POLITEKNIK BANTING SELANGOR

ICING PRO DETECTOR TRAINING KIT (IPDTK)

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 1 2024/2025

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

SUPERVISOR:

Ts. MOHD KHAIRUN NIZAM BIN SA'ADAN

REPORT ENDORSEMENT

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CERTIFICATION OF PROJECT ORIGINALITY & OWNERSHIP

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"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.

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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

Aircraft anti-icing and de-icing are vital processes to ensure safety and operational efficiency, particularly in cold weather conditions. Ice accumulation on critical surfaces, such as the wings and tail, disrupts airflow, reduces lift, and increases the risk of stalling, posing significant hazards during flight. To address these challenges, the aviation industry has emphasized training to equip students with the skills needed to manage de-icing systems effectively.

This project aims to bridge the gap between theoretical knowledge and practical skills by introducing the Icing Pro Detector Training Kit—a hands-on educational tool designed for engineering students and trainees. The kit provides a controlled environment to observe, measure, and manage de-icing processes, enhancing comprehension of anti-icing mechanisms through real-time interaction and data analysis.

Guided by Goethe's principle, *"Knowing is not enough; we must apply,"* this project demonstrates that practical applications deepen theoretical knowledge, facilitating a more comprehensive understanding of de-icing systems. By integrating this training kit into educational programs, students gain critical insights and hands-on experience, preparing them for real-world applications in aircraft safety and efficiency.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

TABLE	TITLE
FAA	Federal Aviation Administration
CAAM	Civil Aviation Authority of Malaysia
MAvA	Malaysian Aviation Academy
IPDTK	Icing Pro Detector Training Kit

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Aircraft anti-icing and de-icing are critical processes to ensure the safety and efficiency of flights, especially in cold weather conditions. These processes involve the removal of ice, frost, or snow from the aircraft's surfaces to prevent weight gain, loss of lift, and control surface effectiveness.

The FAA highlights that "Ice can accumulate on the leading edges of the wings and tail surfaces, disrupting the smooth flow of air over these surfaces, thereby reducing lift and potentially causing the aircraft to stall." (FAA, "Pilot's Handbook of Aeronautical Knowledge", Chapter 4 - "Flight Controls")

The aviation industry works to improve anti-icing and de-icing understanding towards students through comprehensive training programs and resources. These initiatives aim to equip students with the knowledge and skills necessary to handle aircraft in icy conditions safely and efficiently.

This project was created to focus on de-icing understanding towards students by showing and allowing them to practically control the training kits. Since students prefer practical work after learning theory, this project may help them to further understand the mechanisms in the anti-icing and de-icing system.

“Knowing is not enough; we must apply. Willing is not enough; we must do.”
- Johann Wolfgang von Goethe.

Based on the quote above, it shows that students' knowledge should not only be implanted in theory classes. Instead, knowledge also needs to be implemented into practical work. Therefore, the Icing Pro Detector Training Kit is a perfect fit for students to apply their knowledge in de-icing systems, furthermore, increasing their understanding in the subjects by implementing their knowledge that was learnt in theory classes.

1.2 PROBLEM STATEMENT

Aircraft systems are integrated components and subsystems that allow an aircraft to carry out its intended activities safely and effectively. The de-icing system in aircraft is crucial for ensuring safe operation during flights in bad weather circumstances where ice may occur. The learning process for a de-icing system on aircraft can present challenges due to the complexity of these systems and the critical role they play in flight safety.

Aircraft de-icing systems include various components like electrical heating elements, pneumatic boots, engine bleed air, and fluid systems (Nordin, M.F (2021) Mo7: Maintenance Practices). Understanding how these components work together to prevent ice buildup requires an understanding of mechanical, electrical, and fluid dynamics concepts. Understanding aircraft de-icing systems requires knowledge from multiple sources, including aerodynamics, thermodynamics, materials science, and control systems. Integrating into these different areas of study can be challenging for students. Some concepts related to anti-icing systems, such as heat transfer mechanisms, fluid dynamics, and thermodynamic principles, can be abstract and difficult to visualize. Students may struggle to understand these concepts without practical demonstrations or hands-on experiences.

During learning sessions, students frequently struggle to understand how the de-icing systems work (Questionnaire Surveys). Students struggle to understand how ice forms on aircraft surfaces such as wings, tails, and engine components, and how the de-icing system works to prevent ice from accumulating on aircraft surfaces. Some training organizations don't provide or have a complete de-icing training kit to make it easier for students to understand the anti-icing system in greater depth. Using diagrams, illustrations, animations, and videos to visually represent how the de-icing system works does not ensure that the student fully understands, with the use of hands-on demonstrations such as physical models, simulation software or virtual reality tools may help students to understand more easily and imagine the anti-icing system working.

1.3 PROJECT OBJECTIVES

1.3.1 General Project Objectives

The project objectives are:

- To design the training kit to provide students with a comprehensive understanding of aircraft de-icing systems.
- To develop training kit that able to help student encountering de-icing related issues.
- To evaluate students towards understanding how to apply theoretical knowledge in practical scenarios using a training kit.

1.3.2 Specific Individual Project Objectives

1.3.2.1 Product Structure

The specific project objectives are:

- To design better equipment for learning
- To develop and deliver an Icing Pro Detector Training Kit that offers practical aids for teaching and in general of icing form.
- To bridge the gap between theoretical knowledge and practical skills.

1.3.2.2 Product Mechanism

This project aimed:

- To design a switch button for product to operate.
- To develop a mechanism of transportation by using a copper that connects to the compressor inside the product for operating switch.
- To demonstrate a functional transportation mechanism without exposure to the danger of excessive freezing

1.3.2.3 Product Software/Electronic

This project aimed:

- To design a temperature sensor on the product
- To develop a temperature sensor that cooperates with the heating element used on the product.
- To demonstrate an automatic heating element activation based on the temperature sensor.

1.3.2.4 Accessories & Finishing

This project aimed:

- To furnish Icing Pro-Detector Training Kit with appropriate and beneficial accessories to increase and improve its functionality.
- To finish Icing Pro-Detector Training Kit with materials or coatings that are affordable to all aircraft maintenance institutes.
- To design an Icing Pro-Detector Training Kit with aesthetic looks and finishing without affecting the functionality of the product.

1.4 PURPOSE OF PRODUCT

This product can be used by students and instructors, this product could increase students' understanding towards de-icing systems in aircraft. As for instructors, they could show their students how the systems work thoroughly making it easier for them to teach their students. As a result, this project may help increase the industry's newcomer's qualities, which is making the industry more effective.

Icing Pro Detector Training Kit could give an impact towards students' understanding abilities because students could see and experience how the systems work as learning through practical after a theoretical class will increase the insight for the students. Using this product, students may be able to see how the ice formation on certain attitudes and witness the mechanisms in the system works while collecting data on the temperature changes.

1.5 SCOPE OF PROJECT

1.5.1 General Project Scopes

This product is specifically targeted for aircraft maintenance students who study at aircraft maintenance institutions. This product can be used in class while doing practical tasks or manual work such as assembly and disassembling.

The limitation of this product is Icing Pro-Detector Training Kit only shows a simple way of how aircraft de-icing operations work. For example, this product only shows the way ice gets rid-off from the wing. Besides, the product also lacks detailed diagnostic capabilities, limiting the kit's ability to identify specific issues or malfunctions within the operation of de-icing systems.

1.5.2. Specific Individual Scope

1.5.2.1 Product Structure

Icing Pro-Detector training kit is a simple training kit that encompasses a well-defined product structure to ensure the comprehensive functionality and reliability of the icing on aircraft. The product structure will comply with aviation standards, emphasizing durability, accuracy, and seamless integration with the broader icing system for students. Through this structure, the icing pro detector training kit plays a pivotal role in enhancing the overall safety efficiency and operational capabilities of the aircraft.

1.5.2.2 Product Mechanism

Icing Pro-Detector kit's is a simple instrument kit that includes a clear product structure designed to ensure the overall functionality of aircraft anti-icing system.

The product's design prioritizes accuracy, durability, and smooth integration with the larger avionic system for students while adhering to strict aviation regulations. The Icing Pro-Detector kit is essential to improving the general safety, effectiveness, and operational capabilities of the aircraft because of its straightforward but well-defined structure.

The icing pro detector kit is made up of a simplified product mechanism designed to work effectively and dependably with the aircraft's de-icing system. This little device has sensors to identify the freezing temperature and was built with an emphasis on key components. A central processing unit receives data from these sensors, processes it, and sends the results to the cockpit display. The device is a perfect fit for light aircraft or general aviation applications because of its simple mechanism, which guarantees ease of installation, operation, and maintenance. The product mechanism satisfies safety criteria despite its simplistic design, which helps create a trustworthy de-icing system that effectively and efficiently serves the basic requirements of smaller aircraft.

1.5.2.3 Product Software/Electronic

This Icing Pro-Detector kit's electronics and software components used are easy to operate. The temperature sensor is coded to the automatic activation of the heating element with temperature indication which is easy to operate and is beginner friendly giving insights towards the user. The software is programmed to monitor the temperature changes, heating element activation and displaying the temperature. Further providing the real time temperature changes in each stage of process in the de-icing systems, increasing the understanding towards the user.

1.5.2.4 Accessories & Finishing

Since there's a lot of types of aircraft de-icing systems including various methods like electrical heating elements, pneumatic boots, engine bleed air, and fluid systems. Icing Pro-Detector Training Kit is designed to be able to show how aircraft de-icing systems operate in general while focusing on electrical heating elements. Other than that, the project is to be finished with coatings and materials that can give a positive result on formation of ice and for activating the heating element.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 Aviation Industry in Malaysia

The aviation industry in Malaysia, like many other countries, relies on comprehensive training programs to ensure that pilots and ground crew are well-equipped to handle aircraft in icy conditions.

According to the Malaysian Aviation Academy (MAvA), a division of the Civil Aviation Authority of Malaysia (CAAM), their training curriculum includes comprehensive modules on handling aircraft in various weather conditions, including icy conditions. The academy's training programs ensure that both pilots and ground crew are well-prepared for international operations, which often involve flying to regions with different climatic conditions.

In Malaysia, the aviation industry is regulated by the Civil Aviation Authority of Malaysia (CAAM), which sets standards for pilot training, including anti-icing and de-icing procedures. Training programs that incorporate anti-icing and de-icing training kits are crucial for ensuring that pilots and ground crew are prepared to handle aircraft in icy conditions, which are common in certain regions of Malaysia, especially during the monsoon season.

Companies like Safran specialize in de-icing, anti-icing protection, and ice detection systems. While the source does not specify their involvement in Malaysia, such companies could potentially supply training kits and equipment to aviation training centers in Malaysia. Their products and services are likely part of the broader effort to enhance safety and operational efficiency in the Malaysian aviation industry.

"Safran is a global leader in aerospace, known for its innovative de-icing, anti-icing protection, and ice detection systems. The company offers a range of solutions designed to enhance flight safety and operational efficiency in icy conditions. Safran's systems are utilized by numerous airlines and aircraft manufacturers worldwide, ensuring that aircraft can operate safely in diverse and challenging weather environments."- www.safran-group.com

In summary, while the specific details about anti-icing and de-icing training kits in Malaysia are not provided, it's clear that such training is a critical component of aviation safety and efficiency. Training programs that utilize these kits are essential for preparing pilots and ground crew to handle aircraft in icy conditions, contributing to the overall safety and reliability of the Malaysian aviation industry.

2.1.2 Demand for Ice Protection Training Kit

The aviation industry is witnessing a burgeoning demand for specialized training solutions that address the complexities of ice protection systems. This demand is driven by the critical need for aviation professionals to understand and efficiently manage anti-icing and de-icing technologies, which are vital for ensuring flight safety in adverse weather conditions. The increasing frequency of severe weather events, coupled with stringent regulatory requirements, underscores the necessity for comprehensive training kits that can equip students with the skills required to operate, maintain, and troubleshoot these systems effectively.

"This study provides concrete evidence from an academic source supporting the assertion that practical training, such as using simulators and training kits, is more beneficial than theoretical instruction alone." - Munro, I., & Hollingworth, R. (2020). The Impact of Simulation-Based Training on Pilot Proficiency and Safety. International Journal of Aviation, Aeronautics, and Aerospace, 7(2).

In the current market, there is a noticeable gap in accessible, high-quality educational resources focused on ice protection systems. Aviation schools and training centers are actively seeking advanced training modules that provide both theoretical knowledge and practical experience. A well-designed ice protection training kit addresses this market need by offering an all-inclusive educational package, featuring interactive simulations, detailed instructional manuals, hands-on components, and state-of-the-art measurement tools. These kits allow students to engage with real-world scenarios and fault simulations, preparing them to handle both routine operations and unexpected malfunctions with confidence and competence.

The demand for such training solutions is further amplified by the aviation industry's commitment to safety and efficiency. As aircraft technology continues to evolve, the sophistication of ice protection systems also advances, requiring a higher level of expertise from aviation personnel. By integrating comprehensive training kits into their curricula, educational institutions can ensure that their graduates are well-prepared to meet the industry's standards and expectations.

Moreover, the emphasis on safety protocols and the inclusion of protective gear in these training kits highlight the importance of adhering to industry safety standards, fostering a culture of meticulousness and caution among future aviation professionals. This, in turn, contributes to the overall reliability and safety of aviation operations, making the development and adoption of ice rain protection training kits a strategic and necessary investment in the field of aviation education.

In conclusion, the market demand for advanced ice rain protection training kits is robust and growing. These kits provide a vital resource for aviation students, enabling them to acquire the knowledge and skills essential for maintaining flight safety in challenging weather conditions. By addressing this demand, training kit developers can play a crucial role in shaping the next generation of aviation experts, ensuring they are equipped to navigate and mitigate the risks associated with ice accumulation on aircraft.

2.1.3 Types of Ice Protection Training Kit in Market

Ice Protection training kits are instrumental in providing comprehensive education about aircraft anti/de-icing systems, catering to the needs of aspiring pilots and maintenance personnel. These kits are diverse in their approaches, offering various types to address distinct facets of training and knowledge acquisition.

Avotek's Ice and Rain Protection Training System AS61 is designed to provide comprehensive training on aircraft ice and rain protection systems. This educational tool is tailored for aviation maintenance students and professionals to understand the critical aspects of ice and rain protection in aircraft operations.

Figure 2.1: Avotek's Ice and Rain Protection Training System AS61

The AS61 includes practical training modules that simulate real-world ice and rain protection systems found on aircraft, offering a detailed understanding of various components, such as de-icing boots, heated leading edges, and rain removal systems. The system is interactive, allowing students to engage directly with the equipment, which aids in grasping operational principles and troubleshooting techniques effectively.

Covering all major ice and rain protection systems used in modern aviation, the AS61 provides training on pneumatic, electric, and chemical de-icing methods. It includes detailed instructions on the operation, maintenance, and repair of these systems. Advanced simulation capabilities enable the system to mimic various weather conditions, demonstrating the corresponding activation of ice and rain protection systems. This feature helps students understand the operational context and the importance of timely and effective protection measures.

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

2.2.1.1 Basic design of main structure

An Icing Pro Detector training kit with a rectangular structure is a thoughtfully designed educational tool, featuring a systematic product structure that enhances accessibility and practicality for learners studying icing on aircraft. The rectangular shape of the kit allows for easy handling, storage and making it a convenient and versatile resource.

Based on the response to the demand for student beneficial technology, the rectangular training kit integrates a section for electrical-based parts. This compartment includes a beneficial interface and simple software that allows learners to navigate through demonstration icing on aircraft. The design prioritizes simplicity to ensure that users can operate the kit without redundant complexity.

In conclusion, the product structure of this training kit emphasizes portability and effectiveness. Its design is portable models and come with beneficial components to make it easier and accessible experience for students learning aircraft system in icing system.

2.2.1.2 Types of material used for product structure.

1. Hollow Steel

The primary structure of IPDTK is made from hollow steel. The structure is incredibly rigid and stable due to them. This stability is essential to preserving the training kit's integrity, especially when it comes to dynamic elements or simulations. Based on the stability and security of the kit's structure, learners can interact with it with confidence. This benefit is especially important for setting up a secure and comfortable learning environment where students can concentrate on comprehending icing systems without worrying about the structural stability of the training apparatus.

Hollow steel is not only strong and long-lasting, but they can be designed and configured in a variety of ways. They can be customized to match the unique requirements of the icing system training kit because they can be produced to exact specifications. It can withstand the additional weight and stress caused by ice accumulation without bending or collapsing, ensuring that the training kit remains functional and safe under various conditions. Hollow steel can be customized to meet the specific requirements of the kit, offering versatility in establishing a comprehensive and lifelike training environment. This flexibility also extends to the ease of assembling and disassembling the training kit, making it easier to set it up and modify it as needed.

Figure 2.2: Hollow Steel

2. Perspex Panel

Perspex, a brand name for acrylic glass known for its clarity. which enables transparent panels to provide an unobstructed view of the internal components. It allows learners to see the intricate details of icing systems in action, this transparency is particularly helpful in a training context. Perspex panels' see through quality improves the learning environment by allowing visual comprehension and helping to clarify challenging concepts.

Perspex panels not only offer transparency but also help make the training kit lightweight. Acrylic glass is substantially lighter than conventional materials like metal so that the kit is easier to use and more portable. This feature is especially helpful in training situations where flexibility and mobility are important. Perspex panels are lightweight, assembling and disassembling them is made easier. This allows for easy transport and setup in different locations, which encourages flexibility and convenience for training sessions.

Other than that, Perspex panels are easily customized that allows for better design and layout. They can be easily cut, shaped, and drilled without the risk of cracking, allowing for a high degree of precision to simulate different icing conditions and system components accurately. Perspex also can be combined with other materials and technologies, such as embedded heating elements or sensors to enhance the functionality and realism of the training kit.

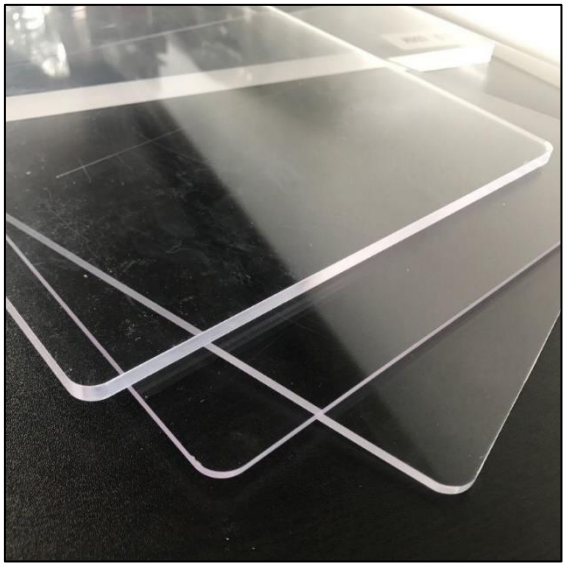


Figure 2.3: Perspex Panel

3. PVC Board

Airfoil and panel that used to cover all the electrical compartment is PVC board. Using PVC Foam Boards comes with numerous benefits to our product such as flexibility in design as they can easily be cut, shaped, and installed with relative ease. It means that custom projects like shape of airfoil ape of airfoil and panel can be attained more efficiently.

PVC Board also help us to maintain are low-maintenance, unlike other materials like wood that require • regular care to prevent degradation. In addition, they are flame retardant, thus offering an added layer of security in applications.

- Cost-efficient: The PVC boards are cost-effective and much cheaper compared to other materials like wood and aluminum, particularly considering the low maintenance cost.
- Portable: Their lightness ensures the energy consumption in transportation is kept to a minimum.

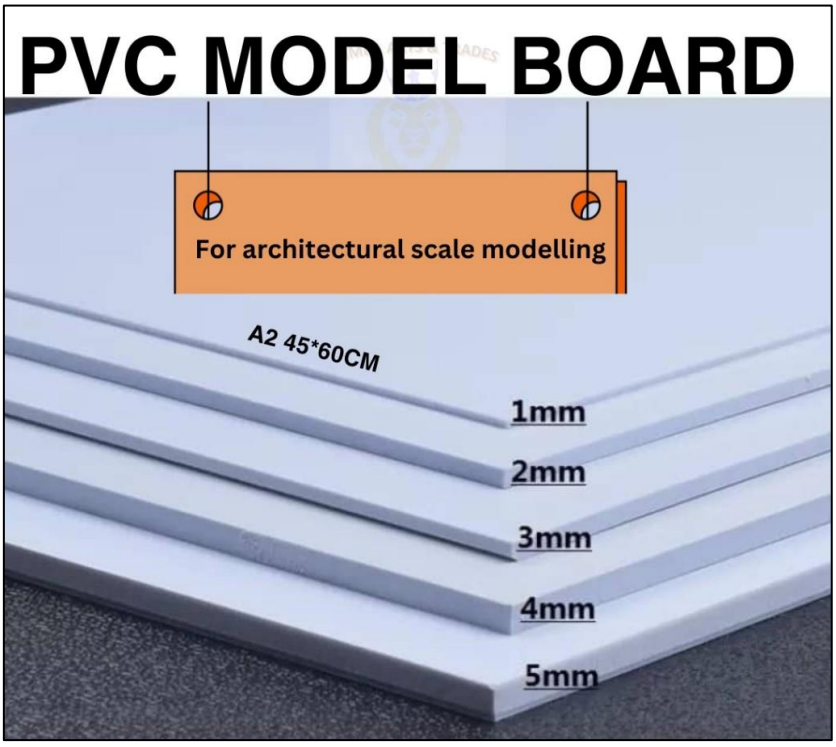


Figure 2.4: PVC Board

4. Aluminium Sheet

In the development of IPDTK, aluminium sheet is used in the construction of the panels for the inspection section, and the part of the preparation section. The selection of aluminium is due to its characteristics which are low density, excellent corrosion resistance and can be easily formed. Pure aluminium is not particularly strong. However, alloying aluminium with copper, manganese, magnesium, and silicon will produce an alloy that has very high strength to weigh ratio. The available thickness of aluminium sheet ranges from 0.2 mm (about 0.01 in) to 6.5 mm (about 0.26 in).

Figure 2.5: Aluminum Sheet

2.2.2 Product Mechanism

2.2.2.1 Basic design of Product Mechanism

The basic training kit known as the Icing Pro-Detector has a well-defined product structure that guarantees the complete operation and dependability of the icing on aircraft. The product design will adhere to aviation regulations, placing a focus on accuracy, longevity, and a smooth transition into the larger icing system for trainees.

2.2.2.2 Types of Components Used for Product Mechanism

Compressors

Refrigeration applications also use rotary compressors, specifically rotary vane or rotary scroll compressors. In rotary vane compressors, refrigerant gas is trapped and compressed as it rotates inside a chamber by means of an offset shaft with rotating vanes. Conversely, rotary scroll compressors compress gas using two interlocking spiral-shaped scrolls, one circling and one fixed. Comparing these two scenarios, reciprocating compressors operate noisier than continuous, reasonably steady compression. Because of their effectiveness, dependability, and small size, rotary compressors are frequently used in bigger household refrigerators, commercial refrigeration equipment, and high-end refrigeration systems.

Figure 2.6: Compressor

Pure Copper (C11000)

Pure copper, also known as electrolytic tough pitch (ETP) copper, is one of the most used types of copper due to its exceptional electrical conductivity, thermal conductivity, and corrosion resistance. It is manufactured by electrolytically refining copper ore to remove impurities, resulting in a high-purity copper product. Pure copper is renowned for its malleability and ductility, making it easy to form into various shapes and sizes. It is extensively utilized in electrical wiring and power transmission due to its low electrical resistance, which minimizes energy loss during transmission. Pure copper is also used in heat exchangers, plumbing pipelines, and architectural applications where its visual appeal and resistance to corrosion are sought. Pure copper has many benefits, but with time it can oxidize and tarnish, so it needs regular care to keep looking and working like new.

Figure 2.7: Pure copper (C11000)

Mapp Welding Gas

MAPP gas (Methylacetylene-Propadiene Propane) is a type of fuel gas used in welding and cutting applications. MAPP gas burns at a high temperature, reaching around 2,020 °C (3,668 °F) in air and up to 2,930 °C (5,306 °F) with oxygen, which makes it suitable for tasks requiring high heat. Unlike acetylene, MAPP gas is stable at higher pressures and less likely to explode under pressure, making it safer for storage and use. It is suitable for a range of tasks, including cutting, brazing, soldering, and heating. It's particularly popular for pipefitting and refrigeration work. MAPP gas can be used in handheld torches without an oxygen tank, making it more portable and easier for smaller-scale work compared to setups with acetylene or other gases.

Figure 2.8: Mapp Welding Gas

Silver Welding Rod

Silver welding rods, often referred to as silver brazing rods, are commonly used in brazing rather than traditional welding. Silver brazing rods create strong joints that can withstand high stress, making them suitable for joining metals where a durable bond is critical. Silver has a relatively low melting point compared to many base metals, allowing it to join metals without melting them. This makes silver brazing ideal for precision work where the integrity of the base metal needs to be preserved. Silver-based rods melt and flow smoothly into joints through capillary action, filling gaps and creating leak-proof bonds. This is essential for applications in plumbing, HVAC, and refrigeration systems. Silver brazed joints are corrosion-resistant, making them suitable for applications exposed to moisture or other corrosive environments.

Figure 2.9: Silver Welding Rod

Portable Fan

An adaptable and practical tool, a portable fan offers comfortable cooling in a variety of environments. These fans are perfect for use in both indoor and outdoor settings because they are lightweight, portable, and frequently run on batteries or rechargeable electricity. Rechargeable or changeable batteries are used by many portable fans, providing portability and convenience without requiring a continuous power supply. Portable fans are more affordable and energy-efficient than larger fans or air conditioners since they usually use less power.

Fig 2.10: Portable Fan

2.2.3 Software / Programming

1. **Arduino**

   Arduino is an open-source electronics platform designed for creating interactive projects with ease. It consists of microcontroller boards, like the popular Arduino Uno, which feature digital and analog input/output pins for interfacing with sensors, motors, LEDs, and other components. The Arduino Integrated Development Environment (IDE) is used for writing, compiling, and uploading code, utilizing a simplified version of C/C++. Known for its user-friendly nature, Arduino caters to both beginners and advanced users and boasts a large, active community that shares tutorials, forums, and projects. Common applications include prototyping, educational purposes, and DIY projects such as robotics, home automation, and wearable technology. Arduino's open-source nature allows users to modify and share both hardware schematics and software, fostering innovation and collaboration.

2.2.3.1 Types of Components Used for Product Software / Programming

1. Arduino uno

The Arduino Uno is a widely used microcontroller board based on the ATmega328P. It features 14 digital input/output pins (six of which can be used as PWM outputs), six analog inputs, a 16 MHz quartz crystal, a USB connection for power and data transfer, a power jack, an ICSP header, and a reset button. It is designed to be simple and user-friendly, making it ideal for beginners and hobbyists. The board can be powered via USB or an external power supply and is programmed using the Arduino IDE, which supports a simplified version of C/C++. Its open-source nature and extensive community support make it a versatile choice for a wide range of electronics projects and prototypes.

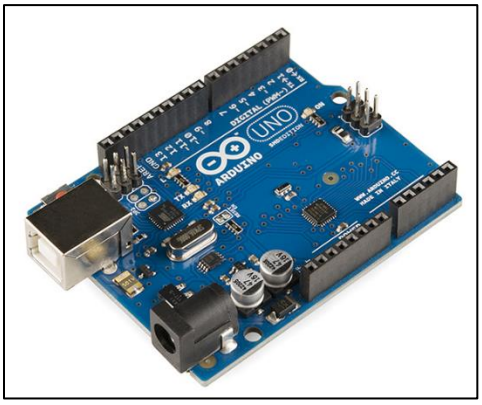


Figure 2.11: Arduino Uno

2. NTC Thermistor Temperature Sensor Module

The NTC Thermistor Temperature Sensor is like a vigilant guardian in electronics, sensitive to even the smallest changes in temperature. As an "NTC" (Negative Temperature Coefficient) thermistor, its resistance decreases as the surrounding temperature rises, making it ideal for precise and responsive temperature measurements. This unique quality allows it to detect temperature shifts in real-time, making it invaluable in a variety of applications, from monitoring room temperature in HVAC systems to safeguarding circuits from overheating. The sensor module, typically equipped with three pins—power, ground, and output—seamlessly connects to microcontrollers, enabling easy integration into larger systems. Its analog output adjusts proportionally with temperature, allowing devices to sense and respond to changes in their environment almost as if they had a sense of "touch." This sensitivity and responsiveness make the NTC Thermistor a reliable, insightful component for any project that depends on accurate temperature control.

Figure 2.12: NTC Thermistor Temperature Sensor Module

3. Relay Module

A relay module is an electrically operated switch that allows you to control high-voltage and high-current devices with a low-voltage control signal, such as from a microcontroller like an Arduino. It typically consists of a relay (an electromechanical switch), an optocoupler for electrical isolation, and driver circuitry to handle the control signal. The module can be triggered by a small current to open or close its contacts, enabling the control of devices like motors, lights, and heating elements. Relay modules are widely used in home automation, robotics, and industrial applications due to their ability to switch heavy loads safely and efficiently with low-power digital signals.

Figure 2.13: Relay Module

4. LCD Display 16x2 I2C

The 16x2 I2C LCD display is like a friendly communicator, bringing digital data to life with clarity and simplicity. With a screen that holds 16 characters across two lines, this display can easily present information—whether it's sensor readings, status updates, or real-time feedback—at a glance. The built-in I2C (Inter-Integrated Circuit) interface simplifies its connection to microcontrollers, using only four pins instead of multiple wiring connections. This efficiency allows it to communicate swiftly with the control board, minimizing setup complexity and freeing up valuable input/output pins for other uses. The I2C LCD's backlighting and adjustable contrast make the display easy to read in different lighting conditions, while its straightforward character-based design makes it versatile across various projects. This display is an ideal companion in any project where data needs to be shared visibly and intuitively, helping devices "speak" to users in a way that feels direct and engaging.

Figure 2.14: LCD Display 16x2 I2C

5. Heating Mat

A heating mat is a specialized electrical device designed to provide controlled and uniform heat over a surface area. Typically made of flexible material, heating mats contain embedded heating elements that generate warmth when powered. They are available in various sizes and power ratings to suit different needs, and some models include features such as adjustable temperature settings or automatic shut-off mechanisms for safety. Heating mats offer a convenient and efficient way to apply warmth to specific areas, making them popular for both domestic and commercial use in environments where regulated temperature is essential.

Figure 2.15: Heating Mat Silicone Rubber

6. Autodesk Inventor

Autodesk Inventor is a powerful 3D CAD software used for product design, engineering, and mechanical simulation. It provides professional-grade design and engineering solutions, enabling users to create precise 3D models, simulate the operation and performance of designs, and generate accurate documentation. Inventor's capabilities include parametric modeling, automated part configuration, advanced simulation tools, and seamless integration with other Autodesk products like AutoCAD and Fusion 360, making it an essential tool for engineers and designers in various industries.

Figure 2.16: Autodesk Inventor

7. ChatGPT

ChatGPT is an artificial intelligence language model developed by OpenAI, based on the GPT (Generative Pre-trained Transformer) architecture. It is designed to understand and generate human-like text based on the input it receives. ChatGPT can engage in conversations on a wide range of topics, answer questions, provide explanations, generate creative content, and assist with various tasks. It has been trained on vast amounts of text data from the internet, enabling it to comprehend and generate responses in natural language with a high degree of coherence and relevance. ChatGPT finds applications in customer service, virtual assistants, content generation, language translation, and more, offering a powerful tool for natural language understanding and generation tasks.

Figure 2.17: ChatGPT

8. Toggle switch

A toggle switch is a type of mechanical switch that is widely used for controlling electrical devices. Its name comes from the rocking motion that the actuator makes when pressed, toggling the switch between on and off positions. Rocker switches are favored for their simplicity, durability, and ease of use, making them suitable for a variety of applications. A rocker switch consists of an actuator that rocks back and forth, pivoting around a central point. When one side of the switch is pressed, it moves into the on position, and when the other side is pressed, it moves back into the off position. This motion is similar to the action of a seesaw, providing a straightforward and reliable means of controlling electrical circuits.

Figure 2.18: Toggle Switch

9. 12V Battery

A 12V battery is a common type of rechargeable battery widely used in various applications, including automotive, renewable energy storage, and backup power systems. It provides a nominal voltage of 12 volts and is typically made up of six 2V cells connected in series. The battery chemistry can vary, with lead-acid, lithium-ion, and nickel-metal hydride being popular choices.

In the context of energy systems, the 12V battery is valued for its reliability, capacity to supply a steady voltage output, and ability to handle high-current applications. Lead-acid 12V batteries are affordable and often used in cars and emergency backup systems, while lithium-ion 12V batteries offer higher energy density, longer cycle life, and lighter weight, making them ideal for portable electronics and solar energy storage.

Maintenance and lifespan depend on factors such as depth of discharge, charge/discharge rates, and operating temperature. Proper management and care are crucial to prolonging battery life and ensuring safety, as overcharging or deep discharging can reduce performance and lifespan significantly.

Figure 2.19: 12V Battery

10. 1.5V Battery

A 1.5V battery is a widely used single-cell battery that provides a nominal voltage of 1.5 volts. It is common in household devices like remote controls, clocks, flashlights, and small electronic gadgets. The chemistry of 1.5V batteries can vary, with alkaline, zinc-carbon, and lithium being the most common types. Alkaline 1.5V batteries are popular for their long shelf life, higher energy density, and better performance under high-drain conditions. These batteries are generally disposable, though some rechargeable versions, like NiMH (nickel-metal hydride), offer similar voltage and are designed for reuse. Their low voltage and compact size make 1.5V batteries ideal for low-power applications where portability and ease of replacement are essential.

Figure 2.20: 1.5V Battery

2.2.4 Accessories & Finishing

2.2.4.1 Basic design of Accessories & Finishing

A training kit's overall efficiency is enhanced by aesthetics and visual appeal, which give it an overall professional look. Smooth lines, simple layouts, and eye-catching finishes are examples of design decisions that can improve the kit's perception and make it more interesting and understandable. Additionally, a well-organized layout reduces cognitive load for users, allowing them to focus on the instructional content without feeling overwhelmed by clutter or unnecessary elements.

2.2.4.2 Types of Components Used for Accessories & Finishing

1. Spray Paint

Spray paint is used to paint the main structure. This is also used for PVC boards to make an aesthetic look and high-quality material. Figure shows spray that is available on hardware with an affordable price.

Figure 2.21: Spray Paints

2. Hot Glue Gun

The Icing Pro Detector Training Kit primary structure put together with a hot glue gun using PVC board, which is a good option for combining materials like PVC and Perspex.

Figure 2.22: Hot Glue Gun

3. Perspex Panel

Perspex panels add significant benefits to the Icing Pro Training Kit, particularly when it comes to illustrating complex aircraft icing systems. Acrylic glass is ideal for hands-on learning environments because of its crystal-clear transparency, which provides a clear perspective of the interior components. This clarity improves visual comprehension by enabling training and students to observe exactly each component functions, which makes difficult icing system concepts easy to understand.

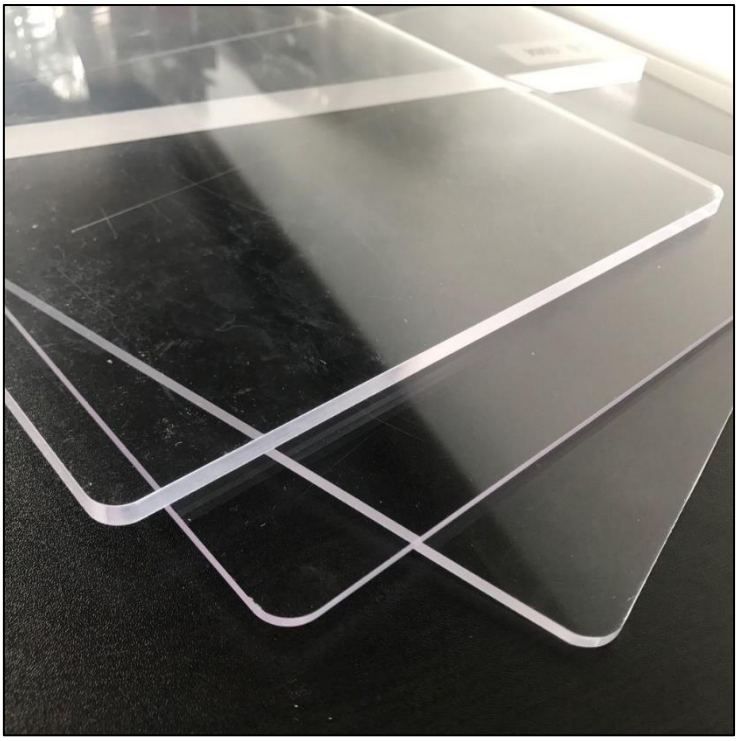


Figure 2.23: Perspex/Acrylic Panel

4. PVC Board

Functionality, durability, ease of shape, and environmental resilience are key design concepts when using PVC board for applications such as airfoil structures and major structural components. Because of its adaptability, low weight, and simplicity of customization, PVC (polyvinyl chloride) board is a common material for educational models and prototyping. It is ideal for generating precise aerodynamic forms and structural elements.

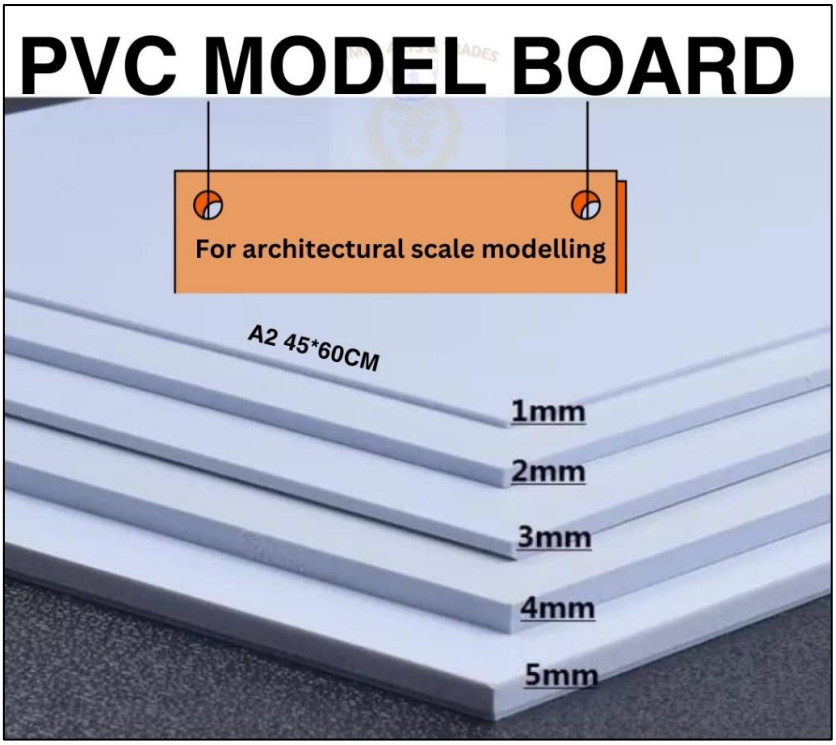


Figure 2.24: PVC Board

5. Tape

A model look, durability, and compatibility with the materials it will cover must all be carefully considered when choosing tape to hide flaws or improve its appearance. Tape is a multipurpose tool that may be used for model-making, product finishing, and even interim repair. It can conceal flaws and improve the overall professional look of the structure.

Figure 2.25: Tape

6. PVC Electrical Box

Using a PVC electrical box for cable management enhances the organization of electrical components and accessories in the Icing Pro Detector Training Kit, resulting in a neater, more professional finish. By securely housing cables, the box keeps wiring organized and prevents tangling, which reduces hazards and interference with other parts. The removable cover allows for easy access, enabling quick adjustments and maintenance without dismantling the kit. Additionally, the lightweight and durable PVC material complements the kit's portability, while its modular design provides flexibility for future modifications or additions. This solution is both cost-effective and practical, improving the training kit's functionality and presentation.

Figure 2.26: PVC Electrical Box

2.3 Review of Recent Research / Related Products

2.3.1 Related Patented Product

ASPECT	DESCRIPTION
Product Name	Avotek's Ice and Rain Protection Training System AS61
Images	
Purpose	To enhance the understanding and practical skills of aviation maintenance technicians in ice and rain protection systems.
Key Features	-Comprehensive training solution for ice and rain protection systems. -Includes real aircraft components. (sensors, controllers, heating elements, de-icing boots). -Interactive and hands-on training scenarios. -Modular design for flexible training. Emphasis on safety and maintenance.
Educational Benefits	- Enhanced learning experience through practical environment. - Development of troubleshooting, maintenance, and repair skills. - Alignment with industry standards. - Engages and motivates students for better retention.
Target Audience	- Aviation Maintenance Schools. - Airline and Maintenance Repair Organizations (MROs). - Regulatory and Certification Bodies.

Table 2.3.1.1: Related Patented Product

2.4 Comparison Between Recent Research and Current Project

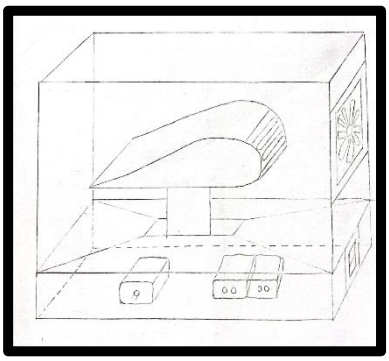
Product	SYSTEM AS61 ICE AND RAIN PROTECTION TRAINING	ICING PRO-DETECTOR TRAINING KIT (Current Project)
Design		
Able to extend and retract	Yes	Yes
Price	Expensive	Affordable
Portability	Yes	Yes
Easy to operate	No	Yes
Overall size	Big	Small
Features	- A detailed mechanism of ice protection system with every feature there are on aircraft real component	- A great teaching aid for instructors to help student visualize.

Table 2.4.1: Comparison Between Recent Research and Current Project

CHAPTER 3

RESEARCH METHODOLOGY

3.1 PROJECT BRIEFING & RISK ASSESSMENT

3.1.1 Utilization of Polytechnic's Facilities

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 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 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 GANT CHART

- **AEM PROJECT GANTT CHART**

PROJECT ACTIVITIES		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Briefing And Group Formation • Create a group with 4 members. • All members have their own ideas for the project. • Meet supervisor and present our own idea. • Only 1 idea accepted	P															
	E															
Search for Project Idea and Name • Do research about aircraft De-Icing training kit. • Do research about the operation of the aircraft De-Icing training kit. • Do some research into the cost of the training kit. • Make research about availability of De-Icing training kit in most training schools. • Come up with the project name which is Icing Pro-Detector Training Kit	P															
	E															

PROJECT ACTIVITIES		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Assignment Chapter 1: Introduction • Do background of study of the project • Do problem statement and objective about the project. • Do project aim, impact, and scope	P															
	E															
Assignment Chapter 2: Literature Review • Do introduction of product • Do extensive research of current products. • Do comparison of product availability on the current market	P															
	E															
Pre-Proposal Presentation (Slides) • Do a power point slide about the project	P															
	E															

PROJECT ACTIVITIES		W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14	W 15
Assignment Chapter 3: Research Methodology • Product description • Product sketching and modelling • List of material and expected expenditure. • Expected result. • Make a Gantt chart	P															
	E															
Final Proposal Presentation	P															
	E															

P	PLANNING
E	EXECUTE

- **AEP PROJECT GANTT CHART**

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
MATERIAL ACQUISITION (PHASE 1) • Hollow Square (2pc) 20ft • Arduino Uno Board • Temperature Sensor Thermistor (LM393) • LCD Display	P															
	E															
MEASURING, FILLING, LEVELLING, AND CUTTING (PHASE 2) • HOLLOW STEEL ➢ 2ft (2pc) ➢ 1.6 ft (8pc) ➢ 1.3 ft (8pc) ➢ 1 ft (2pc) ➢ 0.65 ft (2pc)	P															
	E															
WELDING AND GRINDING (PHASE 3) ➢ Learn arc welding ➢ Learn how to use MIG welding ➢ MIG welding used to join FSLK base structure ➢ Grinder	P															
	E															

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
Programming (Phase 4) • Download Arduino IDE for programming • Add a coding in Arduino IDE • Setup the Arduino uno • Connect all related components to Arduino board	P															
	E															
Project Progress Presentation • Update logbook to supervisor • Do a slide presentation • Meeting with supervisor • Review slide with supervisor	P															
	E															
PRODUCT STRUCTURE PROGRESSION • Spray the main structure • Compressor testing • LCD testing • Wiring connecting process	P															
	E															

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
PRODUCT FINAL TOUCH UP AND FINISHING • Fan base been attached • Tape been used to cover split area • Run a test on the product	P															
	E															
FINAL PRESENTATION • Gant chart has been revised • Prepare a presentation slide • Make a final product testing	P															
	E															

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
AEROMECH • Aeromech exhibition	P															
	E															
COMPLETE OUR PROJECT THESIS • Complete all the chapters in thesis • Update to supervisor for final check thesis	P															
	E															
HANDLING THE PROJECT TO POLITEKNIK BANTING • Give the project to Polytechnic Banting Selangor	P															
	E															

P	PLANNING
E	EXECUTE

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

- **AEM PROJECT FLOW CHART**

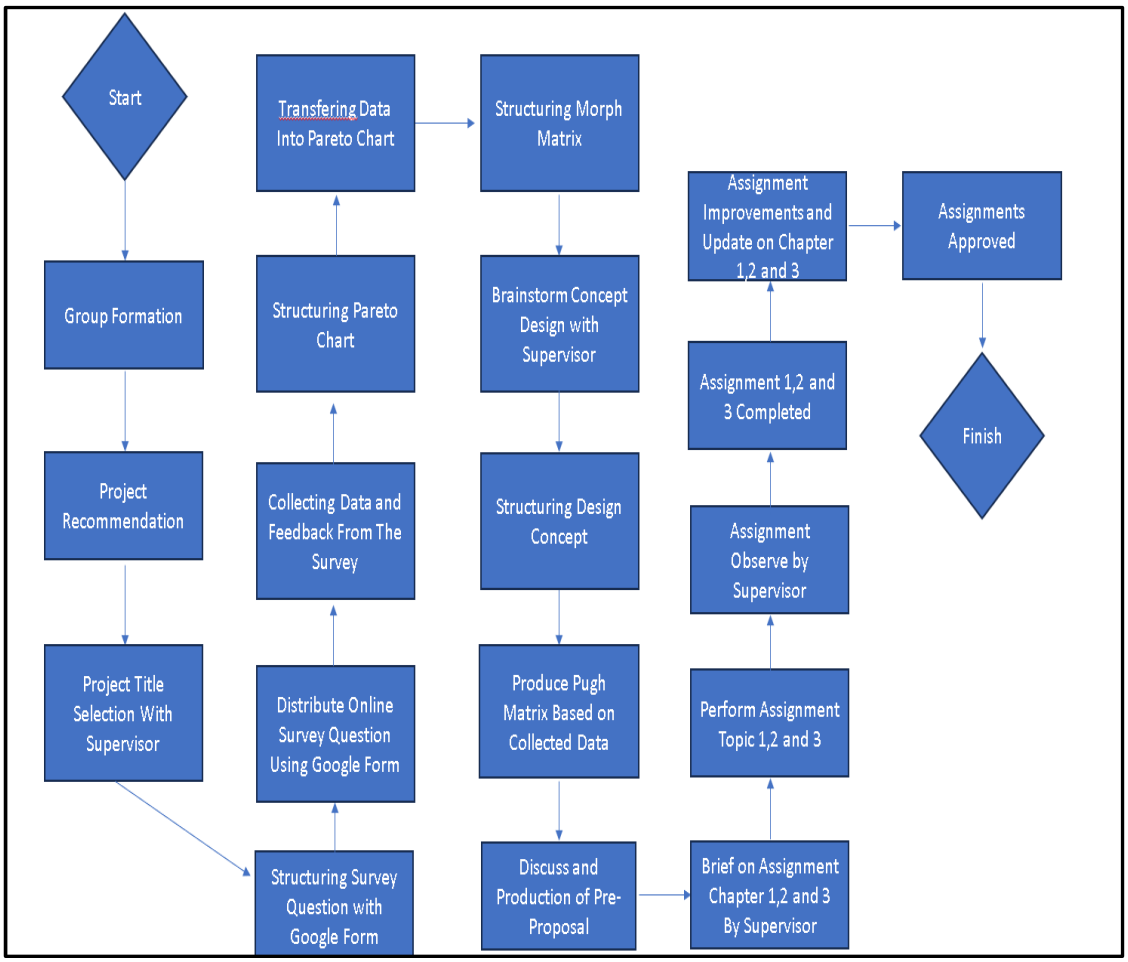


Figure 3.3.1.1: Overall Project Flow Chart for Icing Pro-Detector Kit

- **AEP PROJECT FLOW CHART**

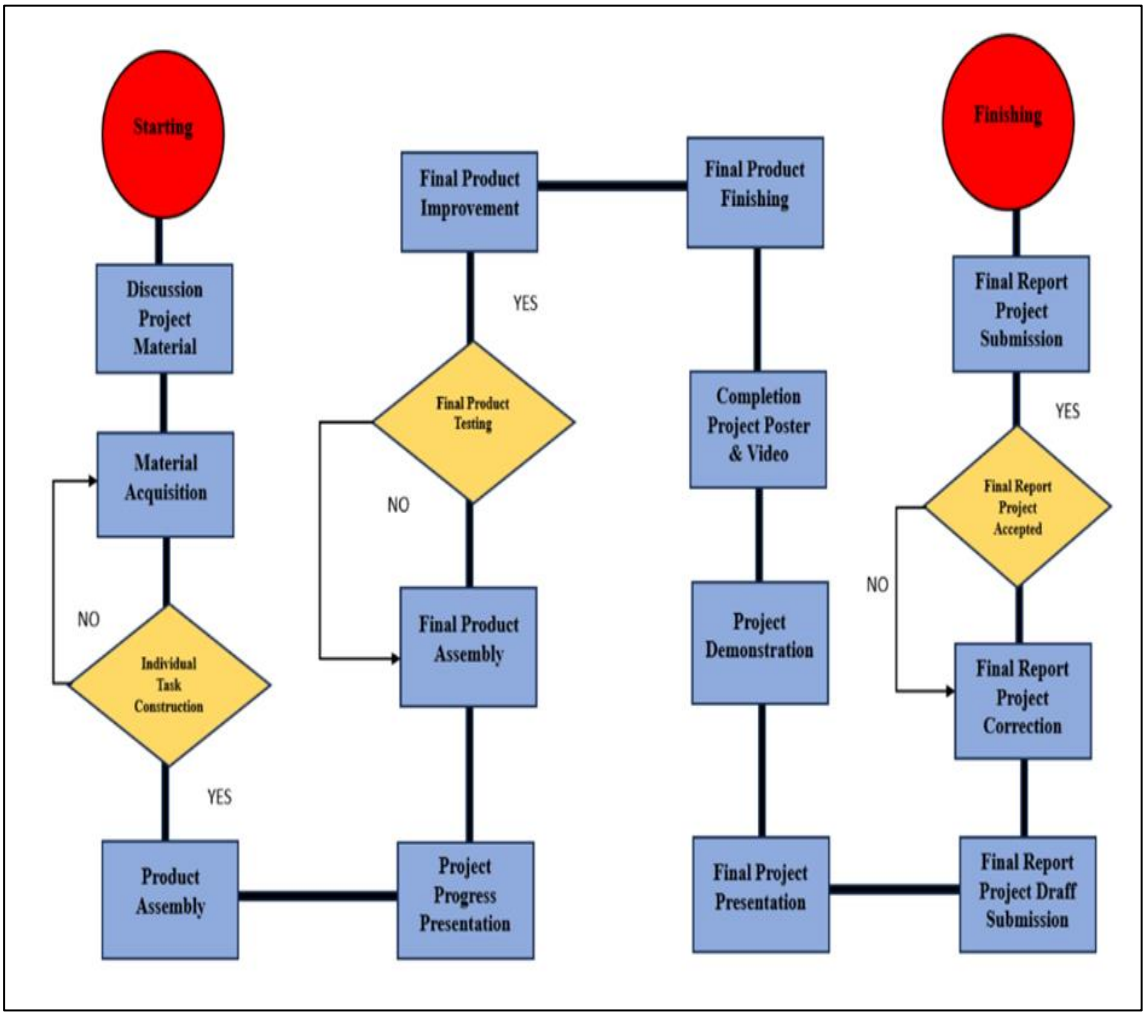


Figure 3.3.1.2: AEP Project Flow Chart for Icing Pro-Detector Training Kit

3.3.2 Specific Project Design Flow

3.3.2.1 Product Structure

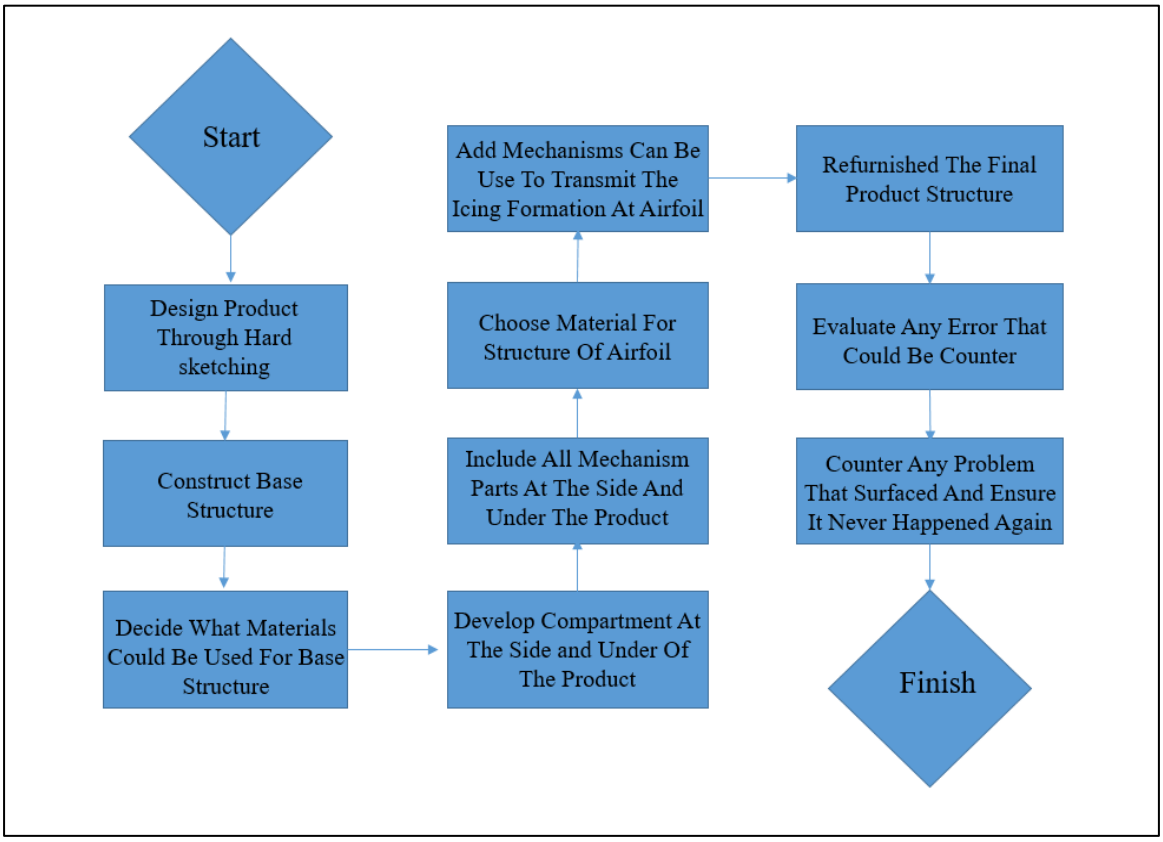


Figure 3.3.2.1: Product Structure Design Flow of Icing Pro-Detector Training Kit

3.3.2.2 Product Mechanism

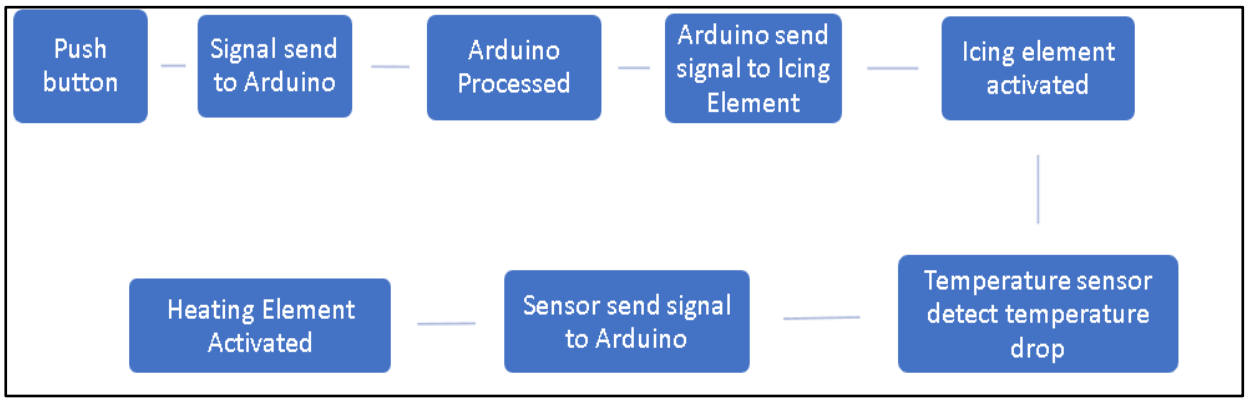


Figure 3.3.2.2: Product Mechanism Design Flow of Icing Pro-Detector Training Kit

3.3.2.3 Product Electrical/Electronic Component

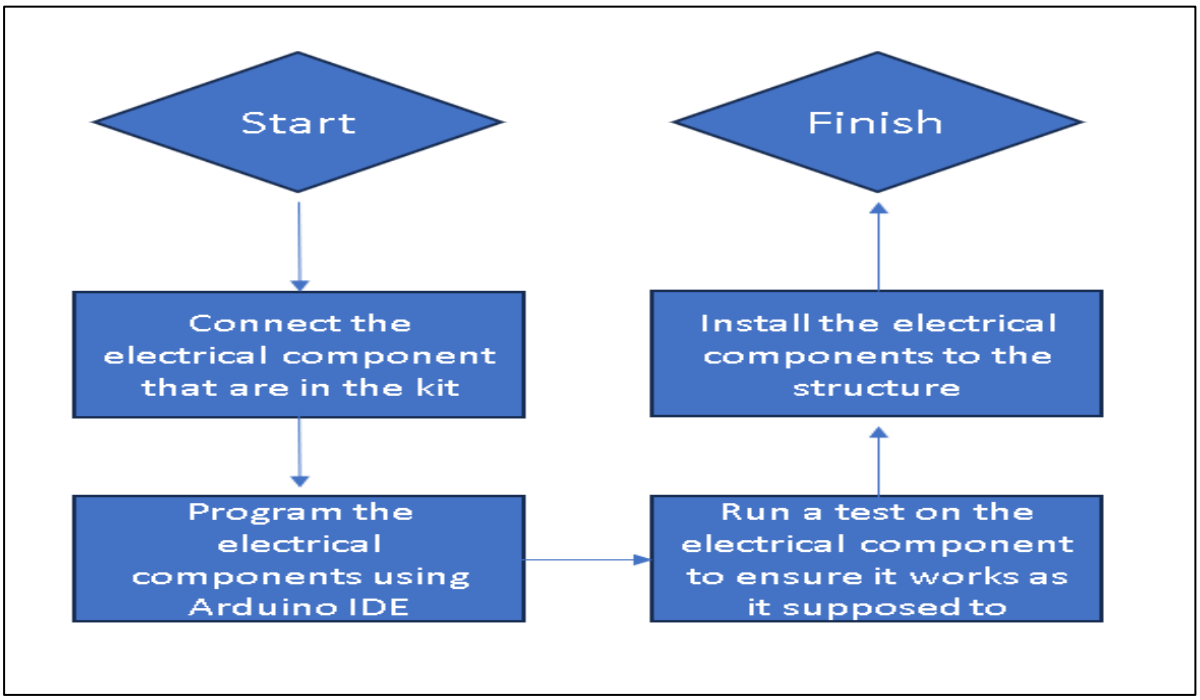


Fig 3.3.2.3: Electronic Design Flow of Icing Pro-Detector Training Kit

3.3.2.4 Accessories and Finishing

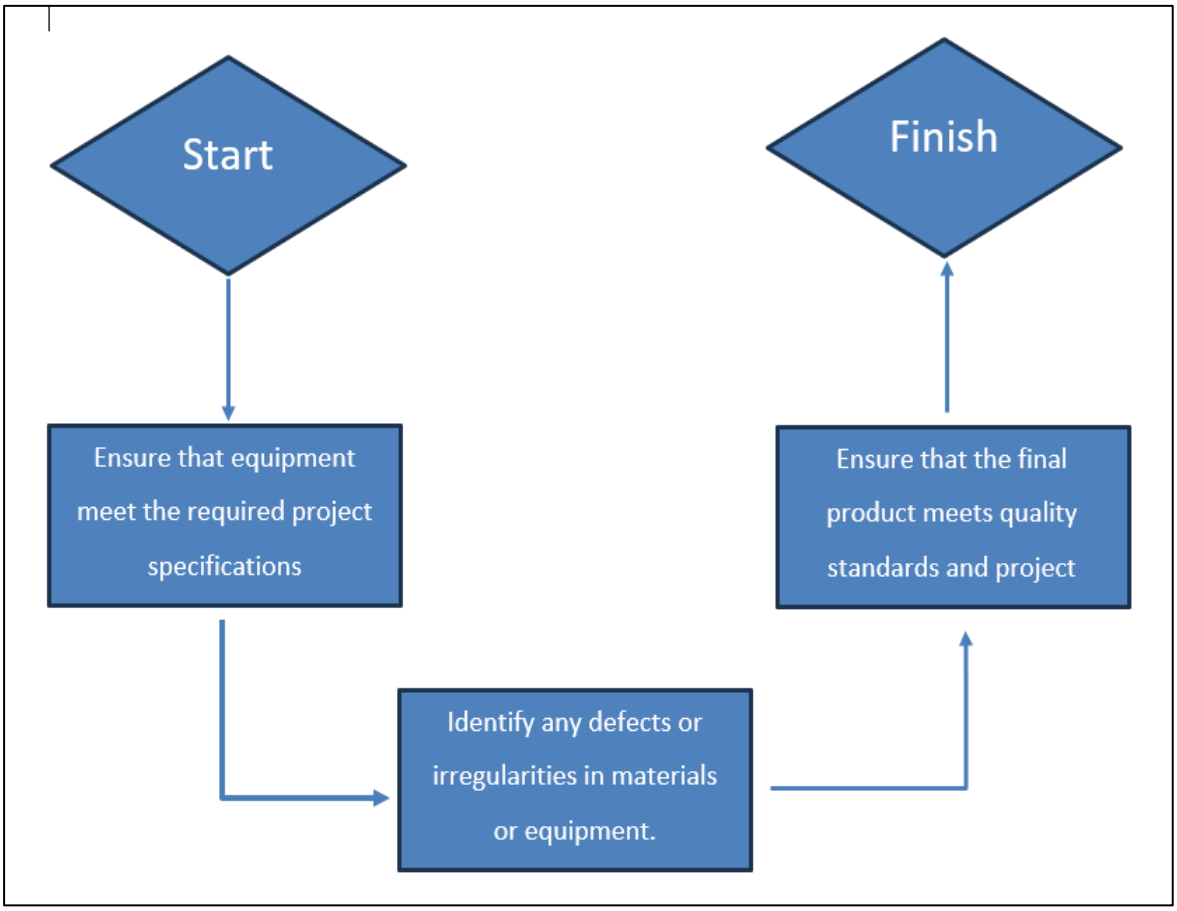


Figure 3.3.2.4: Accessories & Finishing Flow of Icing Pro-Detector Training Kit

3.4 DESIGN REQUIREMENT AND ANALYSIS

3.4.1 Design Requirement Analysis

3.4.1.1 Questionnaire Survey

A questionnaire is a structured set of written or electronic questions designed to collect information or opinions from individuals or groups of people. It is a widely used method in research, surveys, and data collection, aiming to gather standardized and quantifiable data on a particular subject or topic. Questionnaires can be administered in various formats, including paper-based forms, online surveys, or interviews, and they may cover a broad range of topics, from demographic information to attitudes, behaviors, preferences, or experiences. The questions in a questionnaire are carefully crafted to elicit specific and relevant responses, and the collected data can be analyses to draw conclusions, make informed decisions, or gain insights into the perspectives of the surveyed individuals.

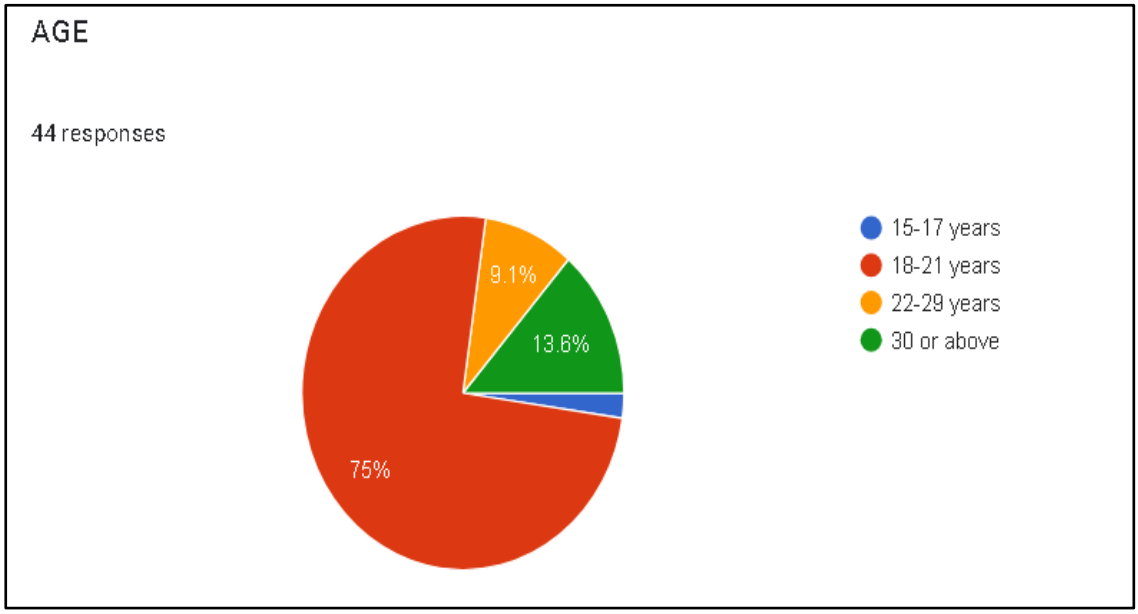


Figure 3.4.1.1.1: Age

This is the example data that was collected from our survey using Google Form. Most of the respondents were 18-21 years of age. Where students of diploma most likely be. However, the minority were 15-17 years. We managed to surpass our target of 20 responses by getting 44 responses.

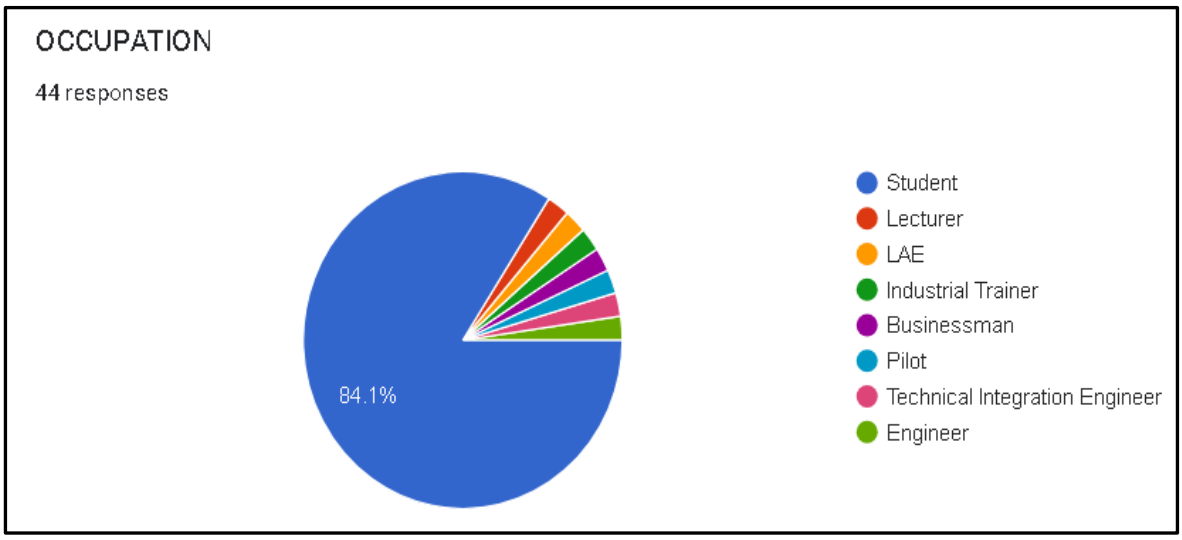


Figure 3.4.1.1.2: Occupation

Based on the charts, we could conclude that most of the respondents are students, which is our primary target for our survey, there are also other occupation such as LAE, Lecturer, and Industrial Trainer.

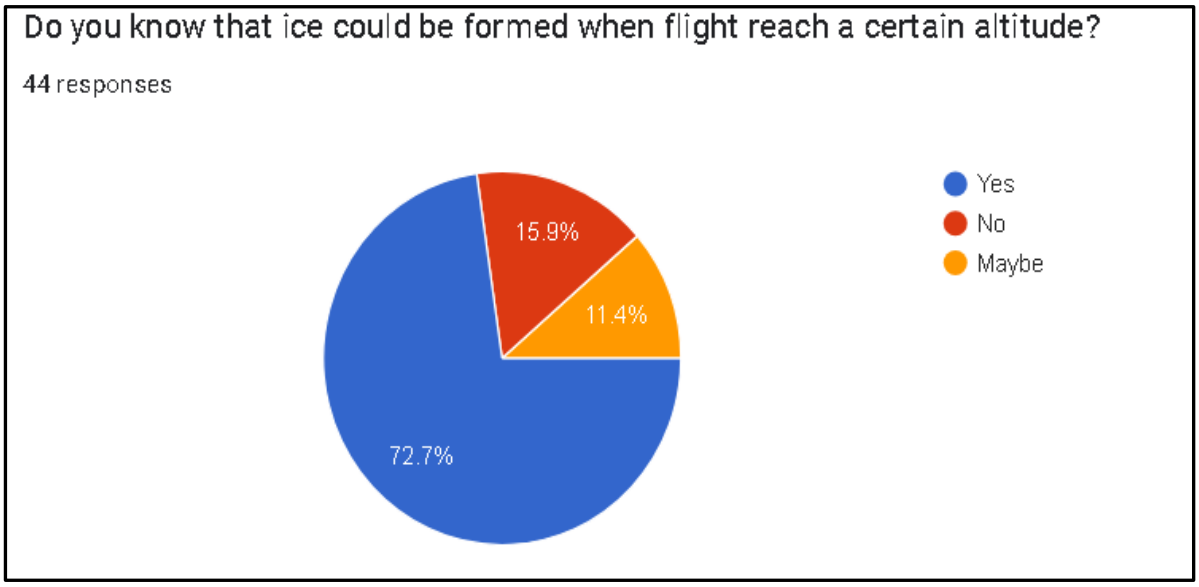


Figure 3.4.1.1.3: Knowledge

The responses that we are getting show that most of them know that ice could form on an aircraft which is common knowledge to Aviation Students.

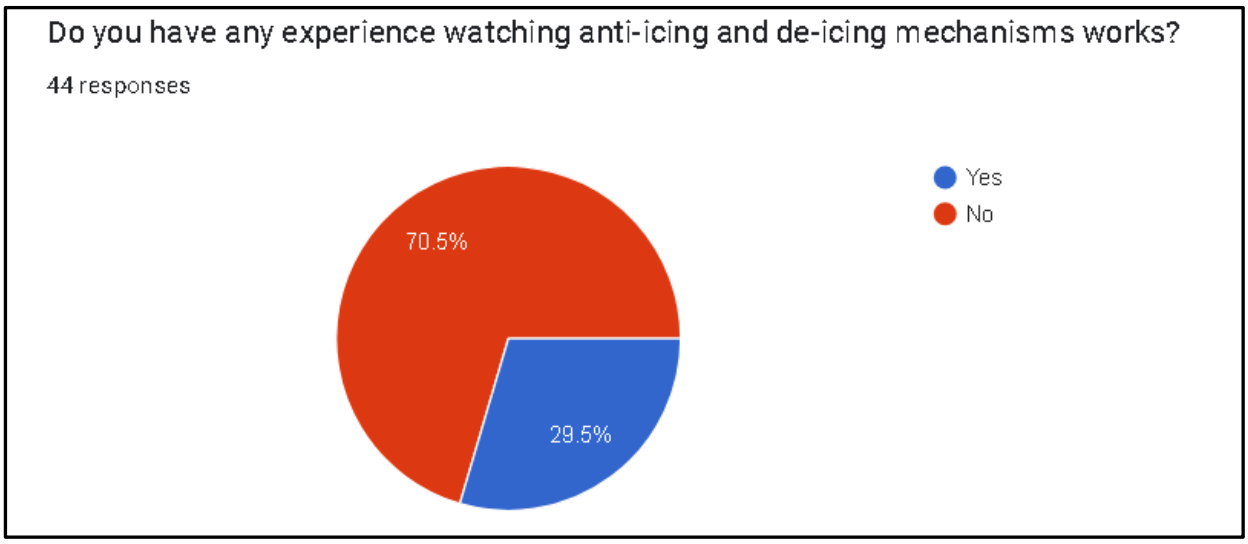


Figure 3.4.1.1.4: Experience

However, most of the respondents never had any experience watching the mechanisms of anti-icing and de-icing work which is supported by the pie chart showing 70.5% of the respondents saying “no”.

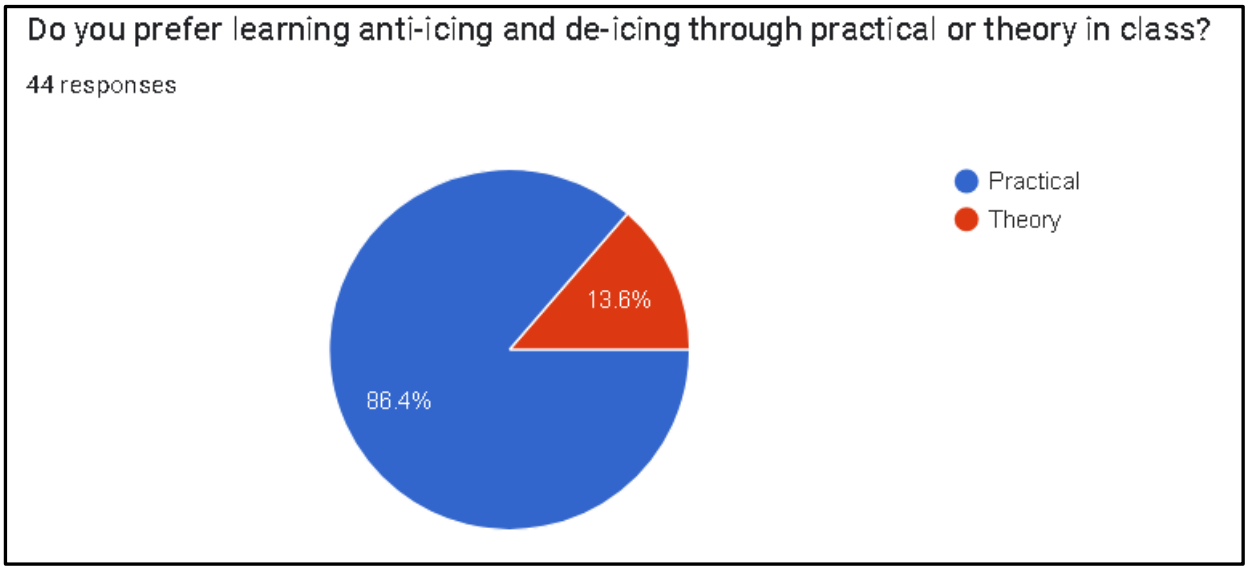


Figure 3.4.1.1.5: Preference

Our vision of developing the Anti-Icing and De-icing Training kit was supported from the questionnaire. Most of the respondents prefer learning through practical classes, in which our training kit could help them improve their understanding of the mechanisms that are involved in the anti-icing and de-icing system.

3.4.1.2 PARETO DIAGRAM

Pareto Diagram: Icing Pro-Detector Training Kit

Respondents Demand	Frequency	Cummulative	Cummulative Percentage	Pareto Baseline
Beneficial	38	38	23%	80%
Performance	36	74	44%	80%
Attractive	36	110	66%	80%
Knowledge	30	140	84%	80%
Understanding	16	156	93%	80%
Experience	11	167	100%	80%
GRAND TOTAL	167			

Figure 3.4.1.2.1: Pareto table for Icing Pro Detector Training Kit

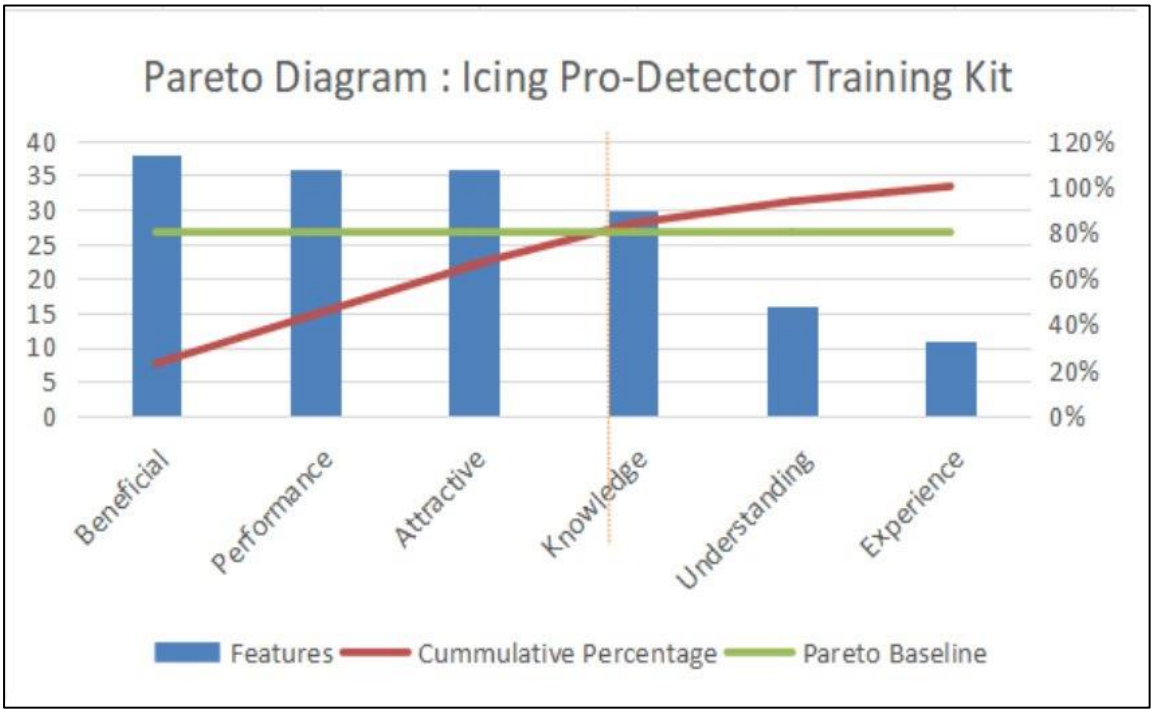


Figure 3.4.1.2.2: Pareto Diagram on Icing Pro-Detector Training Kit

Based on the Pareto Diagram, we can conclude that the benefits of this product are the highest priority and should focus more on that and the second one is how the product works to show to students their performance from the training kit.

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.

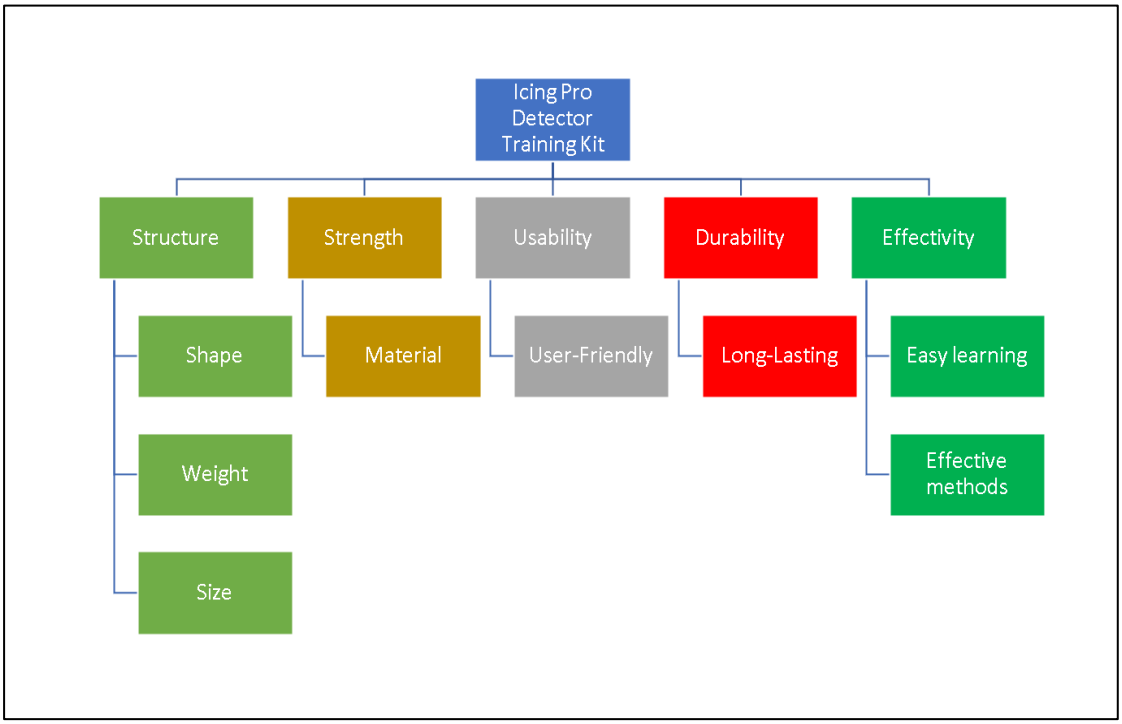


Figure 3.4.2.1: Function Tree

Figure 3.4.2.1 above shows the Function Tree of IPDTK. After analyzing the response from the Google Survey Form, the design concept generation begins with constructing a Function Tree of IPDTK. The product development is divided into several functions which is broken down further into Sub-functions.

3.4.2.2 Morphological Matrix

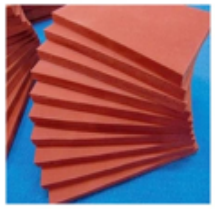
FUNCTION	IDEA 1	IDEA 2	IDEA 3	IDEA 4
MOBILITY	STATIC	PORTABLE	STATIC	PORTABLE
ACCESSORIES	SWITCH	LED LIGHT	SPRAY NOZZLE	TEMPERATURE SENSOR
MATERIAL	3D PRINTER 	WOOD & FABRICS 	ALUMINIUM 	HEAT TEMPERATURE RESISTANT FOAMING SILICONE BOARD 
SHAPE	CONE	ELLIPSE	RECTANGULAR	AEROFOIL
METHOD	ENGINE BLEED AIR	PNEUMATIC BOOTS	FLUID SYSTEMS	ELECTRICAL HEAT ELEMENT
METHOD TO FORM ICE	SALT + ICE	LIQUID NITROGEN	DRY ICE	COMPRESSOR OF AIR
LOCATION OF COMPONENT	PITOT TUBE	RUDDER	ELEVATOR	AILERON

Table 3.4.2.2: Morphological Matrix

We conclude that concept 4 is the best option for our Icing Pro-Detector kit based on our examination of the Morphological Matrix. The primary shape, material, ice-forming technique, accessories, structural material, activation techniques and finally, aero foil material are among the criteria. These standards are used for our project to ensure that the Icing Pro-Detector training kit functions as we had anticipated.

3.4.2.3 Proposed Design Concept Idea 1

FEATURES/FUNCTION	IDEA 1	JUSTIFICATION
MOBILITY	STATIC	IMMOBILE AND ONLY PLACED AT WORKSHOP
ACCESSORIES	SWITCH	EASY TO KNOW EITHER ON OR OFF
MATERIAL	3D PRINTER 	THE RESULT FOLLOW AS PER PLAN
SHAPE	CONE 	CONTROL AIRFLOW EASILY
METHOD	ENGINE BLEED AIR	PREVENT ICE BUILDUP ON CRITICAL AIRCRAFT SURFACE
METHOD TO FORM ICE	SALT + ICE	EASILY TO MELT
LOCATION OF COMPONENT	PITOT TUBE	ALL THE COMPONENT HAVE LEADING EDGE WHICH IS REALISTIC ICE FORMATION CAN BE HAPPENED

Table 3.4.2.3: Concept 1

The reason we chose a 3D printer instead of a more traditional method for creating our product from concept 1 is that the former is known for its exceptional strength and durability, which makes it perfect for our product. However, there are disadvantages to using 3D printing, including the high cost of specialized filaments, resins, and powders, especially for high-performance models. We used salt and ice as a method to make ice, but this isn't practical for forming ice for our product. Finally, we use hot air, or bleed air, to de-ice the ice since it melts more easily.

3.4.2.4 Proposed Design Concept Idea 2

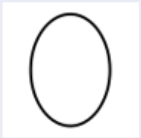
FEATURES/FUNCTION	IDEA 2	JUSTIFICATION
MOBILITY	PORTABLE	EASY TO HANDLE
ACCESSORIES	LED LIGHT	PRODUCE EFFICIENT LIGHTING FOR VISIBLE INDICATOR
MATERIAL	WOOD & FABRICS 	LIGHTWEIGHT AND CHEAPER
SHAPE	ELLIPSE 	MORE EFFICIENT
METHOD	PNEUMATIC BOOTS	CAN BE ACTIVATED AS NEEDED
METHOD TO FORM ICE	LIQUID NITROGEN	TAKE TIME TO BE FROZEN
LOCATION OF COMPONENT	RUDDER	ALL THE COMPONENT HAVE LEADING EDGE WHICH IS REALISTIC ICE FORMATION CAN BE HAPPENED

Table 3.4.2.4: Concept 2

Since wood and fabric are readily available and reasonably priced, we chose them for our product material from Concept 2. However, the disadvantage is that these materials are not appropriate for our ice-forming process. We employed liquid nitrogen as a method to make ice, it is a practical method, but the ice takes time to form. Finally, we use a pneumatic boot method to de-ice the ice, but locating and manufacturing the material can be challenging.

3.4.2.5 Proposed Design Concept Idea 3

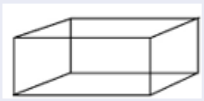
FEATURES/FUNCTION	IDEA 3	JUSTIFICATION
MOBILITY	STATIC	CANNOT CARRY
ACCESSORIES	SPRAY NOZZLE	AS AN OUTPOINT FOR LIQUID
MATERIAL	ALUMINIUM ALLOY 	PREVENT FROM CORROSION
SHAPE	RECTANGULAR 	INCREASE STABILITY
METHOD	FLUID SYSTEMS	MAINTAIN OPTIMAL AERODYNAMIC PERFORMANCE
METHOD TO FORM ICE	DRY ICE	TAKE SOME TIME TO FORM AN ICE
LOCATION OF COMPONENT	ELEVATOR	ALL THE COMPONENT HAVE LEADING EDGE WHICH IS REALISTIC ICE FORMATION CAN BE HAPPENED

Table 3.4.2.5: Concept 3

We utilized aluminum alloy, which is a material from idea 3, for our product because it is substantially lighter than many other metals. However, aluminum alloys can corrode more quickly when exposed to certain chemicals and environmental factors, such as acidic or alkaline situations. We chose dry ice as our method of forming ice, but it wasn't practical for our product because it took a long time. Finally, we use a fluid system to de-ice the ice by applying a liquid to the leading edge of our product, which stops the ice from forming.

3.4.2.6 Proposed Design Concept Idea 4

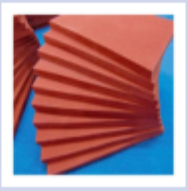
FEATURES/FUNCTION	IDEA 4	JUSTIFICATION
MOBILITY	PORTABLE	EASY TO CARRY
ACCESSORIES	TEMPERATURE SENSOR	TO DETECT ICE FORMATION AND ACTIVATE THE HEATING ELEMENT
MATERIAL	HEAT TEMPERATURE RESISTANT FOAMING SILICONE BOARD 	THE MATERIAL WATER RESISTANT
SHAPE	AEROFOIL 	MORE AERODYNAMIC
METHOD	ELECTRICAL HEAT ELEMENT	CAN PROVIDE UNIFORM HEATING ACROSS COMPLEX SHAPE AND SIZE
METHOD TO FORM ICE	COMPRESSOR OF AIR	CAN BE FROZEN QUICKLY
LOCATION OF COMPONENT	AILERON	ALL THE COMPONENT HAVE LEADING EDGE WHICH IS REALISTIC ICE FORMATION CAN BE HAPPENED

Table 3.4.2.6: Concept 4

The material for our aerofoiled in concept 4 is Heat Temperature Resistant Foaming Silicone Board, which can withstand extreme temperatures, typically ranging from -60°C to +300°C (-76°F to +572°F). We utilize a compressor to create ice, modern compressors are made to be energy-efficient, which lowers operating expenses and has a smaller negative impact on the environment.

Finally, we use an electrical heating element to de-ice the ice. Compared to other heating techniques, electrical heating components are very efficient since they produce heat from nearly all the electrical energy they require. This optimizes heating efficiency and guarantees less energy waste.

3.4.2.7 Accepted vs Discarded Solution

According to all concepts that we research, we decided to choose concept 4 as our final project that we will make it. This is because concept no 4, material used for aerofoiled is Heat Temperature Resistant Foaming Silicone Board which provide exceptional strength and durability also makes them ideal for applications where materials are exposed to high heat, such as in ovens, furnaces, and automotive components. Other than that, the method to form ice we used compressor of air which is excellent because mechanical systems are straightforward and easy to understand, making them an excellent choice for training beginners. Furthermore, the method to de-icing the ice we use electrical heating element which is efficient compared to other heating techniques.

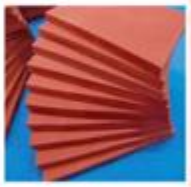
FUNCTION	IDEA 1	IDEA 2	IDEA 3	IDEA 4
MOBILITY	STATIC	PORTABLE	STATIC	PORTABLE
ACCESSORIES	SWITCH	LED LIGHT	SPRAY NOZZLE	TEMPERATURE SENSOR
MATERIAL	3D PRINTER 	WOOD & FABRICS 	ALUMINIUM 	HEAT TEMPERATURE RESISTANT FOAMING SILICONE BOARD 
SHAPE	CONE	ELLIPSE	RECTANGULAR	AEROFOIL
METHOD	ENGINE BLEED AIR	PNEUMATIC BOOTS	FLUID SYSTEMS	ELECTRICAL HEAT ELEMENT
METHOD TO FORM ICE	SALT + ICE	LIQUID NITROGEN	DRY ICE	COMPRESSOR OF AIR
LOCATION OF COMPONENT	PITOT TUBE	RUDDER	ELEVATOR	AILERON

Figure 3.4.2.7: Accepted vs Discarded Solution

3.4.3 Evaluation & Selection of Conceptual Design

3.4.3.1 Pugh Matrix

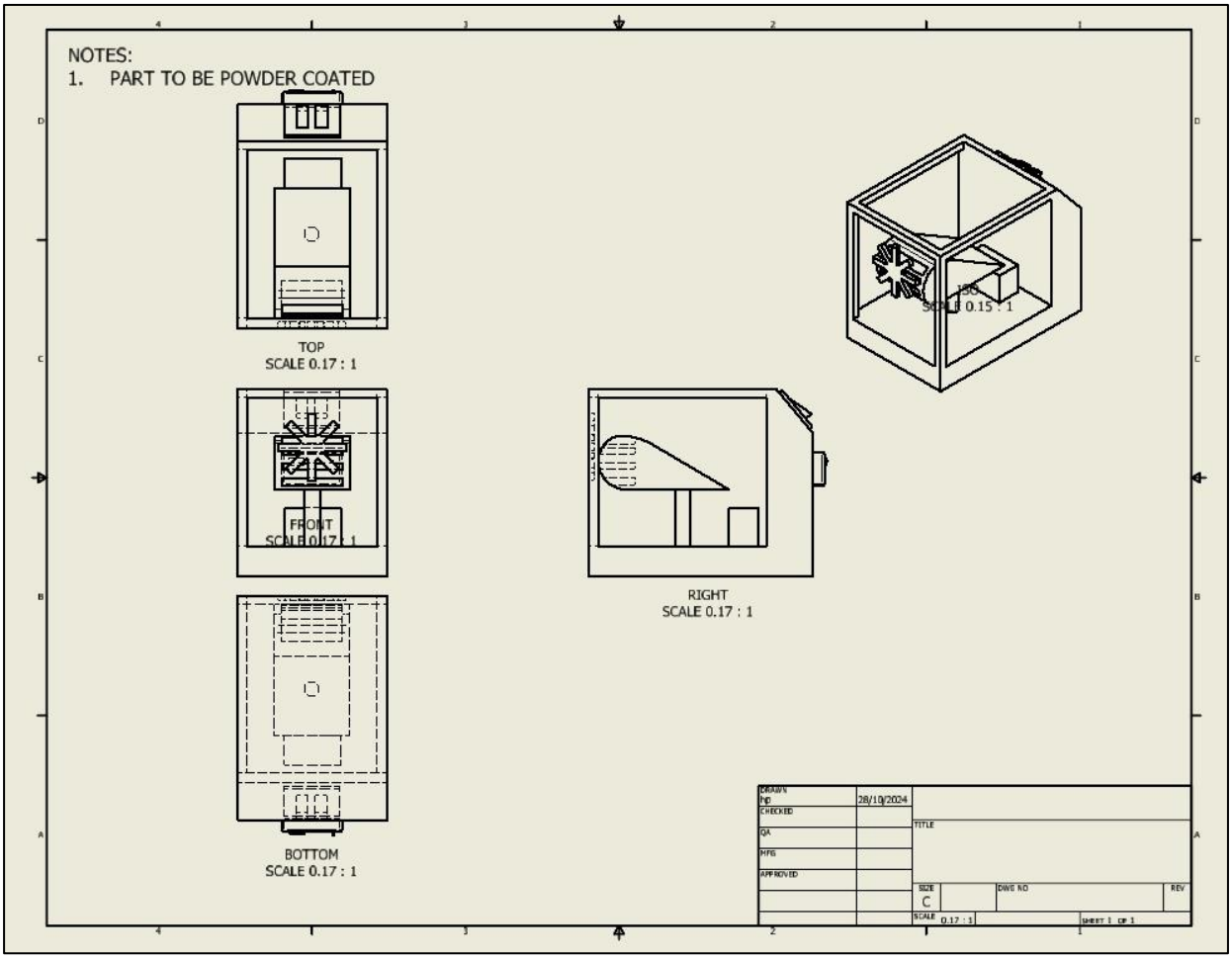
CRITERION	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	ICING PRO DETECTOR TRAINING KIT	CONCEPT 4
COST	0.1	1	3	3	D	3
LONG LASTING	0.2	3	1	3	A	3
MOBILITY	0.2	3	3	1	T	3
DURABILITY	0.2	1	1	3	U	3
EFFECTIVENESS	0.3	3	3	3	M	3
TOTAL SCORE	1.0	2.4	2.4	2.6	-	3.6
RANKING	-	4	3	2	-	1

Table 3.4.3.1: Pugh Matrix

As the Pugh Matrix, we decided to put Concept 4 as **DATUM** as it has the most suitable concept among other concepts. The cost of the concept, the long-lasting material used, the mobility built of the concept, the material which is durable and most effective version of all concepts. After discussions, Concept 4 seems to dominate among other concepts, making it our go to choose.

3.5 PRODUCT DRAWING

3.5.1 General Product Drawing



NAME: Politeknik Banting Selangor	**Orthographic View**
TITLE: Icing Pro Detector Training Kit	**CLASS: DAM4C**
SCALE: 0.08: 1	**UNIT: mm**

Figure 3.5.1.1: Orthographic View

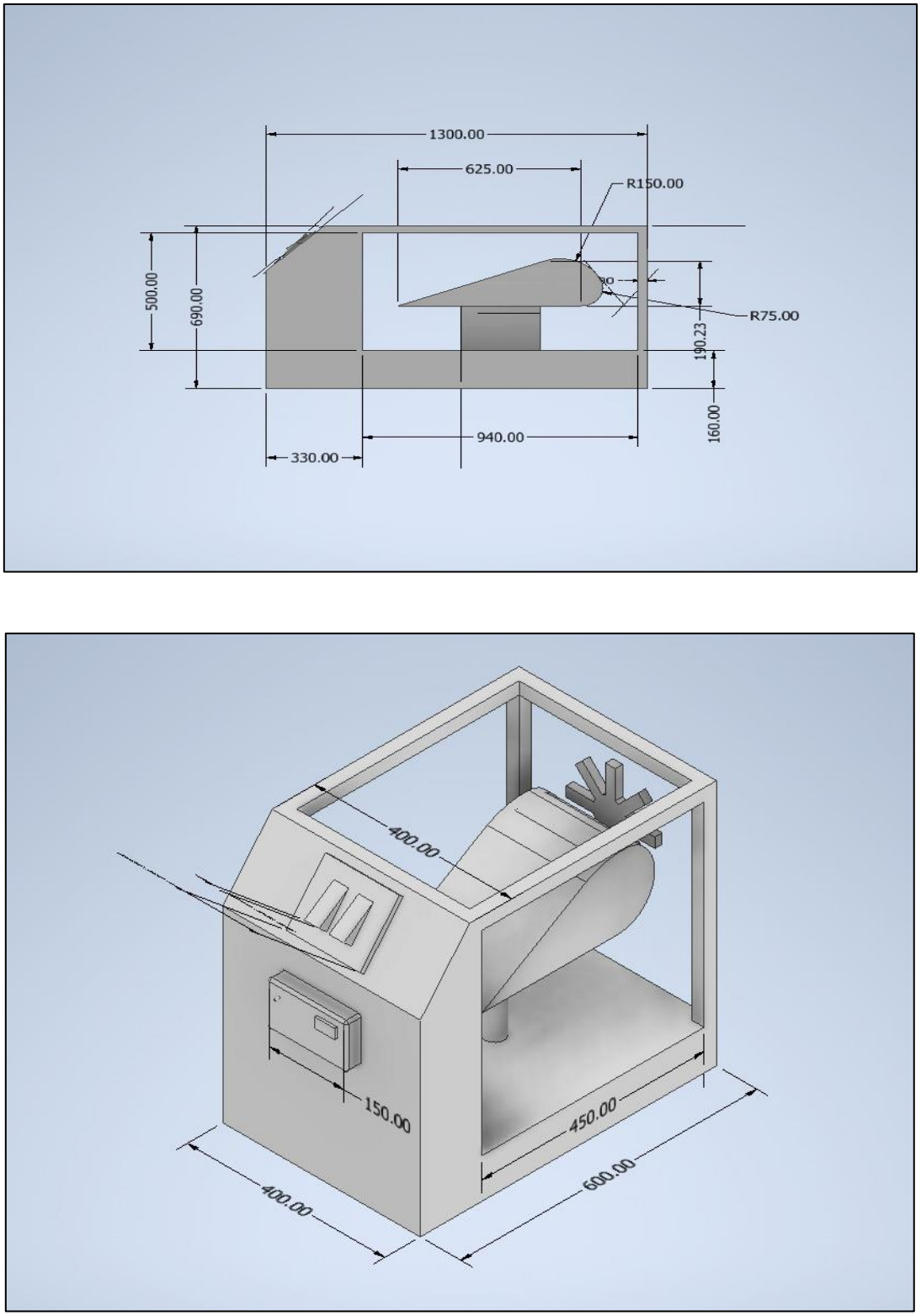


Figure 3.5.1.2: Measurement of Product Drawing

3.5.2: Specific Part Drawing / Diagram

3.5.2.1 Software/ Programming

3.5.2.1.1 Electronic Circuit Diagram

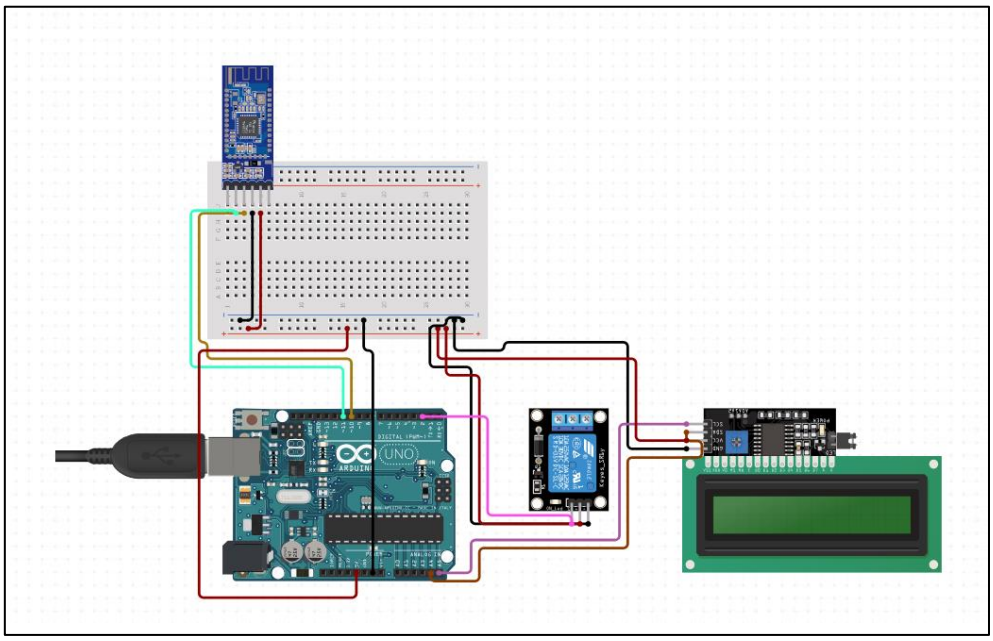


Figure 3.5.2.1.1: Circuit Diagram

3.5.2.2 Arduino Coding

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Initialize the LCD with the I2C address (0x27 is the default for many LCDs)
LiquidCrystal_I2C lcd(0x27, 16, 2);

const int tempPin = A0;  // Temperature sensor analog input
const int relayPin = 7;  // Relay control pin
const float thresholdTemp = 0.0;  // Temperature threshold in degrees Celsius

void setup() {
  // Setup Serial (for debugging)
  Serial.begin(9600);

  // Initialize the LCD
  lcd.init();           // Correct function for LCD initialization
  lcd.backlight();      // Turn on the LCD backlight

  // Display a startup message (optional)
  lcd.setCursor(0, 0);
  lcd.print("Initializing...");
  delay(1000);  // Wait for 1 second
  lcd.clear();

  // Setup relay pin
  pinMode(relayPin, OUTPUT);
  digitalWrite(relayPin, LOW);  // Start with relay off

  // Setup temperature sensor pin
  pinMode(tempPin, INPUT);
}
```

Figure 3.5.2.2: Arduino coding for IPDTK

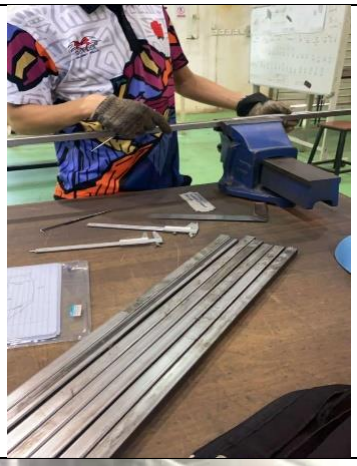
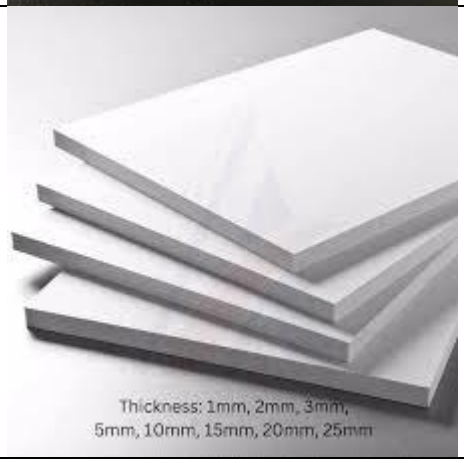
```
void loop() {
  // Read temperature from the sensor
  int sensorValue = analogRead(tempPin);

  // Debug: print the raw sensor value
  Serial.print("Raw Sensor Value: ");
  Serial.println(sensorValue);

  // Invert the temperature calculation for SN-TEMP-MOD
  float temperature = 100 - (((sensorValue * 150.0) / 1023.0)+20);  // Invert the temperature range

  // Debug: print the calculated temperature
  Serial.print("Calculated Temperature: ");
  Serial.println(temperature);

  // Display only the temperature value on the LCD
  lcd.clear();
  lcd.setCursor(0, 0);  // First row, first column
  lcd.print("Temp: ");
  lcd.print(temperature, 1);  // Display temperature with one decimal place
  lcd.print(" C");

  // Control the relay based on the temperature
  if (temperature < thresholdTemp) {
    digitalWrite(relayPin, HIGH);  // Turn on the heating element
    lcd.setCursor(0, 1);  // Second row
    lcd.print("Heating ON ");
  } else {
    digitalWrite(relayPin, LOW);  // Turn off the heating element
    lcd.setCursor(0, 1);  // Second row
    lcd.print("Heating OFF");
  }

  // Wait before the next loop
  delay(1000);
}
```

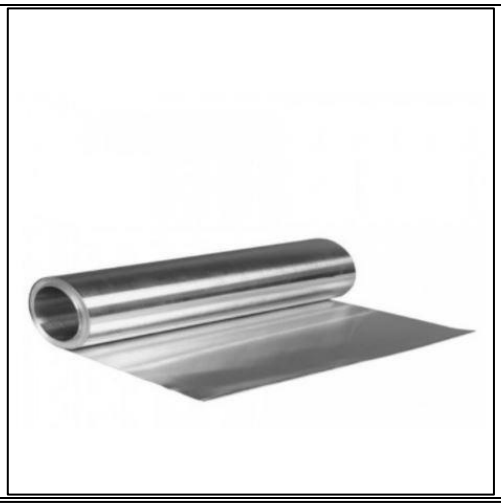
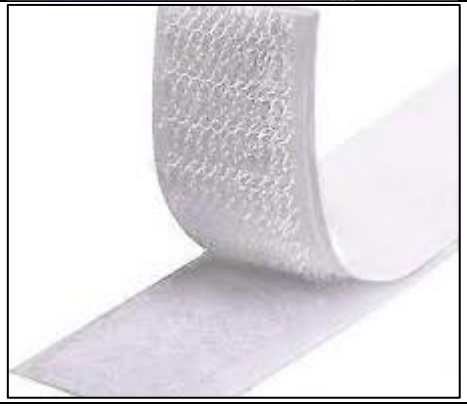
Figure 3.5.2.3: Arduino Coding for IPDTK

3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

3.6.1.1 Mainframe of IPDTK

No	Material	Description
1.		1” hollow steel square is used as the main material to construct the mainframe for IPDTK.
2.		Acrylic sheet is used as the cover of mainframe for viewing the airfoil. All the acrylic sheet is clear as per original
3.		PVC Board is used at the front panel to cover all electrical system, and the airfoil also used the pvc board as their main body of airfoil.

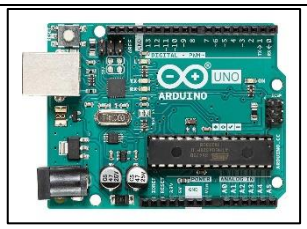
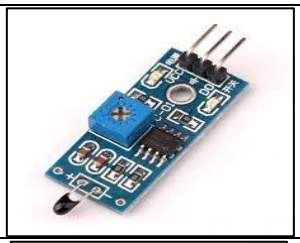
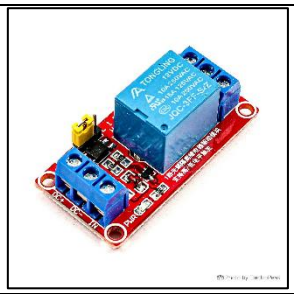
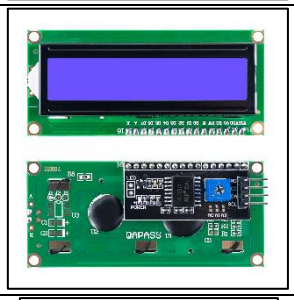
4.		Galvanized zinc sheet is used to cover the base of main structure to get flat base.
5.		#6x1/2 round head self-tapping screws are used as the main fastener to install the panel to the mainframe include pvc board
6.		Double sided tape is used to attach the acrylic sheet to the main structure.
7.		Velcro tape is used for panel can open and close for access for mechanism part and maintenance purpose

3.6.1.2 Mechanism of IPDTK

No	Material	Description
1.		Compressors are used as the main functionality of the product
2.		Copper is utilized to connect the compressor and adhere to the airfoil structure.
3.		Welding gas is used to connect copper

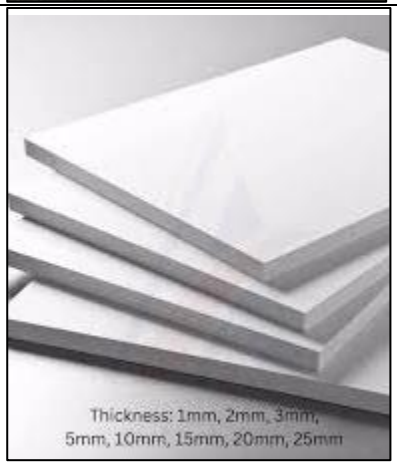
4.		Silver welding rod is used for brazing the copper
5.		Fan is used for a ventilation system for the product

3.6.1.3 Electronic and Software of IPDTK

NO.	MATERIAL	DESCRIPTION
1.		Arduino uno is used to run the programmed software into the circuit and act as the controller
2.		NTC Temperature Sensor Module function to collect the temperature data on the leading edge
3.		Heating mat is used to heat up the leading edge after ice formation occurs to de-ice the leading edge
4.		Relay module function as an automatic switch when the temperature reaches set minimum temperature for the heating element to be turn on
5.		LCD Display 16x2 I2C is used to display the live data of the temperature and heating element
6.		12V Battery powers the heating element to produce heat

7.		1.5V Battery powers the Arduino and the circuits
8.		Toggle switch is used to turn on and turn off the circuits to reduce battery consumption

3.6.1.4 Accessories and Finishing of IPDTK

No	Material	Description
1.		Spray paint is used as the finishing for the main framework structure of IPDTK
2.		Acrylic blade used to cut the acrylic sheet in required measurement
3.		Enhance visibility of the internal component to the audience.
4.		Flexibility in design as they can easily be cut, shaped, and installed with relative ease.

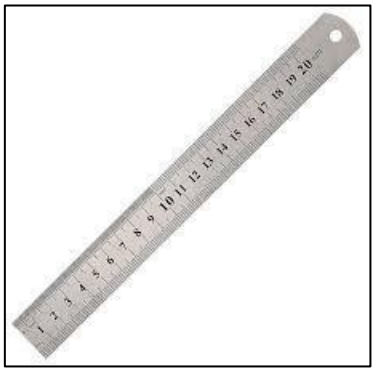
5.		Tape is a multipurpose tool that may be used for model-making, product finishing and even interim repair. It can conceal flaws and improve the overall professional look of the structure.
6.		PVC electrical box for cable management enhances the organization of electrical components and accessories in the IPDTK, resulting in a neater, more professional finish.

3.6.2 Machine and Tools

3.6.2.1 Machines for IPDTK

No	Machines	Description
1.	Portable Electric Drill 	**General Purpose:** To drill holes in the material and to insert screw and other threaded fasteners into the material. **Project Purpose:** To drill holes for panel installation and to fastened the panels to the mainframe with screws.
2.	Hand Grinder 	**General Purpose:** Can be used in various jobs such as cutting, grinding, deburring, finishing and polishing. **Project Purpose:** To cut the acrylic sheet, galvanize zinc sheet and remove rust from the surface.
3.	Solder 	**General Purpose:** Suitable for various electrical tasks such as soldering, wire connecting, circuit board repair, and component assembly. **Project Purpose:** Specifically intended for soldering electrical components, creating secure connections on circuit boards, and repairing electronic devices by ensuring reliable conductivity and stability in circuits.

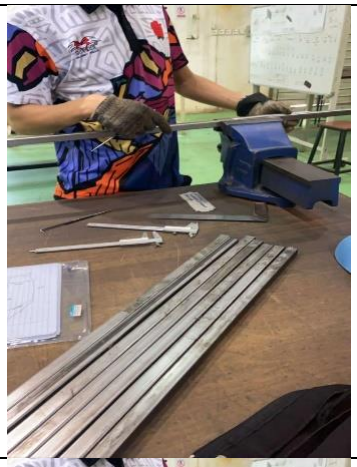
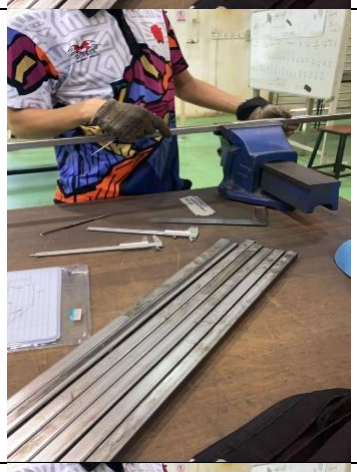
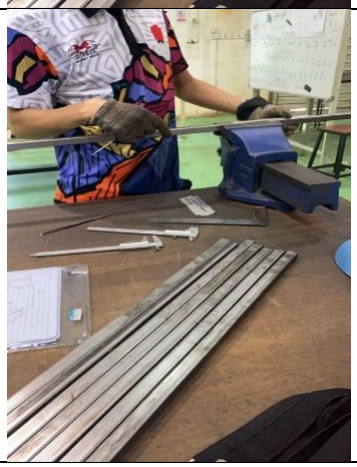
3.6.2.2 Tools for IPDTK

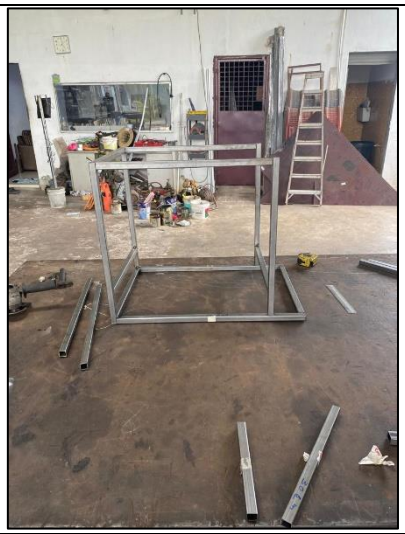
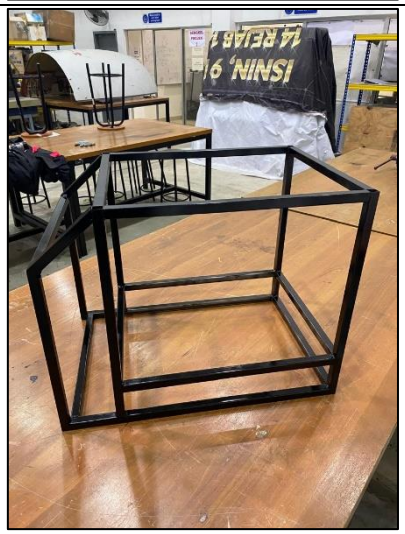
No	Tools	Description
1.	L-Square Ruler 	**General Purpose:** To measure a 90-degree shape and for typical measuring purposes using the scale given **Project Purpose:** Used to make sure the hollow steel at 90 degrees, and used to measure other dimensions
2.	Steel Rule 	**General Purpose:** To measure the length of an object **Project Purpose:** To measure the length and dimensions during measuring phase before cutting the pvc board and acrylic sheet into specific measurements
3.	Hacksaw 	**General Purpose:** Mainly used for cutting through materials such as plastic, steel, and other metals. **Project Purpose:** To cut the hollow steel based on the measurement needed.
4.	Cutter Knife 	**General Purpose:** A part of tools or machines for cutting, chopping, slicing, or scraping surfaces or materials of a workpiece. **Project Purpose:** Cut the pvc board into the measurement without any defect from the cutting process.

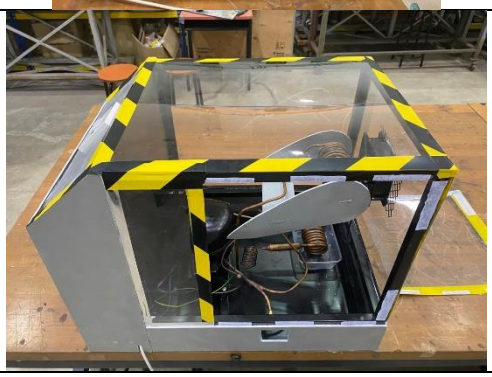
5.	File Tools 	**General Purpose:** The tools used for shaping, smooth, and removing material from a different surface, most commonly wood or metal. **Project Purpose:** Filed the acrylic sheet side and sharp edge on hollow steel to become smooth surface.
6.	Scriber Tools 	**General Purpose:** Ideal for marking and scoring on various materials such as metal, plastic, and wood, assisting in precise layout work, etching, and measurements. **Project Purpose:** Specifically designed for accurately marking cut lines and points on materials like acrylic sheets and galvanized zinc sheets, ensuring precision in layout and alignment for tasks requiring fine detail.

3.6.3 Specific Project Fabrication

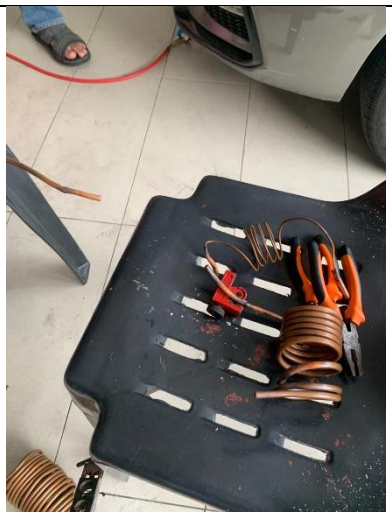
3.6.3.1 Phase 1 (Main Structure)

No	Fabrication Process	Description
1.		The square hollow steel and acrylic sheet was bought from a hardware store. The galvanized zinc sheet is salvaged from the mechanical project workshop.
2.		The length of the square hollow steel is measured and marked. The dimension of the galvanized zinc is measured and marked as per base structure.
3.		The square hollow steel is cut using a hacksaw. The galvanized zinc sheet is cut with cutter tools.

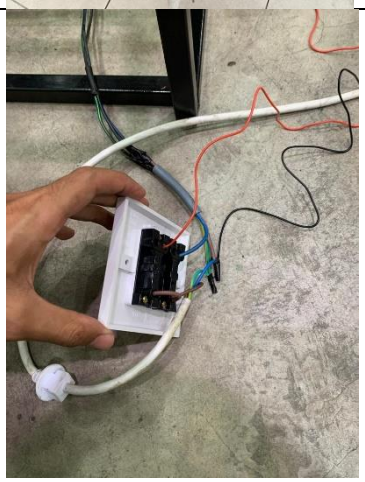
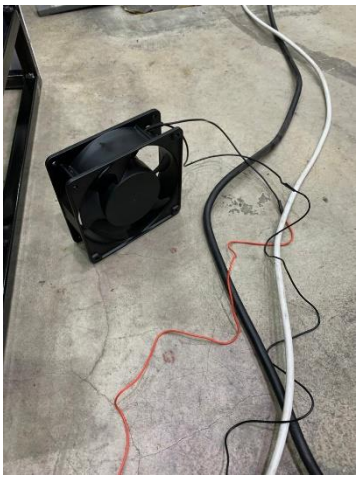
4.		The square hollow steel is welded with Shielded Metal Arc Welding method at metal workshop.
5.		Main structure was sprayed paint and cover up using clear paint to avoid further rusting.
6.		The dimensions of the pvc board and acrylic sheet are measured and marked as per drawing. The pvc board and acrylic sheet is cut with a cutter knife.

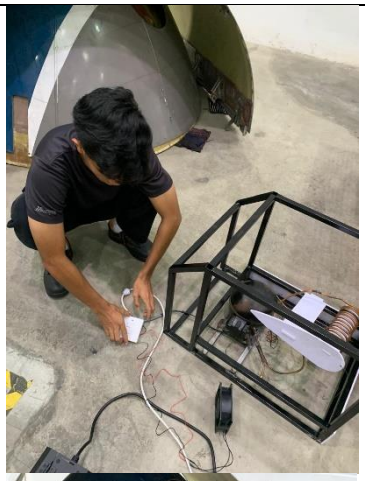
7.		Drilling process of galvanized zinc sheet to cover the base structure using screws.
8.		All the panels have been attached to the main structure.

3.6.3.2 Phase 2 (Mechanism)

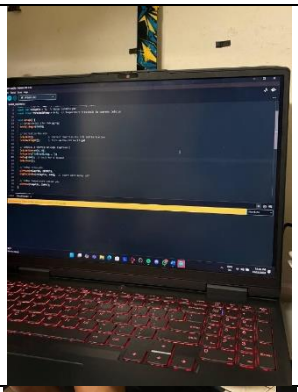
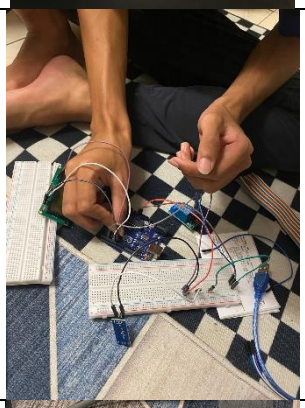
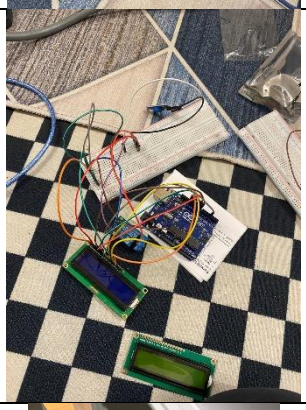
NO.	Fabrication Process	Description
1.		Copper forming process. Form the copper into an aerofoil shape to attach on the wing structure.
2.	 	Copper joining and brazing process. Solder the copper and connect each part of the copper correctly to connect it to the compressor.

	 	
3.		Compressor testing process. After connected the copper on the compressor, we put gas into the compressor to run a testing.

		
4.	 	Process of connecting the fan and compressor. Connect the fan wire and the compressor to the main power switch. Attach all mechanism part with main structure.

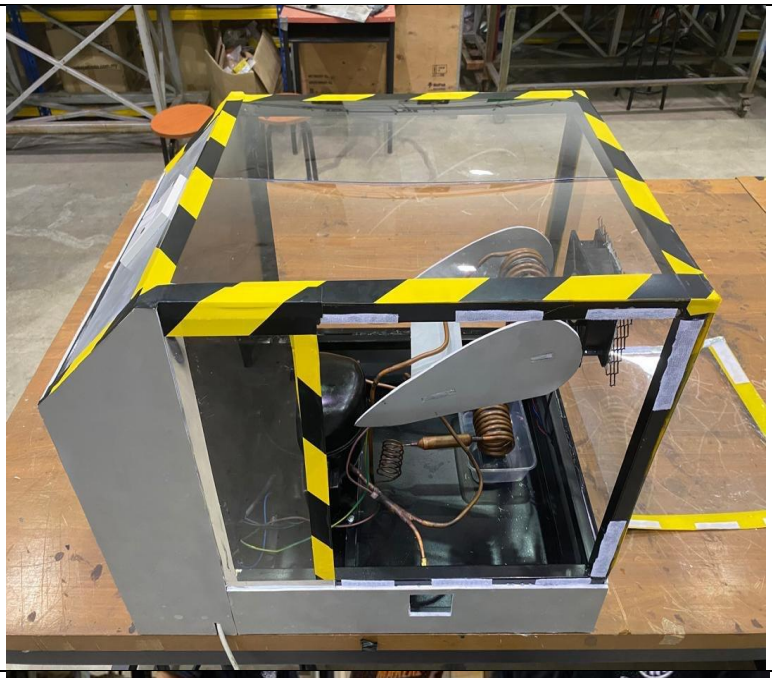
3.6.3.3 Phase 3 (Electronic and Software)

NO.	Fabrication Process	Description
1.		Programming the IPDTK using Arduino IDE
2.		Circuit testing using breadboard and connecting all components together
3.		Components testing to troubleshoot if any defect is detected
4.		Inserting the circuit into the PVC Box

5.			All components are installed and troubleshot for the last time

3.6.3.4 Phase 4 (Accessories & Finishing)

NO	PICTURE	DESCRIPTION
1.		The main framework of IPDTK is painted with the black colour. The paint is applied multiple times so the layer of paint is consistent.
2.		PVC boards were attached to the main structure, and airfoil structures also been created using the same material

3.		Perspex and PVC board panel were attached to complete all the assembly process.
4.		Results after accessories equipment such tape were used to ensure the safety for the sharp edges and enhance the professional and aesthetic look.

3.7 PRODUCT TESTING / FUNCTIONALITY TESTS

Figure 3.7 shows flow chart of product Icing Pro Detector Training Kit (IPDTK) operation procedure

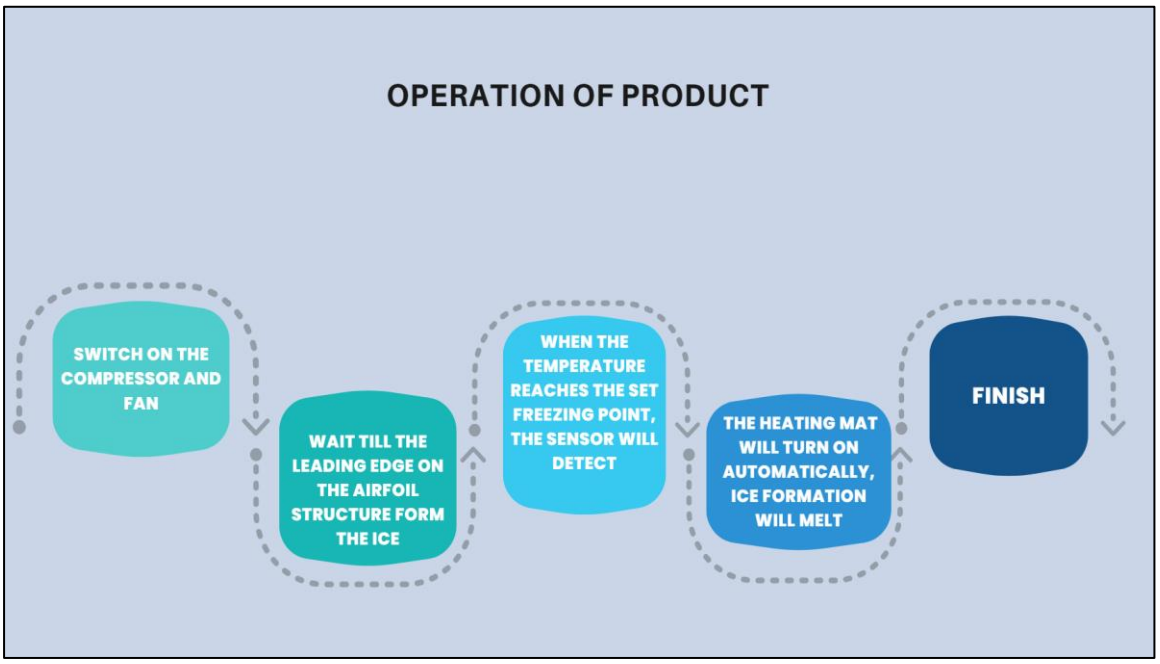


Figure 3.7: Operation of Product

Figure 3.8: Functionality Test

3.8 LIST OF MATERIALS & EXPENDITURES

3.3.1 Product Structure				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Perspex Panel	2	RM28	RM56
2.	Hollow Steel	20ft	RM1.40/ft	RM28
3.	PVC Board	4	RM23.90	RM95.60
4.	Aluminium Sheet	1	FOC	FOC
5.	#6X1/2 Round Head Self Tapping Screw	2	RM2.70	RM5.40
6.	Double Sided Tape	2	RM5	RM10
7.	Velcro Tape	1	RM2	RM2
8.	Welder	1	RM80	RM80
9.	Door Hinge	1	RM5.50	RM5.50
10.	Wallpaper Knife	1	RM 8.10	RM8.10
11.	High Temperature Silicone Board	1	RM60.19	RM60.19
12.	Car Putty and Hardener	1	RM21.50	RM21.50
3.3.2 Mechanical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Compressor Refrigerator	1	RM100	RM100
2.	Copper	1	-	-
4.	Fan	1	-	-
5.	Switch	1	RM3	RM3
6.	Non-Submersible Pump	1	RM11.90	RM11.90
7.	Lighter Gas	4	RM1.50	RM6
8.	Syringe	1	RM5.90	RM5.90
9.	CU Filter	1	RM3.70	RM3.70

10.	**Silver Rod**	**3**	**RM2.50**	**RM7.50**
11.	**Welding Gas**	**1**	**RM18**	**RM18**
3.3.3 Electrical Mechanism				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	**Arduino uno board**	**1**	**RM40**	**RM40**
2.	**NTC Thermistor Temperature Sensor Module**	**1**	**RM1.80**	**RM1.80**
3.	**Heating Mat Silicone Rubber**	**1**	**RM39.90**	**RM39.90**
4.	**Relay Module**	**1**	**RM5.00**	**RM5.00**
5.	**LCD Display 16x2 I2C**	**1**	**RM4.20**	**RM4.20**
6.	**12V Battery**	**1**	**RM48.00**	**RM48.00**
7.	**1.5V Battery**	**1**	**RM3.80**	**RM3.80**
8.	**Toggle Switch 2 Pin**	**1**	**RM3.20**	**RM3.20**
9.	**Heating Electrical Panel Pad**	**1**	**RM26.31**	**RM26.31**
10.				
3.3.4 Accessories & Finishing				
No	**Items**	**Unit**	**Price/Unit**	**Total (RM)**
1.	**PVC Warning Tape**	**1**	**RM7.90**	**RM7.90**
2.	**Deco Tape**	**1**	**RM1.70**	**RM1.70**
3.	**Spray Paint**	**5**	**RM6.50**	**RM32.50**
4.	**Floral Foam**	**3**	**RM1.80**	**RM5.40**
5.	**Sandpaper**	**2**	**RM0.70**	**RM1.40**
6.	**Glue Gun Stick**	**1**	**RM2.70**	**RM2.70**
7.	**Stick Pad**	**1**	**RM1.20**	**RM1.20**
8.	**Wallpaper**	**1**	**RM6.90**	**RM6.90**
GRAND TOTAL				**RM760.20**

Table 3.8: List of Materials and Expected Expenditures

CHAPTER 4

RESULT AND DISCUSSION

4.1 Product Description

4.1.1 General Product Features and Functionalities

This product is an innovation towards learning the De-icing system mechanisms in class. The purpose of the Icing Pro Detector Training Kit is to assist the instructor's teaching and improve understanding of students about icing formation on the leading edge and how the mechanism works to deice the built-up ice on the leading edge. This is because students' understanding about de-icing in theoretical class alone is not enough and this training kit will help them visualize the scenario with practical.

Other than that, Icing Pro Detector will help students understand the types of ice and the temperature at which the ice formation will happen with the help of information table that is provided with the training kit. As on aircraft wings it's hard for student to have access to it on a real scenario.

Finally, the design of the training kit which is smaller compared to previous ice and rain protection training kit by Avoteks makes it easier to be moved around for the instructor to bring it into class for students to witness even during a theoretical class.

4.1.2 Specifics Part Features

Specific Part Features were divided into 4 parts:

- **Product Structure**
- **Product Mechanism**
- **Electronics and Programming**
- **Accessories & Finishing**

4.1.2.1 Product Structure

The structure of Icing Pro-Detector Training Kit was designed with durability and functionality in mind. It is primarily constructed using stainless steel to hold all mechanism parts which are compressors that offer high tensile strength and exceptional durability, allowing it to withstand the demanding conditions when the system is running.

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 result of project running. This training kit was developed and very suitable for gaining knowledge and to understanding in behavior of de-icing process under ATA chapter 30, Ice and Rain Protection.

4.1.2.2 Product Mechanism

The compressor and fan are the most important components in this product mechanism. A refrigerator compressor is the core component that drives the cooling cycle by compressing and circulating refrigerator throughout the system.

The compressor controls and compresses the flow of liquid refrigerant, which is an essential component of refrigeration system. The compressor works directly with the condenser and evaporator coils as well as the expansion valve. A small fan helps in raising the temperature and creating a layer of ice on the copper that is attached to the leading edge.

4.1.2.3. Electronics and Programming

The electronics system in this training kit is controlled by arduino uno. The arduino acts as the 'brain' of the system where it produces the command for the system to work. The electronics under the command of the arduino is the NTC Thermistor Temperature Sensor Module, LCD Display 16x2 I2C, Relay Module, and Heating Element.

The NTC Thermistor Temperature Sensor Module detects the temperature changes on the leading edge of the airfoil wings and transfers the information to the arduino uno and displays the temperature on the LCD.

The collected data from the temperature sensor will trigger the relay module to switch on the heating element once it reaches 0 degree Celsius. The heating element is powered by 12V Battery and by that, the heating mechanism works to de-ice the leading edge.

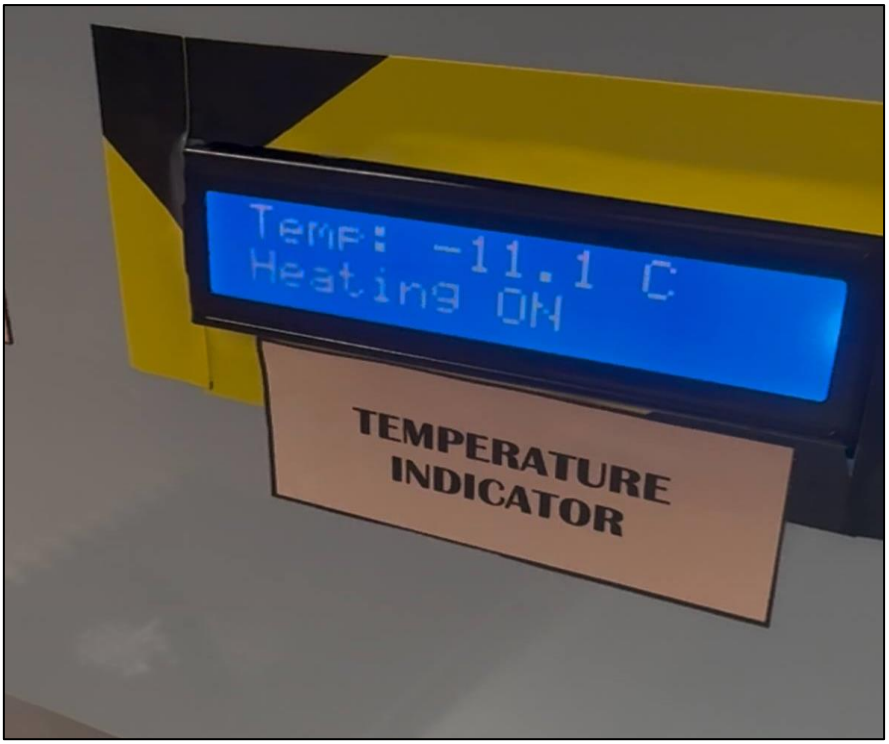


Figure 4.1.2.3: LCD Displaying the working heating element and temperature

4.1.2.4 Accessories and Finishing

The Icing Pro Detector Training Kit is equipped with Perspex Panel as one of the accessories. This is visible to students to observe when the ice form on the leading edge of the airfoil structure. Other than that, tape serves as a versatile tool that can hide imperfections, create clean lines, and improve the overall professional look of the structure. Next, PVC Electrical Box. By adding electrical boxes, IPDTK can effectively manage and organize cables, making the training kit more user-friendly and professional. The use of these boxes not only enhances functionality but also makes the training experience smoother and visually appealing. Apart from that, PVC electrical boxes have removable covers, making it easy to access cables for adjustments or maintenance. This allows trainers or students to troubleshoot or replace wires and accessories as needed without dismantling the entire kit.

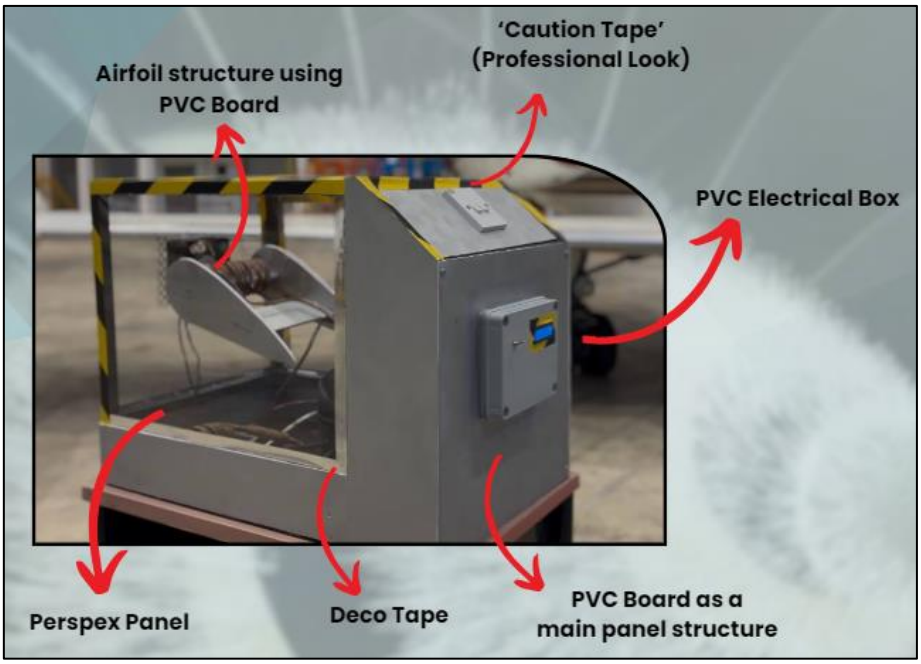


Figure 4.1.2.4: Product Features and Functionalities of Accessories & Finishing Part

4.1.3 General Operation of IPDTK

The Icing Pro Detector Training Kit functions from a variety of electronics components and electrical components. When the product is turned on the compressor will produce ice on the surface of the copper coil with the help of fan that will assist the ice formation.

Furthermore, the ice formation will trigger the arduino to turn on the heating elements as the sensor detected the temperature below 0-degree Celsius and the ice that formed on the leading edge will start to be encountered.

4.1.4 Operation of the Specific Part of IPDTK

4.1.4.1 Product Structure

The panels for the chassis are constructed mainly using acrylic sheet, except for electrical compartments at the front cover, which are made of PVC board and under cover are using zinc sheet. The front panel of the electrical part is attached to the mainframe with four screws at the edge giving the panel the ability to be opened. The undercover also attached to the mainframe with ten screws around the zinc to ensure it can withstand the weight.

All the other panels are attached to the mainframe with double side tape. This allows the panels to be removed and installed at any time for maintenance purposes, such as cleaning, component replacement and repair.

4.1.4.2 Product Mechanism

The icing-pro detector training kit includes a total of three mechanisms. First and foremost, there is the Refrigerator Compressor. Low-pressure, gaseous refrigerant is drawn from the evaporator and compressed by the compressor. The refrigerant's temperature and pressure rise because of this compression. After that, the gas passes through the condenser coils at high pressure and temperature. After passing through a capillary tube or expansion valve, the high-pressure liquid refrigerant quickly expands. The refrigerant cools considerably because of this expansion, which also lowers its temperature and pressure. The cold, low-pressure refrigerant then enters the evaporator coils, it absorbs heat then cools the coil. The refrigerant, now a low-pressure gas again, returns to the compressor, where the cycle repeats.

Next, Copper Coil. Copper is perfect for effectively transporting heat because of its high thermal conductivity. Copper coils between the condenser and evaporator aid in the transfer of heat between the air and the refrigerant. As the air flows over the copper coils in the evaporator, the refrigerant absorbs heat from the indoor air and cools it. By facilitating heat dissipation from the refrigerant to the outside air, the copper coils in the condenser allow the absorbed heat to be released outdoors. Copper coils effectively carry refrigerant between system components with minimal resistance. Their smooth surface and conductivity improve refrigerant flow, contributing to the system's efficiency and reducing the workload on the compressor.

Finally, AC Cooling Fan. Small fans are energy-efficient choices for low-power cooling systems or personal cooling since they use less electricity than bigger fans due to their smaller size. Compared to larger fans, smaller fans provide less airflow. They are adequate for small areas or personal cooling. Small fans are generally very economical for long-term use because of their excellent energy efficiency relative to the volume of airflow they produce.

4.1.4.3 Electronics and Programming

The Electronics system comprises several components which are NTC Thermistor Temperature Module, LCD 16x2 Display I2C, Relay Module and Heating Element. The electronics system provides an automatic activation of the deicing mechanism on the leading edge of the airfoil. The NTC Thermistor Temperature Sensor Module will detect temperature changes on the leading edge.

When the Temperature drops to below 0-degree Celsius, the Arduino will transfer the command to Relay Module to activate the Heating Element that is powered by 12V battery, The Relay Module function as the automatic switch in this system.

Finally, the LCD Display 16x2 I2C will display all the temperature data and display the indicator whether the Heating Element is turned on or not. All the electronics systems are working automatically after they are turned on so that it replicates the real scenarios on an aircraft de-icing system.

4.1.4.4 Accessories and Finishing

The finishing of Icing Pro Detector Training Kit uses a several materials and equipment to meet the required project specifications. Firstly, the PVC board functions as the main panel structure and for the airfoil that will be the area ice form, firmly attached to the primary framework of the product, offering a durable and lightweight foundation. Additionally, a Perspex panel is included to provide a clear view, enabling students to observe the internal workings of the training kit. This transparency is essential for enhancing the educational experience, allowing users to closely study the functionality of the device.

To elevate the visual appeal, spray paint has been applied across the structure, giving it a professional, polished finish. This not only improves aesthetics but also adds a protective layer, increasing the surface's resilience.

Finally, tape is used to secure all components, particularly the PVC and Perspex panels, to ensure a stable and reliable attachment despite uneven assembly lines. This solution not only enhances the overall look of the kit but also improves safety by covering any sharp edges and providing additional stability, ensuring the kit maintains its integrity and withstands repeated use while offering both functional and aesthetic value.

4.2 Product Output Analysis

No	Parameter	Result	Description	Analysis
1	Time to form ice	30second – 1minute	The output of how much time to make an ice formation on the copper coil that attach on the airfoil structure	The time it takes to form ice can change if the outside temperature is different
2	Time for temperature sensor to detect ice formation	5second - 15second	The temperature sensor will send a signal when the temperature reaches a set level	The temperature sensor is set to send a signal to the heating element when the temperature reaches 0 Celsius
3	Time for ice formation to melt	15second – 30second	The heating element will get a signal and automatically will be turn on	The heating element will automatically turn on

Table 4.2.1: Product Output Analysis

No	Operation	Information
1	Max operation time	20 minutes
2	Weight	10 kg
3	Size	Length: 60cm Height: 50cm Width: 40cm

Table 4.2.2: Operation and Information of Product

4.3 Analysis of Problem Encountered & Solution

4.3.1 Product structure

One of the problems encountered in the fabrication process of the mainframe was that the square hollow steel melted when welded and did not get a smooth joint. To solve this, the affected tube was replaced, and the welding is resumed at a different setting.

Next, the cutting of the acrylic took a long time. Cutting acrylic with a cutter knife is difficult because the material has a thickness of 3mm (about 0.12 in) thick. There are between thirty and forty layers required for the cutting process. Changing to grinder machine has consequently solved this issue and guaranteed that we have get a result in straightly and smoothly.

4.3.2 Product Mechanism

A few issues arise during the product's development, according to the part on the mechanism. These problems arise from a lack of understanding regarding the creation and appropriate functioning of the product. The copper coil's icing formation is one of the problems. In the past, the icing process was carried out using a mini submersible water pump, however the pump is insufficiently powerful to run the complete system. Next, we replace the water pump with a refrigerator compressor, which has a higher voltage.

Other than that, the main method is to use butane gas, which has a greater freezing point. However, we are having trouble filling in the compressor because we do not have an adaptor to connect a bottle of butane gas to a copper coil. R22 refrigerant, which shares the same characteristics as butane gas, is used in place of butane gas.

4.3.3 Electronics and Programming

While engaging in the electronics and programming sections of the project there were a few problems that had to be encountered. First, our initial plan is to hire a programmer to help us program the circuits. However, the programmer decided to call off the deal leaving us with no programmer, so we had to study how to program the circuit ourselves.

Other than that, the components that we purchased online came to us and some of them had defects and are not working. We tried to troubleshoot and some of the devices seemed to be malfunctioning. We solved the problem by claiming a warranty and even some of the components we had to repurchase.

Lastly, the problem that we encountered is the programming of the system is not working as intended, so we had to reprogram and rerun the system until we are satisfied with the system.

4.3.4 Accessories and Furnishings

Several challenges emerged during the product's development, specifically concerning accessories and the finishing section. Firstly, the issue arose with the use of Polly putty cream, which failed to create the smooth, uniform finish desired for the airfoil structure’s surface. To address this, a PVC board was selected as a more reliable base material, and it was wrapped in clear wallpaper to achieve the polished, even surface required. This adjustment provided both an aesthetically pleasing finish and enhanced durability, meeting the necessary standards for quality and functionality in the training kit.

Next, an additional issue was the uneven assembly of the Perspex panel when attached to the main structure, which was made of hollow steel. This misalignment not only affected the appearance but also posed potential safety concerns. To resolve this, caution tape was applied along the edges of the panel, enhancing safety by covering any sharp areas and providing a cleaner, more professional look. This solution effectively improved both the aesthetics and safety of the assembly.

Apart from that, another challenge was the use of improper tools for cutting the Perspex panel, resulting in rough, uneven edges that did not meet the desired specifications. Due to the lack of suitable cutting tools, extensive sanding was required to smooth out these edges, significantly increasing the time needed for finishing. Although this approach ultimately produced acceptable results, the time-consuming of sanding highlighted the need for more appropriate tools to streamline the process and improve efficiency in future projects.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievement of the Product

After the project's completion and testing, Icing Pro Detector Training Kit (IPDTK) were able to meet all objectives for providing students with the training kit that able to help them encountering icing-related issues and improving their comprehensive understanding of aircraft de-icing system. The important thing is student understanding how to apply theoretical knowledge in practical scenario using this training kit. 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, the IPDTK aids students in learning and comprehending the concept of de-icing system.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product structure

The objective in designing the structure of IPDTK was achieved. In order to accomplish this objective, the appropriate shape and dimension of the structure is identified, and IPDTK is designed according to these elements. The design of the structure is designed with INVENTOR, and this design is executed in the final product.

5.1.2.2 Product Mechanism

The IPDTK mechanism section's goal was successfully accomplished. The mechanism's objective is to create an ice formation on the copper coil that is attached to the wing structure's leading edge. Fans additionally serve as our product's system for air circulation.

5.1.2.3 Software/Programming

The objective of the software and programming section of IPDTK is achieved. The aim of the software is to create an automatic circuit that can detect temperature changes and counter the ice formation perfectly. The circuit also cut some costs towards the project as it uses less component than the initial plan which is an achievement towards our budget cost.

5.1.2.4 Accessories & Finishing

The final version of the Icing Pro Detector Training Kit (IPDTK) has been developed to fully achieve each objective that was originally set out. Through careful action especially on accessories and finishing section, we ensured that every goal and requirement for functionality and effectiveness has been met, resulting in a product that aligns precisely with our initial aims and expectations. This accomplishment reflects our commitment to delivering a training kit that provides a comprehensive and reliable educational experience for users. The accessories and finishing component which improves the safety of the functional and provides a smooth progression of the product.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The contribution of the project to students is to enhance students' learning experience in aircraft de-icing system, providing hands-on experience and hands-on experiments that can gain their understanding topic of ice. In addition, the contribution of the project to the training institute is to equip students with practical skill in stall behavior and ice performance of the airfoil also enabling them to contribute innovation and address the industry challenges. The impact of the IPDTK towards society 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

The suggestion for future research on IPDTK regarding the structure is on the selection of material used for the mainframe. The mainframe should be constructed with other material such as stainless steel to reduce the weight of the product and at the same time to enhance the product's durability. Other than that, to ensure this product gets more commercial value like portability, at the mainframe attach it with four wheels to make it easier to move from workshop to lecture room. Next, the access panel door will put the door hinge to make it easier for mechanical part access for cleaning & maintenance purposes.

5.3.2 Product Mechanism

Future studies on the mechanism of IPDTK are suggested to focus on the drainage system. To prevent any harm to the electrical and electronic system, the product should have a suitable drainage pipe. A suitable ventilation system, which is crucial for the product's ice development, can then be made to improve this product.

5.3.3 Software / Programming

The IPDTK could be improved more, particularly in the software and programming sector. The improvement that could be made is adding an LED indicator on the airfoil to help indicate whether the heating element is on or off. Other than that, electrical safety features could be improved to prevent short since the circuit is exposed towards water. Furthermore, a mobile application could be added to help students monitor and learn about the system on the move. Finally, the IPDTK should come with a remote-control device so that the instructor could control the product while teaching.

5.3.4 Accessories & Finishing

For future improvement accessories and finishing, the product would like to maximize the efficiency of the product especially on looks. After that, make the improvement on the airfoil structure platform which is can slot the electrical and electronic components to make a better finish and looks neat in the product. Hence, for the electrical and electronic wiring can be improved by utilized a proper cable management and insulate it properly. Other than that, the product also would like to add some cover on top of the airfoil structure with a Perspex Panel so then the user can be observed perfectly. This makes the product look nice and complete finishing looks. It also needs to add some parts which is drain valve for the water droplets can be remove away from the training kit.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
	MUHAMMAD AKID HAZMI BIN MD MARJUNI (24DAM22F1028)
1.1	Background Of Study
1.2	Problem statements
1.3.1	General Project Objectives
1.3.2.4	Specific Individual Project Objectives: Accessories & Finishing
1.4	Purpose of Product
1.5.1	General Project Scope
1.5.2.4	Specific Individual Scopes: Accessories & Finishing
2.1.1	Aviation Industry in Malaysia
2.1.2	Demand for Ice Protection Training Kit
2.2.4	Accessories & Finishing
2.2.4.1	Basic design of Accessories & Finishing
2.2.4.2	Types of Components Used for Accessories & Finishing
2.3.1	Related Patented Product
2.4	Comparison Between Recent Research and Current Project
3.1.1	Utilization of Polytechnic's Facilities

3.2	Overall Project Gantt Chart
3.3.1	Overall Project Flow Chart
3.3.2.4	Specific Project Design Flow: Accessories & Finishing
3.4.2.6	Proposed Design Concept Idea 4
3.6.1.4	Material Acquisition: Accessories and Finishing
3.6.3.4	Phase 4 (Accessories & Finishing)
4.1.2.4	Product Specific Part Description/Functionalities: Accessories and Finishing
4.1.4.4	Operation of the Specific Part: Accessories and Finishing
4.3.4	Analysis of Problem Encountered & Solution: Accessories and Finishing
5.1.2.4	Specific Achievement of Project Objectives Accessories and Finishing
5.2	Contribution or Impact of The Project
5.3.4	Improvement & Suggestions for Future Research: Accessories and Finishing

	ADAM HAFIY BIN MOHD ASRINNIHAR (24DAM22F1042)
1.1	Background Of Study
1.2	Problem statements
1.3.1	General Project Objectives
1.3.2.1	Specific Individual Project Objective: Product Structure
1.4.2.1	Specific Individual Scope: Product Structure
1.5.1	General Project Scope
2.2.1	Specific Literature Review: Product Structure
3.3.2.1	Specific Project Design Flow: Product Structure
3.5	Product Drawing
3.7.3.1	Specific Project Fabrication: Phase 1 (Base Structure)
3.8.1	List Of Material & Expected Expenditures

4.1.2.1	Specific Part Features: Product Structure
4.1.4.1	Operation of The Specific Part: Product Structure
4.3.1	Analysis of Problem Encountered & Solutions: Product Structure
5.1.1	General Achievement of The Project
5.1.2.1	Specific Achievement of Product Structure
5.2	Contribution or Impact of The Project
5.3.1	Improvement & Suggestions for Future Research: Product Structure

	MOHAMAD QUSYAIRY BIN AZMI (24DAM22F1054)
1.1	Background Of Study
1.2	Problem statements
1.3.1	General Project Objective
1.3.2.2	Specific Individual Project Objectives: Mechanical Mechanisms
1.5.1	General Project Scope
1.5.2.2	Specific Individual Scope: Mechanical Mechanisms
2.1.2	Demand for Ice Protection Training Kit
2.2.2	Specific Literature Review: Product Mechanism
2.3.1	Related Patented Product
3.2	Overall Project Gantt Chart
3.3.1	Overall Project Flow Chart
3.4.2	Design Concept Generation

3.6.3.2	Phase 2 (Product Mechanism)
4.1.2.2	Product Specific Part Description/Functionalities: Mechanical / Mechanism
4.3.2	Analysis of Problem Encountered & Solution: Mechanical /Mechanism
5.1.2.2	Specific Achievement of Project Objectives Product Mechanical/Mechanism
5.2	Contribution or Impact of The Project
5.3.2	Improvement & Suggestions for Future Research: Product Mechanical/Mechanissm

	MUHAMMAD AIMAN HAAFIZ BIN MOHAMMED SIDEK (24DAM22F1051)
1.1	Background Of Study
1.2	Problem statements
1.3.1	General Project Objective
1.3.2.3	Specific Individual Project Objectives: Electrical/Electronic Mechanisms
1.4	Purpose of Product
1.5.1	General Project Scope
1.5.2.3	Specific Individual Scope: Electrical/Electronic Mechanisms
2.1.3	Types of Ice Protection Training Kit in Market
2.2.3	Specific Literature Review: Software/Programming
3.3.1	Overall Project Flow Chart For Icing Pro-Detector Training Kit
3.2.2.3	Specific Project Design Flow: Product Electrical/Electronic Component
3.4.2.1	Function Tree

3.4.3	Evaluation & Selection of Conceptual Design
3.5.2.3	Specific Product Drawing: Software/Programming
3.6.1.3	Material Acquisition: Electronic and Software of IPDTK
3.6.3.3	Specific Project Fabrication: Phase 3 (Electronic and Software)
3.8.3	List Of Material & Expected Expenditures
4.1.1	General Product Features and Functionalities
4.1.2.3	Specifics Part Features: Electronic and Programming
4.1.3	General Operation of IPDTK
4.1.4.3	Operation of the Specific Part of IPDTK: Electronics and Programming
4.3.3	Analysis of Problem Encountered & Solution: Electronics and Programming
5.1.2.3	Specific Achievement of Project Objectives: Software/Programming
5.3.3	Improvement & Suggestion for Future Research: Software/Programming

APPENDIX B: TURNITIN SIMILARITY REPORT

ICING PRO DETECTOR TRAINING KIT

by AKID HAZMI

Submission date: 18-Nov-2024 05:05PM (UTC+0800)
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MUHAMMAD AIMAN HAAFIZ BIN MOHAMMED SIDEK	040212-06-0571
MOHAMAD QUSYAIRY BIN AZMI	041128-14-0485

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sempena

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ICING PRO DETECTOR TRAINING KIT

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