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MANUFACTURING AND COMPUTATIONAL FLUID DYNAMIC ANALYSIS OF BLACK HAWK UH-60 ROTOR BLADE WITH MULTIPLE AIRFOIL SHAPES BY USING ANSYS FLUENT

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ABSTRACT

The rotor blades of a helicopter are air foils that provide aerodynamic forces when exposed to a relative motion of air across their surface. The rotational motion of the rotor hub initiated by the helicopter engine develops this relative motion, as well as forward, sideward and backward flight. While developing aerodynamics lift and drag forces, structural loads occur on the blades along their span and across their chord. A helicopter's rotor is generally made of two or more rotor blades.

In this project two rotor blades were developed with different air foil shapes (NACA SC1095 & SC1095R8) and analysed with both static loading conditions and to get more efficiency here materials also changing for each model, and calculating results like deformation, stress, strain, safety factor, values for each model and material separately and to produce better air foil shape here calculating velocity stream lines distribution over the air foil shape and pressure values and coefficient of lift and coefficient of drag values, by knowing all these results finally conclude one air foil shape/ material rotor blade to our black hawk uh-60. After completing this process object convert into stl file format to produce 3d printing model, and the 3d printing process also discussed clearly,

1. INTRODUCTION

A helicopter is a type of rotorcraft in which lift and thrust are supplied by rotors. This allows the helicopter to take off and land vertically, to hover, and to fly forward, backward, and laterally. These attributes allow helicopters to be used in congested or isolated areas where fixed-wing aircraft and many forms of VTOL (vertical takeoff and landing) aircraft cannot perform.

The English word helicopter is adapted from the French word hélicoptère, coined by Gustave Ponton d'Amécourt in 1861, which originates from the Greek helix (ἕλιξ) "helix, spiral, whirl, convolution and pteron (πτερόν) "wing". English language nicknames for helicopter include "chopper", "copter", "helo", "heli", and "whirlybird".

Helicopters were developed and built during the first half-century of flight, with the Focke-Wulf Fw 61 being the first operational helicopter in 1936. Some helicopters reached limited production, but it was not until 1942 that a helicopter designed by Igor Sikorsky reached full-scale production, with 131 aircraft built. Though earlier designs used more than one main rotor, it is the single main rotor with anti-torque tail rotor configuration that has become the most common helicopter configuration. Tandem rotor helicopters are also in widespread use due to their greater payload capacity. Coaxial helicopters, tiltrotor aircraft, and compound helicopters are all flying today. Quadcopter helicopters pioneered as early as 1907 in France, and other types of multi copter have been developed for specialized applications such as unmanned drones.

AIM OF THE PROJECT

The main aim of the project is to reduce the vibration of the helicopter rotor blade by changing the airfoil cross section and changing materials for each object. In this process design foil tool is used to generate naca sc 1095, naca sc 1095R8 air foil coordinates, after generating those coordinates imported into cad tool catia, and with the help of cae tool Ansys workbench knowing static and dynamic loading behaviour of each object,

Here 2 materials (cfrp, basalt fiber) were chosen to do analysing, from analysis deformation, stress, strain, safety factor, natural frequency values for real time boundary conditions, to know object vibrational values here need to what is their natural frequency values at each degrees of freedom. By knowing each frequency value for each object. After completing static and dynamic analysis process then calculate coefficient of lift and drag values, finally, project can conclude with optimum cross section with optimum material to reduce the vibration of the object

LITERATURE REVIEW

The earliest references for vertical flight have come from China. Since around 400 BC,Chinese children have played with bamboo flying toys. The bamboo-copter is spun by rolling a stick attached to a rotor. The spinning creates lift, and the toy flies when released. The 4th-century AD Daoist book Baopuzi by Ge Hong "Master who Embraces Simplicity" reportedly describes some of the ideas inherent to rotary wing aircraft. In 1861, the word "helicopter" was coined by Gustave de Ponton d'Amécourt, a French inventor who demonstrated a small, steam-powered model. While celebrated as an innovative use of a new metal, aluminum, the model never lifted off the ground.

D'Amecourt's linguistic contributionwould survive to eventually describe the vertical flight he had envisioned. Steam power was popular with other inventors as well. In 1906, two French brothers, Jacques and Louis Breguet, began experimenting with airfoils for helicopters.

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In 1907, those experiments resulted in the Gyroplane No.1. Although there is some uncertainty about the dates, sometime between 14 August and 29 September 1907, the Gyroplane No. 1 lifted its pilot into the air about two feet (0.6 m) for a minute. The Gyroplane No. 1 proved to be extremely unsteady and required a man at each corner of the airframe to hold it steady.

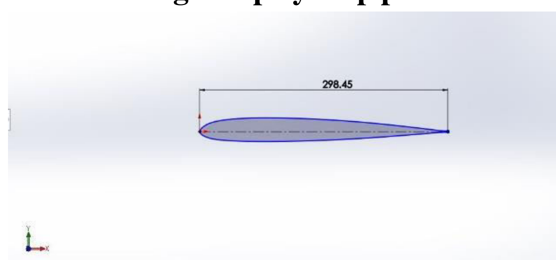
2. BLACK HAWK UH-60

The Sikorsky UH-60 Black Hawk is a four-bladed, twin-engine, medium-lift utility helicopter manufactured by Sikorsky Aircraft. Sikorsky submitted the S-70 design for the United States Army's Utility Tactical Transport Aircraft System (UTTAS) competition in 1972. The Army designated the prototype as the YUH-60A and selected the Black Hawk as the winner of the program in 1976, after a fly-off competition with the Boeing Vertol YUH-61.

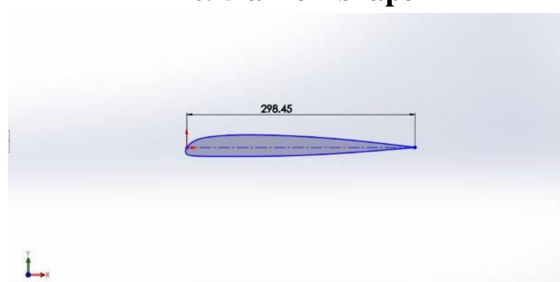
Named after the Native American war leader Black Hawk, the UH-60A entered service with the U.S. Army in 1979, to replace the Bell UH-1 Iroquois as the Army's tactical transport helicopter. This was followed by the fielding of electronic warfare and special operations variants of the Black Hawk. Improved UH-60L and UH-60M utility variants have also been developed. Modified versions have also been developed for the U.S. Navy, Air Force, and Coast Guard. In addition to U.S. Army use, the UH-60 family has been exported to several nations. Black Hawks have served in combat during conflicts in Grenada, Panama, Iraq, Somalia, the Balkans, Afghanistan, and other areas in the Middle East.

DESIGNING PROCESS STEP BY STEP

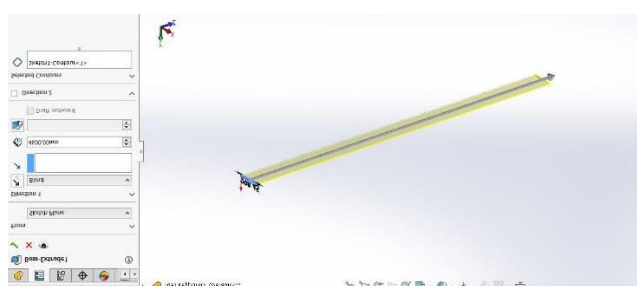
Design step by step process



1095 airfoil shape



1095-r8 airfoil shape



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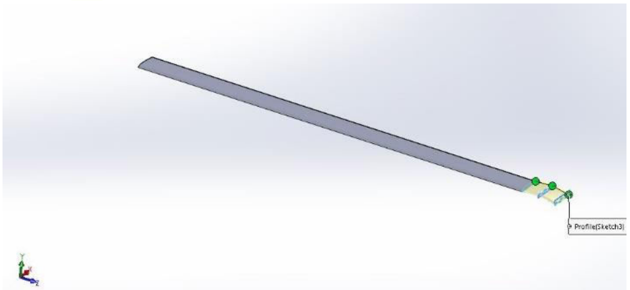
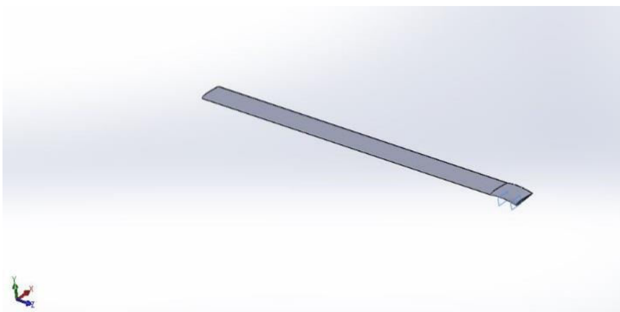
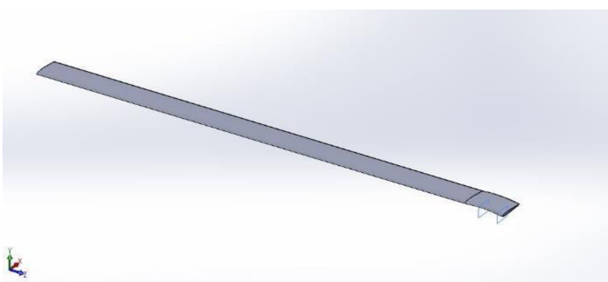




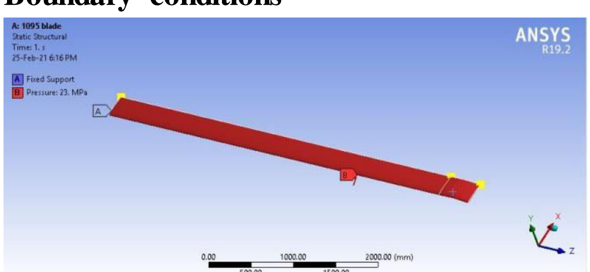
1095 r8 final model



1095 final model

Ansys process

Boundary conditions

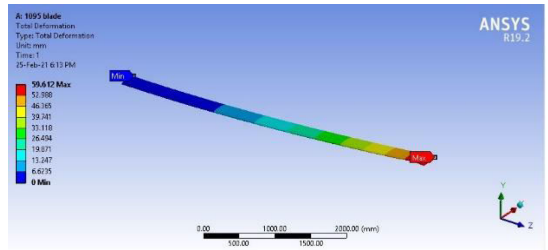


Select pressure and apply it on blade and then enter value as 23Mpa, on it, and then solve the results,

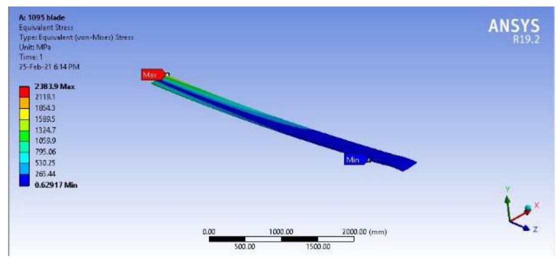
Naca sc1095 blade

Carbon fiber reinforced polymer

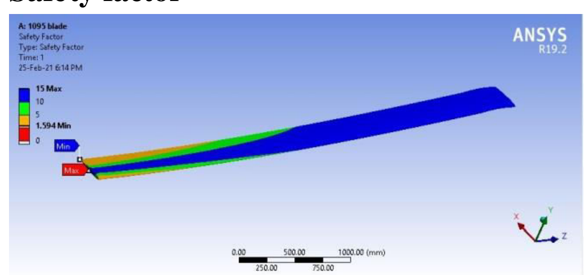
Deformation



Stress



Safety factor



Tables

Naca SC 1095 blade	Cfrp	Basalt fiber
Deformation (mm)	59.612	170.26
Stress (Mpa)	2383.9	2267.2
Strain	0.00090252	0.0024352
Safety factor	1.594	1.8737

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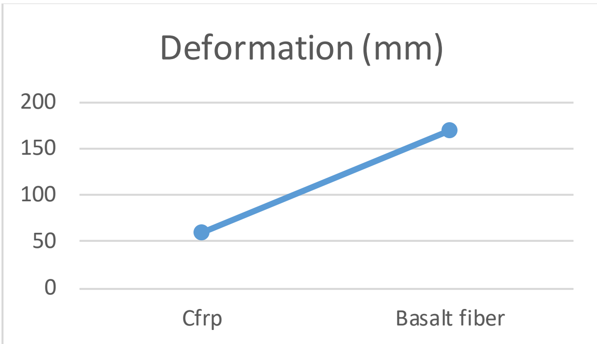
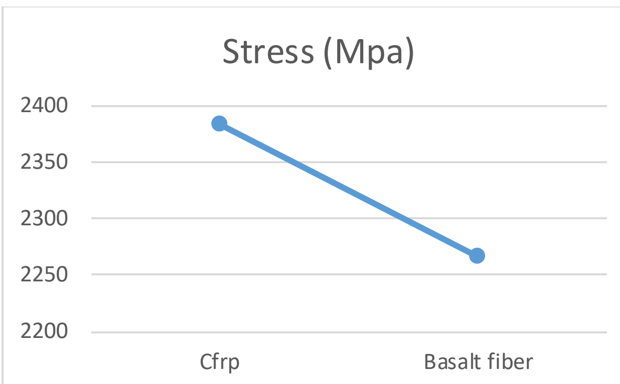
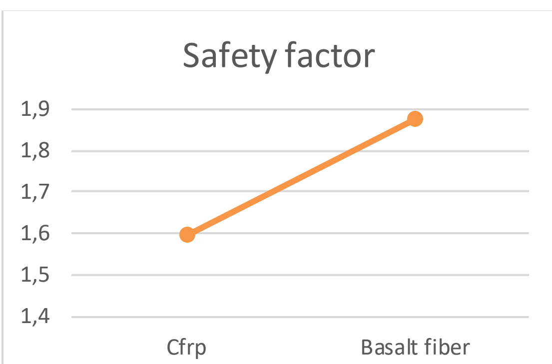
Graphs



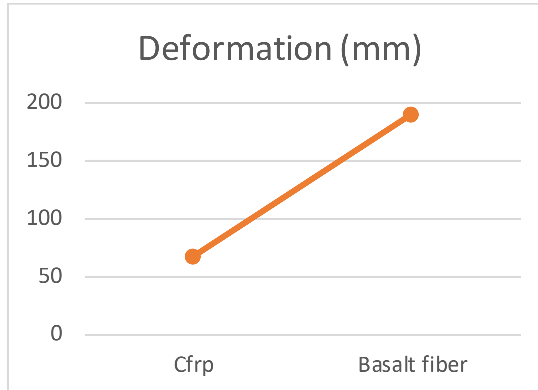


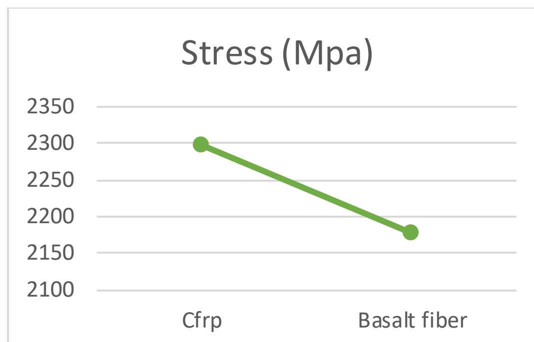


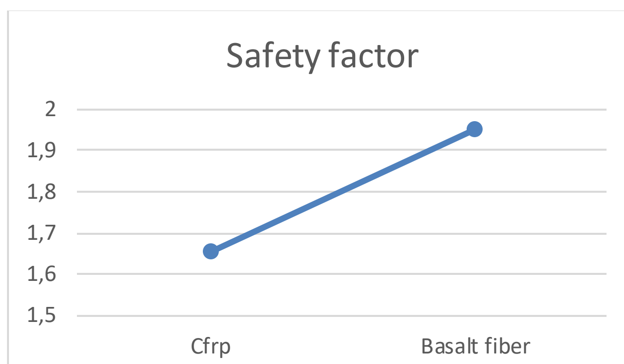
Tables

Naca SC 1095 R8 blade	Cfrp	Basalt fiber
Deformation (mm)	66.173	188.9
Stress (Mpa)	2297.2	2178.7
Strain	0.00086952	0.0023402
Safety factor	1.6542	1.9497

Graphs







Dynamic Analysis results

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Naca SC 1095 blade	Cfrp	Basalt fiber
MODE1 (Hz)	2.9103	5.9877
MODE2 (Hz)	18.231	37.504
MODE3 (Hz)	29.543	60.629
MODE4 (Hz)	51.017	104.93
MODE5 (Hz)	99.873	205.36
MODE6 (Hz)	118.41	229.24

Naca SC 1095-R8 blade	Cfrp	Basalt fiber
MODE1 (Hz)	2.9485	6.0664
MODE2 (Hz)	18.47	37.995
MODE3 (Hz)	29.958	61.48
MODE4 (Hz)	51.679	106.3
MODE5 (Hz)	101.15	207.98
MODE6 (Hz)	117.08	226.69

Conclusion

In this present work Black Hawk UH-60 helicopter rotor blade was designed with two different cross sectional shapes (NACA SC1095, NACA 1095R8) by using cad tool solid works and the model completely developed based on real dimensions, in this process to suggest a good model/material for uh-60 here both static and dynamic analysis process was done with 2 materials (CFRP, basalt fibre). With the help of Ansys work bench both static and dynamic behaviour of air foil shapes were calculated, from static analysis results cfrp material with naca sc 1095 blade series can withstand up to 23 Mpa pressure on it without any breakage, when air foil sc1095R8 were replaced the object strength will increasing nearly 3% to 5% for same material, but when cfrp material is replaced with basalt fibre material overall strength will increases nearly 25% to 40%. From dynamic analysis results naca sc-1095R8 blade is having high vibration frequency range values, and finally thesis can conclude with naca sc1095r8 blade with basalt fibre is optimum than naca 1095 blade with cfrp structure

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