e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:02/Issue:08/August-2020 Impact Factor- 5.354 www.irjmets.com

# DESIGN AND ANALYSIS OF HELICOPTER TURBOPROPELLERS ROTOR USING BLUE EDGE BLADE TECHNOLOGY

**Dr. M. Subramanian**[*1], **X. Bernadette Evangeline**[*2], **Suchitra. M**[*3], **Swetha. D**[*4], **Hari Krishnan. V**[*5]

[*1,2] Professor, Department of Aeronautical engineering, SNS college of Technology, Coimbatore, TamilNadu, India.

[*3,4,5]Students, Department of Aeronautical engineering, SNS college of Technology, Coimbatore, TamilNadu, India.

## ABSTRACT

A rotorcraft empowers the framework to take off and land vertically determined by the motor, it uses an unpowered rotor, driven by streamlined powers (lift, push ,drag, weight) in a condition of autorotation to create lift, and a motor controlled propeller, like that of a fixed-wing airplane, to give push. The impact is a rotorcraft working in a more proficient way than the freewheeling rotor of an autogyro in autorotation, limiting the unfriendly impacts of withdrawing edge slow down of helicopters at higher velocities. Impetus framework incorporates turbo-prop motors as it gives higher perseverance to the ideal state and adding to the fluctuates activity conditions. Headway in flying has lead individuals in flourishing for an altered variant of artworks which meets experimental method of activity that fits in their pocket as well. The primary topic of our undertaking is to build the productivity of the rotor by adjusting the edge profile which empowers in higher perseverance. Then again planning of improved sharp edge profile hence bringing about higher clamor decrease. Financially we tend in commercializing these edges to teach a possible vehicle mode for the travelers through improvement of very good quality rotorcraft.

**Keywords:** Aerodynamic force, rotorcraft, blade profile, high endurance, noise reduction.

## I. INTRODUCTION

The commotion created by rotorcraft and got by onlookers in the far-field mirrors the unpredictability of the streamlined condition where these airplane work. Numerous sources are included (primary and tail rotors, motor, transmission), and every one of these sources fluctuate contrastingly in level, recurrence substance, and directivity as indicated by the flight condition. For a long time, it has been perceived that the one of the most punishing commotion source is Blade-Vortex Interactions (BVI), which produces boisterous, hasty, and emphatically mandate clamor chiefly during diving flight conditions. BVI results from the communication of the vortices made by the fundamental rotor cutting edges with its own edges.

A regular BVI happens when a sharp edge tip vortex shed in the subsequent quadrant is affected by an after cutting edge in the main quadrant . This kind of propelling side BVI is very punishing a result of the high Mach numbers experienced by the cutting edge on the propelling side. The clamor ordinarily proliferates proficiently toward the front of the rotor, either toward the progressing or withdrawing sides. Associations can likewise happen on the withdrawing side, where tip vortices shed in the third quadrant are affected by a cutting edge in the fourth quadrant. These co-operations proliferate rearward of the rotor.

The fundamental boundaries overseeing BVI commotion are the quality and size of the vortices produced by the cutting edge, which is for the most part determined by the stacking dissemination and the speed at the edge tip. the edge/vortex 'miss-separation' which is the separation in the vertical plane between the cutting edge and the vortex and which is primarily represented by the initiated speed through the rotor. the math of communication in the rotor circle plane, or how the vortices are situated regarding the sharp edge at the hour of cooperation, and which is a capacity rotor speed and advance proportion. Structure arrangements planned for diminishing BVI commotion along these lines focus on an adjustment of these three boundaries, either through aloof advancements (sharp edge planform, tip shape, curve, airfoil appropriation, and so forth), through dynamic innovations (higher symphonious control, singular cutting edge control), or through an alteration of the airplane trim (clamor reduction methods). This paper centers around a uninvolved clamor decrease component dependent on a change of the edge planform.

## II. PROBLEM IDENTIFICATION

1. To produce high lift
2. To raise endurance
3. To reduce noise generated

## III. PROPOSED SYSTEM PROGRESS

1. Selection of airfoil

2. Proposed technology

3. Modeling of proposed blade design (CAD model) was designed by CATIA V5

4. Using ANSYS 16.0 the flow analysis of proposed airfoil design is done.

### 3.1 SELECTION OF AIRFOIL

An airfoil or aerofoil is the cross-sectional shape of a wing, blade (of a propeller, rotor, or turbine), or sail (as seen in cross-section).

An airfoil-formed body traveling through a liquid creates a streamlined power. The part of this power opposite to the course of movement is called lift. The part corresponding to the heading of movement is called drag. Subsonic flight airfoils have a trademark shape with an adjusted driving edge, trailed by a sharp following edge, frequently with a symmetric ebb and flow of upper and lower surfaces. Foils of comparable capacity structured with water as the working liquid are called hydrofoils.

The lift on an airfoil is essentially the consequence of its approach. At the point when arranged at a reasonable edge, the airfoil avoids the approaching air (for fixed-wing airplane, a descending power), bringing about a power on the airfoil toward the path inverse to the diversion. This power is known as streamlined power and can be settled into two segments: lift and drag. Most foil shapes require a positive approach to create lift, however cambered airfoils can produce lift at zero approach. This "turning" of the air in the region of the airfoil makes bended smoothes out, bringing about lower pressure on one side and higher weight on the other. This weight contrast is joined by a speed distinction, through Bernoulli's standard, so the subsequent stream field about the airfoil has a higher normal speed on the upper surface than on the lower surface. The lift power can be connected legitimately to the normal top/base speed distinction without figuring the weight by utilizing the idea of course and the Kutta–Joukowski hypothesis.

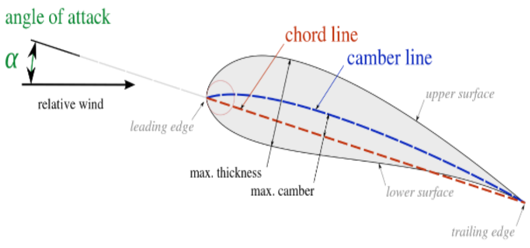

**Fig-3.1.1 :** Airfoil nomenclature

**NACA Airfoil**

The NACA airfoil are the airfoils utilized in airplane wings created by the National Advisory Committee for Aeronautics (NACA). The state of the NACA airfoils is depicted utilizing a progression of digits following "NACA". The boundaries in the numerical code can be gone into conditions to unequivocally produce the cross-area of the airfoil and figure its properties. The early NACA airfoil arrangement, the 4-digit, 5-digit, and altered 4-/5-digit, were produced utilizing scientific conditions that portray the camber (arch) of the mean-line (mathematical centreline) of the airfoil segment just as the area's thickness circulation along the length of the airfoil. Later families, including the 6-Series, are more entangled shapes inferred utilizing hypothetical instead of mathematical strategies. Prior to the National Advisory Committee for Aeronautics (NACA) built up these arrangement, airfoil configuration was fairly self-assertive with nothing to manage the planner aside from past involvement in known shapes and experimentation with adjustments to those shapes.

**NACA Four-Digit Series**

The first family of airfoils designed using this approach became known as the NACA Four-Digit Series. The first digit specifies the maximum camber (m) in percentage of the chord (airfoil length), the second indicates the position of the maximum camber (p) in tenths of chord, and the last two numbers provide the maximum thickness (t) of the airfoil in percentage of chord.

For example, the NACA 2415 airfoil has a maximum thickness of 15% with a camber of 2% located 40% back from the airfoil leading edge (or 0.4c).

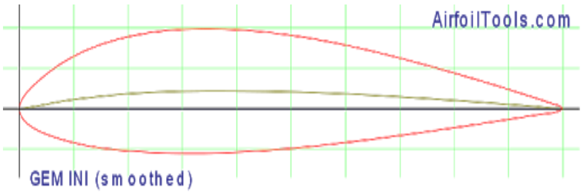

**Fig-3.1.2:** NACA 2415 airfoil

**ADVANTAGES**

1. Good stall characteristics
2. Small center of pressure movement across large speed range
3. Roughness has little effect.

**DISADVANTAGES**

1. low maximum lift coefficient
2. relatively high drag
3. low pitching moment.

**NACA Five-Digit Series**:

The NACA Five-Digit Series utilizes a similar thickness structures as the Four-Digit Series however the mean camber line is characterized diversely and the naming show is more mind boggling. The principal digit, when duplicated by 3/2, yields the structure lift coefficient (cl) in tenths. The following two digits, when partitioned by 2, give the situation of the most extreme camber (p) in tenths of harmony. The last two digits again show the most extreme thickness (t) in level of harmony.

For instance, the NACA 23012 has a most extreme thickness of 12%, a structure lift coefficient of 0.3, and a greatest camber found 15% back from the main edge.

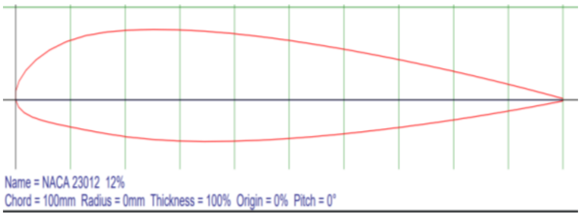

**Fig-3.1.3:** NACA 23012

**ADVANTAGES**

1. Higher maximum lift coefficient
2. Low pitching moment
3. Roughness has little effect

## DISADVANTAGES

1. Poor stall behavior
2. Relatively high drag

## ONERA AIRFOIL

In 1974 the ONERA and AEROSPATIALE undertook jointly a research program to increase helicopter rotor aerodynamics and to design optimised the blade in order to improve the rotor performance to develop the new machine. Eg : ONERA 209 nomenclature

Maximum thickness 9% at 29.3% chord

Maximum chamber 1.6% at 17.1% chord

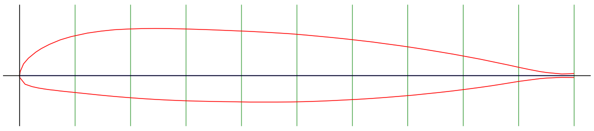

**Fig-3.1.4:** ONERA 209 airfoil

## SELIG 1223 AIRFOILS

Under cambered airfoils, as S1223, have the best proportion of producing an incredibly high lift at least stream speed activity, and furthermore this high lift is created at low approaches. Created in a hydrofoil. Negative upper surface weight (pull) and positive lower surface weight. Selig S1223 high lift low Reynolds number airfoil. Consequently is appropriate for substantial lift payload planes. The lift power prerequisite is higher in freight planes as it needs to lift substantial burdens. This is accomplished by high lift coefficient. The speed prerequisite in load planes is lesser when contrasted with sports plane. Because of lesser speed the drag power is less even if there should arise an occurrence of high drag coefficient.

Selig 1223 nomenclature

Maximum thickness 12.1% at 19.8% chord.

Maximum camber 8.1% at 49% chord

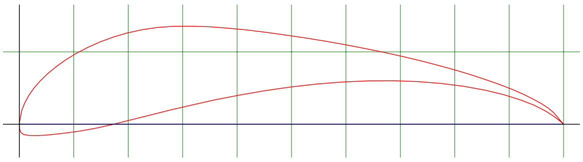

**Fig -3.1.5:** Selig 1223 airfoil

**Table 3.1** The Comparison of NACA4412 and S1223 Airfoil

| NACA 4412 airfoil | | | | S1223 airfoil | | |
|---|---|---|---|---|---|---|
| **Angle of Attack (Degree)** | **Cl (coefficient of lift)** | **cd (coefficient of drag)** | **cl/ cd** | **cl** | **cd** | **cl/c d** |
| 0 | 0.22 | 0.05 | 4.4 | 0.82 | 0.09 | 8.28 |
| 5 | 0.67 | 0.07 | 9.57 | 1.26 | 0.15 | 8.07 |
| 10 | 0.88 | 0.13 | 6.47 | 1.7 | 0.25 | 6.84 |
| 15 | 1.25 | 0.22 | 5.58 | 2.13 | 0.38 | 5.61 |

### DISADVANTAGE

While it is a high lift design it is under cambered and that would be harder to work with during the build and covering. Possibly a little less durable. It has a thin trailing edge which would be more likely to get damaged.

### EPPLER AIRFOIL

The Eppler 423 profile is a high lift, low speed wing profile. A cross-sectional drawing is shown in figure 3.7 . For comparison a cross-section of a NACA 2415 wing profile is shown in figure 3.3. It is clear that the Eppler wing section has a much higher camber which can offer much more lift than the NACA wing. The Eppler 423 has a much higher lift coefficient than the NACA profile and the drag coefficients are comparable for the range of angle of attack. Also, the stall condition for the Eppler is at a higher angle of attack and post-stall angles have a much lower effect on the Eppler performance than on the NACA 2418. Note the abrupt drop in lift coefficient for the NACA profile at the onset of stalling. This testing was run at Pitotstatic pressures of 5 inches of water (about 100 miles per hour) for the Eppler wing and 9 inches of water (about 135 miles per hour) for the NACA wing (running the Eppler wing profile at 9 inches would have exceeded the ratings of the test instruments). Clearly the Eppler profile has significantly more lift capability than the NACA 2418. These tests were run at wind velocities that are realistic for low speed aircraft, and also realistic for wind turbine blades with at high tip speed ratios, as desired for best turbine performance. These results caused interest in considering the Eppler 423 wing profile for a wind turbine and were the basis for testing the Eppler 423 profile as wind turbine blade profile.

### AIRFOIL NOMENCLATURE

Maximum thickness 12.5 % at 23.7 % of chord

Maximum camber 9.5% at 41.4% of chord

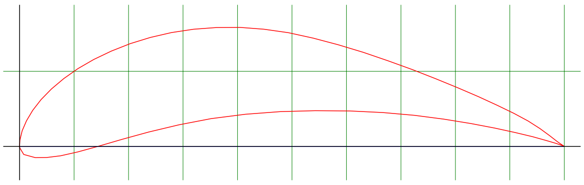

**Fig-3.1.6:** Eppler 423 airfoil

**Table-3.2:** Comparison of various types of airfoil to find CL,CD,CM

| Airfoil | CL max | CD @ Clmax | CM @ Clmax |
|---|---|---|---|
| ch10sm | 1.98 | 0.028 | -0.21 |
| E420 | 2.16 | 0.038 | -0.17 |
| E421 | 2.01 | 0.033 | -0.12 |
| E422 | 1.88 | 0.028 | -0.08 |
| E423 | 2.03 | 0.028 | -0.18 |
| NACA 7413 | 1.54 | 0.038 | -0.05 |
| Selig 1223 | 2.2755 | 0.028 | -0.017 |

From the table 3.2 we can find the airfoil which can produce high lift coefficient ,drag coefficient and coefficient of oment , but some airfoil produce similar values such as E421, E423,Selig1223. So to find the best airfoil not only produce lift, endurance and less drag and also it should be easy to manufacture, further testes are done to check the performance of flight that results are compared and tabulated according to there performances.

**Table 3.3:** Comparison of performance, strength and manufacturability of airfoil:

| Airfoil | Airfoil Criteria Ratings | | |
|---|---|---|---|
| | Excellent=5, Very good=4, Good=3, Fair=2, Poor=1 | | |
| | Aero Performance | Strength | Manufacturability |
| Eppler 421 | 4 | 3 | 3 |
| Eppler 423 | 4 | 4 | 4 |
| Selig 1223 | 5 | 2 | 1 |

By comparing various airfoils of NACA series like four digit series NACA2415, NACA7413 five digit series like NACA23012 and some lifting airfoil like Selig1223,ONERA209,Eppler421,Eppler423,Eppler420. We finally conclude by selecting EPPLER 423 airfoil for our project which has high aerodynamic performance, strength and manufacturability compared to other airfoil.

### 3.2 Proposed technology – BLUE EDGE BLADE TECHNOLOGY

Blue Edge is another type of helicopter rotor cutting edge created by Eurocopter and disclosed at the Heli-Expo in Houston, Texas. The organization asserts that tests they have done show the sharp edge decreases the clamor delivered by a helicopter by three to four decibels. Eurocopter alludes to the edges as a major aspect of their new scope of "Bluecopter" innovation. The Blue Edge rotor was first planned at Onera and DLR during the ERATO program.

Divulging its Blue Edge propelled rotor sharp edge at the current week's Heli-Expo show in Houston, Eurocopter says flight tests have demonstrated the "twofold compass" tip can divide a helicopter's commotion profile on the plummet. The structure decreases the clamor produced by cutting edge vortex collaboration (BVI), the trademark throbbing sound made when the tip of a rotor edge hits the vortex shed by the tip of the previous sharp edge. Eurocopter says the Blue Edge tip shape gives more opportunity for the communication between the edge and vortex, weakening the noice.

**Fig-3.2.1:** Blue edge blade

A five-sharp edge Blue Edge rotor has been in flight test since July 2007 on an EC155 testbed, logging 75 flight hours and exhibiting commotion decreases of 3-4dB, the European producer says, including that the plan is currently prepared to move into creation.

Pretty much every helicopter administrator is very acquainted with clamor grievances. Regardless of whether it be the neighborhood news helicopter or even a clinical helicopter, numerous individuals on the ground don't care for the sound made by turning wing airplane. This week Eurocopter divulged its latest exertion to decrease helicopter commotion with the radical-looking Blue Edge rotor sharp edge. The new sharp edge has been tried on one of the organization's EC155 helicopters and was appeared to decrease clamor 3 to 4 decibels, as per the organization.

Notwithstanding the Blue Edge rotor cutting edge, the organization additionally presented something many refer to as Blue Pulse innovation. Additionally intended to lessen helicopter clamor, the Blue Pulse framework utilizes three fold modules in the following edge of every rotor sharp edge. Piezoelectric engines move incite the folds 15 to 40 times each second in diminish the "slap commotion" regularly heard when a helicopter is plummeting. Both of these advances can diminish commotion by limiting the cutting edge vortex cooperation of the principle rotor on a helicopter. Cutting edge vortex cooperation is the wellspring of the throbbing sound the vast majority of us know about when helicopters fly overhead. The commotion is made when a rotor sharp edge hits the wake vortex deserted from the cutting edge before it.

**BLADE VORTEX INTERACTION:**

An edge vortex collaboration (BVI) is a shaky wonder of three-dimensional nature, which happens when a rotor sharp edge goes inside a closeness of the shed tip vortices from a past cutting edge. The streamlined co-operations speak to a significant subject of examination in rotorcraft research field because of the unfavourable impact delivered on rotor commotion, especially in low speed plummeting flight condition or move, which creates high sufficiency imprudent clamor.

Eurocopter's Blue Pulse innovation is a functioning commotion/vibration dropping framework that utilizes piezoelectric actuators to control following edge folds on every rotor cutting edge.

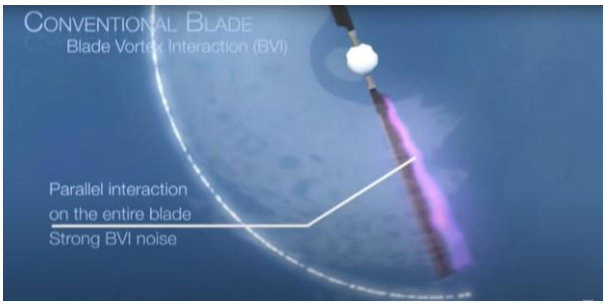

**Fig 3.2.2:** BVI of conventional blade

Piezoelectric actuators can change their shape when an electrical voltage is applied, and impel those folds at 15-40 times each second, viably flying it over-top or down and under the moving toward vortex with each transformation, significantly diminishing sent commotion and vibration. Eurocopter has announced a 5-decibel decline with the framework.

These strategies for BVI decrease have been around for some time, however just currently are they making their mark. The consistent advancement of materials innovation is the thing that has permitted this to be so. The unusual state of the Blue Edge rotor would torment engineers with troublesome bowing and curving burdens that attempt to contort the state of the sharp edge in flight, were it not for the coming of composite materials that can oppose such aeroelastic impacts. With Blue Pulse, piezoelectric actuators made generally of clay light-weight materials and for all intents and purposes no mechanical parts have demonstrated to be powerful while living in the high-g, oscillatory condition of the turning rotor; something that has since a long time ago upset before ventures investigating dynamic sharp edge control.

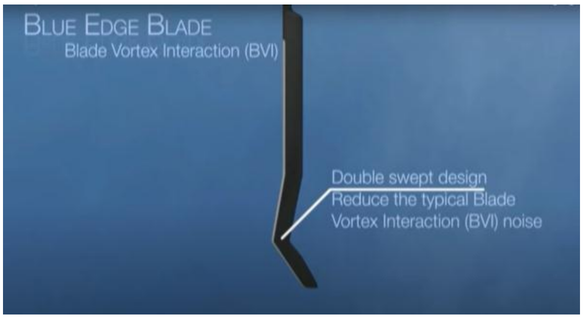

**Fig-3.2.3:** BVI of blue edge blade

Blue Edge™ fundamental rotor cutting edge has a twofold cleared shape to change the sharp edge vortex association (BVI) that happens at the tip of any helicopter edge – essentially diminishing clamor levels made during a commonplace drop profile. higher-pressure air will spill free from a rotor sharp edge at the tip, get sucked toward its upper surface, and make a solid twisting twirl of air, or tip vortex a moving toward edge will regularly come into the region of a tip vortex left by a first cutting edge. At the point when the high-vitality whirling air strikes the rotor cutting edge, it causes an unexpected change in approach and a related change in pressure on the outside of the sharp edge. This is the thing that makes the uproarious imprudent commotion that can be irritating to those on the ground.

On the off chance that the cutting edges are planned in such away that the weight change because of the BVI is diminished, the clamor can be decreased. This is the explanation behind the contrasting states of present day helicopter edge tips. A genuine model is the Eurocopter Blue Edge idea, which Airbus claims diminishes commotion by 3-4 dB.

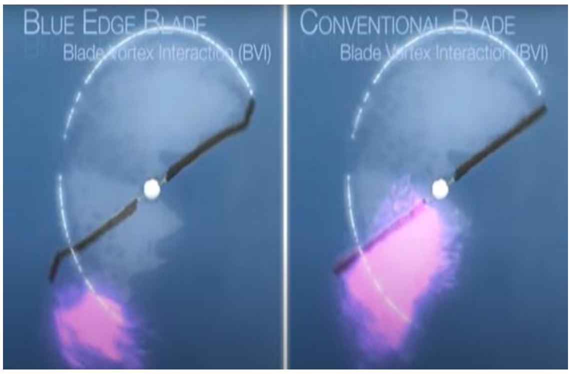

**Fig-3.2.4:** Comparison of blades BVI

This noise reduction technology has been validated flight trials using a five-blade Blue Edge™ main rotor on an EC155, showing a 3-4 dB noise reduction.

### 3.3 Proposed Design geometry

The design and specification which we are taken from the helicopter which we are selected to modify the design is the Eurocopter EC145. The Eurocopter EC145 entire geomentry was taken and also discussed in the above section so by considering certain dimensions like rotor diameter and length and chord length we can design our own blade design with these dimensions and airfoil.

Eurocopter EC145 geomentry

**Main rotor diameter:** 11 m (36 ft 1 in)

**Main rotor area:** 95 $m^2$ (1,020 sq ft)

**Chord :** 0.32 m(1.05 ft)

By considering the rotor diameter and chord length

The main rotor diameter=11m that is equal to 5.5m blade length each side and chord length is 0.32m.

To find the ratio between span and chord = $\frac{s}{c} = \frac{11m}{0.32m} = 17.1$

Therefore span is 17.1 times the chord applying this ratio in our airfoil Eppler 423 gives the chord length = 99.998~100mm

$\therefore$ span of the new blade = c*17.1 = 1710mm

As a result considering the straight helicopter blade and modifying it by using the blue edge blade technology, we attain

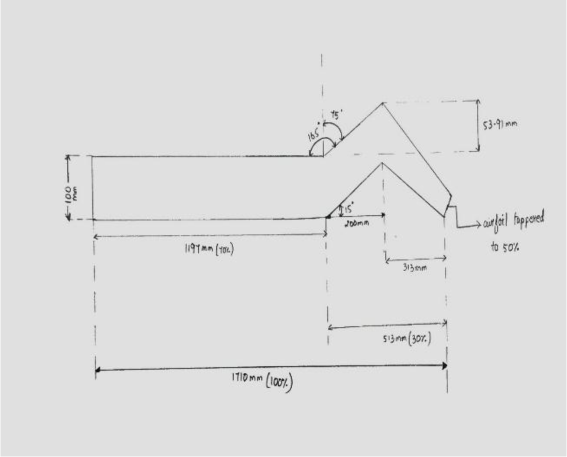

**Fig-3.3.1:** Proposed geomentry ( using blue edge blade geomentry in straight blade)

### 3.3.1CAD MODELING

PC supported plan (CAD) is the utilization of PCs (or workstations) to help in the creation, change, investigation, or advancement of a design. CAD programming is utilized to expand the profitability of the originator, improve the nature of configuration, improve interchanges through documentation, and to make a database for assembling. Computer aided design is a significant modern craftsmanship broadly utilized in numerous applications, including car, shipbuilding, and aviation enterprises, mechanical and compositional plan, prosthetics, and some more. Computer aided design is likewise broadly used to deliver PC movement for enhancements in motion pictures, promoting and specialized manuals, regularly called DCC advanced substance creation. The cutting edge pervasiveness and intensity of PCs implies that even fragrance containers and cleanser distributors are planned utilizing methods incredible by architects of the 1960s. In view of its tremendous monetary significance, CAD has been a significant main impetus for research in computational math, PC illustrations (both equipment and programming), and discrete differential calculation.

The CAD modelling which we are using for our project is **CATIA-V5.**

Commonly referred to as a 3D Product Lifecycle Management software suite, CATIA supports multiple stages of product development (CAx), including conceptualization, design (CAD), engineering (CAE) and manufacturing (CAM). CATIA facilitates collaborative engineering across disciplines around its 3DEXPERIENCE platform, including surfacing & shape design, electrical, fluid and electronic systems design, systems engineering.

CATIA encourages the plan of electronic, electrical, and appropriated frameworks, for example, liquid and HVAC frameworks, right to the creation of documentation for assembling.

**Proposed geometry using catia-v5 software**:

1.Selected airfoil ( Eppler 423) using CATIA-V5

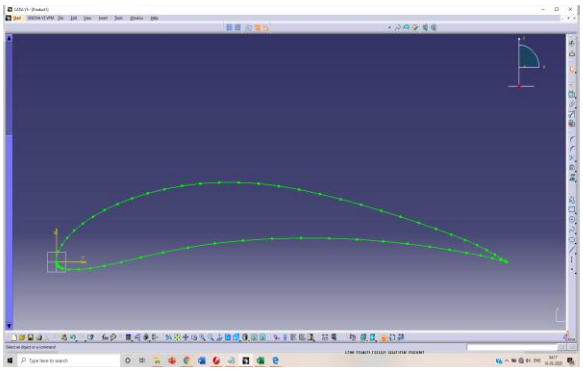

**Fig-3.3.2:** Eppler 423 airfoil

This airfoil was selected for higher lift coefficient and less drag coefficient it produce high Cl max compare with other airfoil like NACA 4 digit and five digit airfoils. It has not only the the high Cl max also it has strength and also it is compared with the high lift producing airfoil like selig1223 in the manufacturability Eppler423 high manufractibility than the selig airfoil because in the selig 1223 airfoil the closing end is more curved and it can be easily damaged or broken while turning into the wing or blade which has high span length.

2. Selected airfoil to straight blade using CATIA-V5

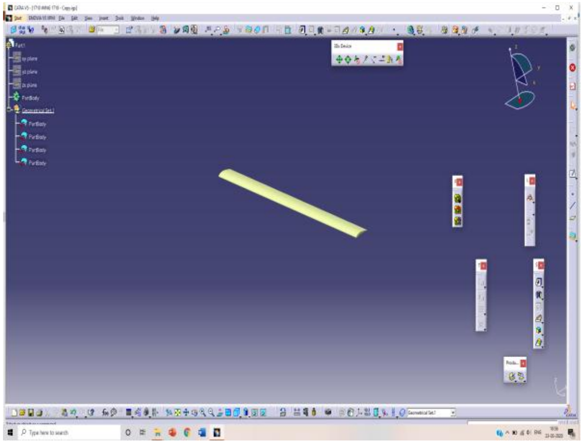

**Fig-3.3.3:** straight blade without modification

3. Proposed geometry using CATIA-V5

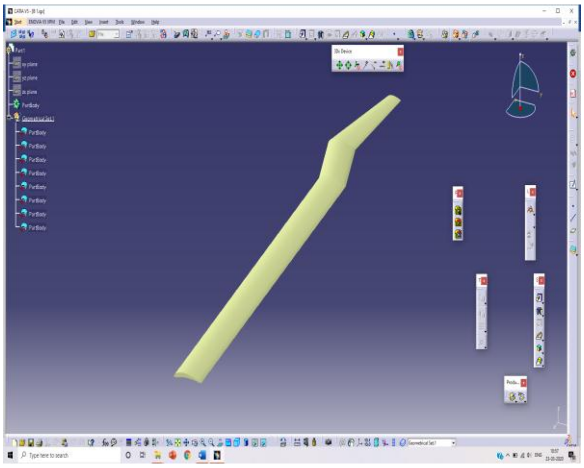

**Fig .3.3.4:** Proposed design geometry

The proposed design geometry is achieved by talking the straight blade made using the given the dimension and giving the change in the body of the blade. To make the change in the design the new technology was used is the blue edge blade technology by using this technology toward the narrow tip of the blade there will be a swept back design applied. This is used to produce high lift during the forward flight and less drag occurred. The main motive is to reduce the noise produced while take off of the helicopter this can be solved by using this proposed geometry of the blade using the blue edge blade technology. So the required design is obtained as a model using the CAD software. The CAD software used to obtain this model is CATIS-V5.

### 3.4 comparison of aerodynamic performance of different airfoils

A sensible determination of high lift and low Reynolds number airfoil is significant piece of streamlined structure process for this sort of low speed UAV. In this examination work, various high lift airfoils appropriate for low Reynolds number system and high lift limit like EPPLER ( E423, E421, E420), SELIG ( S1223, S1223rtl, S2027), WORTMANN (FX74-CL5-140, FX63_137), AG35, NLF 0115, are mulled over for investigation by utilizing computational examination. As the accessibility of air stream is uncommon and the expense of air stream test is unquestionably more costly than recreation based examination, here we are utilizing a calculation based business programming which incorporates the program for foil investigation, and a few 3d examination strategies for planes, for example, a non-straight lifting line strategy for independent wings and two vortex-cross section and a 3d board technique for the examination of streamlined execution of wings and plane working at low Reynolds numbers.

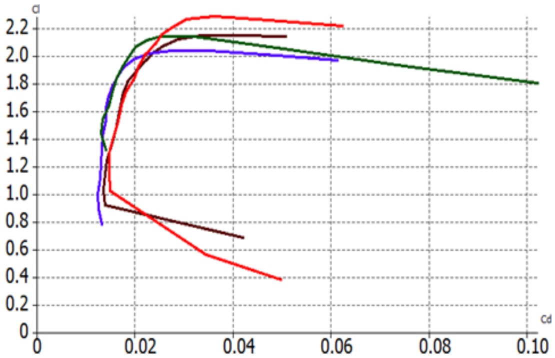

**Fig:3.4.1** $C_L$ vs $C_d$ Graph

The staying ones were analyzed by their drag polar at same Re as appeared in Figure-7 which decreased the rundown to E420, E423, FX74-CL5-140and S1223 as these acquire less drag punishments in the working CL extend (1.4-2.0). It offers more extensive speed range and along these lines would be less influenced by slight mistakes of flying.

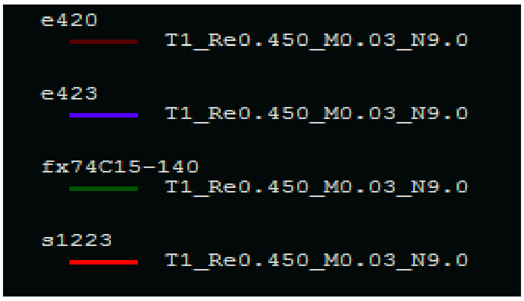
e420
T1_Re0.450_M0.03_N9.0
e423
T1_Re0.450_M0.03_N9.0
fx74C15-140
T1_Re0.450_M0.03_N9.0
s1223
T1_Re0.450_M0.03_N9.0

**Fig:3.4.2 :** Reference lines for different airfoil

The Eppler 423 has a much higher lift coefficient than the NACA profile and the drag coefficients are comparable for the range of angle of attack. Also, the stall condition for the Eppler is at a higher angle of attack and post-stall angles have a much lower affect on the Eppler performance than on the NACA 2418. Note the abrupt drop in lift coefficient for the NACA profile at the onset of stalling. This testing was run at Pitot- static pressures of 5 inches of water (about 100 miles per hour) for the Eppler wing and 9 inches of water (about 135 miles per hour) for the NACA wing (running the Eppler wing profile at 9 inches would have exceeded the ratings of the test instruments). Clearly the Eppler profile has significantly more lift capability than the NACA 2418. These tests were run at wind velocities that are realistic for low speed aircraft, and also realistic for wind turbine blades with at high tip speed ratios, as desired for best turbine performance.

### 3.4.1 analysis results of Eppler 423 airfoil at different AOA

The analysis results of selected airfoil Eppler 423 is given below as figure 4.1 . These picture represent velocity contour of airfoil Eppler 423 with different angle of attack (AOA) like -4°,0°,-4°,8°,12°,16°.

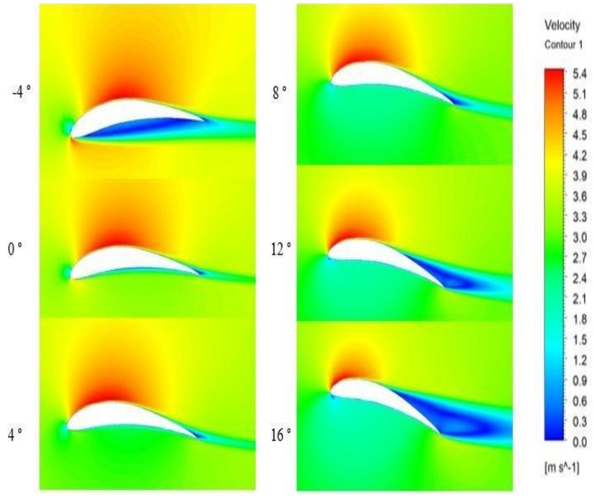

**Fig-3.4.1.1 :** Eppler 423 velocity contour

The analysis results of selected airfoil Eppler 423 is given below as figure 4.2. These picture represent pressure contour of airfoil Eppler 423 with different angle of attack (AOA) like -4°,0°,-4°,8°,12°,16°.

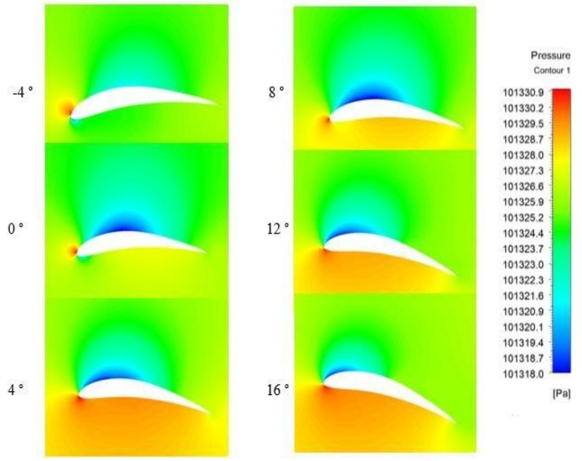

**Fig 3.4.1.2:** Eppler 423 airfoils pressure contour

## IV. DETAILD DISCRIPTION OF ANALYSIS OF PROPOSED BLADE

**Input parameters**

Input velocity : 35 m/s

Air density : 1.225 kg/m$^3$

Gauge pressure : 0

Static pressure : 101325 pa

Temperature : 298k

Viscosity : $1.7894*10^{-5}$kg/m$^{-s}$

Iteration : 100

Area : 0.34363

Enthalpy : 0

Ratio of specific heats : 1.4

**Boundary conditions**

Inlet : velocity inlet

Outlet : pressure outlet

Wall : wall

**Problem Setup**

General-Solver

**Type:** pressure based

**Velocity :** Absolute

**Time:** Steady

**GEOMENTRY**

The file is imported from CATIA by following the step - file>import and it is shown in figure 4.1

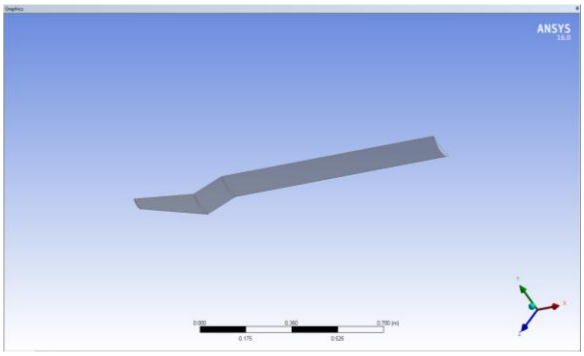

**Fig 4.1:** Geometry

Create an enclosure around the imported geometry from the CATIA V5

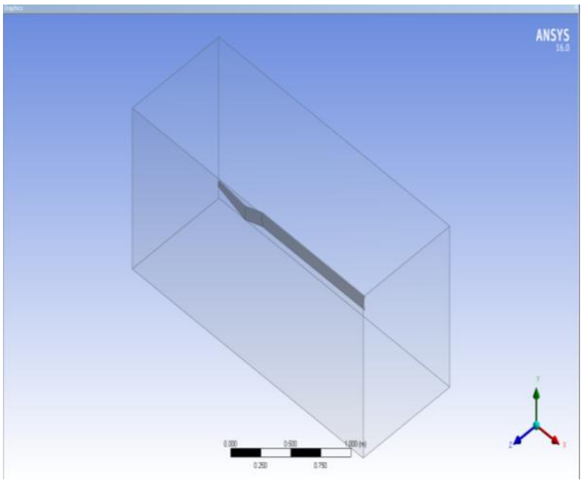

**Fig 4.2:** Geometry with enclosure

**MESHING**

After the displaying is finished the cross section is to be finished. The module used to perform fitting is Fluid Flow (Fluent). The cross section technique utilized here is Automatic Method and the work type is chosen as All Quad. Here in this task Meshing assumes a primary job, since we are getting results by fluctuating the Number of divisions in work .The quantity of divisions are changed at the vertical surfaces (gulf and exit) and the slanted surfaces (dividers).

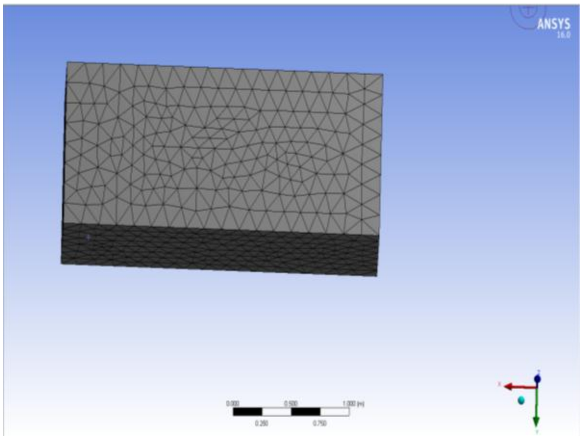

**Fig 4.3 :** Automatic meshing

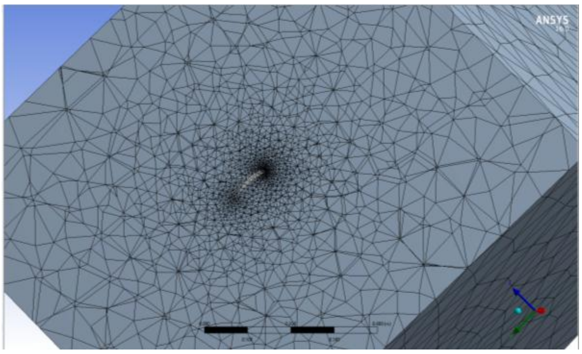

**Fig-4.4 :** Automatic meshing

**STRUCTURED MESHING**

The work acquired at first will be unstructured work (fig.4.3) and this can't be utilized to get precise outcomes. Since the edges are kaleidoscopic the work can be changed over into organized lattice by utilizing Mapped Face Meshing.

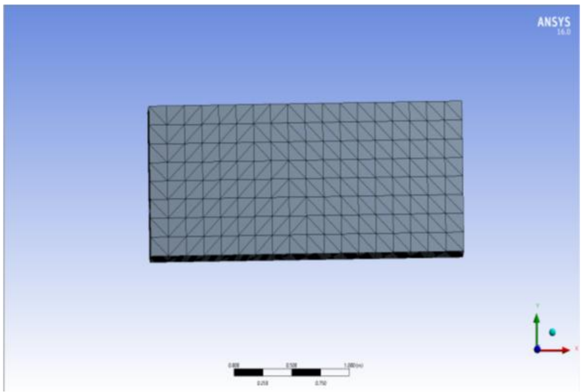

**Fig4.5:** Structured mesh

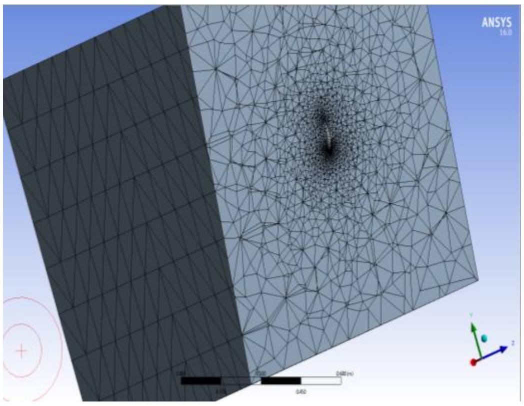

**Fig 4.6:** Structured mesh with cut section

**SOLUTION SETUP**

**Pressure velocity coupling:** coupled

**Turbulent kinetic energy:** second order upwind

**Turbulent dissipation rate :** second order upwind

**Momentum :** second order upwind

**Pressure :** second order

**Solution converged :** 78th iteration

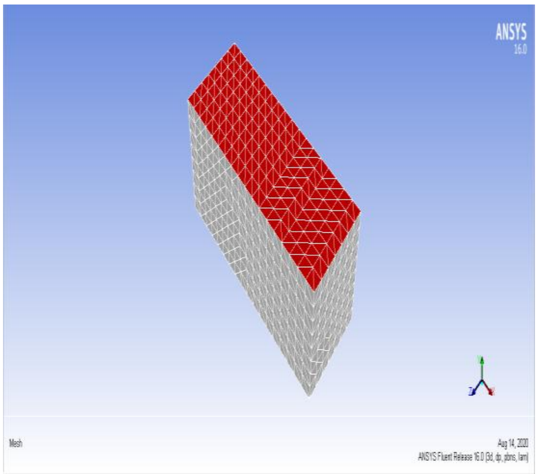

**Fig 4.7 :** Solution setup

After run calculation given number of iteration is 100 with reporting time interval of iteration is one.

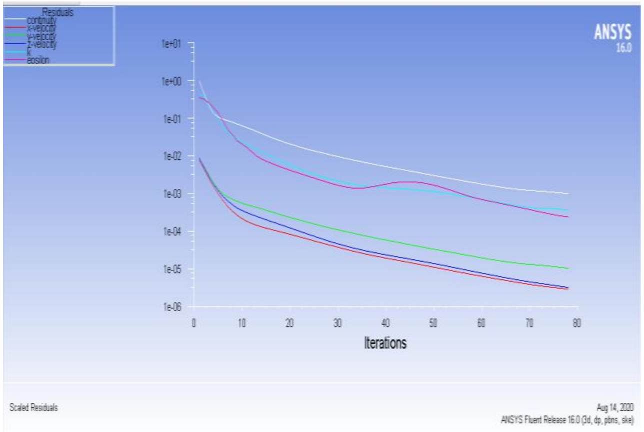

**Fig-4.8** Iteration graph

**STREAMLINE**

Streamline flow was started from the line1 drawn in the result section

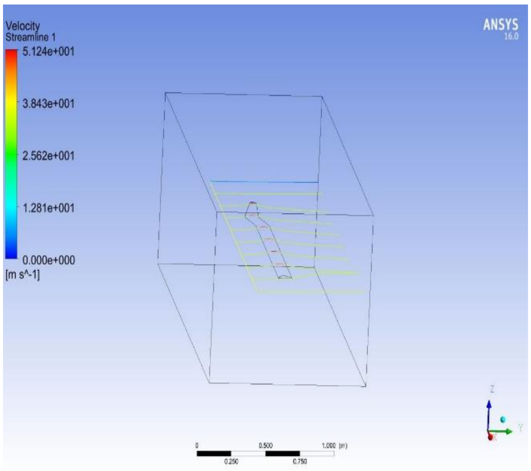

**Fig-4.9:** Streamline flow

Smooth out stream in liquids is characterized as the stream wherein the liquids stream in equal layers to such an extent that there is no disturbance or intermixing of the layers and at a given point, the speed of every liquid molecule passing by stays steady with time.

The streamline flow is started from line1 and # of points is given as 20.

**VELOCITY CONTOUR**

The contour flow is used to see the velocity variation of the flow staring from the symmetric. the minimum velocity value is 0 $e^{+000}$ and the maximum velocity value is 5.124 $e^{+001}$ .

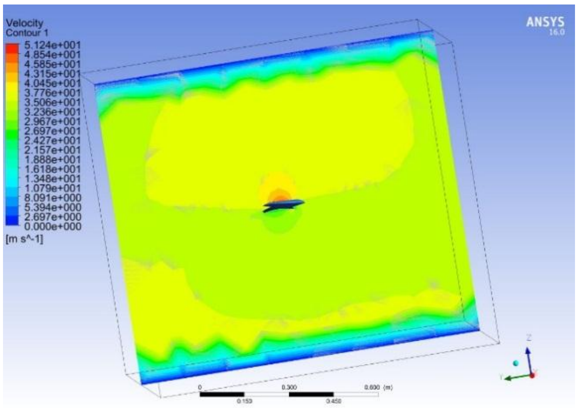

**Fig 4.10:** Velocity contour

**PRESSURE CONTOUR**

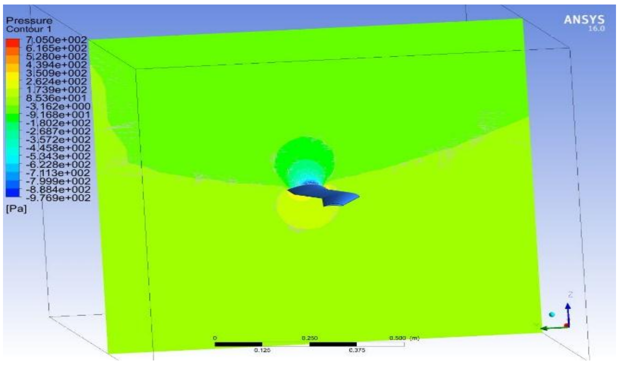

Fig 4.11: Pressure contour

The contour flow is used to see the velocity variation of the flow staring from the symmetric. the minimum velocity value is -9.769e$^{+002}$ pa and the maximum velocity value is 7.050 e$^{+002}$ Pa.

## V. CONCLUSION

A rotorcraft enables the system to take off and land vertically driven by the engine, it uses an unpowered rotor, driven by streamlined powers (lift, push, drag, weight) in a condition of autorotation to generate lift, and a motor controlled propeller, as same as fixed-wing airplane, to give push. The impact is a rotorcraft working in a better proficient way in autorotation of freewheeling rotor of an autogyro in limiting the unfavourable impacts of withdrawing edge slow down of helicopters at higher velocities. The main theme of our project is to increase the efficiency of the rotor by modifying the blade profile using blue edge blade technology. which enables in higher endurance and designing of enriched blade profile (proposed rotor blade profile) thus resulting in higher noise reduction by reducing the blade vortex interaction BVI. when compared to the conventional rotor blade. And increasing the generation of lift by the rotor by using high lift producing airfoil eppler423. Economically we tend in commercializing these blades to inculcate a feasible transport mode for the passengers through development of high end rotorcraft and also in the drone even in the home appliances.

## VI. REFERENCE

[1] Pandey, K. M., A. Surana, and D. Deka. "Numerical analysis of helicopter rotor at 400 rpm." International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307

[2] Perera, G. A. P. R., et al. "Helicopter Main Rotor aerodynamic simulation with CFD." (2016)

[3] Ilkko, Juho, Jaakko Hoffren, and Timo Siikonen. "Simulation of a helicopter rotor flow." Journal of Structural Mechanics 44.3 (2011): 186-205.

[4] Talbot, Peter D., et al. "A mathematical model of a single main rotor helicopter for piloted simulation." (1982).

[5] Rodriguez, Christian. "CFD Analysis on the Main-Rotor Blade ofa Scale Helicopter Model using Overset Meshing." (2012).

[6] McStravick, David M., et al. "Investigation of an Eppler 423 Style Wind Turbine Blade." Energy Sustainability. Vol. 43956. 2010.

[7] Marques, Pascual, et al. "The Jinn Military Unmanned Helicopter Program: Rotor Blade Tip Aerodynamics of the Advanced Technology Demonstrator." International Journal of Unmanned Systems Engineering. 1.3 (2013): 6.

[8] Brocklehurst, Alan. High resolution methods for the aerodynamic design of helicopter rotors. Diss. University of Liverpool, 2013.

[9] Kania, Wojciech, and Wieńczysław Stalewski. "Development of new generation main and tail rotor blade airfoils." Proceedings of 22nd International Council of the Aeronautical Sciences Congress, Paper. No. 181. 2000.

[10] van der Wall, Berend G., et al. "From ERATO basic research to the blue EdgeTM rotor blade." American Helicopter Society 72nd Annual Forum, West Palm Beach, Florida. 2016.

[11] Heine, Benjamin, et al. "On the effects of leading edge vortex generators on an OA209 airfoil." (2009): 1-12.

[12] Klein, Alexander, et al. "Unsteady criteria for rotor blade airfoil design." (2009).

[13] White, Robert Owen. "Rotor blade subsystems attachment." U.S. Patent No. 9,139,297. 22 Sep. 2015.

[14] Schmitz, Fredric H., and Ben Wel-C. Sim. "Radiation and Directionality Characteristics of Helicopter Blade-Vortex Interaction Noise." Journal of the American Helicopter Society 48.4 (2003): 253-269.

[15] Chuiton, F. Le, et al. "Industrial validation of numerical aerodynamics about rotor heads: towards a design optimisation at EUROCOPTER." (2009).

[16] Kottapalli, Anjaney P., and Franklin D. Harris. "Converting a C-130 Hercules into a Compound Helicopter: A Conceptual Design Study." (2010).

[17] Rogers, Victor AB, and Anthony BD Leigh. "Construction of rotor blades for rotary wing aircraft." U.S. Patent No. 3,552,881. 5 Jan. 1971.

[18] Gervais, M., and V. Gareton. "Analysis of main rotor noise reduction due to novel planform design-The blue edge blade." (2011).

[19] Prasad, Kondapalli Siva, Vommi Krishna, and BB Ashok Kumar. "Aerofoil Profile Analysis and Design Optimisation." Journal of Aerospace Engineering & Technology 3.2 (2013): 1-10.

[20] Leusink, Debbie, et al. "Aerodynamic rotor blade optimization at Eurocopter-a new way of industrial rotor blade design." 51st AIAA Aerospace Sciences Meeting including the New Horizons Forum and Aerospace Exposition. 2013.

[21] Gareton, Vincent, Marc Gervais, and Rainer Heger. "Acoustic design and testing of the Eurocopter EC145T2 and EC175B-A harmonized Franco-German approach." (2013).

[22] Brocklehurst, A., and G. N. Barakos. "A review of helicopter rotor blade tip shapes." Progress in Aerospace Sciences 56 (2013): 35-74.

[23] Brentner, Kenneth S., Philip J. Morris, and Leonard V. Lopes. "A method for predicting the noise of a tip-jet driven rotor." Journal of the American Helicopter Society 59.3 (2014): 1-10.

[24] Reza, Mirza Md Symon, Samsul Arfin Mahmood, and Asif Iqbal. "Performance Analysis and Comparison of High Lift Airfoil for Low Speed Unmanned Aerial Vehicle." International Conference on Mechanical, Industrial and Energy Engineering. 2016.

[25] Chandra, Sushil, and Rajan Tyagi. "Study of Eppler 423 Airfoil with Gurney Flap and Vortex Generators." Advances in Aerospace Science and Technology 5.1 (2020): 1-19.