Ultra light aircraft structure design and analysis using ANSYS and CAE tools

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ABSTRACT:

A mechanism called an aero plane can fly by drawing assistance from the atmosphere. It uses either static lift, dynamic lift from an airfoil, or, in a few rare instances, downward thrust from jet engines to counteract the pull of gravity. A wing is a particular sort of fin that generates lift when it travels through air or another fluid. Because of this, wings have streamlined cross sections that behave as airfoils and are sensitive to aerodynamic forces. A wing's lift-to-drag ratio is a measure of its aerodynamic effectiveness. This project used the CAD tool (CATIA) to create the ultra-light aircraft's wing structure and the CAE TOOL to evaluate it (ANSYS WORKBENCH) the project's goal is to decrease the stresses on the wing structure to increase its strength to weight ratio. To do this here 2wing structures were developed (NACA 0012 &0016) analyzing with existing material (al-7075) and with composite materials. From the results we can say which wing structure and which combination of material would be better for ultra light aircraft model

I. INTRODUCTION

Flying small, lightweight, fixed-wing aircraft with one or two seats is known as ultra light aviation (sometimes referred to as micro light aviation in some countries). Weight-shift control and traditional 3-axis control aircraft with ailerons, elevators, and rudder are distinguished in certain nations as "micro light" and "ultra light," respectively. The hang gliding movement, which gained popularity in the late 1970s and early 1980s, was a major factor in the rise of the need for inexpensive powered flight. Several aviation authorities established categories of light, slow-flying aero planes that can be subject to minimum requirements as a result. The resultant aero planes are sometimes referred to as "ultra light aircraft" or "micro lights," however weight and speed restrictions vary from nation to nation. The maximum take-off weight in Europe is limited by the sports (FAI) concept to 450 kg (992 lb) (472.5 kg (1,042 lb) if a ballistic parachute is installed) and a maximum stalling speed of 65 km/h (40 mph). The definition means that the aircraft has a slow landing speed and short landing roll in the event of an engine failure. In most affluent countries, micro lights or ultra light aircraft now account for a significant percentage of the global civilian-owned aircraft. For instance in Canada in October 2010, the ultra light aircraft fleet made up to 19% of the total civilian aircraft registered. In other countries that do not register ultra light aircraft, like the United States, it is unknown what proportion of the total fleet they make up. In countries where there is no specific extra regulation, ultra lights are considered regular aircraft and subject to certification requirements for both aircraft and pilot. In Australia, ultra light aircraft and their pilots can either be registered with the Hang Gliding Federation of Australia (HGFA) or Recreational Aviation Australia (RA Aus). In all cases, except for privately built single seat ultra light aero planes, micro light aircraft or trikes are regulated by the Civil Aviation Regulations. The current UK regulations match the European ones although earlier UK legal microlight definitions described an aeroplane with a maximum weight authorised of (finally) 390 kg, with a wing loading at the maximum weight authorised not exceeding 25 kg per square metre. Other than the very earliest aircraft, all two-seat UK microlights (and until 2007 all single-seaters) have been required to meet airworthiness standard BCAR Section S. In 2007 SSDR, a sub-category of single seat aircraft was introduced, allowing owners more freedom for modification and experiments. In 2015 the SSDR rules changed. The definition of a single seat microlight was adjusted to effectively de-regulate all single seat microlights for airworthiness purposes. There is no airworthiness requirement or annual inspection regime for SSDR microlights although pilots who fly them must have a normal microlight licence, and must observe the rules of the air.[23]In the UK the microlight licence is currently called NPPL (National Private Pilots Licence). It can be upgraded to an LAPL licence with few hours training in Cat A aircraft (Allowing holders to fly any simple single engine aircraft up to 2 tons) Ultralights in New Zealand are subject to NZCAA General Aviation regulationswith microlight specificvariations as described in Part 103[26] and AC103.

The United States FAA's definition of an ultralight is significantly different from that in most other countries and can lead to some confusion when discussing the topic. The governing regulation in the United States is FAR 103 Ultralight Vehicles. In 2004 the FAA introduced the "Light-sport aircraft" category, which resembles some other countries' microlight categories. Ultralight aviation is represented by the United States Ultralight Association (USUA), which acts as the US aeroclub representative to the Fédération Aéronautique Internationale.

Electric powered ultra lights

Research has been conducted in recent years to replace gasoline engines in ultralights with electric motors powered by batteries to produce electric aircraft. This has now resulted in practical production electric power systems for some ultralight applications. These developments have been motivated by cost as well as environmental concerns. In many ways ultralights are agood application for electric power as some model are capable of flying with low power, which allows longer duration flights on battery power. In 2007 the Electric Aircraft Corporation began offering engine kits to convert ultralight weight shift trikes to electric power. The 18 hp motor weighs 26 lb (12 kg) and an efficiency of 90% is claimed by designer Randall Fishman. The battery consists of a lithium-polymer battery pack of 5.6kWh which provides 1.5 hours of flying in the trike application. The power system for a trike costs USD $8285. to $11285. The company claimed a flight recharge cost of 60 cents in 2007.

II. LITERATURE SURVEY

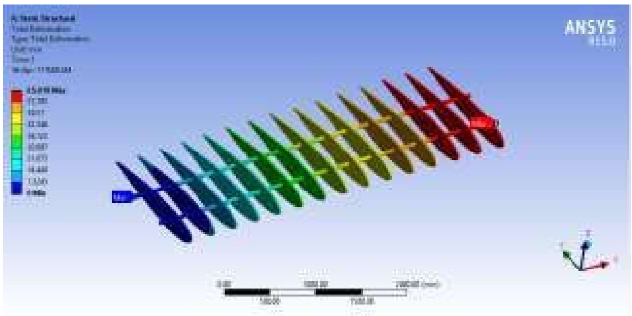
T.V. Baughn and P.F. Packman [1] in 1986, conducted a finite element analysis to determine the structural integrity of a high-wing cable-supported ultralight aircraft. A simple, symmetrical, half-structure macro-model was analyzed and subjected to level flight loading and two-wheel-landing loading conditions. Flexural and bending stiffness for the supported and unsupported wing were also determined. A preliminary damage tolerance analysis was conducted in which selected cable elements and wing compression struts were removed, the redistributed loads calculated, and possible aircraft flight configurations examined. The model can generate all cable loads, displacement of each structural node (for each loading condition), generate displacement plots, and locate potential highly stressed regions. Baughn, T. and Johnson, D. [2] in the same year of 1986, proposed a design change from high-wing cable- supported to strut supported aircraft. One of the most common designs is the high wing cable supported ultralight. Because of its simple shape and method ofconstruction owners like to modify the structure and aerodynamic surfaces to attempt to improve the performance of the aircraft. One of the more common modification requests is for the conversion from a cable supported to a strut supported aircraft. The objective ofthe modification is to reduce the drag and improve the performance of the ultralight. The purpose of their study is to determine the structural performance of the cable supported aircraft and compare it to the structuralperformance of a strut supported version of the same aircraft and to provide an estimate of the change in drag associated with the conversion from cable supported to strut supported. Girish S. Kulkarni [3] in 1987, with the help of all the design guidelines provided by Baughn, T along with considering critical condition in un-accelerated flight, done a Finite element method based structural design to analyze the behaviour of an airplane under Aerodynamic loading

III. DESIGN & IMPLEMENTATION

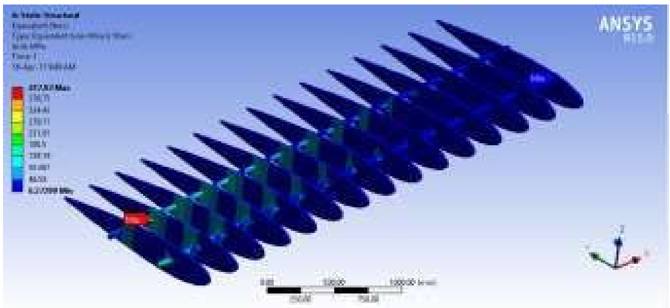
I. NACA 0016 wing structure

Material: al-7075

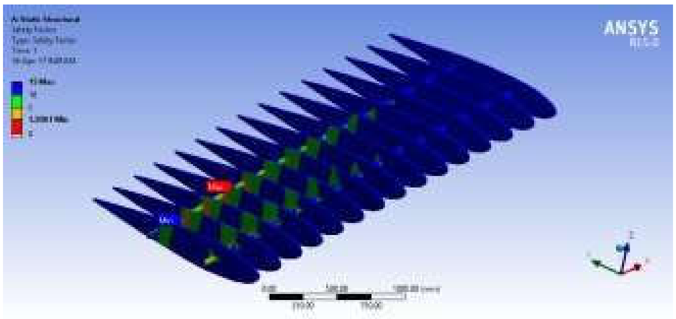
A. Deformation



B. Stress



C. Safety factor

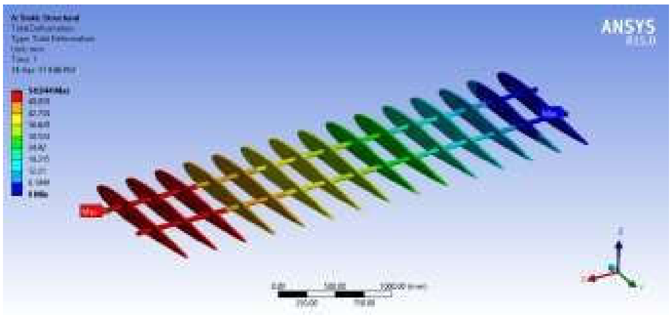


From the above results here we got maximum stress valueis 417.03Mpa and safety factor value is 1.2061 and generally we cannot eliminate complete stresses on the body but we can reduce it by changing design and material properties values. Here we took al-7075 material for both ribs and stringers. To decrease the stress and increase the strength to weight ratio here we changing materials, i.e we took another two materials those are CFRP and KEVLAR materials. Applying same amount of boundary conditions on it and calculated results

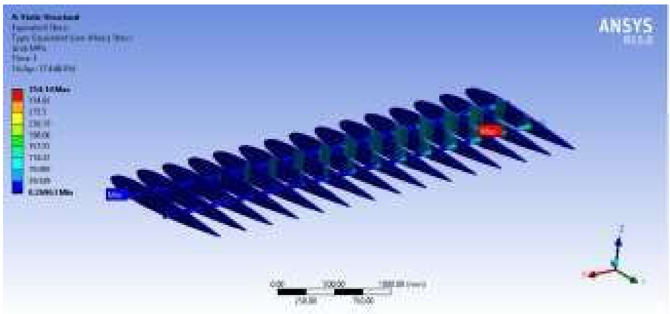
II. NACA 0012 wing structure

Material: al-7075

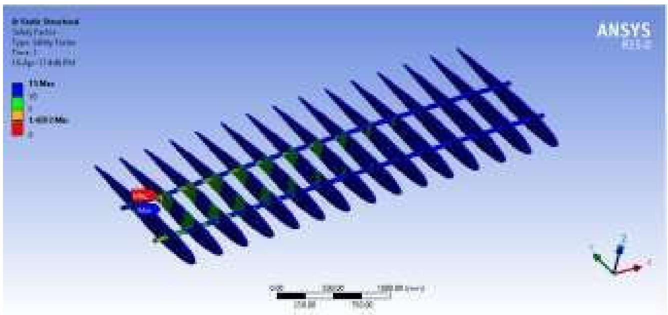
A. Deformation



B. Stress



C. Safety factor



From the above results here we got maximum stress value is 354.14Mpa and safety factor value is 1.4203 and generally we cannot eliminate complete stresses on the body but we can reduce it by changing design and material properties values. Here we took al-7075 material for both ribs and stringers. To decrease the stress and increase the strength to weight ratio here we changing materials, i.e we took another two materials those are CFRP and KEVLAR materials.

Applying same amount of boundary conditions on it and calculated results

IV. RESULTS:

Table 1: NACA 0016 wing structure

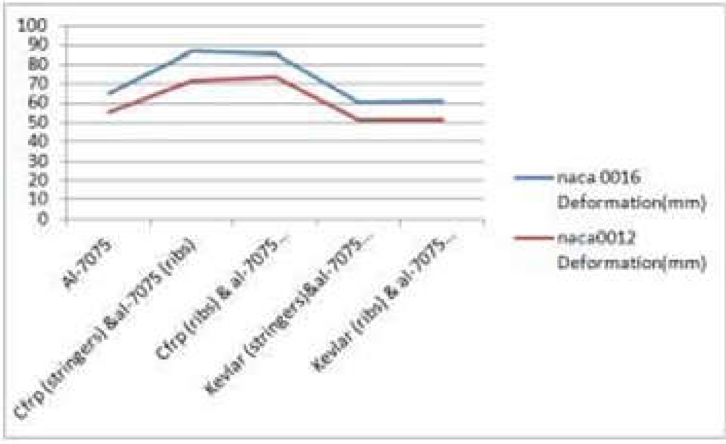
	Deformation (mm)	Stress (Mpa)	Safety factor
Al-7075	65.019	417.03	1.2061
Cfrp (stringers) & al-7075 (ribs)	86.797	434.27	1.1583
Cfrp (ribs) & al-7075 (stringers)	85.716	439.07	1.0796
Kevlar (stringers)&al-7075 (ribs)	60.447	409.77	1.2275
Kevlar (ribs) & al-7075 (stringers)	61.216	425.15	1.5289

Table 2: NACA 0012 wing structure

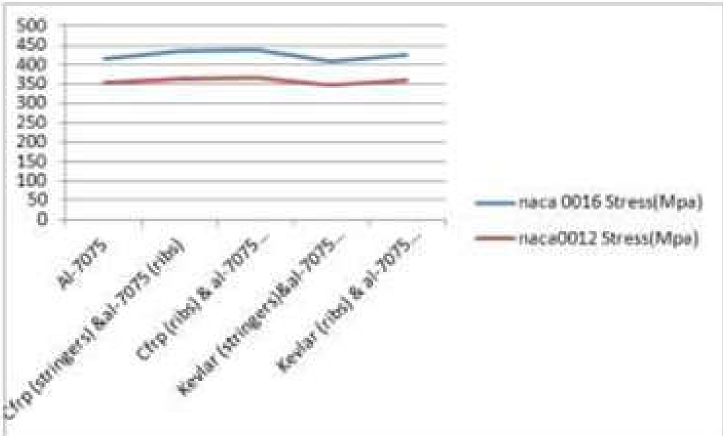
	Deformation(mm)	Stress (Mpa)	Safety factor
Al-7075	54.944	354.14	1.4203
Cfrp (stringers) &al-7075 (ribs)	71.549	362.63	1.3871
Cfrp (ribs) &al-7075 (stringers)	73.663	367.52	1.2897
Kevlar (stringers)&al-7075 (ribs)	51.436	347.85	1.446
Kevlar (ribs)& al-7075 (stringers)	51.303	360	1.8055

Comparison Between Two Wing Structures

A. Deformation

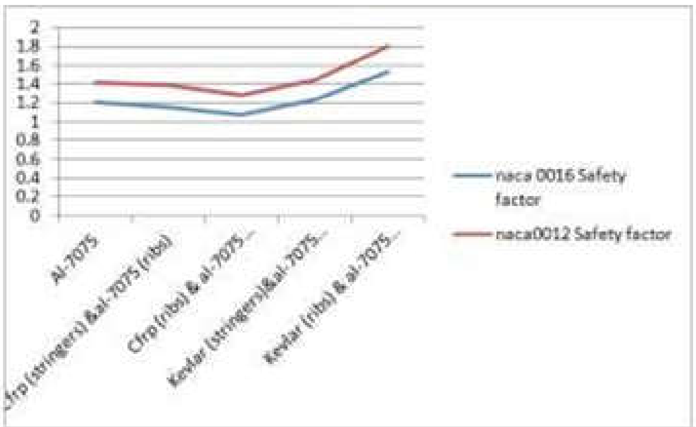


Graph 1: Deformation comparison b/w Naca 0016 & Naca 0012 Stress



Graph 2: Stress comparison b/w Naca 0016 & Naca 0012

B. Safety factor



Graph 3: Safety factor comparison b/w Naca 0016 &Naca 0012

V. CONCLUSION

In this project ultra light aircraft wing structure was developed by using CAD TOOL (CATIA) and analyzed with CAE TOOL (ANSYS WORK BENCH) , in this
project we took different wing structures those are NACA 0012 and NACA 0016 and calculated their maximum strength values. Here we consider al-7075 material as existing material for both structures and applied 14Mpa pressure on ribs and calculated results like deformation, stress, safety factor values. In this case NACA 0016 has huge stress (417.03Mpa) compared with NACA 0012 (354.14Mpa) structure. It means by using NACA 0012 wing structure we can reduce 63Mpa amount of stress it means the strength will increases. To get more efficient wing structure here we using composite materials also those are CFRP and KEVLAR. In this process first we apply CFRP to stringers and ribs (al-7075) then next CFRP (ribs) &al-7075 (stringers), andwe repeat same process for Kevlar &al-7075 materials forboth structures
From the results NACA 0012 wing structure has high strength to weight ratio in all these conditions, finally we can conclude that NACA 0012 wing structure with ribs (Kevlar) stringers (al-7075) materials will increase thestrength of the wing structure compare to existing material

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