POLITEKNIK BANTING SELANGOR

FLOURESCENT PENETRANT TESTING DEVICE

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DEPARTMENT OF AIRCRAFT MAINTENANCE

SESSION 2: 2022/2023

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

SUPERVISOR:

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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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ABSTRACT

Non-Destructive Testing (NDT) is a practice commonly used in the aviation industry to test the strength and integrity of a material or structure without destroying the test sample. One of the methods in NDT is Liquid Penetrant Inspection (LPI). Through this method, various hazardous substances are involved including the fumes from the sprays and Ultraviolet (UV) radiation from the UV lamp. These substances put the health of personnel conducting the procedure at risk. Therefore, Fluorescent Penetrant Testing Device (FPTD) has been successfully designed and developed. FPTD main goal is to mitigate the risk of exposure of the personnel to the hazardous elements, by providing enclosed designated compartments, enabling the procedures to be performed externally. FPTD is fabricated from various used materials which reduces the development cost significantly. FPTD is embedded with various sensors, controlled by UNO ESP8266 Wi-Fi Development Board to monitor the line control parameters. FPTD is also equipped with a UV light to assist the specimen inspection and a GoPro Hero 4 camera is used to conduct this process. Other than that, an exhaust fan is installed to prevent fumes build-up. Therefore, FPTD will be able to mitigate the exposure of the personnel to the hazardous elements while implementing technologies and streamline the whole inspection process. A survey regarding user satisfaction was conducted after the product demonstration. 96.7% of the respondent agrees that FPTD improves the safety of the personnel from exposure of UV light into the eyes. 93.3% of the respondent agrees that FPTD improves the safety of the personnel from exposure of UV light onto the skin, while 96.7% agrees that FPTD ensures the safety of the personnel from hazardous gas or fumes throughout the whole process. Upon experimenting the product on a TAM panel, the product is able to measure the indication with accuracy up to 98.9%, which is significantly higher that the reading obtained with naked eyes.

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LIST OF SYMBOLS

SYMBOLS	MEANING
“	Inch
A	Ampere
cm	Centimetre
G	Gram
Hz	Hertz
m	Meter
mm	Millimetre
V	Volt
W	Watt

LIST OF ABBREVIATIONS

ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
CMOS	Complementary metal-oxide-semiconductor
DHT	Digital Humidity and Temperature
DSLR	Digital Single-lens Reflex Camera
EOS	Electrical-Optical System
ESP	Espressif Modules
ET	Eddy Current Testing
FPI	Fluorescent Penetrant Inspection
FPTD	Fluorescent Penetrant Testing Device
FPTI	Fluorescent Penetrant Testing Inspection
LCD	Liquid Crystal Display
LPI	Liquid Penetrant Inspection
MT	Magnetic Particle Testing
NDE	Non-Destructive Evaluation
NDT	Non-Destructive Testing
PVC	Polyvinyl Chloride
UT	Ultrasonic Testing
UV	Ultraviolet

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Non-Destructive Testing (NDT) is a method of conducting testing on materials, components, structure and/or system without destroying or damaging the items. NDT is an efficient technique to analyses the properties of material, component, structure, or system for characteristic difference and even welding defects and discontinuities without causing damage to the original parts.

In other words, NDT is the process of inspecting and evaluating materials, components or assemblies for discontinuities, or differences in characteristics without damaging or destroying the serviceability of the parts, components, or system.

In the industry nowadays, NDT are widely used in manufacturing, fabrication, aviation, and in-service inspection to ensure product integrity and reliability, to control manufacturing process, to lower production costs, and to maintain a uniform quality level. NDT is practiced in various industry to ensure the necessary integrity for its usefulness and the safety of the public.

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Figure 1.1: Fluorescent Penetrant Testing (Source Advanced Engineering: Google)

Figure 1.1 shows one of many NDT methods, Fluorescent Penetrant Testing, which are commonly used in the aerospace and medical industries. This method allows NDT personnel to detect defects on welds and/or cracks on parts with the aid of UV Light.

"The field of Non-Destructive Evaluation (NDE) or Non-Destructive Testing (NDT) involves the identification and characterization of damages or defects on the surface and interior of materials without cutting apart or otherwise altering the material. In other words, NDT refers to the assessment or evaluation and inspection process of materials or components for characterization or finding defects and flaws in comparison with some standards without altering the original attributes or harming the object being tested." (Dwivedi S.K. et al., 2017).

Based on the statement above, it has been clarified that NDT is very reliable in detecting defects such as cracks, or discontinuities in parts without damaging the originality of the materials. NDT is widely used in many industries such as in the aerospace industry, nuclear industry, and manufacturing.

As stated in the article by Dwivedi S.K. et al, in 2017, there are many variants of NDT available worldwide. The eight most used NDT techniques are:

1. Visual Testing (VT)
2. Ultrasonic Testing (UT)
3. Radiography Testing (RT)

4. Eddy Current Testing (ET)
5. Magnetic Particle Testing (MT)
6. Acoustic Emission Testing (AE)
7. Penetrant Testing (PT)
8. Leak Testing (LT)

1.2 PROBLEM STATEMENT

The current method of conducting Fluorescent Penetrant Test imposed various problems to the conducting personnel. Taking SKC-S Aerosol solvent cleaner which is widely used in Solvent Removable method for an example, contains hydrocarbons mixtures. Breathing the fumes from the spray may lead to asphyxiation, narcosis, cardiac arrest, and aspiration.

*"**Prolonged breathing of penetrant vapors, emulsifier vapors or solvent remover vapors may cause headaches, nausea or tightness or pain in the chest**."* (The American Society for Nondestructive Testing, 2012).

In the conventional method, the personnel will be handling the chemical several times. Hence, the risk of inhaling the fumes is high.

Other than the fumes, the UV light utilized for the inspection process in the conventional method induces several health problems for the personnel. According to the National Center for Environmental Health, people who are exposed to UV light without eye protection have a higher risk of blinding eye diseases. Exposure to UV radiation also may lead to serious health issues including skin cancer and eye cancer.

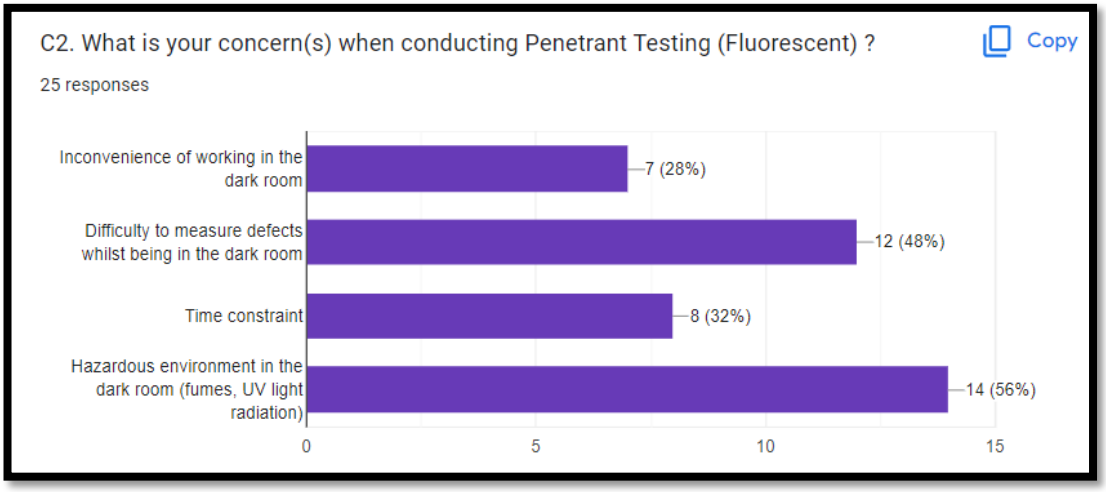


Figure 1.2: User's Concerns When Conducting FPI (Fluorescent)

Figure shows the response from survey form on user's concerns when conducting PTI (Fluorescent). The factor that received the highest number of votes is hazardous environment in the dark room with 56%.

1.3 PROJECT OBJECTIVES

1.3.1 Project Objectives

This project aims to:

- To obtain the design requirements of the Fluorescent Penetrant Testing Device determined by NDT personnel and students studying NDT through survey questionnaire.
- To formulate the conceptual design of the Fluorescent Penetrant Testing Device that meets the user expectation.
- To develop FPTD as per design which able to minimize the risk of hazardous fumes and exposure of UV rays to human skin.
- To evaluate the user satisfaction level upon the completion and demonstration of FPTD.

1.3.2 Specific Individual Objectives

1.3.2.1 Product Structure

This project is aimed:

- To develop FPTD which comprises 2 different phases which is the Preparation Compartment for the first phase, and the Inspection Compartment for the second phase.
- To design a functional access between the two compartments for test specimen transfer purpose
- To demonstrate the function of the Preparation Compartment and the Inspection Compartment

1.3.2.2 Product Mechanism (Mechanical)

This project is aimed:

- To design a conveyor belt that can transport test specimen from preparation section to inspection section.
- To develop a mechanism of transportation by using multiple conveyor roller connected by sprocket and chain and is controlled by an actuator outside the device.
- To demonstrate a functional mechanism of transportation without being exposed to hazardous fumes of solvent remover, penetrant and developer.

1.3.2.3 Software / Electronic

This project aimed to:

- To design and embed the electrical and electronic components to the FPTD which link to the electrical system.
- To design and develop appropriate software programming which encode Arduino programming language as part the image processing and measuring system.
- To design and develop a mechanical system that can decrease human intervention as much as possible.

1.3.2.4 Accessories & Finishing

This project is aimed:

- To furnish FPTD with appropriate and beneficial accessories to increase and improve its functionality.
- To finish FPTD with materials or coatings that are able to block ambient light, while being able to content the fumes and UV light throughout the testing process.
- To design FPTD with aesthetic looks and finishing without affecting the functionality of the product.

1.4 SCOPE OF PROJECT

1.4.1 General Project Scopes

First and foremost, this product is only applicable for fluorescent penetrant testing because this test uses many substances that are hazardous to the personnel conducting the test. The two sections of FPTD, preparation section and inspection section allow the hazardous fumes to be contained inside a closed box.

By using Adobe Photoshop, the dimensions of the defects found on the test subject can be measured without difficulty of taking reading in the dark. FPTD also allows users to review the defects on the test subject outside of the dark room through monitor screen or printed result with 1:1 scale.

1.4.2 Specific Individual Scope

1.4.2.1 Product Structure

FPTD will concentrate on Fluorescent Penetrant Testing to improvise the current testing method, while adhering to American Society for Testing and Materials standards in accordance with ASTM E1219-21. This document specifies the standard practice for Fluorescent Liquid Penetrant Testing using Solvent-Removable method.

FPTD is designed in such a manner that it increases the safety of the personnel by reducing the risk of exposure to the noxious fumes from various chemicals and the UV light throughout the testing process.

1.4.2.2 Product Mechanism (Mechanical)

Foremost, this product can only be used for test subject of specific dimensions. FPTD is a prototype that only allows small to medium sized test subject as the device is portable. The conveyor system and the size of each section are subjected to certain size object to be tested.

Furthermore, this product is designed in such way that it can be portable in order to allow personal to conduct testing without being in a specific dark room in a laboratory.

1.4.2.3 Electronic and Software

This product is designed to keep human intervention as minimal as possible to minimize NDT personnel from being exposed to the dangerous fumes of the material used in penetrant testing and the ultraviolet ray of the UV light. This problem is solved by remotely viewing and identifying defects remotely via the use of a camera where the image is then projected to a desktop device where the defect is then measured using the tools available in Adobe Photoshop.

1.4.2.4 Accessories and Finishing

Since conventional Fluorescent Penetrant Testing using Solvent-Removable method does include the applications of various type of chemicals in spray can, FPTD is designed to be able to hold and organize such cans.

Other than that, the project is to be finished with coatings and materials that are able to bring down the exposure of the personnel to hazardous fumes and UV light throughout the testing process.

1.5 Project Impact

FPTD is designed to be a low-cost device to replace the Fluorescent Penetrant Inspection line. Next, using FPTD creates a workplace that is safer for the personnel since it reduces the exposure of the personnel to the fumes and UV light while conducting LPI.

Other than that, the features in FPTD where picture of the sample is captured gives the personnel sufficient time to conduct the inspection. The design of FPTD is also compact and space savings.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

2.1.1 NDT in AVIATION

NDT plays a very important role in the aerospace sector. This method of testing involves almost all phases in the aviation industry, from the design phase, up to maintenance during operation. To ensure the safety of an aerospace product, researchers utilize NDT in developing a structure that is lightweight, flexible, and durable at the same time. For maintenance purposes, NDT is used to inspect aircraft parts for damage or cracks at regular intervals to maintain the airworthiness of the parts. (*Element Materials Technology (n.d))*

2.1.2 Types of NDT

2.1.2.1 Visual Testing (VT)

It is a technique of collecting visual data on the status of a material and is the most basic and easiest way to examine and analyze material or object without altering it in any shape or form. It can be easily done with the naked eye by inspectors reviewing the material visually with the aid of flashlight. Remote visual inspection (RVI) can also be used to conduct visual testing with the aid of inspection camera by attaching it to a robot or drone and can also be done by using a borescope. *(Marlin Steel Wire Products (February 25,2020))*

Figure 2.1: Visual Inspection by Borescope (Google n.d.)

2.1.2.2 Ultrasonic testing (UT)

It is an inspection method that uses the process of transmitting high-frequency sound waves into a material to identify changes in the material's properties or defects and imperfections on the surface of a material. Pulse echo is the most common technique when conducting Ultrasonic Testing by emitting sound waves into a material and measures the echo or sound reflection produced by imperfection on the surface of the material when they are emitted back to a receiver.

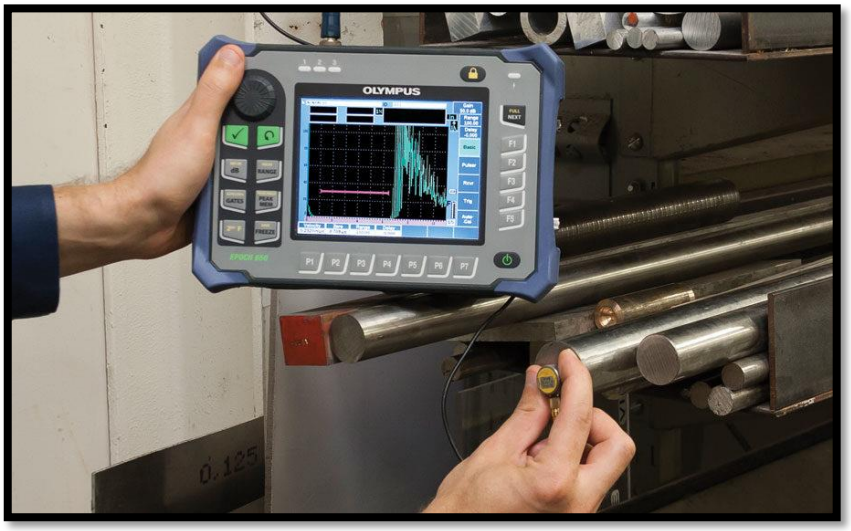


Figure 2.2: Conducting an Ultrasonic Testing (Google n.d.)

2.1.2.3 Eddy Current Testing (ET)

ET is a method that uses measurement of the strength of electrical current also known as Eddy Current in a magnetic field surrounding a material to analyze defects of a material that also includes the location of the defects. The flow of Eddy Current in the magnetic field surrounding conductive material is examined as the defects and imperfection will causes interruption in the surrounding magnetic field.

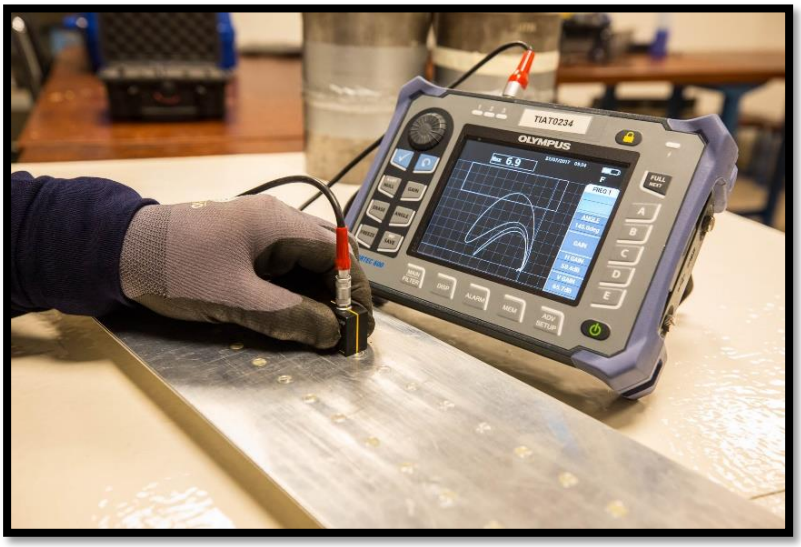


Figure 2.3: Conducting Eddy Current Testing (Google n.d.)

2.1.2.4 Magnetic Particle Testing (MT)

MT is the inspection technique to identify imperfections in a material by examining magnetic disruption in the flow of magnetic field within the material. Magnetic field is induced in a material that is very susceptible to magnetization. The surface of material needs to be covered with iron particles such as iron powder. If there are defects or imperfections within the material, the flow of magnetic field will be disrupted thus creating a visual indicator for the location of imperfections or defects.

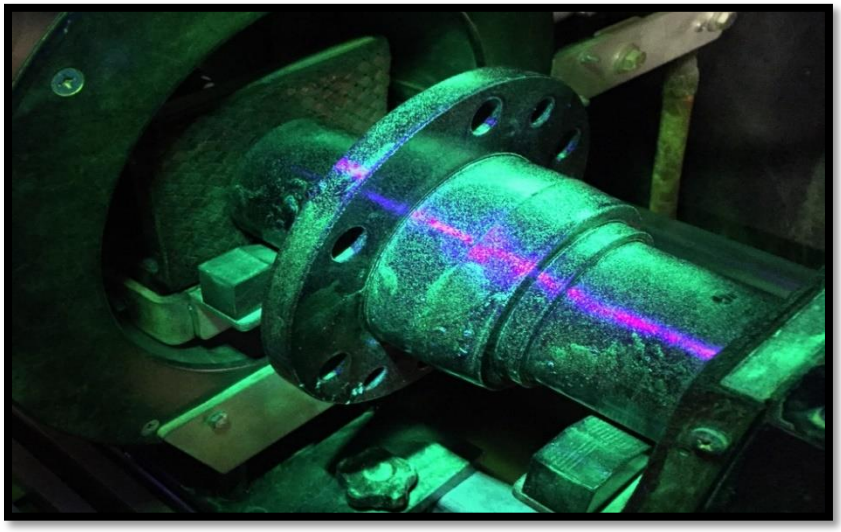


Figure 2.4: Magnetic Particle Suspended at Defected Area (Google n.d.)

2.1.2.5 Penetrant Testing (PT)

Also refers to Liquid Penetrant Testing is a test that uses liquid to coat a material and inspecting for breaks in the liquid to identify defects in material. There are two types of penetrants, fluorescent penetrants, and visible penetrants. It consists of six-stage process,

- surface cleaning (degreasing etc.)
- application of a penetrant liquid (dipping, spray, brush)
- removal of excess penetrant (solvent, water)
- application of developer
- inspection of test surface (visual, television camera)
- post-inspection cleaning (anti-corrosion solutions).

Figure 2.5: Liquid Penetrant Testing (Google n.d.)

2.1.3 Types of Liquid Penetrant Testing

There are two types of Liquid Penetrant Testing that are widely used currently in industry, and these are.

i. Visible penetrants or Dye penetrants
ii. Fluorescent penetrant

2.1.3.1 Visible penetrants or dye penetrants

Contains a red dye that provides high contrast against the white developer background. Sprayed directly onto the test subject and inspection can be done with naked eye without UV light.

Figure 2.6: Dye Penetrant Testing (Google n.d.)

2.1.3.2 Fluorescent Penetrant

The test subject is sprayed with dyes that fluoresces when exposed to ultraviolet radiation (UV ray). Inspection of defects needs to be done in a dark room. The fluorescent dye will be suspended on the surface of the defected parts of the test subject according to ASTM1417. The cracks or defects will hold the fluorescent penetrant within, once the developer has been applied, the cracks will become visible to the naked eye but only if it is subjected under UV light.

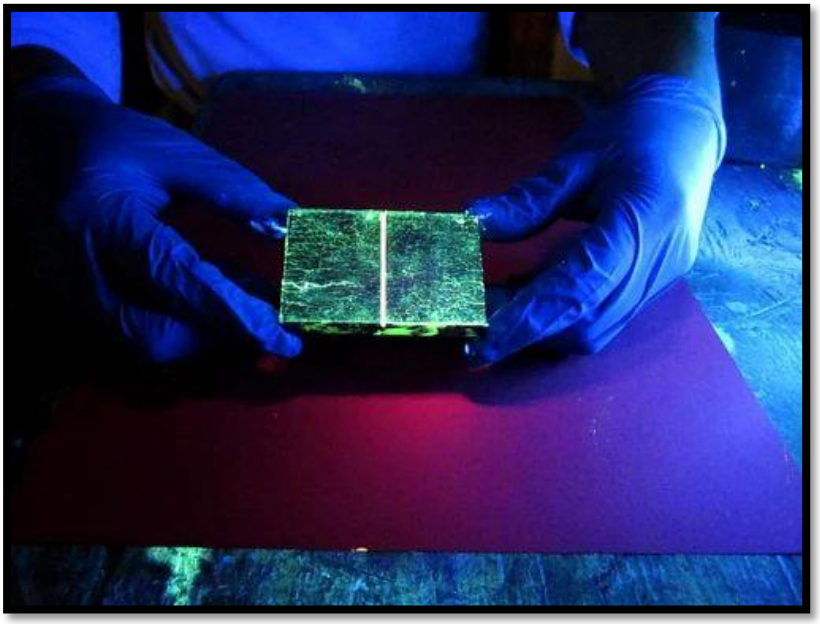


Figure 2.7: Fluorescent Penetrant Testing (Google n.d.)

2.1.4 Liquid Penetrant Inspection Key Player (Magnaflux)

2.1.4.1 Company Overview

Magnaflux was founded in 1934 by Victor de Forest and Foster Doane, this company is based in Wiltshire, United Kingdom. However, Magnaflux only started to work on the production of fluorescent and dye penetrants after working together with Switzer in The United States, Brent Chemicals in The Great Britain, Adler (Blohm & Voss) and Klumpf (Junkers) in Germany.

After over 80 years since the foundation of the company, Magnaflux has now become the major key player in non-destructive testing in general including Penetrant Testing.

2.1.4.2 Magnaflux Penetrant Testing Solvent-Removable Method Products

Products	Description
 ZL-67B	Level 3 water washable fluorescent penetrant for Method A/C liquid penetrant testing

 ZL-27A	Level 3 post-emulsifiable fluorescent penetrant for Method B/C/D liquid penetrant testing
 ZP-5B	Water suspendible developer for Form C liquid penetrant testing
 ZP-14A	Water soluble developer from Magnaflux for Form B liquid penetrant testing
 SKC-S	Cleaner and remover for pre-cleaning before testing and for removing excess surface penetrant.
 C10	Cleaner and remover for pre-cleaning before testing and for removing excess surface penetrant.
 C5	Cleaner and remover for pre-cleaning before testing and for removing excess surface penetrant.
 ZA-915	Stand-alone penetrant testing equipment for moderate volume liquid penetrant inspection.
 EV6000	Portable, handheld LED UV lamp for black light inspection during fluorescent PT or MT testing.

 EV6500	High-intensity, dual-light LED UV lamp for black light inspection during fluorescent NDT
 NDT Light Meters	For measuring UV-A black light and visible white light
 Dual-channel Process Timer	Allows simultaneous programming of two different activities.
 Test Pieces	To measure performance as part of regular system checks for penetrant testing.
 Enclosure Hood	To darken the inspection area to levels well below the common standards and create a very functional inspection environment

Table 2.1: Magnaflux Penetrant Testing Solvent-Removable Method Products

2.2 SPECIFIC LITERATURE REVIEW

2.2.1 Product Structure

The selection of materials for the product structure plays a very significant role in achieving the project objectives. The structure of FPTD is further classified into two main groups, which are the primary structure (main) and the secondary structure.

For the first classification, the main structure frame should be able to support the weight of the casing, panels, and accessories of the product. While the durability of the material for the main structure is the priority, other factors to be considered are the weight, workability, and the cost.

The structures that fall under the second classification are the panels, casing, and veil. Over a wide range of materials available for the panels and the casing, the aspects for consideration are the ability of the material to content the fumes and UV light within the device, surface finish, durability, easy to clean, and cost.

2.2.1.1 Liquid Penetrant System

According to NDT SUPPLY.COM, a Liquid Penetrant System can be arranged in linear, “L” or “U” layout. The process of conducting a Liquid Penetrant Inspection involves several phases. Thus, a Liquid Penetrant Inspection Line is equipped with various equipment.

Figure 2.8: “L” Layout of Liquid Penetrant System (NDT Supply.com, Inc, n.d.)

A Modular LPI System consists of a Pre-cleaning station, Penetrant Station, Dwell Station, Rinse Station, Dryer Station, Rest Station, Developer Station, and Inspection Station. The stations are equipped with grills and rollers.

Inside the Rinse Station and the Inspection Station, also known as the “darkroom”, UV light is required to observe the surface condition of the test piece and for inspection. The Rinse Station and the Inspection Station are enclosed with hoods or curtains to darken the inspection area.

2.2.1.2 Minimum Safety Requirements

According to Occupational Safety and Health Administration, United States

Department of Labor, a safe workplace is defined to be free from serious recognized hazards complying the standards, rules, and regulation under the OSH Act.
zetec.com stated that one of the biggest risks encountered by the NDT personnel is the UV radiation from the black light operation. Hence, it is highly recommended for the personnel to wear appropriate PPE due to the potential of serious burns when coming in contact with the black light bulb. The UV radiation also imposed other serious health problems on the personnel.

2.2.1.3 Types of Material for Product Structure

2.2.1.3.1 Hollow Steel Tube

The primary structure of FPTD is made of hollow steel tubes. Steel is well recognised for its number of properties which are hard, tough, high tensile and fatigue strength, resistant to corrosion and highly malleable.

Figure 2.9: Square Section Hollow Steel Tube (K. Seng Seng Corporation Berhad, n.d.)

Hollow steel in the market comes in various shapes, size, and thickness. Consumers can opt between round section, square section, or rectangular section hollow tubes. The size and the thickness vary depending on the shape.

2.2.1.3.2 Aluminium Sheet

In the development of FPTD, 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.

Figure 2.10: 3003 Corrosion Resistance Aluminium Sheet (MACSTEEL, n.d.)

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 to 6.5 mm.

2.2.1.3.3 Clear Acrylic Perspex

Perspex is a solid transparent plastic made of polymethyl methacrylate. The properties of acrylic Perspex which are excellent optical clarity and transparency, high temperature resistant, high impact resistant, lightweight when compared to glass and highly resistant to many different chemicals make this material suitable for the product development particularly in the construction of the panel for preparation section.

Figure 2.11: Ruudra Scott Clear Perspex Acrylic Plastic Sheet (Source: Desertcart, n.d.)

The clarity of an acrylic sheet depends on the thickness. The thickness ranges from 30mm to 100mm.

2.2.2 Product Mechanism (Mechanical)

Our product consists of two separate sections, the Preparation Section, and the Inspection Section. Fumes from penetrant, solvent and developer are very hazardous to the health being of any individual that will be conducting the test. In order to contain the hazardous fumes from escaping, a mechanical mechanism is required to transport any test subject from the Preparation Section to the Inspection Section. To achieve this, a conveyor system will be connected for both sections.

2.2.2.1 Conveyor System

A conveyor system is a system that is widely used in transporting loads and materials within an area. This system increases efficiency and reduces production time in industry. It minimizes human error. They are various types of conveyor system such as,

i. Conveyor belt
ii. Conveyor chain
iii. Conveyor roller ball mat
iv. Conveyor roller

2.2.2.1.1 Conveyor Belt

Figure 2.12: Conveyor Belt System (Shopee n.d.)

The conveyor belt system uses a long thick and durable material such as rubber and is

connected with two pulleys at both ends. The pulley on both ends moves in the same direction allowing the belt to move and goods can be transported along the belt.

2.2.2.1.2 Conveyor chain

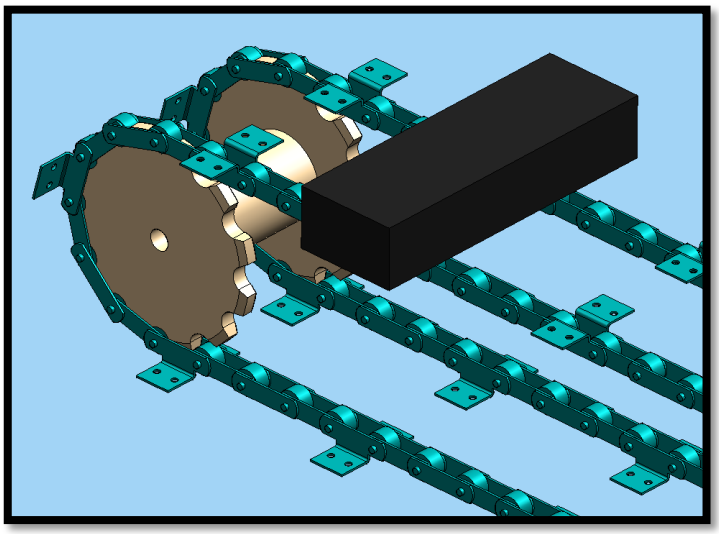


Figure 2.13: Conveyor chain system (Wikipedia from Google)

A conveyor chain is a goods transporting system that runs on an endless chain arranged in parallel. Sprockets fit on both ends. This conveyor system fully utilizes a continuous powered chain arrangement to aid carrying a series of single pendants.

2.2.2.1.3 Conveyor Roller Ball

Figure 2.14: Conveyor Roller Ball (Conveyors and Drives Inc. n.d.)

This conveyor system is used when goods need to be transported on a single system but in multiple directions. The ball are able to move in all directions to meet specific direction of transporting.

2.2.2.1.4 Conveyor Roller

Figure 2.15: Conveyor Roller System (Google n.d.)

Roller conveyors are a series of rollers supported within a frame allowing objects to be transported along the series of rollers. Roller conveyors allow versatility to the type of transfer, diverters, and stops that can be used as part of conveyor system or automation system.

Conveyor roller was opted for our product due to several factors such as,

i) The gap between each roller allows any substances from excess penetrant, solvent, or developer to drool down and not contaminate the whole device. This is to ensure the device can be used multiple times without worrying about contamination.

ii) Conveyor rollers are usually made up of mild steel, galvanized, plastic or stainless steel, this allows for easy cleaning of our conveyor system.

2.2.2.2 Pulley Mechanism

In order for the test subject to be moved along the conveyor system, when one roller moves, the series of rollers will move together, thus pulley system comes in action. For this pulley system, we have decided to connect each individual roller to a chain and sprocket system. To achieve the pulley system, the system is connected to a crank handle that user can turn from outside the device.

2.2.2.2.1 Chain and Sprocket System

Chain is used to connect to the first sprocket called the driver sprocket and will continue to be connected to another sprocket called the driven sprocket. This way, motion and force can be transmitted to other sprockets via the chain from one sprocket to another. A sprocket is a toothed wheel or gear that is fit onto a shaft. This system will allow the conveyor roller to roll on its shaft when force is given to one sprocket. As an additional point, this system prevents the conveyor roller from rolling by itself as its shaft is fitted to the toothed wheel called the sprocket.

Figure 2.16: Chain and Sprocket System (Google n.d.)

2.2.2.2.2 Crank Handle

The crank handle is a mechanical arm that's attached to a slightly longer shaft at a right angle and has a connecting rod at the shaft end, known as conrod that are responsible to convert circular motion into rotary or reciprocating motion.

Crank handles are manually operated by hand-turning and are operated by turning the handle in a circular motion. For our product, this crank handle is used to turn the driver sprocket that is responsible for turning the other driven sprocket connected by roller chain.

Figure 2.17: Crank Handle (Google n.d.)

2.2.3 Electronic and Software

This section elaborates more about the electronic devices and software used in the Fluorescent Penetrant Testing Device to assist in the process of capturing, identifying, and measuring the defect on the work piece.

2.2.3.1 Type of Electronic (Camera)

The electronic used in the Fluorescent Penetrant Testing Device that is used to capture the image is a digital camera. A digital camera uses an array of millions of tiny light cavities or "photosites" to record an image, the image is then sent to the desktop device for further processing procedure.

2.2.3.1.1 Action Camera

An action camera or action camera is a digital camera designed for recording action while being immersed in it. Action cameras are therefore typically compact and rugged, and waterproof at surface-level. They typically use CMOS image sensors and can take photos in burst mode and time-lapse mode as well as record high-definition video.

The action camera was chosen because of its small and compact and additionally because of its simple shape, it is much easier to be implemented to the Fluorescent Penetrant Testing Device. They are also much cheaper to acquire and to run rather than a full size DLSR camera, which is an expensive option to begin with, but they also require an elaborate setup and adaptor to make it possible to be connected to a desktop as an output.

Figure 2.18: GoPro Hero 4 (The Technology Man n.d.)

2.2.3.1.2 Professional DSLR Camera

DSLR refers to digital single-lens reflex camera is a camera that utilizes the mechanism of a single-lens reflex camera in cooperation with the mechanism that of a digital camera imaging sensor. When light enters the camera lens of a DSLR a photographer sees their subject in the optical viewfinder via a reflection of that light from a mirror inside the camera body. When the photo is taken, the mirror swings out of the way and the light goes through to the digital image sensor, where the photo is captured on an SD card. This is different from mirrorless cameras, where the light goes directly to the image sensor and the photographer sees what they're shooting via a rear LCD screen or an electronic viewfinder.

This option was taken into consideration due to the high-definition image. It is capable of capturing what reinforce this choice is due to DSLR camera commonly are made with modularity in mind. Such features include interchangeable lenses, battery extension, and light attachments but, it was not the chosen option due to the price range.

DSLR cameras are usually sold at a premium and may cost over RM 600 even for the cheapest option. Other factors that lead to this decision are also its form factor, DSLR cameras are bulky and heavy to be carried around.

Figure 2.19: Canon EOS Mark 3 (Google n.d.)

2.2.3.1.3 Smartphone Camera

As the name states, a smart phone camera is the image capturing device that is the most abundant and easy-to-access since everyone owns a smart phone. in short smartphone cameras are digital camera that is implemented to a smartphone. They work exactly as the likes of normal digital camera; it is just that they are in a smartphone.

Smartphone camera came into consideration due to its availability, but they are not chosen because the aspect ratio for the image from a smartphone camera is usually not the same than that of a generic desktop display and different even from other smartphone brands. Desktop displays are generally 16:9 aspect ratio if image from different aspect ratio is used image in the display may be displayed as “stretched” or “squeezed” hence making the smartphone camera as an undesirable option.

Figure 2.20: iPhone 14 (ThePCMag n.d.)

2.2.3.2. Type of Software

Software is a set of instructions, data or programs used to operate computers and execute specific tasks. The software implemented in the image processing section of the Fluorescent Penetrant Testing Device is used to identify and measure dimension of the workpiece and defect to be filled in the checklist.

2.2.3.2.1 Adobe Photoshop

Adobe Photoshop is a raster graphics editor developed and published by Adobe Inc. for Windows and macOS. It was originally created in 1988 by Thomas and John Knoll. Since then, the software has become the industry standard not only in raster graphics editing.

Adobe Photoshop is chosen because of its ruler feature that can make measuring object easier this also minimalize programming and allow us to focus on other matter in the project.

2.2.3.2.2 Open CV Python

Open CV is a library for computer vision task, this task varies from movement tracing, facial recognition, and object detection. Open CV can be used on multiple other programming language including Python and Java C++. This program is versatile but still requires programming to be implemented.

Open CV is an option within this project but was decided to be unsuitable as it is much more complicated to use.

2.2.3.3 Type of Electronic (Microcontroller)

In general, a microcontroller is essentially a small computer used to run the operation that we program into it. They are also engineered to be modular and able to be connected to different types of input such as sensors, cameras, and microphones, and likewise with outputs such as LED lights, Haptic devices etc.

2.2.3.1 Arduino UNO Wi-Fi

The Arduino UNO Wi-Fi is a microcontroller or circuit board with Wi-Fi and Bluetooth integrated into it allowing wireless connectivity to our devices. It is capable of becoming a wireless host for multiple devices to be connected as an ad 'hoc.

Figure 2.21: Arduino Uno Wi-Fi Rev2 ABX00021 (Electromaker.io n.d.)

2.2.3.3.2 Arduino Nano

The Arduino nano is a microcontroller/circuit board that is capable of doing simple programming and is breadboard friendly. Unlike the Arduino Uno Wi-Fi the Arduino Nano does not have the capability to be connected to other devices wirelessly but it is still capable of receiving input and executing code and output it to other devices just minus the wireless capability.

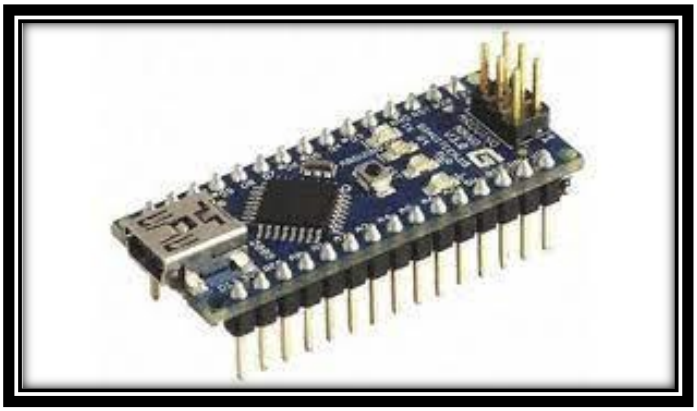


Figure 2.22: A000005 | Arduino, Nano Development Board (RS Components)

2.2.4 Accessories & Finishing of FPTD

The accessories and furnishings in FPTD are to enhance the function of the product, including to improve the user's experience. FPTD is finished in such a way that the product's function is not impacted while having a good aesthetic value.

2.2.4.1 Spray Can Holder

A spray can holder's purpose is to hold spray can, preventing misplaced and to promote a well-organized workstation. The spray can holder in FPTD should be able to hold at least 3 cans at a time.

Figure 2.23: Magnetic Spray Can Holder YKHD-02 (MiSUMi, n.d.)

YKHD-02 Magnetic Spray Can Holder able to hold up to 4 cans with each less than 76 mm in diameter. The cans can be retrieved easily due to the design of upper surface of the holder which is tilted forward at the front.

2.2.4.2 A4 Document Holder

An A4 document holder function in this product is to hold A4-sized papers. In FPTD, A4 document holder is reserved to keep documents including User's Manual and Pre checklist Form.

Figure 2.24: deflect-O A4 Wall Mount Holder (Source: Officeworks, n.d.)

Deflect-O A4 Wall Mount Holder has a high storage capacity, with a pocket depth of 60 mm and dimension of 240 x 75 250 mm. The holder, which is designed with an open end makes it ideal for a variety of document types providing an easy access.

2.2.4.3 Matte Black Spray Paint

The steel tubes and the aluminium sheet are highly reflective in their original state. This condition likely will affect the image quality negatively. Hence, a suitable surface finish is highly required.

Figure 2.25: Samurai 92 Matt Black (SAMURAI, n.d.)

Matte black reflects very little light. The base for the Samurai 92 Matt Black spray paint

is acrylic resin, which has the ability to resist petrol and cracks. The paint is also flexible enough to maintain the paint integrity under various weather factors.

2.3 REVIEW ON RECENT RESEARCH / RELATED PRODUCTS

2.3.1 Related Patented Products

Table 2.2: Nondestructive Inspection Method and Apparatus

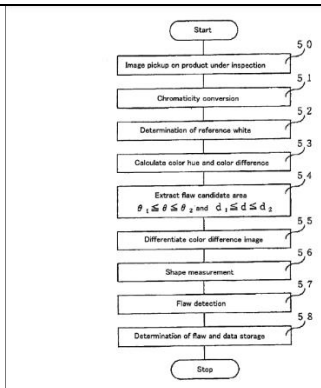
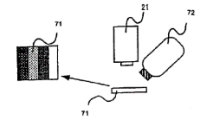
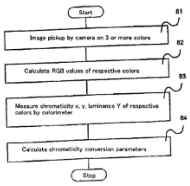
No.	Patented Product	Patent Summary
1.	  FIG.8 	**Patent Title:** Nondestructive Inspection Method and Apparatus **Patent No.:** US6950545B1 **Published Date:** 27/09/2005. **Patent Office Country:** United States **Inventors:** Mineo Nomoto, Daiske Katsuka, Tashio Asano, Kaoru Sakai, Tetsuo Taguchi, Isao Tanaka **Abstract:** The present invention relates to a method for inspecting a crack in a metal surface or the like, and, particularly, to an inspection method and apparatus for nondestructive inspection such as liquid penetrant inspection and magnetic particle testing. The present invention provides a flaw inspection method that essentially comprises the steps of illuminating a surface of a sample to be inspected, obtaining an image of the surface, characterizing a potential flaw on the inspected surface by processing the obtained image, displaying an image of the potential flaw, verifying that the potential flaw is a true flaw, and storing an image of the verified flaw in memory.

Table 2.3: Ultraviolet Remote Visual Inspection System

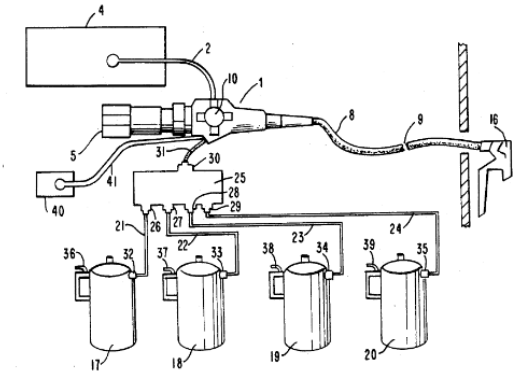
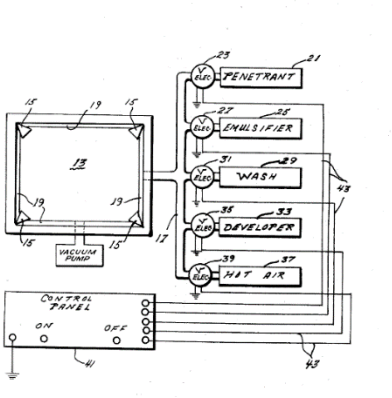
No.	Patented Product	Patent Summary
1.		**Patent Title:** Ultraviolet remote visual inspection system **Patent No.:** US5115136A **Published Date:** 19/05/1992. **Patent Office Country:** USA **Inventors:** Michael D. Tomasch **Abstract:** The invention provides an ultraviolet remote visual inspection system which enables the operator to detect minute cracks and hairline flaws in normally inaccessible places of manufactured parts. The system includes a fiberscope in combination with a source of white light and ultraviolet light and a plurality of cannisters for holding dye penetrant and other materials which can be used to facilitate the inspection. The fiberscope includes an articulated probe having a working channel, an ultraviolet light guide, and an objective lens.

Table 2.4: Automated Liquid Penetrant Inspection System

No.	Patented Product	Patent Summary
1.		**Patent Title:** Automated Liquid Penetrant Inspection System **Patent No.:** US3762216A **Published Date:** 02/10/1973. **Patent Office Country:** USA **Inventors:** E. Mendoza **Abstract:** A system of in situ inspection of critical jet engine parts for defects by applying a high penetrating fluorescent oil and inspecting under a light of the proper wavelength. The system, which is unitized and portable includes an evacuatable chamber suitable for containing the parts to be inspected. A series of tanks containing the pressurized solutions of penetrant emulsifier wash and developer as well as a hot-air tank are operatively connected to the chamber so that the required solution can be applied under proper conditions for the necessary time period to thereby disclose any defect in the critical engine part.

2.3.2 Recent Market Products

Table 2.5: Recent Market Product

No.	Marketed Product	Product Summary
1.		**Product Name:** ZA-915 **Published Date:** N/A **Inventors:** Magnaflux **Description:** The ZA-915 system is one of the most popular penetrant testing systems on the market. As a multistation process for components up to 850 mm x 850 mm x 750 mm in size, it offers the flexibility of modular construction and has the added advantage of simple tank additions to meet your specific requirements. Designed to operate from the left or the right, the system can, when arranged in a straight-line configuration, be used either as a manual unit or in conjunction with a linear robot for fully automatic applications. Alternatively, where space is limited, the ZA-915 can be arranged in a 'U' or 'L' configuration to suit the area available.
2.		**Product Name:** Magnaflux® Fluorescent Dye Penetrant Kit **Inventors:** Magnaflux **Description:** Magnaflux® Fluorescent Dye Penetrant Kit comes with dyes, UV light, and other accessories to help you find the tiniest cracks in just about any metal surface. Highly sensitive fluorescent dyes comply with most military specifications for fluorescent inspection.

3.		**Product Name:** Ultraviolet (UV) VJ-3 Video Borescope **Inventors:** ViewTech Borescope **Description:** Facilitate endoscopic dye and fluorescent penetrant inspection testing by detecting internal and external surface defects such as micro-fracture, delamination, seams, incomplete fusion, and other defects in all non-porous materials

2.4 COMPARISON BETWEEN PATENTED PRODUCT, RECENT MARKETED PRODUCT AND CURRENT PROJECT

Table 2.6: Nondestructive Inspection Method and Apparatus vs. FPTD vs. ZA-915

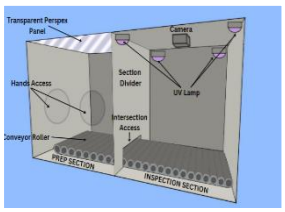
Product	Nondestructive Inspection Method and Apparatus	FPTD	ZA-915
Design	N/A		
Portability	NO	YES	NO
Purpose	To ease the process of indication measuring and record keeping	To reduce the exposure of the personnel from hazardous fumes and UV light	Providing a flexible modular construction for LPI system
Dimension	N/A	80 x 30 x 40 mm	
Indication Measuring	REMOTE	REMOTE	ONSITE
Features	-Remote indication interpretation -Storing image of the flaw in memory	- Compact - Remote indication interpretation - Prevent direct contact of the personnel to fumes and UV light	-Can process components up to 850 x 850 x 750 mm in size

Table 2.7: Automated Liquid Penetrant Inspection System vs. FPTD vs. Magnaflux® Fluorescent Dye Penetrant Kit

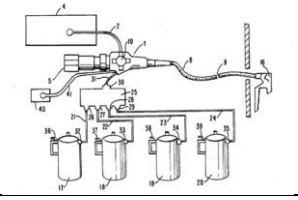
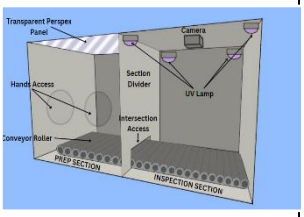
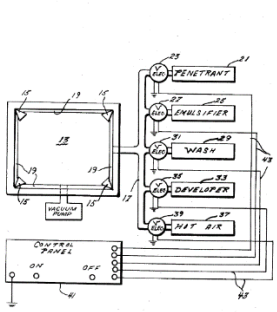
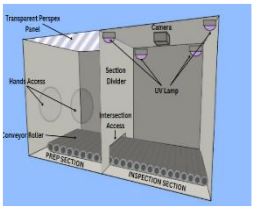
Product	Automated Liquid Penetrant Inspection System	FPTD	Magnaflux® Fluorescent Dye Penetrant Kit
Design			
Portability	NO	YES	YES
Purpose	Although not automated it is made to minimize exposure to UV rays	To reduce the exposure of NDT personnel from being exposed to hazardous fumes and UV light	Inspection done as per normal procedure
Dimension	N/A	80 x 30 x 40 mm	N/A
Indication Measuring	ONSITE	REMOTE	ONSITE
Features	• Remote defect identification • Able to inspect internal defect • Only prevent direct contact to UV rays	• Compact. • Remote indication interpretation. • Prevent direct contact of the personnel to fumes and UV light	• Have a complete setup to do fluorescent penetrant testing

Table 2.8: Automated Liquid Penetrant Inspection System vs. FPTD vs. Ultraviolet (UV) VJ-3 Video Borescope

Product	Automated Liquid Penetrant Inspection System	FPTD	Ultraviolet (UV) VJ-3 Video Borescope
Design			
Portability	NO	YES	YES
Purpose	Automated in terms of applying penetrants, emulsifier, cleaner, and developer.	To reduce the exposure of NDT personnel from being exposed to hazardous fumes and UV light	Inspection of internal parts can be done with borescope
Dimension	N/A	80 x 30 x 40 mm	N/A
Indication Measuring	ONSITE	REMOTE	ONSITE
Features	Automated application of penetrants, solvent, emulsifier, cleaner and developer	• Compact. • Remote indication interpretation. • Prevent direct contact of the personnel to fumes and UV light	Able to inspect internal defects and is displayed on a device

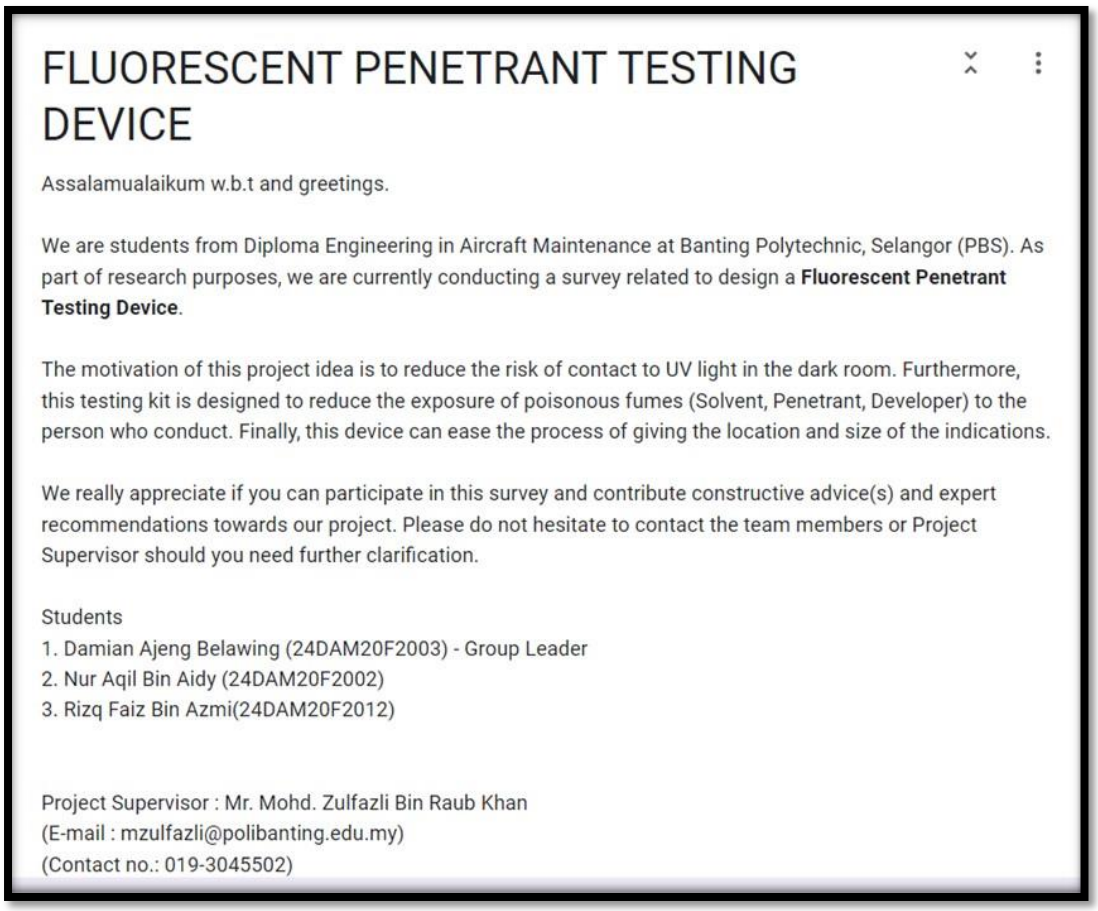
CHAPTER 3

RESEARCH METHODOLOGY

3.1 DESIGN ENGINEERING TOOLS

3.1.1 Design Requirement Analysis

3.1.1.1 Questionnaire Survey



FLUORESCENT PENETRANT TESTING DEVICE

Assalamualaikum w.b.t and greetings.

We are students from Diploma Engineering in Aircraft Maintenance at Banting Polytechnic, Selangor (PBS). As part of research purposes, we are currently conducting a survey related to design a **Fluorescent Penetrant Testing Device**.

The motivation of this project idea is to reduce the risk of contact to UV light in the dark room. Furthermore, this testing kit is designed to reduce the exposure of poisonous fumes (Solvent, Penetrant, Developer) to the person who conduct. Finally, this device can ease the process of giving the location and size of the indications.

We really appreciate if you can participate in this survey and contribute constructive advice(s) and expert recommendations towards our project. Please do not hesitate to contact the team members or Project Supervisor should you need further clarification.

Students
1. Damian Ajeng Belawing (24DAM20F2003) - Group Leader
2. Nur Aqil Bin Aidy (24DAM20F2002)
3. Rizq Faiz Bin Azmi(24DAM20F2012)

Project Supervisor : Mr. Mohd. Zulfazli Bin Raub Khan
(E-mail : mzulfazli@polibanting.edu.my)
(Contact no.: 019-3045502)

Figure 3.1: Questionnaire Survey through Google Form

The survey was conducted through Google Form, questions were divided into FOUR (4) different parts.

- PART A: Respondent's Demographic
- PART B: User's Experience
- PART C: Problem Faced by Users
- PART D: Product Improvement

The survey was distributed to NDT Personnel of General Electric (GE) Company and Semester 5 Session 1: 2022/2023 students of Banting Polytechnic, Selangor

3.1.1.2 Pareto Diagram

Once the survey was completed, the results of all respondents were analyzed in a Pareto Chart for the survey was formed.

Features	Frequency	Cummulative	Cummulative Percentage	Pareto Baseline
Automated Checklist	9	9	26%	80%
Printable Result	8	17	50%	80%
Utilisation of Camera	6	23	68%	80%
Separated Section	6	29	85%	80%
Remote Measuring	5	34	100%	80%
GRAND TOTAL	34			

Table 3.1: Pareto Data Extracted from Survey Response

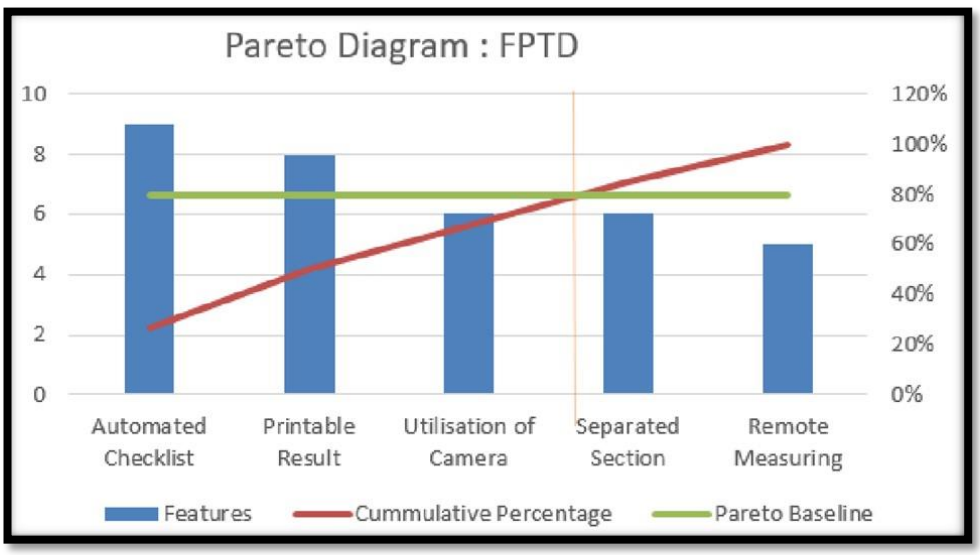


Figure 3.2: Pareto Diagram of FPTD

3.1.2 Design Concept Generation

3.1.2.1 Function Tree

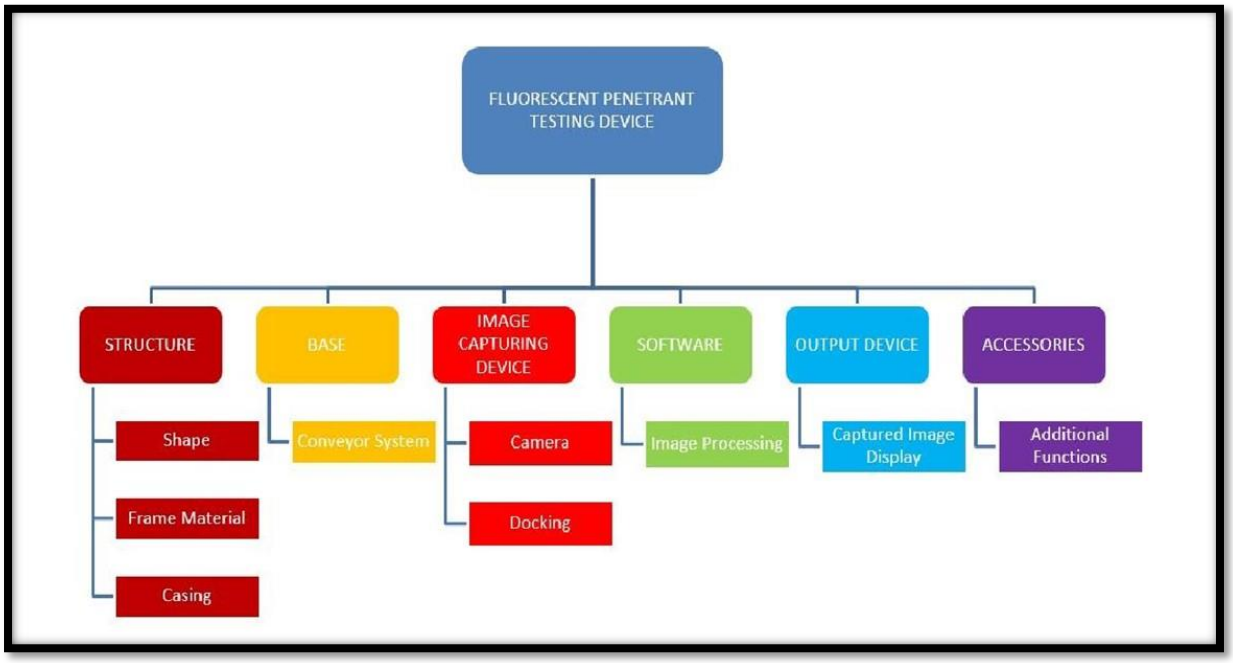


Figure 3.3: Function Tree of FPTD

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

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

3.1.2.2 Morphological Matrix

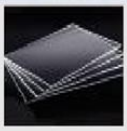
FUNCTION (sub-function)	IDEA 1	IDEA 2	IDEA 3	IDEA 4	IDEA 5
STRUCTURE (Shape)	CUBOID 	SEMISHPERE 	CUBE 	PYRAMID 	
STRUCTURE (Frame Material)	PVC PIPES 	WOOD PLANK 	STEEL HOLLOW TUBE 	ALUMINIUM PIPES 	STEEL BAR 
MATERIAL (Casing)	BLACKOUT FABRIC 	PERSPEX 	SHEET METAL 	PLYWOOD 	CANVAS (TARPAULIN) 

Table 3.2: Morphological Matrix of FPTD (Function: Structure)

Once the Function Tree for FPTD is formed, the following step is to generate an idea for each function and sub-function. The ideas are entirely on our own creativity and some research from the internet.

3.1.2.3 Proposed Design Concept 1

FUNCTION/SUB FUNCTION	CONCEPT 1	JUSTIFICATION
STRUCTURAL SHAPE	CUBOID	ACHIEVABLE 3:4 FRAME RATIO
FRAME STRUCTURE MATERIAL	STEEL HOLLOW TUBES	HIGH STRENGTH
CONVEYOR SYSTEM	CONVEYOR BELT	LESS MECHANICAL PARTS
CASING	BLACK OUT FABRIC	GOOD LIGHT BLOCKING PROPERTIES
CAMERA	ACTION CAMERA	COMPACT AND HIGHER RESOLUTION IMAGE
CAMERA DOCKING	READY MADE	UNIVERSALLY AVAILABLE
IMAGE PROCESSING	ADOBE PHOTOSHOP	READILY AVAILABLE AND EASIER TO MASTER
DISPLAY OUTPUT	ON SCREEN DISPLAY	CONVENIENT TO WORK WITH, SAFER RECORD KEEPING
ACCESSORIES	TOOLS DRAWER	ORGANISED TOOLS AND ACCESSORIES KEEPING

Table 3.3: Proposed Design Concept 1

3.1.2.4 Proposed Design Concept 2

FUNCTION/SUB FUNCTION	CONCEPT 2	JUSTIFICATION
STRUCTURAL SHAPE	CUBE	UNIFORM DISPERSION OF LIGHT
FRAME STRUCTURE MATERIAL	PVC TUBES	EASY TO WORK WITH
BASE STRUCTURE	X,Y – AXIS MOVEMENT	ABLE TO ADJUST SAMPLE POSITION REMOTELY
VEIL/COVER	TARPAULIN	CHEAPER
CAMERA	PHONE CAMERA	MORE USER FRIENDLY
CAMERA DOCKING	3D PRINTED	PRODUCT DESIGNED AS PER PROJECT REQUIREMENT
IMAGE PROCESSING	OPEN CV PYTHON CODING	SIMPLER AND ALTERABLE FEATURES
DISPLAY OUTPUT	PRINTED	ALL TIME ACCESSIBLE
ACCESSORIES	SPRAY CAN HOLDER WITH BOOKLET POCKET	ORGANISED EQUIPMENT AND MANUALS

Table 3.4: Proposed Design Concept 2

3.1.2.5 Proposed Design Concept 3

FUNCTION/SUB FUNCTION	CONCEPT 3	JUSTIFICATION
STRUCTURAL SHAPE	CUBOID	ABLE TO FIT A BIGGER SPECIMEN
FRAME STRUCTURE MATERIAL	WOOD PLANK	EASY TO ASSEMBLE
CONVEYOR SYSTEM	CONVEYOR BELT	ABLE TO MOVE SPECIMEN BY ADJUSTING AN ACTUATOR ROLLER
VEIL/COVER	PLYWOOD	TOTAL COVERAGE FROM LIGHT
CAMERA	PHONE CAMERA	MORE USER FRIENDLY
CAMERA DOCKING	3D PRINTED	PRODUCT DESIGNED AS PER PROJECT REQUIREMENT
IMAGE PROCESSING	ADOBE PHOTOSHOP	ABLE TO ACHIEVE A 1:1 IMAGE TO SPECIMEN RATIO
DISPLAY OUTPUT	BOTH PRINTED AND MONITOR	USER CAN INSPECT THROUGH MONITOR AND ARE ABLE TO DO A RE-CHECK WITH A PRINTED RESULT
ACCESSORIES	SPRAY CAN HOLDER WITH BOOKLET POCKET	ORGANISED EQUIPMENT AND MANUALS

Table 3.5: Proposed Design Concept 3

3.1.2.6 Proposed Design Concept 4

FUNCTION/SUB FUNCTION	CONCEPT 4	JUSTIFICATION
STRUCTURAL SHAPE	CUBOID	ABLE TO FIT A BIGGER SPECIMEN
FRAME STRUCTURE MATERIAL	STEEL HOLLOW TUBE	MORE STURDY
CONVEYOR SYSTEM	CONVEYOR ROLLER	DECREASE CONTAMINATION FROM PENETRANT, DEVELOPER AND PENERANT REMOVER
VEIL/COVER	SHEET METAL	TOTAL COVERAGE FROM LIGHT
	PERSPEX	FOR USER TO LOOK THROUGH DURING PREP
CAMERA	ACTION CAMERA	MORE USER FRIENDLY
CAMERA DOCKING	READY MADE	PRODUCT DESIGNED AS PER PROJECT REQUIREMENT
IMAGE PROCESSING	ADOBE PHOTOSHOP	ABLE TO ACHIEVE A 1:1 IMAGE TO SPECIMEN RATIO
DISPLAY OUTPUT	BOTH PRINTED AND MONITOR	USER CAN INSPECT THROUGH MONITOR AND ARE ABLE TO DO A RE-CHECK WITH A PRINTED RESULT
ACCESSORIES	SPRAY CAN HOLDER, BOOKLET POCKET AND TOOLS DRAWER	ORGANISED EQUIPMENT AND MANUALS AND TOOLS

Table 3.6: Proposed Design Concept 4

3.1.2.7 Accepted vs Discarded Solution

CRITERION	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5	CONCEPT 6
STRENGTH (Material)	Highest (Steel Hollow Tubes Structure)	Low (PVC Tubes Structure)	High (Wood Plank Structure with Plywood Casing)	Highest (Steel hollow tube structure with sheet metal casing)	Low (PVC pipe frame, Perspex casing)	Low (PVC pipe frame, blackout fabric casing)
SAFETY (User)	High (Avoid the exposure of the personnel to hazardous fumes	High (Avoid the exposure of the personnel to hazardous fumes	High (Avoid the exposure of the personnel to hazardous fumes	High (Avoid the exposure of the personnel to hazardous fumes)	High (Avoid the exposure of the personnel to hazardous fumes	High (Avoid the exposure of the personnel to hazardous fumes
COST (Total)	High (High cost of action camera, steel hollow tubes and industrial black out fabric)	Low (Affordable price of mobile phone, PVC tubes and tarpaulin sheet)	Moderate (Low price of wood plank, plywood, mobile phone. Higher cost of 3D printed camera docking and both printer and monitor	Moderate (cheap cost for Perspex and ready made camera dock higher cost for both printed and monitor display output and action camera)	Low (cheap cost for Perspex and ready made camera dock)	Low (cheap cost for blackout fabric and ready made camera dock)
CONVENIENCE (User Friendly)	High (Adobe Photoshop is more practical)	Low (Required time for familiarisation of image processing software operation)	High (Adobe Photoshop is more practical)	High (Adobe Photoshop is more practical)	Low (Developed software might get interrupted with bugs during operation)	High (Adobe Photoshop is more practical)
RELIABILITY	High (Proven standard software for image processing and indications measuring)	Low (Low-quality coding might be utilised in the self-developed software, hence will affect the reliability)	High (Proven standard software for image processing and indications measuring)	High (Proven standard software for image processing and indications measuring)	Low (Developed image processing software might be unstable due to limitation in expertise)	High (Proven standard software for image processing and indications measuring)

Table 3.7: Accepted vs Discarded Solution

After sufficient option for the concept is obtained, all concepts are compared side-by-side according to five criteria which are strength, safety, cost, convenience, and reliability. The concepts are evaluated according to these criteria. After the evaluation, Concept 4 is selected as the accepted solution. Other solutions are discarded and put as project back up.

3.1.3 Evaluation & Selection of Conceptual Design

3.1.3.1 Pugh Matrix

CRITEREON	FACTOR	CONCEPT 1	CONCEPT 2	CONCEPT 3	CONCEPT 4	CONCEPT 5	CONCEPT 6
STRENGTH	0.1	DATUM	1	2	3	1	1
SAFETY	0.3		2	2	2	2	2
COST	0.1		3	2	2	3	3
CONVENIENCE	0.25		1	3	3	1	3
RELIABILITY	0.25		1	3	3	1	3
TOTAL SCORE	1.0		1.5	2.5	2.6	1.5	2.5
RANKING			5	2	1	4	3

Table 3.8: Concept Design Evaluation Using Pugh Matrix (Concept 1 as Datum)

Using Pugh Matrix, the selected solution (Concept 4) is proven as the best solution with Concept 1 as the datum. All concepts are rated according to 5 criterion which are strength, safety, cost, convenience, and reliability.

CRITEREON	CONCEPT 1	CONCEPT 2	CONCEPT 3	MAGNAFLUX GE-54	CONCEPT 4	CONCEPT 5	CONCEPT 6
STRENGTH	3	1	2	DATUM	3	1	1
SAFETY	2	2	2		2	2	2
COST	1	3	2		2	3	3
CONVENIENCE	3	1	3		3	1	3
RELIABILITY	3	1	3		3	1	3
TOTAL SCORE	12	8	12		13	8	12
RANKING	2	5	3		1	6	4

Table 3.9: Concept Design Evaluation Using Pugh Matrix (GE-54 MAGNAFLUX Enclosure as Datum)

By using Pugh Matrix, the selected solution (Concept 4) is proven as the best solution with

Magnaflux GE-54 as the datum. All concepts are rated according to 5 criterion which are strength, safety, cost, convenience, and reliability.

3.2 PROJECT BRIEFING & RISK ASSESSMENT

3.2.1 Utilization of Polytechnic's Facilities

To accomplish the project objectives, various facilities in Politeknik Banting Selangor were utilized. The structure and the roller conveyor were fabricated in Project Workshop, while the wiring and programming were done in Electrical and Electronic Lab. Other than that, we used the shearing square machine in the Airframe Structure Workshop.

In order to use these facilities, permission from the Project Supervisor and Workshop Coordinator is required. Hence, Form D is filled in and submitted prior to entering the workshop. This form required us to list the equipment, machines, and tools to be used in each session.

All machines were handled with care and tasks were done while adhering to General Workshop Rules. This includes wearing the appropriate Personal Protective Equipment (PPE) while performing the tasks.

3.3 OVERALL PROJECT GANTT CHART

Table 3.10: Overall FPTD Project Gantt Chart

3.4 PROJECT FLOW CHART

3.4.1 Overall Project Flow Chart

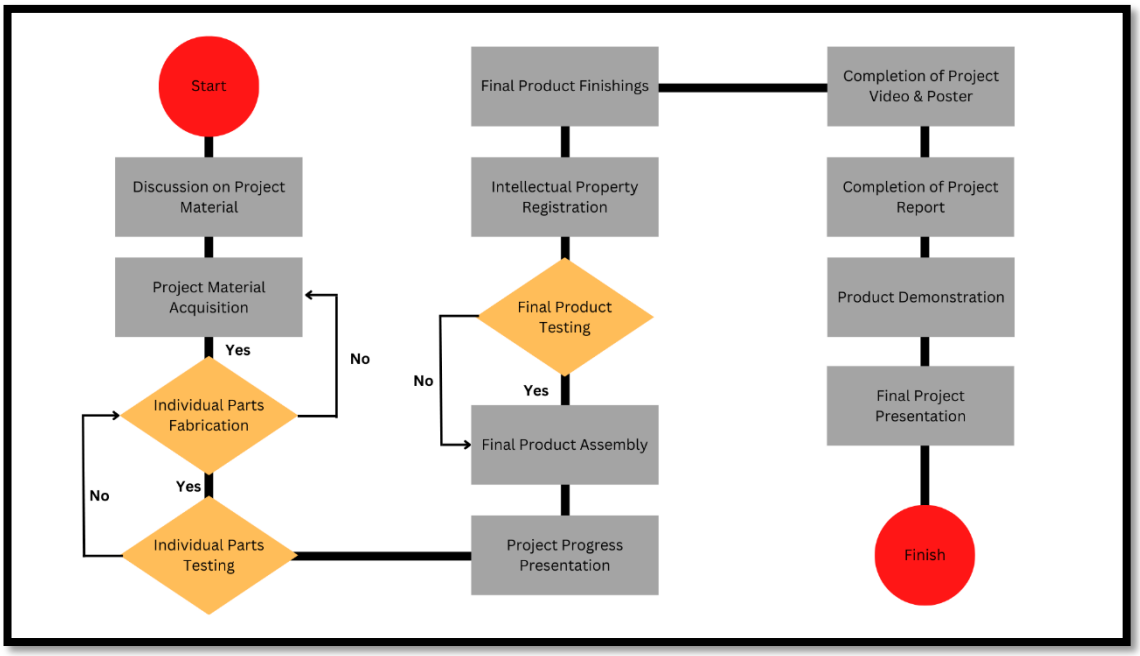


Figure 3.4: FPTD Overall Project Flow Chart

3.4.2 Specific Project Design Flow / Framework

3.4.2.1 Product Structure & Finishing

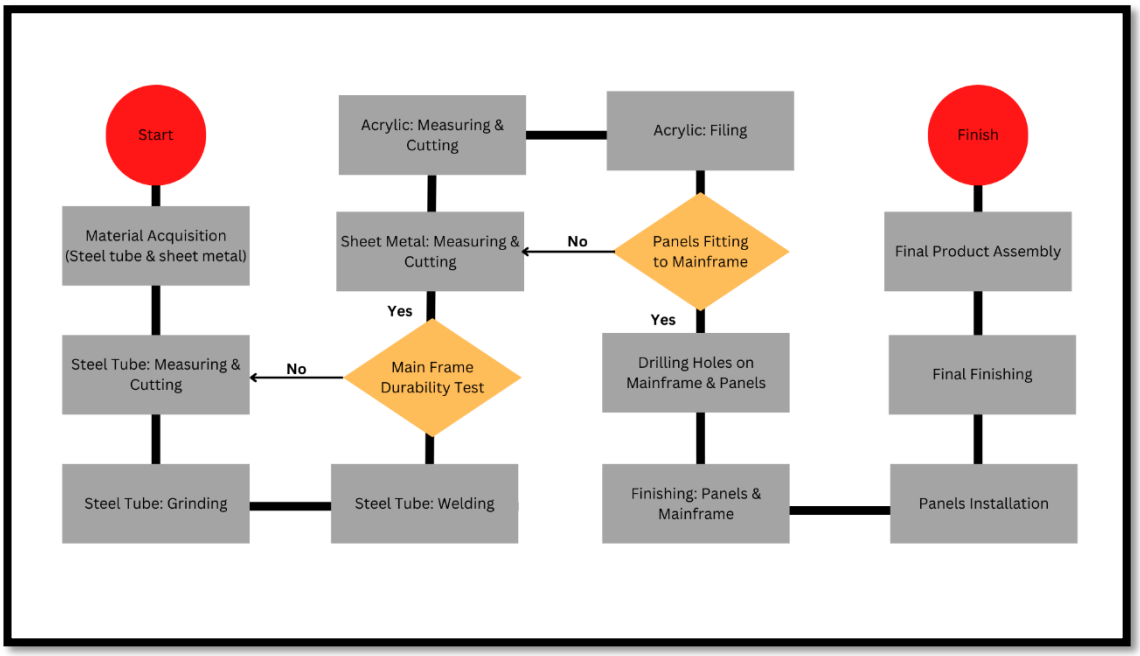


Figure 3.5: Product Structure & Finishing Flow Chart

3.4.2.2 Roller Conveyor

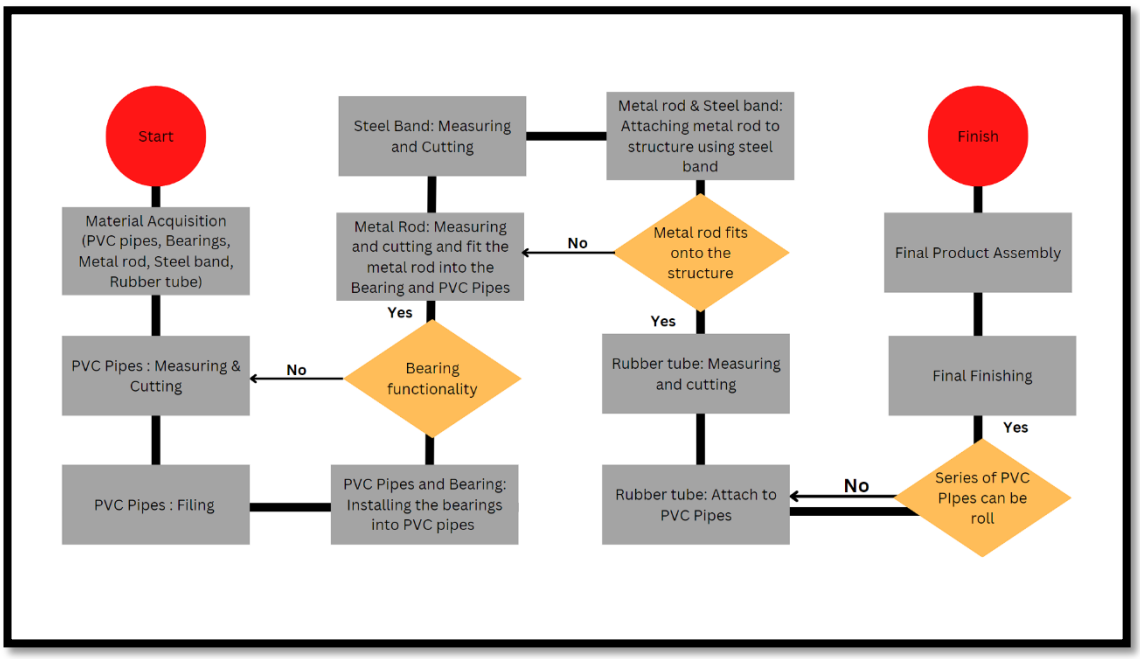


Figure 3.6: Conveyor Roller Flow Chart

3.4.2.3 Electronics & Programming

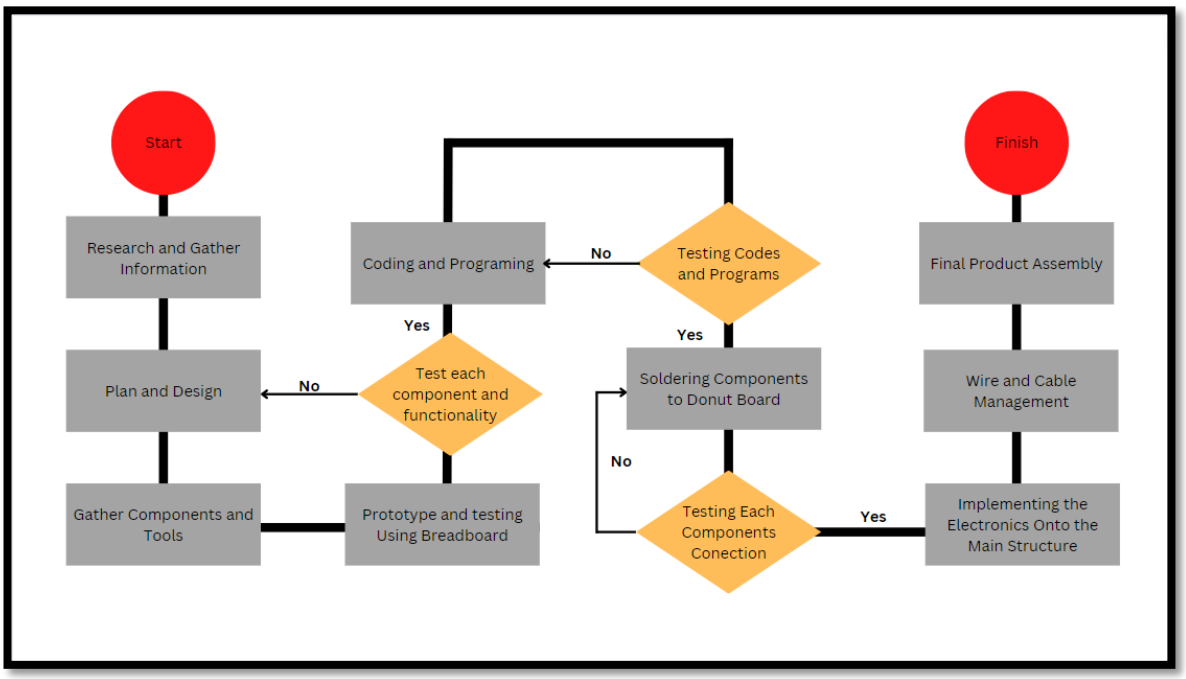


Figure 3.7: Electronic & Programing Flow Chart

3.5 LIST OF MATERIAL & EXPENDITURES

3.4.1 Product Structure				
No.	**Item Details**	**Unit**	**Price/Unit**	**Total (RM)**
1.	Magnetic Door Latch 4s	1	2.20	2.20
2.	BAHCO Sandflex Blade 12”	1	5.00	5.00
3.	#6X1/2 Round Head Self Tapping Screw	2	3.00	6.00
4.	Galvanic Zinc Sheet (3’x8’) 0.35 MM	1	55.00	55.00
5.	5/32 x 2 (10) GI Bolt & Nut	1	3.00	3.00
6.	50MM – 2” B Light Iron Hinges	1	1.30	1.30
7.	#6X3/4 Round Head Self Tapping Screw	1	3.00	3.00
8.	3M Scotch Double Sided Tape 23MM X 1.5M	1	7.00	7.00
9.	KM 2052 Collision Prevention Cushion Tape	1	6.00	6.00
3.4.2 Product Mechanisms				
1.	12MM X 10M SYW Steel Band	1	9.00	9.00
2.	Tyre Bearing	32	1.50	48.00
3.	2” PVC Pipe (10’)	1	17.00	17.00
4.	Super Power 12VDC Motor	1	15.00	15.00
5.	Rocker Switch On/Off/On	1	6.00	6.00
6.	Tyre Bearing	1	1.80	1.80
7.	25MM (1”) PVC Pipe	3	1.40	4.20
8.	SS 5/8” X 1 MM X 6 M 304 SS Ornamental	1	50.00	50.00
9.	¼ 5.8M UPVC Pipe	2	17.00	34.00
10.	¼ UPVC Socket	14	1.00	14.00
11.	¼ UPVC Tee	2	2.50	5.00
3.4.3 Software / Programming				
1.	D1 R2 ESP8266 Wi-Fi UNO Dev. Board	1	29.00	29.00
2.	DHT11 Temperature and Humidity Sensor	1	10.00	10.00
3.	Ambient Light TEMT6000 Sensor	1	10.00	10.00
4.	I2C 16x2 LCD	1	15.00	15.00
5.	40 pcs Dupont Jumper Wire (20cm)	1	4.50	4.50
6.	Donut Board	1	2.00	2.00
7.	18650 Battery Case	1	4.90	4.90
8.	GUVA-S12SD Sunlight UV Light Sensor	1	18.90	18.90

9.	GoPro HERO 4	1	280.00	280.00
10.	UV Light LED Floodlight 100W	1	26.30	26.31
11.	Terminal Block 3A	1	2.70	2.70
12.	PVC Tape 4Pcs	1	3.70	3.70
13.	PVC Insulation Tape 18MM	1	3.50	3.50
14.	Solder Paste/Flux 10G	1	3.50	3.50
15.	Light Luminosity Sensor Module TLS2561	1	15.00	15.00
16.	UGREEN Micro HDMI Port to HDMI Cable Male to Male High Speed Ethernet Support 3D 4K 60Hz GoPro Adapt	1	21.80	21.80
3.4.4 Accessories & Finishing				
1.	Exhaust Fan 6”	1	60.00	60.00
2.	3M Standard Cooker Hood Hose Detachable	1	20.00	20.00
3.	Hose Clip Stainless Steel	1	7.00	7.00
4.	Spray Paint Flat White	1	8.30	8.30
5.	Spray Paint White	1	8.30	8.30
6.	Spray Paint Flat Black	1	8.30	8.30
7.	BOSCH Fiber Sanding Disc P60	2	1.80	3.80
8.	BOSCH Fiber Sanding Disc P100	1	1.80	1.80
9.	BOSCH Fiber Sanding Disc P120	2	1.80	1.80
10.	Samurai U19 Anti Rust Primer	1	10.50	10.50
11.	Samurai SP092** Matt Black	4	16.00	64.00
12.	Flap Disc 4’ A120	2	2.90	2.90
13.	16/3C F/Wire F/Copper	3	2.50	7.50
14.	UMS 2G1W Switch	1	9.00	9.00
15.	13A Plug Top	1	4.00	4.00
GRAND TOTAL				**RM 960.51**

Table 3.11: List of Material & Expenditures

3.6 PRODUCT DRAWING / SCHEMATIC DIAGRAM

3.6.1 General Product Drawing

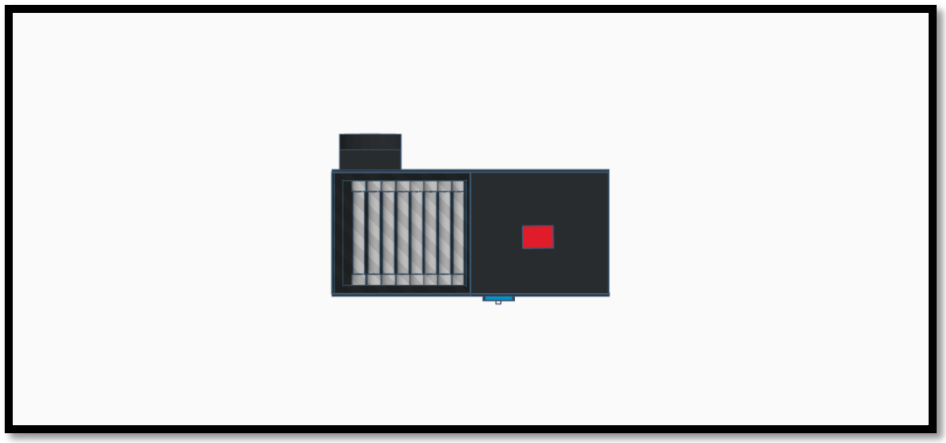


Figure 3.8: Top View of FPTD

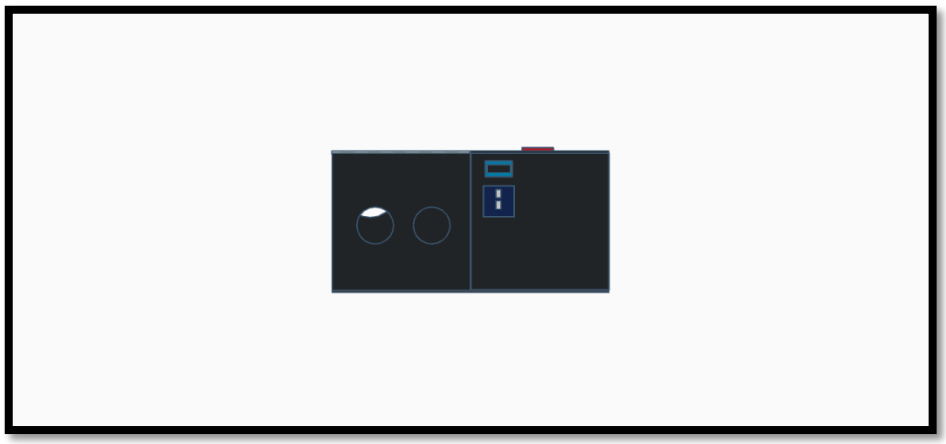


Figure 3.9: Front View of FPTD

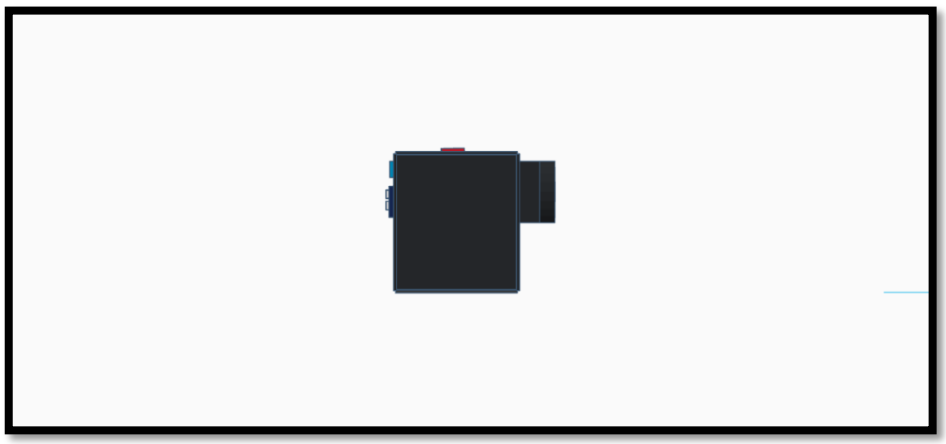


Figure 3.10: Side View of FPTD

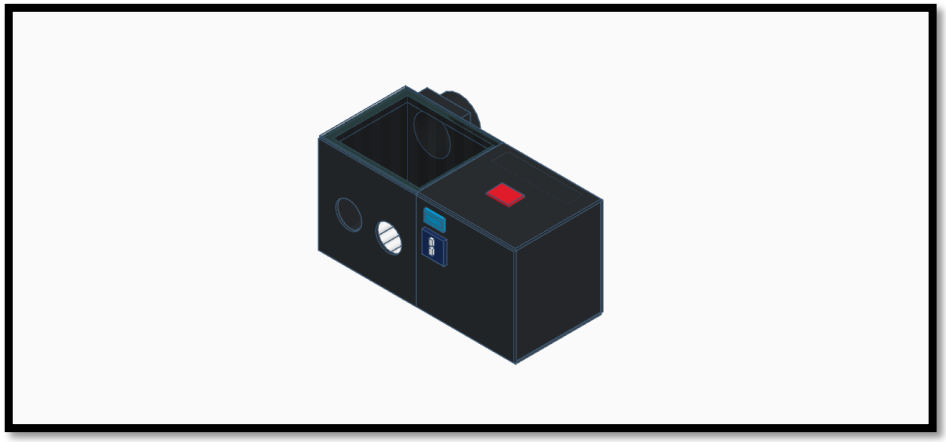


Figure 3.11: Isometric View of FPTD

3.6.2 General Product Dimension

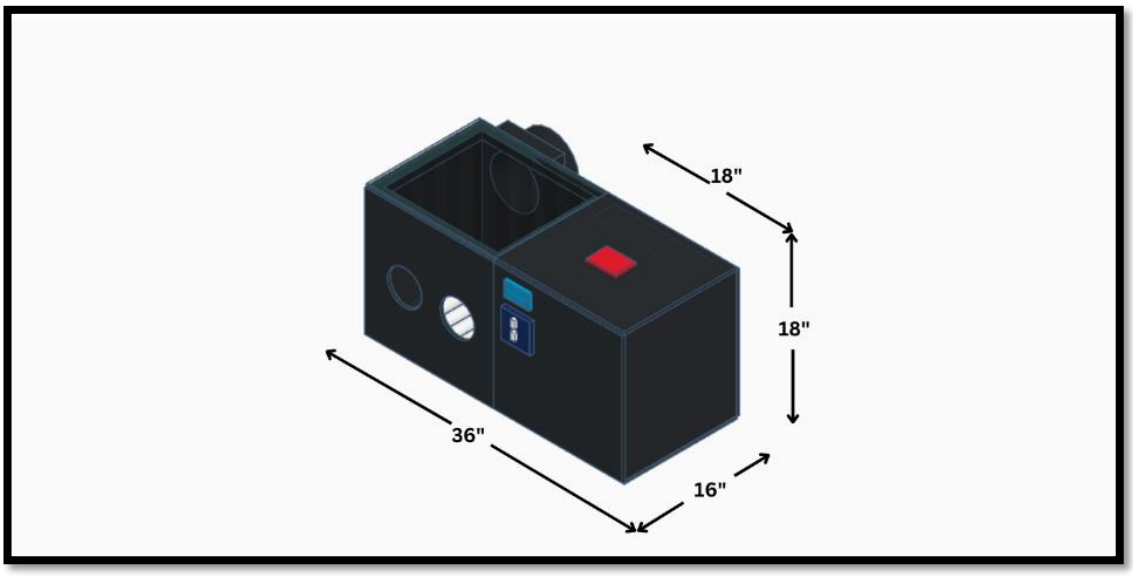


Figure 3.12: FPTD General Dimension

3.6.3 Specific Part Drawing / Diagram

3.6.3.1 Product Structure

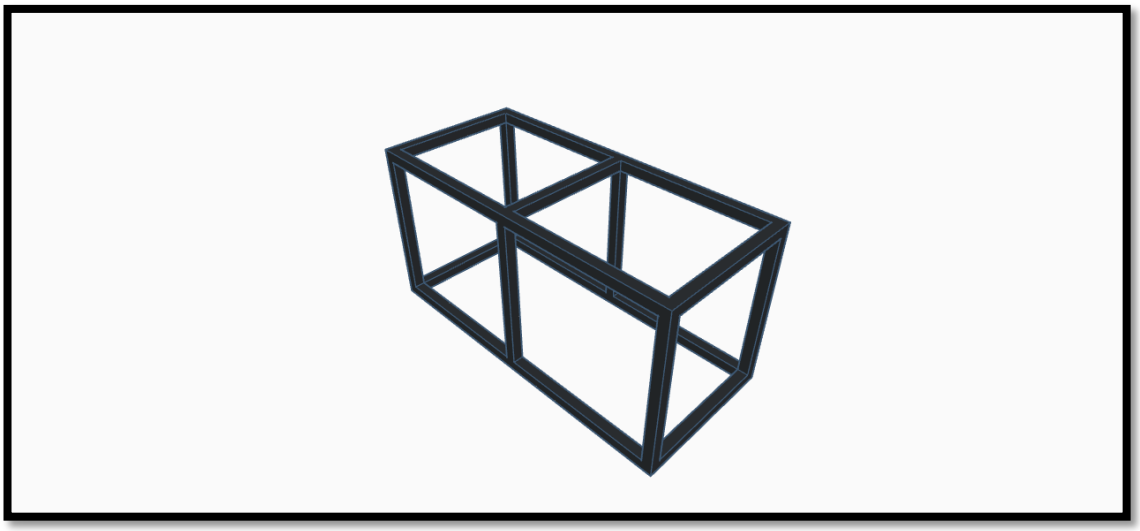


Figure 3.13: Isometric View of Mainframe without Panels Installed

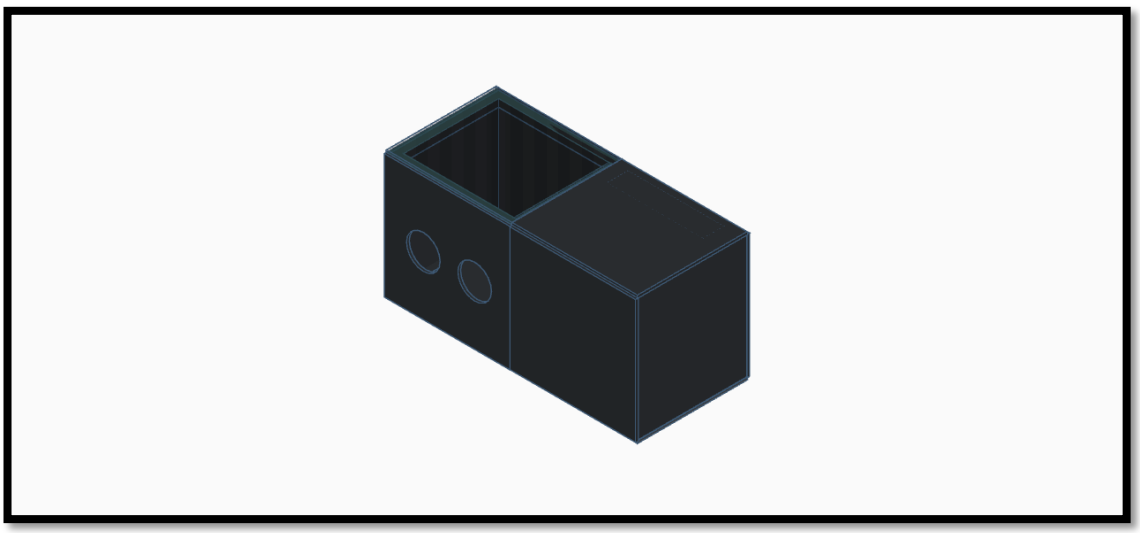


Figure 3.14: Isometric View of Mainframe with Panels Installed

3.6.3.2 Mechanical Mechanism (Roller Conveyor)

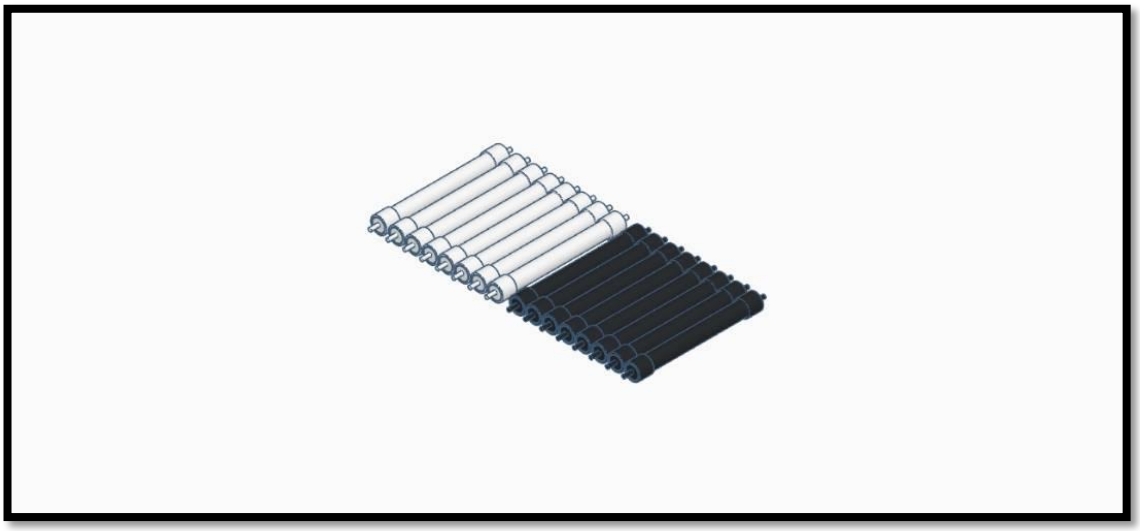


Figure 3.15: Isometric View of Roller Conveyor

Figure 3.16: Top View of Roller Conveyor Attached onto Structure

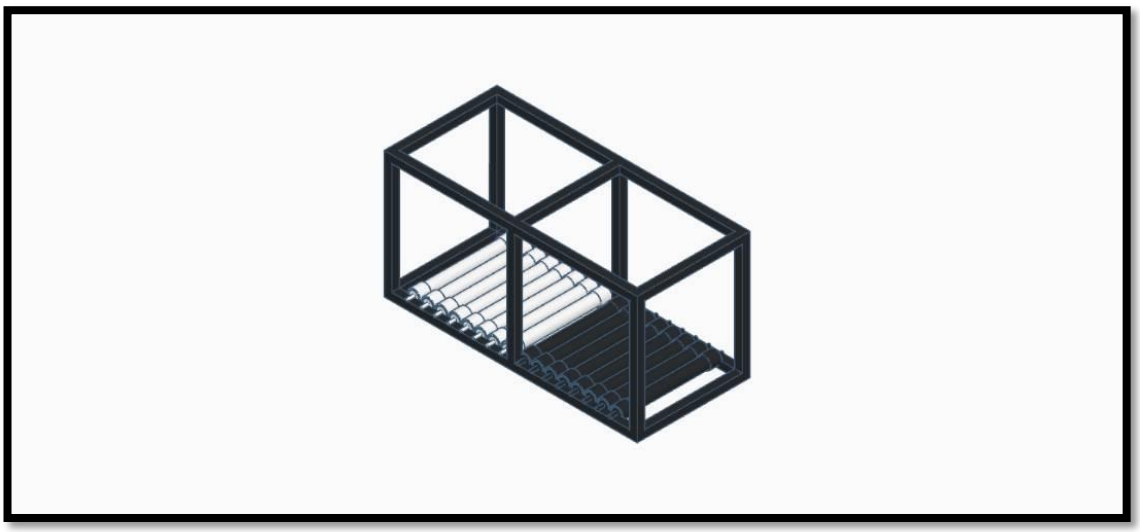


Figure 3.17: Isometric View of Roller Conveyor with The Mainframe Structure

3.6.3.3 Electronic Circuit Schematic

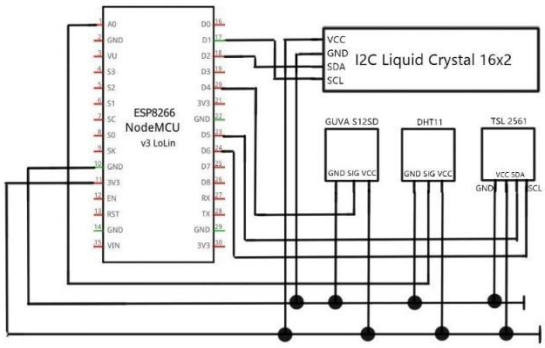


Figure 3.18: Schematic Drawing of the Electronics construction

3.6.3.4 Arduino Coding for Sensors

```
#include <DHT.h>

 DHT.h

 C:\Users\Rizq Faiz\Desktop\IDE\libraries\DHT\DHT.h
// DHT11 Temperature and Humidity Sensor
#define DHTPIN D4
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

// GUVA-S12SD UV Sensor
#define UV_PIN A0

// TSL2561 Ambient Light Sensor
Adafruit_TSL2561_Unified tsl = Adafruit_TSL2561_Unified(TSL2561_ADDR_FLOAT, 12345);

// I2C 16x2 LCD
LiquidCrystal_I2C lcd(0x27, 16, 2); // Update the LCD address if necessary

enum SensorType {
  TEMPERATURE_HUMIDITY,
  UV_LIGHT,
```

Figure 3.19: Arduino Coding for Sensors in Arduino IDE Software

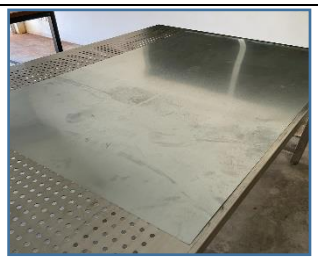
3.7 DEVELOPMENT OF PRODUCT

3.7.1 Material Acquisition

3.7.1.1 Mainframe of FPTD

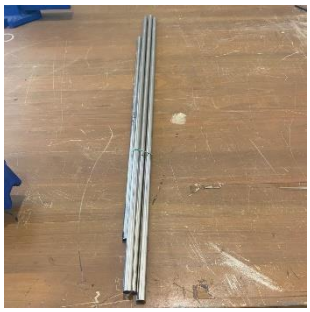
Table 3.12: List of Materials Used for FPTD Mainframe

No	Material	Description
1.	 1” hollow square steel	1” hollow steel square is used as the main material to construct the mainframe for FPTD.
2.	 Acrylic sheet	Acrylic sheet is used as the top and the front panel for the Prep Section. The acrylic sheet for the front panel was painted in black.
3.	 Magnetic door latch	4 magnetic door latch are installed to the front panel of the PREP Section. This is to ease the process of opening and closing the front panel.
4.	 #6x1/2 round head self tapping screw	#6x1/2 round head self tapping screws are used as the main fastener to install the panels to the mainframe.

5.	 Galvanic zinc sheet (3'x8') 0.35 MM	The galvanic zinc sheet is used to construct the panels for: 1) Prep Section base 2) Inspection Section base 3) Prep Section side 4) Inspection Section side 5) FPTD rear 6) Inspection Section front 7) Inspection Section top
6.	 Light iron hinges	Two light iron hinges are installed to front panel of the Prep section to allow the panel to be opened and closed.
7.	 3M Scotch double sided tape	This tape is used to attach the magnetic door latch to the panel. It is an industrial grade tape with proven durability.
8.	 Collision Prevention Cushion Tape	This tape is installed around the fitting of the front panel to the mainframe. This is to improve the fittings of the two engaged parts.

3.7.1.2 Roller Conveyor

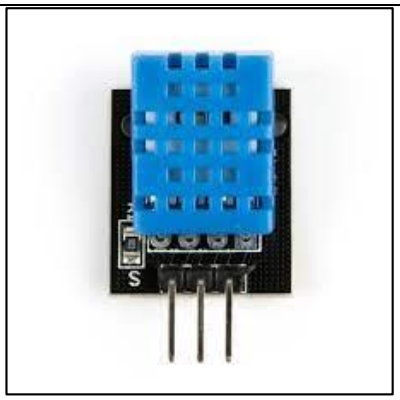
Table 3.13: List of Materials Used for FPTD Roller Conveyor

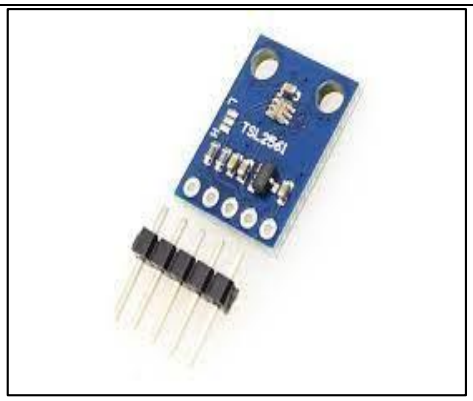
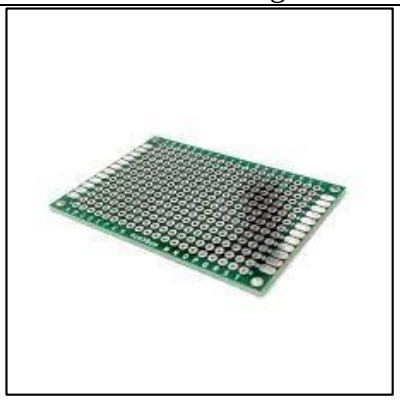
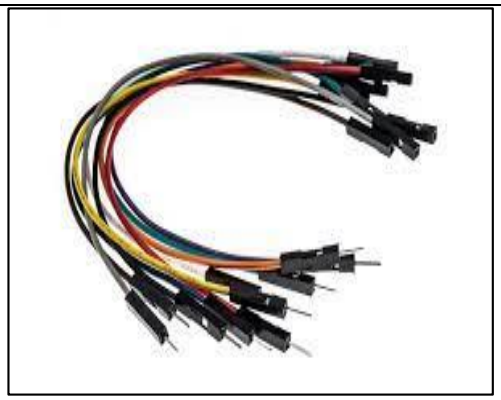
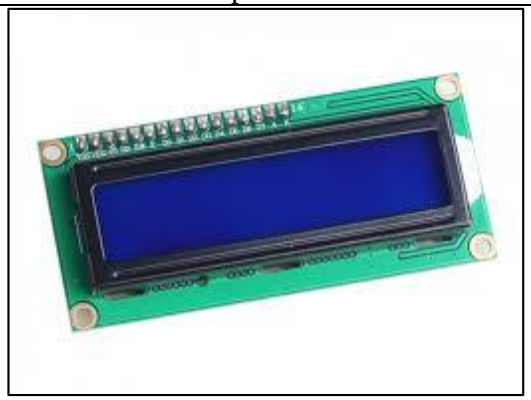
No	Material	Description
1.	 PVC Pipes	This PVC pipes is the main part of the Roller Conveyor system; it will act as the Roller.
2.	 5/8 Tyre Bearing	This bearing will be placed inside each PVC Pipes to ease the roll mechanism.
3.	 Metal Rod	This metal rod is used to hold the bearing inside the PVC pipes, and it will get attached onto the project structure.
4.	 Steel Band	This steel band will help to hold the metal rod in place onto the project structure.

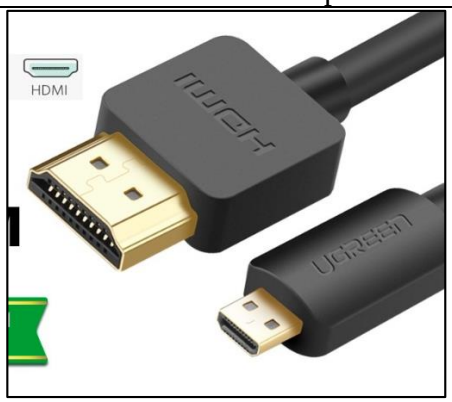
5.	 Rubber tube	This rubber tube will be cut into small pieces, and hold every two (2) PVC pipes to enable other PVC pipes to roll when one PVC pipes is actuated.

3.7.1.3 Electronics & Software of FPTD

Table 3.14: List of Components & Software Used for FPTD Electronics

No	Material	Description
1.	 WeMos D1R2 ESP8266	WeMos D1R2 ESP8266 used as the microcontroller to receive data from the sensors and send the data to the display.
2.	 DHT 11 Temperature and Humidity Sensor	Used to identify the temperature and detect humidity when performing the inspection.
3.	 GUVA S12SD UV Light Sensor	Used to detect and identify the UV light intensity.

4.	 TSL2561 Ambient Light Sensor	Used to identify the light intensity when all the light source in the FPTD device is turned off.
5.	 Donut Board	Used as a base to place all the electronic components permanently.
6.	 Jumper Cable	Used to connect the pins of the sensors and display to the ESP 8266.
7.	 I2C Liquid Crystal 16x2 LCD	Used to display the data from the sensors to be used in the pre-checklist.

8.	 GoPro Hero 4 Silver	Used to capture the image of the workpiece digitally.
9.	 Arduino IDE	It is the main program used to code the ESP 8266.
10.	 Adobe Photoshop	feature that allows you to measure distances, angles, and other dimensions within images.
11.	 UGREEN Micro HDMI Port to HDMI Cable	Used to connect the GoPro signal directly to personnel's device of choice.

3.7.1.4 Mainframe of FPTD

Table 3.15: List of Materials Used for FPTD Furnishings & Finishing

No	Material	Description
1.	 Exhaust fan 6”	A 6” exhaust fan is installed at the Prep section. This provide suction within the section, extracting the fumes from the sprays used during the procedure.
2.	 3M standard cooker hood hose	This hose channels the fumes from the fan to the desired direction.
3.	 Hose clip stainless steel	Hose clip hold the hood hose to exhaust fan extruded part.
4.	 Spray paint flat black	Spray paint flat black is used as the finishing for the product exterior.

5.	 Samurai Anti Rust Primer	Anti rust primer is used as the base coating for the product mainframe.
6.	 Samurai Matt Black Spray Paint	This spray paint is used as the main coating for the interior parts of the product.

3.7.2 Machines and Tools

3.7.2.1 Machines for FPTD Fabrication

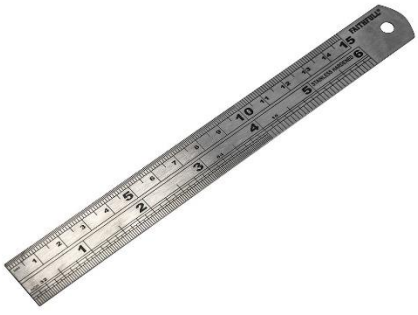
Table 3.16: List of Machines Used for FPTD Fabrication

No	Machines	Description
1.	 Squaring Shear	**General Purpose:** To cut sheet metal to the desired size **Project Purpose:** To cut panels from galvanized zinc sheet
2.	 Portable Electric Drill	**General Purpose:** To drill holes in a material, and to insert screw and other threaded fasteners into a material **Project Purpose:** To drill holes for panel installation and to fastened the panels to the mainframe with screws.
3.	 Pneumatic Drill gun	**General Purpose:** To drill holes in a material, and to insert screw and other threaded fasteners into a material **Project Purpose:** To drill holes for panel installation and to fastened the panels to the mainframe with screws.
4.	 Air Riveter	**General Purpose:** Provide a fast, convenient, and powerful solution for blind rivet installation. **Project Purpose:** To install blind rivets used in attaching the steel band to the mainframe for the conveyor rollers.

5.	 Hand Grinder	**General Purpose:** Can be used in various jobs such as cutting, grinding, deburring, finishing and polishing **Project Purpose:** To cut steel tube and to remove rust from the surface.
6.	 Welding Machine	**General Purpose:** To fuse metal, filling the gap between two metal and hold them together. **Project Purpose:** To hold the joins between the cut frames for the structure.

3.7.2.2 Tools for FPTD Fabrication

Table 3.17: List of Tools Used for FPTD Fabrication

No	Tools	Description
1.	 Screwdriver Set	**General Purpose:** To drive or to turn screws into and out of a threaded holes **Project Purpose:** To drive screws to attach panels onto the product mainframe. Also used to turn screws of electrical connection for switches and plug top
2.	 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 steel tube are bent at 90 degrees, and used to measure other dimensions
3.	 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 materials into specific measurements

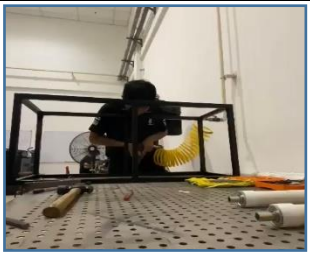
4.	 Center Punch	**General Purpose:** To mark a point on a material to help with drilling **Project Purpose:** To mark a point on the material that was going to be drilled, such as the steel tube.
5.	 Wire Stripper	**General Purpose:** To strip the wire cover exposing the copper wire inside **Project Purpose:** To strip the wire cover and exposing the copper wire inside, to make connection for our exhaust fan, UV light, and to connect all the sensors to the Arduino Board

3.7.3 Specific Project Fabrication

3.7.3.1 Base Structure

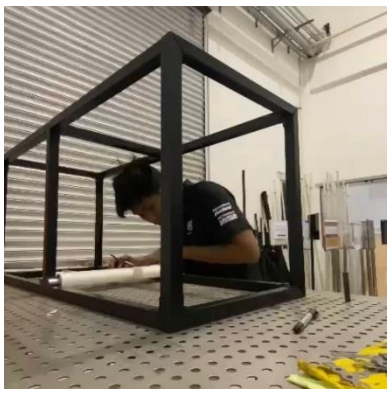
Table 3.18: Project Fabrication for Base Structure

No	Fabrication Process	Description
1.	 Material Acquisition	The square hollow steel and acrylic sheet is salvaged from the project workshop. The galvanized zinc sheet is bought from hardware store.
2.	 Measuring and marking	The length of the square hollow steel is measured and marked. The dimension of the galvanized zinc is measured and marked as per drawing.
3.	 Material cutting	The square hollow steel is cut using hand grinder fitted with diamond disc. The galvanized zinc sheet is cut with squaring shear machine.
4.	 Mainframe welding	The square hollow steel is welded with Shielded Metal Arc Welding method.

5.	 Application of anti-rust primer	Anti-rust primer is sprayed onto the welded mainframe to avoid further rusting
6.	 Measuring and cutting acrylic sheet	The dimension of the acrylic sheet is measured and marked as per drawing. The acrylic sheet is cut with acrylic cutter knife.
7.	 Drilling	Holes are drilled onto the panels and the mainframe to hold the parts together.
8.	 Installation of panels	All panels are being installed to the mainframe.

3.7.3.2 Roller Conveyor

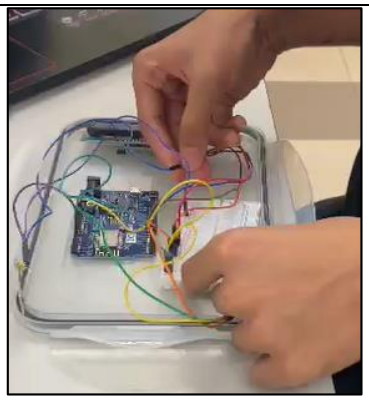
Table 3.19: Project Fabrication for Roller Conveyor

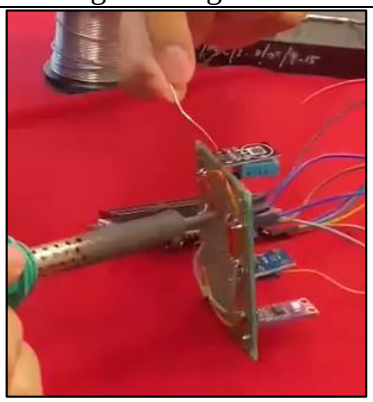
No	Fabrication Process	Description
1.	 Cutting of PVC Pipes and Metal Rod	PVC pipes and metal rod was cut into a specific dimension
2.	 Installing bearing and metal rod into the PVC pipes	Bearing and metal rod are attached inside the PVC pipes and was secured by using hot glue gun
3.	 Measuring	Measurement of where the metal rod will be placed onto the product mainframe was marked before drilling and riveting

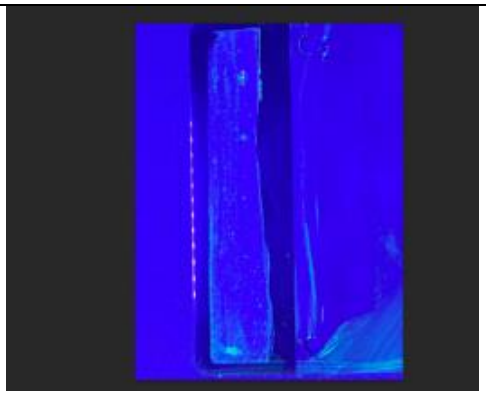
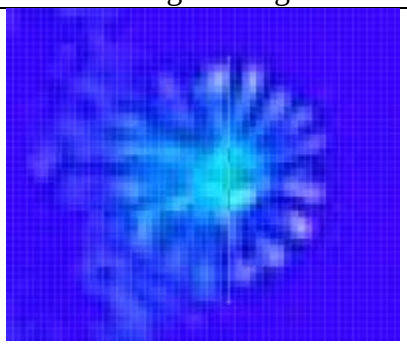
4.	 Drilling and riveting	Holes were drilled into the product mainframe, and metal rod was installed on the mainframe by riveting and was hold in place by a steel band

3.7.3.3 Electronics & Programming

Table 3.20: Electronics Assembly & Programing

No	Fabrication Process	Description
1.	 Components testing	Components testing via constructing the circuit on a breadboard.
2.	 Programming	Programing the ESP 8266 via the Arduino IDE application.

3.	 Programming test run	Testing and tweaking the programming until it is working as intended.
4.	 Components soldering	Soldering the components permanently onto a donut board.
5.	 Electronic implementation	Implementing the electronics onto the main structure.
6.	 GoPro installation	The GoPro is installed to the FPTD inspection section and is connected to a viewing device via UGREEN Micro HDMI Port to HDMI Cable.

7.	 Image testing	Image quality is tested.
8.	 Digital measurement testing	Testing the pixel by pixel measuring system.

3.7.3.4 Product Finishing

Table 3.21: Finishing Process for FPTD

No	Process	Description
1.	 Paint application on panels	The panels are painted with spray paint according to the desired color. The paint is applied in multiple layers to improve the texture and consistency of the finishing.
2.	 Installation of hinges and magnetic latch	The hinges and magnetic latches are installed to the from panel of the Prep Section.
3.	 Re-assemble panels.	The painted panels are assembled and re-installed to the mainframe to accomplish the final product.

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

FPTD is the innovation on the Liquid Penetrant Inspection Line. This product in general consists of two separate compartments / sections. The first section is for the preparation process and the second compartment is for the inspection process.

The first purpose of this product development is to reduce the exposure of the personnel conducting the inspection to hazardous elements such as the noxious fumes from the sprays and the UV light from the lamp used for the inspection process.

Secondly, this product is developed to enhance the user experience while conducting Liquid Penetrant Inspection, specifically for Solvent Removable Method. This product also allows the precise measurements of the flaw indication by using Ruler Tool in Adobe Photoshop.

Finally, the purpose of FPTD is to streamline the process of conducting FPI (Solvent Removable Method). This is achieved through the digitalization of record keeping for the Line Control Checklist and the Inspection Report.

4.1.2 Specific Part Features

4.1.2.1 Product Structure

In general, the structure of FPTD consists of two different sections: the Prep Section and the Inspection Section. The mainframe of the structure is constructed with 1" hollow square steel. The panels are constructed by using galvanized zinc sheet and acrylic sheet. The dimension of each section is 18 x 16 x 18" respectively.

The Prep Section is designed for pre-cleaning, penetrant application, developer application, and excess penetrant removal processes. As for the Inspection Section, this section is designed for the inspection process of the test sample.

4.1.2.2 Mechanical Mechanism

FPTD consists of two (2) different sections, the Prep Section, and the Inspection Section. Only the Prep Section is accessible by the users, so in order for the test subject to be transferred to the inspection section, roller conveyor was equipped in our product.

This roller conveyor system is made by using PVC pipes, bearings, metal rods and is held in place by riveting steel bands around the rod. The PVC pipes were arranged in parallel formation and s connected by using a rubber tube. The rubber tube is connected for every two (2) PVC pipes.

4.1.2.3 Electronics & Programming

The electronics of FPTD are made up of a number of sensors and image capturing devices that are crucial to making the process of UV penetrant testing safer and easier.

These sensors include the DHT11 temperature and humidity sensor, GUVA S12SD UV light sensor and TSL2561 light sensor that are all connected to the ESP 8266 microcontroller to read and display it to the I2C Liquid Crystal LCD.

Then, for the image capturing system the GoPro is installed on top of the inspection section and is connected to a viewing device of choice via UGREEN's Micro HDMI Port to HDMI.

4.1.2.4 Accessories & Finishing

FPTD is equipped with interconnecting rollers to covey the test sample between the sections. An exhaust fan is installed in the Prep Section to remove the fumes built up

from the product. The Inspection Section is equipped with UV light, which will be operated for the sample inspection.

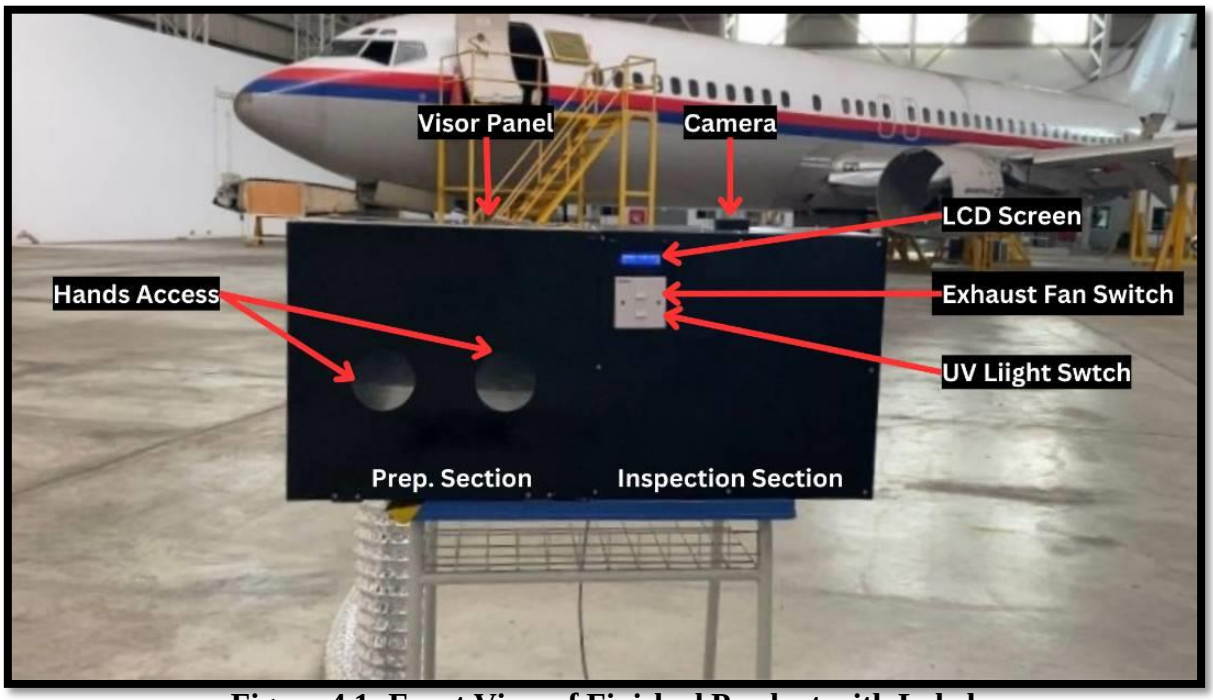


Figure 4.1: Front View of Finished Product with Labels

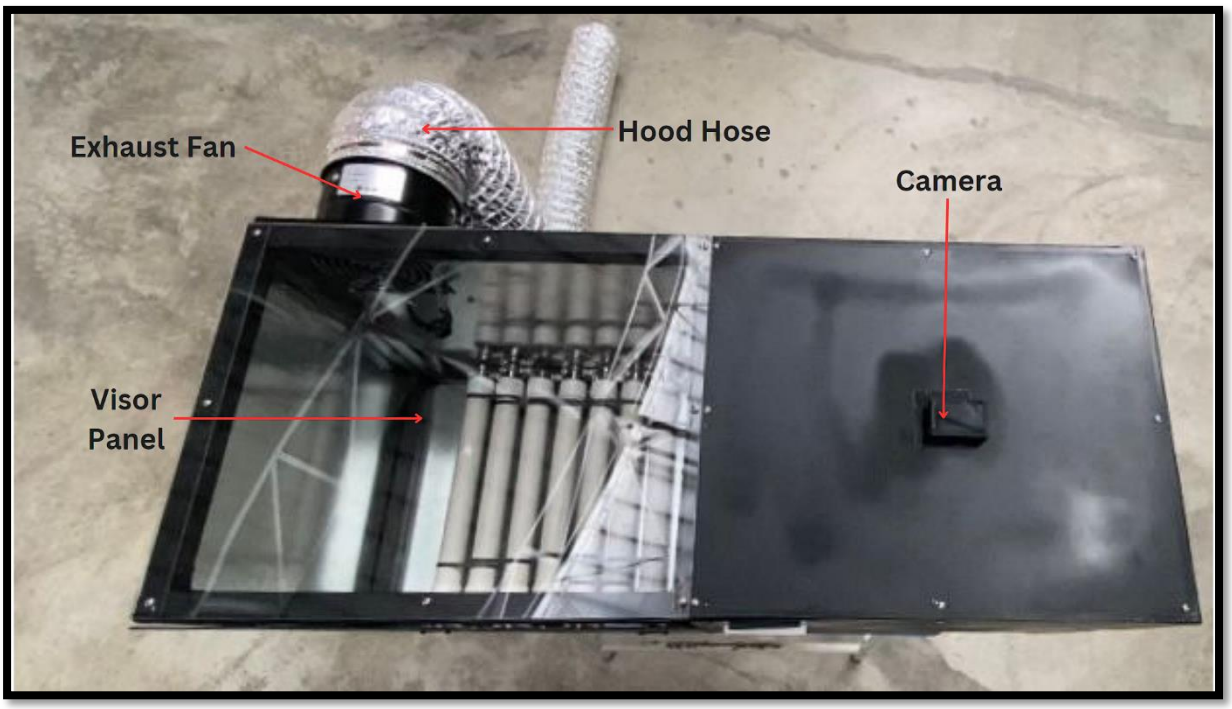


Figure 4.2: Top View of Finished Product with Labels

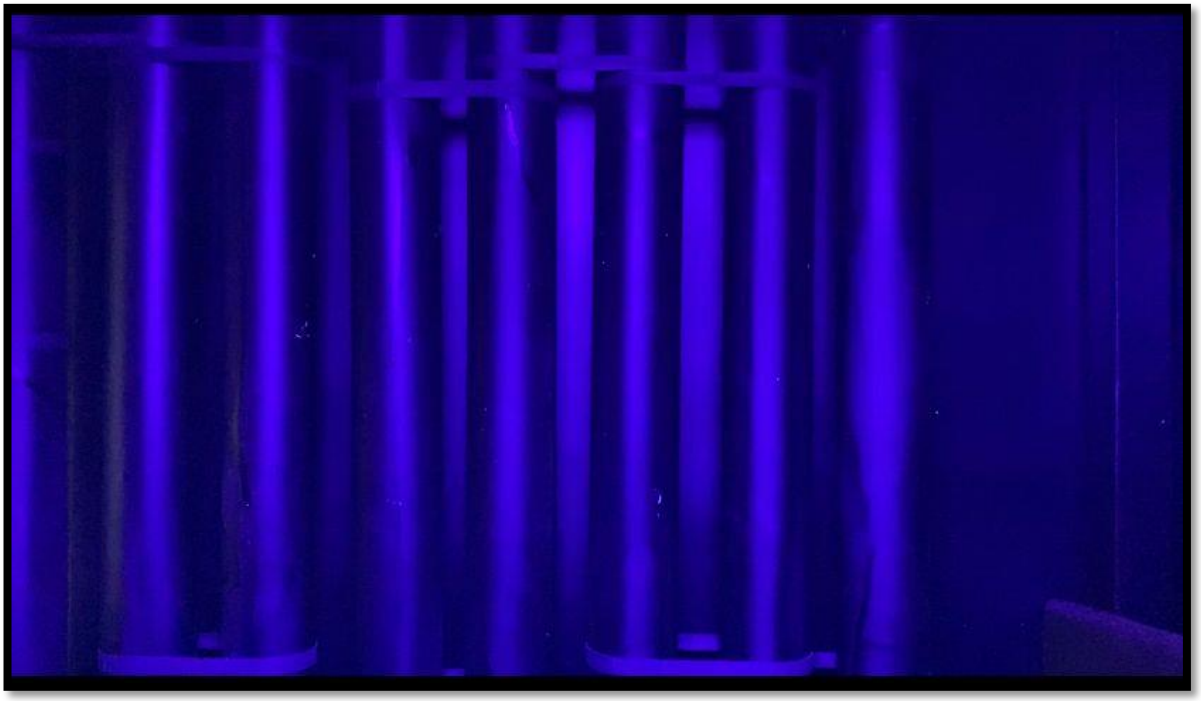


Figure 4.3: Internal View of the Inspection Section Equipped with UV Light

4.1.3 Results for Indication of Flaws / Defects

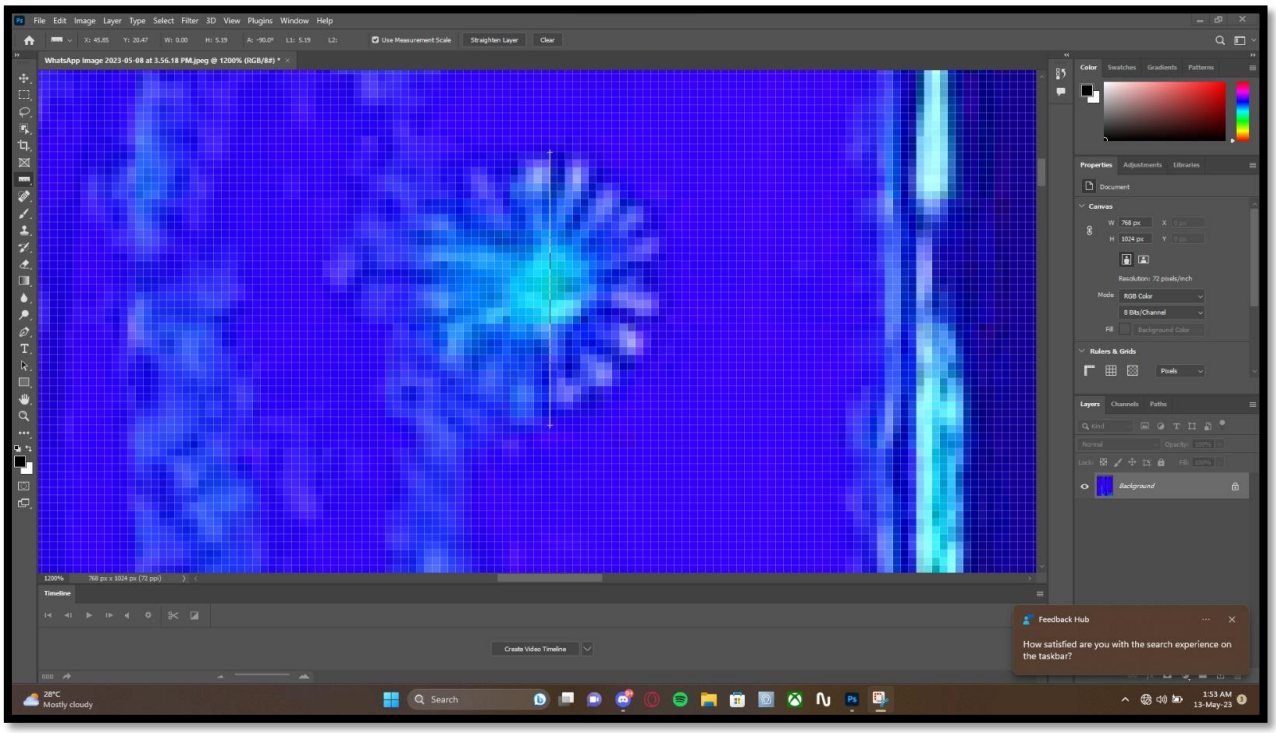


Figure 4.4: Results for Indication of Flaws / Defects

FPTD utilizes the usage of image capturing using a GoPro and the procedure of taking measurements of flaws and indications will be done using the Ruler Tool in Adobe Photoshop. By including the usage of these items, as compared to the conventional method, we are able to increase the accuracy of flaws and indication measuring.

By using the conventional method, the inspection of the sample must be conducted within 10 minutes after the dwell time of the developer application. The evaluation beyond 10 minutes might give false indication and reading. As per the objective of this project, FPTD will be able to allocate additional inspection time for personnel to conduct inspections and evaluation of test subjects by using camera (GoPro) to capture the image of the sample after the dwell time. This will allow the personnel conducting the test to take as long as required to inspect and evaluate the captured image instead of the sample itself.

4.1.4 Results of the Input Sensors for Pre-checklist

Figure 4.5: Reading of UV Light Intensity

- The purpose of the GUVA-S12SD sensor is to measure the intensity of ultraviolet (UV) light in the environment.
- It enables the detection of UV radiation levels, which can be useful for various applications, including UV index monitoring, UV exposure measurement for skin protection, and UV sterilization monitoring.

Figure 4.6: Reading of Light Intensity

- The purpose of the TSL2561 sensor is to measure the ambient light intensity in the environment.
- It detects both visible and infrared light, providing a comprehensive measure of the light levels.

Figure 4.7: Reading of Temperature

- The purpose of the DHT11 sensor is to measure and monitor the temperature and humidity levels in the surrounding environment.
- It is commonly used in applications where temperature and humidity data are required, such as weather monitoring, HVAC systems, and indoor climate control.

4.1.5 Comparison Result Between P&W TAM Panel (reference) With FPTD and Magnaflux Modular FPI Line

Table 4.1: Result Comparison

	REFERENCE	
FPTD	**P&W TAM Panel**	**Measurement with naked eyes**
5.23 mm	**5.29 mm**	5.20
3.62 mm	**3.66 mm**	3.59
2.12 mm	**2.14 mm**	2.09
1.22 mm	**1.24 mm**	1.20
0.55 mm	**0.56 mm**	0.50

By referring the result in accordance to the P&W TAM as the reference we determined our value can achieve an accuracy of 98.9%

4.1.5 General Operation of the Product

Prior to conducting the test, the Line Control Pre-Check is required. This check list consists of several parameters including the temperature, and the ambient light and UV intensity in the Inspection Section. The values of these parameters are obtained from the sensors and will be displayed on the LCD display. The readings are then recorded in the FPTD database.

After the test specimen is placed onto the center of the rollers in the Inspection Section, the preparation process can be executed in accordance with the standard practices. Once done, the specimen is transferred to the Inspection Section via the roller conveyor.

At the Inspection Section, the image of the sample is captured with the camera. The image is then processed with Adobe Photoshop and using the Ruler Tool, the flaw indications are evaluated. The result is then recorded in the FPTD database.

4.1.6 Operation of The Specific Part of the Product

4.1.6.1 Product Structure

The panels for the chassis are constructed mainly using galvanized zinc sheet, except for the top and front panels at the Prep Section, which are made of acrylic sheet. The front panel of the Prep Section is attached to the mainframe with two hinges at the bottom edge giving the panel the ability to be opened. Two magnetic latches are installed at the top edge as the locking mechanism for the panel.

All the other panels are fastened to the mainframe with self-tapping screw. This allows the panels to be removed and installed at any time for maintenance purposes, such as cleaning, component replacement and repair.

4.1.6.2 Mechanical Mechanism

The conveyor roller system was equipped into our product to help the transfer process of the sample from the Prep Section into the Inspection Section and vice versa. For every two (2) PVC pipes, a rubber tube was attached at each end to help all the PVC pipes roll simultaneously.

This conveyor system will be actuated by the hand of the user conducting the inspection. The roller conveyor system can only be actuated from the Prep Section as the Inspection Section is closed completely to minimize the light from entering the Inspection Section.

4.1.6.3 Electronics & Programming

The three (3) sensors which are DHT 11 Temperature and Humidity Sensor is used to identify the temperature and detect humidity when performing the inspection. The GUVA S12SD UV Light Sensor is used to detect and identify the UV light intensity. The TSL2561 Ambient Light Sensor is used to identify the light intensity when all the light sources in the FPTD device are turned off. And then all of these sensors are connected to the ESP 8266 microcontroller to have their data read and then displayed to the I2C Liquid Crystal 16x2 LCD.

4.1.6.4 Accessories & Finishing

An exhaust fan is installed at the Prep Section to prevent the fumes build up in product by removing it. The fume is discharged to the desired area via a hood hose attached to the fan outlet. A UV light is installed at the inspection section to aid in the specimen inspection process. Both UV light and exhaust fan are connected to one power input. This is to reduce the wiring in the product, and at the same time enable effortless control of the power.

All the panels except for the Prep Section top panel are painted with matt black spray paint for finishing. For the mainframe, the finishing is initiated with the application of anti-rust primer before layering it with matt black paint. This is to ensure the structural integrity of the mainframe in the long run by preventing it from rusting.

4.1.7 Post Survey

A post survey was conducted to identify the user's experience towards our project. The post survey was distributed to PBS students who have taken the NDT subject which are Semester 4 and Semester 5 Session 2:2022/2023 student. This survey was also distributed to Certified NDT Personnel and was distributed to the related industry such as the NDT Department of GE Aviation Singapore, and NDT Technician of Leopad Group.

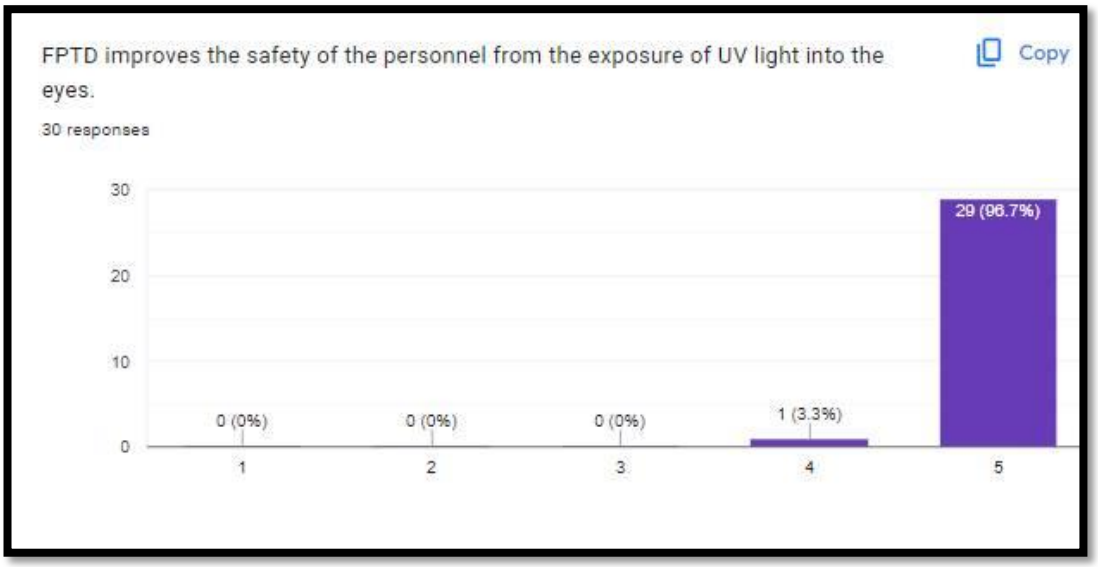


Figure 4.8: Respondent's Perception that FPTD Improves the Safety of the Personnel from Exposure of UV Light Into the Eyes

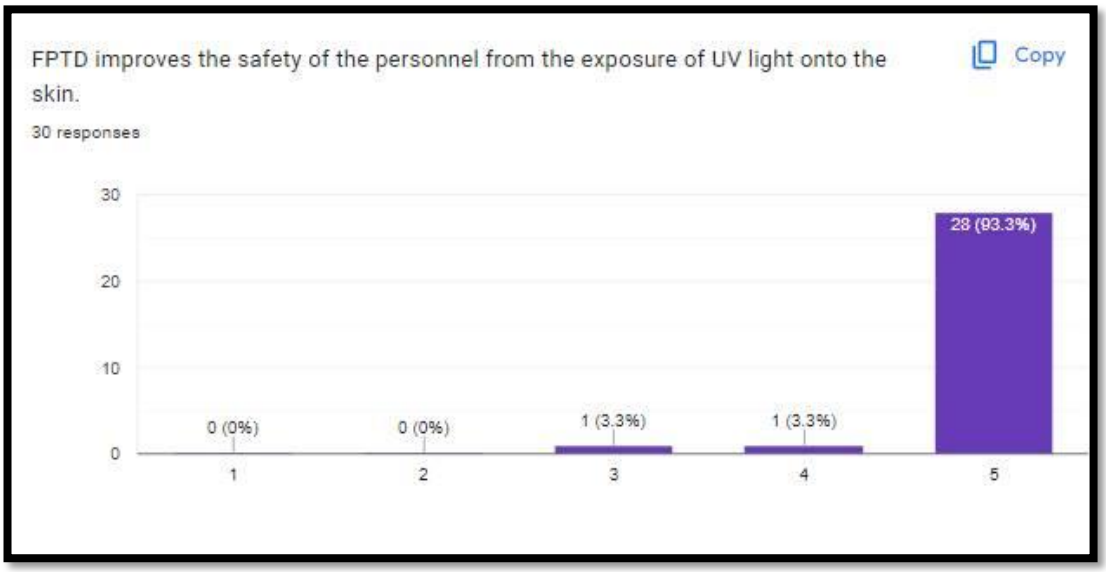


Figure 4.9: Respondent's Perception that FPTD Improves the Safety of the Personnel from Exposure of UV Light onto the Skin

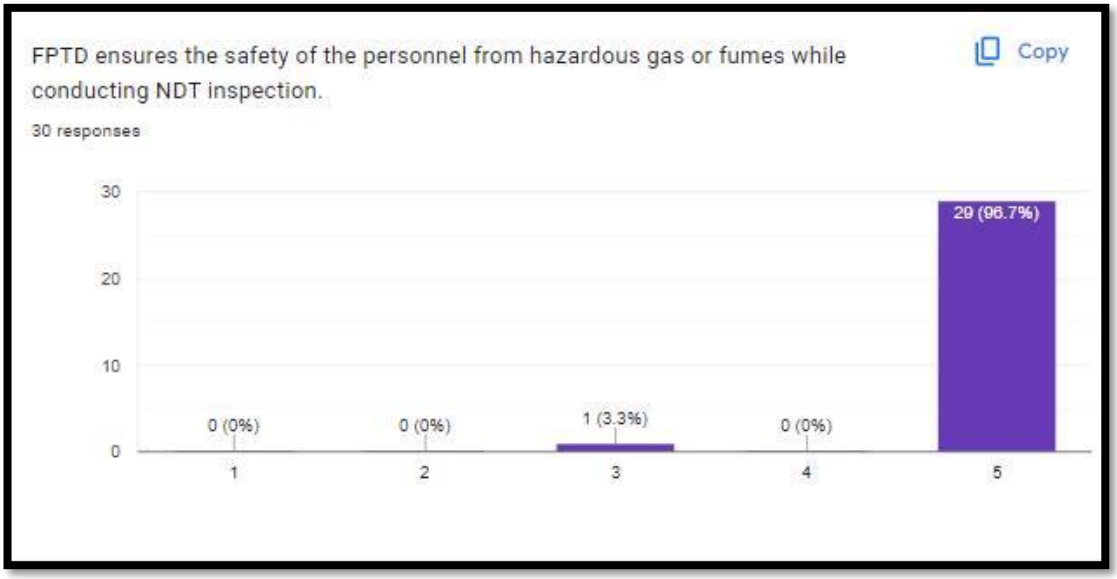


Figure 4.10: Respondent's Perception that FPTD Ensures the Safety of the Personnel from Hazardous Gas or Fumes While Conducting NDT Inspection

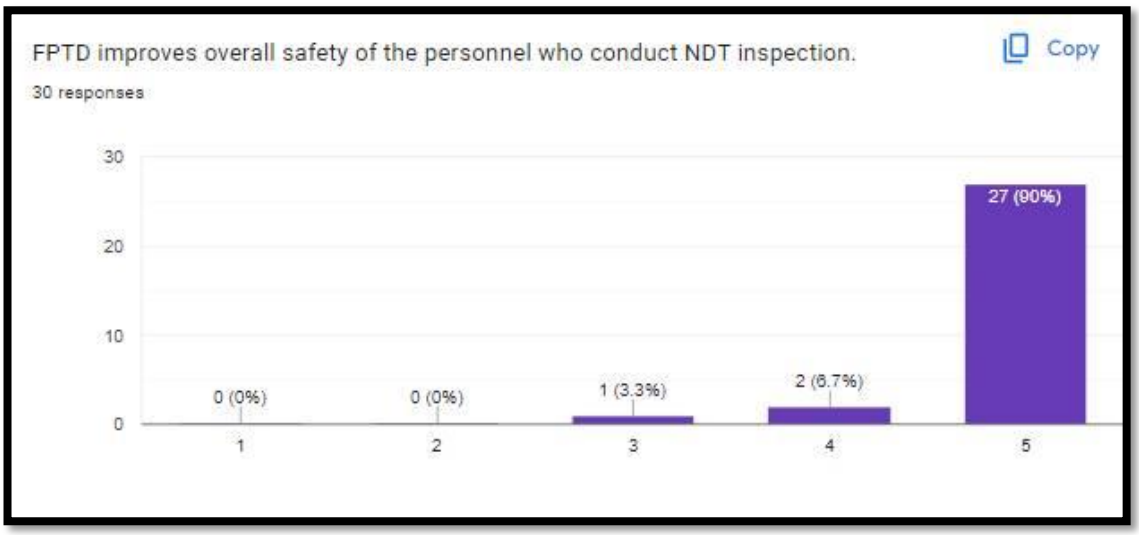


Figure 4.11: Respondent's Perception that FPTD Improves Overall Safety of the Personnel who Conduct NDT Inspection

96.7% of the respondent agrees that FPTD improves the safety of the personnel from exposure of UV light into the eyes. 93.3% of the respondent agrees that FPTD improves the safety of the personnel from exposure of UV light onto the skin, while 96.7% agrees that FPTD ensures the safety of the personnel from hazardous gas or fumes throughout the whole process.

4.2 PROJECT IMPACT/PURPOSE OF PROJECT

The purpose of this project is first to eliminate the hazard of inhaling dangerous fumes or vapors which can cause asphyxiation, narcosis, cardiac arrest, and aspiration. Hazard due to exposure to UV radiation that can increase the risk of blinding eye diseases may also be eliminated. The elimination of these hazards is to provide a safer environment for NDT Technician to conduct Fluorescent Penetrant Inspection (FPI).

Next, FPTD serves the purpose of conducting inspection on test subjects in an easier and more efficient way. This was achieved by using software that is able to inspect and measure defect indication.

The impact that comes from this project is NDT technician will be able to conduct FPI without worrying about being exposed to hazards. This project also reduces the cases of health implication towards NDT technician from exposure of the hazards mentioned above. This project also may give a huge impact on the efficiency of FPI as inspection and measuring procedure will be conducted digitally through a camera and ruler tools in Adobe Photoshop.

4.3 ANALYSIS OF PROLEM ENCOUNTERED & SOLUTIONS

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. To solve this, the affected tube was replaced, and the welding is resumed at a different setting. Other than that, it was hard to retain connect the frame joints perpendicularly. Hence, the joints were connected with brackets instead of welding directly at the joints. This method solved the first problem as well, as we only need to replace the bracket individually instead of the whole tube in the event of over-heating.

For the panels, the problem in the cutting process of the used acrylic sheet. The sheet did not snap off after scoring the line using the acrylic cutter knife as per measurement. This was due to the properties of the acrylic which became elastic instead of brittle. Hence, the lines were scored until it penetrated the other side of the acrylic.

4.3.2 Mechanical Mechanism

The problems encountered in the fabrication process of the mechanical mechanism; the roller conveyor was the fitting of bearings into the PVC pipes. At first, we bought the PVC pipes without measuring the size of the bearing. To encounter this problem, we had to buy a new PVC pipe that would fit the bearings into it.

Next, during the process of attaching the metal rod onto the product mainframe, we first tried to weld it together, but the material of the metal rod was too soft, and it instantly melted. To encounter this problem, we have decided to attach the metal rod onto the product mainframe by using steel band and rivet it.

We also encountered another problem when we were in the process of trying to make all the rollers move simultaneously. At first, we decided to use a car timing belt, but the size of it does not fit all the rollers. Next, we decided to use rubber tire tubes and install it in a cross manner for every two (2) rollers, but it is not strong enough to move all of the rollers simultaneously. To encounter this problem, we installed the rubber tire tube on each end of every roller for every two (2) rollers.

4.3.3 Electronic & Programming

The problems encountered during the process of putting together the electronics and programming are mostly identified during programming.

During the first rendition of the coding some of the sensors were not able to be recognized by the Arduino IDE application, after further research the source of the problem happens to be the library for each of these parts were not installed properly and thus the problem is resolved.

Although the libraries are properly installed one (1) of the sensors still happens to be malfunctioning and it is later found out to be the sensor used (TEMT 6000 light sensor) cannot be connected to the ESP 8266 at the same time as another sensor used (GUVA S12SD UV light sensor) as both of them are analog sensors and the ESP 8266 only accommodate one (1) analog sensor, this is then resolved by replacing the analog light sensor with a digital light sensor (TSL2561 Ambient Light Sensor).

4.3.4 Accessories & Finishing

There was no issue with UV light and the exhaust fan installation, including the wiring. However, the problem was with the finishing. The panels were painted prior to some minor installation of small components such as the LCD display and the switch panel. This caused the painting to peel off from the panel during the installation of these components. Hence, a re-painting job was done on the affected panel.

4.4 Key Benefits of FPTD

Our product, FPTD comes with great key benefits that enhance this product as compared to the conventional method and increase its commercial value, thus increases the chance of penetrating the Non-destructive Testing industry.

Table 4.2: Key Benefits of FPTD

	Modular FPI Line	**FPTD**
Product		
Portability	Station	Portable
Size	328” x 70” x 142”	36” x 16” x 18”
UV Exposure	Yes	Remote Inspection
Inhalation of Fumes	Yes	Enclosed Chamber
Accuracy Result	Naked eyes	Digitally controlled
Time of Inspection	20 Minutes Maximum	Unlimited

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievement of the Product

Upon final project testing, FPTD is able to produce the output as expected. The parameter that indicates the product is a success is the ability of FPTD to produce a measurement that is accurate by using the Ruler Tool in Adobe Photoshop.

Other than that, a post survey is conducted to gather the data on user satisfaction. Based on the data collected, the majority of the respondents agreed that FPTD eliminates the exposure of the personnel to the hazardous elements involved in the whole specimen inspection process.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

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

5.1.2.2 Mechanical Mechanism

Throughout the process of inventing the Fluorescent Penetrant Testing Device (FPTD), the objectives and aims to increase efficiency of conducting the inspection were achieved. The main purpose of including the mechanical mechanism of roller conveyor into our project is to make it easier for the user to transfer test subjects from Prep Section into the Inspection Section and vice versa.

A product of Liquid Penetrant Inspection that comes with a roller conveyor has been developed and designed first, but the conveyor roller was only available during the surface preparation procedure. Our project improvises the design by making the roller conveyor all the way from the Prep Section into the Inspection Section, thus providing a full mechanical mechanism throughout the process of conducting Fluorescent Penetrant Inspection.

5.1.2.3 Electronics & Programming

Throughout the construction of the electronics and compiling the codes for the Fluorescent Penetrant Testing Device (FPTD) the objective to remove the process of entering and leaving a darkroom for inspecting the workpiece is achieved via the use of a camera and viewing device and the use of sensors to achieve data to be used in the pre-check list.

Furthermore, a product that utilizes all these sensors and digital image capturing devices has been created and is able to perform as intended in the objective of this project.

5.1.2.4 Accessories & Finishing

The final product is equipped with several components which enhance the safety features of the product and aid in the inspection process itself. The first component is the exhaust fan, which is to prevent fumes from accumulating inside the product, and the UV light which is used in the inspection of the specimen.

Other than that, the interior of the panels for Inspection Section is painted with matt black, and this creates a dark environment inside the section

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The contribution of the project to our society is to streamline the process for Liquid Penetrant Inspection specifically on Solvent Removable Method. Meanwhile, the contribution of the project in the industry is to provide a safe working environment to NDT personnel. The impact of the FPTD towards society is to enhance the user experience in conducting NDT, which includes students partaking NDT courses and NDT professionals.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

The suggestion for future research on FPTD 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 durability. Other than that, the panels made of galvanized zinc sheet should be replaced with material made of aluminum alloy to reduce the weight of the final product significantly.

5.3.2 Mechanical Mechanism

For future research and development, we would like to increase the efficiency of the process of transferring the test subject from Prep Section to the Inspection Section by installing a motor and a 2-way switch which will be the actuator to move the roller conveyor simultaneously. The function of using a 2-way switch is to allow the motor to rotate in two directions, thus allowing the roller conveyor to move in two directions, resulting the test subject to be transferred to and from the prep section and inspection section automatically.

5.3.3 Electronics & Programming

For future research regarding the electronics and programming of the FPTD, we would like to improve on the modularity of the image capturing device so that it can use not just the GoPro Hero 4 as the means of obtaining an image further making the FPTD more flexible and user friendly.

Furthermore, it would be more desirable to be able to create a standalone application specifically catered to be used with the FPTD instead of using the Adobe Photoshop application.

5.3.4 Accessories & Finishing

For the accessories, a designated column to attach the exhaust fan should be constructed. This is to maximize the efficiency of the fan in removing the fumes by installing the fan closer to the spot of the prepping process, instead of attaching it to the mainframe.

LIST OF REFERENCES

1. 6 River Systems, Warehouse Automation (2022). "What is a Conveyor System? Definition and more." [Accessed on 27th November 2022]. [Online]. Retrieved from: https://6river.com/what-is-a-conveyor-system/
2. Advanced Engineering (2019). "Fluorescent Penetrant Inspection". [Accessed on 25th November 2022]. [Online]. Retrieved from: https://www.advancedengineeringuk.com/products/fluorescent-penetrant-inspection-fpi/
3. American Society for Testing and Materials (ASTM) (2021). "Standard Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process". [Accessed on 27th November 2022]. [Online]. Retrieved from: https://www.astm.org/e1219-21.html
4. ASTM International. (2021). "Standard Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process". [Accessed on 25th November 2022]. [Online]. Available at: https://www.astm.org/e1219-21.html
5. B.E.N (n.d)."What Is AN Arduino?".[accessed on 08th December 2022][Online].Retrieved from:{HYPERLINK "https://learn.sparkfun.com/tutorials/what-is-an-arduino/all"}
6. BRÜCK, C. (n.d.). "Workplace minimum requirements and EU OSH legislation". [Accessed on 26th November 2022]. [Online]. Avalilable at: https://oshwiki.eu/wiki/Workplace_minimum_requirements_and_EU_OSH_legislation
7. Conveyors and Drives, Inc. (ConDrives) (2022). "Ball Transfer Conveyors or Tables". [Accessed on 2nd November 2022]. [Online]. Retrieved from: https://www.condrives.com/product/ball-transfer-table-ball-casters/
8. Carville Limited. (n.d). "Properties & Applications of Acrylic". [Accessed on 30th November 2022]. [Online]. Available at: https://www.carvilleplastics.com/latest_news/key-properties-acrylic/
9. DEUTSCH, V. (n.d.). "History of NDT-Instrumentation". [Accessed on 25th November 2022]. [Online]. Available: https://www.ndt.net/article/wcndt00/papers/idn378/idn378.htm#:~:text=Magnetic%20particle%20crack%20detection&text=Real%20industrial%20application%20was%20made,an%20Italian%20in%201932%3A%20Giraudi.
10. E. Mendoza (1973). "Automated Liquid Penetrant Inspection System". [Accessed on 5th December 2022]. [Online]. Retrieved from: https://patents.google.com/patent/US3762216?oq=Penetrant+test
11. Elsevier Ltd. (2017). " Advances and Researches on Non Destructive Testing: A Review" By: S.K. Dwivedi, M, Vishwakarma, Prof. A. Soni. [Accessed on 28th November 2022]. [Online]. Retrieved from: https://www.researchgate.net/publication/323989118_Advances_and_Researches_on_Non_Destructive_Testing_A_Review

12. Flyability (2022). “What is NDT (None-Destructive Testing)”. [Accessed on 25th November 2022]. [Online]. Retrieved from: https://www.flyability.com/ndt
13. Google Patents. (n.a.). “Nondestructive inpection method and apparatus”. [Accessed on 30th November 2022”. [Online]. Available: https://patents.google.com/patent/US6950545?oq=ndt+penetrant+testing
14. Health and Safety Executive. (2004). “Hydrocarbon releases: consideration of acute health effects”. [Accessed on 25th November 2022]. [Online]. Available at: https://www.hse.gov.uk/offshore/notices/sn_04_04.htm#:~:text=5.,significant%20in%20the%20offshore%20context.
15. Inspectioneering (n.d.). “Overview of Nondestructive Testing (NDT)”. [Accessed on 25th November 2022]. [Online]. Retrieved from: https://inspectioneering.com/tag/nondestructive+testing
16. Johson and Allen Ltd. (n.d.). “LIQUID PENETRANT NDT SYSTEM”. [Accessed on 28th November 2022]. [Online]. Available at: https://www.johnsonandallen.co.uk/product/penetrant-inspection-line
17. Laszlo Lipot: Multimedia Design and Technology Education (n.d.). “Chain and Sprocket”. [Accessed on 27th November 2022]. [Online]. Retrieved from: https://www.notesandsketches.co.uk/Chain_and_Sprocket.html
18. L.A.C. Conveyors and Automation (2019). “What is a Roller Conveyor” By: Harry. [Accessed on 27th November 2022]. [Online]. Retrieved from: https://www.lacconveyors.co.uk/what-are-roller-conveyors-and-how-are-they-used/
19. M.D.Tomasch.(1992).” Ultraviolet remote visual inspection system”.[Accessed on 1st of December 2022].[Online]. Available at {HYPERLINK” https://patents.google.com/patent/US5115136A/en?q=fluorescent+penetrant+test&oq=fluorescent+penetrant+test”}
20. Monroe Engineering, LLC, Inc. (2020). “What is a Crank Handle Used For?”. [Accessed on 28th November 2022]. [Online]. Retrieved from: https://monroeengineering.com/blog/what-is-a-crank-handle-used-for/
21. Magnaflux. (n.d.). “Liquid Penetrant Testing Accessories [Brochure]. [Accessed on 25th November 2022]. [Online]. Available at: https://magnaflux.eu/en/Products/Liquid-Penetrant-Testing/Accessories
22. Magnaflux. (n.d.). “Magnetic Bench Enclosure Hoods”. [Accessed on 28th November 2022]. [Online]. Available at: https://www.magnaflux.com/NA/EN/Products/Magnetic-Particle-Inspection/Equipment/Enclosures.htm
23. Magnaflux. (n.d.). “SAFETY DATA SHEET” [Pamphlet]. [Accessed on 25th November 2022]. [Online]. Available at: https://magnaflux.eu/EU-Files/Safety-Data-Sheets/SPOTCHECKSKC-SaerosolCLPSDSVER17-2-22-08-18.pdf
24. Magnaflux. (n.d.). “The Ultimate Guide to Fluorescent Penetrant Testing” [Brochure]. [Accessed on 25th November 2022]. [Online]. Available at: https://www.magnaflux.com/Magnaflux/Resources/Blog/Fluorescent-Penetrant-Infographic

25. Magnaflux. (n.d.). “ZA-915 Modular Penetrant Inspection Line”. [Accessed on 25th November 2022]. [Online]. Available at: https://magnaflux.eu/EU/EN/Products/Liquid-Penetrant-Testing/Equipment/ZA-915.htm
26. National Center for Environmental Health. (2022). “UV Radiation”. [Accessed on 25th November 2022]. [Online]. Available at: https://www.cdc.gov/nceh/features/uv-radiation-safety/index.html
27. NDT Supply.com, Inc.. (n.d.). “Modular Testing Systems”. [Accessed on 28th November 2022]. [Online]. Available at: https://ndtsupply.com/penetrant/penetrant-testing-systems/ndt-penetrant-testing-systems/modular-testing-systems.html
28. RELINC (2022). “Fluorescent Penetrant Inspection Process”. [Accessed on 25th November 2022]. [Online]. Retrieved from: https://www.relinc.com/fluorescent-penetrant-inspection-process
29. Solution for Conveying Materials and Fluids (SEMCOR) (1907). “How do Conveyor Belts Work?”. [Accessed on 30th November 2022]. [Online]. Retrieved from: https://www.semcor.net/blog/how-do-conveyor-belts-work/
30. Samuarai 2K Aerosol Sdn. Bhd.. (n.d.). “All Products [Brochure]”. [Accessed on 30th November 2022]. [Online]. Retrieved from: https://samuraipaint.jp/product-category/all-products/
31. TeamTesca. (2021).” What is a Microcontroller,Types, Applications, and How doesit Work?”.[Accessed on 08th December 2022]. [Online]. Available from: {HYPERLINK” https://www.tescaglobal.com/blog/what-is-a-microcontrollers-and-how-does-it-work/”}
32. TITUS STEEL. (2019). “THE LANGUAGE OF STRENGHT: UNDERSTANDING THE MECHANICAL PROPERTIES OF STEEL”. [Accessed on 29th November 2022]. [Online]. Available at: https://titussteel.com/the-language- of-strength-understanding-the-mechanical-properties-of-steel/#:~:text=Steel%20has%20a%20number%20of,%2C%20plasticity%2C%20malleability%20and%20creep.
33. The American Society for Nondestructive TestingASNT, (2016). “Codes and Standards Bodies Involved in NDT Industry,” [Accessed on 28th November 2022]. [Online]. Retrieved from: https://www.asnt.org/MajorSiteSections/Standards/Codes_and_Standard_Bodies.aspx
34. United States Department of Labour. (n.a.). “Employer Responsibilities”. [Accessed on 27th November 2022]. [Online]. Available at: https://www.osha.gov/workers/employer-responsibilities
35. ViewTech Borescopes (n.d.). “Ultraviolet VJ-3 Video Borescope” [Accessed on 5th December 2022]. [Online]. Retrieved from: https://www.viewtech.com/borescopes/ultraviolet-uv-borescope/
36. Wikipedia (2009). “Chain Conveyor”. [Accessed on 2nd December 2022]. [Online]. Retrieved from: https://en.wikipedia.org/wiki/Chain_conveyor

37. ZETEC The Inspection Advantage (n.d.). “Destructive and Nondestructive Testing of Welds. How NDT Ensures Quality”. [Accessed on 25th November 2022]. [Online]. Retrieved from: https://www.zetec.com/blog/destructive-and- nondestructive-testing-of-welds-how-ndt-ensures-quality/
38. Zetec, Inc.. (n.d.). “Military Nondestructive Testing: Safety Precautions”. [Accessedon 28th November 2022]. [Online]. Available at: https://www.zetec.com/blog/military-nondestructive-testing-safety-precautions/#:~:text=Safety%20Precautions%20for%20Common%20NDT%20Equipment%20and%20Procedures&text=Due%20to%20the%20potential%20for,result%20in%20serious%20health%20problems

APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
DAMIAN AJENG BELAWING	
1.2	Problem Statements
1.3.2.1	Specific Individual Project Objectives: Product Structure
1.3.2.4	Specific Individual Project Objectives: Accessories & Finishing
1.4.2.1	Specific Individual Scope: Product Structure
1.4.2.4	Specific Individual Scope: Accessories & Finishing
1.5	Project Impact
2.1.1	NDT in Aviation
2.1.4	PT Key Player (Magnaflux)
2.2.1	Specific Literature Review: Product Structure
2.2.4	Specific Literature Review: Accessories & Finishing
2.3.1	Related Patented Product: Non-destructive Inspection Method and Apparatus
2.3.2	Recent Market Product: Magnaflux ZA-915 LPI System
2.4.1	Non-destructive Inspection Method and Apparatus vs. FPTD vs. ZA-915
3.1.2	Design Concept Generation
3.1.3	Evaluation & Selection of Conceptual Design
3.2.1	Utilisation of Polytechnic's Facilities
3.3	Overall Project Gantt Chart
3.4.1	Overall Project Flow Chart
3.4.2.1	Specific Project Design Flow/Framework: Product Structure & Finishing
3.5	List of Materials & Project Expenditure
3.6.1	General Product Drawing
3.6.2	General Product Dimension
3.6.3.1	Specific Part Drawing / Diagram: Product Structure
3.7.1.1	Material Acquisition: Main Structure
3.7.2.1	Machine for Project Fabrication
3.7.3.1	Individual Parts Fabrication: Main Structure

3.7.3.4	Individual Parts Fabrication: Product Finishing
4.1.1	General Product Features & Functionalities
4.1.2.1	Specific Part Features: Product Structure
4.1.2.4	Specific Part Features: Accessories & Fittings
4.1.5	General Operation of the Product
4.1.6.1	Operation of Specific Part of the Project: Product Structure
4.1.6.4	Operation of Specific Part of the Project: Accessories & Finishing
4.3.1	Analysis of Problem Encountered & Solutions: Product Structure
4.3.4	Analysis of Problem Encountered & Solutions: Accessories & Finishing
4.4	Key Benefits of FPTD
4.5	Post Survey
5.1.1	General Achievement of the Product
5.1.2.1	Specific Achievement of Project Objectives: Product Structure
5.1.2.4	Specific Achievement of Project Objectives: Accessories & Finishing
5.2	Contribution or Impact of the Project
5.3.1	Improvement & Suggestion for Future Research: Product Structure
5.3.4	Improvement & Suggestion for Future Research: Accessories & Finishing
NUR AQIL BIN AIDY	
1.1	Background of Study
1.3.2.2	Product Mechanism
1.4.1	General Project Scopes
1.4.2.2	Specific Individual Project Scopes: Product Mechanism
2.1.2	Types of NDT
2.1.3	Types of Penetrant Testing
2.2.2	Specific Literature Review: Product Mechanism
2.3.1.3	Related Patented Product: Automated Liquid Penetrant Inspection System
2.3.2.3	Recent Market Product: Ultraviolet (UV) VJ-3 Video Borescope
2.4.3	Automated Liquid Penetrant Inspection System vs FPTD vs Ultraviolet (UV) VJ-3 Video Borescope
3.1.1	Design Requirement Analysis
3.4.2.2	Specific Project Design Flow / Framework: Roller Conveyor
3.6.3.2	Specific Part Drawing / Diagram: Mechanical Mechanism (Roller Conveyor)

3.7.1.2	Material Acquisition: Roller Conveyor
3.7.2.2	Tools for Project Fabrication
3.7.3.2	Individual Parts Fabrication: Roller Conveyor
4.1.2.2	Specific Part Features: Mechanical Mechanism (Roller Conveyor)
4.2	Project Impact / Purpose of Product
4.3.2	Analysis of Problem Encountered & Solution: Mechanical Mechanism (Roller Conveyor)
5.1.2.2	Specific Achievement of Project Objectives: Mechanical Mechanism (Roller Conveyor)
5.3.2	Improvement & Suggestion for Future Research: Mechanical Mechanism
RIZQ FAIZ BIN AZMI	
1.3.1	General Project Objectives
1.3.2.3	Specific Individual Project Objectives: Software / Programming
1.4.2.3	Specific Individual Scope: Software / Programming
2.2.3	Specific Literature Review: Software/ Programming
2.3.1.2	Related Patented Product: Ultraviolet Remote Visual Inspection System
2.3.2.2	Recent Market Product: Magnaflux Fluorescent Dye Penetrant Kit
2.4.2	Automated Liquid Penetrant Inspection System vs FPTD vs Magnaflux Fluorescent Dye Penetrant Kit
3.4.2.3	Specific Project Design Flow / Framework: Software / Programming
3.6.3.3	Specific Part Drawing: Software / Programming
3.7.1.3	Material Acquisition: Software / Programming
3.7.3.3	Individual Parts Fabrication: Software / Programming
4.1.2.3	Specific Part Features: Electronic Software
4.1.3	Results for Indication of Flaws & Defects
4.1.4	Results of Input Sensors for Pre-checklist
4.1.6.3	Operation of the Specific Part of the Project: Electronic / Software
4.3.3	Analysis of Problem Encountered & Solutions: Software & Programming
5.1.2.3	Specific Achievement of Project Objectives: Electronics & Programming
5.3.3	Improvement & Suggestion for Future Research: Electronics & Programming

APPENDIX B: TURNITIN SIMILARITY REPORT

FPTD Thesis

by Nur Aqil Aidy

Submission date: 27-May-2023 11:13PM (UTC+0800)
Submission ID: 2103129312
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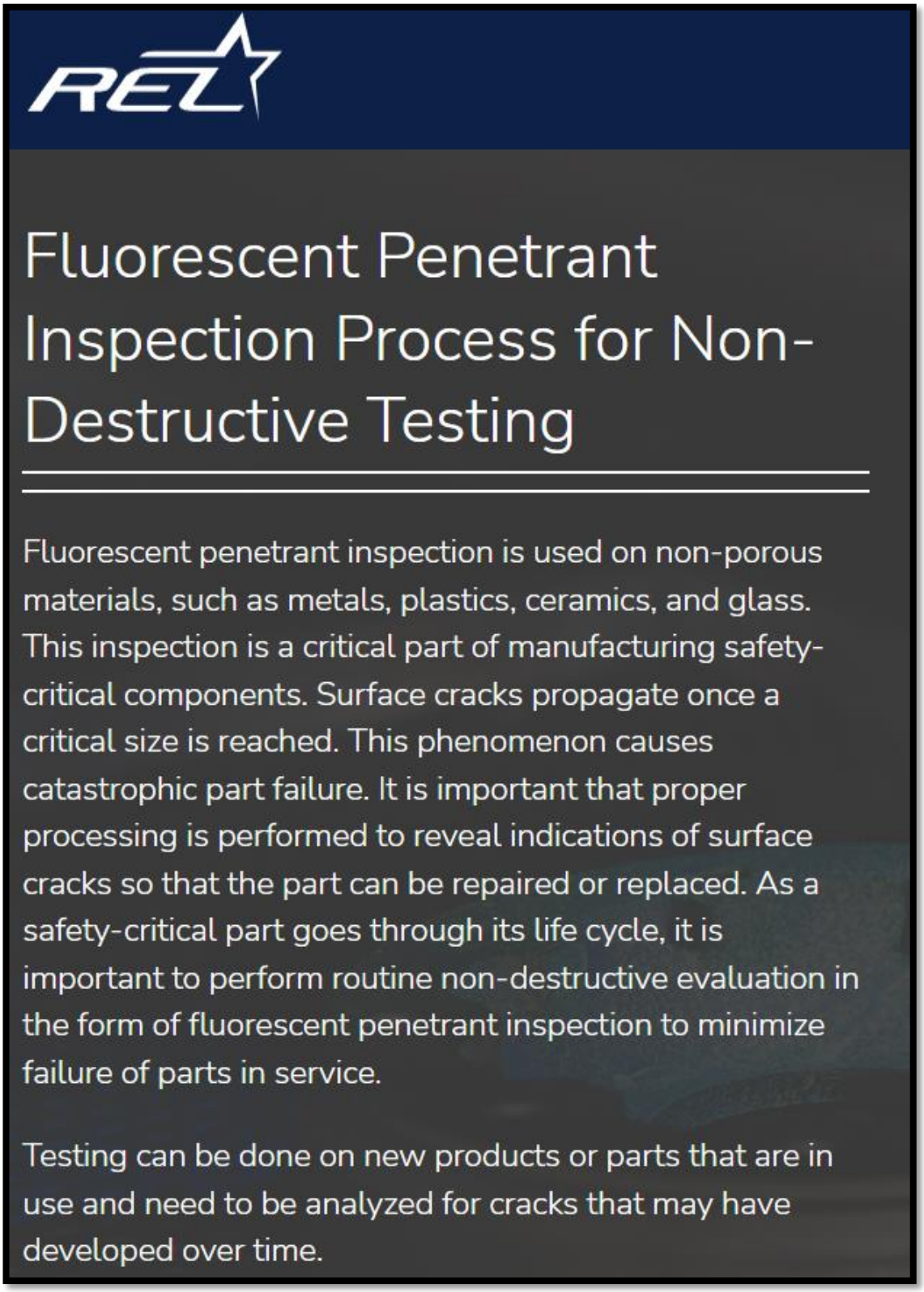
APPENDIX C: FLUORESCENT PENETRANT INSPECTION



APPENDIX D: PATENT FOR AUTOMATED LIQUID PENETRANT INSPECTION SYSTEM

United States Patent [19]
Mendoza

[11] **3,762,216**
[45] **Oct. 2, 1973**

[54] **AUTOMATED LIQUID PENETRANT INSPECTION SYSTEM**

[76] Inventor: **Emilio Mendoza**, 5018 Northfield Drive, San Antonio, Tex. 78228

[22] Filed: **Feb. 23, 1971**

[21] Appl. No.: **118,010**

[52] **U.S. Cl.** **73/104**, 118/9
[51] **Int. Cl.** **G01b 5/28**, G01n 19/08
[58] **Field of Search** 118/7, 9; 73/104

[56] **References Cited**

UNITED STATES PATENTS

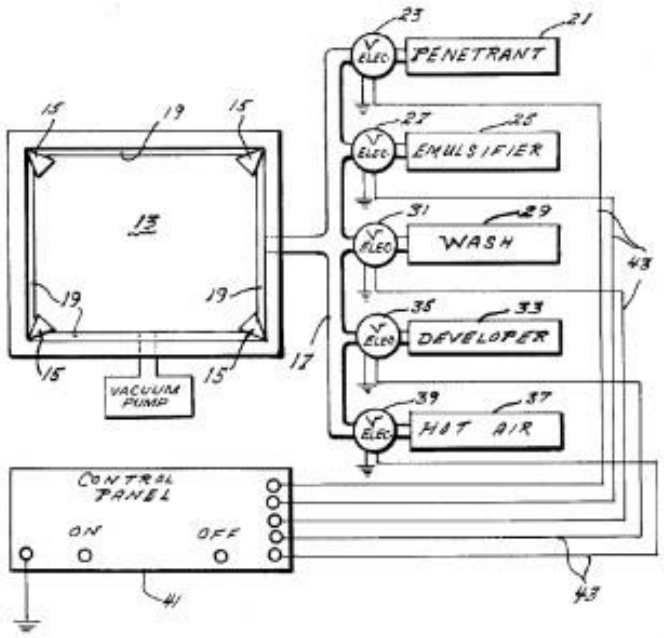
2,515,396	7/1950	De Forest et al.	73/104
2,806,959	9/1957	De Forest et al.	73/104
3,227,130	1/1966	Weinkopf	134/95
3,400,726	1/1968	Du Grail	134/95

Primary Examiner—Herbert Goldstein
Attorney—Harry A. Herbert, Jr. and Arsen Tashjian

[57] **ABSTRACT**

A system of in situ inspection of critical jet engine parts for defects by applying a high penetrating fluorescent oil and inspecting under a light of the proper wavelength. The system which is unitized and portable includes an evacuatable chamber suitable for containing the parts to be inspected. A series of tanks containing the pressurized solutions of penetrant emulsifier wash and developer as well as a hot-air tank are operatively connected to the chamber so that the required solution can be applied under proper conditions for the necessary time period to thereby disclose any defect in the critical engine part.

1 Claim, 1 Drawing Figure



APPENDIX E: CODES AND STANDARDS IN NDT

Codes and Standards

NDT is often prescribed by codes and standards for the fabrication of components, safety critical parts, and in-service equipment. Therefore, it is critical for all refinery, chemical plant, gas plant, and pipeline owners to have thorough understanding and experience in the interdisciplinary field of NDT. In addition to the factors listed above (*Industry Application section*) personnel should continuously develop knowledge about evolving technology and performing up-to-date procedures.

Specific codes, standards, specifications, regulations, and recommended practices may depend on the country and industry performing NDT. The following is a list of organizations (standards bodies) that develop and publish industrial codes, standards, and recommended practices for NDT methods relating to the oil and gas and chemical processing industries:

- The American Society for Nondestructive Testing (ASNT)
- ASTM International
- American Society of Mechanical Engineers (ASME)
- American Petroleum Institute (API)
- American Welding Society (AWS)
- National Board of Boiler and Pressure Vessel Inspectors (NBBI)
- International Organization for Standardization (ISO)
- European Committee for Standardization (CEN)
- European Pressure Equipment Directive (PED)

A complete list of regulations created by the U.S. government may be found in the Code of Federal Regulations (CFR). Regulations critical to the petrochemical and chemical processing industries can be found under Title 10, Energy, and Title 49, Transportation.[1]

APPENDIX F: PATENT FOR ULTRAVIOLET REMOTE VISUAL INSPECTION SYSTEM

US005115136A

United States Patent [19]

Tomasch

[11] **Patent Number: 5,115,136**

[45] **Date of Patent: May 19, 1992**

[54] **ULTRAVIOLET REMOTE VISUAL INSPECTION SYSTEM**

[75] Inventor: **Michael D. Tomasch**, Kew Gardens, N.Y.

[73] Assignee: **Olympus Corporation**, Lake Success, N.Y.

[21] Appl. No.: **562,741**

[22] Filed: **Aug. 6, 1990**

[51] **Int. Cl.**[5] **G01J 5/04**; G01J 5/48

[52] **U.S. Cl.** **250/461.1**; 250/302; 385/117

[58] **Field of Search** 250/461.1, 302; 350/96.25, 96.26, 96.27, 501; 356/241; 606/7

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,798,964	3/1974	Misseroni	73/117.2
3,852,526	12/1974	McCullough et al.	358/100
3,978,720	9/1976	Ford	73/116
3,995,157	11/1976	Holub et al.	250/302
4,065,059	12/1977	Jablin	239/750
4,175,545	11/1979	Termanini	128/666
4,207,874	6/1980	Choy	128/6
4,412,177	10/1983	Petrini et al.	324/226
4,508,369	4/1985	Mode	285/39
4,562,838	1/1986	Walker	606/42
4,621,193	11/1986	Van Hoye	250/302
4,628,207	12/1986	Elferi et al.	250/461.1
4,640,124	2/1987	Diener et al.	73/116
4,643,022	2/1987	Werlberger et al.	73/117.3
4,669,465	6/1987	Moore et al.	606/7
4,696,544	9/1987	Costella	350/96.26
4,791,293	12/1988	Barriere	250/302
4,846,171	7/1989	Kauphusman et al.	606/15
4,918,982	3/1990	Pischinger et al.	73/116

FOREIGN PATENT DOCUMENTS

59-172621	9/1984	Japan	350/96.26
60-15618	1/1985	Japan	350/96.26
61-80218	4/1986	Japan	350/96.26

OTHER PUBLICATIONS

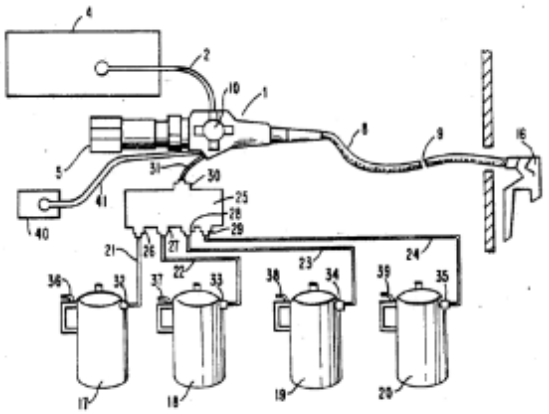
Briggs, W. D., "Flaw Location with Turco Dy z-chek", Turco Products, Inc. of Wilmington, Calif., Jul. 1959.

Primary Examiner—Constantine Hannaher
Assistant Examiner—Jacob M. Eisenberg
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] **ABSTRACT**

The invention provides an ultraviolet remote visual inspection system which enables the operator to detect minute cracks and hairline flaws in normally inaccessible places of manufactured parts. The system includes a fiberscope in combination with a source of white light and ultraviolet light and a plurality of cannisters for holding dye penetrant and other materials which can be used to facilitate the inspection. The fiberscope includes an articulated probe having a working channel, an ultraviolet light guide and an objective lens. The plurality of cannisters are connected to the working channel through a manifold. Dye penetrant, cleaning solution, drying air and developer can be individually delivered to the remote surface to be tested through the working channel from the cannisters. The fiberscope is provided with an adjuster for bending the articulated probe in different directions to facilitate application of the aforesaid materials and the subsequent visual inspection. Dye penetrant which is entrapped in cracks fluoresces brightly when illuminated by the ultraviolet light so that the cracks are easily identified.

11 Claims, 2 Drawing Sheets



APPENDIX G: STANDARD PRACTICE FOR FLUORESCENT LIQUID PENETRANT TESTING USING THE SOLVENT-REMOVABLE PROCESS

ASTM E1219-21 ⓘ

Standard Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process

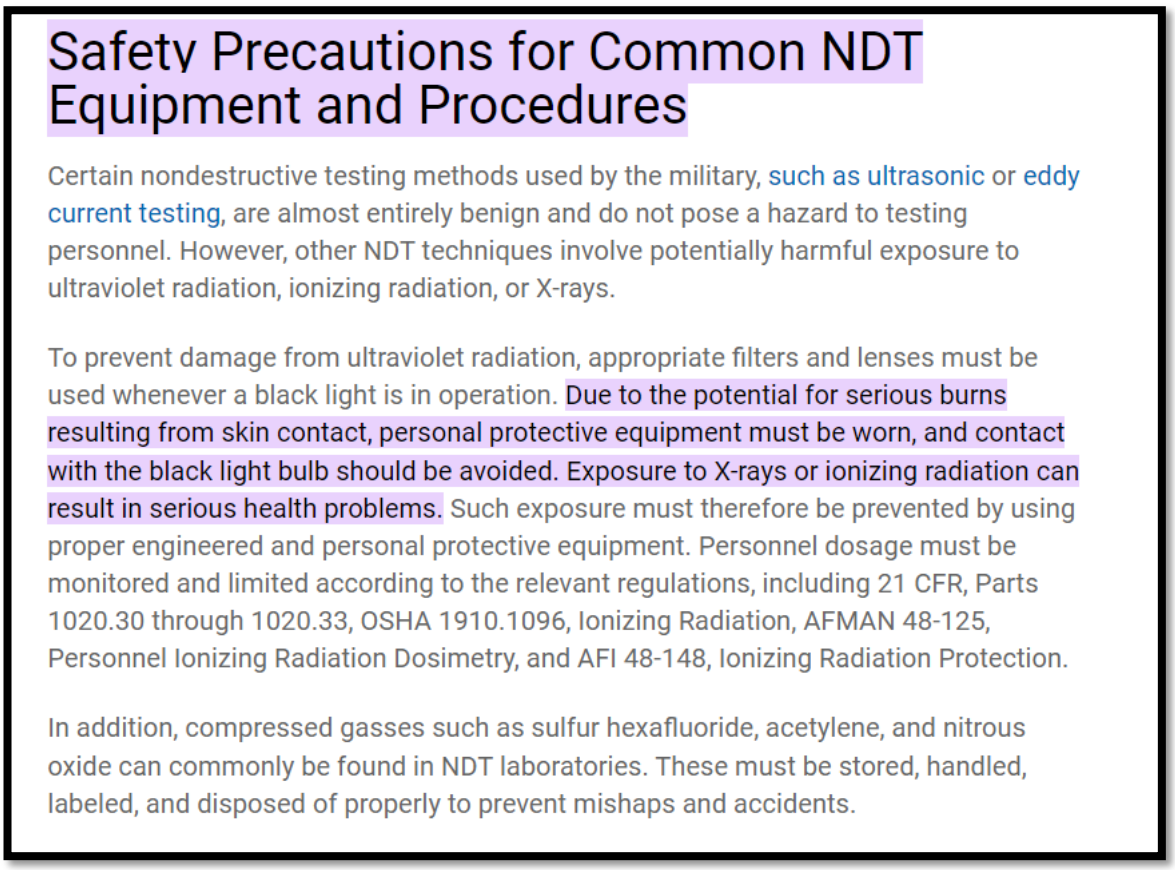
Significance and Use

5.1 Liquid penetrant examination methods indicate the presence, location, and, to a limited extent, the nature and magnitude of the detected discontinuities. This practice is intended primarily for portability and for localized areas of examination, utilizing minimal equipment, when a higher level of sensitivity than can be achieved using visible process is required. Surface roughness may be a limiting factor. If so, an alternative process such as post-emulsified penetrant should be considered, when grinding or machining is not practical.

Scope

1.1 This practice2 covers procedures for fluorescent penetrant examination utilizing the solvent-removable process. It is a nondestructive testing method for detecting discontinuities that are open to the surface, such as cracks, seams, laps, cold shuts,

APPENDIX H: SAFETY PRECAUTIONS FOR COMMON NDT EQUIPMENT AND PROCEDURES



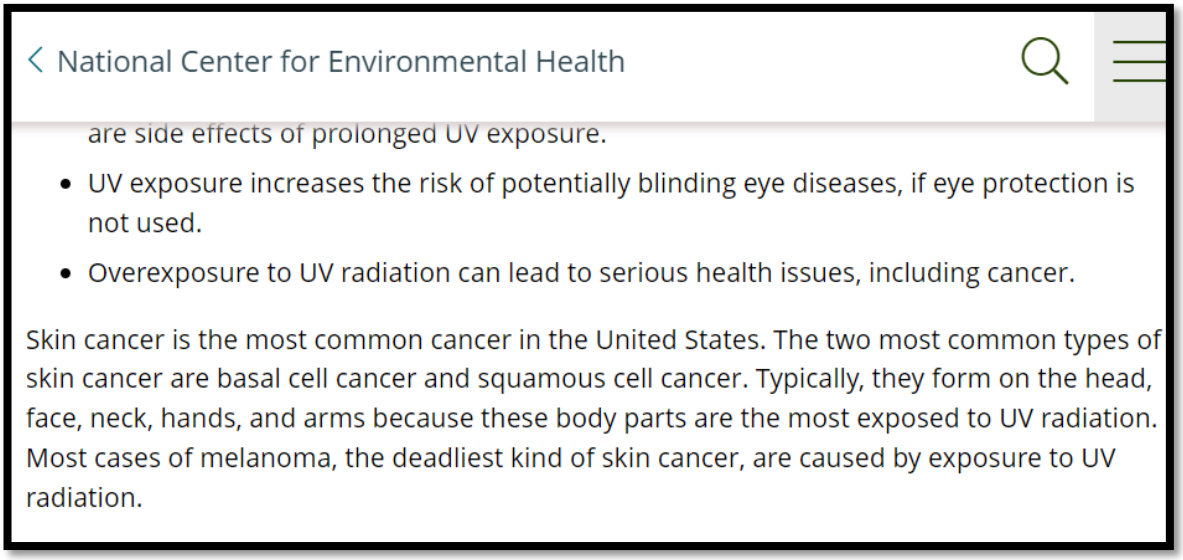
Safety Precautions for Common NDT Equipment and Procedures

Certain nondestructive testing methods used by the military, such as ultrasonic or eddy current testing, are almost entirely benign and do not pose a hazard to testing personnel. However, other NDT techniques involve potentially harmful exposure to ultraviolet radiation, ionizing radiation, or X-rays.

To prevent damage from ultraviolet radiation, appropriate filters and lenses must be used whenever a black light is in operation. Due to the potential for serious burns resulting from skin contact, personal protective equipment must be worn, and contact with the black light bulb should be avoided. Exposure to X-rays or ionizing radiation can result in serious health problems. Such exposure must therefore be prevented by using proper engineered and personal protective equipment. Personnel dosage must be monitored and limited according to the relevant regulations, including 21 CFR, Parts 1020.30 through 1020.33, OSHA 1910.1096, Ionizing Radiation, AFMAN 48-125, Personnel Ionizing Radiation Dosimetry, and AFI 48-148, Ionizing Radiation Protection.

In addition, compressed gasses such as sulfur hexafluoride, acetylene, and nitrous oxide can commonly be found in NDT laboratories. These must be stored, handled, labeled, and disposed of properly to prevent mishaps and accidents.

APPENDIX I: UV RADIATION (NATIONAL CENTER FOR ENVIRONMENTAL HEALTH)



National Center for Environmental Health

are side effects of prolonged UV exposure.

- UV exposure increases the risk of potentially blinding eye diseases, if eye protection is not used.
- Overexposure to UV radiation can lead to serious health issues, including cancer.

Skin cancer is the most common cancer in the United States. The two most common types of skin cancer are basal cell cancer and squamous cell cancer. Typically, they form on the head, face, neck, hands, and arms because these body parts are the most exposed to UV radiation. Most cases of melanoma, the deadliest kind of skin cancer, are caused by exposure to UV radiation.

APPENDIX J: HEALTH EFFECT OF HYDROCARBON

as well as the potential for asphyxiation, fire and explosion. Emergency response procedures should therefore include consideration of the toxic effects of hydrocarbons.

Background

3. Exposure to vapour/aerosol mixtures of hydrocarbons can cause acute adverse health effects at concentrations below those presenting an explosion or asphyxiation risk. The risk this poses during releases should be assessed and adequate controls applied.

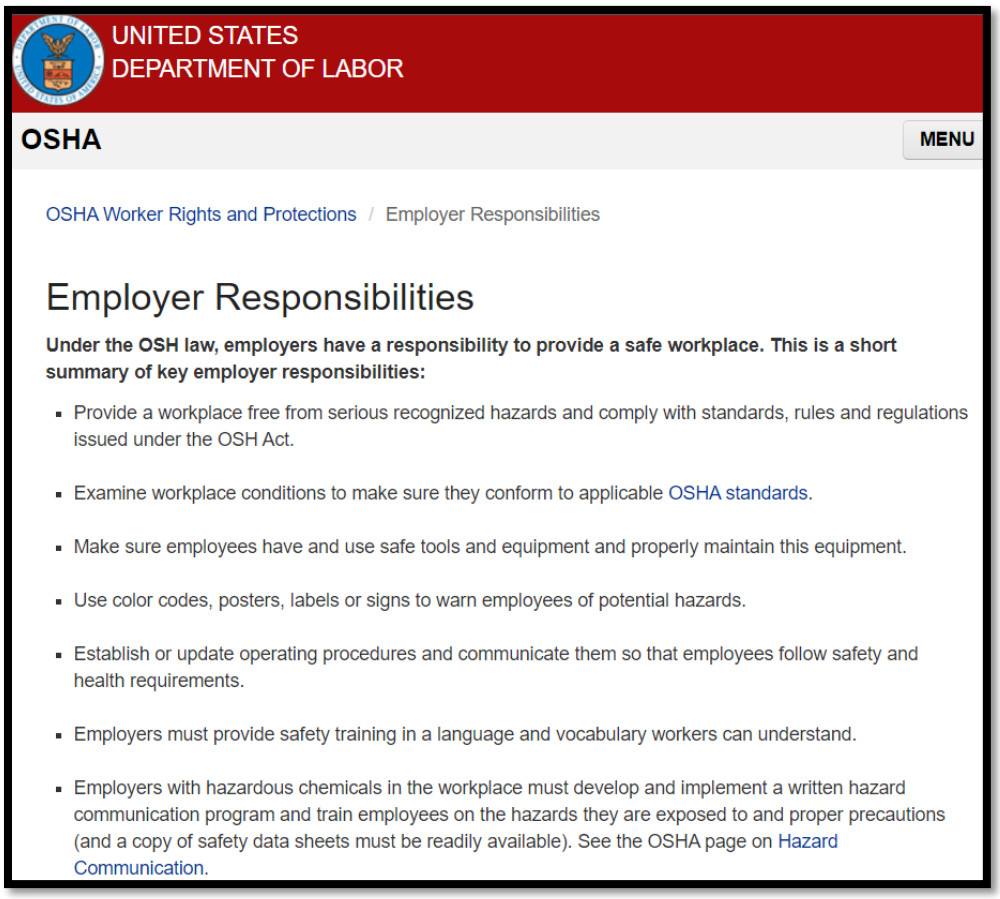
Health effects

4. The acute health effects of hydrocarbon mixtures are generally associated with exposure concentrations at thousands of ppm. However, the exposure concentration and exposure duration leading to the onset of acute health effects varies between individual hydrocarbons, and this may influence the effects of exposure to mixtures.

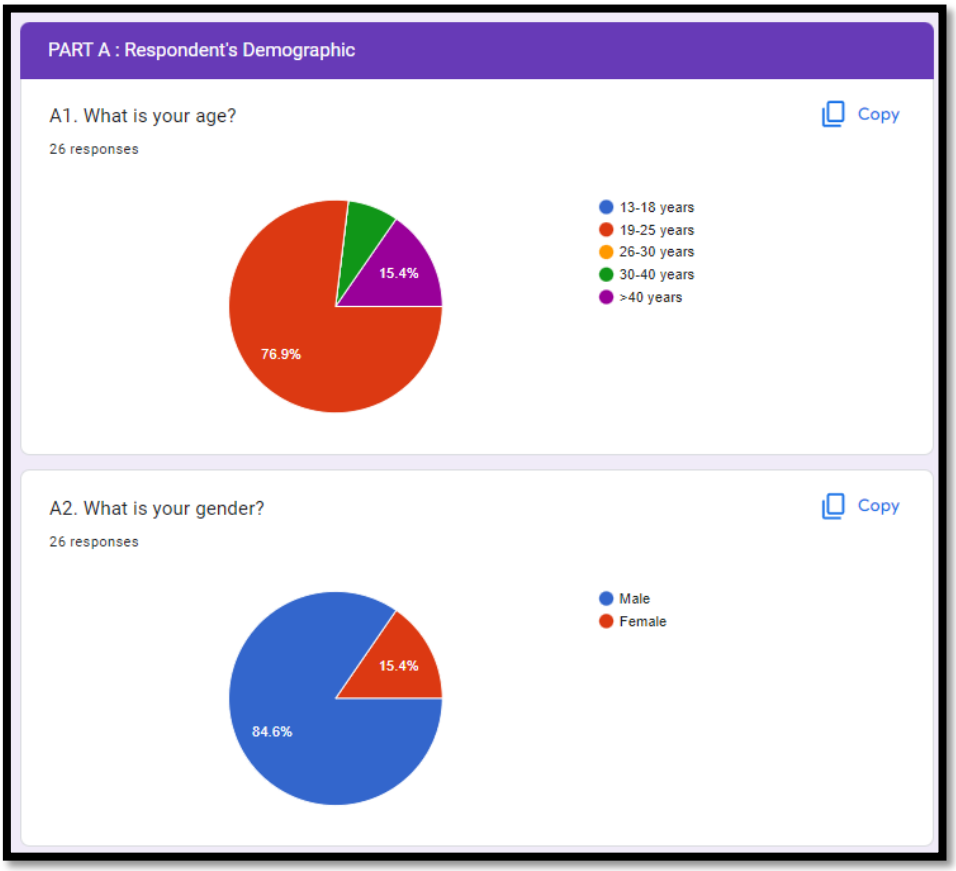
5. Health effects associated with a single exposure to hydrocarbons are asphyxiation, narcosis (ie depression of the central nervous system; anaesthesia), cardiac arrest and aspiration. Of these, the first two are probably the most significant in the offshore context.

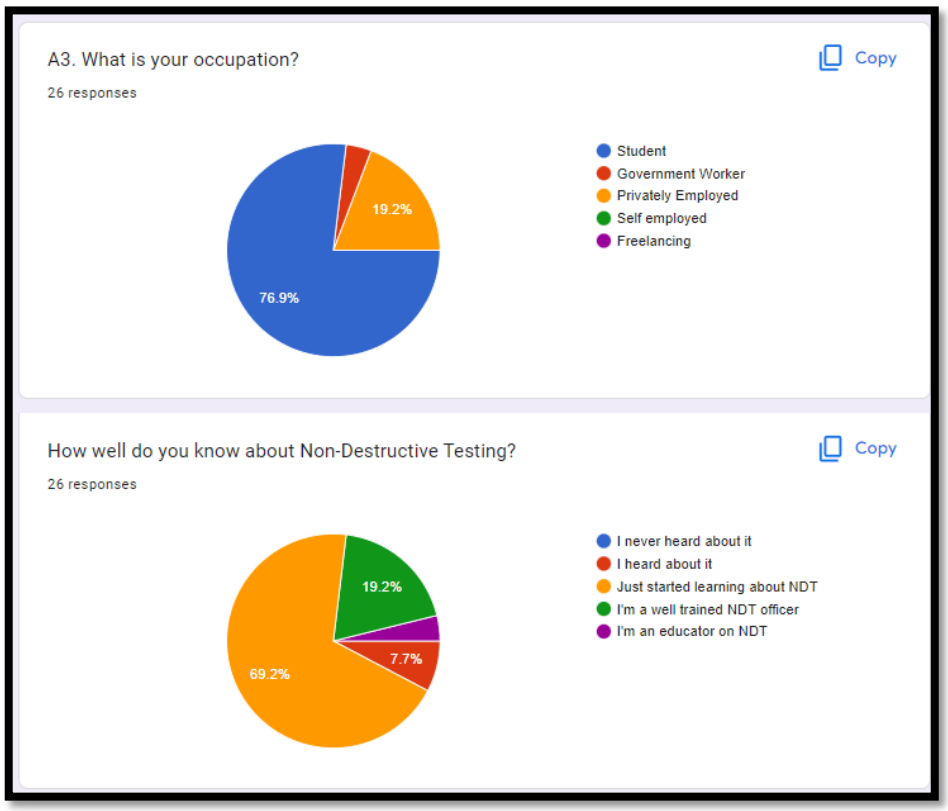
[back to top]

APPENDIX K: OSHA-EMPLOYER RESPONSIBILITIES



APPENDIX L: PRE-SURVEY FORM

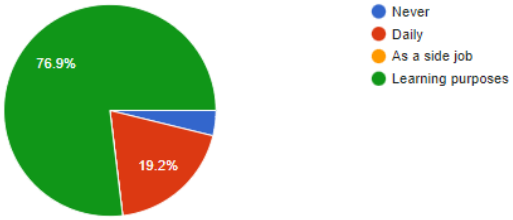




How often do you apply NDT in your daily life?

Copy

26 responses

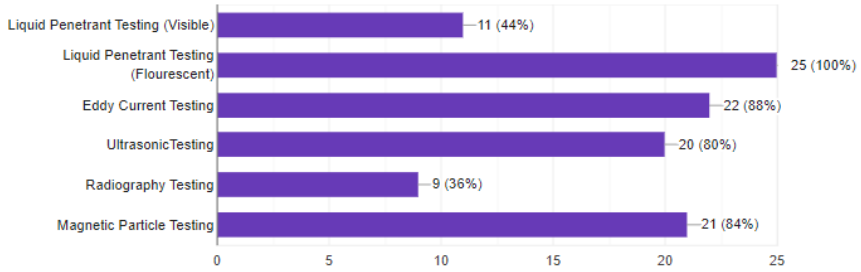


PART B : USER'S EXPERIENCE

B1. What type of NDT have you tried?

Copy

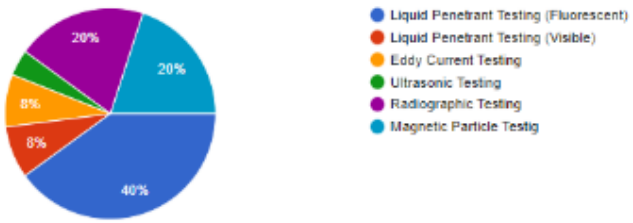
25 responses



B2. Which type of NDT do you experience the most problems while conducting?

Copy

25 responses

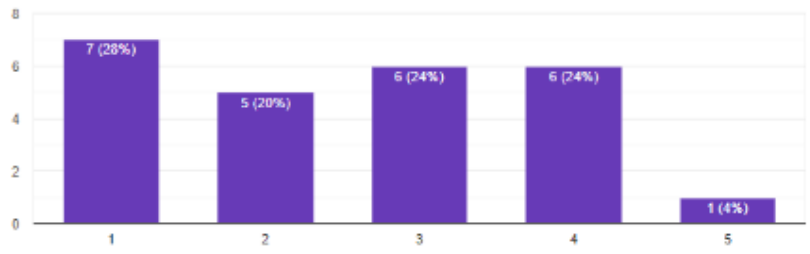


PART C :Type of Problem Faced by User When Conducting Penetrant Testing (Fluorescent)

C1. On a scale of 1 to 5, how difficult it is to conduct Liquid Penetrant Testing (Fluorescent)?

Copy

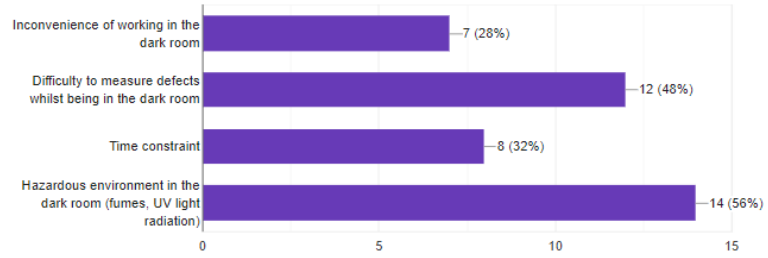
25 responses



C2. What is your concern(s) when conducting Penetrant Testing (Fluorescent) ?

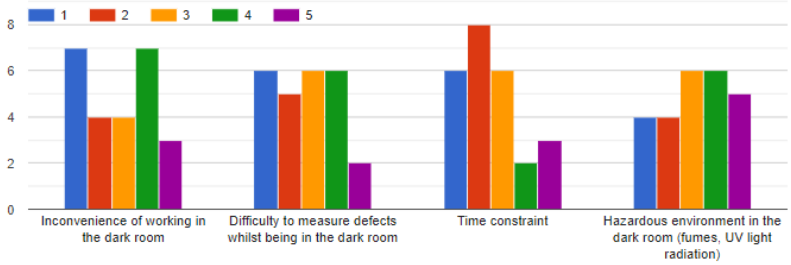
Copy

25 responses



C3. In Liquid Fluorescent Penetrant Testing, rate each problems. (1 being the least problematic and 5 the most problematic)

Copy

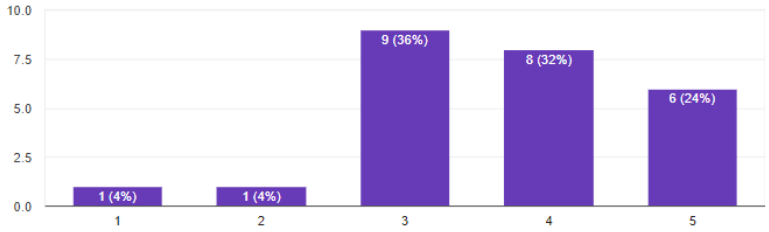


PART D : Product Improvement

D1. Do you agree that Fluorescent Penetrant inspection does require enhancement?

Copy

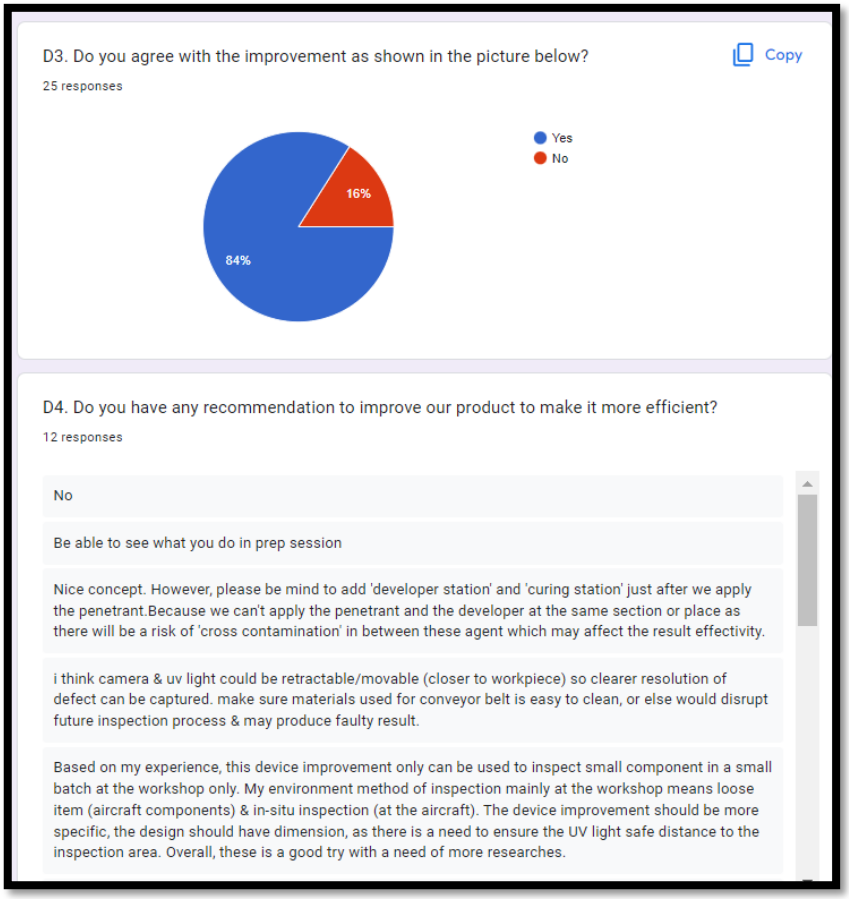
25 responses



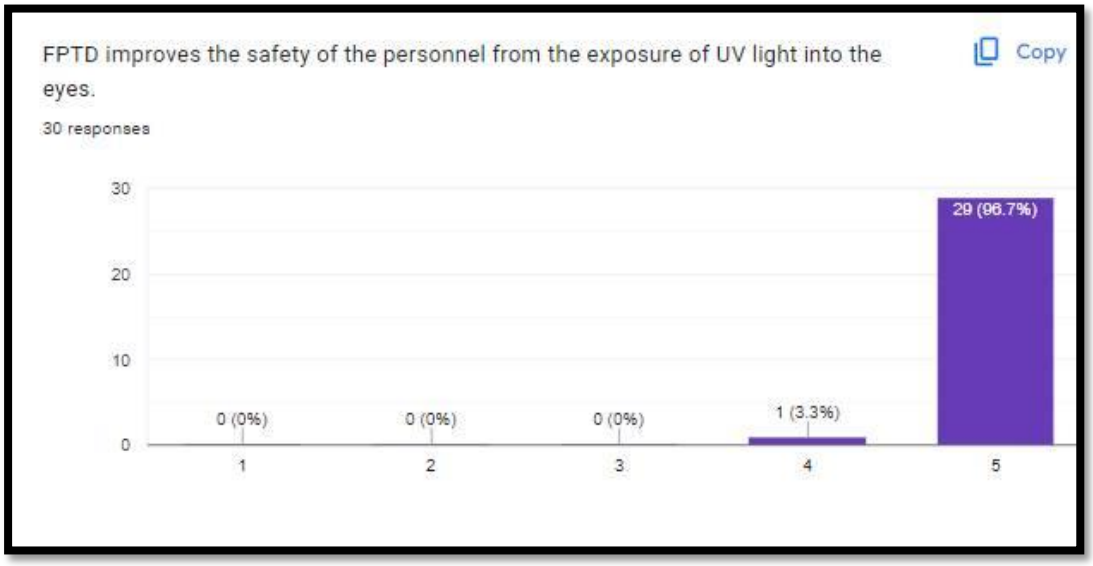
D2. Which improvement(s) of conducting a Liquid Penetrant Test (Fluorescent) would be important?

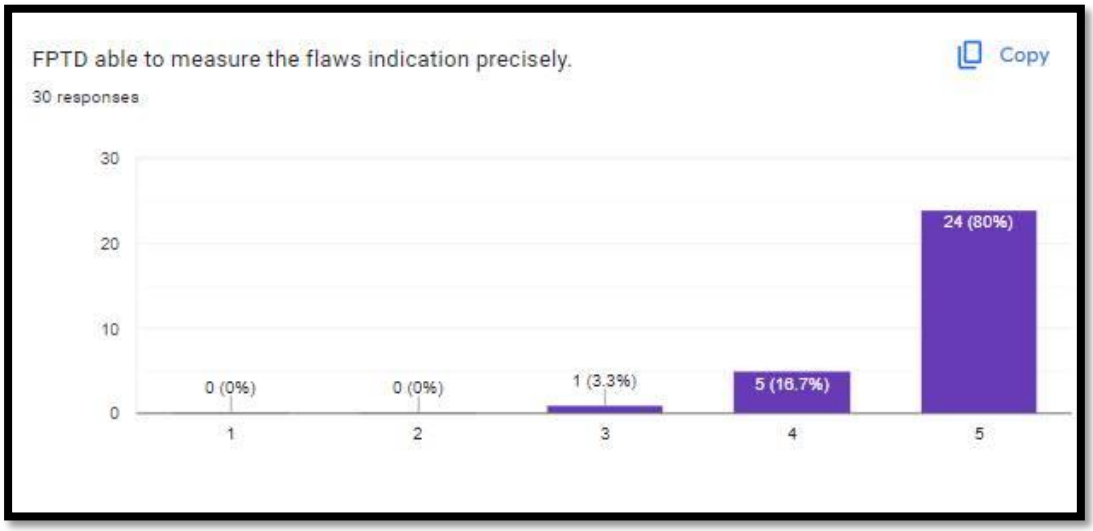
Copy

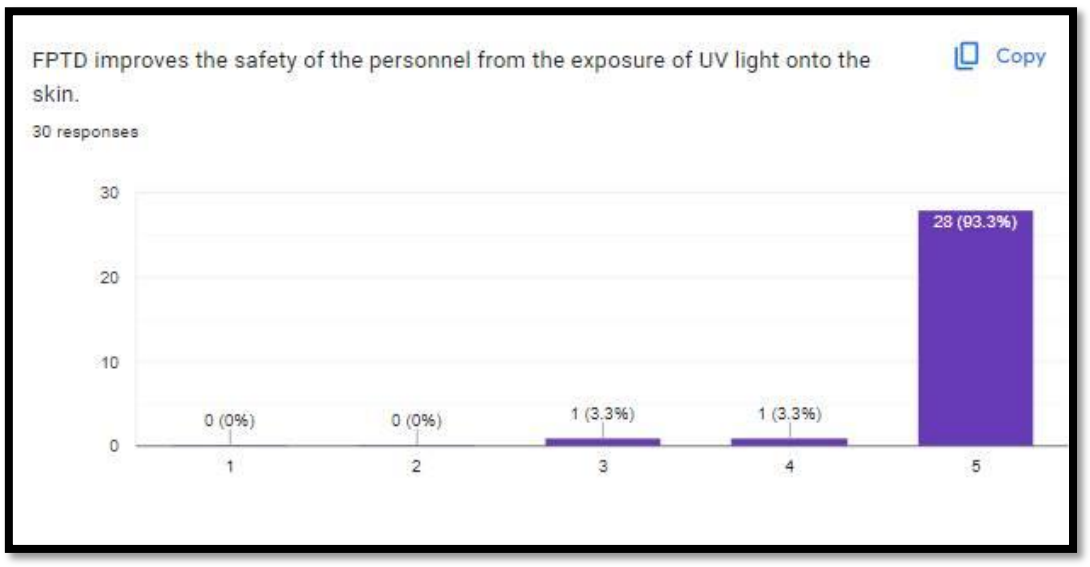
25 responses


D3. Do you agree with the improvement as shown in the picture below?
Copy
25 responses
Yes
No
16%
84%
D4. Do you have any recommendation to improve our product to make it more efficient?
12 responses
No
Be able to see what you do in prep session
Nice concept. However, please be mind to add 'developer station' and 'curing station' just after we apply the penetrant.Because we can't apply the penetrant and the developer at the same section or place as there will be a risk of 'cross contamination' in between these agent which may affect the result effectivity.
i think camera & uv light could be retractable/movable (closer to workpiece) so clearer resolution of defect can be captured. make sure materials used for conveyor belt is easy to clean, or else would disrupt future inspection process & may produce faulty result.
Based on my experience, this device improvement only can be used to inspect small component in a small batch at the workshop only. My environment method of inspection mainly at the workshop means loose item (aircraft components) & in-situ inspection (at the aircraft). The device improvement should be more specific, the design should have dimension, as there is a need to ensure the UV light safe distance to the inspection area. Overall, these is a good try with a need of more researches.

APPENDIX M: POST-SURVEY FORM



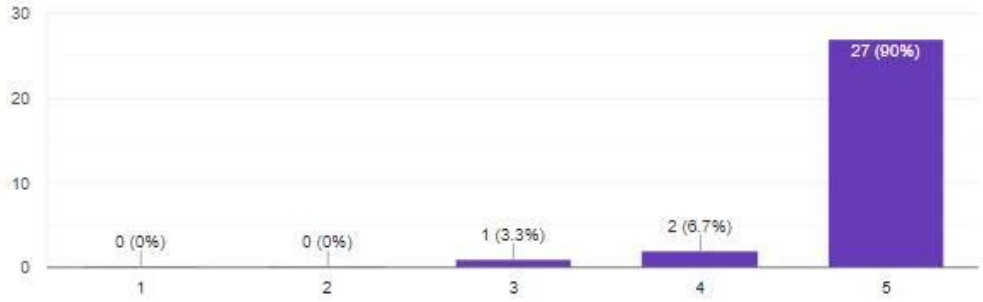




Interactive features on FPTD (eg: Arduino, Sensors, etc.) improves the efficiency of NDT inspection.

Copy

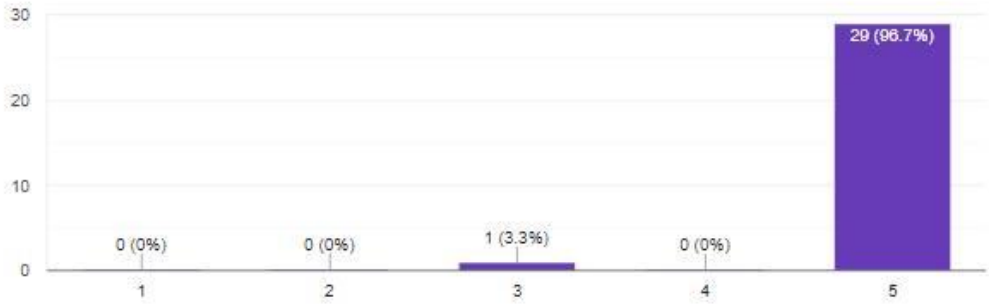
30 responses



FPTD ensures the safety of the personnel from hazardous gas or fumes while conducting NDT inspection.

Copy

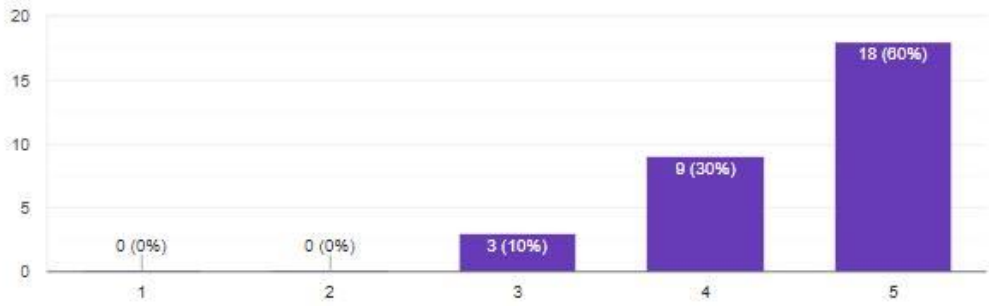
30 responses

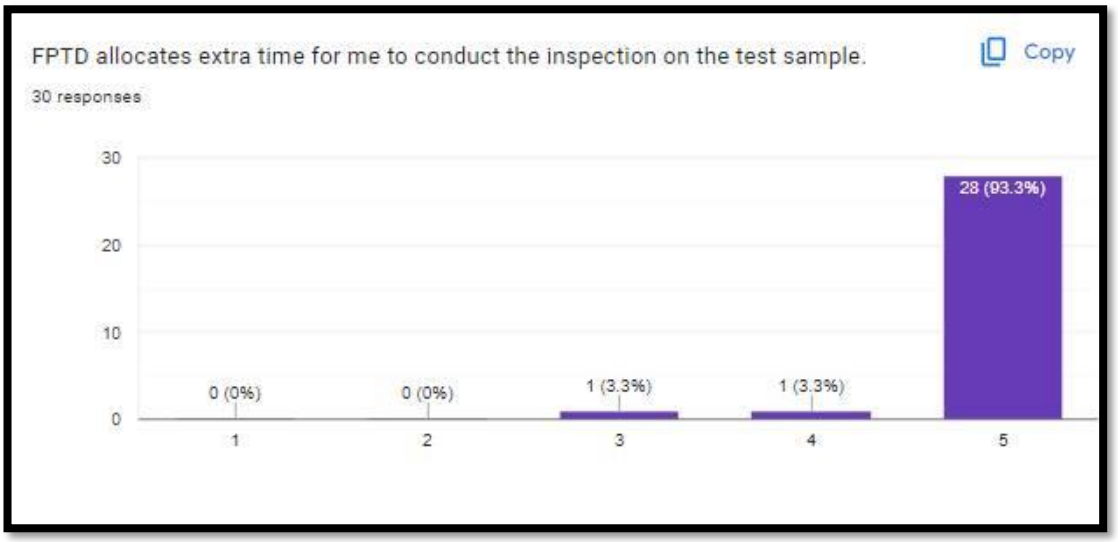


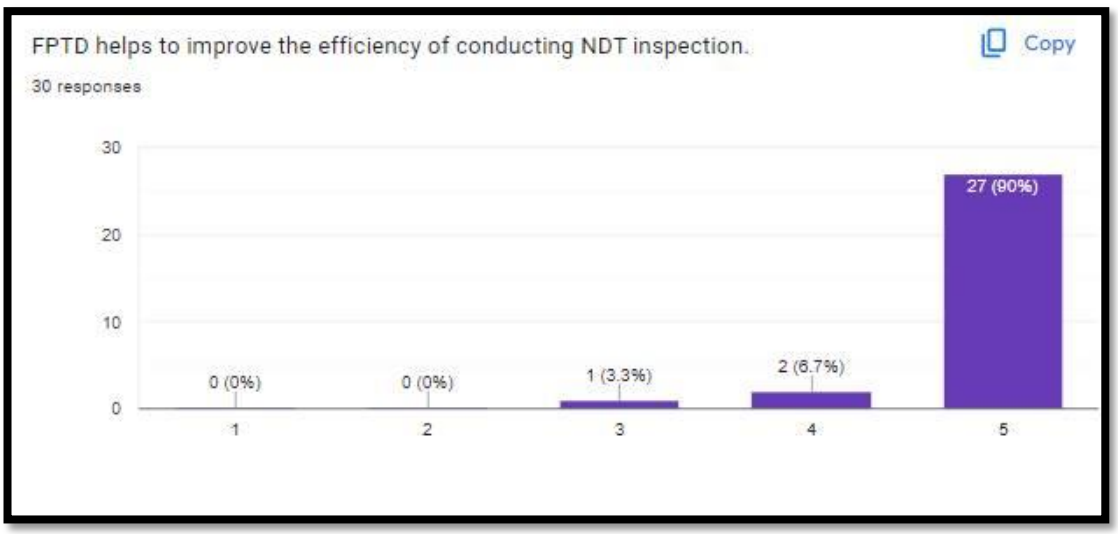
The process of conducting inspection using FPTD is less hassle.

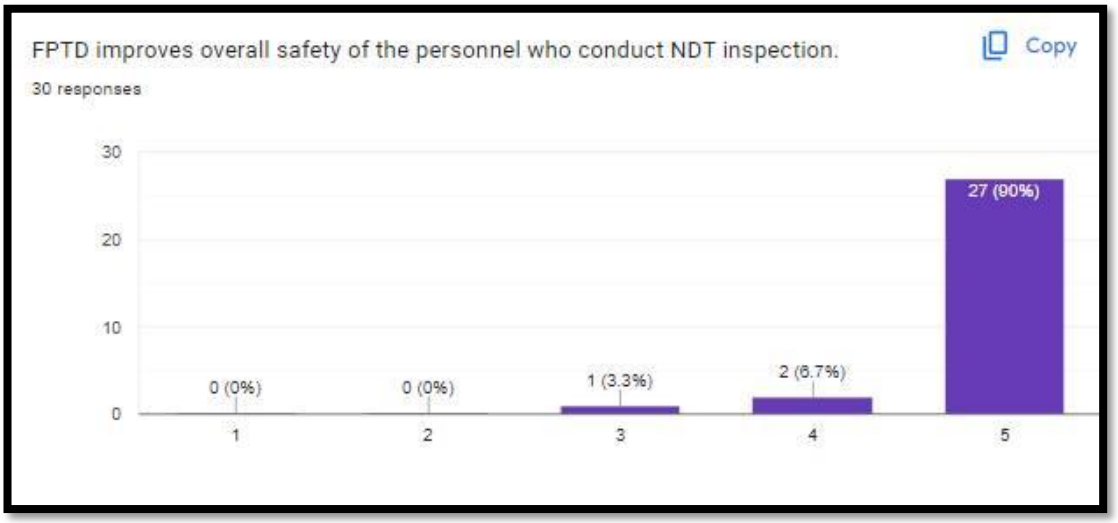
Copy

30 responses

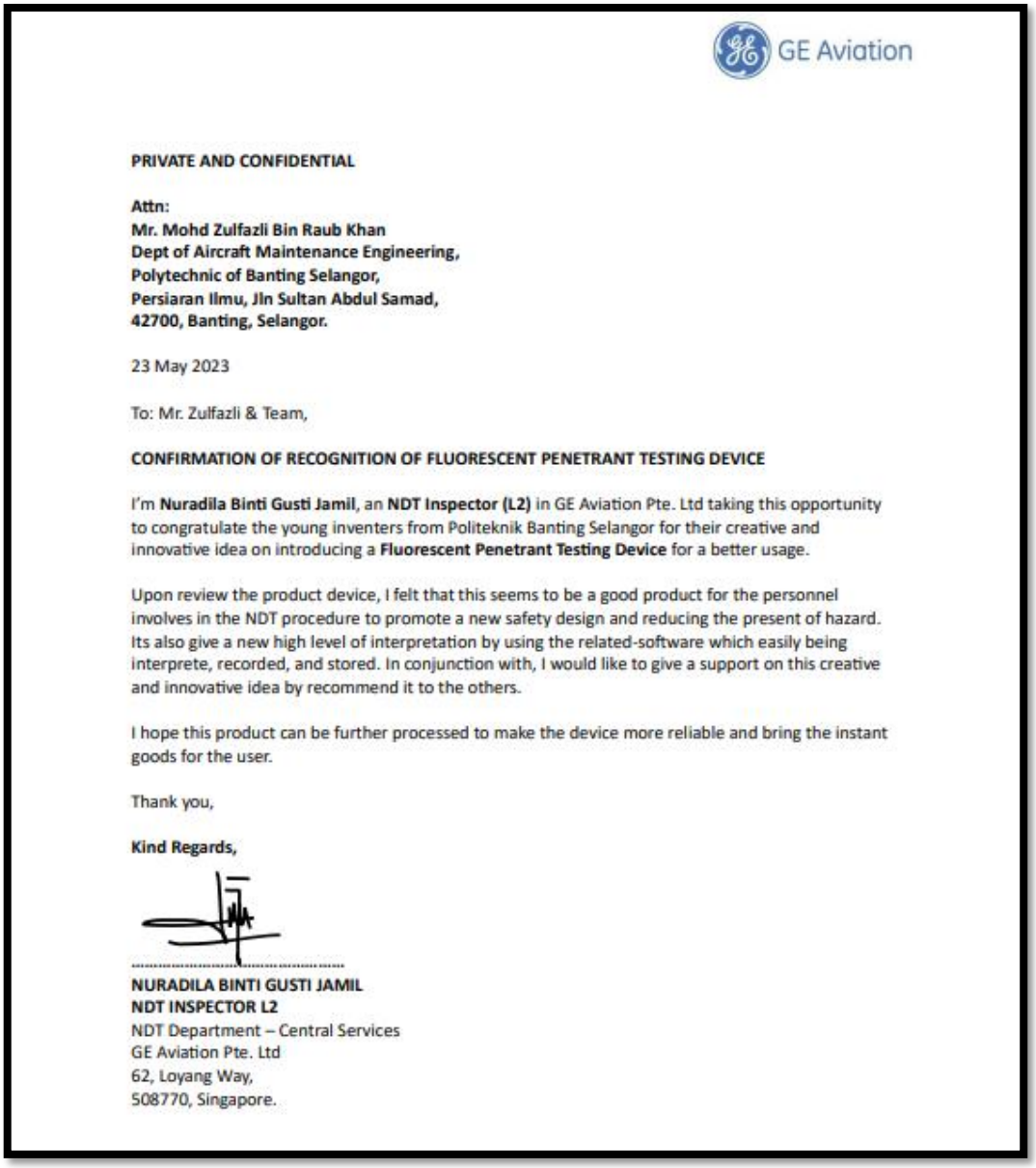



FPTD allocates extra time for me to conduct the inspection on the test sample.
Copy
30 responses
30
20
10
0
0 (0%)
0 (0%)
1 (3.3%)
1 (3.3%)
28 (93.3%)
1
2
3
4
5


FPTD helps to improve the efficiency of conducting NDT inspection.
Copy
30 responses
30
20
10
0
0 (0%)
0 (0%)
1 (3.3%)
2 (6.7%)
27 (90%)
1
2
3
4
5


FPTD improves overall safety of the personnel who conduct NDT inspection.
Copy
30 responses
30
20
10
0
0 (0%)
0 (0%)
1 (3.3%)
2 (6.7%)
27 (90%)
1
2
3
4
5

APPENDIX N: TESTIMONIAL FROM NDT DEPARTMENT OF GE AVIATION SINGAPORE



GE Aviation

PRIVATE AND CONFIDENTIAL

Attn:
Mr. Mohd Zulfazli Bin Raub Khan
Dept of Aircraft Maintenance Engineering,
Polytechnic of Banting Selangor,
Persiaran Ilmu, Jln Sultan Abdul Samad,
42700, Banting, Selangor.

23 May 2023

To: Mr. Zulfazli & Team,

CONFIRMATION OF RECOGNITION OF FLUORESCENT PENETRANT TESTING DEVICE

I'm **Nuradila Binti Gusti Jamil**, an **NDT Inspector (L2)** in GE Aviation Pte. Ltd taking this opportunity to congratulate the young inventers from Politeknik Banting Selangor for their creative and innovative idea on introducing a **Fluorescent Penetrant Testing Device** for a better usage.

Upon review the product device, I felt that this seems to be a good product for the personnel involves in the NDT procedure to promote a new safety design and reducing the present of hazard. Its also give a new high level of interpretation by using the related-software which easily being interprete, recorded, and stored. In conjunction with, I would like to give a support on this creative and innovative idea by recommend it to the others.

I hope this product can be further processed to make the device more reliable and bring the instant goods for the user.

Thank you,

Kind Regards,

.....

NURADILA BINTI GUSTI JAMIL
NDT INSPECTOR L2
NDT Department – Central Services
GE Aviation Pte. Ltd
62, Loyang Way,
508770, Singapore.

GE Aviation

PRIVATE AND CONFIDENTIAL

Attn:
Mr. Mohd Zulfazli Bin Raub Khan
Dept of Aircraft Maintenance Enginee
Polytechnic of Banting Selangor,
Persiaran Ilmu, Jln Sultan Abdul Samad,
42700, Banting, Selangor.

23 May 2023

To: Mr. Zulfazli & Team,

Feedback on Fluorescent Penetrant Testing Device

Dear Sir and Team,

Kindly refer to the feedback below as a reference or rectification that you could make the product more safer and reliable. I wish to bring your kind attention that these comments are just a suggestion to improve the product not to penalise and criticize the product or innovation.

1.0. Product Quality

In terms of the product, the idea was very good as your team bring in an innovation by introducing a new technic of interpretation using the software. Moreover, the product also designated with less-hazard risk. However, as per my review the following points can be improved which are as follows :

- **Customize tray for TAM Panel** – This is for the purpose of maintaining the good condition of the TAM Panel also protect and prevent it from any defects.This also must be take into consideration as the TAM Panel is being used for verification of the process. Therefore, a good care must be applied on the TAM Panel.
- **Timer/Stopwatch** – Attach together timer/stopwatch on the device as to ensure the dwell time of the processed is being monitored by the personnel and initiate awareness to them.
- **Distance Indicator/Measuring Gauge on the Spraying Can**– This is to ensure the standardisation distance on applying(spray) the penetrant or developer on the TAM Panel. As per requirement, the correct practice when applying(spray) the penetrant or developer, there must be a specified gap/spacing towards the TAM Panel.

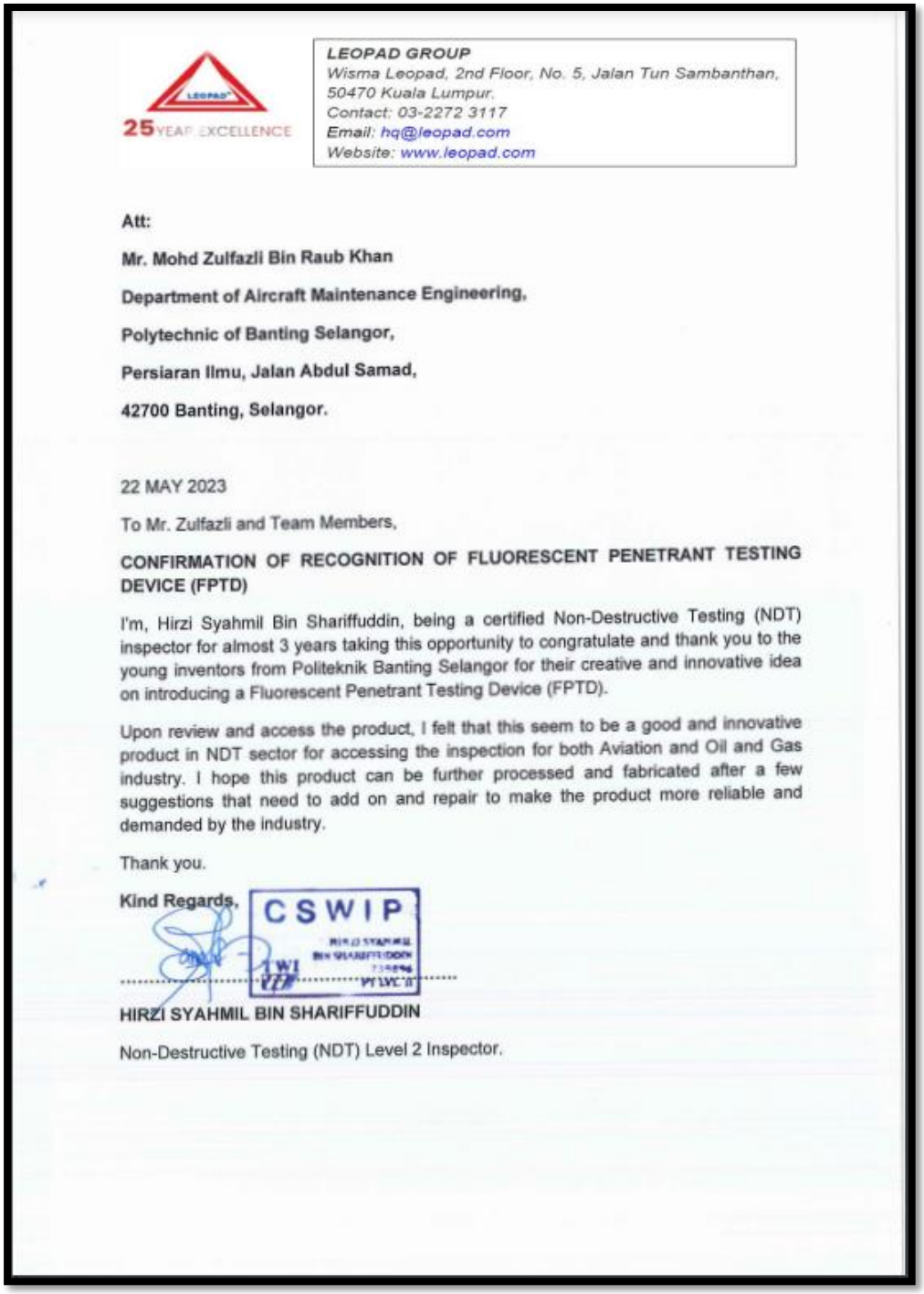
Thanks for reading the suggestion and wish all of the team best of luck. Hope i could see the product in the future.

Thank you,

Kind Regards,

NURADILA BINTI GUSTI JAMIL
NDT INSPECTOR L2
NDT Department – Central Services
GE Aviation Pte. Ltd
62, Loyang Way,
508770, Singapore.

APPENDIX O: TESTIMONIAL FROM NDT DEPARTMENT OF LEOPAD GROUP



25 YEAR EXCELLENCE

LEOPAD GROUP
Wisma Leopad, 2nd Floor, No. 5, Jalan Tun Sambanthan,
50470 Kuala Lumpur.
Contact: 03-2272 3117
Email: hq@leopad.com
Website: www.leopad.com

Att:

Mr. Mohd Zulfazli Bin Raub Khan

Department of Aircraft Maintenance Engineering,

Polytechnic of Banting Selangor,

Persiaran Ilmu, Jalan Abdul Samad,

42700 Banting, Selangor.

22 MAY 2023

To Mr. Zulfazli and Team Members,

CONFIRMATION OF RECOGNITION OF FLUORESCENT PENETRANT TESTING DEVICE (FPTD)

I'm, Hirzi Syahmil Bin Shariffuddin, being a certified Non-Destructive Testing (NDT) inspector for almost 3 years taking this opportunity to congratulate and thank you to the young inventors from Politeknik Banting Selangor for their creative and innovative idea on introducing a Fluorescent Penetrant Testing Device (FPTD).

Upon review and access the product, I felt that this seem to be a good and innovative product in NDT sector for accessing the inspection for both Aviation and Oil and Gas industry. I hope this product can be further processed and fabricated after a few suggestions that need to add on and repair to make the product more reliable and demanded by the industry.

Thank you.

Kind Regards,

CSWIP

1WI

HIRZI SYAHMIL BIN SHARIFFUDDIN

Non-Destructive Testing (NDT) Level 2 Inspector.

LEOPAD GROUP
Wisma Leopad, 2nd Floor, No. 5, Jalan Tun Sambanthan, 50470 Kuala Lumpur.
Contact: 03-2272 3117
Email: hq@leopad.com
Website: www.leopad.com

25 YEAR EXCELLENCE

TESTIMONIAL OF FLUORESCENT PENETRANT TESTING DEVICE (FPTD)

Att:

Mr. Mohd Zulfazli Bin Raub Khan

Department of Aircraft Maintenance Engineering,

Polytechnic of Banting Selangor,

Persiaran Ilmu, Jalan Abdul Samad,

42700 Banting, Selangor.

Feedback on Fluorescent Penetrant Testing Device (FPTD)

Dear Mr. Zulfazli and Team Members,

Kindly refer to the feedbacks below as a reference or rectifications you could make the product more reliable and demanding. I wished to bring your kind attention that these comments are just a suggestion to improve the product not to penalize and critize the product or innovation.

1.0 PROBLEM STATEMENT & PRODUCT OBJECTIVE

In terms of the problem statement and product objective stated, generally, the overall concept can be understood and grasped by the audience. However, as per my review the following items can be improved which are as follows:

- ***It is difficult to evaluate flaw indications in dark rooms*** – The fluorescent penetrant inspection needs to be done in dark area. The darker the area of inspection, the more brilliant the indications appear. This is extremely important, particularly when inspection is being performed for very fine, crack-like defects which may have trapped only a small amount of penetrant.
- ***To streamline the Fluorescent Penetrant Testing procedures*** – Students need to ensure that the project objective is to be used either on aviation industry or oil and gas due to aviation and oil and gas have different rules and regulations that need to follow to perform this test. For example, on aviation industry normally is using fluorescent penetrant water washable testing for aircraft component due to high sensitivity for detecting the defect on the

samples. Only a few times that fluorescent penetrant solvent type is permitted when the Standard of Procedures (SOP) is needed to use a solvent type or the component itself still attachable to the engine. Meanwhile, oil and gas industry are commonly used the fluorescent penetrant solvent type for performing a testing on weldment due to its practical and easier to carry around the site.

2.0 PRODUCT QUALITY

- ***Pulling belt for conveyor*** – My suggestion for the project implemented by Mr. Zulfazli and team members is to build a manual pulling belt for moving the conveyor to send the sample from the preparation section to inspection section.
- ***Angle of inspection*** – It is my concern that the angle of inspection itself is limited due to inaccessible for personnel to conduct the inspection. The reason is that there are many sizes and shapes are available in the actual site and the ability of this product to interpret this test comprehensively is limited. For an example, the flat surface sample need to be inspected for both surface (top and bottom) to determine the defect on the sample while for the rounded surface need to be inspected thoroughly.
- ***Tray for removing the excess solvent liquid*** – A tray for removing the excess liquid is very necessary because this type of penetrant produces a lot of liquid and will make the preparation area moist and stagnate. Suggestion: build and cut a long rectangle hole below the conveyor that can accommodate a long rectangle tray according to the size of the preparation area.
- ***Calibration system according to actual sizing*** – The calibration measurement need to be precise according to actual sizing to get an accurate sizing for defect found. The way I see and understand, the students are calibrating the sample by using the adobe and will cause inaccuracies in measurement if not done correctly. My suggestion for the team is to create a system that can ease the personnel for calibrating any samples without the need for personnel to do the calibration calculation themselves.
- ***A better camera resolution*** – The student's creative idea in using the camera for the inspection should be praised because not only did they make it easier for the workers during the inspection, but it also helped the workers to see the defect more clearly. However, the resolution of the camera used should be of high quality in order to capture clearer images without damaging the image when enlarged to produce a better quality for documentation.

3.0 COMMERCIAL VALUE

As per mentioned in the problem statement, Mr. Zulfazli and team members need to determine which industry is used the FPTD since both industry has a different rules and regulations that need to follow by personnel. The statement "Conformed to BS EN ISO 3452-1" is inaccurate due to the standard itself is used on welding part and mostly in oil and gas industry. As per my understanding, the aviation industry is using the **MIL-STD-6866** (*Liquid Penetrant Inspection, Military Standard, 1989*), **MIL-I-25135** (*Penetrant Inspection Materials, Military Specification, 1989*), and **MIL-STD-1907** (*Penetrant and Magnetic Particle Inspection, Soundness Requirements for Materials, Parts and Weldments, Military Standard, 1990*) standards for performing the penetrant testing. For greater understanding, I have attached a document that you and your team members can refer to.

Thanks for reading wish all of you very best and good luck. Hope I could see the product in future.

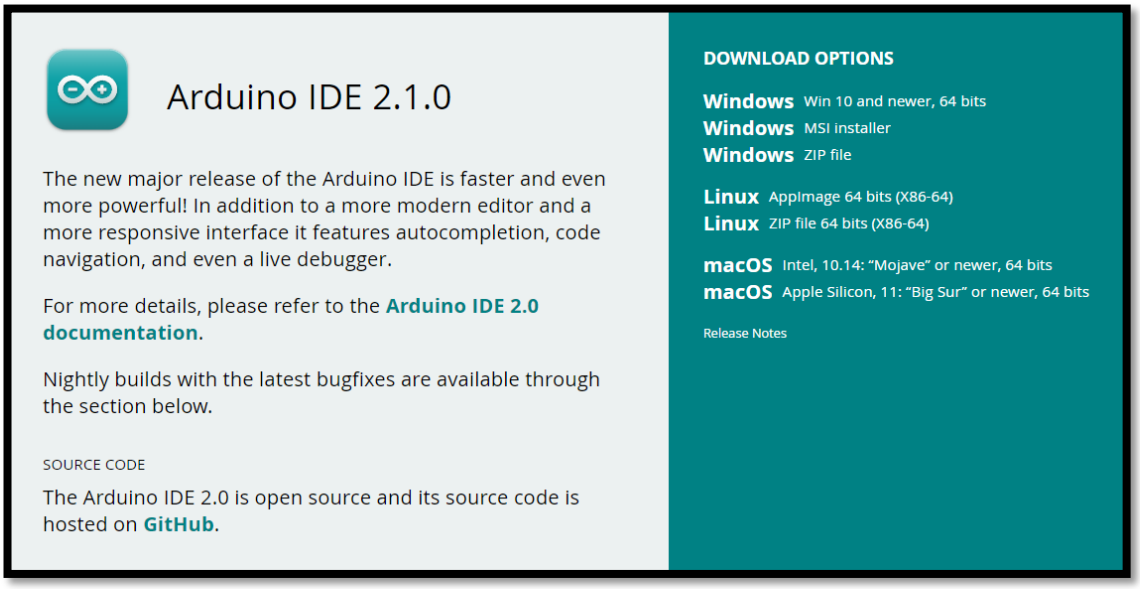
Thank you.

Yours Sincerely,

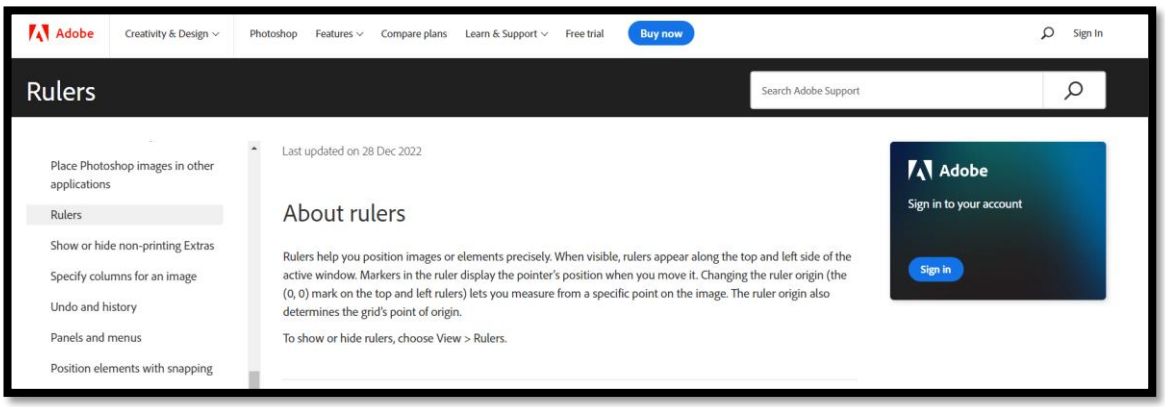
HIRZI SYAHMIL BIN SHARIFFUDDIN

Non-Destructive Testing (NDT) Level 2 Inspector.

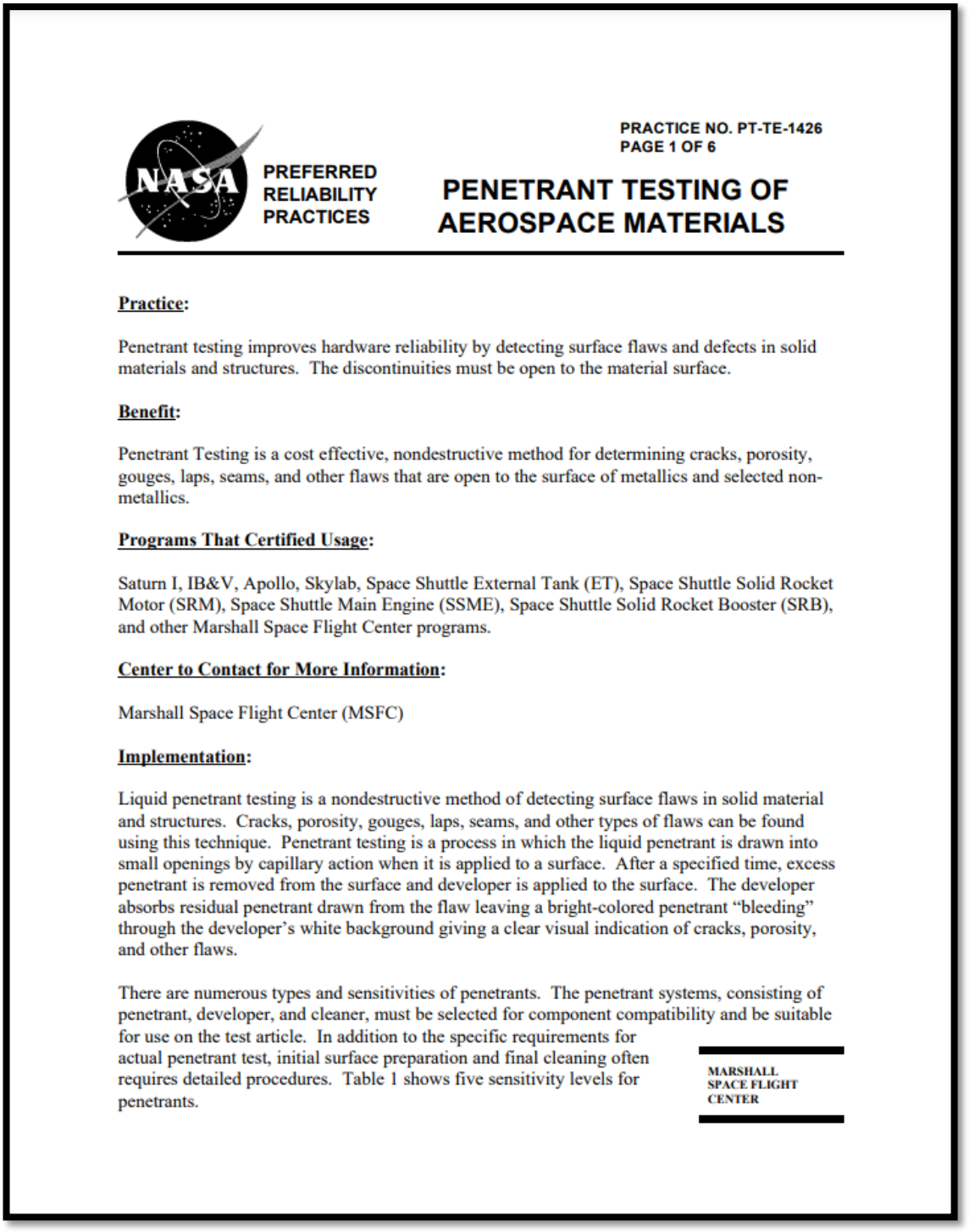
APPENDIX P: ARDUINO IDE



APPENDIX Q: ADOBE PHOTOSHOP RULER TOOLS



APPENDIX R: NDT PRACTICE, PENETRANT TESTING OF AEROSPACE MATERIAL BY NASA



PRACTICE NO. PT-TE-1426
PAGE 1 OF 6

PREFERRED RELIABILITY PRACTICES

PENETRANT TESTING OF AEROSPACE MATERIALS

Practice:

Penetrant testing improves hardware reliability by detecting surface flaws and defects in solid materials and structures. The discontinuities must be open to the material surface.

Benefit:

Penetrant Testing is a cost effective, nondestructive method for determining cracks, porosity, gouges, laps, seams, and other flaws that are open to the surface of metallics and selected non-metallics.

Programs That Certified Usage:

Saturn I, IB&V, Apollo, Skylab, Space Shuttle External Tank (ET), Space Shuttle Solid Rocket Motor (SRM), Space Shuttle Main Engine (SSME), Space Shuttle Solid Rocket Booster (SRB), and other Marshall Space Flight Center programs.

Center to Contact for More Information:

Marshall Space Flight Center (MSFC)

Implementation:

Liquid penetrant testing is a nondestructive method of detecting surface flaws in solid material and structures. Cracks, porosity, gouges, laps, seams, and other types of flaws can be found using this technique. Penetrant testing is a process in which the liquid penetrant is drawn into small openings by capillary action when it is applied to a surface. After a specified time, excess penetrant is removed from the surface and developer is applied to the surface. The developer absorbs residual penetrant drawn from the flaw leaving a bright-colored penetrant "bleeding" through the developer's white background giving a clear visual indication of cracks, porosity, and other flaws.

There are numerous types and sensitivities of penetrants. The penetrant systems, consisting of penetrant, developer, and cleaner, must be selected for component compatibility and be suitable for use on the test article. In addition to the specific requirements for actual penetrant test, initial surface preparation and final cleaning often requires detailed procedures. Table 1 shows five sensitivity levels for penetrants.

MARSHALL SPACE FLIGHT CENTER

PENETRANT TESTING OF AEROSPACE MATERIALS

Table 4. Advantages and Disadvantages of Penetrant Testing Method

Advantages	Disadvantages
1. Detect surface discontinuities on any non-porous material (metals, plastics, glass, and ceramics).	1. Only detects discontinuities open to the surface.
2. Easy to perform.	2. No subsurface detection of discontinuities.
3. Portable (can be accomplished offsite).	3. Possibility of fire or explosion.
4. Low cost.	4. Water-base chemicals may have deleterious effect on some materials, especially steels.
5. Automation possible.	5. Penetrants may be toxic or hazardous.
6. Easy cleanup of penetrants and developers.	6. Penetrant cleaning materials may be toxic or hazardous.

Another hazard with penetrants is the using of dry developers which could be inhaled and become a health hazard. The use of any of the penetrant processes should be performed in a well-ventilated area. If working in a confined area such as a tank, the inspector should have an individual air supply with a full helmet over the head.

The black light used when inspecting fluorescent penetrants can cause severe sunburn and damage to the eyes. The blacklight source should always be checked for missing, cracked, or broken filters and repaired before use. Store penetrants in an approved fire container.

Technical Rationale:

Marshall Space Flight Center has successfully used the penetrant testing method for years. It is a proven method for locating flaws in surface areas of highly stressed areas of components and structures. In addition, it is an effective method for both metallic and nonmetallic materials.

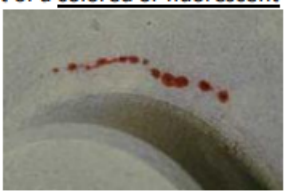
Impact of Nonpractice:

Failure to locate surface flaws in critical stressed areas of parts and structures could result in loss of part or structure, loss of mission, and in extreme cases loss of life.

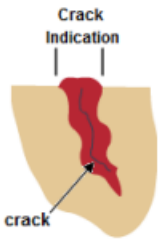
APPENDIX S: INTRODUCTION TO NON-DESTRUCTIVE TESTING TECHNIQUES: LIQUID PENETRANT TESTING

Liquid Penetrant Testing

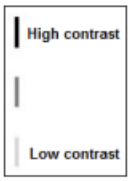
Liquid penetrant testing is one of the oldest and simplest NDT methods where its earliest versions (*using kerosene and oil mixture*) dates back to the 19th century. This method is used to reveal surface discontinuities by bleedout of a colored or fluorescent dye from the flaw. The technique is based on the ability of a liquid to be drawn into a "clean" surface discontinuity by capillary action. After a period of time called the "dwell time", excess surface penetrant is removed and a developer applied. This acts as a blotter that draws the penetrant from the discontinuity to reveal its presence.



The advantage that a liquid penetrant inspection offers over an unaided visual inspection is that it makes defects easier to see for the inspector where that is done in two ways:



- It produces a flaw indication that is much larger and easier for the eye to detect than the flaw itself. Many flaws are so small or narrow that they are undetectable by the unaided eye (*a person with a perfect vision can not resolve features smaller than 0.08 mm*).
- It improves the detectability of a flaw due to the high level of contrast between the indication and the background which helps to make the indication more easily seen (*such as a red indication on a white background for visable penetrant or a penetrant that glows under ultraviolate light for flourecent penetrant*).



Liquid penetrant testing is one of the most widely used NDT methods. Its popularity can be attributed to two main factors: its relative ease of use and its flexibility. It can be used to inspect almost any material provided that its surface is not extremely rough or porous. Materials that are commonly inspected using this method include; metals, glass, many ceramic materials, rubber and plastics.

However, liquid penetrant testing can only be used to inspect for flaws that break the surface of the sample (*such as surface cracks, porosity, laps, seams, lack of fusion, etc.*).

APPENDIX T: ACCEPTANCE CRITERIA FOR LIQUID PENETRANT TESTING

Published on 07-Apr-2023

Acceptance Criteria for Liquid Penetrant Testing

Image Credit @ IRC Engineering Services

The early 1940s, like through the times, had simple non-destructive testing techniques used to detect flaws in various products. The surface was coated in thin paint, and vibration was induced in the subject, which caused the delicate film created on the surface to crack at points of discontinuity. This uncomplicated yet effective technique has been one of the predecessors of the now prevalent Liquid Penetrant Testing method.

Liquid penetrant testing is a commonly used non-destructive testing technique that aids in detecting deformities on the surface of materials. The main subject for such tests is non-porous materials that might have the potential for discontinuities on their surface texture, which may be unacceptable for their intended use.

The Liquid Penetrant Test method provides the location of a variety of surface disparities, some of which are:

- Cracks caused due to Quenching of metal after Heat Treatment
- Defects formed during machining processes like milling, grinding, etc.
- Defects caused due to bending stresses, tensile stresses, etc., may cause fatigue.
- Fractures are caused due to improper or excess application of load.
- Voids and defects in weld zones
- Lap formations in metal

APPENDIX U: CERTIFICATE OF APPRECIATION FOR VIRTUAL INNOVATION COMPETITION 2023

CERTIFICATE

OF APPRECIATION

This is to certify that

DAMIAN AJENG BELAWING
NUR AQIL BIN AIDY
RIZQ FAIZ BIN AZMI
MOHD ZULFAZLI BIN RAUB KHAN

Has participated in an international event

VIRTUAL INNOVATION COMPETITION 2023

For the project entitled

FLOURESCENT PENETRANT TESTING DEVICE
(TERTIARY (SCIENCE AND TECHNOLOGY))

Organized by

DIGIT360, DIGITAL INFORMATION INTEREST GROUP (DIGIT), AND COLLEGE OF COMPUTING, INFORMATICS, AND MEDIA, UNIVERSITI TEKNOLOGI MARA KELANTAN BRANCH

PROF. DR. HAJI ABDOL SAMAD BIN NAWI
Rector
Universiti Teknologi MARA Kelantan Branch, MALAYSIA

Issue Date: 2023-06-07

APPENDIX V: GOLD AWARD CERTIFICATION FOR AEROMECH FINAL YEAR PROJECT COMPETITION

POLITEKNIK MALAYSIA
BANTING

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

AEROMECH

Sijil Penganugerahan

Sekalung tahniah kepada

EN. MOHD ZULFAZLI BIN RAUB KHAN (PENYELIA)	860908565301
DAMIAN AJENG BELAWING	970301136217
NUR AQIL BIN AIDY	020730101005
RIZQ FAIZ BIN AZMI	021206870013

telah menerima anugerah
EMAS

sempena
PERTANDINGAN PROJEK AKHIR PELAJAR AEROMECH SESI II 2022/2023

dengan tajuk projek
FLUORESCENT PENETRANT TESTING DEVICE
pada
25 MEI 2023

bertempat di
POLITEKNIK BANTING SELANGOR

POLITEKNIK MALAYSIA BANTING

TS. ZAINAH BINTI RUJIHAN
PENGARAH
POLITEKNIK BANTING SELANGOR

No. SIRI: PBS/HEP/0001

APPENDIX W: CODING FOR SENSORS IN ARDUINO IDE SOFTWARE


```
#include <DHT.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_TSL2561_U.h>

// DHT11 Temperature and Humidity Sensor
#define DHTPIN D4
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

// GUVA-S12SD UV Sensor
#define UV_PIN A0

// TSL2561 Ambient Light Sensor
Adafruit_TSL2561_Unified tsl = Adafruit_TSL2561_Unified(TSL2561_ADDR_FLOAT);

// I2C 16x2 LCD
LiquidCrystal_I2C lcd(0x27, 16, 2); // Update the LCD address if necessary

enum SensorType {
  TEMPERATURE,
  HUMIDITY,
  UV_LIGHT,
  AMBIENT_LIGHT
};

SensorType currentSensor = TEMPERATURE;

void setup() {
  // Start Serial communication
  Serial.begin(9600);

  // Start DHT11 Sensor
  dht.begin();

  // Start I2C LCD
  lcd.begin(); // Initialize the LCD

  // Start TSL2561 Sensor
  if (!tsl.begin()) {
    Serial.println("Failed to initialize TSL2561 sensor!");
    while (1);
  }

  // Set integration time and gain
  tsl.setIntegrationTime(TSL2561_INTEGRATIONTIME_13MS);
  tsl.setGain(TSL2561_GAIN_1X);

  // Turn on the backlight
  lcd.backlight(); // Adjust backlight settings if necessary
}

void loop() {
  // Read DHT11 Sensor
  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();

  // Read GUVA-S12SD Sensor
  int uvLevel = analogRead(UV_PIN);

  // Convert analog reading to voltage
  float uvVoltage = uvLevel * (5.0 / 1023.0);
```

```
  // Convert voltage to UV intensity in microwatts per square centimeter
  float uvIntensity = uvVoltage * 307.2;

  // Read TSL2561 Sensor
  sensors_event_t event;
  tsl.getEvent(&event);
  float ambientLight = event.light;

  // Print readings to Serial Monitor
  switch (currentSensor) {
    case TEMPERATURE:
      Serial.print("Temperature: ");
      Serial.print(temperature);
      Serial.println(" °C");
      break;
    case HUMIDITY:
      Serial.print("Humidity: ");
      Serial.print(humidity);
      Serial.println(" %");
      break;
    case UV_LIGHT:
      Serial.print("UV Intensity: ");
      Serial.print(uvIntensity);
      Serial.println(" µW/cm²");
      break;
    case AMBIENT_LIGHT:
      Serial.print("Ambient Light: ");
      Serial.print(ambientLight);
      Serial.println(" lux");
      break;
  }

  // Print readings to LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  switch (currentSensor) {
    case TEMPERATURE:
      lcd.print("Temp: ");
      lcd.print(temperature);
      lcd.print("C");
      break;
    case HUMIDITY:
      lcd.print("Humidity: ");
      lcd.print(humidity);
      lcd.print("%");
      break;
    case UV_LIGHT:
      lcd.print("UV Intensity: ");
      lcd.print(uvIntensity);
      lcd.print(" µW/cm²");
      break;
    case AMBIENT_LIGHT:
      lcd.print("Light: ");
      lcd.print(ambientLight);
      lcd.print(" lux");
      break;
  }

  delay(2000); // Delay between sensor readings
}
```