Fluid-Structure Interaction Design of Insect-like Micro Flapping Wing

D. Ishihara*†, N. Ohira*, M. Takagi*, S. Murakami* and T. Horie*

* Department of Mechanical Systems Engineering
Kyushu Institute of Technology
680-4 Kawazu, Iizuka, Fukuoka 820-8502, Japan
† E-mail: ishihara@mse.kyutech.ac.jp

ABSTRACT

Insight into the mechanics of insect flapping flight is essential in the design process of micro air vehicles (MAVs) mimicking insect flapping flight. The aerodynamics of insect flapping flight is strongly dependent on the characteristic motions of flapping wings [1]. The characteristic pitching motion can be created by the interaction between flexible wings and the surrounding air [2 – 4].

In this study, a fluid–structure interaction (FSI) design of insect-like micro flapping wing is proposed. Similar to actual insects, the proposed design actively utilizes the FSI to create the pitching motion of the wing. The proposed design will decrease the mechanical complexity of insect-like MAVs.

The proposed design requires the accurate and stable analysis for the strong interaction. Furthermore, the speedup of computation is required for the parametric study. Therefore, a projection method for the monolithic FSI system using the algebraic splitting [5 – 7] is used to perform the parallel computation of 3-D unsteady FSI analysis.

Each design solution has so-called 2.5-D structure for MEMS processing. The initial design parameters are determined based on a model insect. Finally, some satisfactory design solutions are found, where their aerodynamic thrust is sufficient to support the weight of the model insect.

REFERENCES

[1] Dickinson, M.H., Lehmann, F.-O. and Sane, P.S. (1999). Science 284, 1954–1960.

[2] Ishihara, D., Horie, T. and Denda, M. (2009). Journal of Experimental Biology 212, 1–10.

[3] Ishihara, D., Yamashita, Y., Horie, T., Yoshida, S. and Niho, T. (2009). Journal of Experimental Biology 212, 3882–3891.

[4] Ishihara, D., Horie, T. and Niho, T. (2014). Bioinspiration and Biomimetics 9, 046009.

[5] Ishihara, D. and Yoshimura, S. (2005). International Journal for Numerical Methods in Engineering 64, 167–203.

[6] Ishihara, D., Kanei, S., Yoshimura, S. and Horie, T. (2008). Journal of Computational Science and Technology 2, 185–196.

[7] Ishihara, D. and Horie, T. (2014). Computer Modeling in Engineering and Sciences 101 (6), 421–440.