Advanced Core for Energetics, Hiroshima University Vol. 84

HU-ACE NEWS LETTER

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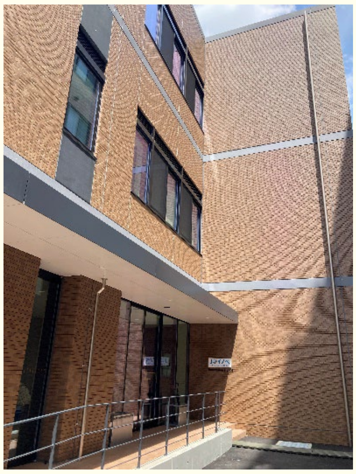
Activities of the Core

Dec. 6, 2023	ACBS 2023 in Akita (co-organized by HU-ACE)
Dec. 12-13, 2023	JCREN 2023 in Bangkok, Thailand (co-organized by HU-ACE)
Dec. 16, 2023	The 7th Higashihiroshima-Ene/Eco Seminar (co-organized by HU-ACE)
Dec. 19, 2023	The 12th Biomass Premium Evening Seminar (co-organized by HU-ACE).
Dec. 21, 2023	The 86th HU-ACE Steering Committee Meeting

Ground Source Heat Pump in J-Innovation Research Center.

It is getting colder and colder in December. The Higashi-Hiroshima Campus of Hiroshima University is located in the Saijo Basin, where the outdoor temperature sometimes drops below 0 degrees C in winter. Air conditioners are generally operated with compression type-refrigerant cycles in combination with outdoor and indoor units. We can imagine that defrosting operations often occur when the outdoor temperature drops below 5 degrees C, and cause indoor heating to stop. On the other hand, ground source heat pumps (GSHPs), which have been introduced on campus, never incur defrosting operations because the outdoor unit functions are buried in the ground. Ground sources generally have higher temperatures in winter and lower temperatures in summer than air sources, leading to the improvement of the energy efficiency of heat pumps. A GSHP installed in the J-Innovation Research Center of the Research Institute for Nanodevices on campus in 2023 also achieves high energy efficiencies of COP>5.0 with stable heat source temperatures of about 16 degrees C, even when the outdoor temperature drops to around 0 degrees C.



We at HU-ACE will continue to contribute to making our campus carbon neutral.

Related Events

The 8th International Symposium on Fuels and Energy (ISFE2024) is scheduled on July 1-2, 2024.
Details is here. https://symposium2024.isfe.hiroshima-u.ac.jp/

We have constructed a roadmap for the development of energy utilization technologies leading up to 2050 and an integration scenario called the “Hiroshima Scenario”. Please feel free to share your thoughts with us.
https://hu-ace.hiroshima-u.ac.jp/wp/wp-content/uploads/2022/10/220921-brochure.pdf

Research consultation and joint research are welcome.

Issued by Advanced Core for Energetics, Hiroshima University
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Research Topics No. 47

Three-dimensional simulation of flow field for propulsive system mimicking fish school

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Research fields: Fluid Engineering, Mechanical engineering

Keywords: CFD, Turbulent flow, Two-phase flow

Abstract

Background

Small underwater propulsors are used in shallow water areas and for riverine research, but conventional screw-based propulsion systems have problems such as entanglement in underwater debris and seaweed, damage to marine and riverine organisms and impossibility of propulsion due to collision with or damage from rocks and other obstacles. As an alternative propulsion system to the screw, the fin-type propulsion, which imitates the swimming motion of fish, is attracting attention. The optimal arrangement that minimizes drag can be found by clarifying the correlation between the fluid field around multiple fin-type systems and the fluid force. Theis knowledge will be useful for new designs that do not use screws.

Methods

The CIP (Constrained Interpolation Profile) method which has a high accuracy for hyperbolic equations, and the Immersed Boundary method for fluid-structure interaction analysis, were used to simulate the three-dimensional flow field around three swimming fish simulating a killifish. The effect of the spatial arrangement of the fish bodies on the time variation and magnitude of the drag coefficient, propulsive force and drag force on each fish body, and the correlation between the spatial distribution of pressure and velocity, were quantitatively evaluated. The fish were placed in a total of 28 conditions with S=0.5L-1.0L and B=0.2L-0.5L in the mainstream and vertical direction, respectively, relative to the length of the fish (L).

Results

Figures 2(a) and (b) shows the fish configurations (S=1.0L, B=0.2L) and (S=0.5L, B=0.3L), respectively, and (c) shows the temporal variation of the pressure distribution around a single fish body. There is uniform flow with constant velocity from left to right in each figure, and the Reynolds number is 5000. It was found that the average of three fish was decreased by 9.61% in the case of Fig. 2(a) compared to Fig. 2(c). This is because the high pressure at the heads of the two rear fish overlaps the tail of the leading fish, which is always pushed alternately by the rear two fish. On the other hand, high-pressure areas of the two rear fish are on the abdomen of the lead one in Fig. 2(b), and a low-pressure area created between the rear two overlaps with the tail fin section of the lead fish. So, the pressure difference between the head and tail becomes even greater, creating a greater drag. Even if the swimming style of fish and the conditions of fluid such as the Reynolds number are exactly the same, the propulsor's arrangement greatly affects the pressure field generated around the fish body and the flow field pushed backward, so we will promote integrated evaluation of energy consumption and propulsion efficiency along with drag force and propulsion force.

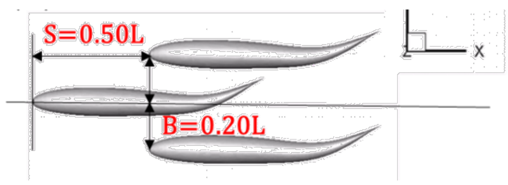

Fig. 1 Example of fish school. S=0.5L, B=0.2L

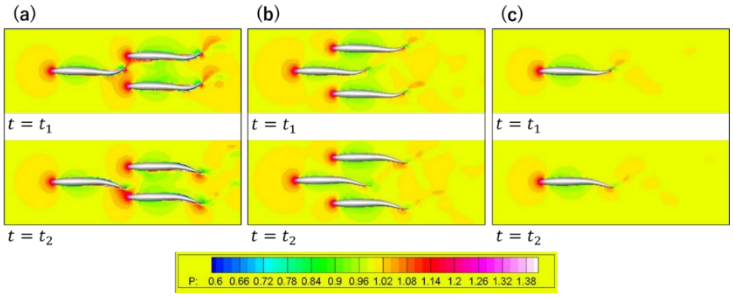

Fig. 2 Pressure Variation (a) S=1.0L, B=0.2L, (b) S=0.5L, B=0.3L, (c) Single Fish

References

1. Yoshida, K., Ogata, Y., Hirai, S., and Hosotani, K.: Artificial Life and Robotics, 2023