit can have dire consequences for spacecraft life, and this is a well-known and much-studied problem. Much less information is known about the effects of atomic oxygen on the internal surfaces of spacecraft. This degradation can occur when openings in components of the spacecraft exterior exist that allow the entry of atomic oxygen into regions that may not have direct atomic oxygen attack but rather scattered attack. Openings can exist because of spacecraft venting, microwave cavities, and apertures for Earth viewing, Sun sensors, or star trackers.

The effects of atomic oxygen erosion of polymers interior to an aperture on a spacecraft were simulated at the NASA Glenn Research Center by using Monte Carlo computational techniques. A two-dimensional model was used to provide quantitative indications of the attenuation of atomic oxygen flux as a function of the distance into a parallel-walled cavity. The model allows the atomic oxygen arrival direction, the Maxwell Boltzman temperature, and the ram energy to be varied along with the interaction parameters of the degree of recombination upon impact with polymer or nonreactive surfaces, the initial reaction probability, the reaction probability dependence upon energy and angle of attack, degree of specularity of scattering of reactive and nonreactive surfaces, and the degree of thermal accommodation upon impact with reactive and non-reactive surfaces to be varied to allow the model to produce atomic oxygen erosion geometries that replicate actual experimental results from space. The degree of erosion of various interior locations was compared with the erosion that would occur external to the spacecraft.

Results of one cavity model indicate that, at depths into a two-dimensional cavity that are equal to 10 cavity widths, the erosion on the walls of the cavity is less than that on the top surface by over 2 orders of magnitude. Wall erosion near the surface of a cavity depends on which wall is receiving direct atomic oxygen attack. However, deep in the cavity little difference is present. Testing of various cavity models such as these gives spacecraft designers an indication of the level of threat to sensitive interior surfaces for different geometries. Even though the Monte Carlo model is two-dimensional, it can be used to provide qualitative information about spacecraft openings that are three-dimensional by offering reasonable insight as to the nature of the attenuation of damage that occurs within a spacecraft in low Earth orbit.



Atomic oxygen erosion on the sides of a cavity relative to the top surface of the cavity as a function of the depth-to-width ratio.

The figure shows that there is more erosion on the side seeing direct atomic oxygen attack until a depth of approximately 5 times the width of the opening, where the erosion is the same on both sides.

Find out more about this research: http://www.grc.nasa.gov/WWW/epbranch/

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