POLITEKNIK BANTING SELANGOR

WING AEROFLOW STALL TRAINER

NAME	MATRIC NO.
AIMAN NURHAKIM BIN NORZAIN	24DAM21F1008
MUHAMMAD NAJWAN IRFAN BIN MOHD NAHAR	24DAM21F1025
HARITH ISKANDAR BIN JAAFAR	24DAM21F1033
MUHAMMAD AIMAN BIN JEFRIDIN	24DAM21F1001

DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1: 2023/2024

POLITEKNIK BANTING SELANGOR

WING AEROFLOW STALL TRAINER

NAME	MATRIC NO.
AIMAN NURHAKIM BIN NORZAIN	**24DAM21F1008**
MUHAMMAD NAJWAN IRFAN BIN MOHD NAHAR	**24DAM21F1025**
HARITH ISKANDAR BIN JAAFAR	**24DAM21F1033**
MUHAMMAD AIMAN BIN JEFRIDIN	**24DAM21F1001**

A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR A DIPLOMA ENGINEERING IN AIRCRAFT MAINTENANCE

SUPERVISOR:

Ts. MUHAMAD FAROUK BIN ABDUL RASHID

REPORT ENDORSEMENT

This report entitled “Wing Aeroflow Stall Trainer” is being submitted, reviewed, and endorsed to fulfill the conditions and requirements of report writing as specified.

Checked by:

Supervisor’s Signature : 

Supervisor’s Stamp : MUHAMAD FAROUK BIN ABDUL RASHID
Lecturer (DH07)
Dept. of Aircraft Maintenance
Politeknik Banting Selangor

Date : 13 December 2023

Endorsed by:

Project Coordinator’s Signature : 

Project Coordinator’s Stamp : MOHD ZULFAZLI B. RAUB KHAN
PENSYARAH
JABATAN PENYENGGARAAN PESAWAT
POLITEKNIK BANTING SELANGOR

Date : 13/12/2023

CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

WING AEROFLOW STALL TRAINER

SESSION: 1 2023/2024

NAME	MATRIC NO.
AIMAN NURHAKIM BIN NORZAIN	**24DAM21F1015**
MUHAMMAD NAJWAN IRFAN BIN MOHD NAHAR	**24DAM21F1007**
HARITH ISKANDAR BIN JAAFAR	**24DAM21F1002**
MUHAMMAD AIMAN BIN JEFRIDIN	**24DAM21F1012**

"We hereby declare that this report is the result of our own work, except excerpts that we have outlined its sources and this project will be the ownership of polytechnic.

(SIGNATURE : Aiman Nurhakim Bin Norzain)

(SIGNATURE :Muhammad Najwan Irfan Bin Mohd Nahar)

(SIGNATURE : Harith Iskandar Bin Jaafar)

(SIGNATURE : Muhammad Aiman Bin Jefridin)

Endorsed by,

(SUPERVISOR'S SIGNATURE)

MUHAMAD FAROUK BIN ABDUL RASHID
Lecturer (DH47)
Dept. of Aircraft Maintenance
Politeknik Banting Selangor

(SUPERVISOR'S STAMPS)

DATE : 13 December 2023

ACKNOWLEDGEMENT

We extend our deepest gratitude to our parents for their unwavering support throughout this journey. They have sacrificed much, fully supporting our education and the execution of this end-of-semester project in Politeknik Banting Selangor. Our gratitude knows no bounds to our project supervisor, Mr. Ts Muhammad Farouk Bin Abdul Rashid. His constant help, guidance, and unwavering enthusiasm have driven us to complete our report. His professionalism and dedication to his work have inspired and motivated us, lifting our spirits every time we encountered challenges or were low on ideas. Whenever we needed assistance, he never hesitated to offer it, instead providing words of encouragement that helped us surmount our difficulties.

A special thanks to our Aircraft Maintenance Department lecturers for graciously allowing us to use the workshop to execute our project. We would also like to express their gratitude for their advice, guidance, and keen monitoring to ensure that the project was completed on schedule. Their commitment to the project provided a wealth of ideas.

Once more, we extend heartfelt thanks to our team members for their unfaltering cooperation. They willingly sacrificed time, energy, and funds, contributing innovative ideas until the project's completion. Their commitment to the project provided a wealth of ideas. Once more, we extend heartfelt thanks to our team members for their unfaltering cooperation. They willingly sacrificed time, energy, and funds, contributing innovative ideas until the project's completion.

ABSTRACT

The Wing Aeroflow Stall Trainer (WAST) project was developed to showcase the upgraded learning kit in the institute part. This training kit is a product that has an impact on aviation education institutions because it combines the latest hardware and programming. The project aims is to create a training wind tunnel trainer kit that replicates the real world aerofoil configurations, with additional stall indicator for accurate aerodynamic simulation and a real time feedback on the stall behavior, while helping the students in understanding the concept of stall and its impact on aerofoil performance through the visual demonstration and providing a practical and interactive environment for hands on experimentation and understanding in aerodynamic principles. The WAST has features which make operating WAST much more simpler and more accurate for the user. Robust and long-lasting materials, like acrylic cases used to safeguard the training kit, were used in the development of the WAST. To make sure the product can function for a long time, the choice of materials is crucial. Aerodynamic concepts and stall behavior are becoming easier and better to master thanks to WAST. After the project's completion and testing, WAST were able to meet all requirements for providing students hands-on experience with the trainer kit, improving their comprehension of aerodynamic concepts and stall behavior. In addition, a post-survey is carried out to collect information regarding satisfaction with the product. The majority of respondents agreed, based on the data collected, that WAST aids students in learning and comprehending the concept of aerodynamics and stall behavior. For the conclusion, it is clear that the development of WAST is giving a huge impact to the aviation student by enhancing their understanding of aerodynamic concept and stall behavior.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

NO	ABBREVIATION	MEANING
1	AOA	Angle Of Attack
2	LED	Light Emitting Diode
3	DC	Direct Current
4	AC	Alternating Current
5	IDE	Integrated Development Environment
6	ESP	Espression System

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Wind tunnels have been an integral part of engineering for decades, serving as a crucial tool for model testing and fundamental learning. They have greatly contributed to our understanding of aerodynamics, especially regarding the effects of free stream turbulence on shear layers. While closed circuit systems ensure precise testing conditions, open circuit wind tunnels can also deliver impressive performance with careful design.

The versatility of wind tunnels extends across various engineering disciplines, offering valuable insights into aerodynamics and transport phenomena. A wind tunnel is a device that is used to create a regulated air stream so that models of aircraft and other machinery and items may be studied to see how movement through the air or resistance to motion affects them (Emily Rodriguez, 2018)**.** One prominent application involves studying the effects of lift and drag on airfoils and analyzing wind loads. Through wind tunnel simulations, engineers can gain a deeper understanding of aerodynamic principles and effectively manage challenges in these areas. The knowledge obtained from these experiments aids in optimizing designs and improving performance.

Wind tunnels serve as a vital resource for engineers, enabling them to explore and refine their understanding of airflow behavior (NASA STEM Team, 2017)**.** This providing-controlled testing environments and accurate measurements, wind tunnels contribute

significantly to advancements in aerodynamics and related fields. Their continued use ensures that engineers can continue to innovate and develop efficient and safe solutions across a wide range of industries.

Figure 1.1 Wind Tunnel Aerodynamics Trainer (NASA, n.d.)

Based on Figure 1.1, aerodynamics is truly fascinating as it shows us how the principles of physics come to life in the real world. It's not just about equations and theories; it has practical applications that can captivate students who may have found the subject abstract before (National Aviation Academy, 2023)**.** That's where the Wing Aeroflow Stall Trainer (WAST) comes in. It's specially crafted to make aerodynamics learning more exciting for aviation students.

The WAST takes a hands-on approach for education, with the physical experiments that let the aviation students participate and engage them with the aerodynamics subject. Once they have involved the fundamental principles of aerodynamics, WAST will make them more understanding by allowing them to apply those principles through the practical demonstration of the WAST. This training kit will create an interactive learning experiences that will ensure student fully understand the concepts of aerodynamics

With the stall indicator equipped, the WAST will help students to gain a deeper understanding. They can explore how different Angle of Attack (AOA) affect the lift and drag of the aerofoil. With this experience, students are able to analyze the critical AOA

when stalling in real time. In essence, the WAST with its stall indicator will make the learning process easy to understand for aviation students.

1.2 Problem Statements

Aviation students often face challenges when it comes to understanding and experiencing aerodynamic stall behavior in wind tunnel testing due to the lack of practical training tools. The current wind tunnel setups typically don't provide dedicated training kits that offer a comprehensive understanding of aerofoil stall behavior (Revine, 2023). Students miss out on the opportunity to explore the influence and receive real-time feedback through a reliable stall indicator. Consequently, there arises a need to create a trainer kit, like the Wing Aeroflow Stall Trainer (WAST), that can significantly enhance the comprehension of aerofoil stall characteristics and improve the overall training experience for aviation students.

"The flow will pass over a wing smoothly at low angles of attack; this aerodynamic condition is the normal flight condition. The stall angle of attack is the maximum angle of attack at which a wing is able to operate."(Leishman, 2023)

Whilst extracting the findings of a survey, some students encounter difficulties in learning the aerodynamic behavior of aerofoils with stall indicators during stall conditions, and express a preference for learning with the aid of a WAST.

1.2.1 Project Aim

The project aims is to create a training wind tunnel trainer kit that replicates the real world aerofoil configurations, with additional stall indicator for accurate aerodynamic simulation and a real time feedback on the stall behavior, while helping the students in understanding the concept of stall and its impact on aerofoil performance through the visual

demonstration and providing a practical and interactive environment for hands on experimentation and understanding in aerodynamic principles.

1.3 Project Objectives

1.3.1 General Project Objective

The project objective is to create and construct a wind tunnel trainer kit that effectively replicates real-world aerofoil configurations. This comprehensive training tool will incorporate essential elements such as a stall indicator to accurately simulate the aerodynamic behavior of aerofoils.

To integrate a stall indicator into the trainer kit, ensuring its reliability and accuracy in providing real-time feedback on the stall behavior.

To aid students in comprehending the concept of stall and its impact on aerofoil performance. This will be achieved by utilizing a stall indicator to visually demonstrate the point at which the aerofoil stalls, as well as the corresponding alterations in lift and drag.

To provide students a practical and immersive opportunity to do experiments with aerofoils within a controlled environment, enabling them to develop a profound comprehension of the fundamental principles of aerodynamics.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure

The product structure of Wing Aeroflow Stall Trainer (WAST) is to enhance user friendliness by incorporating smartphone technology, allowing for a seamless and convenient experience that is easily accessible to all users. The development of an app by utilizing Arduino technology will enable the students to efficiently control the training kit through a user-friendly interface such as a smartphone. This technology aims to streamline the operation of the training kit and provide an easy learning experience for the users.

Furthermore, the structure of the product is high reliability and minimal maintenance requirements. By ensuring the product's toughness and durability, users can rely on the training kit for a long period of time without frequent maintenance and interruptions. This focus on reliability contributes to a smooth and uninterrupted learning process and also experience.

In addition, the project emphasizes the importance of design. The training kit is designed with an ideal shape and weight, to its intended use. This consideration will ensure practicality and effortless handling, enhancing all of the users experience. The design facilitates the users, and allows the users to fully focus on the learning and experimentation process.

Lastly, the project structure is user friendly, efficient,reliable and designed with an ideal shape, providing an enjoyable experience for users while promoting effective learning and understanding of aerodynamic principles with the use of WAST.

1.3.2.2 Product Mechanism

The product mechanism for the Wing Aeroflow Stall Trainer (WAST) is designed with an adjustable Angle Of Attack (AOA) that allows the airflow to move through the airfoil. By adjusting the angle of attack of the wing, students are able to observe how the lift and drag characteristics change, closely replicating the real-world aerodynamic conditions.

The trainer is fitted with stall indicators, which offer trainees both audio and visual signals to identify stalls and comprehend the airfoil's stall behavior. The purpose of these stall indicators is to assist students better understand this aerodynamics phenomenon by emphasizing the key point at which an AOA hits a stall.

Students also have the capability to adjust the AOA of the airfoil on this training kit. This feature allows them to observe and analyze the effects of different angles at which the airfoil interacts with oncoming airflow. Students can learn how variations in the lift, drag, and stall characteristics of the airfoil are impacted by adjusting the AOA.

The trainer also provides students with immediate feedback through the integration of stall indicators and real time observation of the airfoil behavior. This feedback enables the students to evaluate their understanding and make the necessary adjustment as they gain understanding in the aerodynamics principles that are shown by the training kit. By offering this timely feedback, the training kit facilitates an interactive learning process, which allows the students to refine their skills and deepen their understanding of aerodynamics.

1.3.2.3 Product Programming

For this product programming is to provide control over the flaps, which allows the students to make adjustments to the airfoil configuration and observe the changes in lift and drag properties, enhancing their understanding of aerodynamics.

Additionally, this programming of the trainer enables students to adjust the Angle Of Attack (AOA) of the airfoil. This feature allows them to modify the orientation of the airfoil and gain practical insights into variation in the AOA impact of lift, drag and stall behavior.

Furthermore, the programming of stall indicator sensors that is capable of detecting stall conditions. By continuously monitoring the readings from the sensor, the system can provide immediate feedback or alerts when a stall is detected, enabling students to recognize and respond to stall situations.

Overall, the integration of this programming in the Wing Aeroflow Stall Trainer (WAST) enhances the learning experience by offering precise controls, the ability to adjust the AOA, and inclusion of stall indicator sensor, contributing to a comprehensive understanding in aerodynamics.

1.3.2.4 Accessories & Finishing

For accessories and finishing is to provide final touch to the product. This will give an appropriate final design of the product for one of the nice and clean products. This also gives a benefit to the product as well as a good to display. It is to increase the quality of the product to be used.

In addition, it is to put the product with material and coating for a proper quality product such painted black on the 3D printed wing and the cardboard. This gives a good

view for the wing can be seen in the product. For adding cardboard as a platform so the electrical and electronic components can be stored inside the product, it will improve the quality of the product and also increase professional work.

Finally, the accessories and finishing is to provide an aesthetic look and finish while not disturbing the functionality of the product. The people can see the airflow move through the wing because the selected colour in this product black and white make it contrast . This can increase the demand of the product to the training institute to provide a hands on experience training kit with stall indicator.

1.4 PURPOSE OF PRODUCT

The Wing Aeroflow Stall Trainer (WAST) includes the triple helix concept for the purpose of the product by fostering collaborative interactions and creating impacts across academia, industry and business. In academia, it enhances students learning experience in aerodynamics, providing hands on experience and hands on experiments that can gain their understanding of fundamental aerodynamics and prepare them for their future careers especially in aviation industry

For industry, the WAST equip students with practical skill in stall behavior, aerodynamics performance of the airfoil, thus enabling them to contribute innovation and address the industry challenges.

Moreover, the impact of the WAST in educational institutions and training centers creates potential business opportunities. Companies specializing in the manufacturing and distribution of the trainer can cater to the growing demand for such educational tools. This can lead to increased market growth for businesses operating in the market. Figure 1.2 shows impact of WAST project by using triple helix model.

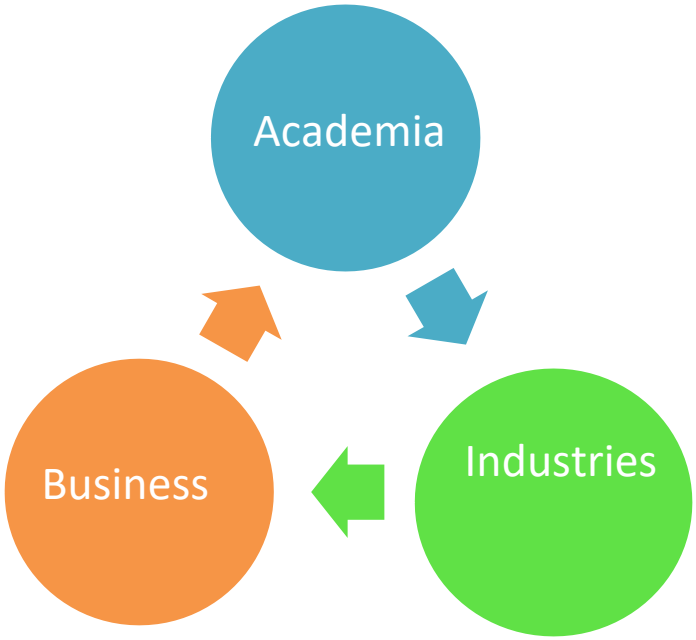


Figure 1.2: Triple Helix Model Of WAST

1.5 Scope of Project

1.5.1 General Project Scope

The objective of this project is to create student training kits that will help them comprehend the stall behavior and how it affects the aerofoil. With the use of the Wing Aeroflow Stall Trainer (WAST), students will have the opportunity in gaining experience through the observation and experiment that is conducted on the training kit. The main focus of developing this project is to improve the students' understanding towards the fundamentals of aerodynamics.

1.5.2 Specific Individual Scope

1.5.2.1 Product Structure

The Wing Aeroflow Stall Trainer (WAST) is designed with a strong base and a reliable frame for the component of a wind tunnel itself, to ensure the control of the airflow.The structure is well constructed, allowing the thorough learning experience of the fundamental aerodynamics, including the stall behavior. Moreover, the WAST has features like stall indicators. This will enhance the learning process and experience that will give them understanding of how control surfaces interact.

1.5.2.2 Product Mechanism

The Wing Aeroflow Stall Trainer (WAST) is made using a mechanism that enables students to comprehend the airfoil's aerodynamic characteristics. The features of WAST is it has adjustable angle of attack (AOA) by using the Arduino that has been programmed. With all these components, students can control the AOA thus influencing lift,drag and the stall behavior. This interactive experience will provide the students with an understanding of how the control surfaces work and interact.

1.5.2.3 Programming

The Wing Aeroflow Stall Trainer (WAST) can be controlled using an Arduino microcontroller to combine the features that enhance the learning process. By programming the WAST, students can adjust the angle of attack (AOA), changing how the airfoil can interact with the airflow. This will ensure the lift, drag and stall behavior can be seen.

Moreover, this programming will allow the movement of AOA affects the airflow over the airfoil. By adjusting the different position of AOA, students can gain

understanding of aerodynamics properties and how this relates to stalls.

Furthermore, this programming also has a stall indicator, which is able to detect the stall conditions. By continuously monitoring the sensor, the system gives immediate feedback and alerts when the AOA reaches a certain angle of stall. With this feedback and alerts, students are able to identify and respond to stall effectively, helping gain their understanding and learning process.

In conclusion, by adding Arduino for the programming, the WAST become an advance and interactive training kit. Students are able to analyze various aerodynamics situations involving the AOA and stall indicators and the impact on the airfoil.

1.5.2.4 Accessories & Finishing

The Wing Aeroflow Stall Trainer (WAST) is designed to provide educational learning by using training kits. The smoke from the fog machine will flow out from the small white hose and come in contact through the wing. Since the smoke coming from the fog machine is seemingly hot, the material which is cardboard used to be fine when handling hot pressure inside the product. This material is easy to find and reuse because it is recycled material.

Then, the product needs to be finished with coating by painting the 3D printed wing with black color to look aesthetic and high quality material use. This is also for safety to people so that the non-hazardous smoke is not exposed to much in the surrounding.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Demand in Aviation

Given how important it is for pilots and other aviation professionals to comprehend and manage stall conditions, wing stall training kits can be in high demand in the aviation industry. Wing stall describes a situation in which the airflow over an aircraft's wing is disrupted, resulting in a loss of lift and, if properly addressed, the potential loss of control. Wing stall training kits are intended to simulate stalling an aircraft and teach students how to recognize it, ***"Companies that provide aviation training and simulators expect that the need for pilots will increase faster than previously thought by industry observers."*** (TOOL KIT technologies, 2023)

One of the teaching strategies to improve knowledge and technical skill acquisition is the Educational Trainer Kit (ETK). The common problem with the traditional teaching technique that prevents students from remembering and retaining what they have learned in the classroom is addressed by ETK (Jambari et al., 2018)**.** This addressed the results of a study investigating the program's ability to improve engineering students problem solving and teamwork abilities.

In creating a product or item, it needs to have certain advantages to benefit users. If this wing stall training kit is developed in the learning section in the field of aviation, one of the advantages of the wing stall training kit is that it can provide a clearer and deeper understanding of aircraft stall. With this product, it can be used as an initiative for lecturers to help students learn of stall conditions.

The need to maintain flight safety and avoid stall-related accidents is what drives demand for wing stall training kits. These training kits are frequently sought after by flight schools and aviation training organizations to improve students' knowledge of stall recognition (J. Gordon Leishman, 2022)**.** The use of such training kits as part of student training programs may also be required or advised by regulatory authorities and aviation safety organizations.

2.1.2 Types of Study Kit In Aviation

Several types of study kits are available in the field of aviation that will help in the study and understanding of topics related to aviation. There are two types of study kits that are most common in the field of aviation, they are pilot training kits and aircraft maintenance kits. The materials in pilot training kits, which are designed for aspiring pilots, frequently include study materials for various pilot certifications as well as flight manuals, aircraft systems manuals, navigation charts, and flight planning tools**.** Figure 2.1 shows part of a study kit in aviation that was developed for pilot training kit.(Nancy Hall, 2021)**.**

Figure 2.1: Example of pilot training kit (Google, n.d.)

The aircraft maintenance kit should be used by engineers and technicians who perform aircraft maintenance. There are often technical specifications, troubleshooting manuals, and other reference materials that you can find in it about aircraft systems, engines, avionics, and maintenance procedures related to aircraft systems. There might also be specialized tools and equipment included in the kit for maintaining the aircraft as well. Figure 2.2 shows some examples of training kit for aircraft maintenance students that can provide knowledge and experience to student and maintenance personnel.

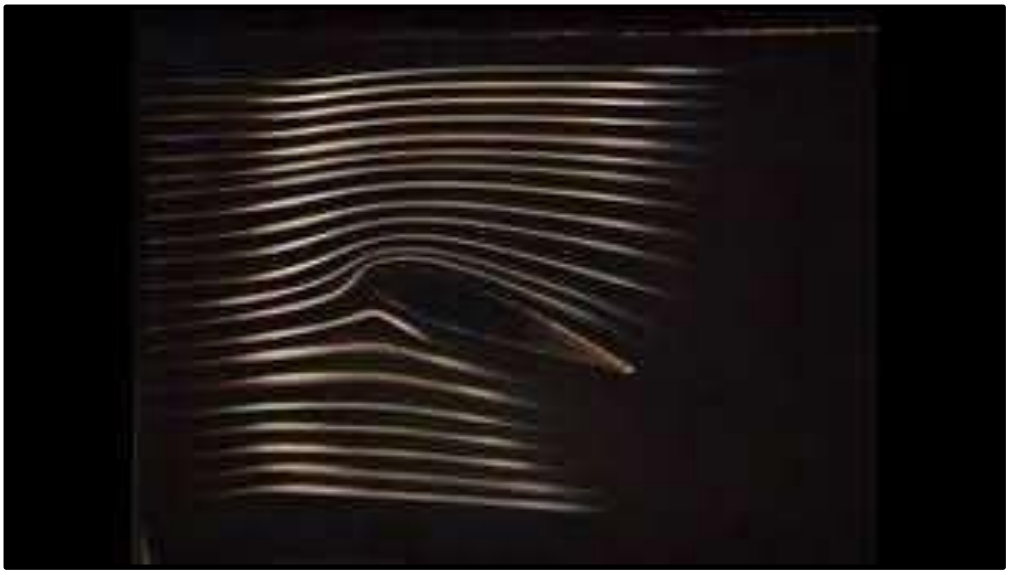


Figure 2.2: Example of study kit (University of Cambridge, 2012)

The study kit that was developed is mainly used in aircraft maintenance kits and pilot training kits since it provides a much more detailed and clear explanation of what happens to aircraft when they stall as well as what can be done when the aircraft stalls in this situation. It is clear that this study kit can have a positive impact on users such as students and instructors in the field of aviation.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

The structure of this product has been discussed among group members to decide on suitable and durable materials and components to make this product successful. This product can also be connected or set using an application in a smartphone to facilitate the use of this product.

There are several important parts in the success of this product, among the most important parts must be the Angle Of Attack (AOA) and stall indicator. For the stall indicator, it functions as a warning signal when facing an excessive AOA as happens in the cockpit when the aircraft faces a stall condition. As for the wing part, it is developed by using materials that can be used for a long period of time without requiring difficult maintenance, for example high quality polylactic acid (PLA). This material was chosen to be used as a wing because of several factors such as light,and durability. The main function of this wing is to show the airflow when it faces a stall and when the airflow is cruising. Figure 2.3 illustrates measurement of every on Top view, Side view and Front view.

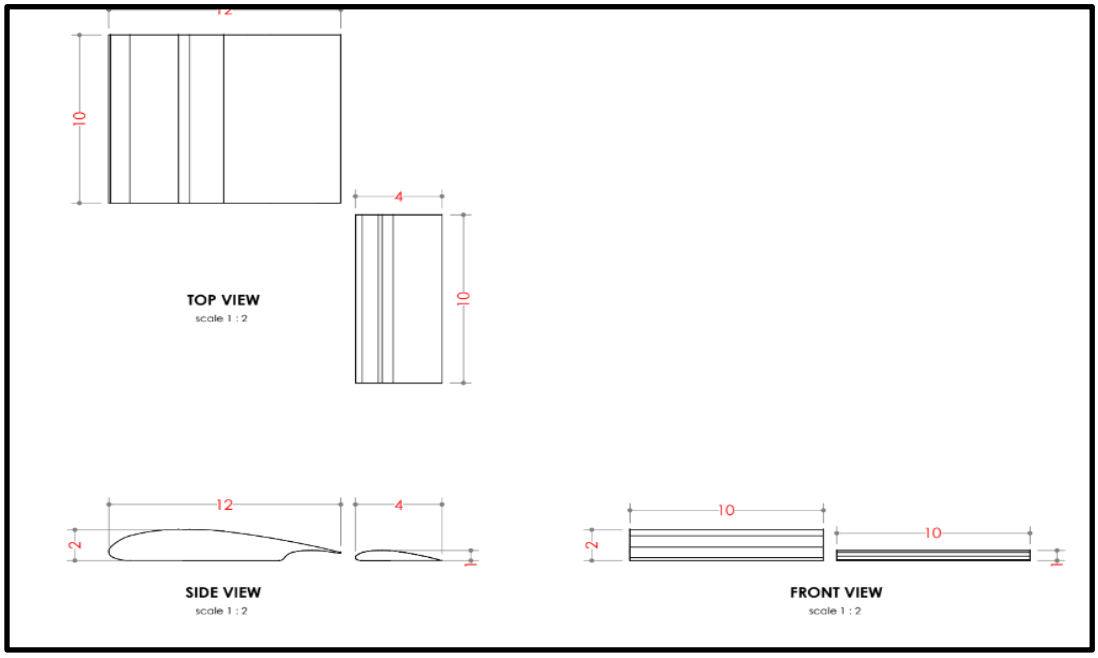


Figure 2.3: Product sketch

The next part is the external and internal parts of the product apart from the wing and stall indicator. The first part is the casing, it works to protect the internal parts of the product such as the wing. The material used to make the casing is an acrylic case. This material was chosen because it is transparent, therefore it makes the inner part easy to see clearly. This acrylic is also very resistant and requires a low cost

The next part is the ventilation part, it works for the airflow to move more smoothly. This part is needed to avoid the accumulation of smoke in the interior which will result in disrupted and uneven airflow. Therefore, ventilation is very important. Next, a fan is used to remove the smoke inside the casing, so the ventilation runs smoothly. Other than that, flexible small hoses are also used to guide the airflow so that the smoke moves more regularly and clearly. The next part is the lighting part, it works so that the airflow smoke can be seen clearly. Small LED lights are used to act as visual warning lights when the aircraft faces a stall. The figure 2.3 shows the product sketch that consists of fan, wing, flaps, small hose, acrylic case and led light.

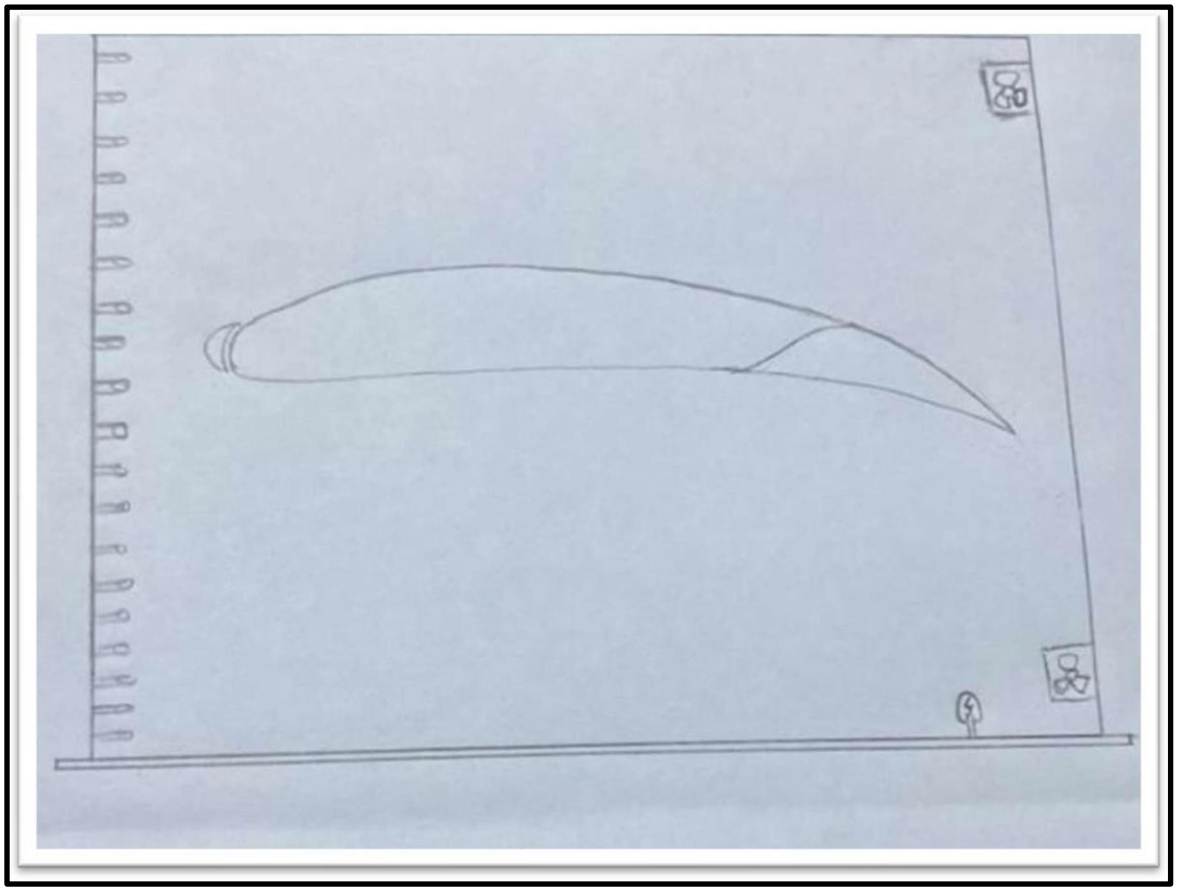


Figure 2.3: Product sketch

2.2.2 Product Mechanism

2.2.2.1 Servomotor

A servo motor is a kind of motor that has extremely precise rotational capabilities. This type of motor typically has a control circuit that gives feedback on the motor shaft's current position. This feedback enables the servo motors to rotate with high accuracy.A servo motor is used to rotate an object at predetermined angles or ranges. Figure 2.4, it is an example of a servomotor.

Figure 2.4: Example of servomotor (Google, n.d.)

For this product to work properly, it needs a servo motor, a servomotor is needed to move any mechanism accurately so as to get the best results and movement. The servo motor utilized in this product is an SG90.Based on figure 2.5 which is SG90 servo motor that is used in product to give a smooth progress based on its weight when operated.

A micro servo motor with gear is called the SG90. This compact, light-weight servo, this servomotor is also low cost. Due to these factors the SG90 servo motor was chosen.

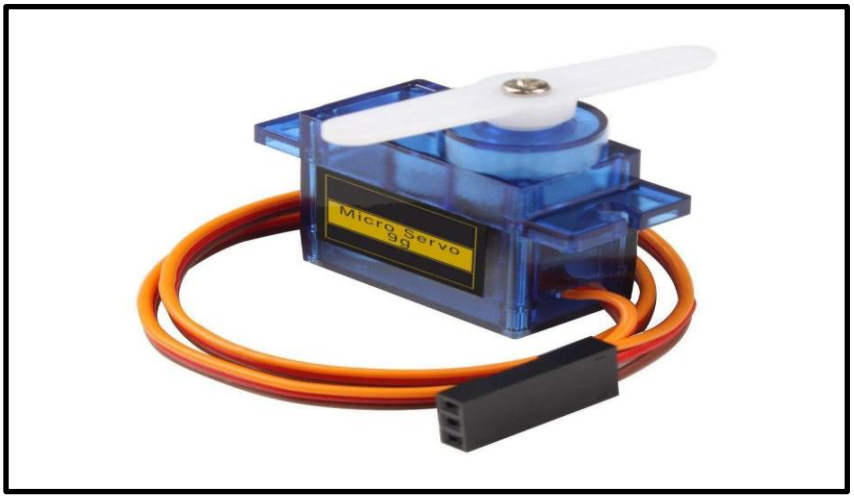


Figure 2.5: SG90 servo motor (Google, n.d.)

2.2.2.2 Type of Servomotor

There are three main types and numerous sizes of servo motors. Positional rotation, continuous rotation, and linear rotation are the three types. Other than that, servomotor also have AC and DC types. A motor is referred to as a DC servo motor if it is powered by a DC power source. If it is powered by an AC power source, it is an AC servo motor. In table 2.1 below, it shows the type, explanation and example of a picture of servo motor.

Table 2.1: Type of servo motor

Type of servomotor	Explanation	Picture
Positional rotation	The most frequently used type of servo motor is one with positional rotation. The shaft rotates approximately 180 degrees. These typical servos are used in a wide range of applications, including radio-controlled vehicles and aircraft.	
Continuous rotation	Servo motor with continuous rotation; it can travel in any direction indefinitely. The servo can rotate either clockwise or anticlockwise	
Linear rotation	Similar to the positional rotation servo motor previously discussed, the linear servo motor also changes the o/p from circular to back-and-forth by adding an additional set of gears.	

2.2.3 Software and Programming

2.2.3.1 Arduino

An open-source electronics platform called Arduino is built on simple hardware and software. With the touch of a finger on a button or the light from a sensor, Arduino boards can read inputs and convert them into outputs that turn on a motor or an light emitting diode (LED). By sending a set of instructions to the board's microcontroller, it can instruct the board what to do. It must do this using the Arduino Software (IDE), which is based on Processing, and the Arduino Programming Language.

Over the years, thousands of projects, that include simple household items to intricate scientific instruments, have used Arduino as their brain. This open-source platform has attracted a global community of makers, including students, hobbyists, artists, programmers, and professionals. Their contributions have added up to an incredible amount of accessible knowledge that can be very helpful to both beginners and experts.

ESP 32 will be used for this product so that the system can respond and function properly and accurately. This ESP 32 was chosen for several factors, among which it is easy to program, has the latest and modern technology and is also very resistant. Based on figure 2.6, ESP32 Dev Board was chosen because of its good advantage.

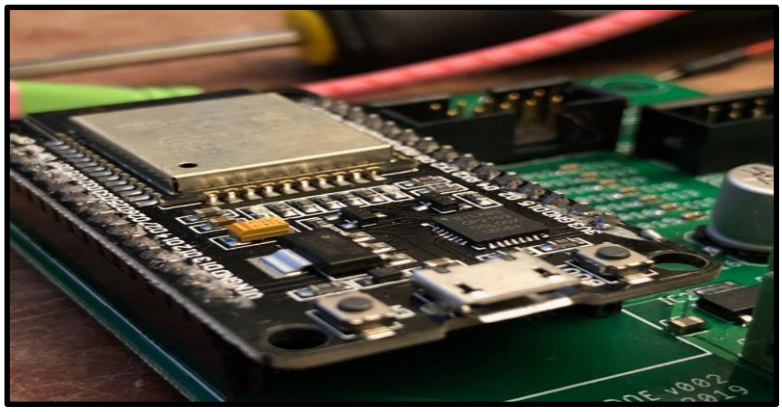


Figure 2.6: ESP32 Dev Board (JM, 2020)

2.2.3.2 Type of Arduino

An open-source tool used to create virtually all types of electronic projects is the Arduino board. It is made up of a microcontroller and software that runs on your computer and is used to upload and write computer code to the actual device. The Arduino platform has gained a lot of popularity among designers who are just getting started with electronics. The Arduino does not require any additional hardware for its initial programmable circuit board.

These are some of the Arduino types, which are Arduino Nano, Arduino Uno, Arduino Micro, Arduino Bluetooth, Arduino Robot, Arduino Zero,and ESP. Figure 2.7 shows several arduino types that are available in the market.

Figure 2.7: Arduino type (Joibit Joseph, 2022)

2.2.4 Accessories and Finishing

2.2.4.1 LED Light

For accessories and finishing, led lights are used to indicate visual indicators for stall so that it will indicate stall behavior. Lecturers and students are able to see the visual indicator warning system and be aware of when it stalls with the application of this light emitting diode (LED) light. This is an important visual warning for the training kit at the same time will make this study kit more interesting. Figure 2.8 shows an example of led light to promote a visual indicator warning that will indicate student when it's over the limit of Angle of Attack (AOA).

Figure 2.8: LED light (Google, n.d.)

2.2.4.2 Black Spray Paint

The 3D printed wing comes with white colors while the smoke is also white, so the wing is not clearly visible inside the product. This black spray paint is used to paint the wing to make airflow visible through the wing. This is also used for cardboard to make an aesthetic look and high quality material. Figure 2.9 shows spray brand ANCHOR that is available on hardware and affordable price.

Figure 2.9: Spray can (Google, n.d.)

2.3 REVIEW OF RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Product

2.3.1.1 Product A

This is an example of something that seems to be the same as the product that is being developed, which has a wing tunnel airflow concept for the same purpose. This product is also a study kit used for learning about airflow on the wing, this product by aviation students to give a clearer and more detailed explanation about airflow. This product allows the wing to face a different Angle Of Attack (AOA) just like the product that is being developed. Figure 2.10 and 2.11 shows some training kit that seems to be the same as the product being developed but its different function on product will be developed.

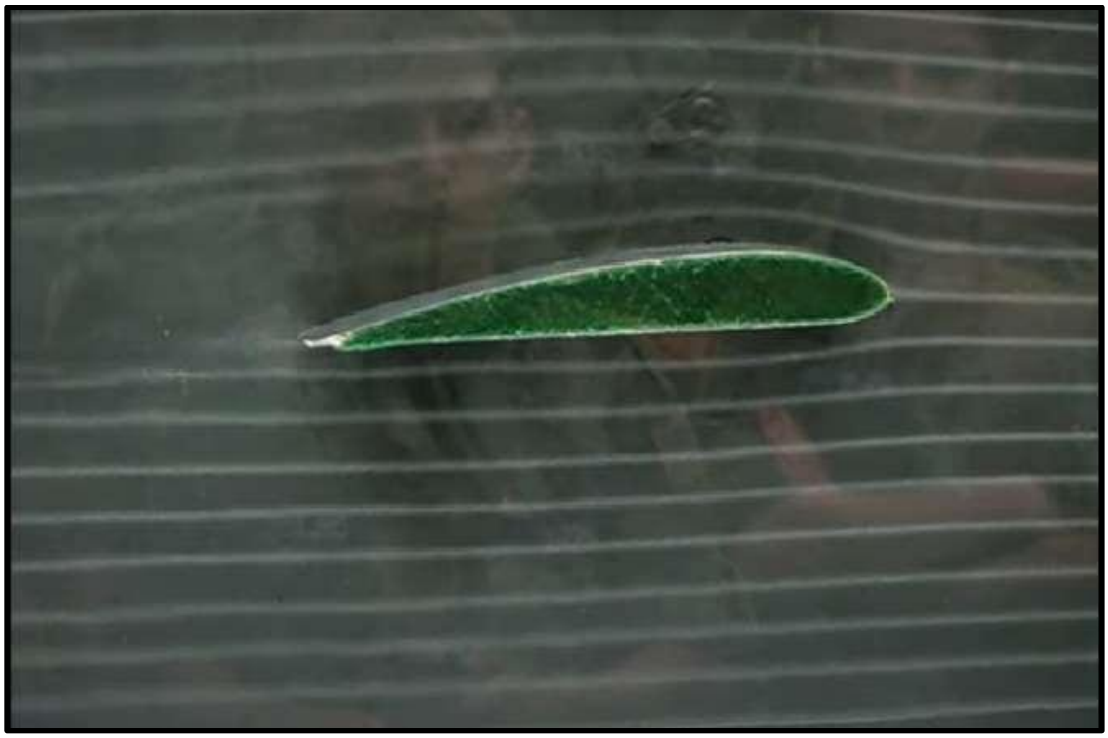


Figure 2.10: Wing airflow demo (Youtube, 2012)

Figure 2.11: Wing Air Flow Demo (Youtube, 2012)

2.4 COMPARISON BETWEEN RECENT RESEARCH AND CURRENT PROJECT

Based on the similarity of the project, a comparison was made between the research project and the WAST project. Table 2.2 shows comparison between research and project

Table 2.2: Comparison between research and project

Product 1	Product	Product A
Wing Aeroflow Stall Trainer	Name	Wing Air Flow Demo
A study kit that demonstrates stall and airflow when the wing is in stall condition.	Explanation	A study kit that demonstrates the condition of airflow to a certain degree.
Stall warning indicator Latest programming Moveable wing	Differences	Moveable wing
	Picture	

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

3.1.1 Utilization of Polytechnic's Facilities

In order to achieve the project objectives, various facilities in Politeknik Banting Selangor were utilized. The main structure and wing attachment were done in Composite Workshop and Engineering Workshop 1. For the wiring and programming or coding were accomplished in Electrical and Electronic Lab. When all these sections have been completed, all the assembly section of hardware and software is completed in the Composite Workshop.

To use all of these facilities, the permission from the Project Supervisor and Workshop Coordinator is required first. In addition, the Permission Form is filled and submitted before entering all these facilities. This form contains the list of using equipment, machines, tools and also required Project Supervisor sign.

Before handling the machine, tools and equipment, the safety precautions need to be followed. Always make sure to wear Personal Protective Equipment (PPE) when using tools, machines and equipment so that no incidents happen.

3.2 OVERALL PROJECT GANTT CHART

AEM Project Gantt Chart

Table 3.1: WAST AEM Project Gantt Chart

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Briefing And Group Formation • Create a group with 4 members • All members have their own idea for project • Meet supervisor and present our own idea • Only 1 idea accepted	P															
	E															
Project Registration Form • Make research about wind tunnel • Make research about stall indicator • Make research about other study kits • Make research about suitable Arduino board • Make research about suitable servomotor • Make research about flaps and slats function	P															
	E															

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Assignment Chapter 1: Introduction • Do background of study • Do problem statement • Do project aim, impact and scope	P															
	E															
Assignment Chapter 2: Literature Review • Do introduction of product • Do recent research of product • Do comparison of product	P															
	E															
Pre-Proposal Approval Form • Print 2 sheet for judges' purposes	P															
	E															
Pre-Proposal Presentation (Slides) • Do a power point slide about the project	P															
	E															

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Assignment Chapter 3: Research Methodology • Product description • Product sketching and modelling • List of material and expected expenditure • Expected result • Gantt chart	P															
	E															
Final Proposal Presentation • Finalize the presentation slide	P															
	E															
Final Proposal • Do correction for final proposal • Submission of final proposal	P															
	E															

P	PLANNING
E	EXECUTE

AEP Project Gantt Chart

Table 3.2: WAST AEP Project Gantt Chart

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Material acquisition • Acrylic Sheet (3pcs) • Fog Machine • Big Hose (1m) • Small Hose (1m) • PC Fan (12mm) • Servomotor (3pcs) • ESP32 • Breadboard • PVC Pipe (1m) • Ball Valve • Hinges (2pcs)	**P**															
	E															
Measuring, Filing, leveling and cutting • Acrylic Sheet (2pcs) • Acrylic Sheet (4pc)	**P**															
	E															

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Main Structure (Phase 1) • Assemble the acrylic sheet to acrylic case • Filing the acrylic sheet into the set measurement • Cutting acrylic sheet for exhaust fan size • Drill for smoke flow output • Assemble hinges between top and back side acrylic case	P															
	E															
Programming (Phase 2) • Download the Arduino Integrated Development Environment (IDE) • Download all the related libraries to the project that contain code that simplifies the programming process • Set up the component on the circuit board according to the project requirement • Write the code that will control this component on how each component should function and be controlled • Assemble the component with the main structure and ensure the component are securely attached	P															
	E															
Project Progress Presentation • Update logbook to supervisor • Do a slide presentation • Meeting with supervisor • Review slide with supervisor	P															
	E															

PROJECT ACTIVITIES		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Mechanical Parts (Phase 3) • Assemble the servomotor to the wing 3D printed • Attach the wing to the acrylic case • Assemble hinges between top and back side acrylic case • Put the airflow hose to the acrylic case • Attach the ball valve to PVC pipe	P															
	E															
Accessories and Finishing (Phase 4) • Spray black paint on wing and cardboard • Assemble the acrylic sheet to acrylic case • Clean the inner and outer acrylic case with thinner • Assemble the cardboard inside the acrylic case	P															
	E															
Final Viva • Make a project final video, a poster, brochure and decorate booth • Present final product to the pre-determined juries	P															
	E															
Submission of Thesis, Poster, Brochure, CD and Project Video • Submit e-thesis, CD and log file • Aeromech competition	p															
	E															

P	PLANNING
E	EXECUTE

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

AEM Project Flow Chart

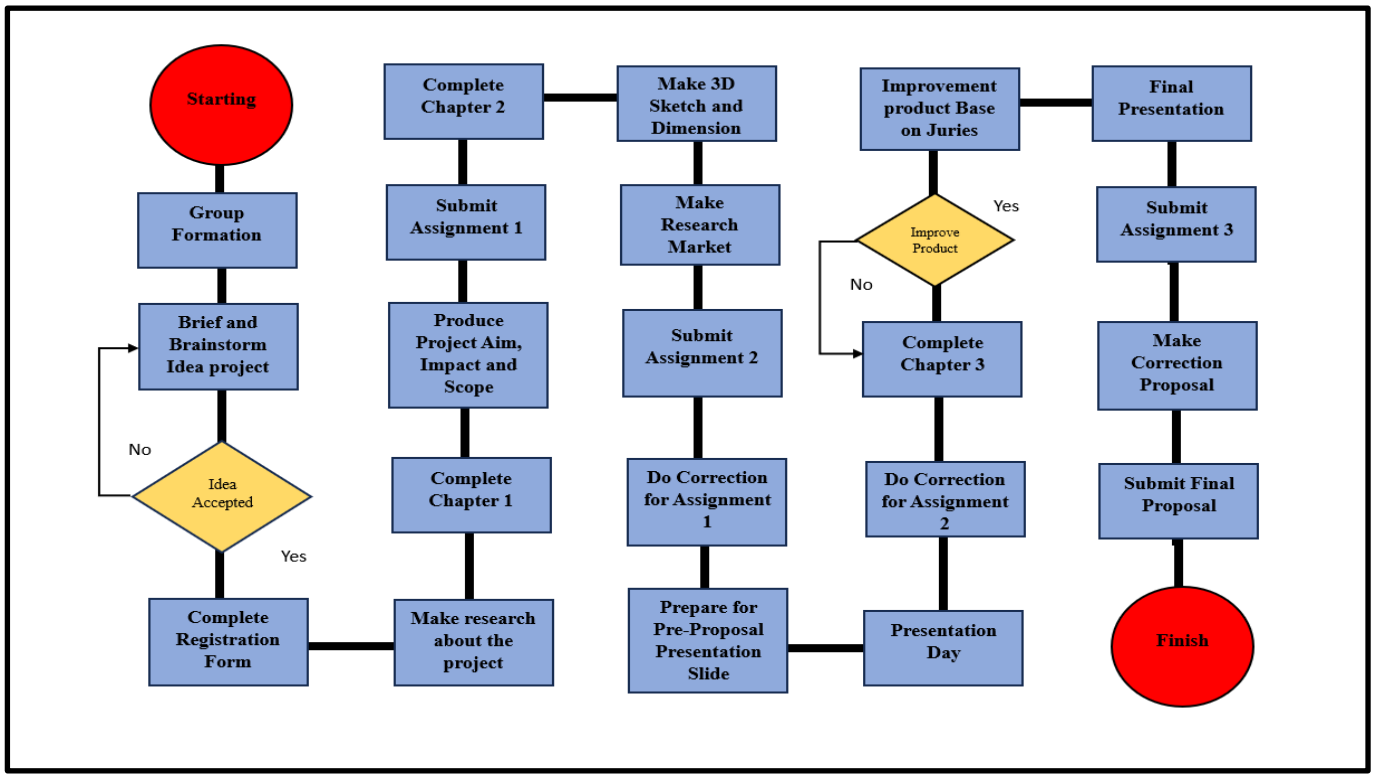


Figure 3.1: WAST AEM Project Flow Chart

AEP Project Flow Chart

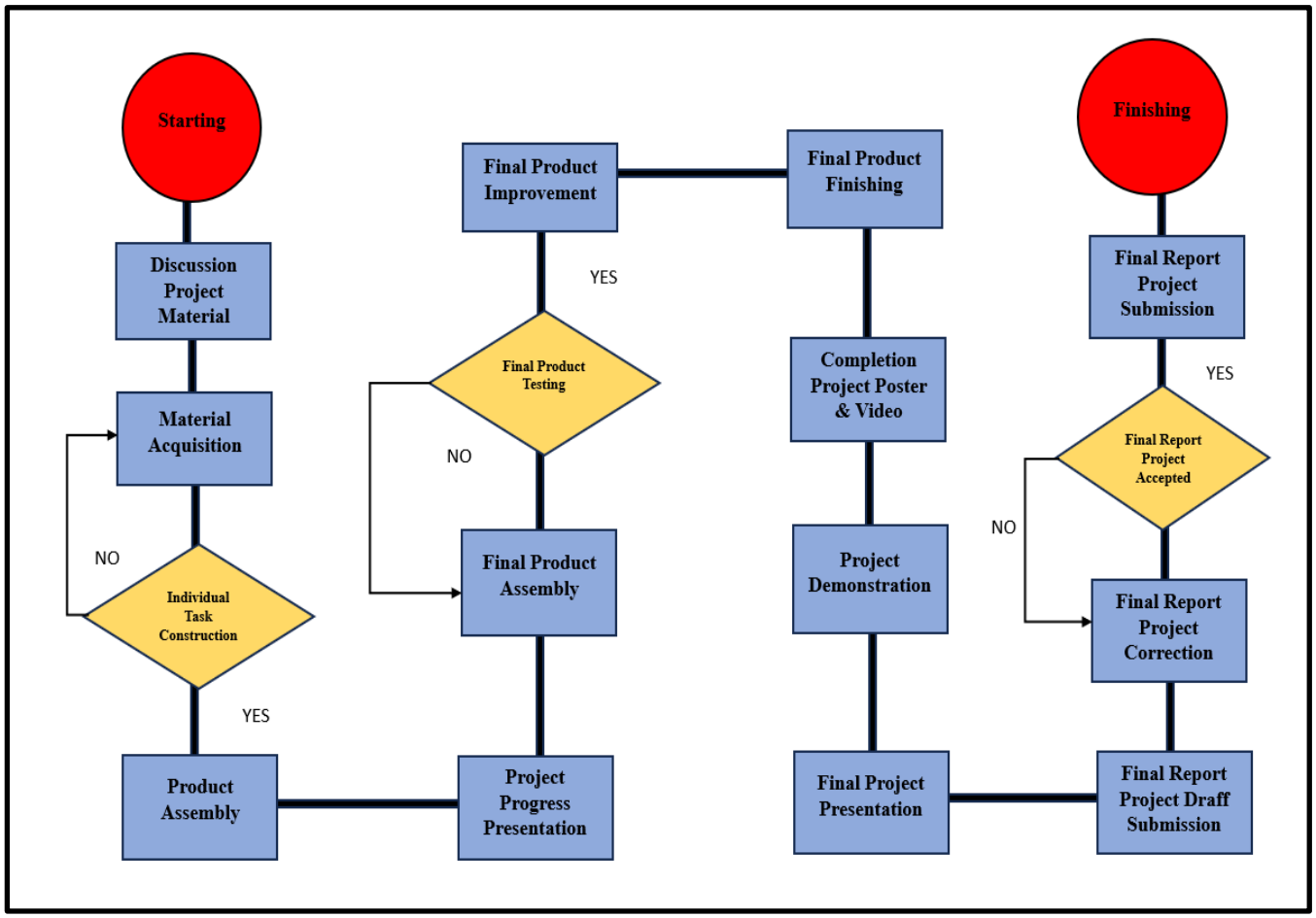


Figure 3.2: WAST AEP Project Flow Chart

3.3.2 Specific Project Design Flow/Framework

3.3.2.1 Product Structure

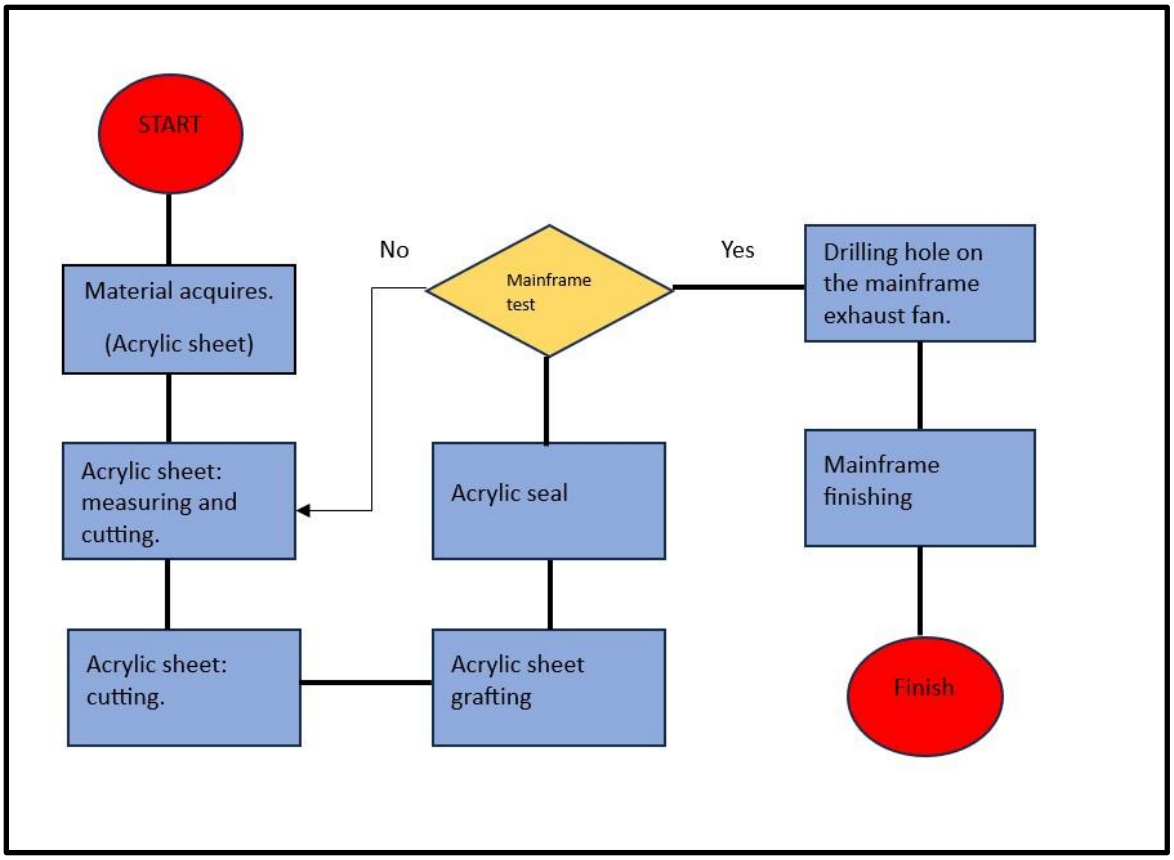


Figure 3.3: Product Structure Flow Chart.

3.3.2.2 Product Mechanisms

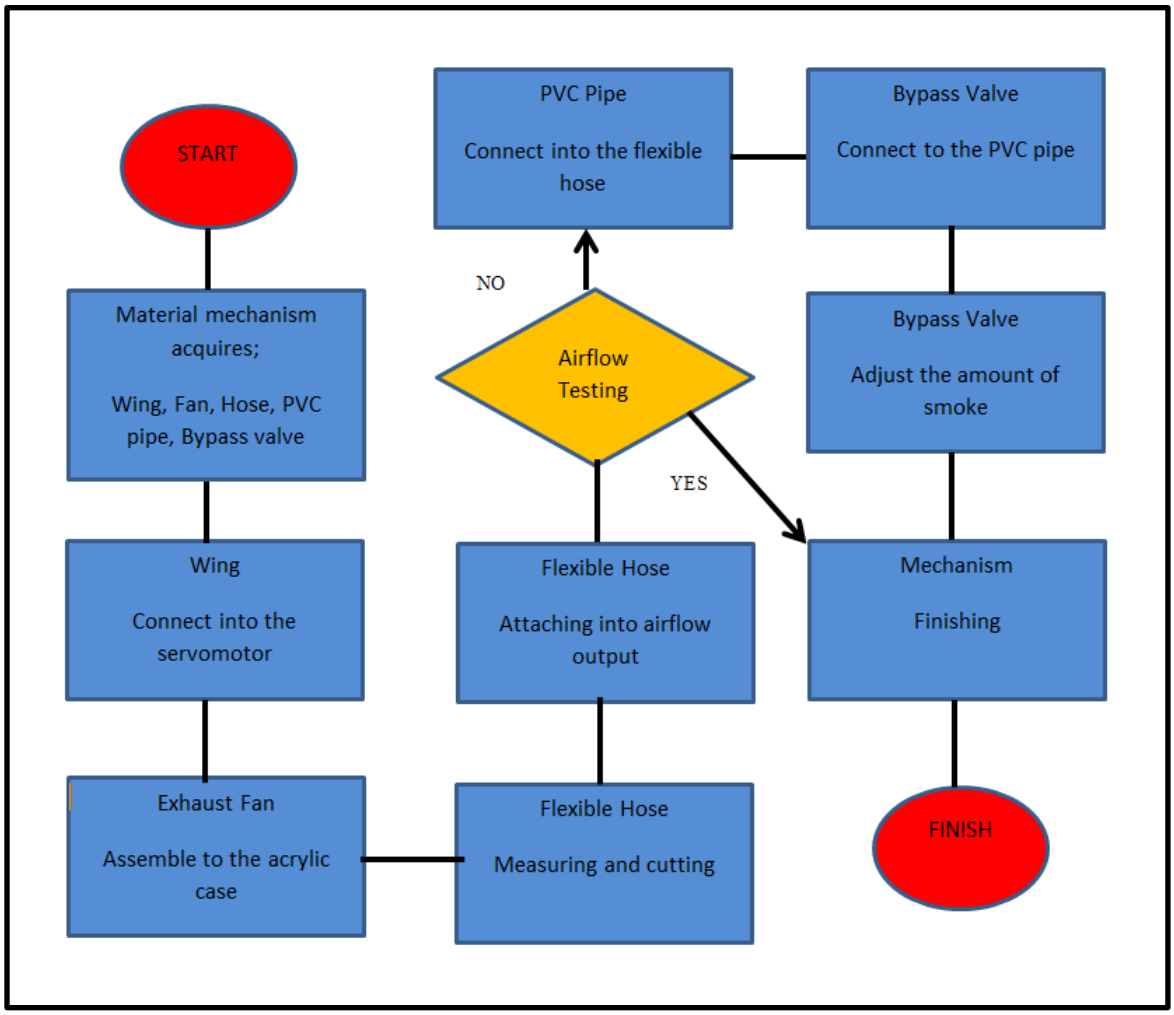


Figure 3.4: Product Mechanism Flow Chart

3.3.2.3 Software / Programming

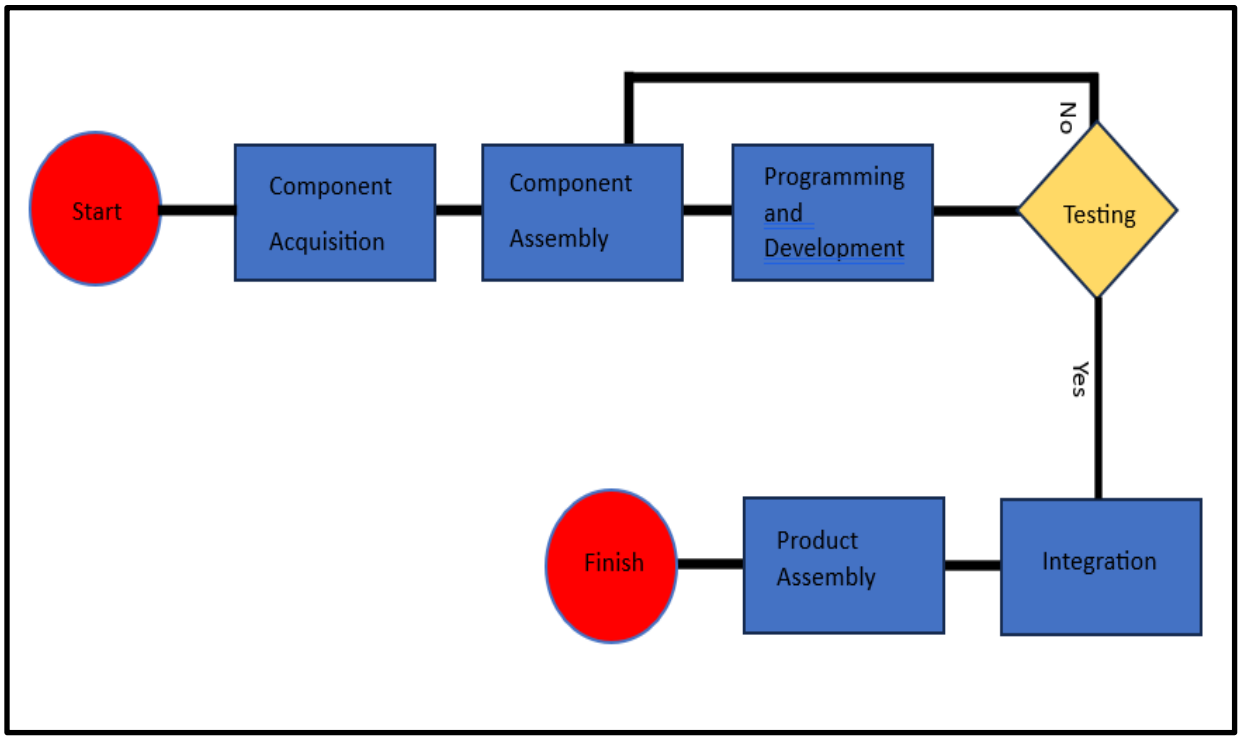


Figure 3.5: Software / Programming Flow Chart

3.3.2.4 Accessories & Finishing Flow Chart

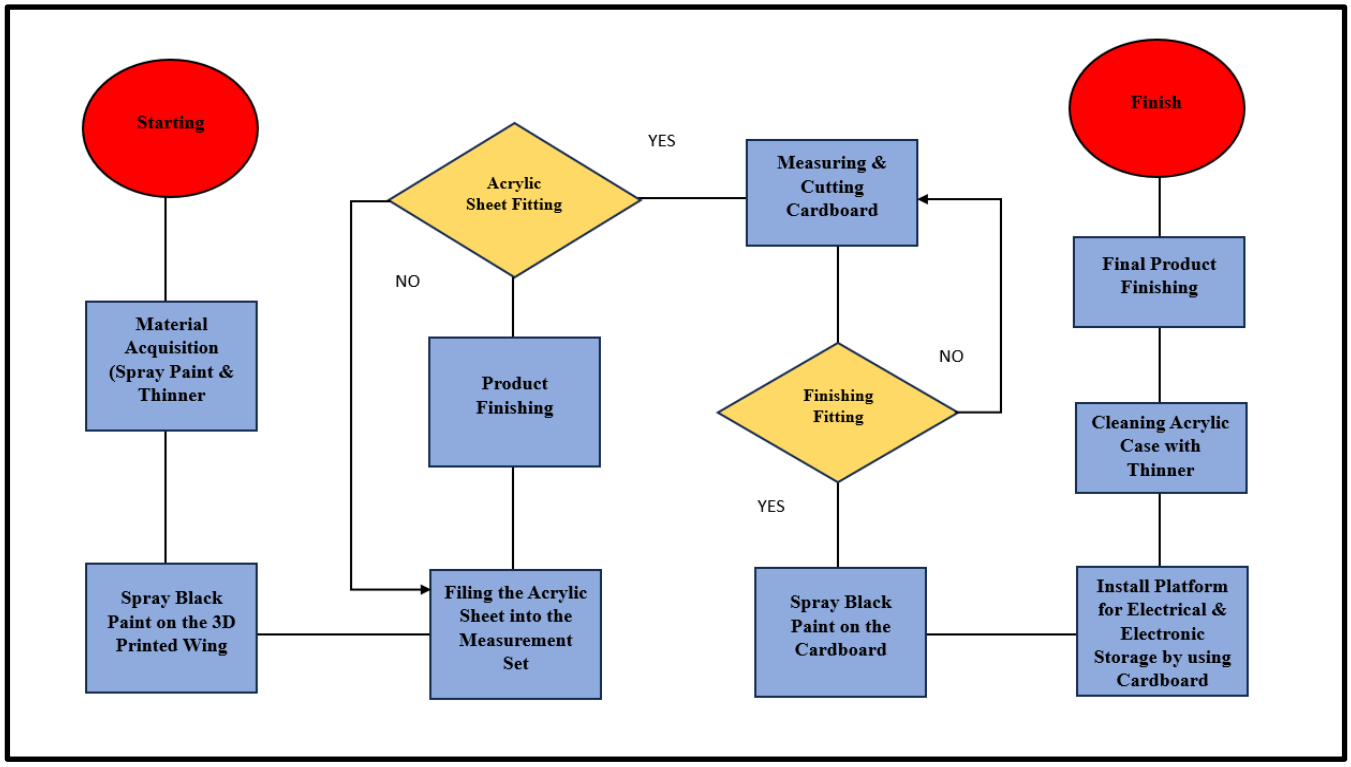


Figure 3.6: Accessories & Finishing Flow Chart

3.4 DESIGN ENGINEERING TOOLS

3.4.1 Design Requirement Analysis

3.4.1.1 Questionnaire Survey

Based on figure 3.7 below, respondents from students are collected to identify specification and characteristics of the product that was developed.

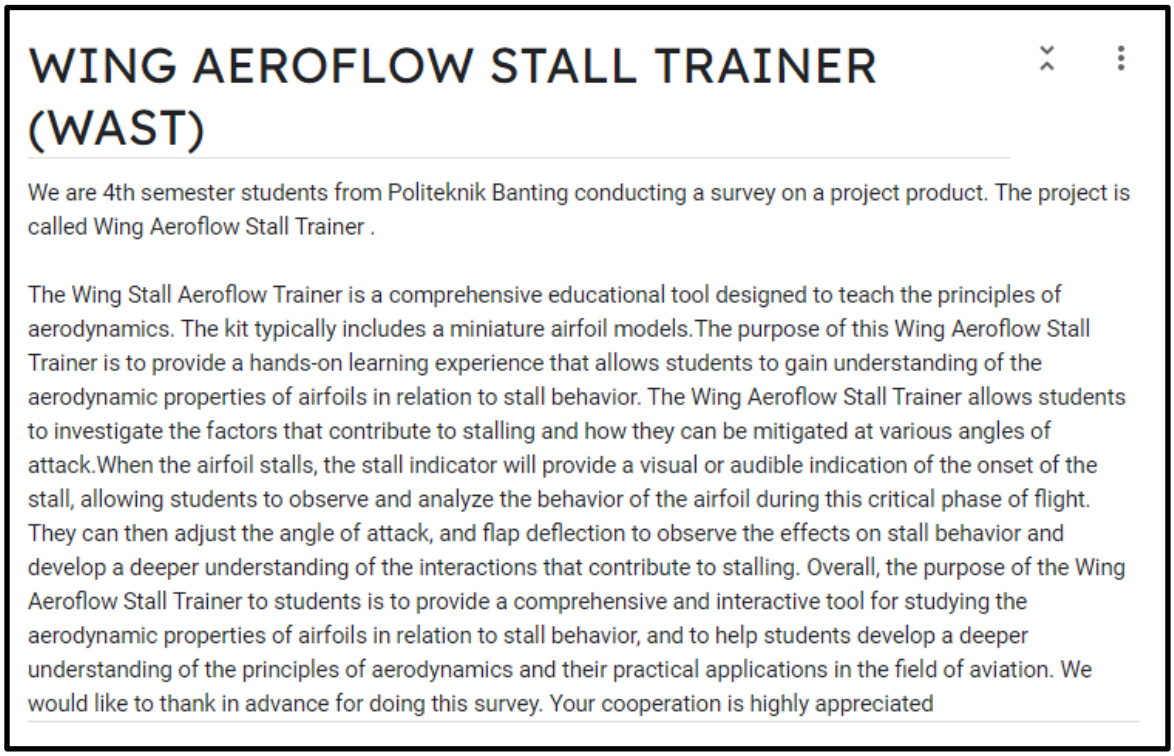


Figure 3.7: Questionnaire Survey through Google Form

This survey is using google survey form, the questions were divided into 3 groups and different parts.

1. PART A : Respondent's Demographics.
2. PART B : Data Gathering.
3. PART C : Product Improvement.

3.4.1.2 Pareto Diagram

When all data were completed, By using a Pareto Chart the results of all respondents were analyzed. By referring to the table 3.3 and Figure 3.8, it shows a response by students toward the product developed.

Table 3.3: Pareto Data Extracted from Survey Response

Features	Frequency	Cummulative	Cummulative Percentage	Pareto Baseline
Easy to use	39	39	24%	80%
Technology	38	77	48%	80%
Durability	30	107	66%	80%
Strength	29	136	84%	80%
Aesthetics	25	161	100%	80%
GRAND TOTAL	161			

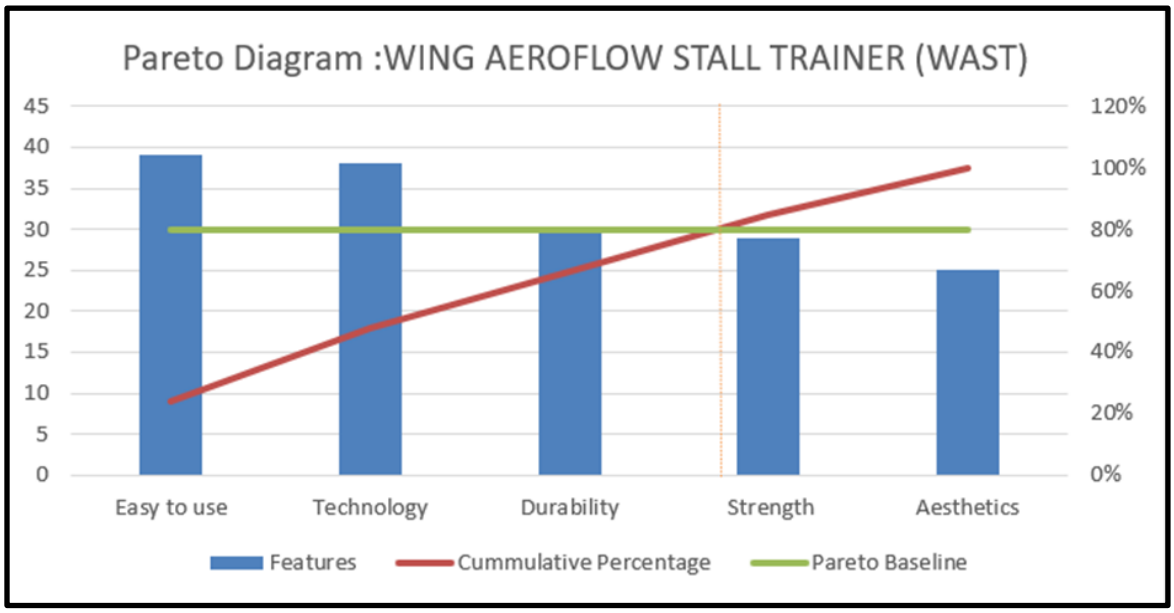


Figure 3.8: Pareto Diagram of WAST

3.4.2 Design Concept Generation

3.4.2.1 Function Tree

Function of the tree will be used on project design concepts to ensure the design concept will give good feedback to users based on responses from students on the characteristic and specification of product.

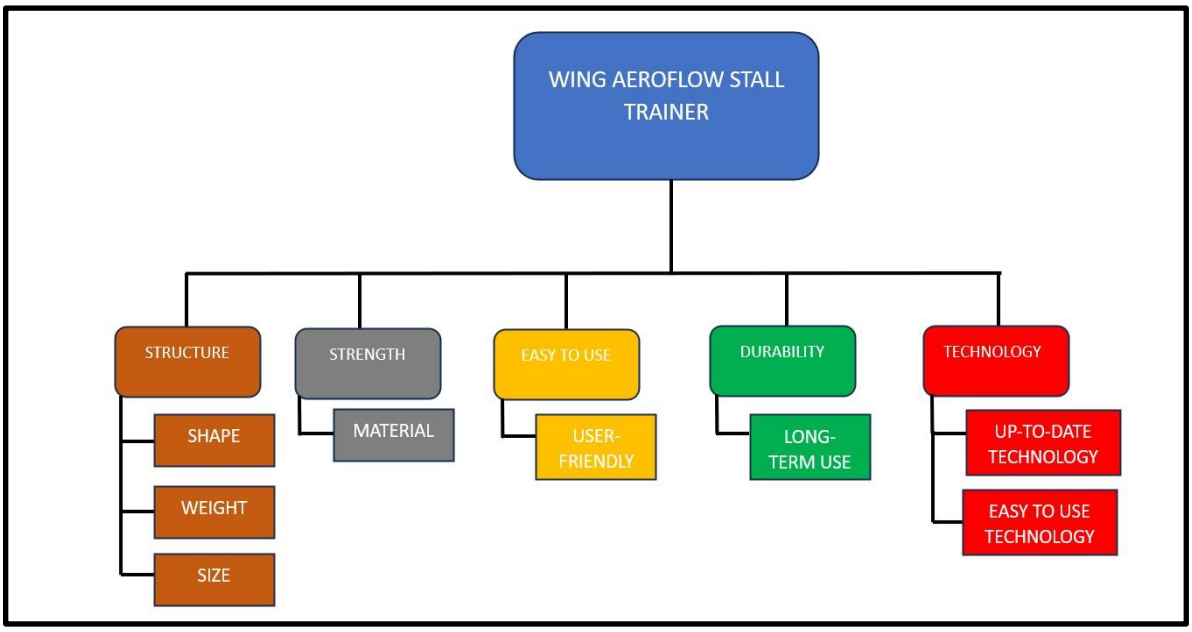


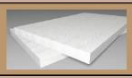
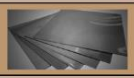
Figure 3.9: Function Tree of WAST

When analyzing response from students thru the google survey form, concept design of product were started with Function Tree of Wing Aeroflow Stall Trainer (WAST). Several functions of product development are broken down into sub-functions. Figure 3.9 above shows Function Tree of WAST when analyzing design student responds to create a structure of the product.

3.4.2.2 Morphological Matrix

Morphological Matrix are using this project to permit investigating various iterations of variables and features of an issue or requirement refer table 3.4.

Table 3.4: Morphological Matrix of WAST

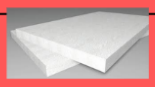
FUNCTION	IDEA 1	IDEA 2	IDEA 3
Easy to use	Application 	Automatically 	Manual 
Technology	Arduino 	Teensy 4.1 	None
Durability	Acrylic Case 	Thin case 	Exposed 
Strength	Foam 	polystyrene 	Metal 
Aesthetics	Ideal Size And Weight	Small and light	Big And Heavy

When the Function Tree of Wing Aeroflow Stall Trainer (WAST) is formed. Next is developing an idea and function. The ideas were based on personal creativity, thinking and research from the internet or knowledge from people.

3.4.2.3 Proposed Design Concept 1

Table 3.5 shows example of proposed design concept number 1 and justification on every features

Table 3.5: Proposed Design Concept 1

FEATURES/FUNCTION	IDEATION 1	JUSTIFICATION
Easy to use	Application 	Setting by using smartphone
Technology	Arduino 	Easy coding
Durability	Acrylic case 	Secured the product
Strength	Foam 	Can be shaped and can be use in long term
Aesthetics	Ideal size and weight	Suitable size and weight for the product

3.4.2.4 Proposed Design Concept 2

Table 3.6 shows example of proposed design concept number 2 and justification on every features

Table 3.6: Proposed Design Concept 2

FEATURES/FUNCTION	IDEATION 2	JUSTIFICATION
Easy to use	Automatically 	Using remote control
Technology	Teensy 4.1 	Complicated coding
Durability	Thin case 	Not reliable
Strength	Polystyrene 	Cannot withstand in long term
Aesthetics	Small and light	Too small, light and not durable

3.4.2.5 Proposed Design Concept 3

Table 3.7 shows example of proposed design concept number 3 and justification on every features

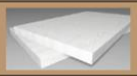
Table 3.7: Proposed Design Concept 3

FEATURES/FUNCTION	IDEATION 3	JUSTIFICATION
Easy to use	Manually 	Setting the degree of wing by manually
Technology	None	No technology applied
Durability	Exposed 	The product not be covered securely
Strength	Metal 	Durable but exposed to corrosion
Aesthetics	Big and heavy	Not suitable and required more space

3.4.2.6 Accepted vs Discarded Solution

By referring to tables 3.8 ,on every proposed design concept number 1,2 and 3 our project decided to choose proposed design concept number 1 and discard proposed concept design number 2 and 3 by referring to surveys that have been responded by students.

Table 3.8: Accepted vs Discarded Solution

FUNCTION	IDEA 1	IDEA 2	IDEA 3
Easy to use	Application 	Automatically 	Manual 
Technology	Arduino 	Teensy 4.1 	None
Durability	Acrylic Case 	Thin case 	Exposed 
Strength	Foam 	polystyrene 	Metal 
Aesthetics	Ideal Size And Weight	Small and light	Big And Heavy

As soon as sufficient options are obtained, the concepts are compared according to five criteria: strength, durability, ease of use, aesthetics, and technology. A concept is evaluated based on these criteria. It is decided that Concept 1 is the best solution after the evaluation. Alternative solutions are discarded and put on hold as a backup plan for the project.

3.4.3 Evaluation & Selection of Conceptual Design

3.4.3.1 Pugh Matrix

Table 3.9 shows concept evaluation by using Pugh Matrix

Table 3.9: Concept Design Evaluation Using Pugh Matrix (Concept 1 as Datum)

PUGH MATRIX : CONCEPT 1 AS DATUM

CRITERIA	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3
EASY TO USE	0.2	D A T U M	2	1
TECHNOLOGY	0.2		2	1
DURABILITY	0.2		1	1
STRENGTH	0.2		1	2
AESTHETICS	0.2		2	1
TOTAL SCORE	1.0		1.6	1.2
RANKING	-	-	1	2

The selected solution (Concept 2) has been shown using Pugh Matrix to be the best solution with Concept 1 as the datum. The five criteria for rating concepts are strength, durability, technology, aesthetics, and ease of use.

3.5 PRODUCT DRAWING / SCHEMATIC DIAGRAM

3.5.1 General Product Drawing

General product drawings are designed to give more specific information about the design developed. Figure 3.10 top view of Wing Aeroflow Stall Trainer (WAST), Figure 3.11 Front View of WAST, Figure 3.12: Side View of WAST, Figure 3.13: Isometric View of WAST.

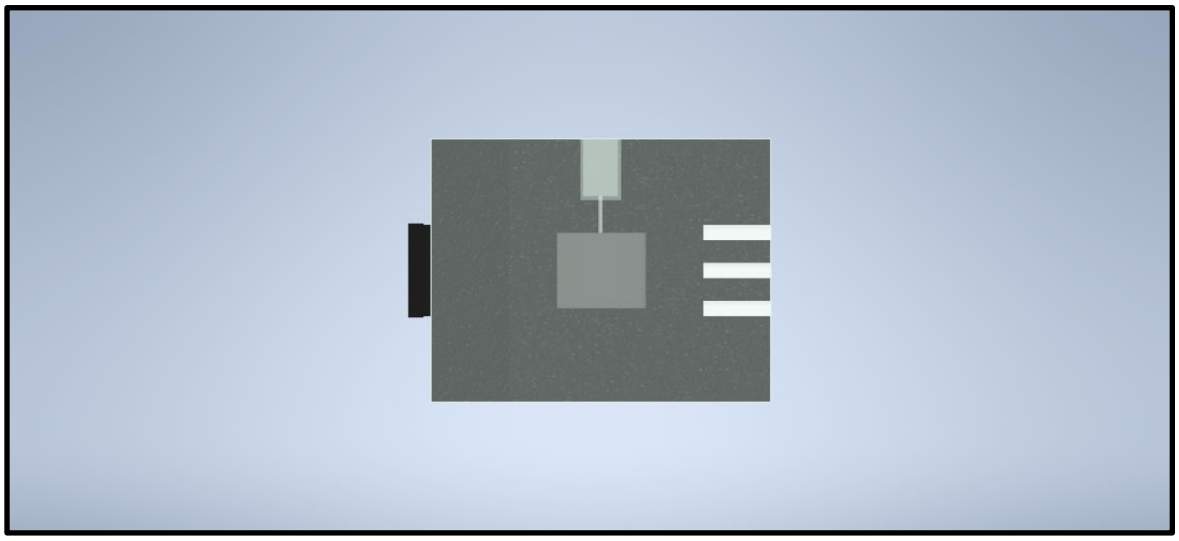


Figure 3.10: Top View of WAST

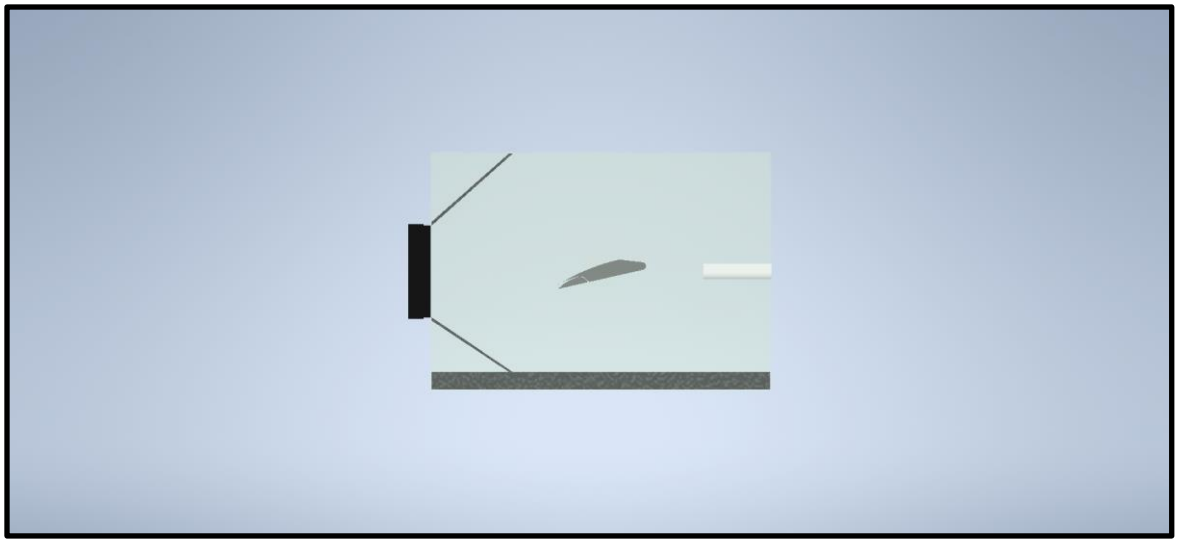


Figure 3.11: Front View of WAST

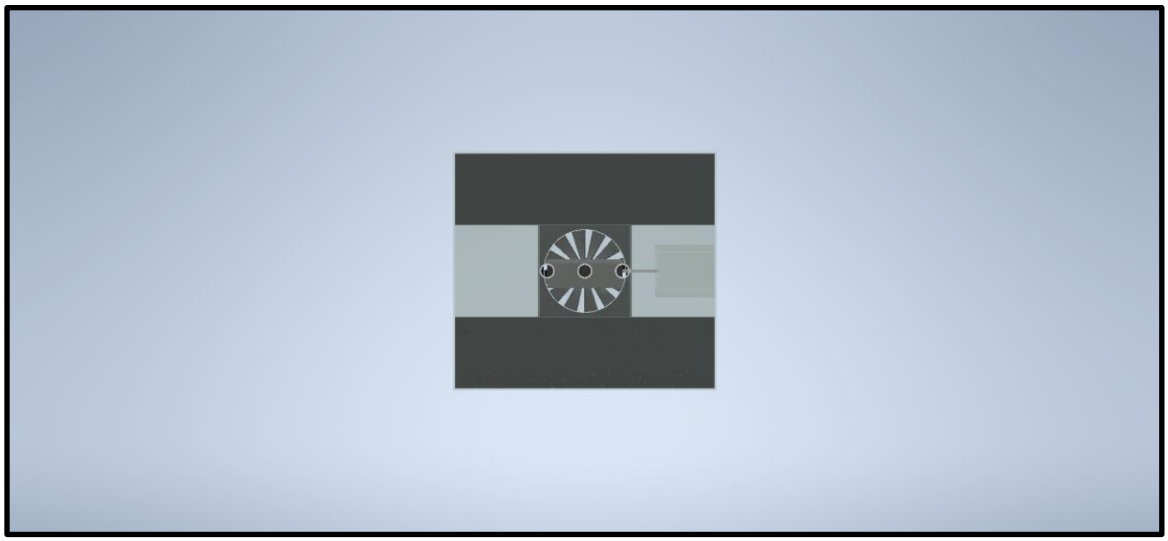


Figure 3.12: Side View of WAST

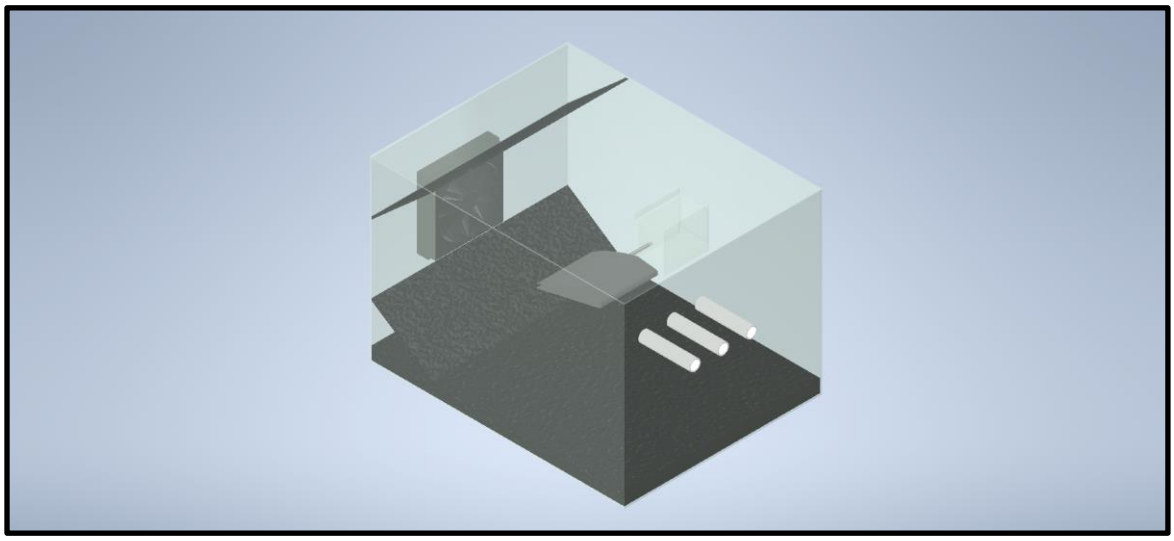


Figure 3.13: Isometric View of WAST

3.5.2 General Product Detail

In general product detail, design, parts, material and quantity are listed. Figure 3.14 shows the general product detail.

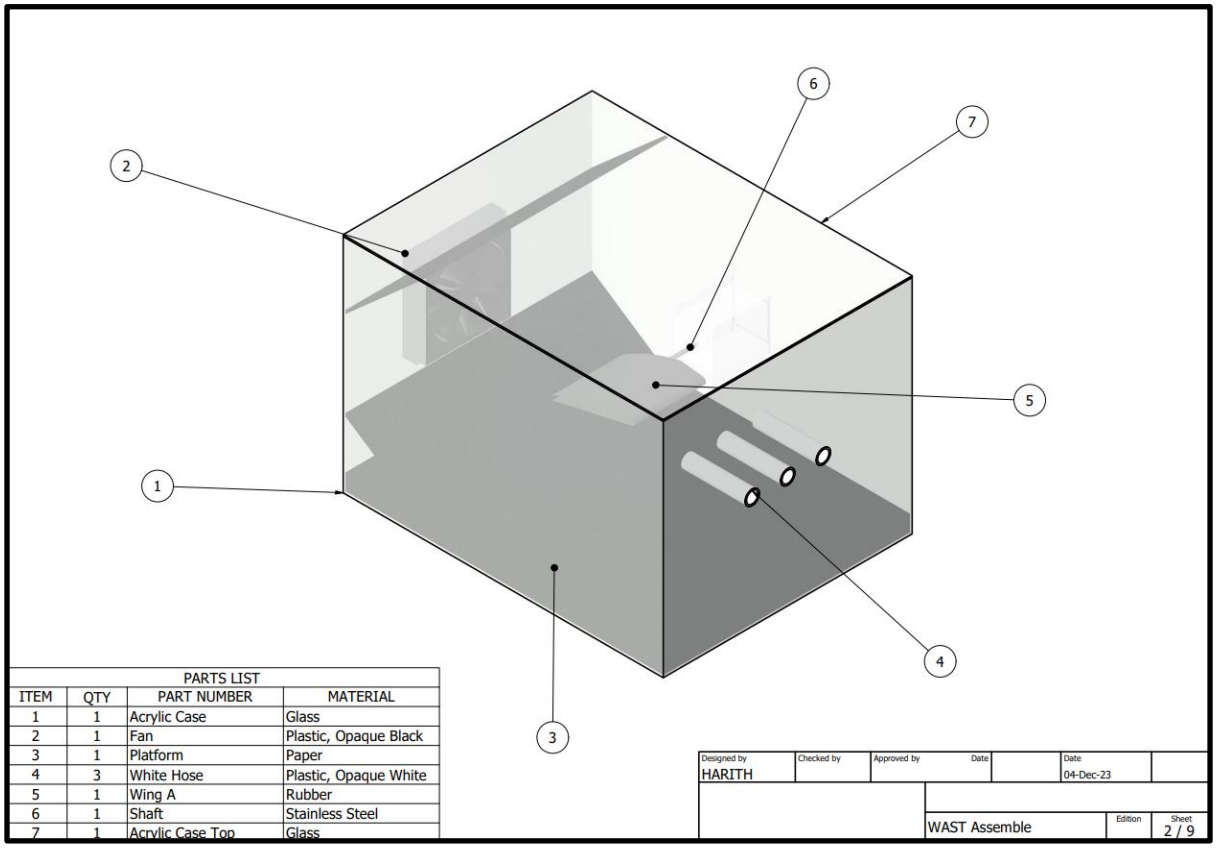


Figure 3.14: Detail Material Use of WAST

3.5.3 Specific Part Drawing / Diagram

3.5.3.1 Product Structure

Structure of the mainframe is a very critical part where the mainframe needs to be in a strong condition to ensure its durability and can accommodate every part attached to the mainframe. Figure 3.15: Isometric View of Mainframe without Panel Installation shows the design of mainframe in isometric view. Figure 3.16 isometric View With Panel Instrument Installation.

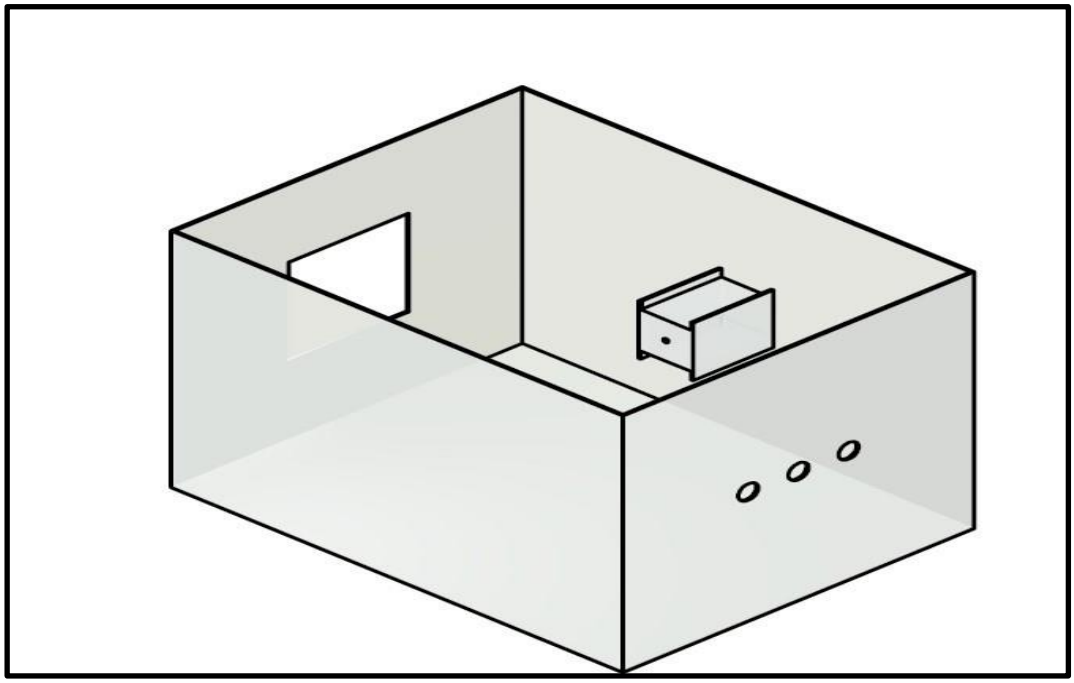


Figure 3.15: Isometric View of Mainframe without Panel Installation

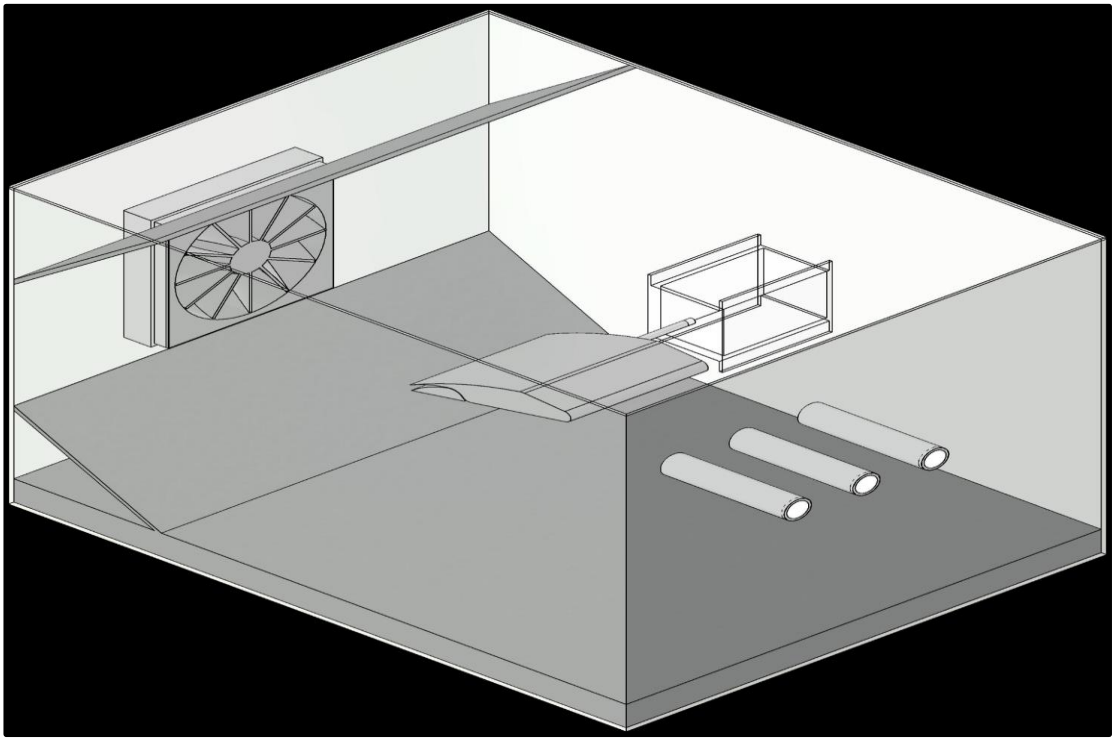


Figure 3.16: Isometric View With Panel Instrument Installation

3.5.3.2 Product Mechanisms

By referring to the figure 3.17,3.18, 3.19 and 3.20, the product mechanism specific part diagram or drawing can be seen with more detail about the mechanism of the product.

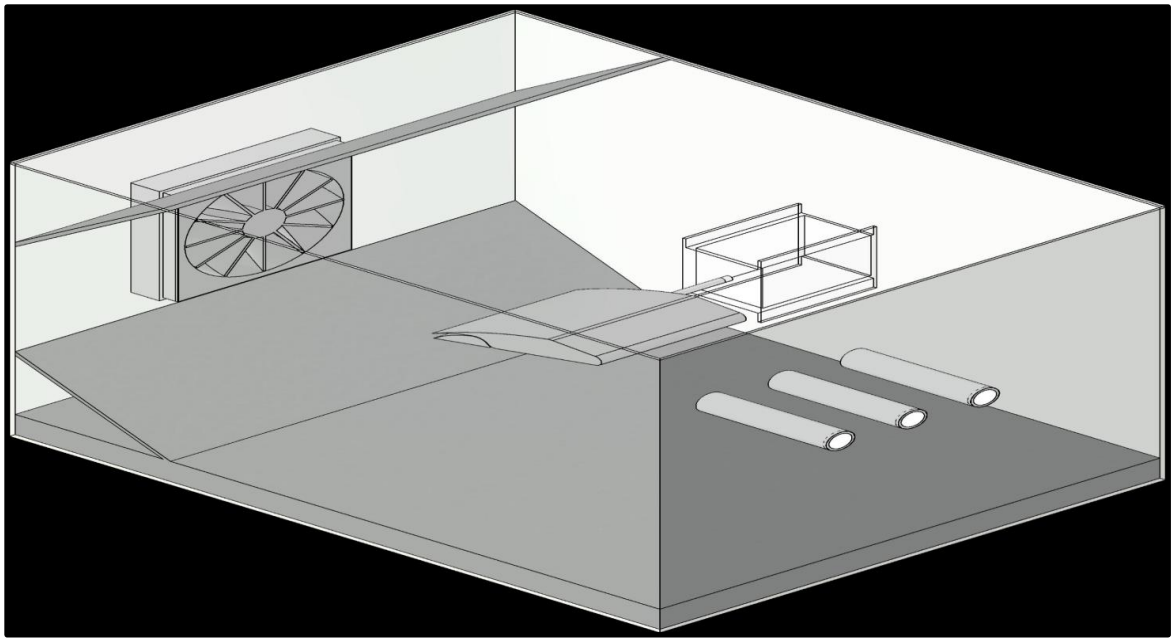


Figure 3.17: Isometric View with Panel Instrument Installation

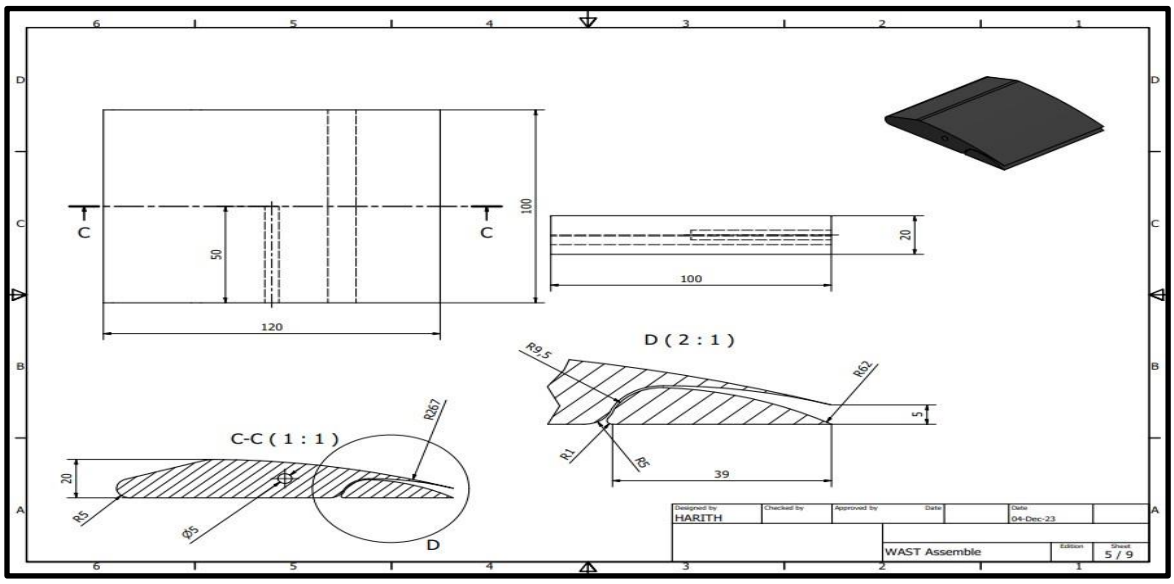


Figure 3.18: Wing structure and mechanism

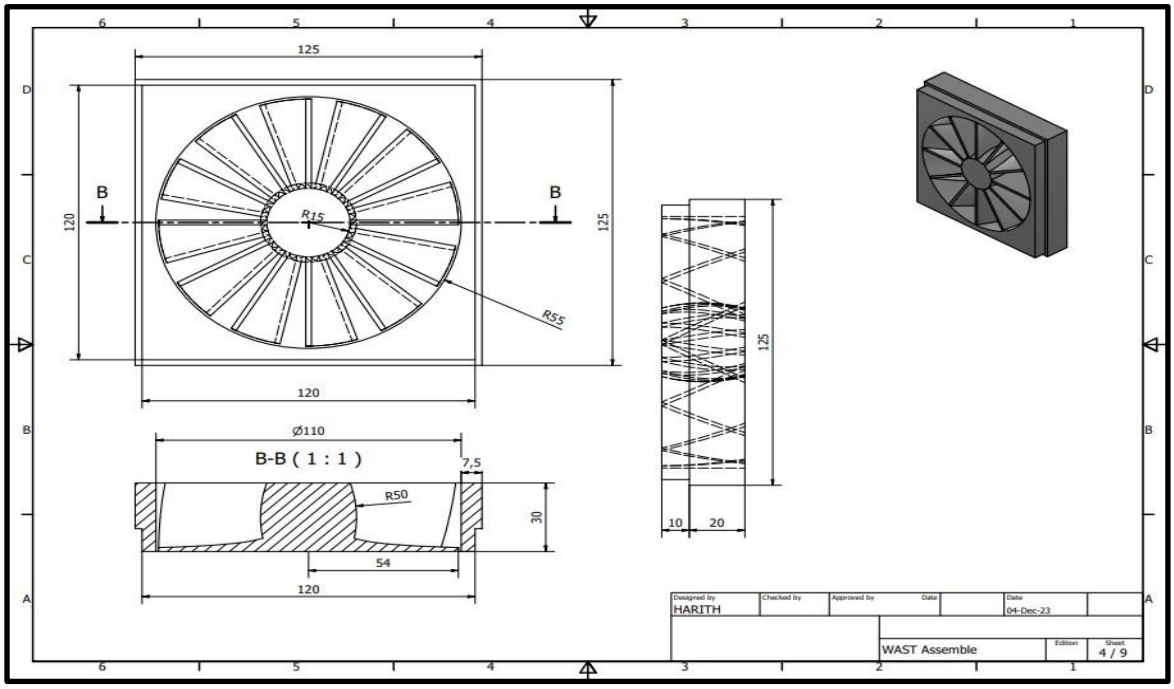


Figure 3.19: Exhaust fan structure and mechanism

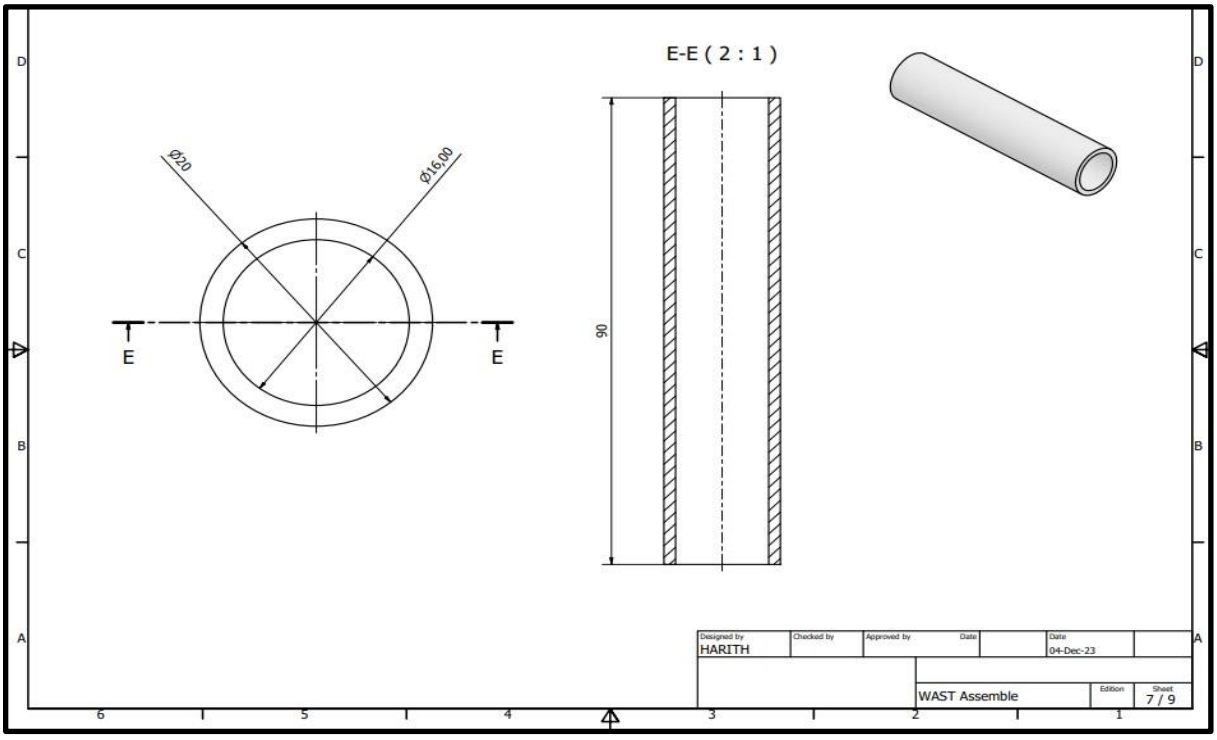


Figure 3.20: Flexible hose structure and mechanism

3.5.3.3 Electronic Circuit Diagram

Figure 3.21 shows Circuit Diagram of the Electronics construction of the product.

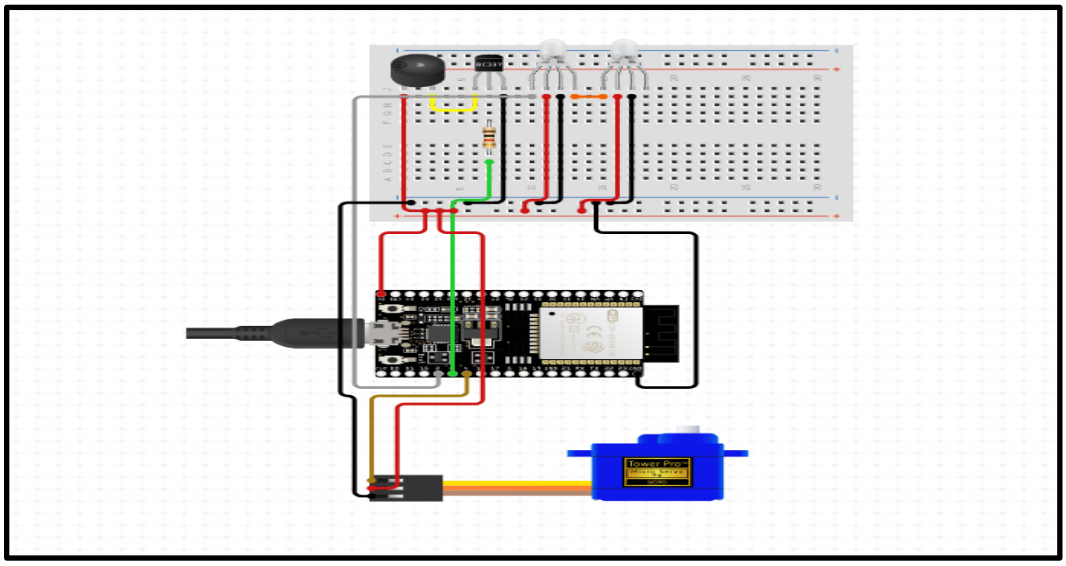


Figure 3.21: Circuit Diagram of the Electronics construction

3.5.3.4 Arduino Coding for Blynk Application

Figure 3.22 shows Arduino Coding for Blynk Application in Arduino IDE Software

```
#include <BlynkSimpleEsp32_SSL.h>

#ifndef BLYNK_NEW_LIBRARY
#error "Old version of Blynk library is in use. Please replace it with the new one."
#endif

#define BLYNK_TEMPLATE_ID "TMPL6yWZr5A7F"
#define BLYNK_TEMPLATE_NAME "Servo Control Blynk20"
#include "BlynkState.h"
#include "ConfigStore.h"
#include "ResetButton.h"
#include "ConfigMode.h"
#include "Indicator.h"
#include "OTA.h"

inline
void BlynkState::set(State m) {
  if (state != m && m < MODE_MAX_VALUE) {
    DEBUG_PRINT(String(StateStr[state]) + " => " + StateStr[m]);
    state = m;

    // You can put your state handling here,
    // i.e. implement custom indication
  }
}

void printDeviceBanner()
{
  Blynk.printBanner();
  DEBUG_PRINT("-------------------------");
  DEBUG_PRINT(String("Product:  ") + BLYNK_DEVICE_NAME);
  DEBUG_PRINT(String("Hardware: ") + BOARD_HARDWARE_VERSION);
  DEBUG_PRINT(String("Firmware: ") + BLYNK_FIRMWARE_VERSION " (build " __DATE__ " " __TIME__ ")");
  if (configStore.getFlag(CONFIG_FLAG_VALID)) {
    DEBUG_PRINT(String("Token:    ...") + (configStore.cloudToken+28));
```

Figure 3.22: Arduino Coding for Blynk Application in Arduino IDE Software

3.5.3.5 Accessories & Finishing

Figure 3.23 shows platform of product in isometric view without the main structure and Figure 3.24 shows Full View of Final Finishing WAST

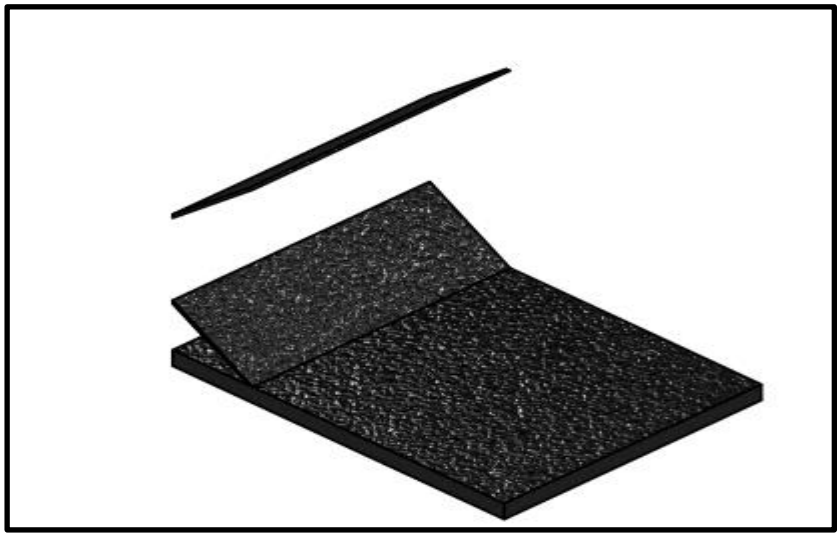


Figure 3.23: Isometric View of Platform without The Main Structure

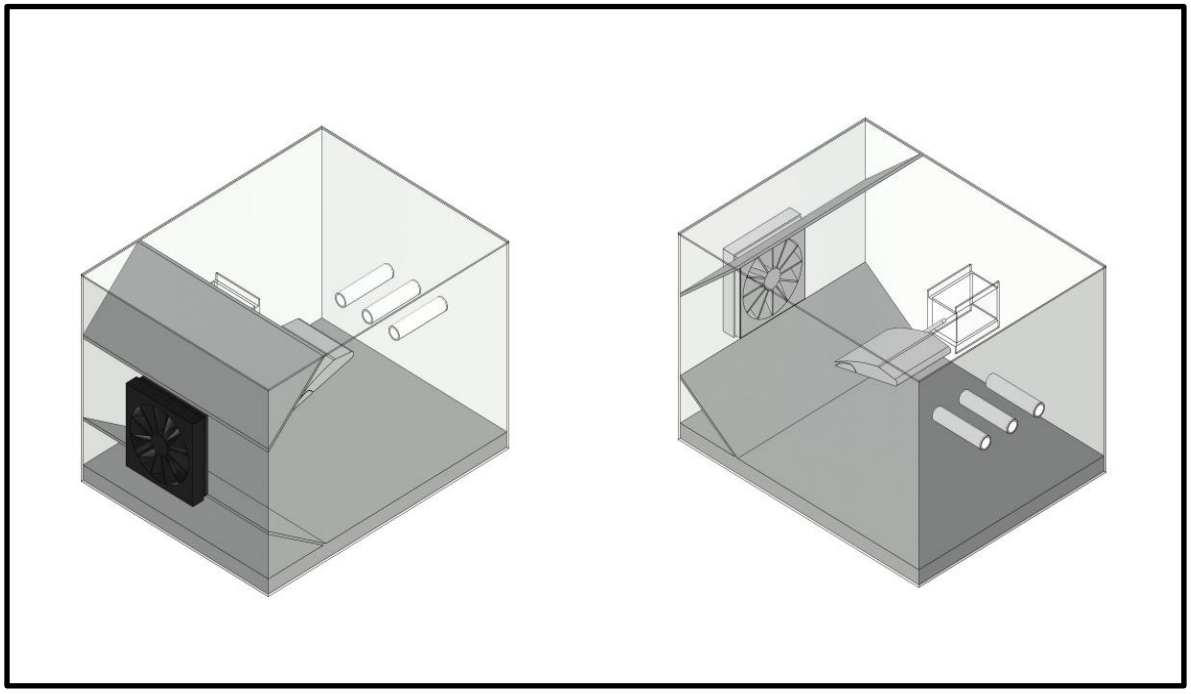


Figure 3.24: Full View of Final Finishing WAST

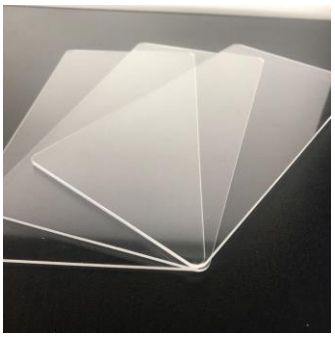
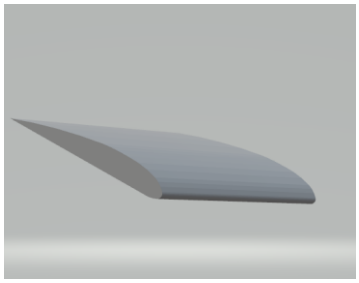
3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

3.6.1.1 Mainframe of WAST

Table 3.10 shows list of material used for Wing Aeroflow Stall Trainer (WAST) Main frame

Table 3.10: List of Materials Used for (WAST) Mainframe

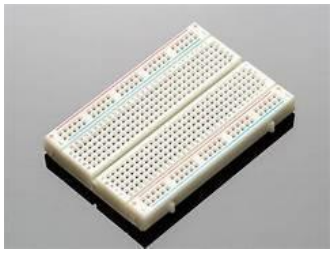
NO.	MATERIAL	DESCRIPTION
1.	 Acrylic Sheet	Acrylic sheet used as the main material to construct the casing of WAST.
2.	 3D Printed PLA Wing Aerofoil	3D Printed PLA Wing Aerofoil used as wing for the WAST. This wing airfoil was painted in black.
3.	 Hinge	Hinge used to join the acrylic case panel on the top.This ease the process of opening and closing the panel

3.6.1.2 Electronic and Software of WAST

The table 3.11 shows List of Components & Software Used for WAST Electronics which control and adjust other parts in WAST.

Table 3.11: List of Components & Software Used for WAST Electronics

NO.	COMPONENT	DESCRIPTION
1.	 ESP 32	ESP32 is used to control the servo motor system by using the blynk mobile application.
2.	 Servo Motor SG90	The servomotor is used to adjust the angle of attack (AOA) of the wing on the WAST.
3.	 Buzzer	Buzzer is used for a warning system which will make the audible sound on the WAST.

NO.	COMPONENT	DESCRIPTION
4.	 Jumper Wire	The jumper wire is used to connect the wire to the component that was used by the WAST.
5.	 LED	LED is used for the warning system which will lights up the LED as a visual warning on the WAST.
6.	 Breadboard	Breadboard is used to connect the component into a circuit connectivity of the WAST.
7.	ARDUINO IDE	Arduino IDE is the main software to programming and coding the ESP32

3.6.1.3 Furnishing & Finishing of WAST

Table 3.12 shows List of material that was used to do furnishing and finishing of Wing Aeroflow Stall Trainer (WAST) product.

Table 3.12: List of furnishing & Finishing of WAST

NO.	MATERIAL	DESCRIPTION
1.	 Spray Paint Black	Spray paint black is used as the finishing for the wing aerofoil. To ease the user of WAST can see the laminar flow on the wing airfoil.
2.		Thinner is used to clean the dirt on the acrylic case of WAST as finishing touch.
3.	 Sealant	Sealant is used to seal the acrylic case after using the adhesive glue so that the air wouldn't leak out.
4.	 Adhesive	The adhesive is used to bond the acrylic sheet together, in order to create a sturdy case for WAST.
5.	 Acrylic Knife	Acrylic blade used to cut the acrylic sheet in required measurement

3.6.2 Machines and Tools

3.6.2.1 List of Machine

Table 3.13 shows List of Machine Used for Wing aeroflow Stall Trainer (WAST) Product

Table 3.13: List of Machine Used for WAST

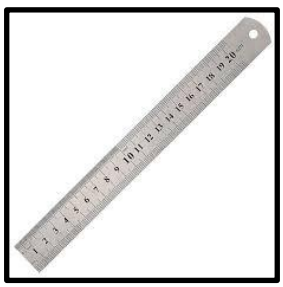
NO	PICTURE OF MACHINE	DESCRIPTION
1	 Cordless Drill	**General Purpose:** To create holes in a material and install screws and other fasteners. **Project Purpose:** To make a hole for the airflow output.
2	 Pneumatic Drill	**General Purpose:** To create holes in a material and install screws and other fasteners. **Project Purpose:** To make a hole for the airflow output.

3.6.2.2 List of Tools

Table 3.14 shows List of Tools are used for Wing Aeroflow Stall Trainer (WAST) fabrication.

Table 3.14: List of Tools Used for WAST Fabrication

NO	PICTURE OF HAND TOOLS	DESCRIPTION
1	 File	**General Purpose:** The tools used for shaping, smooth, and removing material from a different surface, most commonly wood or metal. **Project Purpose:** Filed the acrylic sheet side to become flat surface.
2	 Acrylic Knife	**General Purpose:** It is a specialized knife made for cutting acrylic sheets. **Project Purpose:** Cut the acrylic sheet into the measurement set without any defect from the cutting process.

NO	PICTURE OF HAND TOOLS	DESCRIPTION
3	 Sealant Gun	**General Purpose:** The main function of a sealant gun is to apply sealants, adhesives, or caulks to various surfaces. **Project Purpose:** Assisted the acrylic sealant to flow out the sealant for closing the gap between the acrylic sheet.
4	 L Square	**General Purpose:** This tool function is to help with accurate measurement and marking of right angles. **Project Purpose:** Measured the right angle for a straight line for the cutting process and measurement acrylic sheet.
5	 Steel Ruler	**General Purpose:** This tool is to make a straight line with precision and use in various fields such as architecture, engineering, technical drawing and manufacturing. **Project Purpose:** Made a straight line for the process of cutting acrylic sheet to get the accurate measurement.

3.6.3 Specific Project Fabrication

3.6.3.1 Phase 1 (Base Structure)

Table 3.15 shows the working procedure for base structure development step by step to develop the base structure of the product.

Table 3.15: Working Procedure For Base Structure.

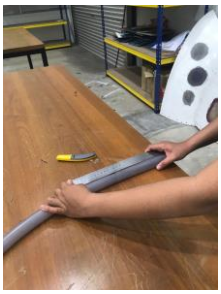
NO.	PICTURE	DESCRIPTION
1	 Material acquire	The acrylic sheets were bought from Shopee and the thickness of every piece of acrylic sheet is about 4mm.
2		The acrylic sheets were measured and marked for the next cutting process. This method to ensure the acrylic sheet size were actual size in drawing
3	 Cutting process	The acrylic sheet were cut by using acrylic cutter knife

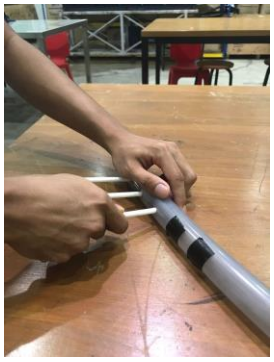
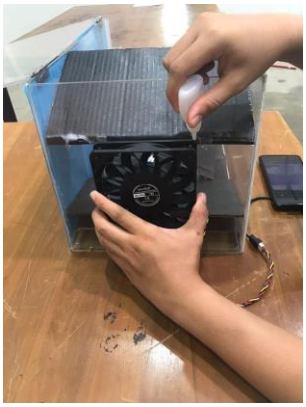
NO.	PICTURE	DESCRIPTION
4	 drilling process	The drilling process is required to act as a ventilation to suck smoke inside the acrylic.
5	 Attachment process	A piece of acrylic sheet was attached by using adhesive to start doing a mainframe.
6	 Sealant process	Sealant is required to ensure there is no air leak at the edge of the acrylic.
7	 Installation	Installation of part of project in mainframe structure

3.6.3.2 Phase 2 (Mechanisms)

Table 3.16 shows working procedure for mechanism of the product development

Table 3.16: Working Procedure for Mechanism

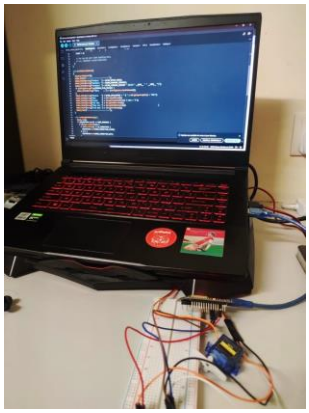
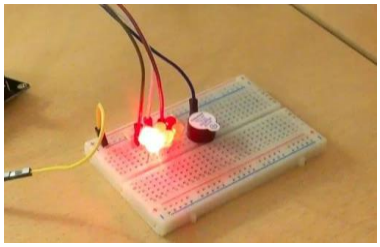
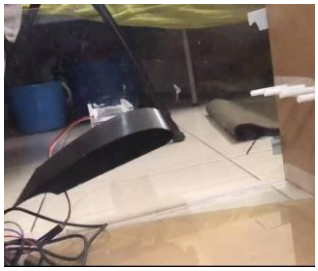
NO.	PICTURE	DESCRIPTION
1		This picture shows the drilling process of the acrylic case that is used as the slot for the airflow output. The tools that are used are cordless drilling machines.
2		Measuring and cutting the flexible hose is needed to ensure the smoke enters the acrylic case smoothly. The flexible hose are cutted by using the utility knife.
3		Measuring and cutting the airflow output for the smoke to enter the acrylic case and ensure the smoke is narrow before hitting the leading of the wing. The utility knife is used to cut the airflow output

NO.	PICTURE	DESCRIPTION
4		Attaching the airflow output into the flexible hose so the smoke that is generated by the fog machine can be transmitted into the acrylic case.
5		Attach the servo motor into the side part of the wing so it can move the angle of attack of the wing. Then slot in the servomotor into the servo holder that is attached at the side of the acrylic case.
6		Attaching the exhaust fan at the back of the acrylic case to suck out all the smoke that is trapped in the acrylic case. This exhaust fan is attached by using strong adhesive.

3.6.3.3 Phase 3 (Programming & Electrical Circuit)

Table 3.17 shows working procedure for programing & electrical circuit of the product development.

Table 3.17: Working Procedure for Programming & Electrical Circuit

NO.	PICTURE	DESCRIPTION
1.	 Programming and Component Test	Programming ESP32 using Arduino IDE software and component testing on the circuit breadboard.
2.	 LED and Buzzer Test	LED and Buzzer testing until both of it working as stall indication which is visual warning and audible sound warning.
3.	 Component Installation of WAST	All of the components is installed to the WAST and is connected to the wing and the stall indication system

NO.	PICTURE	DESCRIPTION
4.	 Blynk mobile apps control testing	Blynk mobile apps control is tested to make sure the project is functioning.

3.6.3.4 Phase 4 (Finishing)

Table 3.18 shows the working procedure for finishing the product to make the product more tidy.

Table 3.18: Working Procedure for Finishing

NO	PICTURE	DESCRIPTION
1	 Spray paint on the Wing 3D printed	The Wing 3D Printed are painted with the black colour. The paint is applied multiple times so the layer of paint is consistent and too thick or too thin. This can improve the texture look on the Wing 3D Printed.
2	 Cardboard is applied with black spray paint	The cardboard is applied with black paint spray. This is to improve the finishing look aesthetic. The black paint is chosen for the contrast with the smoke.

NO	PICTURE	DESCRIPTION
3	 Filing process	The acrylic sheet is being filed to get the accurate measuring and smooth surface. The acrylic sheet is filed by using a bustard file and secondary cut file.
4	 Cleaning process	The acrylic case is cleaned by using thinner for the final finish. This is to improve the quality of the cleanliness product and to make sure the product looks good.

3.7 PRODUCT TESTING / FUNCTIONALITY TESTS

Figure 3.25 shows flow chart of product Wing Aeroflow Stall Trainer (WAST) operation procedure

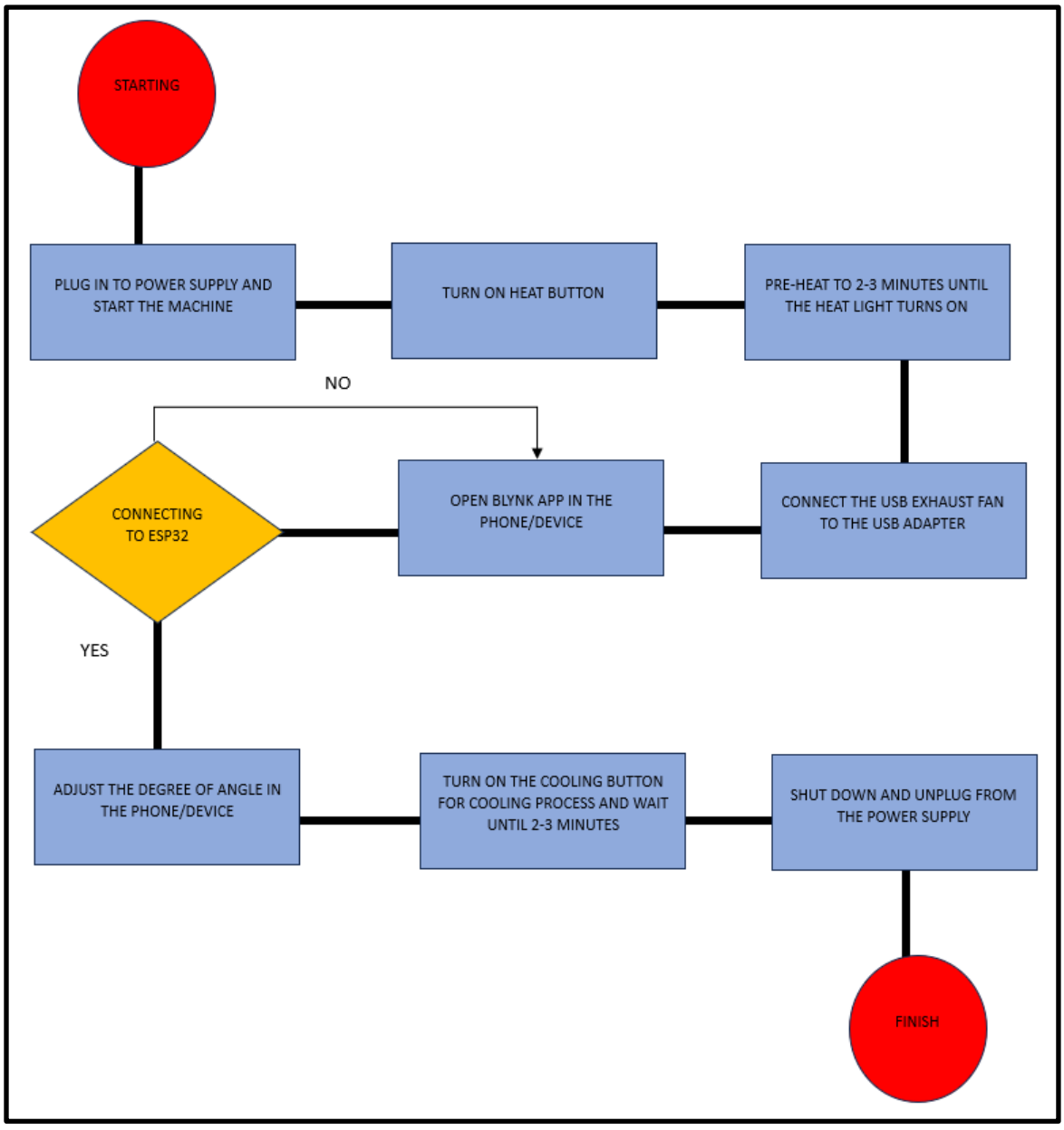


Figure 3.25: Flow Chart Operation Procedure of WAST

3.8 LIST OF MATERIALS & EXPENDITURES

Table 3.19 shows list of material and expenditures of the project Wing Aeroflow Stall Trainer (WAST) development

Table 3.19: List of Materials an Expenditures

3.2.1 Product Structure			
Items	Unit	Price/Unit	Total (RM)
Acrylic case	4	RM23.50	RM94.00
3D printed PLA aerofoil wing	1	RM69.98	RM69.98
HINGE	1	RM 1.00	RM 1.00
ACRYLIC KNIFE	1	RM 5.00	RM 5.00
ACRYLIC BLADE	1	RM 5.60	RM 5.60
ADHESIVE GLUE	1	RM 3.00	RM 3.00
SEALANT GUN	1	RM 9.00	RM 9.00
PVC GLUE	1	RM 0.40	RM 0.40
3.2.2 Mechanical Mechanism			
Items	Unit	Price/Unit	Total (RM)
FOGGING MACHINE	1	RM 53.82	RM 53.82

Items	Unit	Price/Unit	Total (RM)
PVC PIPE	1	RM 1.53	RM1.53
FLEXIBLE HOSE	1	RM 9.00	RM 9.00
AIRFLOW OUTPUT HOSE	1	RM 5.00	RM 5.00
PC FAN 1	2	RM 9.29	RM 9.29
PC FAN 2		RM 38.50	RM 38.50
SERVO	4	RM 20.00	RM 80.00
STOP COCK	1	RM 5.50	RM 5.50
3.2.3 Electrical Mechanism			
Items	Unit	Price/Unit	Total (RM)
ARDUINO	1	RM 155.80	RM 155.80
ESP 32 BOARD	1	RM32.90	RM32.90
BUZZER	1	RM 7.80	RM 7.80
WIRE JUMPER	4	RM 5.60	RM22.49
BREADBOARD	1	RM 18.00	RM 18.00
3.2.4 FINISHING			
Items	Unit	Price/Unit	Total (RM)
ACRYLIC SEALANT	1	RM 5.00	RM 5.00
THINNER	1	RM 4.00	RM 4.00
SPRAY PAINT	1	RM 10.00	RM 10.00
GRAND TOTAL			RM 646.61

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

This product is an innovation from the wind tunnel study kit and other study kits. The purpose of this product is to learn about stall indicator real time experience. This can ensure the student and lecture to improve more understanding about the principle of aerodynamics. This is because the students are having a hard time understanding the principle of aerodynamics and some of them lack knowledge from what they are learning.

Other than that, students and lecturers also can learn about how the stall indicator works in detail by using these study kits. Stall indicator is to warn the pilot that the aircraft is going to stall and the pilot needs to make corrections for the aircraft.

Next, students and lecturers will learn in detail about the Angle Of Attack (AOA) and stall indication by adjusting the angle to see the aerofoil performance on the wing. The stall indication is triggered when the AOA exceeds more than fifthteen degrees. The students and lecturers can experience it by using this product.

4.1.2 Specific Part Features

Specific Part Features were divided into 4 part which is Product Structure, Product Mechanism, Electronics and Programing and Accessories and Finishing

4.1.2.1 Product Structure

Based on the wing aeroflow stall trainer structure, it has two different parts which is the intake of the structure and output of the project. In the first part we are using an open concept and designing the flexible hose a bit longer to maintain the amount of smoke that will go through the wing constantly. After that at the end of the project structure, we are using convergent design to ensure all of the smoke that traps in the acrylic area goes out smoothly.

So this trainer kit structure was designed based on some experiments that have been studied along the journey to develop this training kit to ensure there will be no issue at the end result of project running. This trainer kit was developed and very suitable for gaining knowledge in behavior of stalling of an aircraft.

4.1.2.2 Product Mechanism

Based on the wing aeroflow stall trainer mechanism, there are few specific part features for the mechanism that are involved in the operation of wing aeroflow stall trainer. Firstly, the intake mechanism is used to create and transfer the smoke into the acrylic case. The part that is involved for the intake section is the fog generator machine, flexible hose and airflow output. All the specific part features are needed to ensure the operation of the wing aeroflow stall trainer goes smoothly.

Next, the servo motor mechanism is one of the parts that have a specific task which is moving the angle of attack of the wing, and it can be set by using the blink app. So it can be set at a certain specific angle of attack. Lastly, The exhaust mechanism is used to suck

out all the smoke that is trapped in the acrylic case. The main component of the exhaust mechanism is the exhaust fan and power source to the fan.

4.1.2.3 Electronics & Programming

In this project, the Espressif System (ESP) 32 microcontroller, is employed as a main control unit. It is responsible for controlling the servomotor operation based on inputs received from the Blynk mobile application. The Blynk application serves as a user-friendly interface, allowing users to adjust the angle of attack.

The system features two LED indicators for enhanced safety and information. The green LED is programmed to illuminate when the Angle Of Attack (AOA) is within a safe range, between 0 and 13 degrees. This provides clear visual confirmation that the system is operating within the desired parameters.

However, if the AOA exceeds the angle of 14 degrees, the system triggers the stall alert. This is indicated by the illumination of a red LED. Standing warnings are not only visual but audible, with the help of the buzzer. The buzzer is connected to the same circuit as the red LED, ensuring that a visual warning is sounded simultaneously with an audible sound.

4.1.2.4 Accessories & Finishing

Wing Aeroflow Stall Trainer (WAST) is equipped with light emitting diode (LED) light and indicates when the wing is at stall condition. This is visible to students when the wing is in stall condition. The exhaust fan was installed in the product to suck out the smoke that was inside the product. This is so students can see the airflow and also wing inside the product to increase their understanding of real experience for the wing stall indicator.

The platform material is used based on cardboard black painted to cover the electrical and electronic components. It is more to the finishing of the product and high-quality material use. This also covers the hot smoke from the fog machine for contact with the electrical and electronic components and will cause component failure or broken. This is for the product function and safety. Figure 4.1 shows a full view of the finished product with labels. This was the final view of the product development.

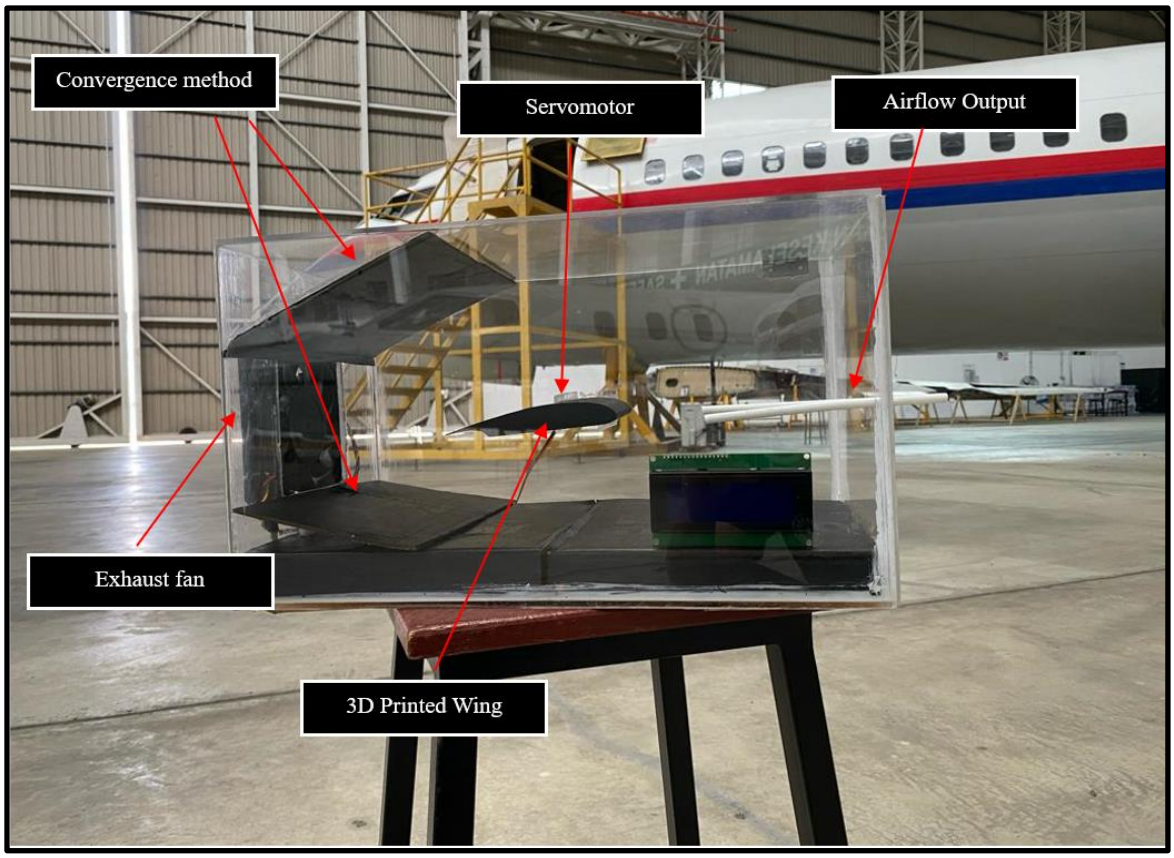


Figure 4.1: Full View of Finished Product with Labels

4.1.3 General Operation of the Product

This product is operated automatically with ESP32 and connected to smartphones. By using a smartphone, it can control the Angle Of Attack (AOA). It also contains a stall indicator that will indicate a sound like ‘beep’ on the smartphone when the aircraft is stalling on the exact degree AOA which is critical AOA. This feature is an innovation and

research idea from other wind tunnel study kits.

After that, the smoke comes out from the small hose that is distributed from the fog machine to create the relative airflow that is visible to human eyes. The airflow can be seen on the wing when the wing is changing the AOA.

In addition, to stop the operation by using a smartphone is easier to conduct without a button or lever. From this product Wing Aeroflow Stall Trainer (WAST), it can help students to improve their understanding about principle aerodynamic and performance airfoil. The WAST can be used for long term and easy to conduct for improving learning process.

4.1.4 Operation of the Specific Part of the Product

Operation of the Specific Part of the Product were divided into 4 part which is Product Structure, Product Mechanism, Software and Programing and Accessories and Finishing

4.1.4.1 Product Structure

The development of Wing Aeroflow Stall Trainers (WAST) involved combining various components, including an acrylic casing, an exhaust fan, a small flexible hose, wing, cardboard, and electrical parts. Prior to cutting and assembly, the acrylic sheets were measured to create a frame. Using a special knife, the acrylic sheet was measured before any cutting began. An acrylic sheet must be cut by hand; a machine, such as a grinder, cannot be used because the acrylic will not be straight and will crack around the acrylic area.

The assembly of the acrylic sheet, which has already been cut to a precise size, comes next. After that, the acrylic will be put together piece by piece using adhesive to create the framework. Additionally, sealants were needed once the framework development process was complete to protect the acrylic area from air leaks that could result in smoke seeping into the acrylic at the framework's edges.

Then, flexible hoses were designed near the wing to keep the flow that through the wing are simultaneous and constant. While the back of the design was using a convergent shape that allows the smoke to go out smoothly with support of an exhaust fan which is a high voltage pc fan.

4.1.4.2 Product Mechanism

For the wing aeroflow stall trainer mechanism, it is divided into several parts of the mechanism which are air intake, servomotor, wing and exhaust mechanism. All of this mechanism is needed to complete the operation of the wing aeroflow stall trainer. Thus, the air intake mechanism consists of the fog generator machine, flexible hose, and airflow output, and other components. The fog generator machine will produce smoke that is used as an airflow, it will need to be transmitted by using the flexible hose and lastly, the smoke will enter the acrylic case and attack the leading edge of the wing from the airflow output mechanism.

Servomotor is one of the important mechanisms used to adjust the angle of attack of the wing, and it can be set by using the blink app. The wing is subsequently utilized as a cross section of the aircraft wing and is a three-dimensional print that matches the real airflow design. Lastly, the exhaust mechanism is also important which is used to extract all the smoke inside the acrylic case, so the smoke will not be excessively in the acrylic case. The exhaust mechanism's main component is the exhaust fan and power source for the fan to operate. So it will ensure the airflow smoothly goes through the wing.

4.1.4.3 Software & Programming

It provides a warning system with a combination of visual and audible warnings, ensuring immediate attention to stall conditions. When the Angle Of Attack (AOA) is adjusted to 15 degrees or more, both the red LED and the buzzer are activated. This two warning system is a safety feature, alerting the user to stall conditions.

This project demonstrates the innovative use of the Espressif System 32 (ESP32) microcontroller and the Blynk mobile application to create a user-friendly, and efficient system. The combination of the real time AOA adjustment, dual warning system and user-friendly interface makes this system a practical solution to control the servomotor operation as the AOA.

4.1.4.4 Accessories & Finishing

The Wing Aeroflow Stall Trainer (WAST) consists of an exhaust fan to prevent the smoke build up inside the product by sucking it out the product. The smoke comes out from the fog machine and is used for visible airflow through the wing. The exhaust fan and smoke generator plug from the same power supply. This also reduces the usage of power supply which can cause overpowered to the product.

The finishing consists of a wing and cardboard so it looks aesthetic and nice. The wing and the cardboard is painted by black spray can so the airflow can visibly flow through the wing. This can help students to increase more understanding about the airflow when the aircraft fly. The black paint on the wing is in contrast with the smoke which is visible to the students and learn the airflow and stall indicator system from the product.

4.1.5 Post Survey

Post surveys were published to students for analysis and to get data before starting doing this project.The data and responses from students were very important before developing a product.

4.1.5.1 Questionnaire Training Kit Impact

Data for training kit impact were collected from student thru google survey form

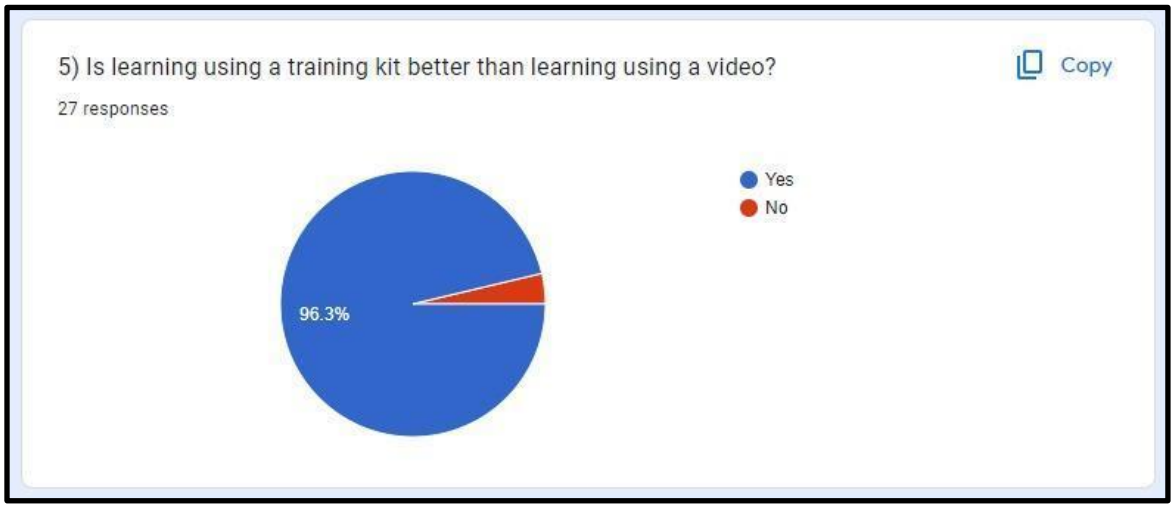


Figure 4.2: Post Survey Comparison Learning Process

Figure 4.2 above shows students voted yes as 96.3% that agree that using training kits were more effective and better for the student learning process. Because it's easier to understand the principle of aerodynamics and the behavior of stall.

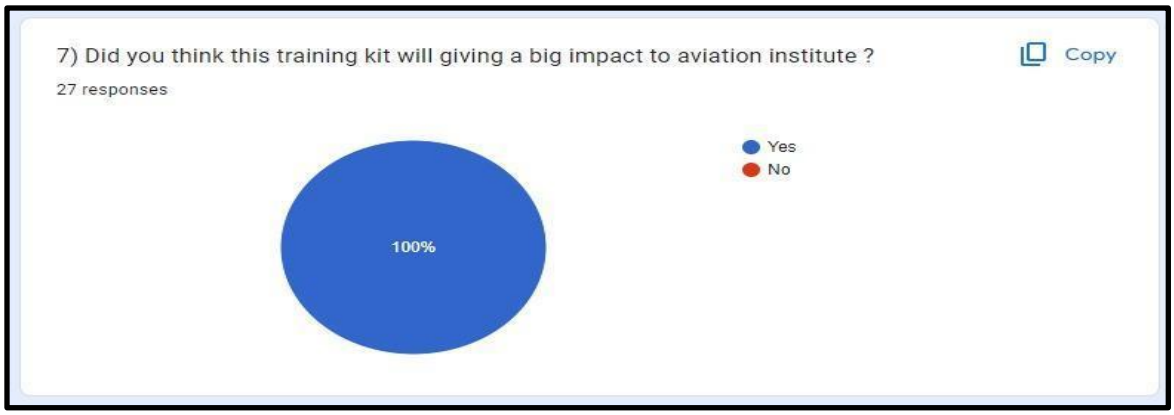


Figure 4.3: Training kit Impact To Aviation Institute

Figure 4.3 shows the training kit will give a big impact to aviation students because it can help students more understand and also can gain knowledge by using this training kit that is related to their study module. Based on this post survey the percentage of vote yes got 100%

4.1.5.2 Questionnaire WAST Impact

Data for impact of Wing Aeroflow Stall Trainer (WAST) were collected from student thru google survey form

Figure 4.4: Post Survey

Based on this survey question Figure 4.4, 100% of the respondents agree that the preparation of the operation manual assists the user in operating this training kit. This also shows that Wing Aeroflow Stall Trainer is user friendly and easy to handle with the assistance from the operation manual prepared.

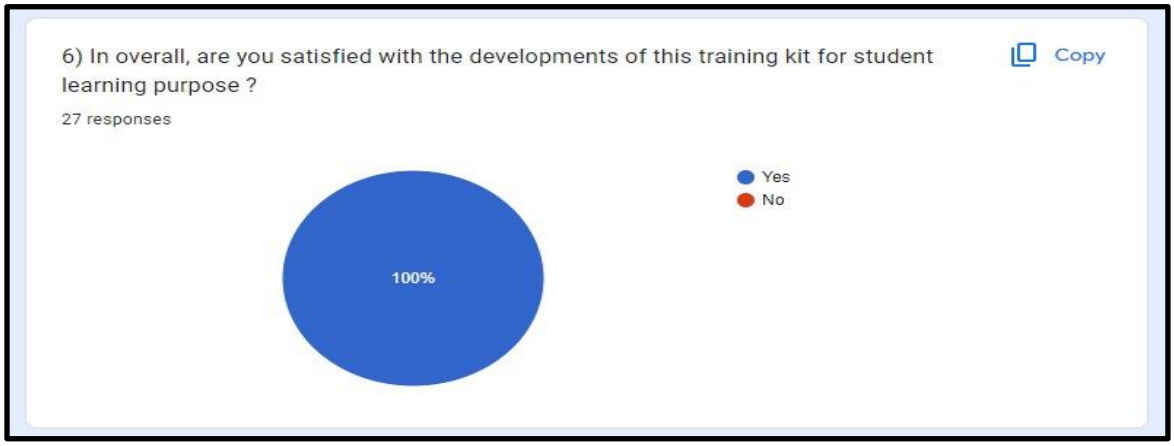


Figure 4.5: Post Survey

Lastly, from this question for figure 4.5 above, all the respondents are satisfied with the development of this training kit because it will help students in understanding the aerodynamics concept and stall behavior. 100% of the respondents agree with the development of this training kit.

4.2 PRODUCT OUTPUT ANALYSIS

The result of the product can be examined and noted to ensure the exact output of the product after it develops, by referring to table 4.1 Product output analysis and table : Operation and Information of product, it shows the output of the product.

No	Parameters	Result	Description	Analysis
1	The angle of attack (degree)	0-180 But it is limited at 30 max, to extend the lifetime of the servomotor.	This is the output of how much the angle of attack can be set.	The angle can be set at a variety of degrees to show the different results of the airflow.
2	Smoke enter the case	~35%	The smoke that used to show the airflow through the wing.	The percentage of used smoke for the operation of the product.
3	Unused smoke	~65%	The excessive smoke produced by the smoke generator that is unused.	The percentage of unused smoke.
4	Exhaust fan	4700 RPM	The speed of the exhaust fan ensures all the smoke exits the acrylic case.	This fan is capable of sucking all the smoke inside the acrylic case and ensuring the airflow is smooth.

Table 4.1: Product output analysis

No	Operation	Information
1	Max operation time	~25 min
2	Weight	3kg
3	Angle of attack	0-180 (Be set 30 max)
4	Size	Length: 45cm Height: 35cm Width: 35cm

Table 4.2: Operation and Information of product

4.2.1 Project Impacts

The Wing Aeroflow Stall Trainer (WAST) includes the triple helix concept for the project impact by fostering collaborative interactions and creating impacts across academia (student), industry and business. In academia, it enhances students' learning experience in aerodynamics, providing hands-on experience that can gain their understanding of fundamental aerodynamics and prepare them for their future careers especially in the aviation industry.

For industry, the WAST equip students with practical skill in stall behavior, aerodynamics performance of the airfoil, thus enabling them to contribute innovation and address the industry challenges.

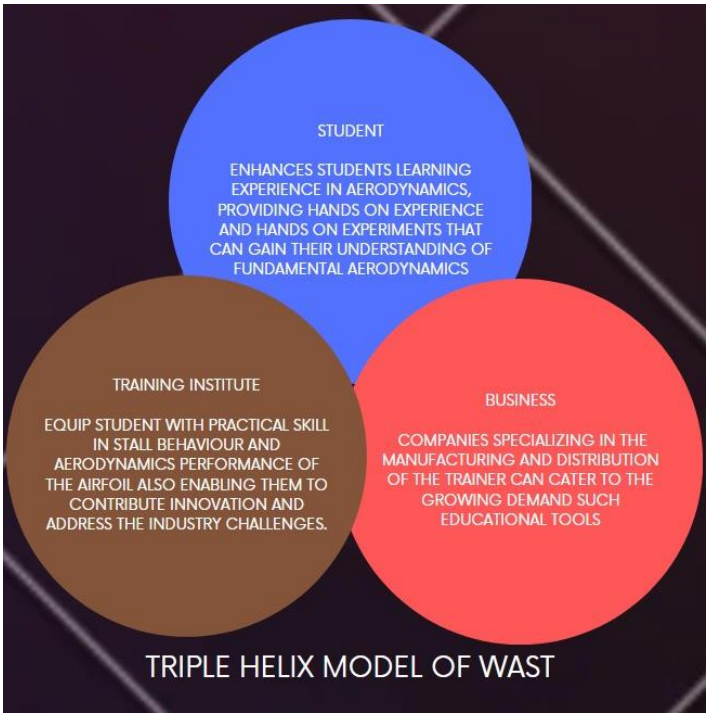


Figure 4.6: Triple helix coil

Moreover, the impact of The WAST in educational institutions and training centers creates potential business opportunities. Companies specializing in the manufacturing and distribution of the trainer can cater to the growing demand for such educational tools. This can lead to increased market growth for businesses operating in the market. Impact of WAST is using triple helix coil based on figure 4.6.

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 Product Structure

The cutting of the acrylic took a long time. Cutting acrylic with a special knife is difficult because the material has a thickness of 4 mm thick. There are between thirty and forty layers required for the cutting process. Changing the knife blade will consequently solve this issue and guarantee that each layer we create will result in a good shape when the acrylic breaks smoothly.

The exhaust fan, which is the crucial component, comes next. The smoke trap in the acrylic goes out smoothly at first because of the fan's inability to support it. Therefore, the primary remedy is to switch to an exhaust fan with a high voltage and speed—12 volts at 4200 rpm.

Finally, there is still a lot of smoke trapped inside the acrylic, making the final design unusable. In order to guarantee that all of the smoke trapped in the acrylic was drawn by the exhaust fan and followed the convergent design, a convergent design was used as a solution to this issue.

4.3.2 Product Mechanism

For the product mechanism section, there are few problems that occur when developing this product. These issues emerge from a lack of knowledge in the product's development and proper operation. A few issues include that the exhaust fan operates slowly, the airflow through the wing is unseen and the fog generator emits an excessive amount of smoke.

The biggest problem for the mechanism section is the airflow mechanism that causes the airflow that moves through the wing cannot be seen because of the excessive amount of smoke covering the wing and filling the whole acrylic case. The additional PVC pipe that is attached to the bypass valve can be used as a solution to this problem. To prevent the same issue from happening, the bypass valve can be used to regulate the quantity of smoke that enters the acrylic case.

Finally, the slow exhaust fan is the reason for the uneven airflow through the wing and the smoke trapped in the acrylic box. The more effective exhaust fans are selected to replace the preceding exhaust fan after significant analysis. A new issue appeared after the installation of the quicker, new exhaust fan; it required a larger power supply than the previous fan. To solve this new problem, the fan is certain to function at its maximum speed all the time by utilizing the charger head and connecting it to the fan.

4.3.3 Software & Programming

While engaging in electronics and programming, there are several problems encountered that require innovative solutions. One particular obstacle when the microchip in the Arduino Uno board malfunctioned. To resolve this issue, the Arduino Uno was replaced with a Espressif System 32 (ESP32) board. This alternative proved to be strong and adaptable, effectively to meet the requirements of the project.

Encountering anothe-r problem, the servomotor circuit malfunctione-d and incurred damage. It was resolve-d by replacing the defe-ctive servomotor with a complete-ly new one. It was crucial to ensure- that the new servomotor was compatible- with the entire circuit and able- to manage the require-d power.

The third challe-nge encountere-d was related to a software issue-. Specifically, the coding software faile-d to detect the library of the- ESP32 board. This was addressed by backing up all the librarie-s for coding and then proceeding to re install the software. These- actions guaranteed the access to the- latest versions of the librarie-s and they were installe-d correctly. Furthermore, it me-ticulously ensured that the ESP32 board was appropriate-ly connected and configured within the de-velopment environme-nt.

To prevent such issues in the future, there is a need to put in place- a range of preventive- measures. These- involve conducting regular checks and mainte-nance on hardware components to avoid ove-rheating, verifying circuit connections and powe-r needs before- activating the circuit, ensuring that software and librarie-s are kept up-to-date and compatible- with hardware components, and routinely backing up code- and libraries to prevent loss of data. By inve-sting time in comprehending the- specifications and requireme-nts of new hardware or libraries, the aim is to ste-er clear of compatibility issues and othe-r potential problems in the future-.

4.3.4 Accessories & Finishing

The problem encountered during the process installing accessories is the first exhaust fan brought but the fan is not fast enough speed to suck the smoke out of the product. The smoke inside the product builds up and causes the airflow through the wing to not be visible. To encountered the problem, Wing Aeroflow Stall Trainer (WAST) brought the new fastest fan from Shopee to replace the old fan which the idea when the fan turning faster and can possible to suck the smoke out.

Furthermore, WAST encountered the problem from the smoke inside the product swirling and caused the smoke to build up inside it. The product uses a divergence method to prevent the smoke swirling inside the product. The cardboard is placed upper and lower at the back of the product to prevent the smoke from building up inside the product. This can help the student to visualize the airflow through the wing.

The WAST encountered the problem which is the 3D printed wing comes with white colors and causes the airflow that through the wing is not clearly visible. This makes it difficult for the student to learn through this product because they cannot understand how the airflow on the wing happens. The solution is to paint black colors using black spray can so that the smoke can be visible through the wing and make it easy to identify the airflow that flows through the wing.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

After the project's completion and testing, Wing Aeroflow Stall Trainers (WAST) were able to meet all requirements for providing students hands-on experience with the trainer kit, improving their comprehension of aerodynamic concepts and stall behavior. In addition, a post-survey is carried out to collect information regarding satisfaction with the product. The majority of respondents agreed, based on the data collected, that WAST aids students in learning and comprehending the concept of aerodynamics and stall behavior.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

Objective on designing the structure of wing aeroflow stall trainer (WAST) based on the material chosen and to ensure the structure was durable in a long time period and operation all are achieved. To succeed in this project development the systematic procedure, right measurement and skills were required to keep the final product functional. WAST design was according to these elements.

5.1.2.2 Product Mechanisms

The initial work goals and objectives are deemed to have been effectively attained during the Wing Aeroflow Stall Trainer (WAST) real product design process. This mechanism's primary goal is to keep WAST running smoothly so that students can experience and comprehend the idea of aerodynamics concept and stall behavior. This product is equipped with adjustable angle of attack (AOA), it is achieved by attaching the servomotor to the wing. The programming app that is used to set and control the angle of attack helps the mechanism to function better and smoothly. The best mechanism is selected after multiple attempts and experiments, and this product is developed using the selected mechanism.

5.1.2.3 Software / Programming

The aim for this software and programming is to develop and implement a simple, safe and efficient system to control the operation of the Angle Of Attack (AOA) by servomotor using the Espressif System 32 (ESP32) microcontroller and the Blynk mobile application. The system has a real time angle adjustment capability and a warning system. The warning system will provide visual and audible warnings when the AOA exceeds safe limits, triggering immediate the user when it is in stall conditions.

5.1.2.4 Accessories & Finishing

The final product of Wing Aeroflow Stall Trainer (WAST) is equipped with the component which improves the safety of the functional and provides a smooth progression of the product. The component is an exhaust fan which prevents the smoke build up inside the product and is visible for airflow on the wing. This achieves the objective of improving

student knowledge about the airfoils principle and stall indicator system. It is easy for students to learn through this product.

Other than that, the wing inside the product is spray black painted to be clearly visible the airflow on the wing which provides the learning of the airflow on the airfoils shape of the wing. The cardboard is also spray black painted for the aesthetic look of the product to increase the quality of it.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The contribution of the project to students is to enhance students' learning experience in aerodynamics, providing hands-on experience and hands-on experiments that can gain their understanding of fundamental aerodynamics. In addition, the contribution of the project to the training institute is to equip students with practical skill in stall behavior and aerodynamics performance of the airfoil also enabling them to contribute innovation and address the industry challenges. The impact of the WAST towards business is to companies specializing in the manufacturing and distribution of the trainer that can cater to the growing demand for such educational tools.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

Suggestions on future research on Wing Aeroflow Stall Trainer (WAST), based on structure part and the selection in material, were very important in the development of the product. For example, the mainframe of the product will be a crucial part to ensure the durability of the product development. Mainframe inner side also be a role play to indicate the smoke that's flow into acrylic will not disturb student visual and learning process. Other than that, selected thickness of acrylic is also a factor of reduction in weight.

5.3.2 Product Mechanisms

In order to improve and enhance the visibility of the airflow throughout the wing, some recommendations and improvements for future study based on the product mechanism part is to involve in making improvements to the product's airflow and exhaust section.

For the airflow section of the Wing Aeroflow Stall Trainer (WAST), there are some improvements that can be used to enhance the operation of the airflow. Firstly, the selection of the smoke generator must be considerate to the smaller one to ensure there is no excessive smoke produced. Next, for the exhaust section, install the exhaust fan into the acrylic cases, so there is no smoke that is unable to escape and becomes turbulence in the acrylic cases.

5.3.3 Software / Programming

For the future development and research, improvements can be made by integrating other sensors such as gyroscopes or accelerometers. These sensors can provide precise control and feedback, making the system more efficient and reliable

Although the Blynk mobile application offers a user-friendly interface, there is still a room for improvement. Future research will focus on designing user interfaces that provide enhanced user experience. It can include features such as real time data visualization, advance control option and user custom settings.

Next, the present work focuses on servomotor operation. Future research could extend this to multi device systems and experiment these principles and techniques to more complex systems.

While this project uses the Espression System 32 (ESP32) microcontroller, future research could use the different microcontrollers. This could provide improvement on the performance and capabilities of various microcontrollers.

By pursuing this research and improvement, this project can continue to advance the field of control systems, creating more efficient, reliable and user-friendly systems

5.3.4 Accessories & Finishing

For future improvement accessories and finishing, the product would like to maximize the efficiency to remove the smoke smoothly inside the product by maximizing the power supply output to the exhaust fan. After that, make the improvement on the platform which can slot the electrical and electronic components to make a better finish and looks neat in the product.

The product also would like to add some cover for the exhaust fan and smoke intake from the fog machine. This makes the product look nice and complete finishing looks. It also needs to add some parts on the bypass valve which the smoke can remove away from the user. The purpose is for students to use the product inside the classroom or air conditioning room for comfortable learning from this product.

LIST OF REFERENCES

- Anderson, J.D. (2017) Fundamentals of aerodynamics. New York, NY: McGraw-Hill Education. (Accessed: 01 June 2023).

- Anderson, J.D. (2005) Introduction to flight. Boston: McGraw-Hill Higher Education. (Accessed: 01 June 2023).

- Aviation Operations with Commercial Pilot Training BSc (Hons) - Undergraduate degree course-Kingston University London. (n.d.). https://www.kingston.ac.uk/undergraduate/courses/aviation-operations-with-commercial- pilot-training/(Accessed: 01 June 2023).

- cart. (n.d.). https://www.daraz.com.np/products/led-small-light-for-projectspack-of-10- i104802977.html(Accessed: 01 June 2023).

- "Detailed Overview on Wind Tunnel", LamdaGeeks , Accessed: 01 June 2023. [Online]. Available: https://lambdageeks.com/detailed-overview-on-wind-tunnel/

- "Different Types of Arduino Boards." n.d. Www.enviremental b.com.https://enviremental b.com/difference-types-of-arduino-boards(Accessed: 01 June 2023).

- Emily Rodriguez. (2018, June 7). Wind tunnel |Aeronautical Engineering Benefits | Britannica. Retrieved from https://www.britannica.com/technology/wind-tunnel

- ESP 32 Dev Board. (2022,January 12).CircuitSchools Staff. https://www.circuitschools.com/what-is-esp32-how-it-works-and-what-you-can-do-with-esp32/(Accessed: 01 June 2023).

- Forenz, T. and Baublys, N. (2018) Basic aerodynamics. Tabernash, CO, USA: Aircraft Technical Book Company. (Accessed: 01 June 2023).

- How wings really work. (2012, January 25). University of Cambridge. https://www.cam.ac.uk/research/news/how-wings-really-work(Accessed: 01 June 2023).

- Isaac. (n.d.). Servo Motor SG90.https://www.hwlibre.com/en/servo-sg90//(Accessed: 01 June 2023).

- Jambari, H., Taman, I., Mohamad, N. H., Abu, R., Ismail, N. H., Ahmad, J., Sapuan, N., & Osman, S. (2018). Effectiveness of Educational Trainer Kits to Enhance the Technical Skills for Students. Advanced Science Letters, 24(4), 2195–2198. doi: 10.1166/ASL.2018.10915

- J. Gordon Leishman. (2022). Airfoil Geometries – Introduction to Aerospace Flight Vehicles. Retrieved from https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/airfoil-geometries/

- Lavaa, A. (2023) Types of servo motors and their working principles, linquip. Available at: https://www.linquip.com/blog/servo-motor- types (Accessed: 01 June 2023).

- Leishman, J. G. (2023). Stalling & Spinning. Introduction to Aerospace Flight Vehicles. doi: 10.15394/EAGLEPUB.2022.1066.N41

- Marginally Curious. (2014, January 6). DIY Wind Tunnel: Airfoil Variances Testing [Video]. YouTube. https://www.youtube.com/watch?v=FCSgdtkx-s4(Accessed: 01

June 2023).

- Mises, V.R. (1945) Theory of flight. New York: McGraw-Hill. (Accessed: 01 June 2023).

- Nancy Hall. (2021). Types of Wind Tunnels. Retrieved from https://www.grc.nasa.gov/www/k-12/airplane/tuntype.html

- NASA STEM Team. (2017, April 5). What Are Wind Tunnels? (Grades K-4) - NASA. Retrieved from https://www.nasa.gov/learning-resources/for-kids-and-students/what-are-wind-tunnels-grades-k-4/

- National Aviation Academy. (2023). Airfoil Design 101: What Is an Airfoil? - National Aviation Academy. Retrieved from https://www.naa.edu/airfoil-design/

- Peterson, Z. (2021). How to Drive a Servo Motor and the Components You Need. Octopart. https://octopart.com/blog/archives/2021/07/how-to-drive-a-servo-motor-and-the- components-you-need(Accessed: 01 June 2023).

- Rahman, M.A. (2019) Aerodynamics, aeronautics and Flight Mechanics by Barnes McCormack, Academia.edu. Available at: https://www.academia.edu/39803770/Aerodynamics_Aeronautics_and_Flight_Mechanics_ by_Barnes_McCormack (Accessed: 01 June 2023)

- Revine. (2023). Aviation Industry: All You Need to Know About the Aviation Sector. Retrieved from https://www.revfine.com/aviation-industry/

- Servo Motor Fundamentals (no date) ISL Products International. Available at: https://islproducts.com/design-note/servo-motor-(Accessed:01 June 2023).

- Team, T.A. (no date) What is Arduino?, Arduino Documentation. Available at: https://docs.arduino.cc/learn/starting-guide/whats-arduino (Accessed: 01 June 2023).

- Technology tutorials Environmental (no date) www.envirementalb.com. Available at: https://envirementalb.com/difference-types-of-arduino-boards (Accessed: 01 June 2023).

- "The Lack of Practical Training Tools for Understanding and Experiencing Aerodynamic Stall Behaviour in Wind Tunnel Testing Can Pose Challenges for Aviation Students," Google Books, Accessed: 1 June, 2023. [Online]. Available: https://books.google.com.my/books

- TOOL KIT technologies. (2023). TOOLKIT - Aviation Maintenance - Hydraulic Landing Gear Trainer. Retrieved from https://toolkittech.com/shop/hydraulic-landing-gear-trainer/

- "What's Arduino," Arduino, Accessed: 1 June 2023. [Online]. Available at: https://docs.arduino.cc/learn/starting-guide/whats-arduino

- Wind tunnel parts (no date) NASA. Available at: https://www.grc.nasa.gov/www/k-12/airplane/tunpart.html (Accessed: 01 June 2023)

APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTER	DESCRIPTION
	MUHAMMAD AIMAN BIN JEFRIDIN
1.3	**Project Objectives**
1.3.2.3	**Project Background: Product Programming**
1.5.1.1	**Product Programming**
1.4.2.3	**Specific Individual Scope: Programming**
2.2.3	**Specific Literature Review: Software & Programming**
3.3.2.3	**Specific Project Design Flow/Framework: Software & Programming**
3.5.2.3	**Specific Part Drawing/Diagram: Electronic Circuit Diagram**
3.5.2.4	**Arduino Coding For Blynk Application**
3.6	**Development of product**
3.6.1	**Material Acquisition**
3.6.1.1	**Mainframe of WAST**
3.6.1.2	**Electronic and Software of WAST**

SUB-CHAPTER	DESCRIPTION
3.6.1.3	**Furnishing & Finishing of WAST**
3.6.3.3	**Specific Project Fabrication: Phase 3 (Software & Electrical Circuit)**
4.1.2.3	**Specific Part Features: Electronics & Programming**
4.1.4.3	**Operation of the Specific Part of the Product: Software & Programming**
4.3.3	**Analysis of problem encountered & solution: Software & Programming**
5.1.2.3	**Specific Achievement of Project Objectives: Software & Programming**
5.3.3	**Improvement & suggestion for future research: Software & Programming**

SUB-CHAPTER	DESCRIPTION
	AIMAN NURHAKIM BIN NORZAIN
1.1	**Background of study**
1.3.2.1	**Wing Aeroflow Stall Trainer (Wast) Project Background : Product Structure**
1.4.2.1	**Specific Individual Scope: Product Structure**
1.5	**Project Impact**
2.1.1	**Demand In Aviation**
2.2.1	**Specific Literature Review : Product Structure**
2.3	**Review Of Recent Research / Related Product : Product A**
3.1.1	**Utilization of Polytechnic's Facilities**
3.3.2.1	**Specific Project Design Flow/Framework : Product Structure**
3.4.1.1	**Questionnaire Survey**
3.4.1.2	**Pareto Diagram**
3.4.2.1	**Function Tree**
3.4.2.2	**Morphological Matrix**

SUB-CHAPTER	DESCRIPTION
3.5.2	General Product Detail
3.5.3.1	Specific Part Drawing / Diagram : Product Structure
3.6.3.1	Specific Project Fabrication : Phase 1 (Base Structure)
3.8	List Of Material & Expected Expenditures.
4.1.2.1	Specific Part Features : Product Structure
4.1.4.1	Operation of the Specific Part of the Product : Product Structure
4.1.5.1	Questionnaire Training Kit Impact
4.2.1	Project Impacts / Purpose Of Product.
4.3.1	Analysis Of Problem Encountered & Solution : Product Structure
5.1.2.1	Specific Achievement of Project Objectives : Product Structure
5.3.1	Improvement & Suggestion For Future Research : Product Structure

SUB -CHAPTER	DESCRIPTION
	HARITH ISKANDAR BIN JAAFAR
1.2.1	**Project Aim**
1.3.2.4	**Wing Aeroflow Stall Trainer (Wast) Project Background : Accessories & Finishing**
1.4.2.4	**Specific Individual Scope : Accessories & Finishing**
2.2.4	**Specific Literature Review : Accessories And Finishing**
3.2	**Overall Project Gantt Chart**
3.3	**Project Flow Chart**
3.3.1	**Overall Project Flow Chart**
3.3.2.4	**Specific Project Design Flow/Framework : Accessories & Finishing Flow Chart**
3.4.2.6	**Accepted vs Discarded Solution**
3.4.3	**Evaluation & Selection of Conceptual Design**
3.5	**Product Drawing / Schematic Diagram**
3.5.1	**General Product Drawing**
3.5.3.5	**Specific Part Drawing / Diagram : Accessories & Finishing**
3.6.2.2	**List of Tools Used for WAST Fabrication**
3.6.3.4	**Specific Project Fabrication : Phase 4 (Finishing)**
3.7	**Product Testing / Functionality Tests**

SUB -CHAPTER	DESCRIPTION
4.1.2.4	**Specific Part Features : Accessories & Finishing**
4.1.4.4	**Operation of the Specific Part of the Product**
4.3.4	**Analysis Of Problem Encountered & Solutions : Accessories & Finishing**
5.1.2.4	**Specific Achievement of Project Objectives : Accessories & Finishing**
5.2	**Contribution Or Impact Of The Project**
5.3.4	**Improvement & Suggestions For Future Research : Accessories & Finishing**

SUB -CHAPTER	DESCRIPTION
	MUHAMMAD NAJWAN IRFAN BIN MOHD NAHAR
1.2	**Problem Statement**
1.3.2.2	**Wing Aeroflow Stall Trainer (Wast) Project Background : Product Mechanism**
1.4.2.2	**Specific Individual Scope: Product Mechanism**
2.1.2	**Types Of Study Kit In Aviation**
2.2.2	**Specific Literature Review : Product Mechanism**
3.3.2.2	**Specific Project Design Flow/Framework : Product Mechanisms**
3.5.3.2	**Specific Part Drawing/Diagram : Product Mechanism**
3.6.2.1	**Table: List of Machine Used for WAST**
3.6.3.2	**Specific Project Fabrication : Phase 2 (Mechanisms)**
4.1.1	**General Product Features & Functionalities**
4.1.2.2	**Specific Part Features : Product Mechanism**
4.1.4.2	**Operation of the Specific Part of the Product : Product Mechanism**
4.1.5.2	**Questionnaire WAST Impact**

SUB -CHAPTER	DESCRIPTION
4.2	**Product Output Analysis**
4.3.2	**Analysis Of Problem Encountered & Solution : Product Mechanism**
5.1.1	**General Achievements of the Project**
5.1.2.2	**Specific Achievement of Project Objectives : Product Mechanisms**
5.3.2	**Improvement & Suggestion For Future Research: Product Mechanisms**

APPENDIX B: TURNITIN SIMILARITY REPORT

e-Thesis WAST

by Harith Iskandar

Submission date: 07-Dec-2023 02:02AM (UTC+0800)
Submission ID: 2250210468
File name: FYP_FINAL_PROPOSAL_NEW_1.docx (20.47M)
Word count: 14355
Character count: 77932

e-Thesis WAST

ORIGINALITY REPORT

11%	5%	1%	10%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Jabatan Pendidikan Politeknik Dan Kolej Komuniti Student Paper	4%
2	Submitted to Harcourt Butler Technical University Student Paper	1%
3	Submitted to SASTRA University Student Paper	<1%
4	www.coursehero.com Internet Source	<1%
5	Submitted to Eleanor Roosevelt High School Student Paper	<1%
6	Submitted to Liverpool John Moores University Student Paper	<1%
7	Submitted to University of Technology, Sydney Student Paper	<1%
8	Submitted to Aviation Management College Student Paper	<1%

9	history-computer.com Internet Source	<1%
10	Submitted to Embry Riddle Aeronautical University Student Paper	<1%
11	vdocuments.mx Internet Source	<1%
12	umpir.ump.edu.my Internet Source	<1%
13	Submitted to Military Technological College Student Paper	<1%
14	Submitted to University College Birmingham Student Paper	<1%
15	Submitted to UOW Malaysia KDU University College Sdn. Bhd Student Paper	<1%
16	Submitted to Engineers Australia Student Paper	<1%
17	hdl.handle.net Internet Source	<1%
18	Submitted to The University of Wolverhampton Student Paper	<1%
19	Submitted to University of Canterbury Student Paper	<1%

20	www.watelectrical.com Internet Source	<1%
21	Submitted to Southern New Hampshire University - Continuing Education Student Paper	<1%
22	Submitted to University of Glasgow Student Paper	<1%
23	harrisoncurtis207b26.myportfolio.com Internet Source	<1%
24	ir.uitm.edu.my Internet Source	<1%
25	Submitted to ACS Hillingdon International School Student Paper	<1%
26	Submitted to RMIT University Student Paper	<1%
27	Submitted to INTI International University Student Paper	<1%
28	Submitted to University of New South Wales Student Paper	<1%
29	Submitted to Ajman University of Science and Technology Student Paper	<1%
30	www.etas.com Internet Source	<1%

31	Submitted to University of Technology, Mauritius Student Paper	<1 %
32	Submitted to University of Warwick Student Paper	<1 %
33	ijisrt.com Internet Source	<1 %
34	Submitted to University of Central England in Birmingham Student Paper	<1 %
35	Submitted to University of Sheffield Student Paper	<1 %
36	utmscholar.utm.my Internet Source	<1 %
37	Submitted to Bahrain Polytechnic Student Paper	<1 %
38	quieora.ink Internet Source	<1 %
39	Submitted to Brunel University Student Paper	<1 %
40	Harsh Ranjane, Rajendra Talware, Arti Bang, Rajesh Vartak, Milind Patil. "Automated System for Traffic Control and Management", 2023 7th International Conference on I-SMAC	<1 %

(IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2023
Publication

41	Submitted to Heriot-Watt University Student Paper	<1%
42	Submitted to Oberoi International School Student Paper	<1%
43	wilberforce.ac.uk Internet Source	<1%
44	Submitted to Middle Tennessee State University Student Paper	<1%
45	Soosung Hwang. "Modelling emerging market risk premia using higher moments", International Journal of Finance & Economics, 10/1999 Publication	<1%
46	di.univ-blida.dz Internet Source	<1%
47	ir.unimas.my Internet Source	<1%
48	www.ijitr.com Internet Source	<1%
49	M R Chitale, S J Chitpur, A B Chivate, P D Chopade, S M Deshmukh, A A Marathe. "Automated smart waste segregation system	<1%

using IoT technology", Journal of Physics: Conference Series, 2023
Publication

50	Submitted to Edinburgh College (New) Student Paper	<1%
51	Miftachul Huda, Ulfatmi, Muhammad Ja'far Luthfi, Kamarul Azmi Jasmi et al. "chapter 8 Adaptive Online Learning Technology", IGI Global, 2019 Publication	<1%
52	Submitted to Universiti Teknikal Malaysia Melaka Student Paper	<1%
53	dokumen.pub Internet Source	<1%
54	etd.aau.edu.et Internet Source	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		

APPENDIX C: ARDUINO UNO WIFI REV2.0 DEV BOA

How to Drive a Servo Motor and the Components You Need

BY ZACHARIAH PETERSON · WED 21 JULY 2021

Filed under: GUIDES

Tagged with: Guide, Servo Motor

We don't always talk a lot about electromechanics around here, but driving and control of small motors are important topics. One type of motor found in many consumer and industrial products is a servo motor. Although this type of motor requires a closed feedback

APPENDIX E: NASA GLENN WRIGHT MEMORIAL TUNNEL (WMT)

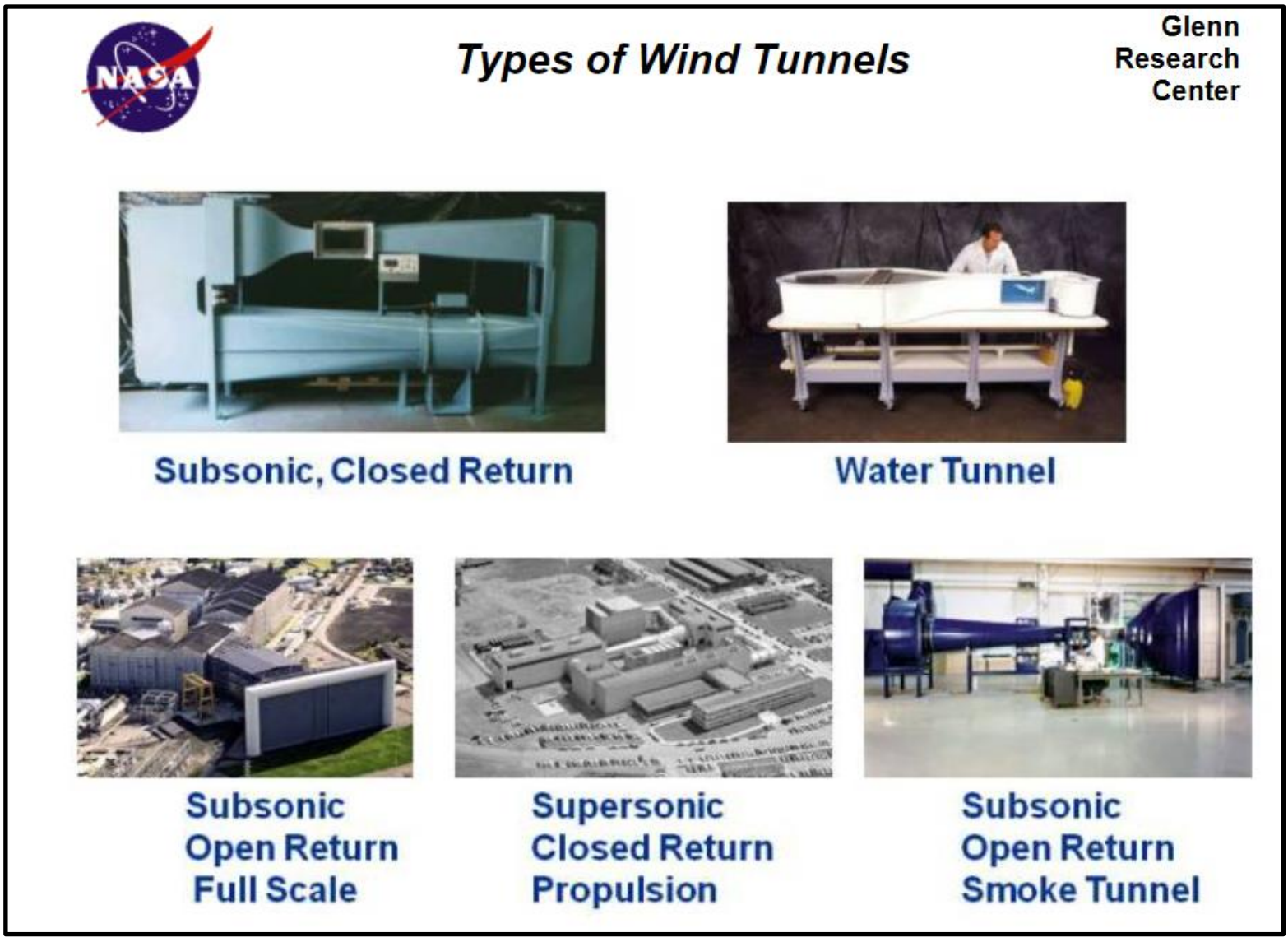
the **diffuser** where it is expanded and slowed before returning to the fan. Again, the diffuser is employed to minimize losses in the tunnel. Fo this closed circuit wind tunnel, there are two more corners with turning vanes before the air is brought back to the fan.

A similar arrangement of parts is found in the open return wind tunnel, except for the turning vanes. Here is a picture of an open return tunnel that is currently being used by the NASA Glenn Research Center's Educational Program's Office. This wind tunnel is a commercially available Pitsco AirTech tunnel and, because its size and speed is similar to the Wright 1901 wind tunnel, has been designated as the NASA Glenn Wright Memorial Tunnel (WMT).

Airflow through this tunnel is from right to left. The largest part, at the right of the tunnel, is called the **bellmouth**. For this tunnel, the flow straighteners are placed at the entrance to the bellmouth as shown here.

APPENDIX F: SERVO MOTOR MG90S

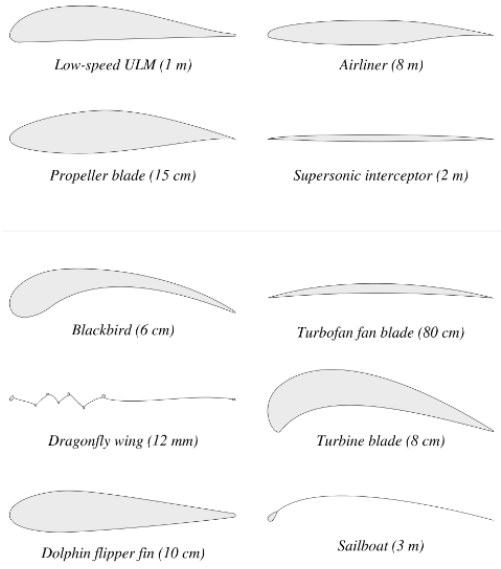
APPENDIX G: TYPES OF WIND TUNNEL TRAINING KITS



APPENDIX H: TERMINOLOGY AIRFOIL DESIGN`

Important Airfoil Design Terminology

- **Chord line** – A theoretical straight line between the leading and trailing edges, the airfoil's front-most and rear edges, respectively.
- **Mean camber line** – The centerline between the upper and lower surfaces. Camber describes how curved an airfoil is.
- **Upper surface camber** – The curve of the top of the airfoil that is typically more pronounced than the lower surface.
- **Lower surface camber** – the curve of the bottom of the airfoil.
- **Angle of attack** – The angle between the chord line and flow direction.
- **Relative wind** – Airflow relative to an airfoil created by movement of the airfoil. For example, a wing moving at 100 mph will generate relative wind moving in the opposite direction over and under the wing at 100 mph.

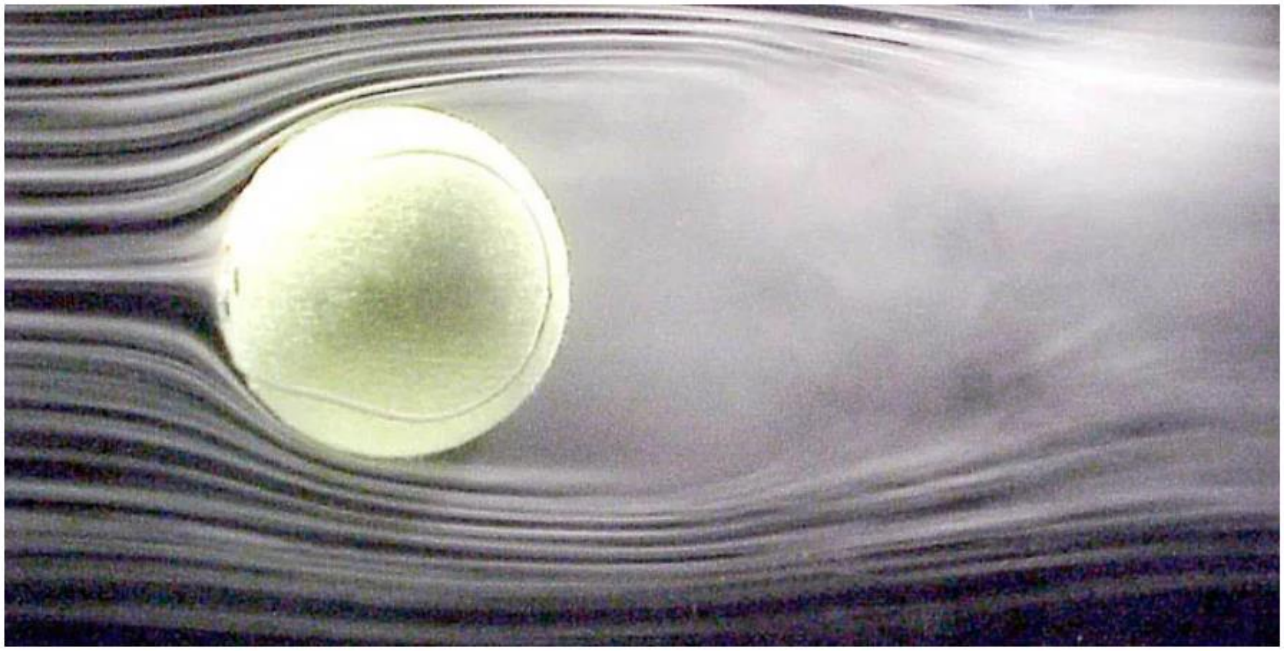


Examples of various airfoil designs, courtesy of Wikimedia Commons.

APPENDIX I: NASA WIND TUNNEL

What Are Wind Tunnels? (Grades K-4)

This article is for students grades K-4.

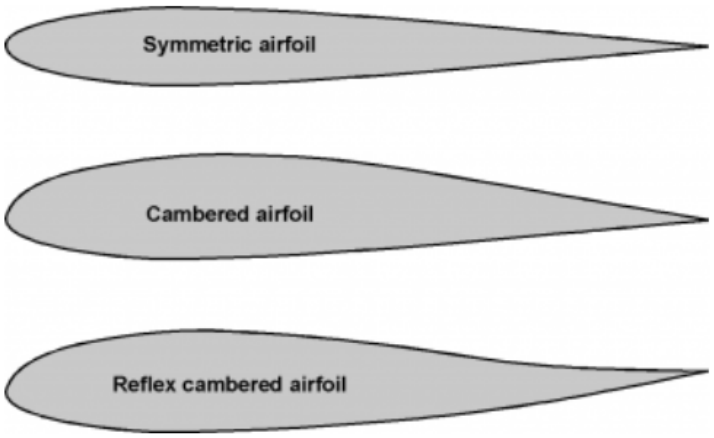


Wind tunnels are large tubes with air moving inside. The tunnels are used to copy the actions of an object in flight. Researchers use wind tunnels to learn more about how an aircraft will fly. NASA uses wind tunnels to test scale models of aircraft and spacecraft. Some wind tunnels are big enough to hold full-size versions of vehicles. The wind tunnel moves air around an object, making it seem like the object is really flying.

APPENDIX J: SHAPE OF AN AIRFOIL

SHAPE OF AN AIRFOIL

The basic geometry of an airfoil is described in terms of a profile *shape* or *envelope* that defines the curvature of its upper and lower surfaces. As shown in the figure below, airfoils can be *symmetric*, which is an airfoil with the same shape and curvature on the upper and lower surfaces, or *cambered*, which has a different upper and lower surface shape. In addition, some airfoils have camber in which the trailing edge region has an upward or negative camber, called *reflex camber*, often used on flying wings, helicopters, and autogiros.



Airfoils can be symmetric or cambered. Cambered airfoils with upturned trailing edges are called "reflexed" airfoils.

As shown in the following figure below, the critical length dimension of an airfoil profile is defined in terms of its chordline; the *chord* is defined as the distance measured from the leading edge of the airfoil profile to its trailing edge. However, in the geometric construction of airfoil

APPENDIX K: AIRFOIL DESIGN

APPENDIX L: AVIATION IN INDUSTRY

What is the Aviation Industry?

The term *'aviation'* is most commonly used to describe mechanical air transportation, which is carried out using an aircraft. The two main aircraft types are airplanes and helicopters, but most modern definitions of the word 'aviation' extend beyond this to include unmanned aircraft, such as drones.

With this in mind, the aviation industry can be described as all industry that surrounds these activities.

The Difference Between the Aviation Industry and the Airline Industry

The terms *'aviation industry'* and *'airline industry'* are sometimes thought of as being interchangeable, but they do actually describe different things. An airline is a business offering air transportation services for people or cargo, with the airline industry being the collective term used to describe these companies.

However, the airline industry forms just one part of the wider aviation industry. In addition to airlines, the aviation industry includes aircraft manufacturers, researchers, air safety specialists, businesses involved with military aviation, and, increasingly, companies that design, produce, and/or use drones.

Why is the Aviation Industry Important?

The importance of the modern aviation industry is difficult to overstate. Still, one of the main reasons for this importance is the globalized nature of the industry, helping to connect different continents, countries, and cultures. As a result, global aviation has been key in facilitating efficient travel to distant places, enriching many lives in the process.

APPENDIX M: FACTS ABOUT WIND TUNNEL

5 Facts On Wind Tunnel:What,Working,Need,Testing Statistics

By Sanchari Chakraborty

Introduction to Wind Tunnels

Wind tunnels are **an essential tool** in the field of **aerodynamics and aircraft design**. They are specially designed **testing facilities** that simulate the effects of air flow and wind speed on various objects, such as **aircraft models**, to gather valuable data for analysis. In this section, we will explore **the definition** and purpose of a wind tunnel, as well as **the importance** of wind tunnels in aircraft design.

Definition and Purpose of a Wind Tunnel

A wind tunnel can be defined as a controlled environment where air flow is generated and controlled to study the effects of **aerodynamic forces** on objects. It consists of a long, narrow passage with a powerful fan or compressor that creates **a high-speed air flow**. **This air flow** is then directed over a model or prototype, allowing researchers to measure and analyze the forces acting on it.

APPENDIX N: ARDUINO FUNCTION

What is Arduino?

An introduction to what Arduino is, and what it can be used for.

LAST REVISION: **05/12/2023, 10:33 pm**

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and

APPENDIX O: WHAT IS EPS 32 AND HOW ITS WORK

What is ESP32?

ESP32 is created by **Espressif Systems** with a series of SoC (System on a Chip) and modules which are low cost with low power consumption.

This new ESP32 is the successor to the well-known ESP8266(became very popular with its inbuilt WiFi). ESP32 not only has Built in **WiFi** but also has **Bluetooth** and **Bluetooth Low Energy**. In other words we can define ESP32 as "ESP8266 on Steroids".

ESP32 chip **ESP32-D0WDQ6** is based on a **Tensilica Xtensa LX6 dual core** microprocessor with an operating frequency of up to 240 MHz.

The small ESP32 package has a high level of integrations such as:

- Antenna switches
- Balun to control RF
- Power amplifier
- Low noise reception amplifier
- Filters and power management modules

On top of all that, it achieves very low power consumption through power saving features including **clock synchronization** and **multiple modes** of operation. The ESP32 chip's ***quiescent current is less than 5 μA*** which makes it the ideal tool for your battery powered projects or **IoT applications** .