Hypersonic Laminar Flow Control Using Strategic Surface Patterning

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BRIEF DESCRIPTION

Dr. Xiaolin Zhong and colleagues in the UCLA Department of Mechanical and Aerospace Engineering have developed a method of maintaining laminar flows over air transportation vehicles and space reentry vehicles at high supersonic and hypersonic speeds by strategically applying surface roughness.

BACKGROUND

The transition of boundary-layer flows over hypersonic vehicles significantly affects the performance and design of their thermal protection systems. The laminar-turbulent flow transition can have a first-order impact on lift, drag, control, and heat transfer properties of the vehicles. Surface roughness has been traditionally used to trip the hypersonic boundary-layer transition by putting it near the leading edge of the body surface. However, the possibility of using surface roughness to stabilize hypersonic boundary layers has not been explored. The ability to maintain laminar boundary-layer flows by delaying the laminar-turbulent flow transition can result in lower drag, lower heat flux to the surface, and higher fuel efficiency.

INNOVATION

Researchers in UCLA's Department of Mechanical and Aerospace Engineering have developed a novel passive control strategy to maintain laminar flows over air transportation vehicles and space reentry vehicles at high supersonic and hypersonic speeds. The strategy focuses on delaying the laminar-turbulent flow transition. By applying an array of surface patterning in the appropriate region determined by detailed flow field calculations, one can delay the transition and maintain controlled laminar flow. The result is a substantial reduction in drag force, surface heating, and increased fuel efficiency of hypersonic vehicles. The technology may be applied to produce various surface roughness elements, which can be easily attached or removed from the vehicle surface.

APPLICATIONS

- Produce standard surface roughness elements to affix to hypersonic vehicle surfaces:
- Commercial spacecraft (government and private)
- Space shuttles
- Reentry capsules
- Space tourism
- Hypersonic aircraft
- Experimental aircraft
- Military vehicles
- Produce standard surface roughness elements to affix to high supersonic vehicle surfaces:
- Multirole fighter planes
- Reconnaissance aircraft
- Future supersonic business jets

ADVANTAGES

- Much simpler than a developing technology that employs plasma discharges, which requires a complex system for energy generation and control
- Simpler and more efficient than approaches that utilize porous coating, the only viable current alternative:

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OTHER INFORMATION

KEYWORDS

laminar flow, hypersonic, supersonic, space, turbulence mitigation, roughness, airplanes, space, aircraft, Mach number, perturbation, vehicle efficiency

CATEGORIZED AS

- **Engineering**
  - Engineering
- **Security and Defense**
  - Other
- **Transportation**
  - Aerospace
  - Other

RELATED CASES

2013-207-0

- Stabilization of surface roughness is dependent only on geometric parameters, rather than material properties
- Much simpler manufacturing
- Roughness elements can be affixed and removed from vehicle surfaces easily, allowing for quick modifications without changing the fundamental structure of the vehicle.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,071,798	09/11/2018	2013-207

RELATED MATERIALS

- Duan, L., Wang, X., and Zhong, X. Stabilization of a Mach 5.92 Boundary Layer by Two-Dimensional Finite-Height Roughness. AIAA Journal, Vol. 51, No. 1 (2013), pp 266-270.

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