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SELECTION OF AIRFOIL FOR LSU-05 AIRCRAFT WING WITH NUMERICAL AERODYNAMIC ANALYSIS

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Abstract

Analysis with numerical method has been done for the selection of LSU-05 unmanned vehicle airfoil.The analysis process is done by comparing four airfoil's performance at a certain reynolds number. The four airfoil shapes are compared by comparing the simulation result of their aerodynamical properties such as lift coefficient, drag coefficient, and the polar drag. The needs of the aircraft itself is to be able to carry a payload of 30 kg, range of 200 km, and endurance of 3 hours. The NACA 4415 airfoil is chosen because it meets the requirement for LSU-05.

***Key Words**: airfoil, LSU-05, aerodynamics, subsonic speed.*

1. Introduction

With the development of technology in the field of aerospace, particular aircraft engineering. Aircraft has evolved to have a variety of configurations. National Institute of Aeronautics and Space (LAPAN) in this case trying to develop a UAV type aircraft (Unmanned Aerial Vehicle) with a simple configuration. This plane is called the LSU - 05 (LAPAN Surveillance UAV) intended have area surveillance mission. Then to obtain the optimal design configuration,study is conducted on all fields,particularlyin the field of aerodynamics, by performing calculations on the configuration of the aircraft. It is necessary to chooseairfoil that suits the needs of the aircraft in order to create the optimal wing configurations. The aircraft mission requirement is to be able to carry a minimum payload of 30 kg,to a minimum distance of 200 km, or about 3 hours of flying hours.

The selection is done by comparing the four airfoils which are expected to meet the needs of the lift force on the wings of the plane. The airfoils to be compared are the Eppler 210, 214 Eppler, NACA 6412, and NACA 4415. The calculation will be done using XFoil software, and will be verified with the results of wind tunnel testing done on Reynolds where the same number,i.e.Onemillions.

2. Objectives

The purpose of this paper is to determine which airfoil wing suit the needs of the LSU-05 aircraft as a surveillance aircraft capable of carrying a payload of 30 kg minimum.

3. Scope of study

This calculation is performed by using a software-based numerical method named XFoil aerodynamic which is only used for the calculation of airfoil.

4. Methode

Calculations were performed using the numerical methods with software XFoilparts of parameters assumed at sea level conditions. Eppler airfoil compared are 210, 214 Eppler, NACA 6412, and NACA 4415. The process is by way of comparing the data with the calculation results in predictions that XFoil software can meet the wing configuration for LSU-05 aircraft from the four types of the airfoil. Output in the form of software XFoil figures - figures that convert the excel form. After the calculation of the data obtained later in the analysis where the airfoil wing configuration that meets for LSU-05 aircraft.

The equations used are:

$$CL = \frac{2L}{\rho V^2 S} \tag{1}$$

$$CD = \frac{2D}{\rho V^2 S} \tag{2}$$

$$CD = CD_0 + CD_I \tag{3}$$

5. Result

5.1. Numerical Results

Results of calculations using the software XFoil is the lift coefficient and drag coefficients. The results of calculations with XFoil are displayed in Fig. 1.

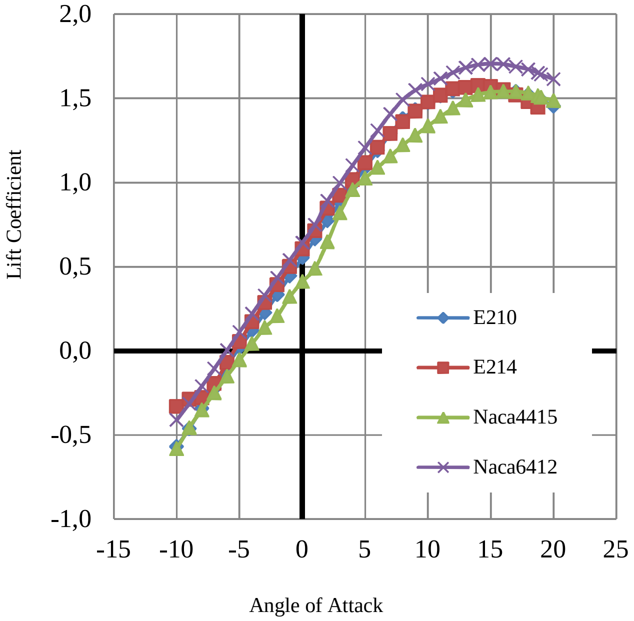

Fig. 1.Lift Coefficient forAngle of Attack.

Fig. 1 shows a comparison of the four types of airfoils to be analyzed. The graph illustrates the change of lift coefficient for angle of attack. For the coefficient of lift types Eppler 210 and 214 have similar characteristics seen from the coefficient value, the maximum value of C_L occurs in 14^o angle of attack but for the kind of NACA 6412 C_L maximum value occurs at 15^o angle of attack while the NACA 4415 occurred at an angle of attack 16^o. From the four types of the airfoils, NACA 4415 is the most sufficient for coefficient values required by LSU-05 wing.

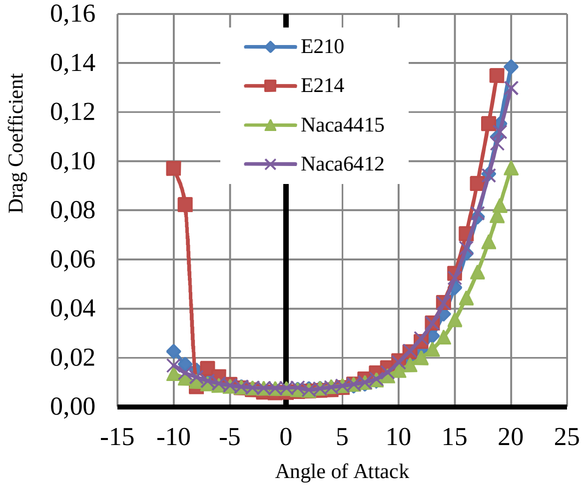

Fig. 2.Drag Coefficient for Angle of Attack.

The change in the drag coefficient on the four types of the airfoils are very small value (Figure 2) for CD_0 and C_D. But with increasing angle of attack especially on the angle of attack above 15°the change is very large. NACA 4415 has a small drag coefficient value compared with other types of airfoil above 15° angle of attack. From the comparison of the airfoils, NACA 4415 airfoil is the most sufficient for the drag coefficient for the wing LSU-05.

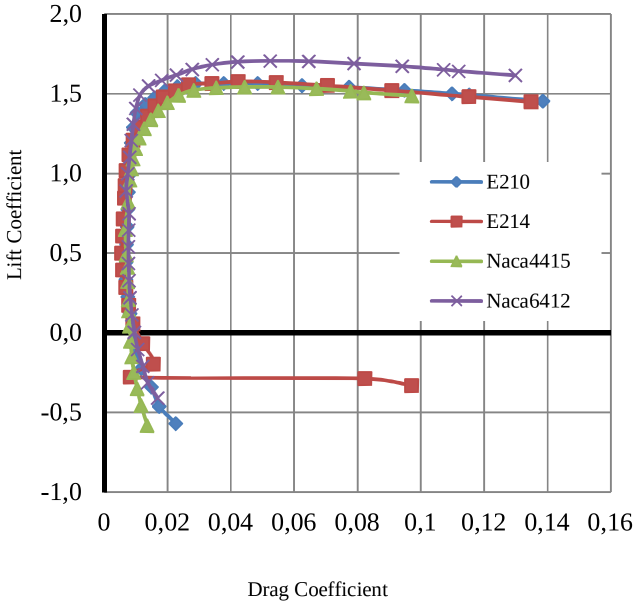

Fig. 3. Drag polar.

With a drag coefficient values are almost the same, the airfoil has a lift to drag ratio for NACA 6412 airfoil (figure 3) but in this case the NACA 4415 has a small value of the drag coefficient and the lift coefficient of the wing that meets the needs of the LSU-05 so that the airfoil selected.

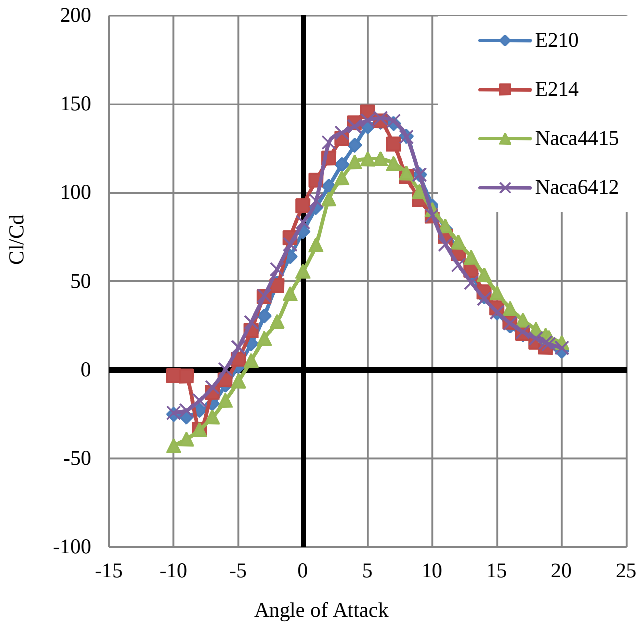

Fig. 4.Aerodynamics Efficiency for Angle of Attack.

From the aerodynamic efficiency, NACA 4415 airfoil characteristics among the lowest efficiency airfoil airfoil-other comparison. It is also a consideration in the selection of the airfoil. With the fulfillment of the selection criteria other then the efficiency factors can be ruled out first in this case.

5.2. Comparison With Wind Tunnel

The chosen airfoil is NACA 4415.The airfoil compared with the results from the wind tunnel to verify that the results of the software XFoil value approaching value results from wind tunnel tests. Wind tunnel test results obtained from the references that do test on Reynolds number about one million.

The comparison of coefficient lift for angle of attack is shown in Fig. 6.

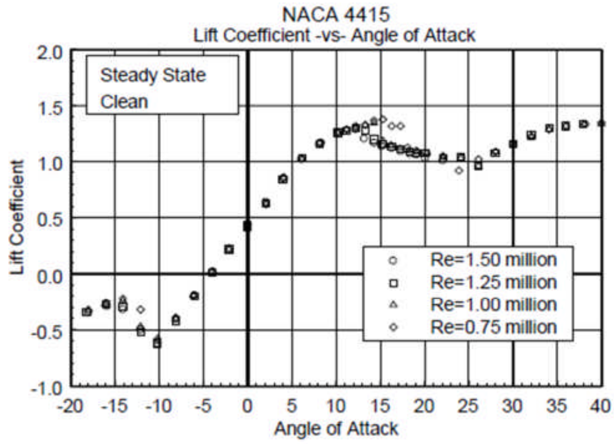

Fig. 5.Wind tunnel data from reference.[3&4]

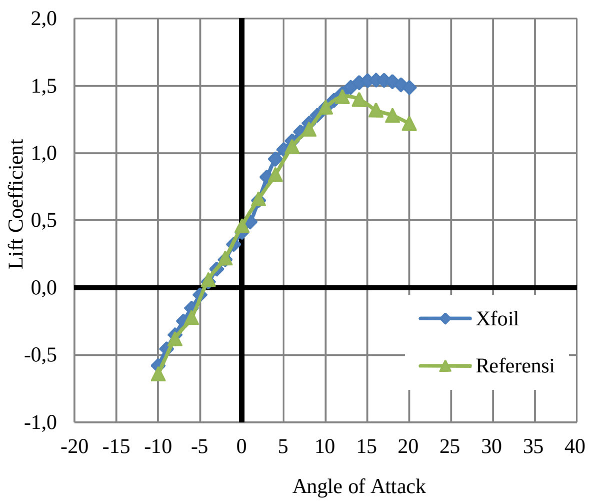

Fig. 6.XFoil Software and Reference.[2)]

Data obtained from the results of the wind tunnel reference (Fig. 5) with the data of calculation software XFoil (Fig.6) compared to the same Reynolds number of one million. From these images can be seen that the results of the wind tunnel and software XFoil not too far away. So using XFoil software can be used to calculate the coefficient of aerodynamic airfoil type to another, and the results can be said to be valid.
The comparison of Drag Polar is shown in Fig. 8.

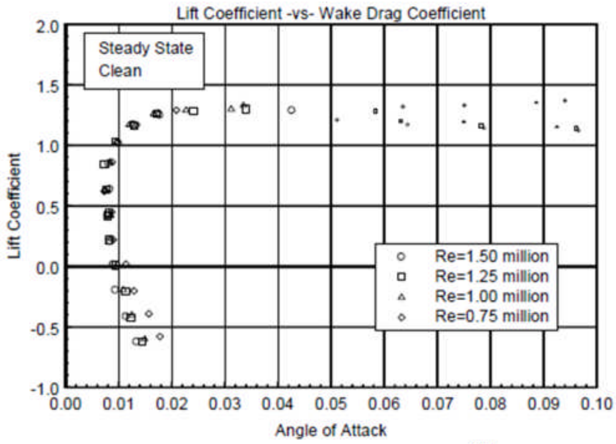

Fig. 7.Wind tunnel data from reference[3&4)]

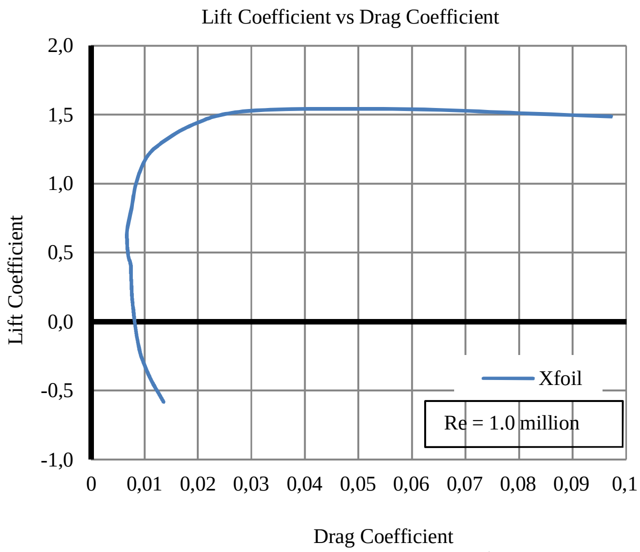

Fig. 8.XFoil Software and Reference[2)].

From the picture above can be seen that the drag polar wind tunnel results with almost the same results XFoil software. So the use of software to use calculations XFoil with another type of airfoil could be valid.

6. Conclusion

From the analysis above it can be concluded that:

- The selection criteria airfoil which can meet the LSU-05 aircraft is NACA 4415 airfoil.
- In terms of the coefficient of lift (C_L) is sufficient to meet current cruise even during takeoff and landing for this case has not been taken into account.
- Airfoil NACA 4415 has a contour are easily made into wings.
- Comparison of the results with wind tunnel software XFoil on Reynolds number is quite close to one million.

References

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5) http://www.airfoiltools.com/

Table.1. The results of calculations with software XFoil.5

	E210			E214			Naca4415			Naca6412		
alpha	CL	CD	Cl/Cd	CL	CD	Cl/Cd	CL	CD	Cl/Cd	CL	CD	Cl/Cd
-10	0.569	0.023	-25.201	0.331	0.097	-3.409	0.581	0.014	-42.822	0.409	0.017	-24.233
-9	0.462	0.017	-26.550	0.288	0.082	-3.494	0.456	0.012	-39.050	0.314	0.014	-22.766
-8	0.341	0.015	-22.796	0.278	0.008	-33.640	0.350	0.010	-33.705	0.209	0.012	-17.212
-7	0.224	0.012	-19.220	0.196	0.016	-12.624	0.250	0.009	-26.599	0.104	0.011	-9.802
-6	0.083	0.010	-8.621	0.069	0.012	-5.609	0.151	0.009	-17.211	0.004	0.010	0.400
-5	0.019	0.009	2.183	0.055	0.009	6.046	0.053	0.008	-6.343	0.112	0.009	12.838
-4	0.121	0.008	14.828	0.173	0.008	22.345	0.043	0.008	5.362	0.220	0.008	26.944
-3	0.226	0.007	30.376	0.285	0.007	41.362	0.138	0.008	17.745	0.328	0.008	41.849
-2	0.334	0.007	48.816	0.394	0.006	47.523	0.207	0.008	27.182	0.435	0.008	56.736
-1	0.444	0.007	64.098	0.500	0.006	74.504	0.323	0.008	43.000	0.540	0.008	70.853
0	0.554	0.007	78.085	0.607	0.006	92.746	0.413	0.007	55.682	0.644	0.008	83.286
1	0.665	0.007	91.738	0.714	0.006	107.078	0.489	0.007	70.592	0.748	0.008	95.492
2	0.774	0.007	103.780	0.846	0.006	119.661	0.648	0.007	96.443	0.891	0.007	128.444
3	0.883	0.008	115.866	0.924	0.007	130.586	0.821	0.008	108.298	0.998	0.007	133.906
4	0.987	0.008	126.838	1.017	0.007	139.456	0.957	0.008	117.292	1.103	0.008	137.481
5	1.088	0.008	137.336	1.117	0.008	145.615	1.027	0.009	119.142	1.208	0.009	140.933
6	1.191	0.009	139.777	1.210	0.009	140.603	1.090	0.009	119.158	1.310	0.009	142.050
7	1.290	0.009	139.169	1.290	0.011	127.495	1.157	0.010	116.653	1.408	0.010	140.509
8	1.379	0.010	131.962	1.361	0.014	109.017	1.224	0.011	111.135	1.493	0.011	131.551
9	1.433	0.013	110.331	1.423	0.016	96.205	1.282	0.013	100.834	1.549	0.014	110.270
10	1.475	0.016	92.470	1.478	0.019	86.844	1.337	0.015	90.487	1.585	0.018	87.306
11	1.515	0.019	79.585	1.519	0.022	75.536	1.393	0.017	81.290	1.618	0.023	70.965
12	1.545	0.023	66.739	1.558	0.027	65.460	1.443	0.020	72.134	1.654	0.028	59.361
13	1.564	0.029	54.150	1.565	0.034	56.060	1.491	0.023	63.534	1.682	0.034	49.308
14	1.564	0.038	41.386	1.577	0.042	43.900	1.523	0.028	53.683	1.700	0.042	40.311
15	1.565	0.049	32.260	1.571	0.054	35.057	1.537	0.035	43.375	1.706	0.052	32.538
16	1.551	0.062	24.832	1.551	0.071	26.975	1.542	0.044	34.741	1.704	0.065	26.370
17	1.541	0.077	19.928	1.520	0.091	20.537	1.541	0.055	28.102	1.690	0.079	21.412
18	1.521	0.095	16.038	1.480	0.115	15.617	1.532	0.067	22.817	1.673	0.094	17.768
18.8	1.501	0.110	13.658	1.449	0.135	12.849	1.517	0.078	19.485	1.651	0.107	15.403
19	1.492	0.115	12.947				1.507	0.082	18.366	1.642	0.112	14.668
20	1.454	0.138	10.496				1.487	0.097	15.297	1.615	0.130	12.442