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Professor Solkeun Jee's joint research team predicts turbulent flow transitions around objects and develops precise simulation techniques

☐ GIST (Gwangju Institute of Science and Technology, President Kiseon Kim) School of Mechanical Engineering Professor Solkeun Jee's research team developed a technique to accurately predict the flow transition* phenomenon, which is the beginning of turbulent flow around an object, through collaborative research with Professor Donghun Park of the Department of Aerospace Engineering at Pusan National University.

* flow transition: a phenomenon in which the flow changes from laminar flow** to turbulent flow***

** laminar flow: Fluids flow smoothly, and the change in velocity is also gentle.

*** turbulent flow: The speed, pressure, etc. of flow change rapidly, and there are many different sizes of vortices.

- The results of this research are expected to contribute to the accurate prediction of fluid resistance by predicting the starting point of turbulent flow that causes fluid resistance in vehicles such as automobiles, ships, and airplanes. An ability to predict the flow transition can contribute to the development of high-speed aircraft and eco-friendly vehicles based on accurate flow simulation.

☐ Finding the mathematical solution of the turbulent flow equation is one of the unsolved problems in the field of mathematics (Millennium prize problems). Complex flow equations can be solved numerically using supercomputers (numerical analysis). In this study, a numerical analysis technique was developed that can be applied to the flow transition phenomenon, which is the beginning of turbulence.

☐ The research team was able to achieve both high fidelity and high efficiency by proposing a novel method of incorporating large-eddy simulation* with the theory of flow stability.

* large-eddy simulation: Turbulent flow has eddies of various sizes, and a technique that capture large eddies which contain most of the turbulent kinetic energy without a model is called a large-eddy simulation.

- High fidelity refers to the accuracy of the direct numerical simulation method, which is known to be the most accurate among flow simulation methods, is guaranteed, and the high efficiency means that the computational cost is reduced by more than 100 times compared to the direct numerical simulation method.

- The research team became aware of the importance of the turbulence model used in the large-eddy simulation. By verifying several models, it was possible to find a turbulence model that is effective during the laminar-to-turbulent transition. The turbulence model does not guarantee the performance in the transition process. In this study, an additional analysis was performed to see if the model equation is suitable for flow physics.

☐ Professor Solkeun Jee said, "This is a basic study that can be used to predict the boundary layer transition required for the development of supersonic/hypersonic high-speed aircrafts. The flow simulation technique developed in this study is expected to contribute to clarifying the transition phenomenon in which turbulence, which is a difficult engineering problem, begins."

☐ Under the guidance of Professor Solkeun Jee, Ph.D. student Minwoo Kim participated as the first-author. Professor Donghun Park of the Department of Aerospace Engineering at Pusan National University, a specialist in aerodynamics, performed an analysis based on the stability theory of the flow, and a large-eddy simulation combined with the stability theory was performed at GIST.

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of Science and Technology Information, and by the GIST Research Institute. The research results were published online on August 1, 2020, in *Computer Methods in Applied Mechanics and Engineering*, a renowned international academic journal in the field of mechanical engineering and multidisciplinary engineering, and will be published in the November print issue.

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