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Research paper

A Study on Model Aircraft F1A Glider Glide Performance According to Airfoil

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Abstract

The objective of this study was to investigate the effect of airfoil difference of F1A glider on gliding flight sink rate of model aircraft for improving competition score of F1A glider and providing basic data necessary for the development of model aircraft in Korea. Altitude Reached, set time, and sink rate were measured for a model aircraft of conventional airfoil with a large under camber and low airfoil (LDA) concept aircraft. Model aircraft of airfoil with a large under camber and model aircraft of airfoil with an LDA (low-drag airfoil) concept were constructed. They flew twice each at Osom airfield in Hwasung city, Gyeonggi province, Korea under zero wind condition. After comparing the lift-to-drag ratio of lift coefficient and drag coefficient for the angle of attack, an altimeter was installed in each model aircraft. After each flight, data of each model were analyzed and sink rate with altitude was compared. All data were analyzed using SPSS version 18.0 for Windows. Mean (M) and standard deviation (SD) were calculated. Independent sample t-test was performed to determine inter-group difference. Statistical significance level was set at $p < 0.05$. Results of this study were as follows. First, the optimized lift-to-drag ratio according to angle of attack was obtained through airfoil data analysis. Second, flight altitude and sink rate were determined. Third, through data analyses, a more scientific approach was made possible for competition operation.

Keywords: *Aeromodelling, Aircraft, Glider, Airfoil, Angle of Attack, Sink Rate*

1. Introduction

Model aircraft, a kind of aviation sport, is operated by the pilot operating the model aircraft. It is the most representative of aviation sports with a very fast development in the history of aviation sports worldwide.

Model aircraft plays a role in the backdrop of increasing number of people participating in aviation sports in their leisure time as one characteristic of the modern society which has reached an era of leisure. It has the longest history in aviation sports with many club members (about 100,000 people nationwide). Presidential, Air Force Chief of Staff, and Minister of Land, Transport, and Maritime host competition annually and around 1,000 people attend each competition. It is the most important sporting event in aviation sports fields considering the number of club members and competitors [1].

Model aircraft is defined by the Sporting Code of the Fédération Aéronautique Internationale (FAI) currently used by about 100 countries. The Fédération Aéronautique Internationale (FAI) has 11 CIAM subcommittees, including model aircraft. There are 12 subcommittees in the model aircraft category, including free flying events. It is also made up of national NAC (National Air Sport Controls) [2]. In Korea, NAC is the Federation of Korea Aeronautics (KFA) and the Korea Aero Models Association (KAMA) is an affiliate organization that promotes and encourages this hobby of clubs, supports air experience classes in elementary, junior high, and high schools, organizes and hosts national competitions. Once every two years, national athletes from each sport are selected and given the opportunity to participate in FAI-sponsored world championships [3].

Free Flight category as one of model aircraft categories does not operate externally like RC planes or drones. It is designed to be stabilized by a combination of settings such as flight shape, center of gravity, and attachment angle of main wing and tail wing even when flying becomes unstable due to gusts or rising airflow during flight.

F1A glider category, a free-flying category, was also known as Nordic A / 2 before the Fédération Aéronautique Internationale (FAI) enacted in 1948. It was based on model glider specifications made by Sweden and Finland in the 1940s [4]. As of November 2016, FAI has many athletes and clubs around the world. There are about 600 registered competitors on the ranking that lists only international athletes with good scores.

Although 60 years have passed since the 1951 World Championships in Yugoslavia with various international competitions on the way, restricted regulations of wing area of 32 ~ 34 dm2, weight of 410 g or more, and pull string tension of 5 kg with less than 50 m remain unchanged. Since world championships, various international competitions, and domestic official competitions are conducted in such a manner that the set time after launching the flight body is summed in each round and ranked, it is necessary to ensure high altitude and efficient gliding design with gliding flight before starting gliding flight to obtain good results in the restricted range.

F1A glider flies in a circle to detect ascending airflow during flight. If an ascending air current is detected, the athlete will run to make a departure and the airframe accelerated at high speed is separated from the hook having a tensile strength of 12 kg or more, which is 30 times the minimum airframe weight of 410 g. When the bunt is done, it rises to an altitude of 20 m or more than the tow line length and then starts a gliding flight. Because it is an endurance flight game, it uses airfoil with a large under camber that is hard to see on practical or RC airplanes as it is only pursuing the lowest sink rate when flying. Compared to main wings made of D-BOX structure manufactured by using blast furnace until 1987 (in 1988, the strength of the main wing and horizontal tail wing of the D-BOX structure made of composite material became stronger), the maximum thickness of 9 mm (6%) was developed based on the main wing airfoil prototype 150 mm [5]. Although airfoil with large under camber has the advantage of low sink rate in gliding flight, it has disadvantage in that it does not acquire high altitude due to large drag at the moment of bunting after accelerating in tow flight.

To compensate for the disadvantage of airfoil with a large under camber, world champion Roland Koglot used an airfoil with the concept of LDA (low-drag airfoil) and compared to existing airfoil with a large under camber. The gliding flight starts at an altitude of about 80 m to 110 m after rising from the tow line to 30 m ~ 60 m. It became a necessary condition to win the competition by attaining an altitude through the bunt after a sudden acceleration as athletes participating in each tournament are becoming significantly better.

Although the importance of airfoil has been raised to achieve good results in F1A glider race, there have been few studies using scientific approach. Therefore, the purpose of this study was to investigate the sink rate of gliding flight according to the altitude through pilot flight after constructing airfoil glider with the concept of airfoil and LDA (low-drag airfoil). It will provide basic data necessary to improve F1A glider competition scores. This study aims to improve the competition score of F1A glider by investigating the influence of airfoil difference of glider flight on glide flight rate. Results of this study will provide basic data necessary for the development of model aircraft in Korea.

2. Contents and Methods

2.1. Subjects

Subjects of this study were model aircrafts of airfoil with a large under camber and those of airfoil with LDA (low-drag airfoil) concept.

2.2. Experimental Tools and Methods

Altitude acquisition, set time, and sink rate of airfoil and airfoil glider of the concept of airfoil and LDA (low-drag airfoil) were measured. The experiment was conducted at Osom Airfield, Hwaseong City, Gyeonggi Province, Korea. Aircrafts of airfoil with large under camber and LDA (low-drag airfoil) concept airfoil glider were made. They flew twice in zero wind condition. An altimeter was mounted on the selected airfoil. A F1A glider national competitor flew twice with each model after confirming the no-wind condition at Osom Airfield in Songsan-myeon, Gyeonggi-do province, Korea. Data of each model were analyzed. Lift coefficient, drag coefficient, and lift-to-drag ratio for the angle of attack were compared and analyzed for sink rate according to altitude after the flight.

2.3. Data Processing

All data obtained from this experiment were analyzed with SPSS version 18.0 for Windows. Mean (M) and standard deviation (SD) were calculated to provide descriptive statistics of all dependent variables. Independent sample t-test was used to determine inter-group measurements. Statistical significance level was set at $p < 0.05$.

3. Main Subjects

3.1. Airfoil Selection

An important issue in determining F1A glider glide performance is airfoil selection. For the selection of the most suitable airfoil, airfoil used by participating athletes was selected. Makarov was selected as the airfoil with the large under camber, BE6356, while the airfoil with the concept of LDA (low-drag airfoil) was selected as MID-101 and MID-103. In this study, airfoil with the highest lift-drag ratio (Cl/Cd) will be determined through aerodynamic analysis by using profili2.

3.1.1 Makarov

The shape of Makarov, an airfoil with a large under camber, is as follows.

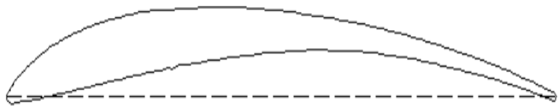

Fig. 1: Two-dimensional cross-sectional shape of Makarov airfoil.

This airfoil, Makarov, has Max thickness 6.40% at 21.4% of the chord and Max camber 6.78% at 48.7% of the chord.

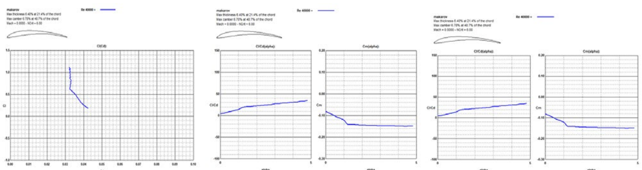

Fig.2: Analysis graph of Makarov airfoil.

Table 1: Analysis results of Makarov airfoil.

Makarov-Re=40000							
Alfa	Cl	Cd	Cl/Cd	Cm	T Xtr	B Xtr	Power F.
0.0	0.1844	0.0424	4.3491	-0.0818	0.9029	0.076	1.8676
0.2	0.2409	0.0404	5.9629	-0.0886	0.896	0.0733	2.9267
0.4	0.3107	0.0387	8.0284	-0.0977	0.8909	0.0717	4.4751
0.6	0.3789	0.0374	10.131	-0.1065	0.8848	0.0723	6.2361
0.8	0.4307	0.0365	11.8	-0.1124	0.8753	0.0809	7.7441
1.0	0.4934	0.0356	13.8596	-0.1206	0.868	0.1151	9.7353
1.2	0.6157	0.0324	19.0031	-0.1402	0.8689	1.0000	14.9111
1.4	0.6544	0.0324	20.1975	-0.1427	0.8608	1.0000	16.3388
1.6	0.672	0.032	20.574	-	0.846	1.000	16.876

	8	7	9	0.1422	6	0	5
1.8	0.706	0.0327	21.5902	-0.1438	0.8367	1.0000	18.1409
2.0	0.7368	0.0327	22.5321	-0.145	0.8275	1.0000	19.3409
2.2	0.7564	0.033	22.9212	-0.1447	0.8134	1.0000	19.9349
2.4	0.7915	0.0328	24.1311	-0.1463	0.8054	1.0000	21.4685
2.6	0.8109	0.0331	24.4985	-0.1459	0.7917	1.0000	22.0609
2.8	0.8402	0.0329	25.538	-0.1465	0.7806	1.0000	23.4087
3.0	0.8794	0.0323	27.226	-0.1483	0.7738	1.0000	25.5315
3.2	0.8913	0.0329	27.0912	-0.1467	0.756	1.0000	25.5764
3.4	0.9274	0.0324	28.6235	-0.148	0.7475	1.0000	27.5648
3.6	0.9448	0.0328	28.8049	-0.1472	0.7326	1.0000	27.9986
3.8	0.9755	0.0326	29.9233	-0.1479	0.7216	1.0000	29.5545
4.0	1.0087	0.0323	31.2291	-0.1491	0.7124	1.0000	31.3647
4.2	1.0258	0.0328	31.2744	-0.1481	0.6973	1.0000	31.6753
4.4	1.0671	0.032	33.3469	-0.15	0.6883	1.0000	34.4475
4.6	1.0795	0.0327	33.0122	-0.1484	0.6712	1.0000	34.2994
4.8	1.1158	0.0320	34.8688	-0.1494	0.6597	1.0000	36.8324

As shown above, aerodynamic characteristics around the airfoil when the angle of attack varied from 0° to 5° in 0.2° increments at Re = 40000 were analyzed. The optimal angle of attack was 3° when the lift ratio (Cl) and the drag coefficient (Cd) were compared

3.1.2 BE6356

The shape of BE6356, an airfoil with a large under camber, is as follows.

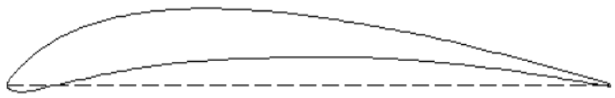

Fig. 3: Two-dimensional cross-section of BE6356 airfoil.

The airfoil BE6356 was characterized to have a maximum thickness of 6.10% at 20.2% of the chord and a maximum camber of 6.29% at 36.2% of the chord.

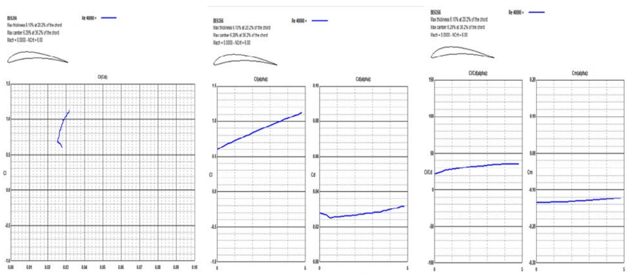

Fig. 4: Analysis graph of BE6356 airfoil.

Table 2: Analysis results of BE6356 airfoil.

BE6356-Re=40000							
Alfa	Cl	Cd	Cl/Cd	Cm	T Xtr	B Xtr	Power F.
0.0	0.5996	0.0278	21.5683	-0.1342	0.8532	0.2222	16.7012
0.2	0.6269	0.0274	22.8796	-0.1348	0.8418	0.2439	18.1154
0.4	0.6543	0.0268	24.4142	-0.1356	0.8299	0.3085	19.7483
0.6	0.6793	0.0252	26.9563	-0.1349	0.8213	1.0000	22.2173
0.8	0.6970	0.0256	27.2266	-0.134	0.8057	1.0000	22.7305
1.0	0.7252	0.0256	28.3281	-0.1343	0.7956	1.0000	24.1239
1.2	0.7446	0.0260	28.6385	-0.1337	0.7818	1.0000	24.7122
1.4	0.7693	0.0261	29.4751	-0.1335	0.7703	1.0000	25.8525
1.6	0.7919	0.0263	30.1103	-0.1331	0.7586	1.0000	26.7948
1.8	0.8127	0.0265	30.6679	-0.1326	0.7453	1.0000	27.6471
2.0	0.8398	0.0264	31.8106	-0.1324	0.7367	1.0000	29.1514
2.2	0.8556	0.0271	31.5720	-0.1316	0.7210	1.0000	29.2036
2.4	0.8807	0.0270	32.6185	-0.1311	0.7112	1.0000	30.6111
2.6	0.8984	0.0275	32.6691	-0.1304	0.6972	1.0000	30.9651
2.8	0.9213	0.0276	33.3804	-0.1298	0.6861	1.0000	32.0400
3.0	0.9417	0.0280	33.6321	-0.1292	0.6745	1.0000	32.6370
3.2	0.9616	0.0284	33.8592	-0.1286	0.6617	1.0000	33.2027
3.4	0.9868	0.0283	34.8693	-0.1280	0.6529	1.0000	34.6384
3.6	1.0019	0.0291	34.4296	-0.1273	0.6377	1.0000	34.4622
3.8	1.0254	0.0292	35.1164	-0.1266	0.6277	1.0000	35.5596
4.0	1.04	0.029	34.866	-	0.614	1.000	35.5994

	25	9	2	0.1260	8	0	
4.2	1.0631	0.0303	35.0858	-0.1253	0.6033	1.0000	36.1758
4.4	1.0842	0.0307	35.3160	-0.1246	0.5929	1.0000	36.7727
4.6	1.1005	0.0315	34.9365	-0.1239	0.5795	1.0000	36.6500
4.8	1.1237	0.0316	35.5601	-0.1233	0.2704	1.0000	37.6954

As shown above, aerodynamic characteristics around the airfoil when the angle of attack varied from 0° to 5° in 0.2° increments at Re = 40000 were analyzed. The optimal angle of attack was 3° when the lift ratio (Cl) and the drag coefficient (Cd) were compared and the load ratio (Cl / Cd) was analyzed. The optimum lift-drag ratio (Cl/Cd) is 33.6321.

3.1.3 MID-101

The shape of MID-101, an airfoil of LDA (low-drag airfoil) concept, is as follows.

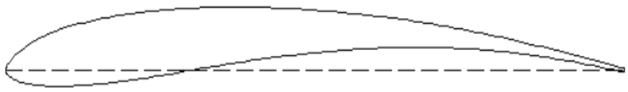

Fig. 5: Two-Dimensional Cross Section of MID-101 Airfoil.

This airfoil, MID-101, has Max thickness 7.70% at 19.4% of the chord and Max camber 4.50% at 52.4% of the chord.

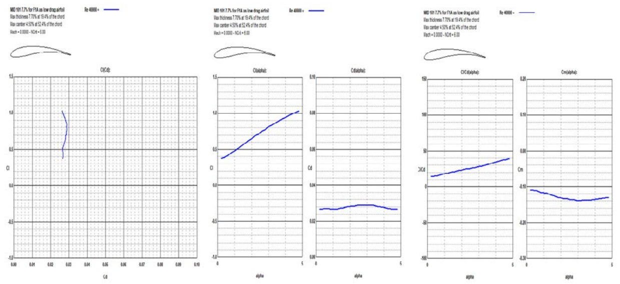

Fig. 6: Analysis graph of MID-101 airfoil.

Table 3: Analysis results of MID-101 airfoil.

MID 101-Re=40000							
Al-fa	Cl	Cd	Cl/Cd	Cm	T Xtr	B Xtr	Power F.
0.2	0.3695	0.0265	13.9434	-0.1100	1.0000	0.5773	8.4757
0.4	0.3887	0.0267	14.5581	-0.1103	1.0000	0.6012	9.0763
0.6	0.4129	0.0269	15.3494	-0.1115	0.9966	0.6298	9.8631
0.8	0.4508	0.0269	16.7584	-0.1150	0.9881	0.6734	11.2518
1.0	0.4791	0.0266	18.0113	-0.1165	0.9774	0.7389	12.4669
1.2	0.5105	0.0265	19.2642	-0.1190	0.9635	1.0000	13.7641
1.4	0.5458	0.027	20.2148	-0.1224	0.9512	1.0000	14.9344
1.6	0.5823	0.0274	21.2518	-0.1256	0.9390	1.0000	16.2170
1.8	0.621	0.027	22.366	-	0.928	1.000	17.637
	8	8	9	0.1292	4	0	3
2.0	0.6484	0.0282	22.9929	-0.1304	0.9129	1.0000	18.5146
2.2	0.6908	0.0283	24.4099	-0.1340	0.9027	1.0000	20.2881
2.4	0.7122	0.0287	24.8153	-0.1340	0.8854	1.0000	20.9421
2.6	0.7549	0.0287	26.3031	-0.1373	0.8746	1.0000	22.8535
2.8	0.7761	0.029	26.7621	-0.1370	0.8565	1.0000	23.5765
3.0	0.8163	0.0287	28.4425	-0.1391	0.8449	1.0000	25.6976
3.2	0.8358	0.0289	28.9204	-0.1381	0.8247	1.0000	26.4397
3.4	0.8654	0.0287	30.1533	-0.1382	0.8078	1.0000	28.0507
3.6	0.8963	0.0282	31.7837	-0.1380	0.7896	1.0000	30.0906
3.8	0.9183	0.028	32.7964	-0.1366	0.7671	1.0000	31.4282
4.0	0.9431	0.0276	34.1703	-0.1354	0.7455	1.0000	33.1839
4.2	0.97	0.0271	35.7934	-0.1342	0.7243	1.0000	35.2524
4.4	0.9947	0.0267	37.2547	-0.1328	0.7009	1.0000	37.1558
4.6	1.0154	0.0265	38.317	-0.1311	0.6744	1.0000	38.6109
4.8	1.0366	0.0264	39.2652	-0.1294	0.6463	1.0000	39.9772

As shown above, aerodynamic characteristics around the airfoil when the angle of attack varied from 0° to 5° in 0.2° increments at Re = 40000 were analyzed. The optimal angle of attack was 3.4° in the analysis of the loading ratio (Cl / Cd) by comparing the lift coefficient (Cl) and the drag coefficient (Cd). The optimum lift-drag ratio (Cl/Cd) is 30.1533.

3.1.4 MID-103

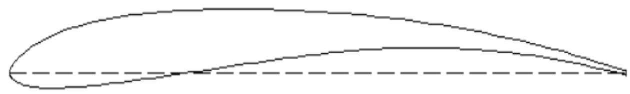

Fig.7: Two-dimensional cross-section of MID-103 airfoil.

The airfoil MID-103 is characterized to have a maximum thickness of 7.35% at 20.6% of the chord and a maximum camber of 4.50% at 55.0% of the chord.

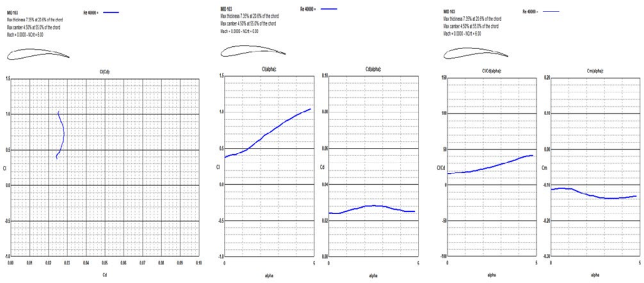

Fig. 8: Analysis graph of MID-103 airfoil

Table 4: Analysis results of MID-103 airfoil.

MID 103-Re=40000							
Al-fa	Cl	Cd	Cl/Cd	Cm	T Xtr	B Xtr	Power F.
0.0	0.3742	0.0245	15.2735	-0.1125	1.0000	0.6679	9.3431
0.2	0.3923	0.0243	16.1440	-0.1119	1.0000	0.7193	10.1116
0.4	0.4062	0.0240	16.9250	-0.1104	1.0000	0.7974	10.7869
0.6	0.4113	0.0241	17.0664	-0.1084	1.0000	1.0000	10.9451
0.8	0.4350	0.0247	17.6113	-0.1099	1.0000	1.0000	11.6155
1.0	0.4563	0.0253	18.0356	-0.1108	1.0000	1.0000	12.1830
1.2	0.4762	0.0259	18.3861	-0.1115	1.0000	1.0000	12.6877
1.4	0.5147	0.0265	19.4226	-0.1155	0.9896	1.0000	13.9343
1.6	0.5518	0.0269	20.5130	-0.1191	0.9753	1.0000	15.2377
1.8	0.5969	0.0274	21.7847	-0.1239	0.9631	1.0000	16.8307
2.0	0.6287	0.0278	22.6151	-0.1261	0.9460	1.0000	17.9317
2.2	0.6744	0.0280	24.0857	-0.1305	0.9328	1.0000	19.7796
2.4	0.7017	0.0282	24.8830	-0.1315	0.9128	1.0000	20.8439
2.6	0.7374	0.0282	26.1489	-0.1336	0.8956	1.0000	22.4546
2.8	0.7764	0.0280	27.7286	-0.1360	0.8780	1.0000	24.4326
3.0	0.8054	0.0280	28.7643	-0.1366	0.8564	1.0000	25.8142
3.2	0.8388	0.0276	30.3913	-0.1375	0.8363	1.0000	27.8342
3.4	0.8761	0.0270	32.4481	-0.1384	0.8174	1.0000	30.3715
3.6	0.9013	0.0266	33.8835	-0.1376	0.7916	1.0000	32.1679
3.8	0.9276	0.0263	35.2700	-0.1368	0.7650	1.0000	33.9692
4.0	0.9545	0.0258	36.9961	-0.1359	0.7364	1.0000	36.1447
4.2	0.9815	0.0254	38.6417	-0.1348	0.7050	1.0000	38.2826
4.4	1.0080	0.0251	40.1594	-0.1337	0.6717	1.0000	40.3197
4.6	1.0298	0.0252	40.8651	-0.1323	0.6340	1.0000	41.4695
4.8	1.0510	0.0254	41.3780	-0.1308	0.5966	1.0000	42.4200

As shown above, aerodynamic characteristics around the airfoil when the angle of attack varied from 0° to 5° in 0.2° increments at Re = 40000 were analyzed. The optimal angle of attack was 3.4° in the analysis of the loading ratio (Cl / Cd) by comparing the lift coefficient (Cl) and the drag coefficient (Cd). The optimum lift-drag ratio (Cl/Cd) is 32.4481

As a result of aerodynamic analysis, airfoil BE6356 has the largest under camber with 33.6321 of lift-drag ratio (Cl/Cd); however, the lift-drag ratio (Cl/C) of airfoil MID-103 is 32.4484, which has the concept of LDA (low-drag airfoil).

3.2. Glider Selection

According to results of analysis of airfoil, BE6356 with a large under camber and MID-103 with airfoil with LDA (low-drag airfoil) concept were produced as shown in Table 1.

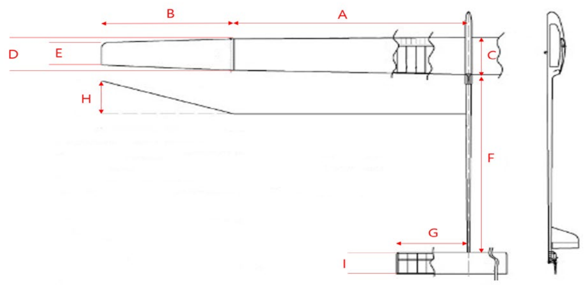

Fig. 9: Glider shape.

Table.5: Glider specifications.

Specification	Large under camber airfoil glider	LDA concept air-foil glider
Wing Root Length (A), mm	680	680
Wing Tip Length (B), mm	490	490
Root Chord (C), mm	150	150
Dihedral Chord (D), mm	130	130
Tip Chord (E), mm	100	100
Tail Moment (F), mm	730	730
Stabilizer Chord (I), mm	85	85
Stabilizer Length (Gx2), mm	470	470
Wing Tip Height (H), mm	145	145
Dihedral Break, mm	140	140
Weight, g	412	410.5
Wing Airfoil	BE6356	MID-103

3.3. Test Flight

Due to the limitation of the size of 300m × 800 m of Osom Airfield in Songsan-myeon, Hwaseong-si, Gyeonggi-do province, Korea at 6 am on May 7, 2018, the glide time was limited to two minutes and two flights were conducted. Two F1A glider national players flew twice with each model – BE6356 and MID-103. Data were extracted through altimeter built in MTK Timer for flight altitude measurement. Flight data such as speed during bunt maneuver to get off the tow, gain altitude, altitude, and average sink rate during flight are as follows.

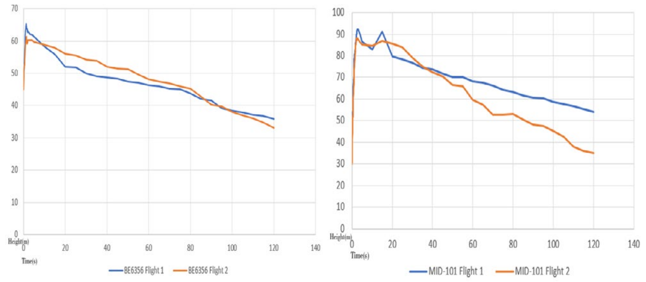

Fig. 10: Flight altitude change graph.

Table. 6: Flight altitude data

Flight mode	Time(s)	Altitude(m)	
		Flight 1	Flight 2
Bunt	0	48.4	45.1
	0.1	49.5	48.9
	0.2	50.2	51.3
	0.3	52.3	51.8
	0.4	53.4	52.6
	0.5	57.3	52.6
	0.6	57.3	54
	0.7	59.1	56.2
	0.8	61.2	56.2
	0.9	63.2	58.9
	1	63.8	59.5
	1.1	64.3	60.1
	1.2	65.2	60.1
	1.3	65.2	61.2
	1.4	64.4	61.4
	1.5	63.8	60.5
	1.6	63.8	59.1
	1.7	63.8	59.1
	1.8	63	59.1
	1.9	62.7	59.5
	2	63.2	60.2
Glide	3	62.1	60.2
	4	61.9	60.2
	5	61.3	59.8
	10	58.2	58.9
	15	55.8	57.9
	20	52.1	56.1
	25	51.8	55.5
	30	50	54.3
	35	49.1	53.8
	40	48.8	52.1
	45	48.3	51.5
	50	47.5	51.2
	55	47.1	49.7
	60	46.4	48.1
	65	46	47.5
	70	45.2	46.8
	75	45.1	46
	80	43.8	45.2
	85	42.1	42.9
	90	41.6	40.2
	95	39.2	39.8
	100	38.5	38.1
	105	37.8	36.9
	110	37.2	36.1
	115	36.7	34.7
	120	35.9	33.1
Bunt velocity(m/s)		7.4	7.6
Vy avg(m/s)		0.23	0.23

Flight mode	Time(s)	Altitude(m)	
		Flight 1	Flight 2
Bunt	0	40.6	30
	0.1	48.7	41.3
	0.2	51	44.3
	0.3	54.2	51.7
	0.4	54.2	51.7
	0.5	54.2	51.7
	0.6	65.7	60.6
	0.7	67.8	62.2
	0.8	69.3	64.8
	0.9	70.3	66.8
	1	72.7	68.6
	1.1	78.4	73.4
	1.2	79.2	75.1
	1.3	80.8	76.5
	1.4	81.1	78.3
	1.5	82.1	79.7
	1.6	83.7	81.9
	1.7	84.9	84.3
	1.8	85.8	84.9
	1.9	86.2	85.1
	2	86.8	85.4
	2.1	88.9	87.9
	2.2	89.8	87.9
	2.3	90.2	87.2
	2.4	90.9	87.4
	2.5	91.5	87.9
	2.6	92	88
	2.7	92	88
	2.8	92	88
	2.9	92	88
	3	92.2	87.7
Glide	4	89.9	86.4
	5	86.6	85.1
	10	82.9	84.6
	15	91.1	86.9
	20	79.8	85.6
	25	78.3	83.9
	30	76.8	78.9
	35	74.5	75
	40	73.7	72.6
	45	71.9	70.4
	50	70.3	66.5
	55	70.1	65.9
	60	68.3	59.6
	65	67.5	57.3
	70	66.1	52.9
	75	64.3	52.7

	80	63.4	53
	85	61.7	50.3
	90	60.7	48
	95	60.3	47.4
	100	58.8	45.1
	105	57.6	42.6
	110	56.6	38.1
	115	55.3	36.1
	120	54	35.1
Bunt velocity(m/s)		17.2	19.2
Vy avg(m/s)		0.34	0.45

As shown above, the MID-103 airfoil glider rose at an average speed of 18.2m/s during the bunt maneuver and started to glide at 28.25m higher altitude than the BE6356 airfoil glider. However, BE6356 airfoil glider showed lower average sink rate than the MID-103 airfoil glider at 0.17 m/s.

4. Conclusion

F1A glider is a flying body where the performance of the flight endurance is emphasized. To achieve good performance in the regulated range in which the set times are summed and ranked in each round, high altitude acquisition and gliding needs to be ensured when launching before beginning gliding flight. To ensure the gliding property, a wing design with a large aspect ratio and a large camber airfoil should be used for high lift coefficients even at low angle of attack. In this paper, an aerodynamic analysis of a large under camber airfoil BE6356 and airfoil MID-103 with low-drag airfoil (LDA) was conducted through test flights. As a result, BE6356 airfoil glider can glide at a lower sink rate than MID-103 airfoil glider at 0.17 m/s.

However, at the beginning of the gliding flight, the MID-101airfoil glider started to glide at an average height of 28.25 m. By comparing the altitude at which the glide starts and the sink rate, MID-103airfoil glider is advantageous in F1A glider competition.

5. Discussion

Currently, the history of domestic aviation sports has a starting point from model aircraft. As of 2017, there are more than 100,000 model aircraft competitors in Korea. In recent years, performances of athletes have improved, achieving good results in various world championships. Behind the development of domestic model aircraft market, various intensive technologies of model aircraft play a major role. However, performances of athletes participating in model aircraft competitions have been averaging to a certain extent. Their performances tend to depend on the performance of the model rather than the performance of the athletes. Therefore, it is necessary to develop various models. Model aircraft is a miniature version of a general airplane. It requires very precise technology. This technology is very important for achieving fundamental technology integration of Korea's aviation basic industry in the future. By determining glider performance according to glider airfoil, this study has the following implications.

First, it is possible to determine the optimized lift-to-drag ratio according to angle of attack through airfoil data analysis.

Second, it is possible to determine flight altitude and sink rate.

Third, through data analyses, a more scientific approach is possible when operating the competition.

Fourth, this study provides basic data for the development of domestic aviation industry.

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