Designing a new aerodynamic profile for the SAE Brasil Aerodesign competition

Crossref doi
https://doi.org/10.56238/Connexpemultidisdevolpfut-092

Pedro Gabriel Nunes Magalhães Barbosa
E-mail: pedrobarbosa.1353@saojudas.br

Bruna Niccoli Ramirez
Dr.
supervisor
E-mail: bruna.ramirez@saojudas.br

Anderson Figueiredo da Costa
Dr.
E-mail: anderson.costa@saojudas.br

ABSTRACT
Aerodynamics is a science that is part of physics, and with the appearance of the first airplane it became more and more profound and a whole new area. His study influenced everything from the design of the Antonov An-225, which was the largest fixed-wing aircraft in the world before the War in Ukraine, to the design of model airplanes for the SAE Brasil Aerodesign competition. The work shows the study and design of a new aerodynamic profile for the USJT extension project, Equipe Ozires USJT Aerodesign. This new profile appears as an optimized alternative to two traditional profiles of the project, the E423 and S1223, offering superior properties mainly in its coefficient of support and performance.

Keywords: Aerodynamics, Airfolio, SAE Brasil Aerodesign.

1 INTRODUCTION

Aerodynamics is a science that is part of physics, and with the emergence of the first airplane it became more and more in-depth until it originated a whole new area. The main objective of aerodynamics is to study the interaction of air with the aircraft, in other words, it studies the movement of fluids in solid bodies and the interaction of solids in fluids, especially oxygen (ANDERSON, 2001). It is very important to know the basic concepts of this area when determining the geometry of a wing.

The wings are the fundamental components that support the plane during its flight. For the wings, there are numerous designs, sizes, positions and shapes used by the various manufacturers. Each model is produced to meet the needs of the project. The wings can be classified as to their attachment to the fuselage in high, medium or low. The number of wings can also vary in monoplanes and biplanes (RODRIGUES, 2014). Before determining the geometry of the wings, it is important to choose the correct wing profile to meet the minimum lift and drag requirements, for example.

An aerodynamic profile is a surface designed for the purpose of obtaining an aerodynamic reaction from the flow of the fluid, in this case the air, around it. The terms airfoil, aerodynamic profile or wing profile are used as nomenclature of this surface (RODRIGUES, 2014). Imagine that an aircraft manufacturer cuts a wing vertically, observing the wing by the view of the cut can see the ribs, which are internal structures of a wing, in them are evident the shape of the wing profile.

In the same way that Boeing and Embraer choose a wing profile for their projects, with the Ozires USJT Aerodesign Team, even if on a much smaller scale, it also needs an aerodynamic profile to build its model airplane aiming at the competition of SAE Brasil Aerodesign.

The Ozires Team is an extension project offered by the São Judas Tadeu University where students design and build a model airplane, learning fundamental concepts of Aeronautical Engineering, learning to work in teams and facing real problems of the aeronautical industry.

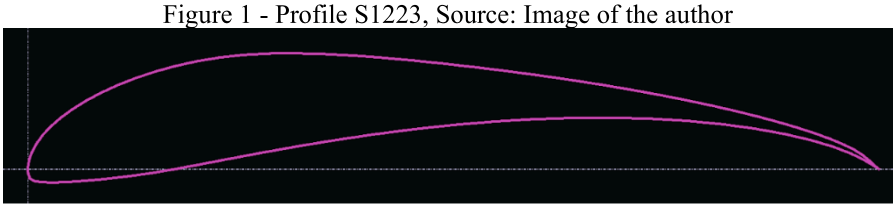
In this article, we will document the entire process done to make and choose the profile that the Ozires Team called the Eppler 50 USJT and used in its model airplane in the year 2022.

2 METHODS

Thinking of building a wing for the first model aircraft of the Ozires USJT Aerodesign Team, it was analyzed which profiles were most used among the teams with tradition in the competition. After an analysis of coefficients such as lift, drag and efficiency in the Airfoil Tools database, two of SAE Brasil Aerodesign's most traditional profiles were chosen, the S1223 and the E423.

The S1223 (FIGURE 1) was a profile that drew the attention of the team due to its high support coefficient. However, in research there were reports from other teams it was found that the complexity for the construction of the same made it unfeasible for a model airplane (SANTOS, PATRICIO, MAIA, 2018).

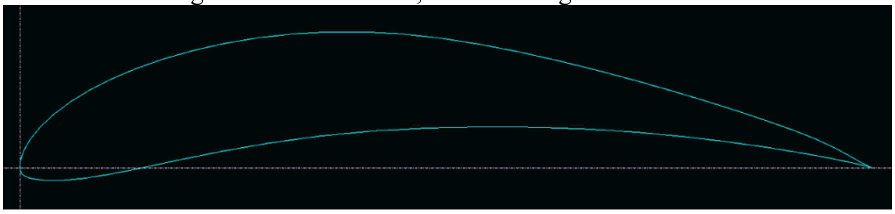
Figure 1 - Profile S1223, Source: Image of the author



One observation, during the initial stage of projection of the model airplane, the Ozires Team always looked for the best configurations seeking the best model airplane possible. However, not always the best type of wing or the best engine would be viable for the project. In engineering feasibility is a topic that should always be taken into account, after all, a project is only a success if there is a possibility of it getting off the ground.

The S1223 profile has a very thin trailing edge, usually in academic aerodesign projects balsa wood is used, a very light material, with a resistance and low cost. However, when cutting a plate of this material the possibility of the trailing edge breaking is gigantic.

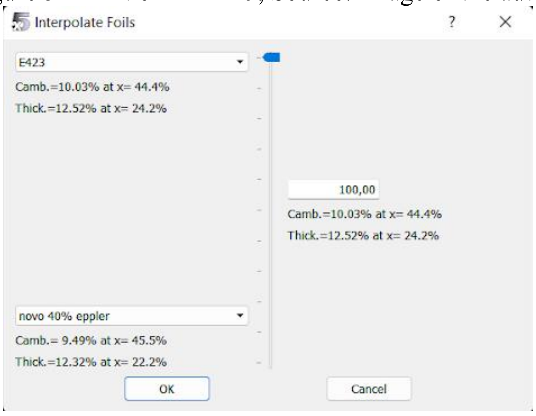
Figure 2 - Profile E423, Source: Image of the author



The E423 profile (FIGURE 2) is also a good configuration, with the trailing edge much more feasible to build, a profile that has even been considered by the previous generation of the Ozires Team to be the one used in the model airplane. Even so, the Aerodynamics group of the current team did not want to give up the lift coefficient that the S1223 profile presented.

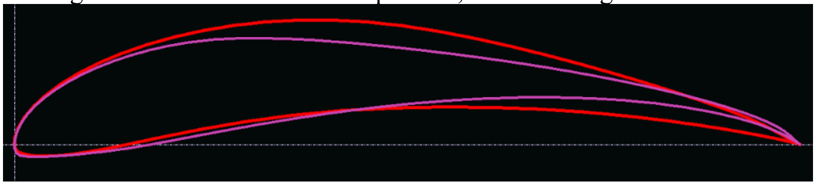
In initial research we were presented with the open source software called XFLR-5, a very light simulation program that could offer us preliminary analysis to evolve the project. In addition to providing analysis of profiles and wing geometry, in this software there is also the function "interpolate foils" (FIGURE 3), which provides the option to mix wing profiles.

Figure 3 - Print of XFLR-5, Source: Image of the author



So we had the idea of merging the S1223 and E423 profiles, with the aim of increasing the trailing edge of the S1223 without losing its lift coefficient. Below (FIGURE 4) one can firmly analyze the difference between the trailing edge of the two profiles.

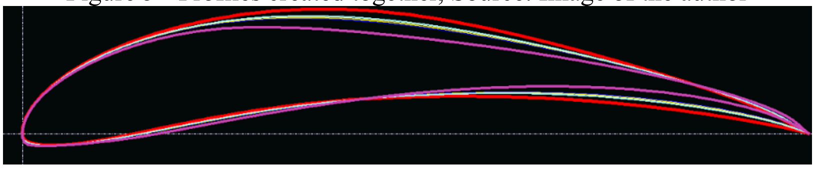
Figure 4 - Difference between profiles, Source: Image of the author



With this in mind, 5 variations were created (FIGURE 5), all using the S1223 profile as a base and interpolating the E423. Thus, 5 new profiles were born, all with a 5% variation in the mixture between E423 and S1223.

To better understand the illustration below (FIGURE 5), the Eppler 40% profile will be used as an example, one of the new profiles created. This name originates from the idea that the Selig-1223 profile has 40% Eppler-423 in its composition. That is, the 50% Eppler profile is a Selig-1223 that has 50% of the Eppler-423 in its composition and so on.

Figure 5 - Profiles created together, Source: Image of the author



Thus, with 5 new profiles in hand, analyses were made within the XFLR-5, using the Reynolds Number, 2.3x105 based on the conditions and characteristics presented at the competition venue, São José dos Campos-SP (SANTOS, PATRICIO, MAIA, 2018). In addition, the speed of 12 m/s was used, an estimate of the speed at which the model airplane will be on its takeoff.

Three main parameters were chosen for analysis and choice of the profile: coefficient of support x drag coefficient (Cl x Cd), coefficient of support x angle Alpha (Cl x α) and Coefficient of Yield x angle Alpha (Cl/Cd x α). These data can be analyzed below (FIGURES 6,7,8 and 9):

Figure 6 - Legend for graphs 7,8 and 9

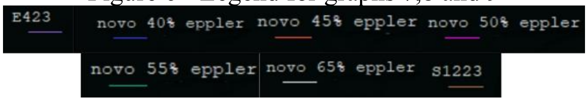


Figure 7 - ClxCd chart with the 5 profiles created, Source: Image of the author

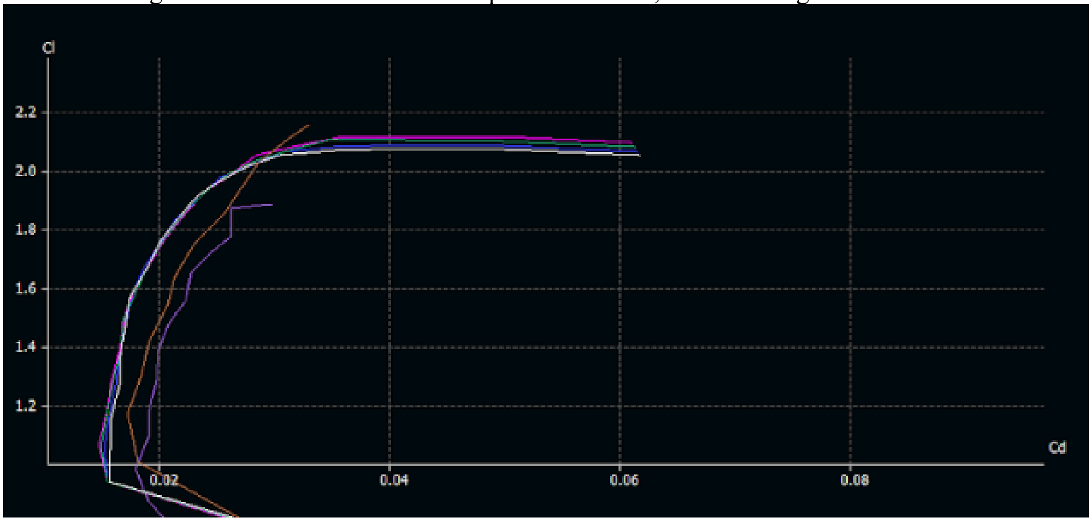


Figure 8 - ClxAlpha Chart with the 5 profiles created, Source: Image of the author

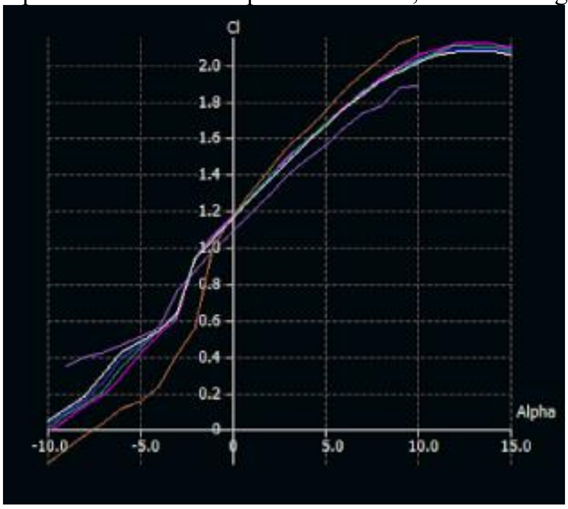
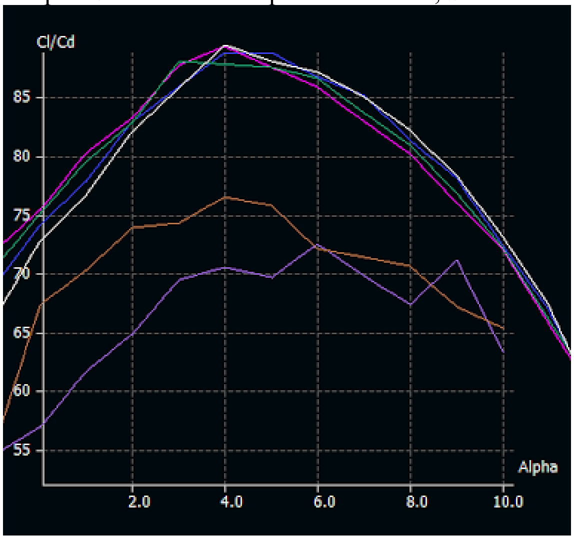


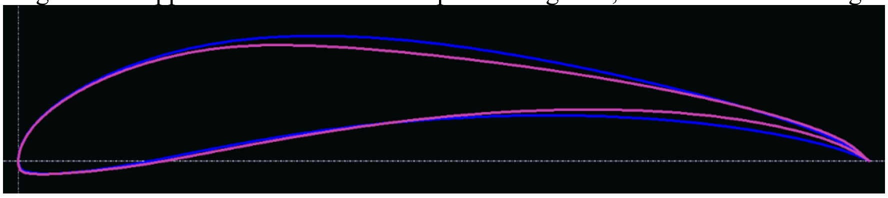
Figure 9 - Cl/CdxAlpha Chart with the 5 profiles created, Source: Image of the author



3 RESULTS AND DISCUSSIONS

After the analysis of the results obtained with the XFLR-5, it was found that the S1223 profile with 50% of E423 in its composition was the best profile made by the Ozires Team, surpassing even the results of the base profiles, presenting coefficients of support, drag and yield higher than the other profiles analyzed. In addition, it can be observed (FIGURE 10) that the adversity found with the thickness of the trailing edge was resolved, increasing its thickness and preventing eventual breaks. With this, the Aerodynamics team was able to proceed with the project of designing the best possible wing geometry for SAE Brasil Aerodesign, dubbing the new discovery the Eppler 50 USJT.

Figure 10 - Eppler 50 USJT and S1223 profiles together, Source: Author's image



4 CONCLUSIONS

Through this study it can be concluded that the XFLR-5 is a great tool for preliminary study in the design of a wing, contributing to the design of the model airplane of the USJT Aerodesign Ozires Team for the competition. In addition to having a low operating cost, it presents results close to reality. The simple and uncomplicated interface helped a team without experience to achieve their goals.

It is important to note that the data presented do not finalize the research, this program does not replace a CFD (Computational Fluid Dynamic) analysis that will be done in the detailed phase of the project. The XFLR-5 does not take into account viscosity, for example. the Ansys and SimScale programs, which were made available to the team as a form of sponsorship, will present more accurate data.

FOMENTATION

The work was awarded a Scholarship by the PROCIÊNCIA 2022/2 Program, PROCIÊNCIA 2023/1, PIBIC, PIBITI, Art. 170, Art. 171 and research funding agencies.

REFERENCES

ANDERSON JR, John. Fundamentals of Aerodynamics 3 ed. Nova York: McGraw-Hill, 2001.

HOMA, Jorge. Aerodinâmica e Teoria de Voo: Noções Básicas. 28ª edição. ASA - Edições e Artes Gráficas Ltda. 2010.

RODRIGUES, Luiz Eduardo Miranda José. 1973 - Fundamentos da Engenharia Aeronáutica com Aplicações ao Projeto SAE-AeroDesign: Aerodinâmica e Desempenho / Luiz Eduardo Miranda José Rodrigues – Salto/SP: www.engbrasil.eng.br, 2014. 320p.

RODRIGUES, Luiz Eduardo Miranda José. 1973 - Fundamentos da Engenharia Aeronáutica com Aplicações ao Projeto SAE-AeroDesign: Volume Único / Luiz Eduardo Miranda José Rodrigues – Salto/SP: www.engbrasil.eng.br, 2014. 508p.

RODRIGUES, Luiz Eduardo Miranda José. 1973 - Fundamentos da Engenharia Aeronáutica / Luiz Eduardo Miranda José Rodrigues. - 1. ed. - São Paulo: Cengage Learning, 2021.

SANTOS, Moisés; PATRICIO, Kenned; MAIA, Geovanna. Seleção de Perfil Aerodinâmico para uma Aeronave Rádio Controlada destinada a competição SAE Brasil Aerodesign. II Simpósio de Pós-Graduação em Engenharia Mecânica. Paraíba. p. 1-4. Novembro, 2018.