MODELING OF THE UNDERWATER AIRFRAME - GLIDER

Alexey V. Cherkasov

The article shows opportunity to calculate and develop an underwater glider as alternative to the classic one, which would be less complicated and less time consuming in construction. To create the model of the device the author has developed a special method of identification system. The model of the underwater glider is developed in order to research the mechanism of buoyancy control and dynamics of the vehicle movements especially in shallow waters.

Keywords: underwater glider, System Identification Theory, dynamic angles, glider masses identification, buoyancy control, autonomous underwater vehicle.

Development of the underwater glider basing on the model derived from the physical laws can be very complicated in construction. It is required much time to create the model of the trial design. Thus there are alternatives which are less complicated and are not as time consuming. There are original equations [1,2] of the movement of the underwater vehicle which include basic constructions elements of the gliders, buoyancy control, wings, control panel on the surface and line interconnection between the glider and the internal masses drive connection. To create the model of the underwater glider the special method of identification system was developed. Identification system is the well-known method of characteristics compilation based on the experimental data. [3]. These data can be adjusted during the process of parameters creation or modeling. The evaluation of the model is usually based on the way it operates when the trial data are entered.

The information from the model behavior will show the general information about the dynamic system of the glider and its qualities what is very important for the further design of the control system. The development of the control system is founded on the subsystem of ballast which allows the vehicle to move and operates as the input data for the control process. Moreover the ballast subsystem is the buoyancy drive that has the general effect on the dynamic characteristics of the vehicle. Also these data can be used as the input signal. The system output results into the buoyancy or the total shift in the weight of the vehicle during the whole gliding process. Due to this effect the dynamic force of the vehicle can be considered as the gliding angle, depth, velocity components, degree of the pitching angle (trim difference) and the location of the transporting masses inside the vehicle. The main objective of the modeling is to evaluate the efficiency of the ballast subsystem in order to improve the vehicle dynamics and create the optimal model used in the glider control system design.

Kinematics of the vehicle is shown on the Figure 1. Adopted the system of references *i, j* and *k*. Let *i* and *j* inertial conjugate axis which is horizontal and perpendicular to the gravitation accordingly. *k* is the conjugate axis with the direction of the gravity vector and is positively

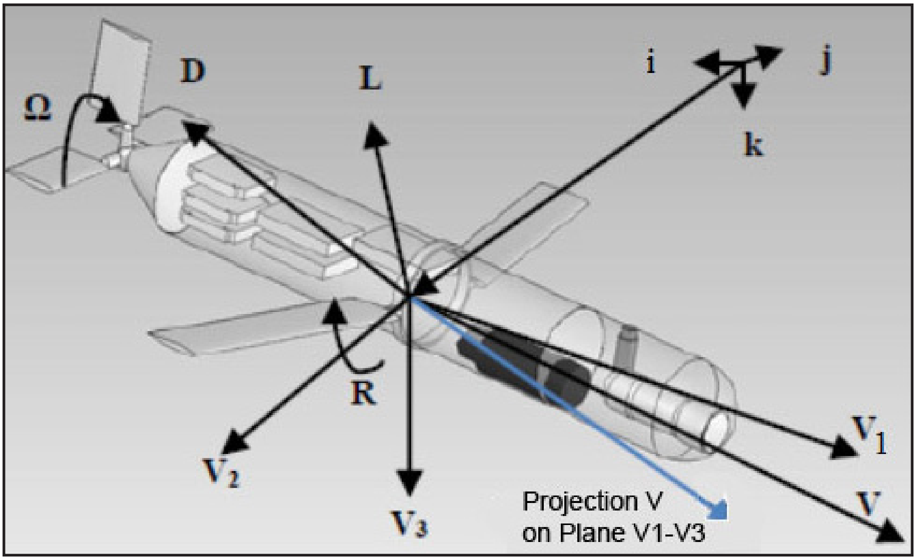

Figure1. The dynamic forces of the glider.

descending. The value of the inertness for $k=0$ coincided with the water surface, in this case k is the depth.

According to the Figure 1 the center of the center reference of the vehicle will be the bouyancy center (BC) and the angle of attack α is the angle between V_1 and the projection V (velocity in the vertical plane) for V_1-V_3 planes with V_2 being the secondary component of the velocity. Sideslip angle (drift) β is defined as the angle between the projection V on the plane V_1-V_3 and V. In the traditional aviation literature the orientation of the air flow reference system to the body reference system is characterized by two dynamic angles; the angle of attack, α and the angle of the sideslip, β. The basic wind reference system is defined by the shift of one axis with the velocity relatively to the body for V.

$$\alpha= tan\text{-}1\ (V_3/V_1)\ u\ \beta= tan\text{-}1(V_2/\ |V|) \qquad (1)$$

According to the Figure 2, in order to control the angle of gliding and velocity the vehicle must force the BC moving the inside masses (loads) and changing the buoyancy.

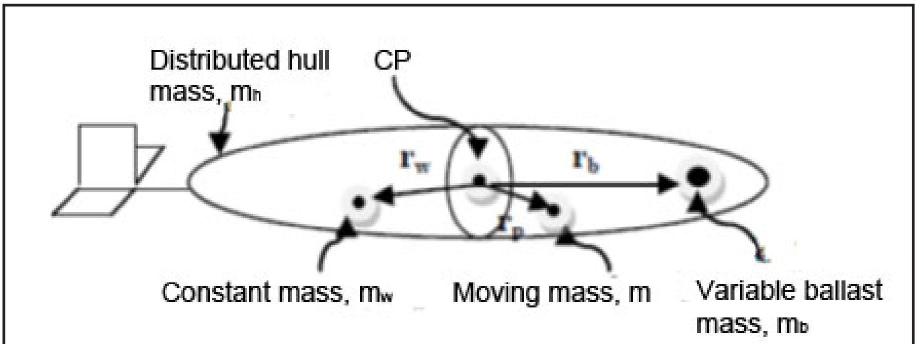

Figure 2. Defining of the underwater glider masses

The total weight of the vehicle or body weight can be defined with the following formula

$$m_v=m_h+ m_w+ m_b+ m \qquad (2)$$

The point mass mw and changing of the ballast weigh are defined by the vector r_w and r_b from the BC for the appropriate masses. Vector

r_p describes the position of the masses m in the system of references connected to the body in the time t. The parameters of the static masses m_w and r_w can be regrouped to identify the time of the trim balance and the list with the help of other point masses. The weight of the liquid ejected by the vehicle will be m. The result buoyancy will be $m_0 = m_v - m$, so the vehicle receives the negative buoyancy if m_0 is positive and the positive buoyancy if m_0 is negative.

Restricting the movements in the vertical plane we can neglect the dynamic influence. In the equations of dynamics the vertical plane can be classified into invariable plane. In the aircraft dynamics the limited longitudinal plane is analyzed which is often used. In many constructions of gliders the separate (individual) algorithms and drive connections are used in the operation during the horizontal and vertical movements. In the simplified model of glider the vertical movement is controlled by the portable loads and ballast of the variable mass during the vertical movements without side (diametrical) movements due to the use of the fixed tail vane in order to plan particularly vertical movements. Thus we can come to the conclusion that all side components such as V_2 are equal to zero, for the exception of pitching. Herewith the research on the operation of vertical movements will be of the most importance to control the glider.

Nowadays the model of the underwater glider is developed in order to research the mechanism of buoyancy control and dynamics of the vehicle movements. The experiments will take place in the shallow waters on the depth not more than 30 meters. The prototype of the vehicle will be tested on reliability to achieve the linear motion. The form (profile) of the model will be round and cylindrical identical to the experimental one. The form is determined by the vehicle reluctance to the hydraulic pressure.

Intensity of the ballast changes is the source of input data for the imitation of system control and the depth, pitch attitude and the resulted buoyancy are the output data. More over it is very important to understand the principal of the buoyancy in actual practice. Thus the simulation during the surfacing and immersion is the same. So the control impact changes from outthrust to filling (retraction) of the ballast system.

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