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NEWS | NOVEMBER 22 2019

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Scilight 2019, 471107 (2019)
https://doi.org/10.1063/10.0000281

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Total temperature affects hypersonic boundary layer transition

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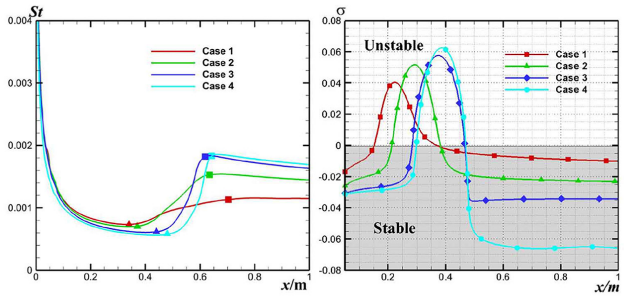
Simulations of a hypersonic sharp cone find that total temperature should be considered in wind tunnel studies of boundary layer transition.



Accurate predictions of the boundary layer transition, which marks the onset of turbulence, is crucial to the design of hypersonic aircraft. While ground wind tunnels are used to mimic in flight conditions for studying boundary layer transition, experimental predictions often vary from actual flight measurements.

One of the reasons behind this variance could be total temperature, which is measured with a probe on the surface of the aircraft. Few studies, however, have examined how total temperature influences hypersonic boundary layer transition. Zhao et al. considered the effect of total temperature on hypersonic boundary layer transition and found transition positions vary with different total temperatures.

The authors simulated a 7° half-angle sharp cone with four different total temperatures, but with the same Mach number, Reynolds number, and turbulence intensity. When they looked at the boundary layer transition, they found that as total temperature increases, the transition starting point on the sharp cone moves backward and the transition region shortens.

Their results indicate the importance of considering total temperature when studying boundary layer transition in wind tunnel experiments, in addition to other parameters. Author Jinshan Zhao also suggests that future wind tunnel experiments need to be conducted in a variety of facilities with different temperatures.

“The real flight test is expensive, and no single ground-test facility can simulate all aspects of hypersonic flight, so both low and high total temperature facilities are needed in the transition experiments,” Zhao said.

Next, the authors will use wind tunnel experiments to further study the effect of different total temperatures on boundary layer transition for the same 7° half-angle sharp cone.

Source: “Numerical study of total temperature effect on hypersonic boundary layer transition,” by Jinshan Zhao, Sen Liu, Lei Zhao, and Zhigang Zhang, *Physics of Fluids* (2019). The article can be accessed at https://doi.org/10.1063/1.5125116.

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