Aerodynamics characteristics of glider GL-1 based on computational fluid dynamics

E Amalia*, M A Moelyadi, R Julistina, C A Putra

Faculty of Mechanical and Aerospace Engineering, Institute of Technology Bandung, Jl. Ganesha 10 Bandung 40132, Indonesia

*ema@ftmd.itb.ac.id

Abstract. Glider GL-1 was especially designed for thermal updraft condition of Indonesia. The development of GL-1 is the first in Indonesia to design a glider for aero sport purpose in cooperation with FASI. This glider needs a minimum aerodynamics efficiency of 8.333 to meet design requirement derived from thermal updraft condition, which needs rate of descent little than 3 m/s at gliding angle of 2 degree. Optimum flight condition for maximum range performance has been calculated to be 25 m/s at a condition of altitude between 300 – 2000 m with Reynolds number of 1 – 1.5 million. Computational Fluid Dynamics (CFD) was employed to do numerical analyses to predict aerodynamics characteristics of the glider. CFD by using half-glider meshing results maximum lift coefficient of 1.326 at angle of attack of 8 degree, and maximum aerodynamics efficiency of 19 at angle of attack 2 degree. The result of CFD by using full-glider meshing gives maximum lift coefficient of 1.2556 at angle of attack 10 degree and maximum aerodynamics efficiency of 16 at angle of attack of 2 degree. Both of half-glider meshing and full-glider meshing are employing k-ε turbulence model. Comparison with preliminary design result and benchmarking with similar gliders data was also done.

1. Introduction

FASI or Indonesian Aero Sport Federation is a house of aero sport activities in Indonesia. Its activities are including aeromodelling, motorized flight, parachuting, hang gliding, micro-light flight, and sailplaning/gliding. According to [1], recently, animo to aero sport in Indonesia, specifically gliding is very big. This conclusion comes from interview result with practitioner of aero sport of FASI. However, there is a limitation in glider that can fly well in thermal updraft condition of Indonesia. In FASI, only the glider of Schweizer SGS 1-26 that serve gliding activity frequently. The SGS 1-26 was manufactured by Schweizer Aircraft Company, United States and was designed on 1950’s. Because SGS 1-26 is relatively old, it has low performance. That is why the gliding achievement of Indonesia remains only in national level. A newer glider available in FASI is ASW 20 which was manufactured by Schleicher Centrair, Germany. The ASW 20 is rarely flown in FASI because its performance is not good in thermal updraft condition of Indonesia which is narrow and weak. It was said that most of the thermal updraft in Indonesia has 0.5 – 3 m/s vertical speed, with about 200 – 300 m in diameter and about 5000 – 6000 feet maximum height. With situation explained above, there is a strong need to design and manufacture a national glider of Indonesia for aero sport activity in Indonesia to achieve better achievement in aerosport competition.

The effort to design a national glider was conducted and is still under progress. The national glider of Indonesia named GL-1 is a glider that has configuration like a conventional low speed aircraft. It
has a high wing and a T-tail and only one payload, i.e. the pilot. With the range of pilot’s weight of 70 to 110 kg, it will make a movement of the center of gravity of 9 centimetres. The wing of GL-1 has a high aspect ratio and tapers in near-tip wing portion. Figure 1 shows the three-view drawing of glider GL-1 and table 1 gives the data of glider GL-1. “Gajah Layang” GL-01 is the previous name of glider GL-1. In this paper, the name of glider GL-1 is used. More information about glider GL-1 is available in reference [1] and this following website: https://glidernasionalgl1.wordpress.com.

From the characteristic of Indonesia’s thermal updraft condition, design requirement of a national glider GL-1 is derived as can be found in detailed in reference [1]. It should have maximum rate of descent of 3 m/s and maximum turning radius of 150 m. This requirement leads to a minimum aerodynamics efficiency of 8.333 for a condition of maximum rate of descent of 3 m/s for non optimum flight as calculated with method from reference [2]. Moreover, in reference [1], [3], and [4], some preliminary calculation of performance of glider GL-1 has been done for optimum flight derived from condition of thermal updraft of Indonesia as mentioned above. The optimum flight condition is for maximum range with maximum aerodynamics efficiency (\(C_l/C_D\)) and for maximum endurance with minimum rate of descent. Based on the national aeroport competition’s rule, for maximum range flight condition, we took the rule for short flight, which is the release altitude is 1000-2000 ft with a condition of ready to landing when in an altitude of 500 ft. So, we took a release height for GL-1 to fly which is within 1500 ft and using gliding symmetric flight method in reference [2]. As for maximum endurance flight condition, we took the rule for endurance with a release height for GL-1 to fly which is within 1500 ft with using thermal updraft as much as possible. So, for maximum endurance flight condition, we used cross country flight method in reference [2]. In calculating the endurance, we used an average value of thermal updraft vertical speed of 1.75 m/s. Some performance prediction of GL-1 for optimum flight condition of maximum range and maximum endurance are as listed in table 2. In this paper, we only concern with the flight condition of maximum range to be analyzed by CFD because there is still a big difference between the result of reference [1], [3], and [4] as can be seen in table 2.

The preliminary aerodynamics characteristic as appears in table 2 column 2, which is based on reference [1], has been calculated by using DATCOM, that is mainly based on empirical data. Because DATCOM has a limitation of making centered drag-polar only, an effort to construct uncentered drag polar has been carried out as presented in reference [3] and [4] and used to produce performance prediction in table 2 column 3. DATCOM is still used in preliminary design phase as a quick estimation although the result is different with the result of the more accurate method, as can be seen in reference [5] and [6]. In reference [5], it gives pessimistic result compared to other method and shifting in \(C_l\) curve. While in reference [6], different gradient of \(C_l\) curve was predicted. However, the result of DATCOM is still worthwhile to be included because for evaluation of drag polar it gives reasonable agreement with other methods as could be seen in [5] and [6].

Because now glider GL-1 has reached detail design phase, more thorough aerodynamic characteristics evaluation is needed. Main objective of this study is to use CFD (Computational Fluid Dynamics) as a tool to predict aerodynamic characteristic of the glider, especially to reach maximum flight range with a flight velocity of 25 m/s, which is close enough to the predicted value in reference [1] as in table 2, which is 24.3 m/s. We recalculate again the value of velocity by using slightly different flight condition in this detail design phase. In doing CFD simulation in this study, we use two different meshing configurations, i.e. half-glider and full-glider meshing with the same k-\(\varepsilon\) turbulence model. Then, the other objectives are to compare the result of current study by of CFD with the result of preliminary design done in reference [1], [3], [4] and [7], and doing benchmarking by comparing with the data of existing gliders.
Figure 1. Three view drawing of glider GL-1 [1].

Table 1. Data of glider GL-1 [1].

| Wing                  | Vertical Tail          | Horizontal Tail         |
|----------------------|------------------------|-------------------------|
| Area (m$^2$)         | 0.827                  | Area (m$^2$)            |
| AR                   | 2                      | AR                      |
| b (m)                | 1.286                  | b (m)                   |
| Root Chord1 (m)      | 4.302                  | Arm (m)                 |
| Root Chord2 (m)      | 1.357                  | Taper Ratio             |
| Tip Chord (m)        | 0.857                  | Croot (m)               |
| MAC (m)              | 0.428                  | Ctip (m)                |
| Taper Ratio          | 0.5                    | MAC (m)                 |
| Taper Ratio Outer    | 0.7                    | LE_swept ($^\circ$)     |
| Leading Edge         | 0.5                    | 6.4                     |
| Swept (Outer Wing)   | 3                      |                         |
| Dihedral (degree)    | -3                     |                         |
| Twist (degree)       |                        |                         |
Table 2. Performance prediction of GL-1 from preliminary design in brief.

|                              | With Data of Reference [1] | With data of Reference [3] and [4] |
|------------------------------|-----------------------------|-----------------------------------|
| **In Maximum Range**         |                             |                                   |
| Condition:                   |                             |                                   |
| (CL/CD)max                   | 24                          | 30                                |
| CL                           | 1.18                        | 0.8                               |
| CD                           | 0.048                       | 0.027                             |
| Gliding angle (degree)       | 3.0                         | 1.8                               |
| V (m/s)                      | 24.3                        | 22                                |
| t (minute)                   | 7.5                         | 10.4                              |
| Maximum Range (km)           | 11.0                        | 13.7                              |
| **In Maximum Endurance**     |                             |                                   |
| Condition:                   |                             |                                   |
| (RD)min (m/s)                | 0.76                        | 0.66                              |
| Gliding angle (degree)       | 2.1                         | 2.15                              |
| V (m/s)                      | 18.5                        | 17.5                              |
| Vaverage (m/s)               | 12.9                        | 12.7                              |
| Range (km)                   | 11.1                        | 12.1                              |
| Maximum Endurance (minute)   | 14.4                        | 15.9                              |

2. Theory

In this study, derived from flight condition of glider GL-1 at maximum flight range as appeared in reference [1], [3], and [4] and also discussed in section 1, we deal with a flow with Reynolds number between 1 million to 1.5 million and the velocity of 25 m/s. It falls into category of high Reynolds number where turbulence occurs. In this kind of flow, the inertia forces in the fluid become significant compared to viscous forces. This study is an applied CFD one, so that we used treatment of such kind flow in an existing code, ANSYS CFX. For a flow with turbulence, the code provides evaluation method by using turbulence models, which consist of statistical turbulence model, large eddy simulation, and detached eddy simulation. In this study, we chose statistical turbulence model, which is k-ε turbulence model. It is a “two-equation turbulence model” which has the advantage of good compromise between accuracy and numerical effort. In this type of turbulence models, velocity and length scale are treated by using separate transport equations (hence the term “two-equation”). In this section we briefly cover about the theory that underlying k-ε turbulence models which was taken from reference [8] and [9].

Statistical turbulence model is based on the principle of modifying original unsteady Navier-Stokes equation into average and fluctuating quantities to produce RANS (Reynolds Average Navier-Stokes) equation. It consists of mean flow quantity only, and modelling turbulence effect without the needs for resolution of turbulence fluctuation. Statistical averaging procedure was employed to get RANS equation. However, this averaging process introduces additional unknown terms containing products of fluctuating quantities, which acts like additional stresses in fluid. This stress is called “Reynolds” or “turbulent” stress, which is difficult to determine and becomes a new unknown. Reynolds stress should be modelled by additional equation with known quantities so that the equation could reach “closure”. The equations used to close the system of equation determine the type of turbulence models.

RANS equation is as appeared in equation (1) and (2). Here τ is the molecular stress and ρ\( \overline{uu}_i \) is the Reynolds stresses. For k-ε turbulence models that is used in this study, we introduces two new variables into the system of equation. Based on the eddy viscosity principle, the continuity equation is still the same with equation (1), but the momentum equation becomes equation (3).
\[
\frac{\partial p}{\partial t} + \frac{\partial}{\partial x_j} (\rho U_j) = 0
\]  
\tag{1}

\[
\frac{\partial \rho U_i}{\partial t} + \frac{\partial}{\partial x_j} (\rho U_i U_j) = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j} (\tau_{ij} - \rho \bar{u}_i \bar{u}_j) + S_M
\]  
\tag{2}

\[
\frac{\partial \rho U_i}{\partial t} + \frac{\partial}{\partial x_j} (\rho U_i U_j) = -\frac{\partial p'}{\partial x_i} + \frac{\partial}{\partial x_j} \left( \mu_{eff} \left( \frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i} \right) \right) + S_M
\]  
\tag{3}

Where \( S_M \) is the sum of body forces, \( \mu_{eff} \) is the effective viscosity by including turbulence defined by equation (4), and \( p' \) is the modified pressure of which the definition is shown in equation (5). The last term of equation (5) is neglected in ANSYS-CFX.

\[
\mu_{eff} = \mu + \mu_t
\]  
\tag{4}

\[
p' = p + \frac{2}{3} \rho k + \frac{2}{3} \mu_{eff} \frac{\partial U_k}{\partial x_k}
\]  
\tag{5}

Parameters employed to construct two equations used for the system to reach “closure” are discussed briefly in sub-section 2.1 for k-\( \varepsilon \) turbulence models used in this study.

2.1. k-\( \varepsilon \) turbulence model

For reaching the closure, k-\( \varepsilon \) turbulence model use the gradient diffusion hypothesis to relate the Reynolds stresses to the mean velocity gradients and the turbulent viscosity. The turbulent viscosity is modelled as the product of a turbulent velocity and turbulent length scales. The turbulent velocity scale is computed from the turbulent kinetic energy, which is provided from the solution of its transport equation. The turbulent length scale is estimated from two properties of the turbulence field, usually the turbulent kinetic energy and its dissipation rate. The dissipation rate of the turbulent kinetic energy is provided from the solution of its transport equation. The k-\( \varepsilon \) turbulence model relates turbulent viscosity to turbulent kinetic energy and dissipation rate with equation (6). In this study, we use default k-\( \varepsilon \) turbulence model provided by ANSYS-CFX solver.

\[
\mu_t = C_{\mu} \rho \frac{k^2}{\varepsilon}
\]  
\tag{6}

3. Methodology

This study is a continuation of CFD study of wing of glider GL-1 which part of its results was published in reference [7]. Wing of glider GL-1 has lift coefficient of 0.7498 with total lift of 3,258.34 N at zero angle of attack. Methodology of this study is as shown in figure 2 and will be explained in this section.

Step 1 in figure 2 is to fetch geometry of glider GL-1 in IGES from CATIA or SolidWork. Figure 3 shows the geometry we use in this study. Step 2 in figure 2 is geometry repairing for meshing. Original geometry file often has some gaps that needs to be fixed so that the geometry is smooth and continuous to apply meshing on it.
Figure 2. Methodology used in this study.
Figure 3. The geometry of glider GL-1 as an input.

Figure 4. Computational domain for meshing in Step 3 of figure 2.

Figure 5. Unstructured grid on the surface of glider GL-1 by using half-glider model.
As stated in step 3 on figure 2, meshing process in this step is using half glider by applying plane of symmetry, so that computational domain is such as in figure 4 and unstructured grid on the surface of the glider is as illustrated in figure 5. Total mesh by using half-glider meshing is about 2 million elements.

Step 4 in figure 2 is employing ANSYS-CFX as a solver for CFD analysis. The governing equation is RANS with k-ε turbulence model as explained in section 2. Free stream velocity is 25 m/s. The boundary condition is the inlet at the front, outlet at the back, symmetry at the left, and pressure far-field at the right, top, and bottom, as shown by figure 4. The convergence criterion to achieve is $10^{-4}$. Numerical simulation was carried out at angle of attack -6 to 12 degree with an increment of 2 degree. Results of step 4 and 5 of figure 2 is discussed in section 4.

Since there is a discrepancy between the result of CFD by using half-glider meshing and the result from preliminary design as in reference [1], [3], and [4] and also there is a plan to do CFD simulation with side slip and rudder deflection as suggested in reference [10], a CFD simulation by using full-glider model of meshing was designed. Step 6 of figure 2 is mesh building by using full-glider model constructed from geometry drawing as illustrated in figure 3. Figure 6 shows computational domain used in step 6, and figure 7 gives an illustration of unstructured grid result. The unstructured grid with full glider consists of about 6 million elements.

![Figure 6. Computational domain used in step 6 of figure 2.](image)

Step 7 in figure 2 is to carry out numerical simulation for full glider mesh as shown in figure 7 for angle of attacks of 0, 2, 4, 8, 10, and 12 degree. We employed k-ε turbulence model. We used the same velocity of 25 m/s. In step 8 of figure 2, the results was compared with to preliminary design result and half-glider result. In step 9, result of current study will be compared to CFD result of existing gliders or benchmarking. Results of step 7, 8, and 9 of figure 2 are discussed in section 4.
Figure 7. Unstructured grid used in step 6 of figure 2.

4. Result and Discussion
In this section, we present the results of this study or step 4, 5, 7, 8, and 9 in figure 2. First, from step 4 and 5, we get the result of numerical simulation compared to preliminary design result computed by DATCOM of reference [1] and [7] as shown in figure 8 for lift coefficient. Then we compare the result of half-glider simulation with preliminary design of reference [1], [3], and [4] for drag polar and aerodynamics efficiency as shown in figure 9 and 10. Because reference [3] and [4] is a reversed engineering result, we cannot get the data of $C_L$ versus angle of attack, $\alpha$, so we do not compare it in figure 8.

From figure 8, we see that the result of CFD with half glider meshing has a good agreement with the result of CFD for glider wing from reference [7], i.e. the value of $C_L$ at 0 degree of angle of attack is below the one of CFD for wing of the glider. This judgement is true for an aircraft with conventional configuration as the glider GL-1 as shown in figure 1 and 3 according to reference [11]. However, for angle of attack higher than 2 degrees, $C_L$ from half-glider meshing does not follow this
rule of thumb as can be seen in figure 8. Moreover, the result of $C_L$ from CFD by using half-glider meshing is pessimistic compared to the DATCOM result of reference [1]. Result in reference [5] is similar; there is a shifting in $C_L$ curve. In this reference, results of $C_L$ from MSES and XFOIL are optimistic compared to DATCOM. This discrepancy could be from the fact that DATCOM uses empirical method based on many aircraft database, and DATCOM does not include database for low speed aircraft yet as indicated in reference [6].

In figure 9, we compare drag polar of current study of CFD by using half-glider meshing with drag polar of GL-1 from DATCOM of reference [1], drag polar that is reversed-engineered from flight manual data as presented in reference [3] and [4], and result of CFD wing from reference [7]. We can see in figure 9 that result of DATCOM of reference [1] and result of current study by using half-glider meshing is pessimistic, resulting in higher $C_D$ for the same $C_L$ if we compared to the result of reversed-engineering of reference [3] and [4]. We can also see that part of result of DATCOM is close to the result of CFD wing of reference [7]. A similar partially good agreement in drag polar with DATCOM result is also found in reference [5] and [6], which make DATCOM result is still worthwhile to use. Furthermore, because the result of reference [3] and [4] based on actual gliders, we trust the result of $C_D$ of the reversed-engineering more. Therefore, we can conclude that half-glider meshing results a partially good prediction of $C_L$ and need further improvement in the prediction of $C_D$.

![Lift Coefficient Comparison](image)

**Figure 8.** Lift coefficient comparison of half-glider meshing with preliminary design result.
**Figure 9.** Drag polar comparison of half-glider meshing with preliminary design result.

**Figure 10.** Aerodynamics efficiency comparison of half-glider meshing and preliminary design result.
As for aerodynamics efficiency comparison, it is shown in figure 10. We can see that because of the prediction of $C_D$ that still need an improvement as discussed in previous paragraph, prediction of aerodynamics efficiency by employing half-glider meshing of current study gives a lower value of 19 compared to preliminary design results of reference [1], [3], [4], and [7] which is 24 or 30. However, it is still bigger than minimum aerodynamics efficiency of design requirement which is 8.333 for the range of AOA 0 to 5 degree (which corresponds to $C_L$ of 0.7 to 1.2) where the GL-1 will fly.

From the result of CFD by using half-glider meshing, we see a need to improve CFD model in order to get a better prediction of $C_L$ and especially $C_D$. We get a partially good prediction for $C_L$ with judgement from reference [11]. Besides that, we notice that in reference [10] and [12], CFD analyses of gliders were carried out in full-glider meshing because aerodynamics characteristic prediction will be conducted for non-symmetric condition involving control surface such as rudder in further study. Therefore, we decided to use full-glider meshing too to continue this study as illustrated in step 6 to 9 in figure 2 and discussed in section 3. We employ unstructured meshing as illustrated in figure 7.

First, we present the result of step 8 of figure 2 which is a comparison of full-glider meshing with preliminary design result of reference [1], [3], [4], result of CFD wing which partly presented in reference [7], and half-glider meshing result as can be seen in figure 11 for lift coefficient. We can briefly say that we do comparison of current study of full-glider meshing with preliminary design result in step 8. In figure 11, we can see that the prediction of $C_L$ from full-glider meshing is better than from half-glider meshing, which is $C_L$ of aircraft is lower than $C_L$ of its wing. Although it is pessimistic compared to DATCOM result, because of DATCOM has not included database of low-speed aircraft as indicated in reference [6], we more believe the result of CFD by using full-glider meshing. Then, the problem of predicting $C_L$ has been solved by using full-glider meshing.

![Lift Coefficient Comparison](image_url)

**Figure 11.** Lift coefficient comparison of full-glider meshing with preliminary design result.
**Figure 12.** Drag polar comparison of full-glider meshing with preliminary design result.

**Figure 13.** Aerodynamics efficiency comparison of full-glider meshing with preliminary design result.
In figure 12, we added comparison with reference [3] and [4]. We cannot do comparison of variation of lift coefficient with angle of attack in figure 11, because reference [3] and [4] do not provide this data. From figure 12, we can see that the result of full-glider meshing gives similar result with half-glider meshing (see figure 9), which is it predicts higher $C_D$ for the same $C_L$. To correct this, more grid close to the surface of glider GL-1 is needed, so that the total grid will be more than 9 million. This effort is still in progress because of problem in computer capability that available in this study. We are improving the computer capability so that we hope in a near future, we will improve prediction of $C_D$.

While for aerodynamics efficiency, since the lift coefficient and drag polar prediction such as discussed previously shows lower aerodynamic efficiency of 16 compared to half-glider meshing (19) and preliminary design results (24 or 30) as shown in figure 13. However, it has fulfilled minimum aerodynamic efficiency of design requirement of 8.33 for angle of attack 0 to 5 degree (which correspond to $C_L$ of 0.65 to 1.05) where glider GL-1 will fly. If we succeed in improving prediction of $C_D$ by improving mesh near to the surface of glider GL-1 as described in previous paragraph, we will get better aerodynamics efficiency.

From step 8 in figure 2, we can conclude that full-glider meshing gives good result in predicting $C_L$ compared to half-glider meshing and still need further improvement in predicting $C_D$. To validate this result, we did step 9 which is benchmarking with data of other existing gliders. Here we will use CFD result of glider V5-Rondone from reference [12], real data of glider PW-5 Smyk from reference [13], and flight test result of glider GROB G-103 from reference [14]. Figure 14 gives an illustration of configuration of these gliders. We can see that all of them have conventional configuration with mid-wing and T-tail except PW-5 Smyk that has no T-tail. Table 3 gives a list of some parameters emphasizing that we do benchmarking of glider GL-1 with existing gliders in the same class.

![Picture of PW-5 Smyk](https://en.wikipedia.org/wiki/PW-5)

![Picture of V5-Rondone](Reference [11])

![Picture of GROB 103 Twin II](https://en.wikipedia.org/wiki/Grob_G103a_Twin_Ii)

![Picture of GL-1 of current study](GL-1 of current study)

**Figure 14.** Illustration of configuration of gliders for benchmarking.
Table 3. Some parameters of gliders for benchmarking purpose.

| Glider Name   | Wing Span (m) | Wing Area (m$^2$) | Aspect Ratio | Glider Length (m) |
|---------------|---------------|-------------------|--------------|-------------------|
| PW-5 Smyk     | 13.45         | 10.16             | 17.8         | 6.22              |
| V5-Rondone    | 20            | 11.973            | 33.41        | 7.88              |
| GROB 103 Twin II | 17.5       | 17.8              | 17.1         | 8.18              |
| GL-1          | 14.28         | 12                | 17           | 6.79              |

Figure 15, 16, and 17 shows benchmarking result for lift coefficient, drag polar, and aerodynamics efficiency respectively. In figure 15 for lift coefficient, we cannot include data of PW-5 Smyk because the data provided in reference [13] is the gradient of lift curve only. From figure 15, we could see that the result of half-glider meshing is optimistic compared to V5-Rondone and GROB 103 Twin II. It has been discussed previously that it has been corrected by doing CFD simulation in which a full-glider meshing was employed. Indeed that in figure 15, the result of CFD full-glider meshing agrees well with the result of V5-Rondone and GROB 103 Twin II. So, we can validate that result of CFD by employing full-glider meshing which is good in predicting $C_L$.

![Lift Coefficient Comparison for Benchmarking](image)

Figure 15. Lift coefficient comparison for benchmarking.

Figure 16 gives benchmarking result of drag polar. Here, we have also the result of PW-5 Smyk from reference [13]. From this figure we validated the fact that current study with half-glider meshing and full-glider meshing still needs further improvement in prediction of $C_D$. We can see, that existing gliders in the same class have minimum $C_D$ of 0.015 to 0.02, while half-glider meshing gives minimum $C_D$ of 0.033 and full-glider meshing gives minimum $C_D$ of 0.043. The result of current study is still about twice of $C_D$ value of existing gliders.
Finally yet importantly, figure 17 gives benchmarking result of aerodynamics efficiency. We can see that maximum aerodynamics efficiency for existing gliders is in the value between 25 to 38, while half-glider meshing gives value of 19 and full-glider meshing gives value of 16. This value is a direct effect of prediction of $C_D$ that is still need improvement as discussed above, because the value of $C_L$ is already in the same range with existing gliders.
5. Conclusion

Current study of CFD by employing half-glider meshing gives partially good result for $C_L$ prediction below angle of attack of 4 degree and gives $C_D$ value about twice as the one of the preliminary design result. Half-glider meshing gives maximum aerodynamic efficiency of 19 that still below the target of 24 or 30 from preliminary design, but above minimum aerodynamic efficiency from thermal updraft condition (8.333). Then, the study was continued with doing CFD by employing full-glider meshing, and gives improvement in prediction of $C_L$ compared with preliminary design result. However, CFD with full-glider meshing has not improved the prediction of $C_D$. Full-glider meshing gives maximum aerodynamics efficiency of 16 that still below the target of 24 or 30 from preliminary design, but above minimum aerodynamic efficiency from thermal updraft condition (8.333). This conclusion is validated by benchmarking with existing gliders, which shows that the value of $C_L$ from current study is in the range of the same class gliders but $C_D$ value is about twice as the value of the same class gliders.

Acknowledgments

This study was funded by P3MI research funding of Institute of Technology Bandung. We wish to thank Dr. Taufiq Mulyanto and team of design group for providing data of glider GL-1.

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