# Flow Interaction of Sailing Drone using Numerical Method

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Abstract : *There is an accelerating need for ocean sensing where autonomous vehicles can play a key role in assisting engineers, researcher and scientists with environmental monitoring and collecting oceanographic data. This paper is performed to develops an autonomous sailing drone to be used as a sensor carrying platform for autonomous data acquisition at Sea. From a sailing drone design viewpoint, it is important to establish reliable prediction methods for sailing drone's resistance. The required power for the propulsion unit depends on the ship resistance and speed. There are three solutions for the prediction of ship resistance as follow analytical methods, model tests in tanks and Computational Fluid Dynamics (CFD). The present paper aims at simulating sailing drone friction resistance using numerical method. The dynamic mesh motion is used to describe the sailing drone movement.*

Key words : *Sailing Drone, Autonomous Vehicles, CFD, Dynamic Mesh, Friction Resistance.*

## 1. INTRODUCTION

Thanks to the great advancement of computer performance, numerical analysis of sailing drone resistance using computational fluid dynamics (CFD) is being widely adopted, and the results are being applied to actual design of sailing drone. In the present study, for sailing drone hull hydrodynamic analysis, a "dynamic mesh" motion type technique was applied. The present computational results were investigated to predict the hull total resistance.

## 2. COMPUTATIONAL MODEL AND BOUNDARY CONDITION

Hull resistance is the total force that opposes the forward motion of the drone at a corresponding speed in calm sea. The total resistance of sailing drone consists of air and hydrodynamic resistances. Hydrodynamic resistance is affected by the wetted surface area of the sailing drone hull. It can be divided into viscous and wave resistances. Normally, frictional resistance component plays an important role as it takes the largest portion of the total resistance.

The CFD model is illustrated as the figure 2 with L is sailing drone length. The boundary domain is the area where flows (Air and Sea water) influences the sailing drone hull.

The fluid domain boundaries are designed to be placed with a sufficient distance from the area of investigation. The volume of fluid (VOF) method is used to locate the free surface (between the air and water).

Fig. 1 Sailing Drone 3D drawing

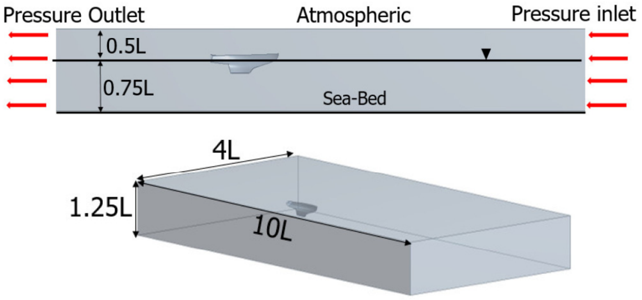

Fig 2 Sailing Drone CFD model

The outlet and inlet boundary conditions is static pressure without the velocity component to ensure calm sea conditions. The dynamic mesh capability is used to simulate problems with boundary motion so the dynamic mesh for sailing drone translational motion need to be required. In order to describe the sailing drone motion, the UDF (User definition file) is complied.

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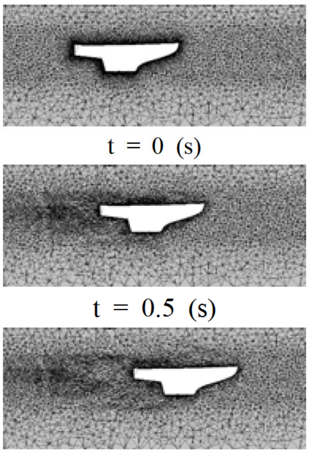

t = 0 (s)

t = 0.5 (s)

t = 1.15 (s)

Fig. 3 Dynamic mesh motion

Simulations presented in this study were performed for 3 selected test conditions for different sailing drone speeds as presented in table 1.

Table 1 The sailing drone case studies

| Case | 1 | 2 | 3 |
|---|---|---|---|
| Sailing drone speed | 4 knots (2.06 m/s) | 5 knots (2.57 m/s) | 6 knots (3.09 m/s) |

## 3. RESULTS AND DISCUSSIONS

After simulation setup for the sailing drone and boundary domain, simulations will run and export output data under tested conditions. Due to using the VOF (volume of fluid), the free surface between air and water is made as shown in Figure 4.

Fig. 4 Volume fraction of water

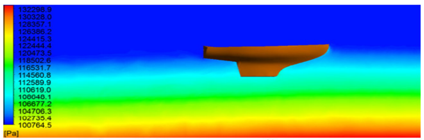

Fig. 5 Pressure Contour

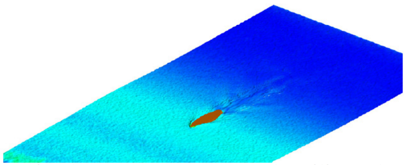

Fig. 6 Flow Pattern around sailing drone

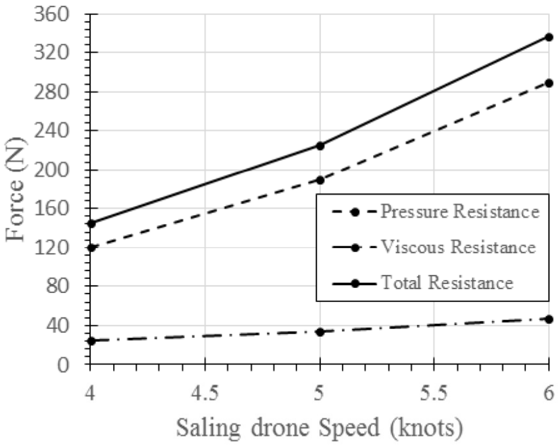

Fig. 7 Resistance components value calculated by CFD

The fig.7 show the two main hydrodynamic resistances including pressure and viscous resistances. From this results, the increase in sailing drone speed lead to hull resistance without considering the heaven motion. The pressure resistance account up to 80% of the total resistance.

## 4. CONCLUSIONS

From this study, several conclusions are obtained as follows:

1. Normally, frictional resistance component plays an important role as it takes the largest portion of the total hull resistance. For example, skin friction can account for up to 90% of the total resistance, for a slow-speed ship. However, in our sailing drone model, the results illustrate that the pressure resistance is higher than viscous resistance.
2. The transformation mesh is extremely sensitive method, it is necessary to setup dynamic mesh values carefully.

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