

## TECHNOLOGY SOLUTION

### Mechanical and Fluid Systems

# Supersonic Spike Diffuser

Double the pumping efficiency in one quarter the space.

Standard cylindrical and second-throat diffusers allow supersonic gas flows to expand within their walls and pull a vacuum on any upstream void. However, the high-Mach-number shock reflections that occur in the center of the plume create substantial losses and result in an inefficient pumping process. Centerbody diffuser designs provide an improvement by reducing the maximum Mach number of the core flow, but also increase the number of oblique shocks in the system by introducing multiple turns into the system.

A new type of spike diffuser recently developed by NASA Stennis Space Center is able to provide approximately double the pumping performance of second-throat diffusers via Pareto-efficient reduction of both core Mach number and flow deflection. This enables substantially lower vacuum pressures to be achieved for a given feed pressure/mass flow via the use of higher-expansion-ratio driving nozzles. Spike diffusers are also spatially compact, requiring only ~25% of the length of second-throat designs

#### BENEFITS

- Starting pressure ratio ~50% of conventional diffuser geometries
- Lower vacuum achievable for a fixed feed pressure/mass flow
- Spatially compact
- Reduced structural overhead

#### APPLICATIONS

The technology has several potential applications:

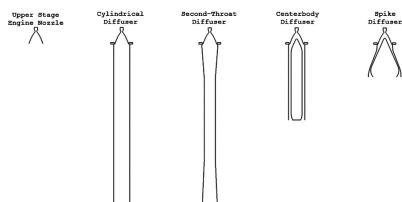
- Altitude Simulation
- Steel Industry (Degassing)
- Chemical Processing (distillation, drying, stripping, evaporation, etc.)
- Oil and Gas Refinement (vacuum distillation)
- Edible Oil Processing (deodorization, hydrogenation, etc.)
- Artificial Fiber Manufacturing
- Flavors and Fragrances (vacuum distillation)



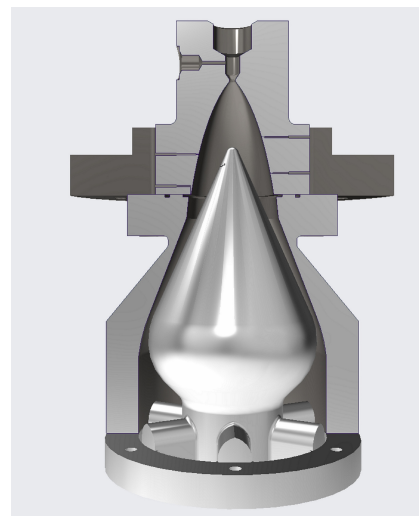
## THE TECHNOLOGY

The basic mode of operation for all passive supersonic diffusers is to enable a plume's inherent power to drive the outer boundary of the exhaust jet to the diffuser wall so that the entire cross-section of the flow has a speed greater than that of sound. This allows mass removal from the area surrounding the nozzle via entrainment. The result is a low-pressure environment similar to the altitude at which the nozzle was designed to operate. Additionally, the nature of supersonic flow prevents pressure interference from the downstream environment.

The specific geometry of each coupled nozzle-diffuser system dictates how efficiently it is able to operate, with the primary indicator of performance being the stagnation-to-ambient pressure ratio at which the plume attaches to the wall and "starts" the diffuser. Cylindrical diffusers simply provide a surface for plume attachment and have the worst performance of all geometries but are easy to construct. Second-throat diffusers are characterized by an additional area contraction which provides better resistance to ambient backpressure. Centerbody diffusers reduce shock losses by placing an aerodynamic obstruction in a cylindrical diffuser to prevent high Mach number plume expansion. They provide the best performance and smallest physical envelope of historically-used diffuser types. Spike diffusers are unconventional by comparison and are characterized by the use of an aerodynamic centerbody which expands beyond the diameter of the rocket itself, reducing high Mach number losses and a single turning of the entire core flow so that its velocity has a strong radial component. Additionally, they feature contouring of the surrounding aeroshell in a manner that provides an axial area ratio profile similar to that of second throat diffusers. By combining desirable aspects of the conventional diffuser types, they are able to provide the best overall aerodynamic performance in the smallest spatial envelope.



Diffuser Aerodynamic Geometry Comparison



Spike Diffuser Aerosurfaces

## PUBLICATIONS

Patent Pending