WARTA ARDHIA
Jurnal Perhubungan Udara

The Hydroplaning Flight Performance Simulation and Verfication of a Flying Boat Remote Control Model

Simulasi dan Verifikasi Prestasi Terbang Model Remote Control Flying Boat Saat Hidroplaning

Sayuti Syamsuar
Pusat Teknologi Industri dan Sistem Transportasi, Badan Pengkajian dan Penerapan Teknologi (BPPT)
email: sayuti.syamsuar@bppt.go.id

INFO ARTIKEL

Histori Artikel:
Diterima: 11 Januari 2016
Direvisi: 10 Februari 2016
Disetujui: 29 Maret 2016

***Keywords*:**
flying boat remote control model, simulation, hydro.

Kata kunci:
remote control (RC) model flying boat **,** simulasi, hydro

ABSTRACT / ABSTRAK

The Wing in Surface Effect Aircraft A2B type B with Lippisch configuration has higher hydrodynamics drag compared to engine powered aircraft during hydroplaning. This paper explains parts of analysis in aircraft design to identify the aerodynamics and hydrodynamics characteristics of flying boat remote control model during hydroplaning phase. At first, flying boat model was three-dimensional photographed using laser camera in order to produce solid drawing for CATIA program. The three-dimensional model, later, analyzed by using CFx software in AnSys program. The wing planform has dihedral angle while the airfoil used is NACA 23012. The aerodynamics and hydrodynamics characteristics of this three-dimensional model is represented for alpha = 0^0. Whilst the speed used in simulation was 0 to 25 knots. In verifying the data of the simulation results, the Unmanned Aerial Vehicle (UAV) "Alap-alap" flight test data was used in which it has the same T/W ratio for the pitch angle, acceleration in Z body axis, altitude, and speed. The aerodynamics lift in Z axis of flying boat model during simulation is proportional to the aerodynamics lift in Z axis of UAV "Alap-alap" during take-off.

Pesawat *Wing In Surface Effect* A2B tipe B *konfigurasi Lippisch* mempunyai hambatan air yang cukup besar dibandingkan tenaga mesin saat *hydroplaning*. Makalah ini berisikan bagian dari analisis dalam perancangan untuk mengetahui karakteristik aerodinamika dan hidrodinamika dari remote control model jenis *Flying Boat* pada fase *hydroplaning*. Pada awalnya, dilakukan pemotretan 3 D terhadap pesawat model *Flying Boat* menggunakan kamera laser untuk menghasilkan *solid drawing* pada program CATIA. Model 3 D dianalisis dengan menggunakan piranti lunak CFx pada program AnSys. *Planform* sayap, memiliki dihedral dan menggunakan *airfoil* jenis NACA 23012. Karakteristik aerodinamika dan hidrodinamika untuk model 3 D dipresentasikan pada posisi sudut alpha =0^0. Sedangkan kecepatan yang digunakan adalah 0–25 *knots*. Untuk memverifikasi data hasil simulasi, digunakan data uji terbang pesawat udara tanpa awak "Alap-alap" yang mempunyai T/W rasio yang sama, yaitu sudut pitch, kecepatan arah sumbu Z pada sumbu benda, ketinggian dan kecepatan. Gaya angkat aerodimaka arah sumbu Z pada simulasi RC model Flying Boat sebanding dengan gaya angkat aerodinamika arah sumbu Z pada UAV "Alap-alap" saat *take off*.

INTRODUCTION

The background of this research came from the problem of the aerodynamics lift and hydrodynamics resistance against a the power of the Wing in Surface Effect (WISE) craft A2B prototype B type. The power were not enough to counter the hump drag (water resistance) of craft during high speed hydroplaning. The flight performance requirements of the WISE craft due to the drag forces interaction between hull, pontoons, reverse delta wing, weight acting on the center of gravity, c.g position during hydro planing have been calculated in the research [9]. The thrust measurement, weight and balance measurement of the second prototype of the WISE craft A2C B type with a 4,300.0 Newton Maximum Take off Weight (= MTOW) and a 115.0 HP power have been analyzed [9].

The Thrust per Weight (= T/W) ratio is around 0.4. The step position calculation is implemented on the RC model Flying Boat C type [9]. The simulation of the numerical analysis had been carried out on the full configuration 3 D configuration of the Flying Boat remote control model. The hydroplaning speed range between 0 to 25 knots gives the aero and hydrodynamics characteristics of the full configuration model. The MTOW is 260.0 Newton.

LITERATURE REVIEW

At the present time WISE craft is poised between success and failure. Wing In Surface Effect craft is not experiencing a high level of activities in the 1960-80's, but there is still a low level of activities underway worldwide which proceeds with mixed successes. Those projects of note are [1]:

- Aquaglide, Russia, by ATTK which recently exhibited their 5-seat craft at ILA 2006, Berlin. The Amphibius Type A is shown in Figure 1 [1].

Figure 1. Aqua glide, Russia (Source: Benson, T, 2005)

- The Korean Ocean Research and Development Institute (KORDI) multi-million dollar funded development program to create high speed WISE craft based transport/logistics sea network in Korea is shown in Figure 2 [1].

The surface effect on the upper of water surface comes from the wing tip vortex where the vortices are blocked by the ground phenomenon. The effect is analyzed by using CFX ANSYS Computational Fluid Dynamics (CFD) [11]. The basic concepts of Hydrodynamics are relations between Fluid Particles, theoretical approach and definition of an Elementary Particle of fluid [7].

Figure 2. C type prototype Korean versions. (Source: Benson, T, 2005)

Figure 3 is the hump drag curve of the Hoverwing compared to the conventional WISE craft. The internal research for this is carried out by Jamaluddin, A [5].

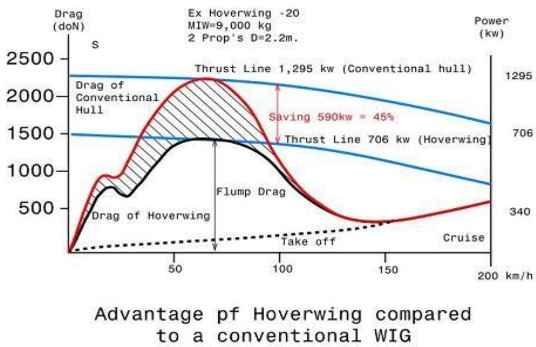

Figure 3. The hump drag versus speed during hydroplaning and take off. (Collu, M et. al, 2007)

The aerodynamic lift on the wing of WISE craft will be increases instead of the speeds, and the hump drag will be minimize. The craft will be liftoff and airborne in liftoff speed, V_{LOF} at 150 km/h.

The Flying Boat Remote Control Model

The Flying Boat remote control model has been developed to verify the adaptive control system during ground effect altitude connecting to the elevator, δ_e control surfaces deflection on the longitudinal mode [10]. The CFD analysis is focused to show the vortex flow visualization on the wing tip. The T/W ratio is around 0.4 became from experience [9]. The step position calculation of WISE craft is implemented on the Flying Boat remote control model design.

The engine power used on the Flying Boat remote control model is around 5.5 HP with MTOW = 260.0 Newton [5]. The wing of the Flying Boat remote control model uses NACA 23012, the Horizontal Tail Plane (= HTP) uses the NACA 0010 and the Vertical Tail Plane (= VTP) uses the NACA 0012 on the root and the NACA 0010 on the upper. The new NACA 23012 airfoil produces a reasonably high maximum lift and a low profile drag, which results in an unusual high value of the speed-range index. In addition, the pitching-moment coefficient is very small. In other hand, this airfoil configuration is useful for Short Take off and Landing capability [2], [3], [6] and [8].

The objective of this research is to verify the Flying Boat remote control model simulation data with the Unmanned Aerial Vehicle (=UAV) “Alap alap” flight test during take off. The aircraft performance verification of Surface Effect craft is based on the flight performance criteria namely the T/W ratio. The Aspect Ratio of PUNA “Alap-alap” is 10.0.

The Aspect Ratio of RC model Flying Boat is around 5.0 and UAV “Alap-alap” is 10.0. The configuration and the aspect ratio of Flying Boat remote control model and the UAV “Alap-alap” are shown in Figure 4.

The aerodynamics and hydrodynamics problems on the full configuration model were solved by using CFD.

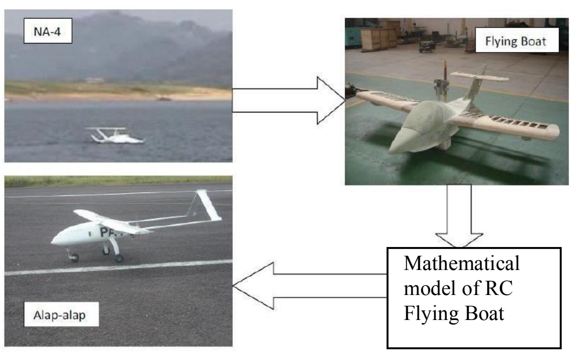

Figure 4. The Flying Boat remote control model and Unmanned Aerial Vehicle “Alap alap” (Source: S. Syamsuar, 2015)

METHODOLOGY

The equilibrium relationships of the hydrodynamics, aerodynamics and the equilibrium relations of forces and moments must all be used on the formula.

The hump drag during hydro planing on the water surface for Flying Boat remote control model simulation more then the rolling friction, μ during take off of the Unmanned Aerial Vehicle “Alap-alap”.

The hypothesis of the research about the same T/W ratio between 2 (two) aircraft are giving the similar flight performance results.

The drawing Process

The three dimension of HTP and hull of the Flying Boat remote control model have been measured by using the laser photo camera and then processed it in the computer. This drawing were transferred to CATIA software. The Figure 5 shows the photo camera laser tracking process of HTP. The laser stickers are template around the surfaces areal. Every stickers made the electromagnetic wave reflected to the laser camera. The computer analyzed the spectrum from the laser camera that made the three dimensions drawing. Figure 6 shows the fuselage or hull.

Figure 5. Laser photos tracking on HTP.

Figure 6. Laser camera photos tracking on the fuselage of RC model Flying Boat.

RESULTS AND DISCUSSION

The meshing and the lifting forces of the full configuration were calculated by CFD software. This program took so much time for computation from meshing as input data to the results. These CFD results are then compared to the references. The water line is 10 cm. Figure 7 shows the model geometry with α = 5^0 without towing tank [10].

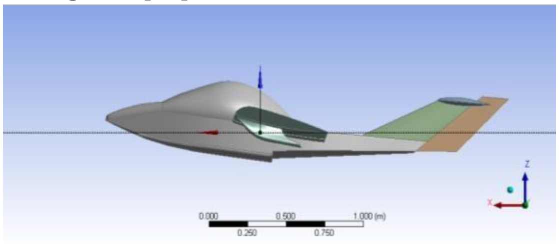

Figure 7. Model geometry with α = 5^0 without towing tank.

The Figure 8 shows the geometry of Flying Boat remote control model on the towing tank.

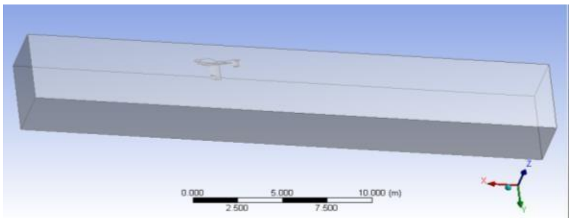

Figure 8. The Flying Boat remote control model on the towing tank.

Figure 9 shows the meshing process of the Flying Boat remote control model with α = 5^0 [10]. This figure presents also the ground effect characteristics of Flying Boat remote control model.

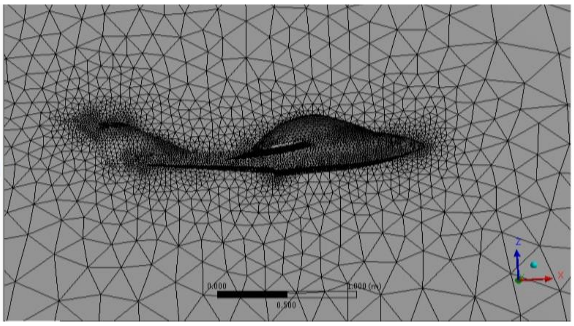

Figure 9. Meshing of the model with α = 5^0, Airspeed, V = 25.0 knots.

The boundary condition of the Flying Boat remote control model with α = 0^0 and α = 5^0 is shown in Figure 10 [10].

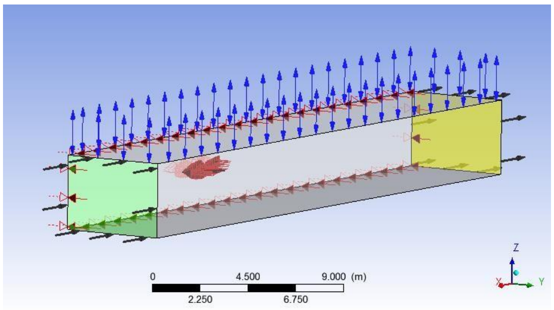

Figure 10. The boundary condition of the remote control model of Flying Boat with α= 0^0 and α = 5^0.

The results are taken from ZX plane at Y offset = 0 m with α = 0^0. The pressure distributions is shown in Figure 11. It shows of pressure distribution result. The bottom of the leading edge has the maximum pressure.

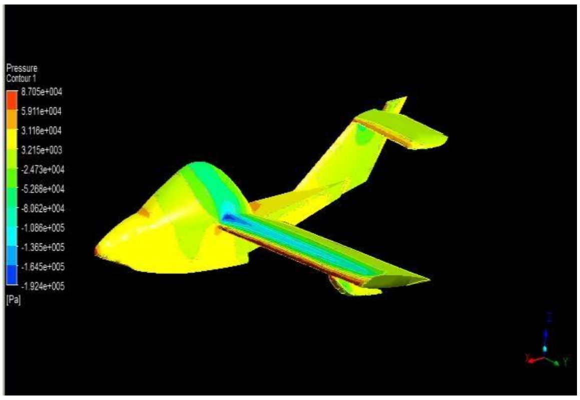

Figure 11. Pressure distribution with α = 0^0, Airspeed, V = 25.0 knots.

The air velocity streamlines is shown in Figure 12. The laws that govern the motion of a fluid element have been established in these results [7].

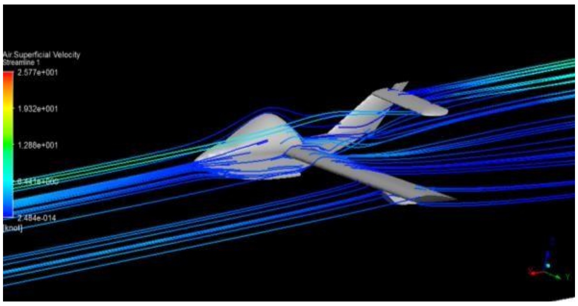

Figure 12. Air velocity streamline with α = 0^0, Airspeed, V = 25.0 knots.

The streamlines from the Air Velocity Streamline indicate no downwash effect on the HTP. The Z force of the lifting surface is shown in Figure 13. The purpose of this results are to establish general relationships from the momentum equations, the first of which gives the balance of forces along a streamline.

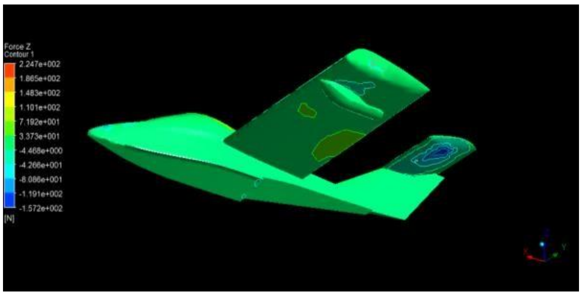

Figure 13. Force Z (lifting) force with α = 0⁰, Airspeed, V = 25.0 knots.

The Thrust (Newton) per Weight (kg) ratio was around 0.4 to build the Flying Boat remote control model. The Z axis, the center of gravity, c.g., and the step positions were made at the angle between $(2 - 10)^0$. The Unmanned Aerial Vehicle "Alap alap" flight testing data during take off at MTOW = 260.0 Newton and power engine = 5.5 HP, such as pitch angle, acceleration in Z body axis (-10.0 m/sec2), altitude$_{CRUISE}$ (550.0 feet) and True Airspeed$_{CRUISE}$ (60.0 knots) are shown in Figure 14, Figure 15, Figure 16, Figure 17 and Figure 18. The ground roll phase are starting from t = 2,840.0 second to t = 2,860.0 second.

Figure 14. The ground roll phase during take off of Unmanned Aerial Vehicle "Alap-alap".

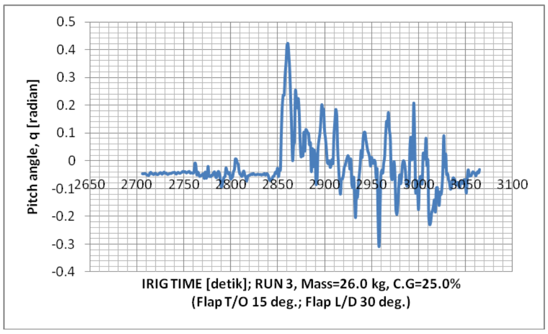

Figure 15. The Pitch Angle, θ of Unmanned Aerial Vehicle "Alap alap" flight testing data during take off.

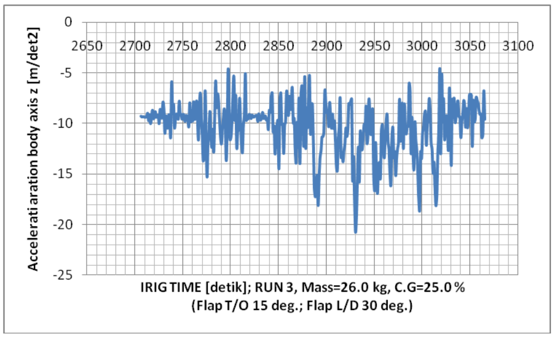

Figure 16. The Acceleration in Z body axis, a_z of The Unmanned Aerial Vehicle "Alapalap" flight testing data during take off.

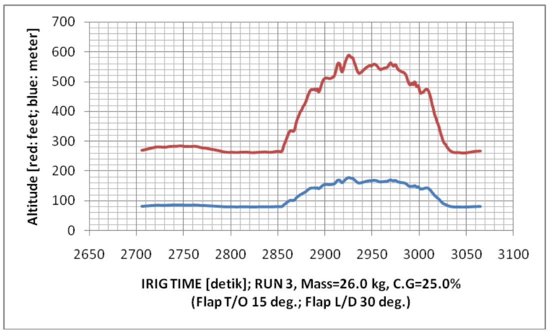

Figure 17. The Altitude of the Unmanned Aerial Vehicle "Alap alap" flight testing data during take off.

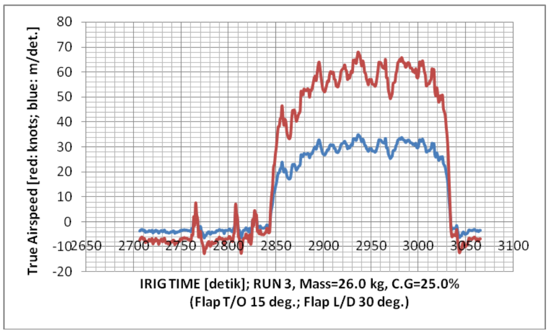

Figure 18. The True Airspeed flight testing d of the Unmanned Aerial Vehicle "Alap alap during take off

CONCLUSIONS

The CFD simulation and the verification on the full configuration of the Flying Boat remote control model with original NACA 23012 airfoil results in several conclusions:

The aerodynamics and hydrodynamics characteristics during hydroplaning in speed between 0.0 to 25.0 knots with T/W ratio is around 0.4 has been simulated by using CFx AnSys.

The Flying Boat remote control model is able to take off in stable conditions which is performed by time histories (t) of Unmanned Aerial Vehicle "Alap alap" during take off as indicated by Figure 15.

Hump drag during hydroplaning is 40 % higher then the take off run drag of the cruise phase.

The run time histories (t) take off phase of the UAV “Alap-alap” is 20.0 second.

The Z aerodynamic lift of RC model Flying Boat (= 224.7 Newton) is proportional with the model weight. The vertical aerodynamic force in body axis of the UAV “Alap-alap” during take off is 260.0 Newton.

The Flying Boat remote control model simulation during hydroplaning is approved by UAV “Alap-alap” take off flight testing data.

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