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Professor Solkeun Jee's joint research team contributes to the analysis of aerodynamic characteristics of high-speed aircraft by predicting the start of supersonic turbulent flow

□ GIST (Gwangju Institute of Science and Technology, President Kiseon Kim) School of Mechanical Engineering Professor Solkeun Jee and Pusan National University Department of Aerospace Engineering Professor Donghun Park developed a technique to accurately predict the flow transition* phenomenon, which is the beginning of turbulent flow in the supersonic flow** situation around the object, through simulation (numerical analysis).

* flow transition: when flow changes from laminar flow*** to turbulent flow****

** supersonic flow: when the velocity of the flow is faster than the velocity of sound

*** laminar flow: when the flow is smooth and the change in velocity is also gradual

**** turbulent flow: when flow speed and pressure changes rapidly and vortices of various sizes exist

◦ The result of this study is that it predicts the starting point of turbulent flow, which causes drag and heating of high-speed aircraft. The phenomenon of drag and heating increase significantly at the start of turbulence, which can lead to poor performance of the vehicle.

◦ The direct simulation method*, which is the most accurate numerical analysis technique, has a limitation when the computational amount is very large. In this study, the researchers proposed a novel method that combines the flow stability theory** with the large-eddy simulation*** and achieved two goals of high precision and high efficiency in the numerical analysis of the flow transition phenomenon, which is an engineering challenge.

* direct simulation method: Turbulent flow has various sizes of eddies, and a technique that directly analyzes even small eddies numerically without a model is called direct simulation, which has a limitation when the amount of calculation is large.

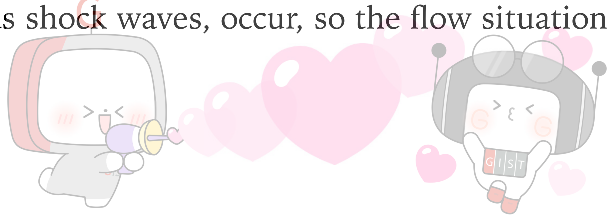
** stability theory: As the stability of the laminar flow decreases, unstable elements are amplified, causing the flow to transition to turbulent flow. The theoretical approach to the stability of laminar flow is called stability theory.

*** large-eddy simulation: Among the vortexes of various sizes of turbulent flow, the technique of directly interpreting the vortex with large kinetic energy without a model is called a large-scale simulation.

◦ High precision means that the accuracy of the direct simulation technique, which is known to be the most accurate among numerical analysis techniques, is guaranteed, and high efficiency means that the computational amount is reduced by more than 100 times compared to the direct simulation technique.

□ The development of high-speed aircraft such as fighter jets and space shuttles is a key technology in the era of defense and space exploration. Finding the mathematical solution of turbulent flow equations is considered one of the unsolved challenges in the field of mathematics, and simulations using supercomputers can provide solutions to complex turbulent flow equations.

◦ The research team extended the proven high-precision and high-efficiency calculation technique of supersonic flow to subsonic flow (flow velocity is slower than sonic velocity). In supersonic flow, physical phenomena that do not appear in subsonic flow, such as shock waves, occur, so the flow situation



is more complex. The research team effectively simulated the transition from laminar flow to turbulent flow in a supersonic flow situation using this technique.

- Professor Solkeun Jee said, "This research is a basic study that can be used to predict the boundary layer transition required for the development of supersonic/hypersonic high-speed aircraft. The flow simulation technique developed in this study is expected to contribute to the design of supersonic vehicles by clearly identifying the transition phenomenon where turbulence begins."

- This research was conducted by GIST Professor Solkeun Jee and performed by Ph.D. student Jiseop Lim as the first author, and Pusan National University Department of Aerospace Engineering Professor Donghun Park, an aerodynamics expert and professor of aerospace engineering, performed analysis based on the theory of flow stability. The large-eddy simulation combined with stability theory was conducted at GIST.

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