

MORPHING OF AIRCRAFT TRIM TABS ACCOMPANYING ELECTRORHEOLOGICAL FLUID CONTROLLED ACTUATORS

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Aeronautical Engineering

By

NITHEESH KUMAR S (REG NO :37260028)

SOWMYA S (REG NO:37260042)



**DEPARTMENT OF AERONAUTICAL ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119 APRIL 2020



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INSTITUTE OF SCIENCE AND TECHNOLOGY
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Accredited with "A" grade by NAAC
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119
www.sathyabama.ac.in



DEPARTMENT OF AERONAUTICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of NITEESH KUMAR S (Reg. No. 37260028) and SOWMYA S (Reg. No. 37260042) who carried out the project entitled "**MORPHING OF AIRCRAFT TRIM TABS ACCOMPANYING ELECTORHEOLOGICAL FLUID CONTROLLED ACTUATORS**" under our supervision from December 10 to April 2021.

Internal Guide

MR.VENKATESH S,ME., Ph.D-,

Head of the Department

Dr. BOOMADEVI ME. PhD.,

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We Niteesh Kumar S (Reg No. 37260028) and SOWMYA S (Reg No. 37260042) hereby declare that the Project Report entitled “**MORPHING OF AIRCRFT WING TRIM TABS ACCOMPANYING ELECTORRHEOLOGICAL FLUID CONTROLLED ACTUATORS** ” done by us under the guidance of **MR.VENKATESH S M.E., Ph.D,** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.

DATE:

SIGNATURE OF THE CANDIDATE

PLACE: CHENNAI

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PROJECT ASSOCIATES

NITHEESH KUMAR S.

SOWMYA S.

ABSTRACT

The gadget of lookup is never-ending. Industrial manner improvements cannot be accomplished totally by way of developing the effectivity of common production methods and tools; instead, new picks principally primarily based on novel thoughts are required. Based on the electrorheological impact modern in electrorheological fluids, one promising and novel approach exists. This paper focuses on the microstructure behavior and residences of ER fluids, as good as t by way of potential of their education and engineering applications, in order to focal factor on the evolution of new areas in which ER fluids can be used, which will develop to be a new horizon for the next generation.

Bionics in plane format is being viewed as a way to beautify aerodynamic performance. By altering the geometry of their wings, Swift can control their waft normal overall performance (they alter their wing sweep to suit the speed). In order for an aircraft to function in-flight configuration changes for most fulfilling performance, a variety of morphing applied sciences based absolutely on sensible substances and structures will be needed. Not fully are wise materials structural, but they can moreover be active. Optical fibers, electrorheological and magneto rheological fluids, shape memory alloys and polymers, and multi-functional Nano-composites are currently available.

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CHAPTER 1

INTRODUCTION

1.1 Rheology:

For impervious materials, it is the relationship between shear stress and shear strain, while for liquids, it is the relationship between shear stress and shear strain. The science of fluidity is utilized to liquids. Property curves are in many instances used to figure out the fluidity of materials

1.2 Morphing:

An aircraft that morphs during flight to improve its performance is referred to as a morphing aircraft. High sweep is ideal for higher-speed flight. It is a catalyst for change. High sweep is ideal for higher-speed flight.

Advantages:

- to improve aircraft performance by expanding its flights range
- To reduce drag and to improve range
- To reduce vibration and control flutter
- Reduce noise
- To improve performance and stealth capability
- Long shelf life
- Reduce time to repair and configure.

1.2.1 Morphing Aircraft Wing:

The simple precept of an aero aircraft is that gravity is overcome through the lift generated via the drift of air over the aircraft's wings, which is based on the wing form and size, as nicely as the aircraft's velocity. Thrust is a way to counteract drag. In some ways, the wing configuration influences the aerodynamic overall performance of a given aero aircraft fuselage or body. For every mission, an superior wing configuration will be observed for a given thrust and airspeed. Depending on the dimension that changes, a wing's diploma of morphing can be categorize .

medium, or small. The wings are made up of foldable wings, variable sweep wings, variable-span (telescoping) wings, and deployable wings the large class includes folding wings, variable sweep wings, variable-span (telescoping) wings, and deployable wings. The medium class consists of twisting wings, bendy winglets, variable-chord (telescoping) wings, and variable-camber wings. The small class consists of wings with variable airfoils and bulging wings. A multi-mission plane can be constructed to perform properly in a variety of flight conditions. A fighter with folding wings or variable-sweep wings, for example, can function well at both excessive and low speeds, decreasing gas consumption and improving the flight envelope significantly. The plane can take shorter starting distance if they have a variable chord or variable-camber wings. The aerodynamic performance of low-speed aircraft can be more advantageous by way of variable wings, flexible wings, and twist wings. Different morphing stages require one of a kind materials and structures to meet their one-of-a-kind requirements. In this study, piezoelectric materials were used to manipulate the aerodynamic pressure in the helicopter rotor blade trailing-edge flap. Several exclusive types of shrewd materials and structures, along with piezoelectric, electro-strict, strict magneto, reminiscence alloys for structure and optical fiber, had been investigated in the course of 1990s.

1.3 Electrorheological fluids:

Electrorheological fluids (ER) in an electrically remoted fluid embody extraordinarily high-quality non-conducting then again electrically energetic particles (up to 50 meters in diameter). ER fluids are a kind of sensible fluid. Mixing maize flour with a moderate vegetable oil or (better) silicone oil can be used as a simple ER liquid.

- 1). The suspension tends to fibrillate on mainly elongated condensed particles customary parallel to the issue in a magnitude vicinity in the order of three kv /mm.
- 2) To shear the fluid between electricity plates, a pressure proportional to the rectangular of the electric powered subject is required. The laptop therefore acts like a stable at low shear stresses.

3) The fluid flows like a viscous fluid at stresses greater than that yield stress, but again proportional to the rectangular of the electric powered field, with a large viscosity.

1.3.1 Advantages:

One benefit is that an ER unit controls a great deal extra mechanical power, i.e. it can act as a electricity amplifier, than the electrical energy to control this effect. But the most important advantage is the response speed, and the manipulate of such giant amounts of mechanical or hydraulic electricity has few other effects.

1.4 Microscopic view:

With the growing electric field, the widths of the vivid bands increase. The ER fluid undergoes a transition to a gel-like kingdom when an electric powered subject is used, the particles structure chains first alongside the area route that then coalesce to columns if the diluted concentration of the section is now not too diluted.

1.5 Two-types of ER Fluids:

ER fluid is a substance that modifications its obvious viscosity according to its strength, and its essential elements encompass quickly response speed, and extraordinarily low strength consumption amongst different things. ER fluid The presently developed ER fluids can be categorized in terms of their properties into two types

1.5.1 Particle-type:

Colloidal Fluids of this sort are solvents with dispersed particles that have aspects and colloidal fluid features. The horizontal axis shows the pace of shape, whereas the vertical axis suggests the stress of shape, and the characteristics exchange in accordance to the electricity of E.

1.5.2 Homogeneous-type:

Such fluids are produced the utilization of low molecular liquid glass or macromolecular glass and have features. Shearing anxiousness is almost proportional to shearing pace and its course is regulated by the use of the electric powered field, in particular viscosity. As a result, a mechanical manage pressure proportionally to the pace can be acquired in a steady electric powered location and the equal of the so-called differential manipulate can be mechanically realized..

1.6 Structure of Electrorheological fluid (ERF):

Polarization of the particles and the creation of an increasing field single-sphere width chains E. Changes in fluid properties in the particle chain. The ER technique is based on two perspectives of a "sheet" in planes parallel to the E-field ER fluid. If an appropriate ERF is not established, the ER technology does not apply to engineering. Today, a number of countries have produced ERFs of a suitable nature and have started large-scale development after the patent has been received. Many forms of ERF are available

They usually consist of three parts:

1. Liquid base: The basic liquid usually consists of mineral oils and other solutions selected for their electrical insulator characteristics Viscosity and electricity (10^{-9} - 10^{-4} ohm/cm is usually required) are the principal property of the base liquid.
2. Additives: A suspended stable particles that are strongly polarized. The apparent ER results of an ERF are the effects of these additives. The additives consist usually of small particles or powders of approximately 5-25 μ m diameters which can be suspended for a long time in the base oil. Particles shape several particle chains which, according to the theory behind the ER phenomenon's, can withstand shear stress by applying an electric field and can easily be polarized.
3. Surfactant. The surfactant can avoid ERF particle decay and causing EF impact by triggering the particles. ER fluid may be a blend of several kinds of basic oils,

particles or powders, according to the study. The features of ERFs are related not only to the characteristics of the fluid base and particulate matter but also to the volume/mass fraction of the base fluid. Study into the properties and experimental methods used to manufacture ER fluids is still kept confidential.

1.6.1 The ideal ERF should contain the following qualities in the view of its application in engineering:

1) If an electrical vicinity is added, the viscosity and yield stress can amplify to a massive extent can produce an obvious ER affect (even to the constant state). In the ER fluid the easiest yield stress will exceed 7-10 kPa. Of course, the large the greater the profit. It used to be repolished that the yield stress values would exceed 20 kPa for the most best ERF generated so far.

2) It can convert the ERF to a low voltage invulnerable (the limit the voltage the better). The electric powered area stress typically is hoped no longer to exceed 3kV/mm. The fluid is immoderate voltage perforated, i.e. discharges are possible.

3) The base liquid want to be negative in insulation content material material cloth (i.e. the electric powered powered resistance be high). The frequency of the electric powered powered powered fields can then be multiplied and the have an influence on of the ER can be greater obvious while at the identical time decreasing the electrical energy wished to produce the affect of the ER.

4) The ERF's chemical steadiness does no longer deteriorate in storage or operation

5) The amazing gravity of the base liquid have to be similar to that of the particles internal it and this ERF will preserve its particles from sedimenting.

6) For the well-being of its consumers, the ERF be non-toxic.

7) ERF processing be as convenient and comparatively lower priced as possible.

8) The ERF ought to be barring water. The cutting-edge density is elevated by way of the usage of the use of the water, thereby consuming large fuel. ERF will moreover freeze at 0°C and boil in water at 100°C. Now, scientists will focal factor on discovering ERF barring water and have been excessive nice on a large scale. ERF used to be once designed for 200°C, alternatively the most efficient operational range is 40-150°C.

9) If there is no electric field, the ERF's viscosity ought to be as low as possible, so that its viscosity can be managed in a huge range and this is one of the fundamental elements limiting its use in engineering.

10) It ought to now not be corrosive and have to now no longer cause metallic elements to put on and tear.

1.7 Preparation of ER fluid:

Electrorheological fluids are labelled in accordance to their liquid base constituent and are carried out accordingly. Many electrorheological fluids are available, for example:

- 1) Starch – ER fluids hooked up (STB)
- 2) Silica – ER fluids primarily based on (SIB).
- (3) ER fluids in Arabic – gum.

1.7.1 REVIEW OF ER FLUIDS AND ITS PROPERTIES:

Dynamic efficiency for electrical rheological fluids has increased in large numbers mainly because of changes in conductivity and related permittivity of particles and oil components. A dynamic output force, which is the minimal stress needed to get the fluid flowing under the area applied, is one of the main features of an electron fluid. Higher dynamic yield stress is usually wanted and range approximately 100Pa-over 3KPa in existing electro rheological fluids. ER fluid flows over the electrodes between both open, low viscosity electrode flat plates have null potential, while the arrangement has a voltage potential of 750 volt across the 0.25 mm distance that generates 3 kV/mm of electric field (E-field). Studying the form and work of living beings as a model of reverse engineering for the creation of materials or produce. ER Fluid demonstrates that outstanding features such as rapid reaction, simple interfaces between electrical input and mechanical power output and control make them the next alternative for many applications. The computational simulation effects of the flat morphing wings are higher when compared with twisted wings and various morphing speeds can be done with lightweight smart materials that have lower energy. The latest test calculated the ERF's complex viscosity successfully to 0.6 steps at low flow rates and 0.2 Pa-s for high flow rates the presented valve configuration can withstand fluid pressure of 1 MPa, which is a more effective operating mode than any haptic or damping implementations in the documentation. The fountains were arranged in the upper and lower layers, so that the flap would rotate both upwards and downwards. The heat from the applied current was inspected by the Spring actuator. Recent advances in the use of intelligent materials and systems for aircraft are examined. In particular four application categories: actuators, controls, controllers and structures are discussed. The NACA 4-digit airfoil plotting and press distribution methods are compared and compared to the experimental, numerical calculations with zero angle of attack. The results achieved are calculated. In this work the wing model is held inside the wind tunnel and for different angles of incidence and flap deflection the timer and hinge moment coefficients are measured.

1.7.2 ERF MODEL SPECIFICATION AND SELECTION ER:

ER fluid is organized to produce the first-rate colloidal answer with the aid of the integration of quite a number service fluids and steady additives. For deciding on the acceptable ER fluid type to be used for the morphing plane wing model, the easy mixture of additives like the pumpkin starch, maize starch and maize flour, and provider fluids such as sunflower oil, paraffin oil, silicone oil and veg oil of a range of combination are validated. In order to select the right ER fluid for morphing wing technologies the convenient chemical checks such as PH take a seem at and electrode tests for 12 separate ER fluid models are tested. All the combinations from the PH test are base fluids of a range of levels. The rheological components ought to consist of the fluid of excessive and reasonable concentration. The higher ER fluid is the combination of excessive and reasonable electrical conductivity potato and paraffin oil. Few fewer colloidal fluids have now no longer flawlessly dissolved and consistent particles remain suspended.

The indispensable electrode examination between the plates of copper. As dielectric ER fluids, dielectric steady (K), everyday of allowability (μm , immersed sector of the fluid (A), hole between the system of the electrode plate (D), Capacity, $C = k\epsilon$. The electrical load of the $Q=CV$ sector. The electric powered area between the electrodes is measured as, $E = \mu$, the use of the electrode. So E was once once brought to the electric powered field. Substantial limit between the electrodes takes location between electric powered fields furnished except the interplay of the fluid ER, for that motive growing the fluid yield depth and the place absorbed is around 0.625 per 4 m between electrons. The shear stress of the electrodes is no greater increased:

(a) Zero IN MORPHING WING TECH FLUID Impact. The morphological wing model used to be designed with a sheet and the flatted (potato paraffin oil) was once chosen between each f Wing business for plane Electronic Theology The primary principle of the electrode take a seem to be at is that the ER fluid is dealt with as the dielectric medium between the cotton plates. Since ER fluids are dielectric, dielectric (K), fluid immersion location (A), distance between electrode plates (D) and dielectric capacitance produced throughout electrodes are decided between electrodes by using 5000 V DC barring fluids touch. i.e., the free area is determined as between the dielectric fluid-carrying ER fluid electrodes, which capability ER fluid with no ER fluid

is extended via 1.25, the place ER fluid shocking decrease in manageable has an ER fluid, which will make bigger the fluid yield and t for an electrodes 4mm dividing divide

(b) Response to zero electric powered area Electric field responses to gradual viscosity High viscosity model of NACA 4412 airfoil that makes use of balsa wood sheets to pick out a flapped location of the wing models that are geared up with two copper plates. Copper boards are used as dielectric medium between the copper boards with the electric powered DC 33 R fluid. As ER fluids behave as dielectric fluid, the popular steady (K) is decided by using way of along with the 12 5000 V DC fluid free three fluid except the touch of fluid.

1.7.3 ER FLUID EFFECT IN MORPHING WING:

The model of a diaphragm wing constructed with a sleeve sheet and the selection of the floppy (paper + paraffin oil) between the two aircraft wings the primary principle of the electrode test is that the ER fluid is treated as the dielectric medium between the cotton plates. Because ER Fluids functioning as Dielectric fluids, the dielectrically constant(K), permittivity constant(A), fluid immersed area(D) and dielectric capacity produced between electrodes are calculated, the free-farm is calculated between electrodes by applying 5000VdC without fluid contact. E.g., ER fluids is measured around 1.25 when ER fluid is used for the abrupt decrease in potential of ER fluid between electrodes, which increases the fluid output intensity and t increases the electrode difference of 4mm.

If the shear tension of the fluid does not rise Answer to zero electric field Electric field responses to slow viscosity High viscosity model constructed using a balsa wood sheet with NACA 4412 airfoil and choosing the blowing part of the model wing that carries it Two plate of Electro copper. Copper boards are used as dielectric medium between the copper boards with the electric DC 33 R fluid. Since ER fluids function as dielectric (K), a dielectric constant (12 applicable with 5000 V DC without fluid contact) is measured. When an ER fluid has been added to the ER fluid, a rapid potential decrease between the electrodes is measured to improve the yield intensity between

the fluid and the electric fluid. The electro rheological fluid DC electrical field of 1.25 is applied with bale wood and can be manufactured.

1.7.4 Preparation procedure:

1) Two separate ER fluids have been packed, as stated above. For the SIB fluid, after adding some water, coarse silica was ground by planetary friction. Then it was heated in an oven at 70°C for 12-14 hours with finely powdered semi solid mass. The powder without sintering was taken careful to rinse.

2) A homogenous thin powder was re-milled (dry) to the dried mass. A microscope electron was used for analysis of the form and scale of the particle. The particles were found to be abnormal in shape, varying from 1 to 5 μ .

3) Xylene was used as a dispersing phase for the supplementation of triple distilled water (as surfactant) and glycerol mono-oblade. This solution was constantly agitated with the addition of silica powder. This resulted in a semi-solid paste which eventually became homogeneous colloidal suspension with a good flow ability, following a continuous shearing of the dash point cylinders.

4) The ER effect was demonstrated only after this liquid condition was achieved. The fluid was approximately 200 kilo ohms ohm etic resistance in the electrode gap. Two silica-containing fluids were prepared, respectively 36% (w/w) and 42% (w/w). The water and surfactant content of both of these mixtures was 5.5% (w/w).

5) The first kitchen floor was planetary grinding dry for preparing the STB fluid. Particles with dimensions ranging from 15 to 25 hundred were considered almost spherical. The combination of xylene and a small volume of water has been applied to the ground starch.

6) The mixture was constantly mixed with increasingly applied surfactant (glycerol mono-oblade). Two starch-containing liquids were packed, respectively 40% (w/w) and 55% (w/w). Water and surfactant content is 4% (w/w) each for all these suspensions.

7) The electrode gap's ohms resistance to these fluids was 400 kilograms.

1.8. Objectives:

Intelligent materials and systems have one or more of the following three major features:

1. Self-actuating – the machine generates after stimulation an output such as power, shift, heat, and light.
2. The device may produce electrical or magnetic signals or submit straining that can be measured to characterize the environment by automatically responding to environmental changes
3. The system itself is self-adaptable to the environment (this feature for these applications in hand is the use of smart material polymer and electrorheological flow to manufacture a rectangular aircraft wing and three different step inputs of electric current are regulated specifically on structures that control the aircraft at different levels.
 1. Input voltage of 1 KV/mm with a counter clockwise direction of flow of current in the wing membrane having positive deflection in the aircraft control surface by disconnecting direct supply to ER fluid.
 2. Input current of 1 KV/mm with a clockwise direction of flow of current in the wing membrane having negative deflection in the aircraft control surface by disconnecting direct supply to ER fluid.
 3. Input current of 1 KV/mm directly into the ER fluid gives the erect position of the wing membrane with zero deflection in the aircraft control surface.

CHAPTER 2

LITERATURE SURVEY

2.1 LITERATURE SURVEY:

Pedro ran the Wind tunnel check outcomes with dazzling dimensions Gamboa, F. Lau, for the Morphed wing, to Improve its everyday overall performance at a given flight speed, Tip, root and actuation plates and, Rotating rib nut, to beautify aircraft fundamental overall performance at unique degrees of flight Wind tunnel test. Real time CFD check used to be as quickly as done. The wing pores and pores and pores and skin is flexible and needs to be stretched prevents the use of the wind tunnel scale barring adaptations: M. Abdulrahim and J. Cocquyt, "Development of Mission Capable Flexible Wing Micro Air Vehicles", University of Florida, Gainesville, FL 32611-6250, 2002 Mujahid Abdulrahim and Rick Lind, "Flight Testing and Response Characteristics of a Variable Gull-wing Morphing Aircraft", University of Florida, 2004.

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Yuanhui Tian, Yonggang Meng did a research on Electrorheological Fluids, to assist in understanding the structural strengthening effect and other behaviors of ER fluids under elongation. Tensile test was done to assist in understanding the structural strengthening effect and other behaviors of ER fluids

under elongation. Real time test and numerical test was done. The tensile behavior of ER fluids based on zeolite and silicone oil under different voltages has been studied. 1W. M. Winslow, J. Appl. Phys. 20, 1137 ~1949. 2 D. McLean, Mechanical Properties of Metals ~Krieger, Huntington, 1977

Qian Zou, Yonggang Meng worked on Electrorheological Fluids to assist in understanding the structural strengthening effect and other behaviors of ER fluids under elongation. Tensile test was done to assist in understanding the structural strengthening effect and other behaviors of ER fluids under elongation. Real time +96test and numerical test was taken. The tensile behavior of ER fluids based on zeolite and silicone oil under different voltages has been studied. The tensile behavior of ER fluids based on zeolite and silicone oil under different voltages has been studied 1W. M. Winslow, J. Appl. Phys. 20, 1137 ~1949. 2 D. McLean, Mechanical Properties of Metals ~Krieger, Huntington, 1977."

Bambang Sugiyono Agus Purwono, Bambang Irawan VAWT studied the naca series airfoil by using Turbine Blades NACA to analyze the effect of the wind speed variation to the power generated by Vertical Axis Wind Turbine (VAWT) using NACA 4412. Wind tunnel test* vertical axis wind turbine test was under taken, to analyze the effect of the wind speed variation to the power generated by Vertical Axis Wind Turbine (VAWT) using NACA 4412 Turbine blades. Real time test, numerical test was taken. The F ratio exceed F table $3.635,9027 > 5.77$, it means the null hypothesis is rejected or there is an effect between average wind speed to the power

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Alex E. Ockfen, Konstantin I. Matveev, studied about the Morphed wing, to boost the aerodynamic lift Model. Software analysis Ground effect, Flap, Airfoil NACA 4412, CFD, Fluent Airfoil, CEF analysis, Fluent, real time results Drag coefficient significantly increases as the flap is deflected. This increase is due to larger pressure underneath the airfoil yielding increased pressure drag, along with the growing separation zone on the upper surface of the flap. Ground proximity shows minimal effects on drag as the flap addition dominates. "Fluent, 2005. Fluent 6.2: User's manual. Gallington, R.W., 1987. Power augmentation of ram wings. Proceedings of Conference on RAM Wings and Ground Effect Craft, RINA, London, UK."

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CHAPTER 3

AIM AND SCOPE

3.1 AIM:

Intelligent materials and systems have one or more of the following three major characteristics: The device self-actuates generate after stimulation an output such as power, displacement, heat and light. The device may produce electrical or magnetic signals or experience a strain that is calculated to characterize the environment by itself sensing in response to environmental changes. The machine will adapt itself to the environment to adjust its geometry. We use this fluid to quickly react the deflection in line with the incidence angle and measure the time drag-and-drag ratio

3.2 SCOPE:

3.2.1 Automobile Industry:

Researchers will develop and manufacture new kind of components that suit the automotive needs perfectly with the ER technology. For example, ER technologies may be used to create a variable speed fan clutch to cool the engine, a car clutch, a brake with a controllable stopping torque, shock absorbers or suspension systems with controllable damp. The features of these components are

the high-performance, minimum wear and tear, long service life, easy to produce, low-cost, microcomputer controlled, fine sensitivity and rapid response.

.3.2.2 Hydraulic Industry:

Different valves commonly used may be replaced by the flow range and pressure reduction valves, engineered and manufactured using the ER technique. Comprising a compact design, no moving parts (such as valve heart), no need for precise mechanical testing (such as hole processing, the core valve), low cost, low wear and tear, long service life and fluid rate and strain, can be conveniently operated using an electronic signal in comparison with today's various types of valves. Thus, the hydraulic industry is expected to revolutionise those valves.

3.2.3 Fluid Sealing Field:

An electrically operated rotary sealing system may be developed by engineers using the ER technique to challenge rubber and MRI screening. These benefits can be described as fine screening, no wear, no more life and no need for heavy magnetic fields.

3.2.4 Robot Industry:

Engineers can build and manufacture flexible joints that are small in volume, quick in reaction, flat, wear and tear free, and can be operated directly by the microsystems. The hydrae-electric control systems currently in use will do much more than these ER connectors.

CHAPTER 4

MATERIALS AND EXPERIMENTAL METHOD

4.1 Methodology:

The electro-rheological material is the suspension of very fine dielectric particles in the presence of an applied electric field in an insulation medium which exhibits controllable rheological conduct. The operating mode can be divided into: Shear, squeeze mode, flow mode Our work suggests a shear mode for regulation of the electrode contained in the aero foil with varying inputs of the wing that matches its shape. Mode of flow: 2 electrodes are set and the flow movement between two electrodes is regulated by the vibrating power. Shear mode: one electrode can rotate freely relative to another electrode so that the vibration balance by the

control of the shear force is achieved. Mode squeeze: the electromagnon's breach varies and natural force squeezes the electrorheological fluid. Commercially available ER fluid is very expensive, but to make the ER fluid we select the carrier substance as a paraffin oil and additive as a maize starch.

An electro rheological material is a suspension in the presence of electronically applied field of very fine dielectric parts in an isolated medium which exhibits controllable rheological behavior. The operating mode can be divided into:

- a) Flow mode: Two electrodes are set and the flux movement between two fixed electrodes is regulated by vibration control
- b) Shear: One electrode is able to rotate with respect to another electrode such that vibration is regulated by the shear force
- c) Squeeze mode: the electrode distance is varying in the squeeze mode and the electric rheological fluid is compressed by regular strength.

Our study proposes to manage the outline of the electrode in the airfoil by three different inputs to construct the wing of the aero plane. Commercially accessible ER fluids have very high costs and are thus used for the production of some

portable fluids and particles of ER fluids by different levels. Select the carrier and the additive material for low-cost ER fluid pre-This powder would then be combined with the number of fluids that have been poured into a powdered glass flask. After testing, an adequate mixture of ER fluid will be selected from the prepared ER fluid samples. Viscosity tests, temperature tests, sedimentation tests and abortion tests are needed. Paration. We choose paraffin oil and additive stuff as com stuff for the carrier paper.

The needed voltage for rheological changes across a given ER fluid thickness is around 1 to 4 kV/mm relatively small. The current ER fluid density is typically between 10 and 103 amp/cm² in general, higher complex rates are required and they range from 100 to over 3 kPa in current ER fluids. In comparison with the hinged controller board, within the wind tunnel the different locations of the upward and downward deflection of the wing and its elevated distribution are empirically determined.

4.2 MATERIALS USED:

The basic materials which are used are wood, cycle stokes, wire, aluminum plate, Arduino board, jumper wires, servo motors.

4.2.1 WOOD:



4.2.1 Fabrication on wood

The Fabrication is done using wood with wing span as 60 cm and chord 20 cm.

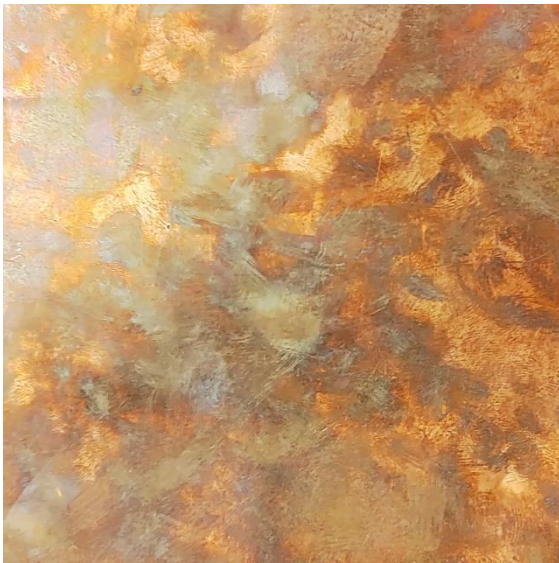
4.2.2 CYCLE STOKES:



4.2.2 cycle stokes

The cycle stokes are used to fix the control surface (second part of airfoil), and the trim tabs (the third part of the airfoil) to the main wing and also which helps in rotation of the control surface and trim tabs.

4.2.3 Copper plate, Paraffin Oil and Corn Starch:



4.2.3 copper plate

The copper plate is cut into two thin stripes and placed in the trim tabs where the ER fluid is placed.



4.2.3. paraffin oil

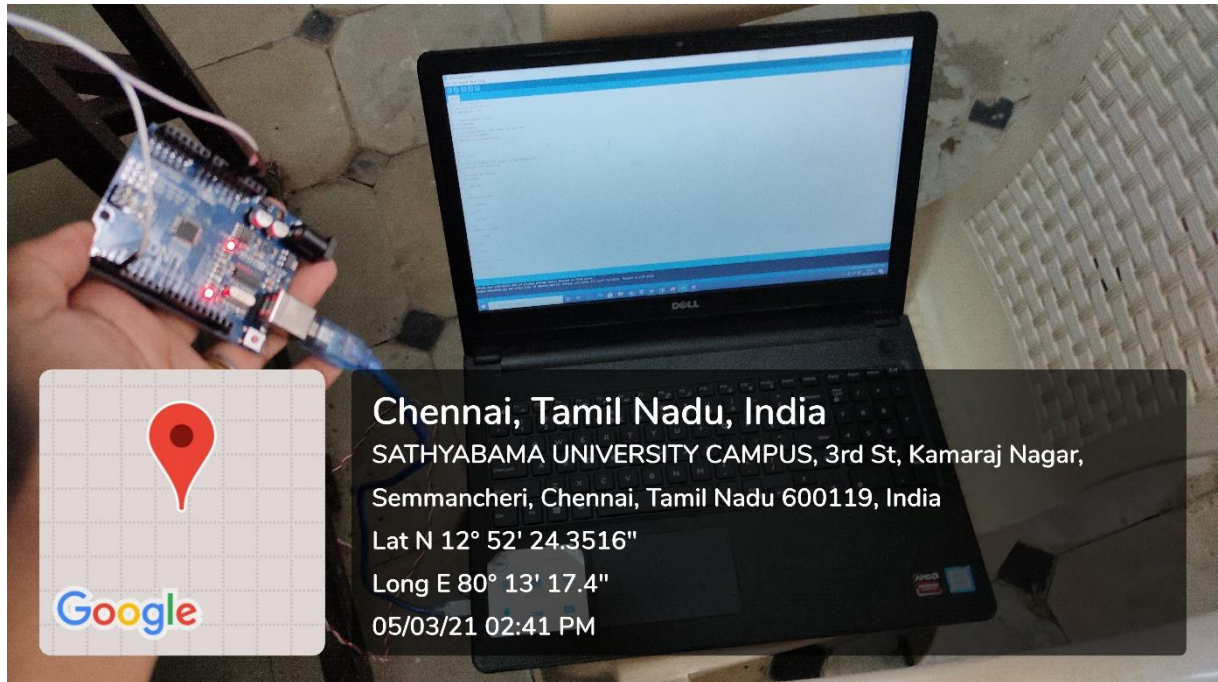
Paraffin oil is a transparent, colorless, odorless, and tasteless oil. We are using this as a carrier material.



4.2.3 corn starch

Corn starch is a white, tasteless, odorless powder, and it is used as a additive material.

4.2.4 Arduino Board and Jumper Cables:



4.2.4 Arduino board and jumper cables

The Arduino board is used to control the control surface on the wing. The coding was done and uploaded into Arduino board using the cable.

4.2.5 Servo motor:



4.2.5 Servo motor

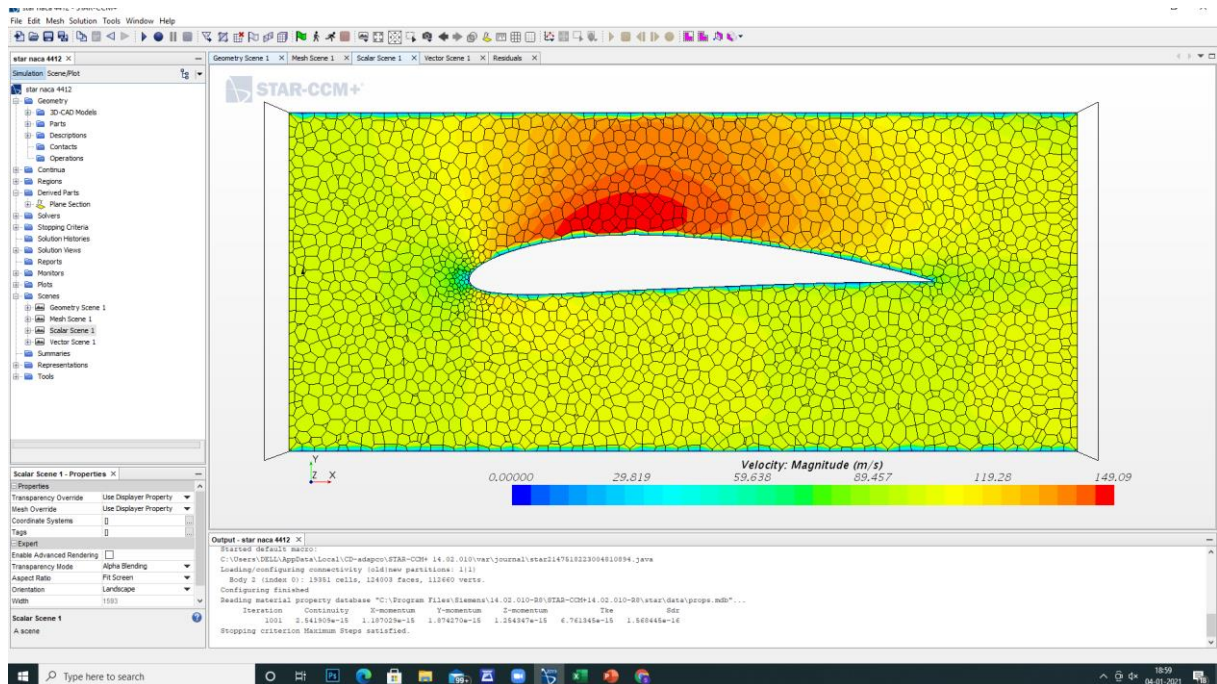
A servomotor is a rotary or linear actuator which enables precise angular or linear position, speed and acceleration control. The servo motor is driven with jumper cables from 0 deg to 180 deg by the Arduino panel.

CHAPTER 5

RESULTS AND DISCUSSIONS

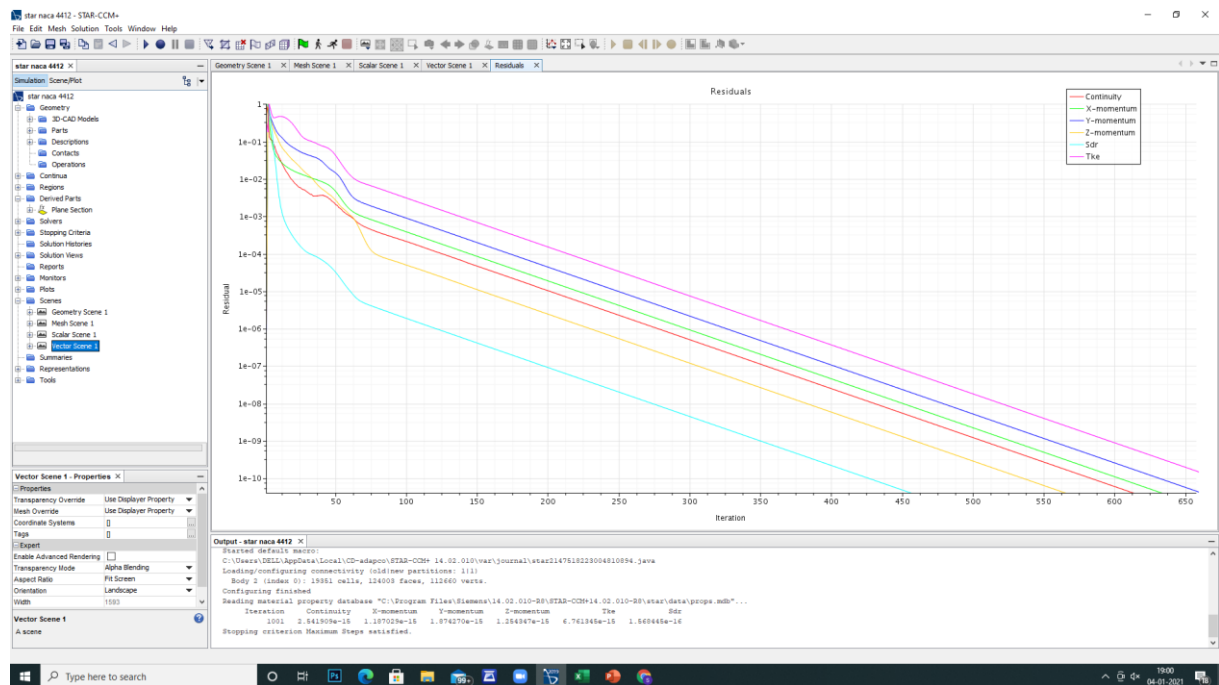
5.1 DESIGN:

NACA Series 4412:



5.1 Design of the aero foil in STAR CCM

5.1.1 RESIDUALS:



5.1.1 Residuals of the model

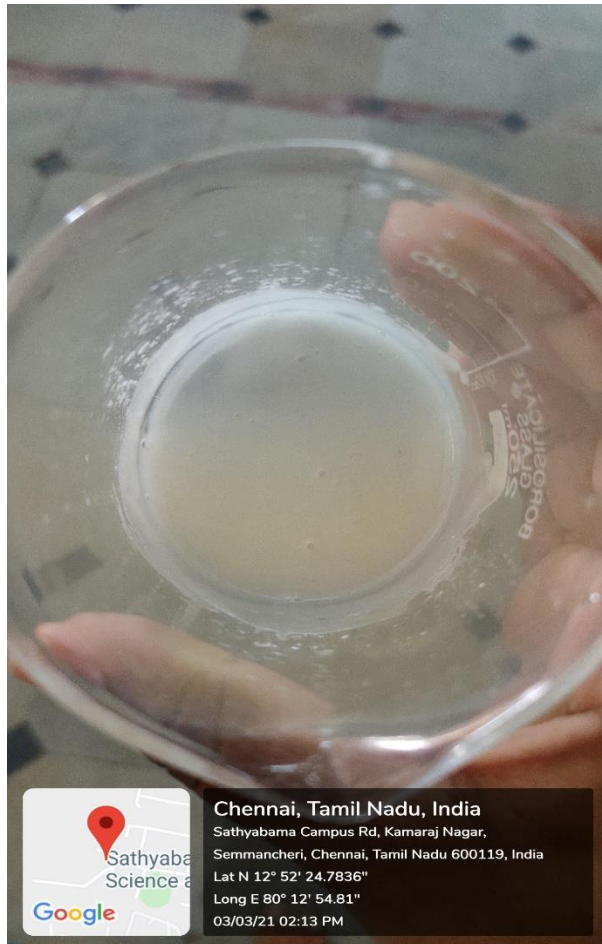
5.2 Morphing / Fabricating:



5.2. Fabrication of wing

The Fabrication is done using wood with wing span as 60 cm and chord 20 cm. The middle part which is the Control surface is controlled using Arduino UNO board and Servo Motor.

5.3 ER Fluid Preparedness:



5.3 preparation of er fluid

ER Fluid is prepared by a combination of different carrier fluid and additive material to yield the perfect colloidal solution. The best ER fluid model id a combination of Corn Starch/ Flour as additive and Paraffin oil as a carrier fluid.

5.4 Testing of ER Fluid:

The ER fluid is tested by passing electric current voltage of 230 V to 5000 V. When the electric current is passed the liquid solidifies and stands between the copper plates but the current is cut out it starts to liquidity.



5.4.1 when the electricity is passed



5.4.2 when the electricity is cut

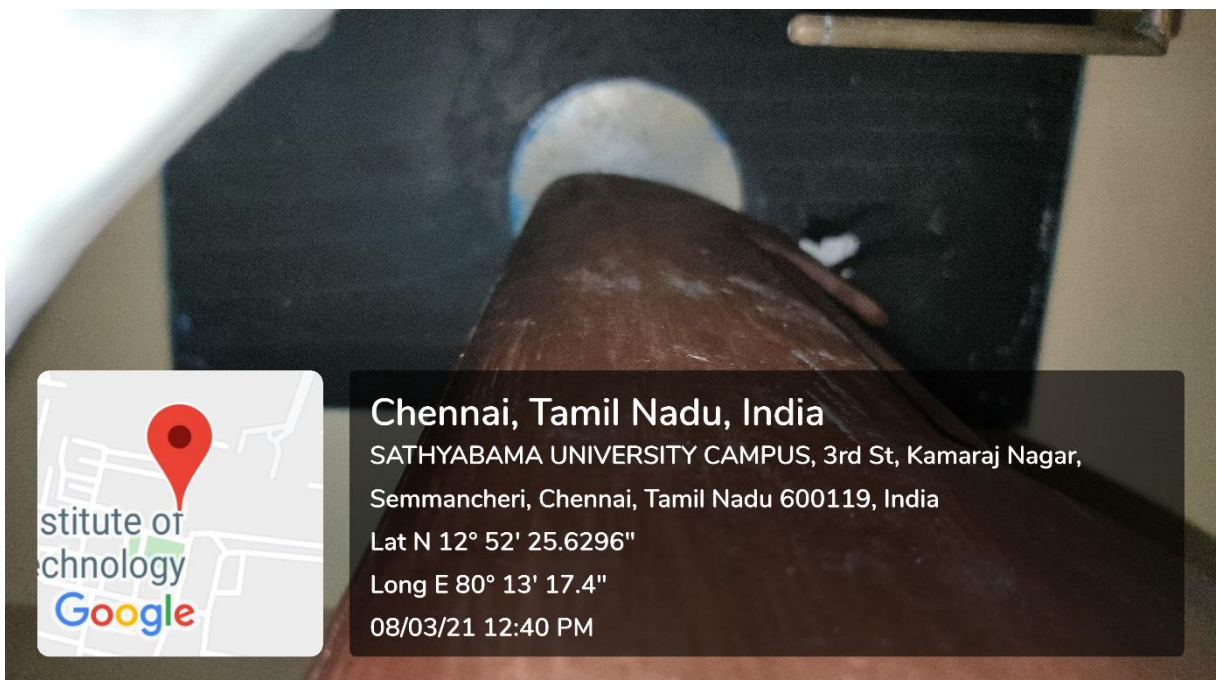
5.5 Testing the model in wind tunnel:



5.5 Testing the model in wind tunnel

The testing of wind tunnel is measured from 60 to 1200 rpm and in the wind tunnel the wing models are mounted in order to verify the flow test performed in a smoke tunnel test.

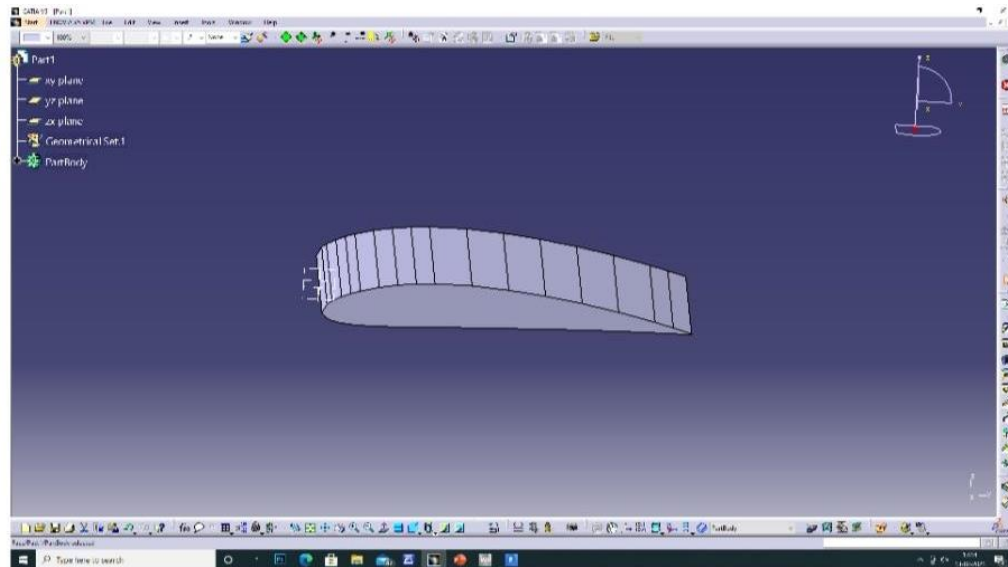
5.5.1 Smoke Tunnel Test:



5.5.1 Smoke tunnel test

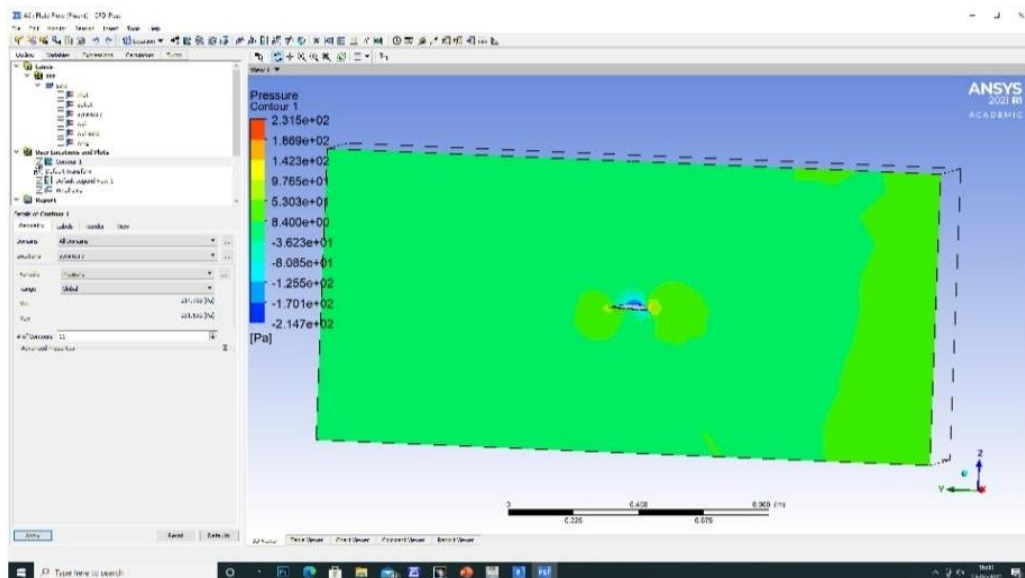
5.6 DESIGN ANALALYSIS REPORT:

5.6.1 CATIA MODEL:



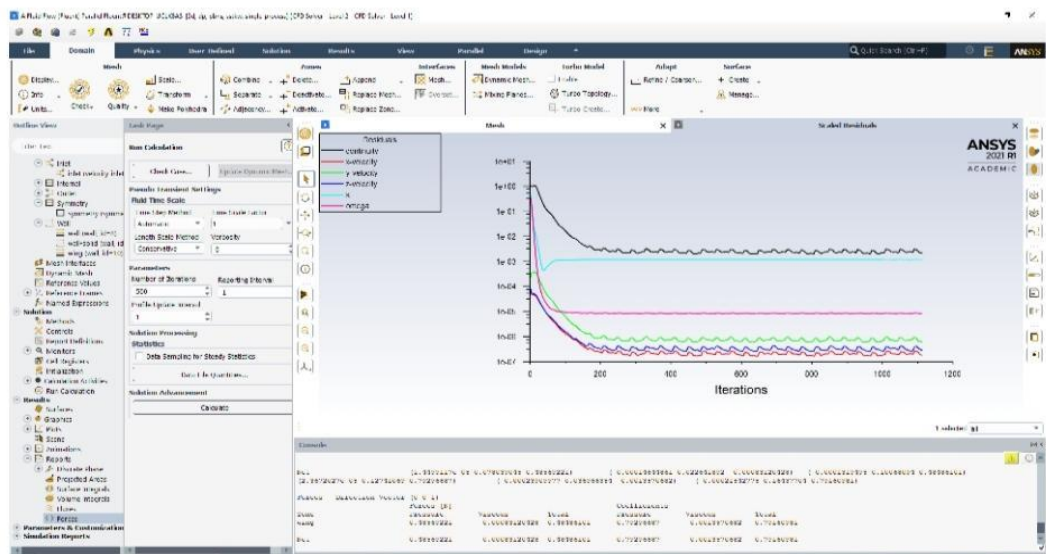
5.6.1 Design of CATIA model

5.6.2 NACA series 4412:



5.6.2 pressure model of the wing in Ansys

Graph:

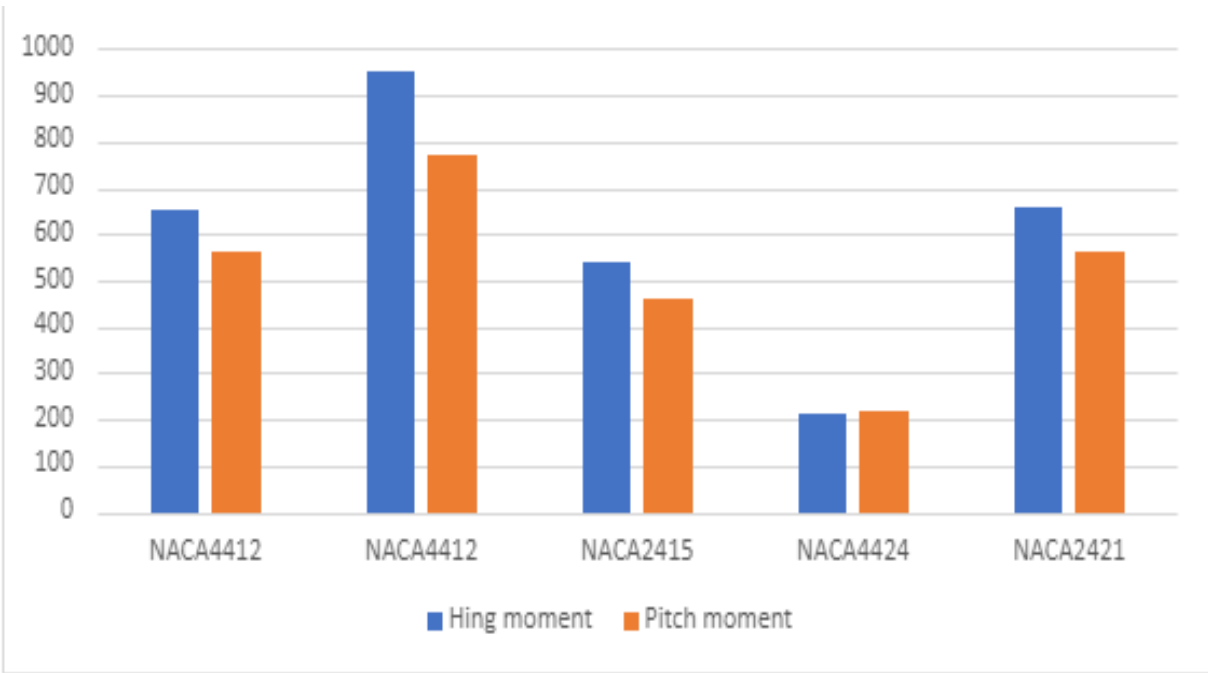


5.6.3 residuals of the Ansys wing model

5.7 CHART COMPARISON:

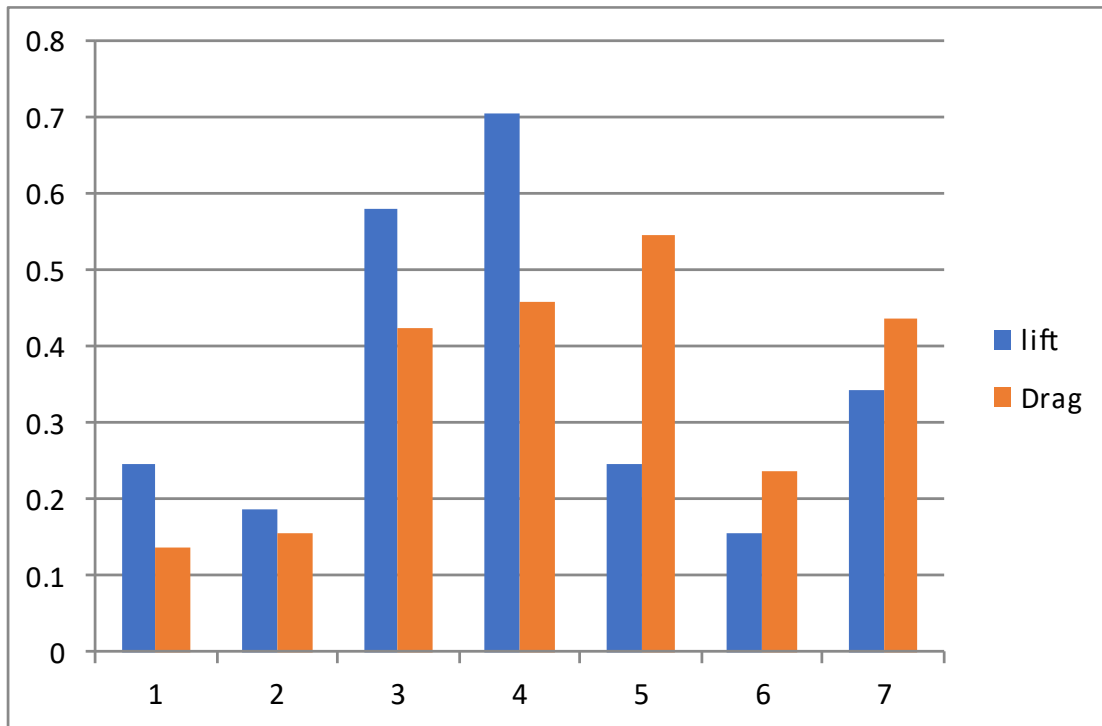
5.7.1 HINGE MOMENT AND PITCH MOMENT COEFFICIENT:

5.7.1 Pitch moment and Hinge coefficient

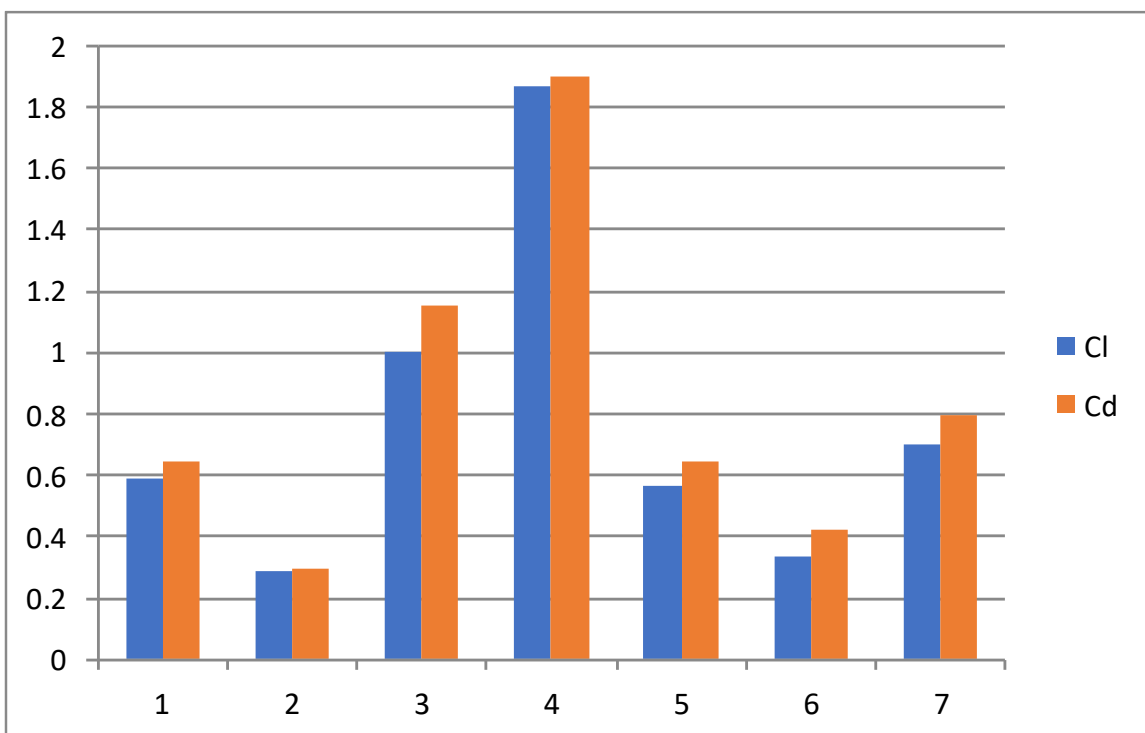


5.7.2 EXISTING MODEL:

5.7.2.1 Lift and Drag

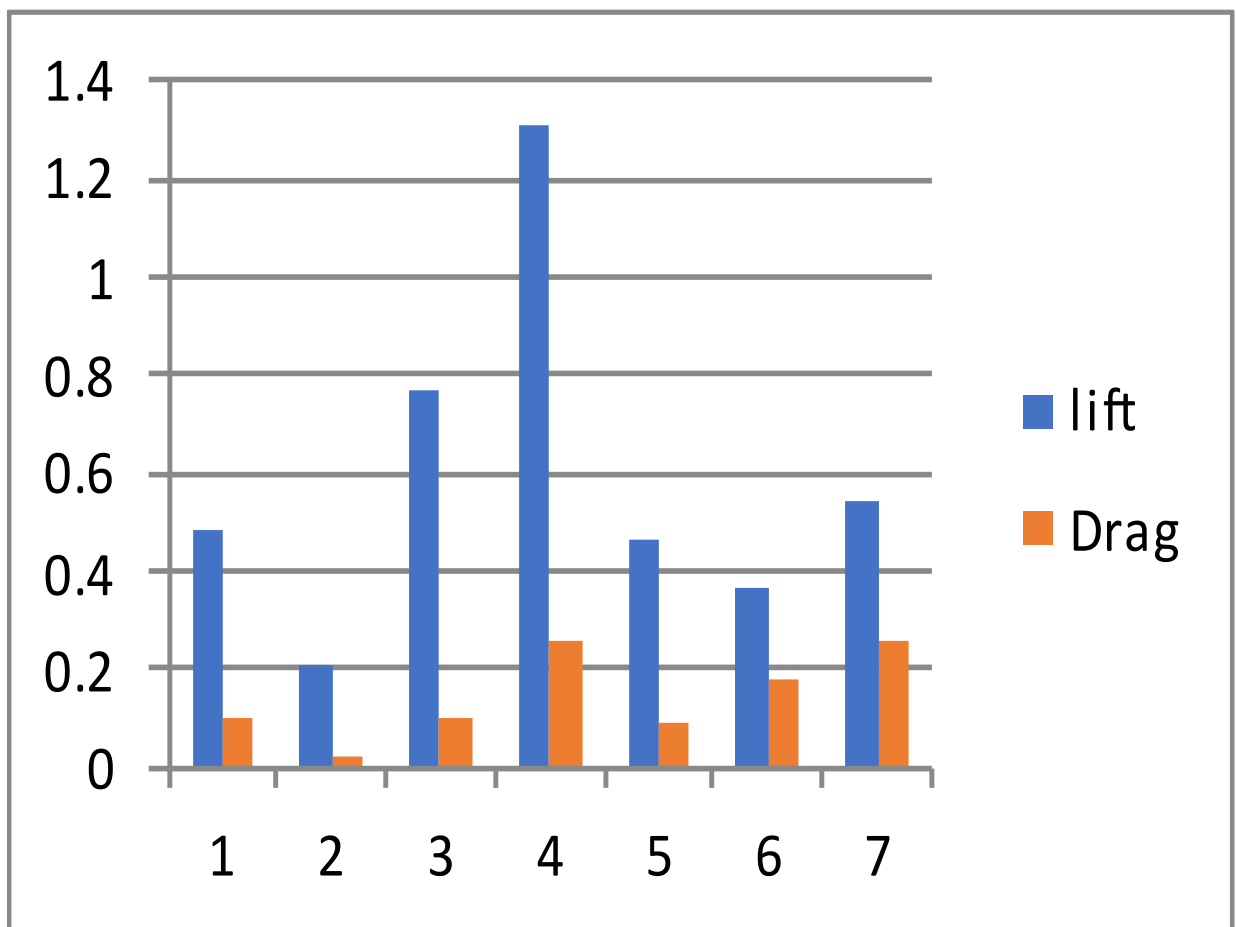


5.7.2.2 Coefficient of Lift and Coefficient of Drag

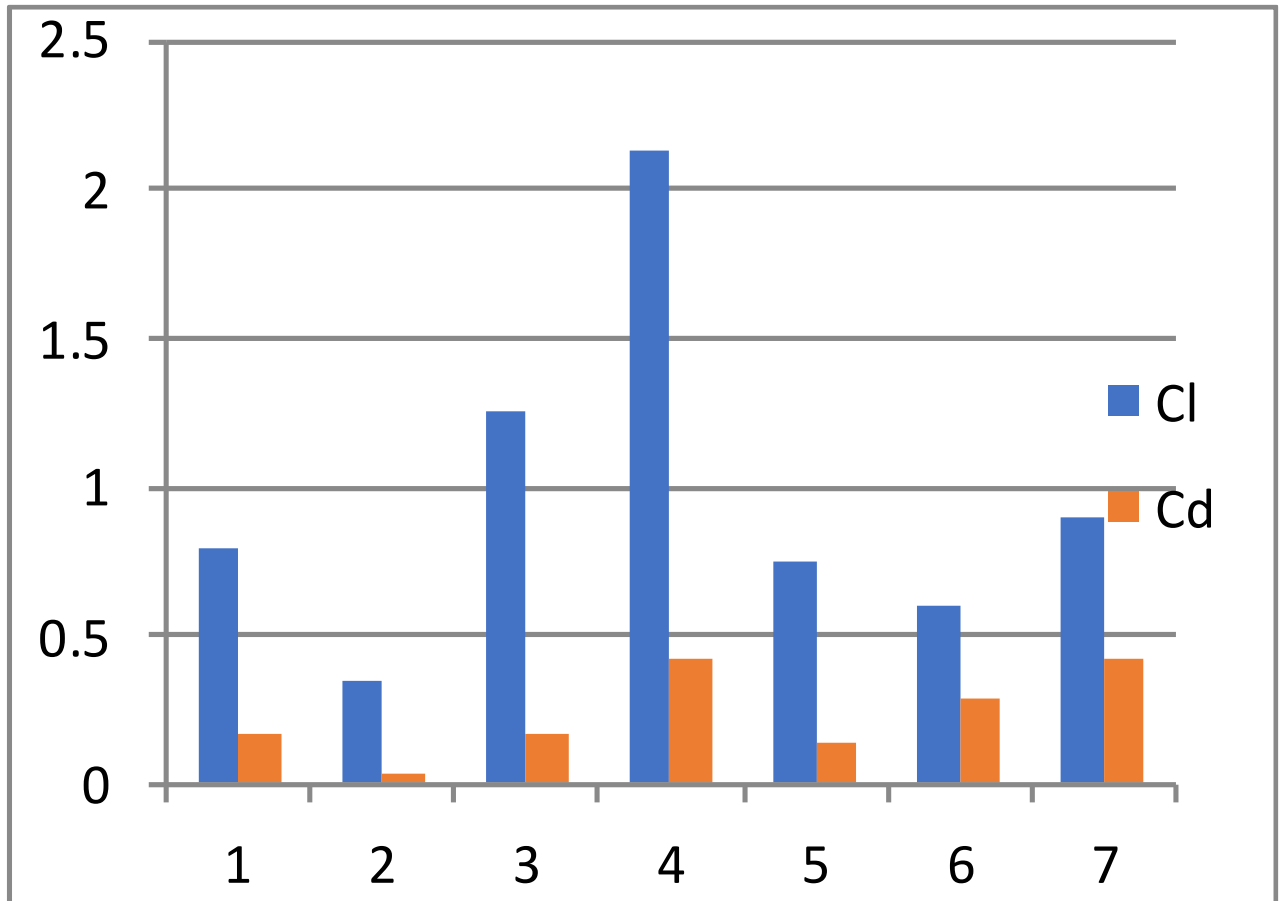


5.7.3 OUR MODEL:

5.7.3.1 Lift and Drag



5.7.3.2 Coefficient of Lift and Coefficient of Drag



CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMARRY AND CONCLUSION:

The various position of upward and downward deflection of wing and its lift and drag estimation are calculated approximately for flap morphed wing model containing ER fluid as well as conventional wing model of similar configuration to validate the lift, pitching moment and control hinge moment efficiently. Thus, the obtained results of the morphed wing model containing the ER fluid possess quick response which produces high L/D ratio in a short period of control hinge moment and proved that the ER fluid controller acts as a high dynamic response of the wing model configuration. The fluid is thicker and thicker in appearance and this viscosity grows along with shear-resistance developments. The ER fluid should be reversible by applying an electrical file when changing from liquid to solid. The transition from liquid to solid can be regulated by electricity very quickly. The change time was estimated to be just approximately 10⁻⁵ seconds. Advanced methods of microcomputer operation. ER technique is a new kind of potential difficulty since it is increasingly used as it's fascinating properties; certain areas of business might be revolved The ER fluid is the secret to an ER process. The ER fluid is the right approach for vibration management and can be used in engineering applications. Applications of morphing aircraft with intelligent materials and systems have been examined. These materials are now used on many micro aircraft, unmanned aerial vehicles and aircraft of full size which indicate the great potential of intelligent materials and structures in aircraft morphing.

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