Ansys + Nagoya University, NAFT

"Ansys Fluent® software, with its simple GUI and powerful visualization capabilities, is a guidepost in our aerodynamic design. For our team, it was challenging to perform the wind tunnel testing of a rocket flying at 400 km/s. However, using Ansys Fluent simulation software to visually understand the pressure distribution and interference with the airflow allowed us to select an appropriate design without hesitation."

— **Haruki Iwata**
Rocket Group PM **/** Nagoya University, NAFT

/ Nagoya University's NAFT Successfully Optimizes Rocket Aerodynamics With Ansys Software

When designing a rocket, one of the key considerations that researchers face is accurately predicting its drop location. Getting this correct is imperative to ensuring safety, preventing potential damage, and avoiding the loss of the rocket itself — which harms data recovery rates. Solving this problem is a top priority for Nagoya University Aerospace and Flight Technologies (NAFT), a team at Nagoya University in Japan that uses their unique free-form fin rocket designs to participate in joint launch experiments hosted by hybrid rocket organizations.

/ Challenges

NAFT had to overcome three key challenges to succeed in their goals. First, the rocket they are developing has dynamic free-form wings, which require complex flow field analysis. Second, they were tasked with minimizing drag in their fin geometries. Third, the team's analyses required them to study many different conditions depending on the attitude of the aircraft in flight.

/ Technology Used

- Ansys Fluent fluid simulation software
- PyAnsys® Python-based platform for engineering simulation and optimization
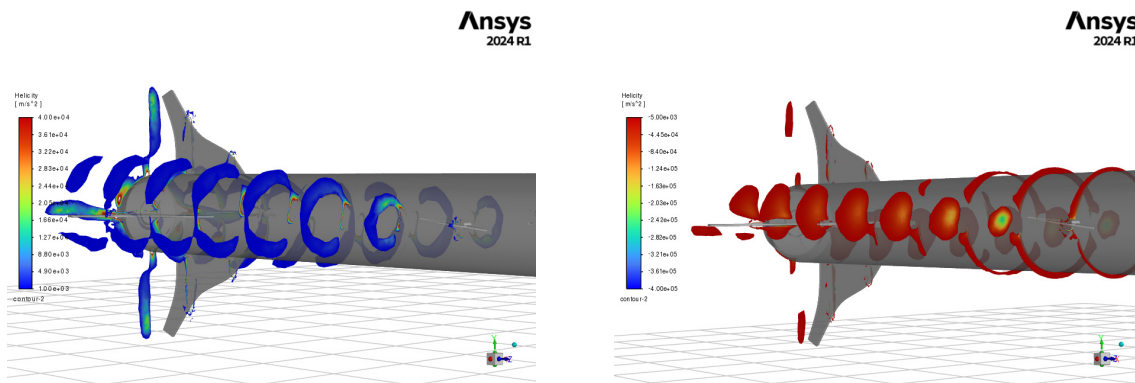

A team photo of NAFT and their hybrid rocket

/ Engineering Solutions

NAFT used Ansys software to obtain aerodynamic parameters during flight and analyze a variety of conditions, including different fin shapes, airspeeds, and attitudes (i.e., the pitch or roll angle.) Simulation, and the abundant visualization features provided by Ansys software, enabled the team to:

- Use pressure contour plots and flow velocity vectors to quickly and accurately understand the flow field and changes in aerodynamic characteristics due to the design
- Design a smaller free-form fin shape that provides more efficient lift, rather than the trapezoidal fins used by many organizations
- Visualize the vortices generated by a moving wing with the Lambda2 criterion, which is a measure of swirling motion
- Automate the analysis and create a trajectory simulator using the PyFluent package that enables Pythonic access to Fluent software


A contour plot created by Ansys Fluent software that shows helicity and enables researchers to see where vortices are and how they are generated.

Benefits

- Accurately calculating the rocket's aerodynamic characteristics to help predict the drop position. In the 2023 Noshiro Space Event, the difference between the actual drop position and the position predicted using Fluent simulation was only 120 m, leading to the complete recovery of the vehicle.
- Utilizing Fluent software's visualization capabilities to study the vortex at the blade tip, which has a significant impact on blade performance, to determine a suitable shape for control.
- Automating their analysis in PyFluent after establishing a stable convergent mesh and analysis method setup. This resulted in a reduction of one hour per analysis compared to manual analysis, thereby reducing design time.
- Efficiently analyzing simulations under many different conditions by using the Fluent software's ability to converge calculations in a short time.
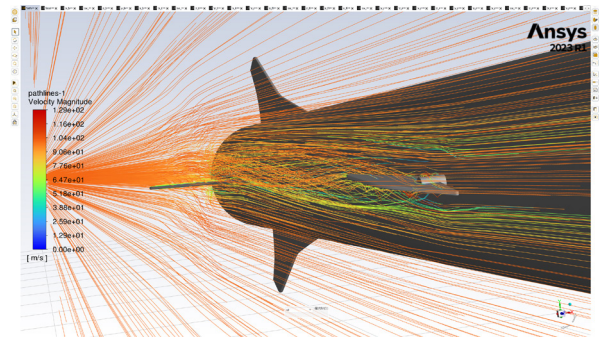
A pathline diagram showing a single particle's history of movement. This enables the team to see the movement of air due to the rotation of the moving wing.

Group Description

The Nagoya University Space Development Team (NAFT) is one of the largest student hybrid rocket organizations in Japan with a long history in this field. They are focused on developing space-related projects under their slogan: "link space — bringing space closer to you." NAFT consists of five teams: Rocket Team, Can-SAT Team, Space Balloon Team, MARS Rover Team, and Education Team. NAFT participates in joint launch experiments held by hybrid rocket organizations throughout Japan, such as the 2023 Noshiro Space Event and the 2024 Izu-Oshima Joint Launch Experiment.

When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

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