BACHELOR THESIS & COLLOQUIUM – ME 184841

THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY FOR MAIN ENGINE COOLING SYSTEMS INSTALLATION TRAINING

TITO SATRIA BUWANA
NRP. 04211641000043

Supervisor I
Dr. Eng. Trika Pitana, S.T., M.Sc.
NIP. 197601292001121001

Supervisor II
Ir. Hari Prastowo, M.Sc.
NIP. 196510301991021001

"This page is intentionally left blank."

BACHELOR THESIS – ME184841

THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY FOR MAIN ENGINE COOLING SYSTEMS INSTALLATION TRAINING

TITO SATRIA BUWANA
NRP. 04211641000043

SUPERVISOR
Dr. Eng. Trika Pitana, S.T., M.Sc.
NIP. 197601292001121001
Ir. Hari Prastowo, M.Sc.
NIP. 196510301991021001

DEPARTMENT OF MARINE ENGINEERING
FACULTY OF MARINE TECHNOLOGY
SEPULUH NOPEMBER INSTITUTE OF TECHNOLOGY
SURABAYA

2020

"This page is intentionally left blank."

SUPERVISOR APPROVAL SHEET

THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY FOR MAIN ENGINE COOLING SYSTEMS INSTALLATION TRAINING

BACHELOR THESIS

Submitted To Comply One Of The Requirements To Obtain A
Bachelor Thesis Engineering Degree
On

Laboratory of Marine Operational and Maintenance (MOM)
Bachelor Program Departement of Marine Engineering
Faculty of Marine Technology
Sepuluh Nopember Institute of Surabaya

Prepared by :
Tito Satria Buwana
NRP. 04211641000043

Approved by
Academic Supervisor,

Dr. Eng. Trika Pitana, S.T., M.Sc. ( )
NIP. 197601292001121001

Ir. Hari Prastowo, M.Sc. ( )
NIP. 196510301991021001

“This page is intentionally left blank.”

APPROVAL FORM

THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY FOR MAIN ENGINE COOLING SYSTEM INSTALLATION TRAINING

BACHELOR THESIS

Submitted in fulfilment of requirement for the degree of Bachelor Engineering

at

Digital Marine Operation and Maintenance (DMOM)

Bachelor Program of Marine Engineering Faculty of Marine Technology

Sepuluh Nopember Institute of Technology

Prepared by:

Tito Satria Buwana

NRP. 04211641000043

Approved by,

Head of Department of Marine Engineering

Beny Cahyono, S.T., M.T., Ph.D

NIP. 197903192008011008

SURABAYA

AGUSTUS, 2020

THE APPLICATION OF VIRTUAL REALITY TECHNOLOGY FOR MAIN ENGINE COOLING SYSTEMS INSTALLATION TRAINING

Name	: Tito Satria Buwana
Student Number	: 04211641000043
Department	: Marine Engineering
Supervisor I	: Dr. Eng. Trika Pitana, S.T., M.Sc.
Supervisor II	: Ir. Hari Prastowo, M.Sc.
Field of Study	: Digital Marine Operation and Maintenance (DMOM)

ABSTRACT

The main engine functions as the main propulsion device on the ship. The main engine works by combustion which is then converted into mechanical energy to run the propulsion system on the ship. In addition to combustion, the main engine also has many interconnected mechanical components, the movement of each component creates friction and causes heat to emerge. To maintain optimal engine performance, a system is needed to keep the engine susceptible to the specified limits. Installation of the ship cooling system must be carried out by personnel who are experts in their fields. Starting from design to installation. To help train young engineers to more easily learn and understand how to install a ship cooling system, it will be easier to use hands-on methods. To reduce the risk of damage during practice and by prioritizing work safety, virtual technology applications can be the right solution for conducting training.

This research will begin with problem identification, data collection, analysis stage, VR object creation, and Trial Phase. Submission of this thesis will be an application-based android operating system that can be controlled remotely. This technology can enhance the understanding and skills of ship engineers in the design and installation of main engine cooling systems.

Keyword: Virtual Reality, cooling, Installation Training, 3D modeling.

TABLE OF CONTENT

TABLE OF FIGURE

TABLE OF TABLE

CHAPTER 1
INTRODUCTION

1.1. Background

One of the essential system onboard in a ship is engine cooling system. This system is used to control the temperature of the engine. Jacket water cooling system is the one that cool the engine through cylinder liner. The discharge temperature of jacket water cooling is around 90 C so that this system may be called High Temperature Cooling (HT), supply water that used in this jacket cooling is fresh water which supplied from expansion tanks. Jacket water cooling circulated water needs to be cooled after out from engine. Temperature requirement for jacket water cooling before inlet is around 80 C, so it must be cooled from 90 to 80 C. That is why it requires central cooling system. This central cooling system not only cool HT but also cool lubricating oil. Central cooling system may be called Low Temperature Cooling (LT). LT got water supply from expansion tanks too. Moreover, the central cooling system must be cooled by another system which called seawater cooling system. This last system used sea water as the supply water.

The design and installation of a cooling system must be handled by experts who have been tested and trained. For training in the design and installation of a cooling system on ships it would be better if done in direct practice. but there arises the risk of damage to practical tools and work hazards. Direct training practices will also cost more. but with the development of technology, new breakthroughs emerged to conduct training by visualizing practical training with virtual reality.

Virtual reality or virtual reality is a technology that allows users to interact with a virtual condition that cannot be served by the actual environment. Through virtual reality, users can feel or experience the sensation of being in a fictitious environment from a program that is simulated by a computer. The latest development of virtual reality technology today is the VR desktop. Desktop VR is also known by other names such as Window on World (WoW) or non-immersive VR (Onyesolu, 2006). This non-immersive VR application is much cheaper and makes inroads in the field of industrial training and development. VR has the possibility to be made public that can be utilized in education where computer-based virtual learing environments (VLEs) are packaged as VR desktops. This shows how virtual reality technology can be applied in educational programs (Ausburn & Ausburn, 2004).

Virtual reality becomes a rapidly developing topic and can become a solution to support the maritime industry sector, such as in a marine survey, and inspection. The significant advantages of using virtual reality are simple and effective, do not need to spend a lot of effort and time, also less expense than real training methods. In this final project also has intended to keep up the educational world with modern information technology.

1.2. Research Problem

There is some problem occurs based on the background above, there is :

a. How to implementation virtual reality technology to main engine cooling systems installation.
b. How to model the real condition of the main engine cooling systems installation into 3D modelling and install into a virtual reality application maker.
c. How to adjust the proportional dimension of ship main engine cooling systems into virtual reality application make
d. How to adjust the user is dizzy feelings when using virtual reality applications due to dizzy.

1.3. Research Limitation

A limitation was made so that the study is not too broad to aspects that are not far from relevance so that research can be more focused to do; the limitation of this study is as follows:

a. The virtual reality system is for main engine cooling systems.
b. This research aims to introduce the installation of main engine cooling systems on ships

1.4. Research Objective

The objective of this final project based on the problem occur are :

a. To implement virtual reality technology to develop and simulate ship main engine cooling systems installation
b. To model the real condition main engine cooling systems installation into 3D modelling and install into a virtual reality application maker.
c. To adjust the proportional dimension of main engine cooling systems installation into virtual reality application make.
d. To adjust the user dizzy feelings when using virtual reality applications due to dizzy.

1.5. Research Benefit

The desired benefit from the results of this final project is:

a. The virtual training software can increase the competence and quality of marine engineers
b. Virtual training can reduce cost spending
c. Virtual Reality training can be applied for engineers reality in anywhere and anytime

"This page is intentionally left blank."

CHAPTER 2
LITERATURE STUDY

2.1. Problem Overview

cooling systems on ships are very important. the sustainability of the mechanical system is very dependent on the ship's cooling system. Main engine cooling systems is a system designed by engineers. if the design is not in accordance with the existing specifications and rules, then the system will not work properly which will result in failure of the scientific system that is in the ship.

good training for ship engineers will greatly help to increase the competence of these engineers. the use of good and accurate work simulations will be very helpful in training for engineers. Expensive to make environmental simulations and reasons for limited space and time spent on conducting inspection training for surveyors. Virtual reality technology can be a solution to this problem because virtual reality does not make risky and takes many costs invested.

2.2. Ship’s Main Engine Cooling Systems P&ID

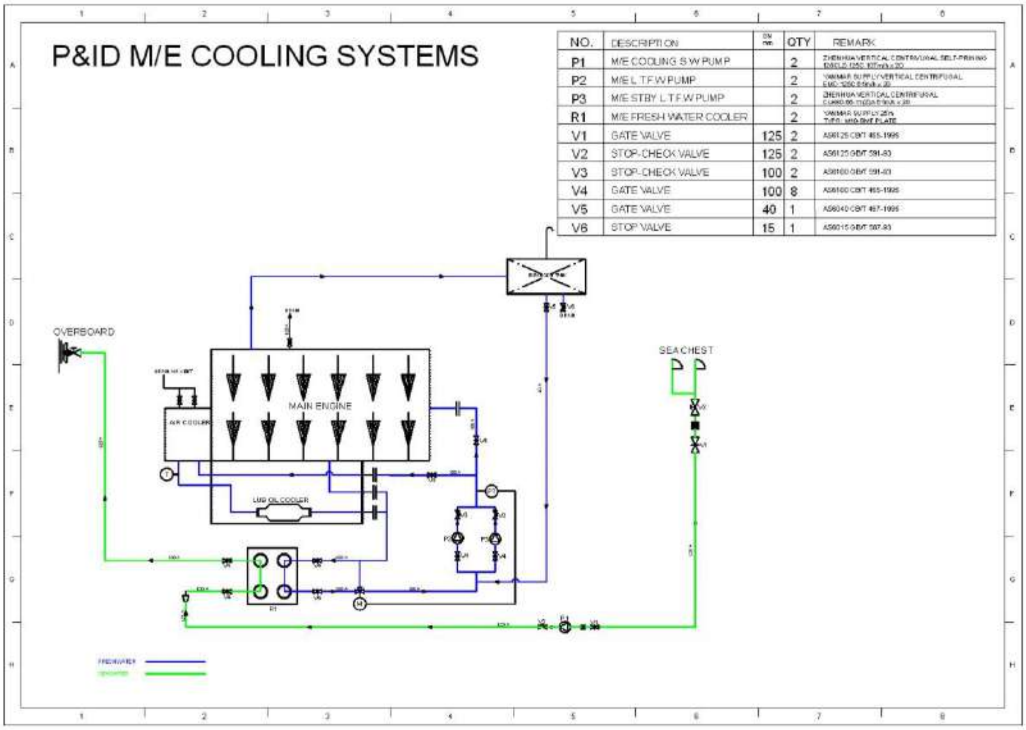


Figure 2.1 P&ID M/E Cooling Systems
Source: (ARS co. Ship Design & Consulting Company,2019)

2.2.1. Definition

In the engine cooling system, there are 3 main components that should be cooled, such as :

1. Engine block / jacket
2. Air inlet to engine (turbocharger)
3. Lubricating oil

In the combustion process, there are some heat which is left in the part of engine. Those heat should be cooled by cooling system in order to maintain the operating temperature that required by engine maker. But, noticed the water temperature couldn't be so cool to prevent the thermal stress that might be happened during the process of cooled the engine.

Combustion process needs three main factor, heat, air and fuel. The temperature of air income to engine should be keep cool for getting high density, so the volume is greater. It is cooled by after cooler or intercooler.

When the exhaust gas turn the turbines and the compressor, so the incoming air become a rather hot, so that the inlet temperature in scavenge air cooler is maintain as low as possible to get the minimum consumption of the fuel oil.

Lubricating oil is used to lubricate, cleaning, protecting, and cooling. As a cooling of moving part in engine, lubricating oil absorb heat from material (crankshaft, camshaft, timing gears etc.). It cause the temperature of lubricating oil become higher and reduce the viscosity, so that lubricating oil is needed to be cooled to getting back the viscosity required.

Cooling system based on cooler media is divided by two system, can be described as follow:

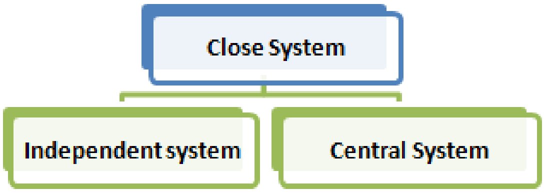
a. Air media cooling systems

Cooling system which use air for cooler media usually use in car and bike cycle cooling system, we call this system is Air Radiator.

b. Water media cooling systems

This system is directly used sea water to cooled the needed component. Water media cooling system call open system if the cooler media is direct touch with fresh air.

This system is used fresh water to circulate in the close system to cooled the needed component. Then the fresh water is cooled by sea water, those fresh water is circulating back to cooled the component. This close system is divided into two, those are :



- Independent systems

Fresh water is used to cool every component separately, not by one heat exchanger.

- Central systems

Fresh water that used to cool the component is collecting to be cooled in one heat exchanger. Heat exchanger in central cooler use sewater to cool fresh water. So, the equipment that directly related to sea water is not much and the problem of corrosion could be reduced.

This close system is divided into two circuit, these are :

1. Sea water circuit

Sea water as the fluid which used to cooled central cooler. Sea water is taken from sea chest using a sea water pump. The output is directly dispose to overboard.

2. Fresh water circuit

Fresh water as the fluid which cooled by sea water used to cooled the component needed. This fresh water circuit is divided into two again, these are :

- High temperature circuit

Fresh water is used to cool the jacket water cooler and supplied by the jacket water pump, and the remains of evaporation processed on de-aerating tank is to be reused for cooling.

- Low temperature circuit

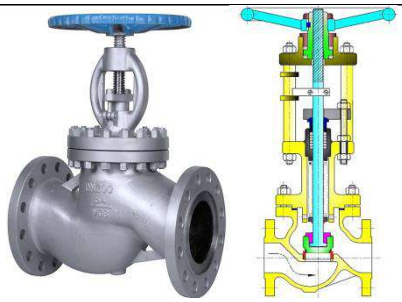
Fresh water is used to cooled the lubricating oil and charge air cooler (scavenge air).

2.2.2. Cooling Systems Objective

The heat generated by combustion in the main engine and friction of mechanical parts can cause damage if not controlled properly. The main engine cooling system aims to keep the main engine temperature at the desired temperature. this is done to maintain the performance of the main engine in order to remain good.

2.2.3. Main Engine Cooling Systems Equipment on Board

Table 2.1 List of Main Engine Cooling Systems Equipments

No	**List Name**	**Picture**
1	Gate Valve	 Figure 2.2 Gate Valve *Source: (MediaExpert)*
2	Stop-check Valve	 Figure 2.3 Stop-checkValve *Source: (MarineInsight, 2010)*
4	Three Way Valve	 Figure 2.4 Three Way Valve *Source: (Jiaxing Seaman Marine Co., 2009)*

5	Strainer	 Figure 2.6 Strainer *Source: (Alamy, 2019)*
6	Lubricating Oil Cooler	 Figure 2.7 Lubricating Oil Cooler *Source: (Google.com)*
7	Main Engine Sea Water Cooling Pump	 Figure 2.4 Main Engine Sea Water Cooling Pump *Source: (MarineInsight, 2010)*
8	Main Engine Low Temperature Fresh Water Cooling Pump	 Figure 2.9 Main Engine Low Temperature Fresh Water Cooling Pump

		Source: (Pro Tech Co.)
9	Main Engine Standby Low Temperature Fresh Water Cooling Pump	 Figure 2.10 Main Engine Standby Low Temperature Fresh Water Cooling Pump *Source: (Rifqy, 2017)*
10	Main Engine Fresh Water Cooler	 Figure 2.11 Main Engine Standby Low Temperature Fresh Water Cooling Pump Source: (Google.com)

2.3. Virtual Reality

The first fifteen years of the 21st century has been significant, rapid advancement in the development of VR. Computer technology, especially powerfull and small mobile technologies, have exploded while prices are always driven down. The rising of smartphones with high-density displays and 3D graphics capabilities has enabled a generation of lightweight and practical VR devices. Depth sensing cameras sensor suites, natural human interfaces and motion controllers, are already a part of daily human computing tasks. The game industry has continued to drive the development of consumer virtual reality.

2.3.1. History of Virtual Reality

2.3.1.1. Panoramic Painting

Figures 2.14 is the panoramic paintings from the nineteenth centuries. These paintings were intended to fulfil the viewer's entire field of vision, making them feel present at some historical event or scene and creating the illusions that we are present somewhere we are not.

Figure 2.5 Rocky Mountain Panoramic Painting
Source : (TheFreshUK, 2017)

2.3.1.2. 1838 -- Stereoscopic photo and viewer

In 1838 research of Charles Wheatstone explain that the brain processes the different two-dimensional images from each eye into a three dimensions object as the picture in figure 2.15. Viewing two sides by sides images through a stereoscope gave the user a sense of depth and immersion. (TheFreshUK, 2017)

Figure 2.6 The Stereoscopic Photo
Source: (TheFreshUK, 2017)

2.3.1.3. 1929 –The First Flight Simulator

In 1929 Edward Link created the first example of a commercial flight simulator shown in figures 2.16. The simulator controlled by motors that linked to the rudder and steering to control and change the pitch & roll and a small motor-driven device simulates turbulence and disturbances. During

World War II this flight simulator was used by over 500,000 pilots for initial training and improving their skills. That was the need for safer ways to train pilots that the US military. (TheFreshUK, 2017)

Figure 2.7 The Link Trainer
Source : (TheFreshUK, 2017)

2.3.1.4. 1930 – Science fiction story predicted VR

Figure 2.8 Stanley G. Weinbaum
Source : (TheFreshUK, 2017)

In the 1930s a story of science fiction Pygmalion's Spectacles written by Stanley G. Weinbaum in figure 2.17, contains the idea of a pair of goggle that let the user experience fictional worlds through holographic, smell, taste, and touch. (TheFreshUK, 2017)

Figure 2.9 Pygmalion’s Spectacles
Source: sffaudio (2017)

2.3.1.5. 1950 – Morton Heilig’s Sensorama

In the mid-1950s cinematographer, Morton Heilig developed and created the Sensorama as shown as figure 2.19 below, which was an arcade-style theatre that will stimulate all the senses, not just sound, and sight. It adds some featured like smell generators, stereo speakers, a stereoscopic 3D display, fans, and a vibrating chair. The Sensorama is intended to immerse the user in the film entirely. (TheFreshUK, 2017)

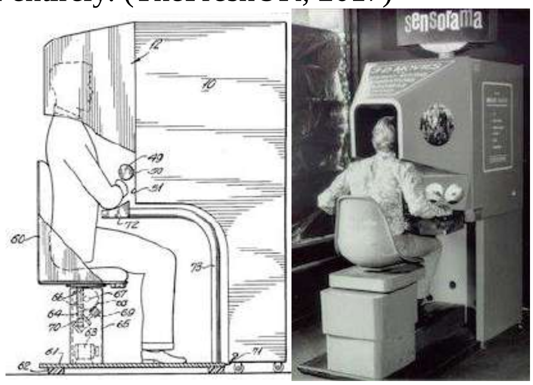


Figure 2.10 Morton Heilig’s Sensorama
Source: Morton Heilig(2017)

2.3.1.6. 1960 – The first Head-Mounted VR

Figure 2.20 is Morton Heilig’s next finding innovation was the Telesphere Mask, and was the first example of a head-mounted display (HMD), although it is for the non-interactive film medium without any motion tracking. The headset provided stereoscopic 3D and full vision with stereo sound. (TheFreshUK, 2017)

Figure 2.11 Head-Mounted Display
Source : (TheFreshUK, 2017)

2.3.1.7. 1968 – Sword of Damocles by Ivan Sutherland

In 1968 Bob Sproull and his teacher Ivan Sutherland created Sword of Damocles as shown in figure 2.12 below, the first VR / AR Head-Mounted Display that was connected to a computer, and not a camera. This discovery was significant, and that was too heavy for any user to wear and was suspended from the ceiling comfortably. The wearer would also need to be strapped into the device. The computer-generated graphics were very primitive, wireframe rooms and objects.

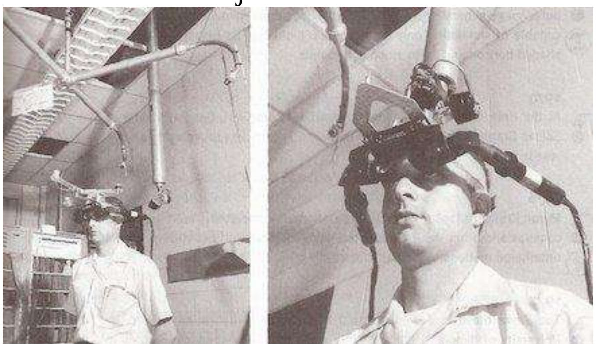


Figure 2.12 Sword of Damocles
Source : (TheFreshUK, 2017)

2.3.1.8. 1987 – Virtual reality the name born

Jaron Lanier in 1987, the founder of the Visual Programming Lab (VPL), coined the term “virtual reality.” The research area now had a name; after all of this development in virtual reality, there still was not an all-encompassing term to describe the field. They are the first company to sell Virtual Reality goggles, as shown in figure 2.22, and the price is around $9400 - $49,000 at that time and gloves around $9000. A significant development in the area of virtual reality haptics.

Figure 2.13 Virtual Reality goggles and gloves
Source : (TheFreshUK, 2017)

2.3.1.9. 1991 – Virtuality Group Game Machines

The Virtuality Group launched games machines, as shown in figure 2.23. Players would wear a set of Virtual Reality goggles and play on gaming machines with realtime with immersive stereoscopic 3D visuals. Some units were also linked together for a multi-player gaming experience.

Figure 2.14 Gaming Machine
Source : (TheFreshUK, 2017)

2.3.1.10. 1993 New VR glasses by SEGA

Sega announced the VR headset for the Sega Genesis console in 1993 at the Consumer Electronics Show in 1993. The wrap-around prototype glasses had head tracking, stereo sound and LCD screens in the visor, as shown in figure 2.24. However, technical development difficulties meant that the device would forever remain in the prototype phase despite having developed four games for this product. This was a massive flop for Sega. (TheFreshUK, 2017)

Figure 2.15 Sega Genesis console
Source : (TheFreshUK, 2017)

2.3.1.11. 1995 – Nintendo Virtual Boy

The Nintendo Virtual Boy was a 3D gaming console that was hyped to be the first-ever portable console that could display beautiful 3D graphics, as shown in figure 2.25. It was a failure despite price drops for the first time released in japan in America for $180. The reported reasons for this failure is a lack of software support, there was a lack of colour in graphics, and it was difficult to use the console in a comfortable position. The following year they discontinued its production and sale. (TheFreshUK, 2017)

Figure 2.16 Nintendo Virtual Boy
Source : (TheFreshUK, 2017)

2.3.1.12. Virtual reality in the 21st century

It seems that 2016 will be a pivotal year in the VR industry. Many inventions for consumer devices that seem to finally answer the unfulfilled needs made by VR in the 1990s that come to market at that time. Developer versions of final consumer products have also been available for a few years, so there has been a steady stream of software projects creating content for the imminent market entrance of modern virtual reality (Tumey, 2018). Recently companies like Google have already released virtual reality products such as Google Cardboard, a headset that uses a smartphone to drive it. Other companies like Samsung have taken this concept further with products such as the Galaxy Gear, which is mass-produced and contains "smart" features such as gesture control.

2.3.2. Working Principle of VR

The Virtual Reality idea is to deliver a sense of being there, at least giving the eye what it would have received, and to have the image change instantly as the point of view is changed (Smith, et al., 2004). The factor about the perception of reality feel is driven by various visual cues, brightness, like relative size, and angular movement. One of the strongest and powerful is perspective; for example, binocular form in that the right and left eyes see different images then fusing these images into one 3D perception is the basis of stereovision. (Onyesolu, et al., 2011)

The basic perception of depth provided by each eye seeing a slightly different image is most useful for objects very near the user. Objects farther away mostly cast the same image on each eye. Virtual Reality was synonymous with glasses that provide a display for each eye. Each display delivers a different perspective picture of what the user sees. As the user moves head with googles, the picture rapidly changes and updates, so that the user feels like they are the cause of these changes by moving the head and the computer following the user movement. (Onyesolu, et al., 2011) You feel you are the cause, not the effect.

2.3.3. Virtual Reality Components

The components necessary for building VR are divided into the hardware components and the software components.

2.3.3.1. Hardware Components

Table 2.2 Hardware Component

No	Name	Description	Picture
1	Head-Mounted Displays	Head-mounted displays place a screen in front of each of the viewer's eyes at all times	 Figure 2.17 VR Glasses

2	Input Device	Function to interact with the virtual environment and objects within the virtual environment. Such as like joystick, instrumented glove, keyboard, and voice recognition.	 Figure 2.18 Remote VR
3	Smartphone	As a device to run the virtual reality application, with a specification of the Android operating system and minimum ram is 4 GB.	 Figure 2.19 SmartPhone

2.3.3.2. Software Component

The software components are divided into some components that are, 3D modelling software, digital sound editing software, and Virtual Reality simulation software.

Table 2.3Software Component

No	Software	Description
2	3D Modeling	It has a function to specifies the visual properties of these objects and constructing the geometry of the objects in a virtual world. For example is a blender, 3DS Max, Autocad 3D.
3	Digital Sound Editing	Digital sound editing software is a function to mix and edit sound that objects make within the virtual environment
4	VR Simulation	It is used to set the rules that the virtual world follows and program how these objects behave. In this thesis is using the Unity application.

2.3.4. Application of VR and Related Research

Virtual Reality is being applied in all areas of social business, and many VR applications have been developed for training in a variety of areas like military, medical, equipment operation. Also in manufacturing, education, simulation, design evaluation (virtual prototyping), simulation of assembly sequences, architectural walk-through, ergonomic studies, and maintenance tasks, assistance for disabling, study and treatment of phobias like fear of height, entertainment, rapid prototyping and much more.

2.3.4.1. Life-Saving Appliances Inspection Training Using VR Application

Rafiqi Zulfauzi. S. T has researched the development of Life Safety Appliances training inspections using virtual reality applications on container type vessels, namely MV. Meratus Bontang, but the scope and limits studied were only for navigation decks, B decks, and Upper forecastle decks. In this follow-up research, the development of fire safety equipment inspection using virtual reality will be carried out. In the maritime sector or out of the maritime sector, virtual reality can answer and illustrate the specified challenges and solution.

2.3.4.2. Virtual Wind Park

To illustrate to the city about future installation by virtual product. For example, in figure 2.29 below is an example of virtual wind - park installation at the Baltic Sea, this marketing using virtual reality to inform and to make the public know.

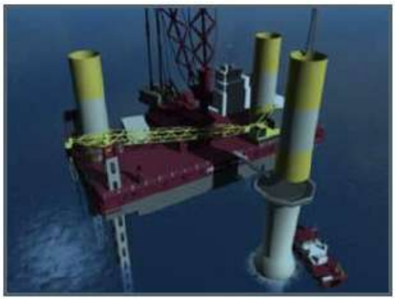


Figure 2.20 VR visualisation in offshore.
Source: Virtual and augmented reality for the maritime sector – applications and requirements (2010)

2.3.4.3. Design Review

In Germany, many shipyards are in the process of integrating with virtual reality to their standards procedure of the design. They are a focus on using VR as a tool for review where stakeholder discusses several aspects, and this supported by the national German Research Project, like in figure 2.30.

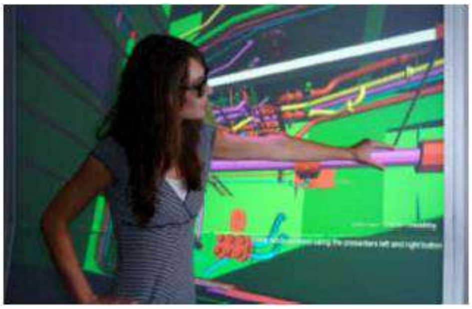


Figure 2.21 VR review at IGD's Maritime Graphics lab in Rostock.
Source: Virtual and augmented reality for the maritime sector – applications and requirements (2010)

2.3.4.4. Game-Based for Maritime Security Training

The game engines combine handling and rendering of 3D objects with an efficient way to describe interaction and behaviour. A dangerous game approach introduces new media in the training of ship crews for virtual fire fighting accident, as shown in figure 2.31.

Figure 2.22 Fire Fighting Simulating.
Source: Virtual and augmented reality for the maritime sector – applications and requirements (2010)

2.3.4.5. Simulation Training for Operator

Virtual Reality can offer extremely efficient and cheap for practising and training of handling object or vessel for the operator. For example, in figure 2.32, in this figure below show a new underwater vessel, that complex for operation, so that virtual training is the best solution.

Figure 2.23 Simulator for an underwater vessel.
Source: University of Girona

2.3.4.6. Maintenance Support

Figure 2.33 describes that is combining real object and digital content, using a combination of VR and AR, by mixing computer-generated content with a live video stream of a scene. That can be helpful and useful to support a ship crew that has limited resources and competencies. In this system will present the repair procedure of a pump or filter.

Figure 2.24 Adjustment of a ship engine governor with AR.
Source: Virtual and augmented reality for the maritime sector – applications and requirements (2010)

2.3.4.7. BMW Research For Verifying Product Design Using VR

In 1999, BMW company had researched the Virtual Reality capability for verifying product designs (Gomes de Sa, et al., 1999). So it is proven to be a useful tool for workers evaluates product design. They are stated that Virtual Reality has the significant potential to diminish the number of physical prototypes needed to improve overall product quality and to obtain quick answers intuitively during the concept phase of a product.

2.3.4.8. Motorola VR Research for training to run a pager assembly line

Motorola developed a virtual reality technology for training workers to run a pager assembly line (Wittenberg, 1995). They found that virtual reality can be used to train manufacturing personnel successfully and that participants trained in virtual reality environments perform better on the job than those trained for the same time in real environments.

2.3.4.9. GE Corporate Research To Develop VR Application

In 1998, GE Corporate Research developed virtual reality software applications, which allowed engineers to interactively fly through a virtual jet engine (Abshire, et al., 1998). They reported that the applications were used successfully to enhance design communication and to solve maintenance problems early, with the benefit of minimal cost, delays, and effort. They also reported that using virtual reality applications helped make maintenance an integral part of their product design process. The success stories from industry show that virtual reality technology-literate professionals are a present and future industry need.

2.3.4.10. Boeing Research for Virtual Space eXperiment (VSX)

Boeing is the largest aircraft manufacturers in the world developed the Virtual Space eXperiment. Virtual Space eXperiment is a demonstration of how the design of aircraft and other complex systems involving interactions of human interaction (Kalawsky, 1993). It is a three dimensional virtual model of the interior and exterior of a tilt-rotor aircraft in a virtual world that allows persons to interact with various items such as maintenance hatch, cargo ramp.

Moreover, McDonnell Douglas uses a system to evaluate how a virtual environment can aid the design of a new engine type. The system is utilised to explore the process of installing and removing the engine, especially for detecting the potential interface with other devices.

2.3.4.11. Virtual Reality Technology To Design And Build A Cars

The automotive industry starts to use virtual reality technology to design and concept, build cars. It can take two years or more to advance from the development of an initial concept for a new type of car to the moment that a production version rolls off the assembly line. The engineering team developed a virtual reality system for evaluating process installation feasibility in automotive assembly. (Shin)

2.3.4.12. Virtual Reality For Education

Mathematics and science teachers have used VR for explaining abstract spatial data. Virtual Reality is a powerful tool for education since people comprehend images much faster than they grasp lines of text or columns of numbers. Virtual reality offers immersive multisensory environments that engage students and allow them to visualise information . (Bricken, et al., 1992) used VR to help students learn elementary algebra. They used three-dimensional space to express algebraic concepts and to interact with spatial representations in a virtual environment. They concluded that VR has the potential for making a significant improvement in the way students learn mathematics. Then (Haufmann, 2000) used Virtual Reality in mathematics and geometry education, especially in vector analysis and descriptive geometry. Their survey showed that all participants of a total of 10 students rated VR as a perfect playground for experiments, and all participants wanted to experience Virtual Reality again. Students also thought it was easier to view a 3D world in VR rather than on a flat-screen.

2.3.4.13. Virtual Reality In The Field of Architects

In Japan, customers bring the architectural layout of their home kitchen to the Matsushita store and plug it into the computer system to generate its virtual copy. They can install appliances and cabinets, and change colours and sizes to see what their complete kitchen will look like without ever installing a single item in the actual location. Similarly, Mike Rosen and Associates has been using an interactive and immersive VR technology to assist its building industry clients in the design, visualisation, marketing, and sales (Neil, 1996).

2.3.5. Advantages of Virtual Reality

Virtual reality technology has great value in situations where exploration of environments or interactions with objects or people is inconvenient or impossible, or where an environment can only exist in computer-generated form. Virtual Reality application for inspection training is less-expenses and have to go to the real condition. Virtual training can be access in anytime and anywhere.

2.4. Expected Result

The result of this thesis will be in the form of android application as figure 2.34. The developments from previous research that conduct by (Rafiqi, 2019), are expected to be applicated on inspection for surveyor training and educational purpose. Also expected to be used for familiarisation for a new crew in the new ship that the new crew of the ship will be working on due to the rotational shift.

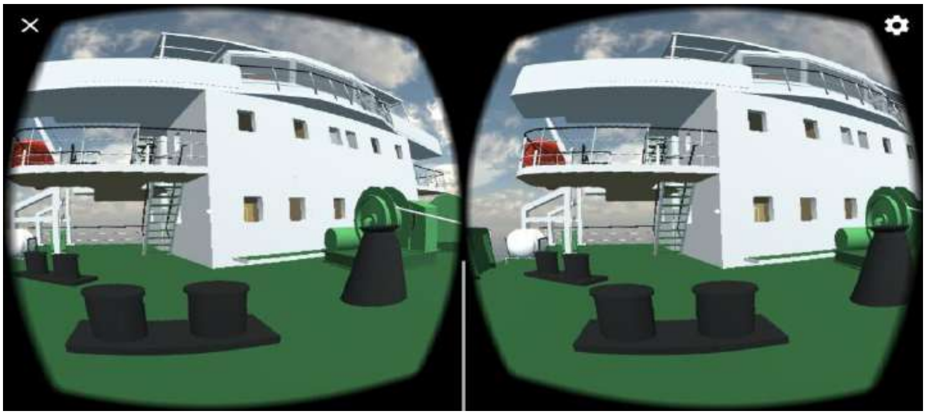
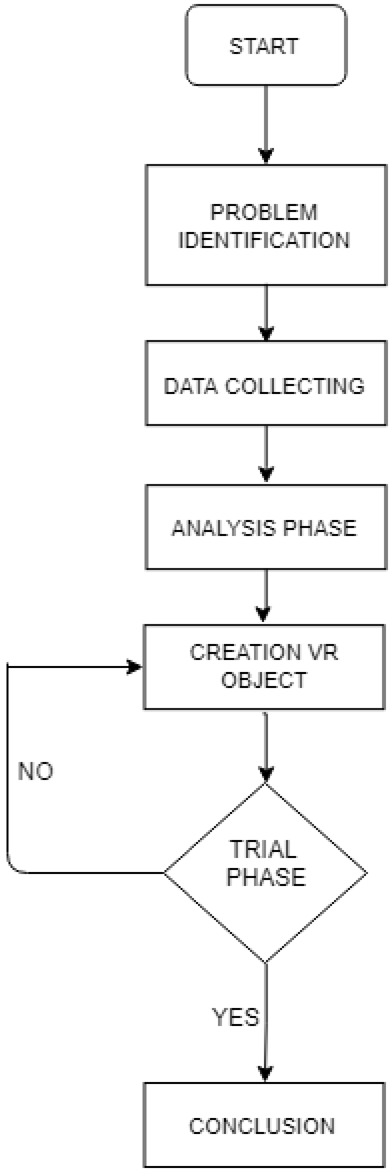


Figure 2.25 Outside View
Source: (Rafiqi, 2019)

"This page is intentionally left blank."

CHAPTER 3
METHODOLOGY



3.1. Problem Identification

The first process is to identify the possible problem that may happen during the process of this research, such as:

a. Modelling the actual condition of the main engine cooling systems to the 3D Object.
b. Converting the 3D model of main engine cooling systems to the virtual reality application
c. Determining the device specifications for compatibility of virtual reality applications.

3.2. Data Collecting

To obtain the data by directly go to the field for main engine cooling system equipment and installation to determine precisely how to desain and install the main engine cooling systems. The data that should be collected is :

a. List of main engine cooling systems equipments in engine room
b. Main engine cooling systems installation
c. Dimention of main engine cooling systems

3.3. Analysis Phase

Analyse phase is to defining every equipment that needs to build in virtual reality application such as the proportional dimension and location and make as same as onboard based on drawing on lubricating oil system keyplan, and analysis every possible main engine cooling systems installation desain and equipment placing.

3.4. Creating VR Object

Creating and design virtual obstacle as the same close as possible to the real object using an application to create a 3D object and become an input to the virtual reality application maker. This process must be done with care and focused because minor faults in this phase will steer the direction of progress and inaccuracy will cause repetition in this phase.

3.5. Trial Phase

In this stage will be thoroughly tested for the virtual reality program that has been made in android platform base by ten respond with different specification of their device due to the compatibility. The purposes of this phase are to make sure the application is working correctly without no error and bug, also confirm that it is progressing by requirements. In the trial phase will be done by giving a try of 10 responden and evaluate their advice comment. If it passes in this trial phase, it will be finished, and the conclusion can be made, and if it does not pass or there is an error or bug, it will analyse why the error happens and back to creation Virtual Reality object or the step before. Furthermore, there will be an assesment using questionnaire form to the user / responden.

"This page is intentionally left blank."

CHAPTER 4

DATA ANALYSIS AND RESULT

4.1. Research Object

Due to the availability of PT. Meratus Line Company to be surveyed in Surabaya, MV. Meratus Benoa is chosen to be an object target for being a model in virtual reality application.

Figure 0.1 MV. Meratus Benoa
Source: By Author (2020)

4.2. Data Collection

The data and material to build the fire control plan virtual reality application consist of :

1. General Info of the ship MV. Meratus Benoa
   General info is used to know the dimensions of the ship for 3D modelling in virtual reality application, so the dimension is on a comparable scale.
2. General Arrangement of the ship MV. Meratus Benoa
   GA is used as a basis of room design and location of its room
3. Cooling systems P&ID of MV. Meratus Benoa
   Cooling systems P&ID is used as a guided to the placement and to list and define every object of fire fighting equipment
4. Visual data
   Photos and videos on the actual condition based on a survey that has been conducted.

4.2.1. Ship General Data

This data below is used to know the size to determine the proportional scale and as additional information in the application.

Table 0.1 General Info of MV.Meratus Benoa

General Info	
IMO	9509231
MMSI	525025061
Call Sign	PNPC
Flag	Indonesia
Vessel Type	Cargo
Gross Tonnage	3668 T
Deadweight	5107 t
Length Overall x Breath Extreme	106,68m x 20,6m
Draught	4,215 m
Built	Indonesia
Home Port	Surabaya

4.2.1.1. List of Equipment

To determine the list and location of main engine cooling systems equipment, P&ID as shown in figure 4.3 can be a reference, but with the validation in the actual condition, and precision location of each equipment.

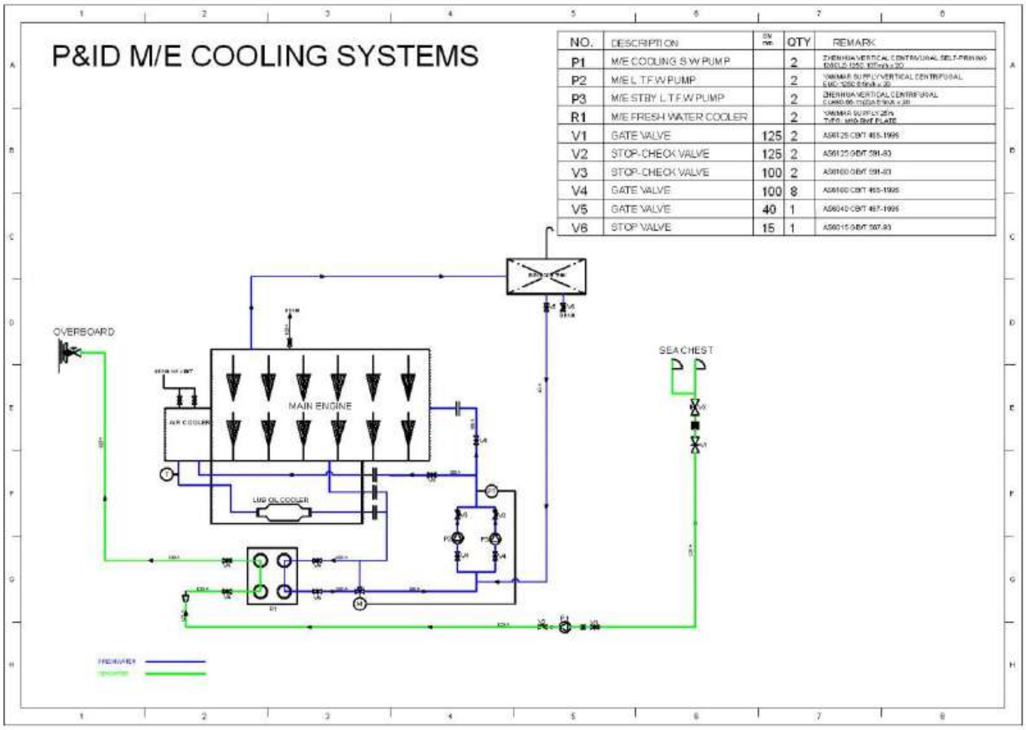


Figure 0.2 Redrawed of MV.Meratus Benoa Cooling Syatems P&ID
Source: PT.Meratus Benoa Company

Table 0.2 Cooling System Equipment List

NO.	DESCRIPTION	DIAMETER (mm)	QTY
P1	MAIN ENGINE COOLING SEA WATER PUMP	-	2

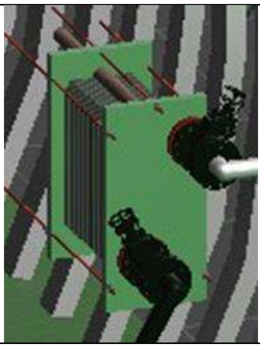
P2	MAIN ENGINE LOW TEMPERATAURE FRESHWATER PUMP	-	2
P3	MAIN ENGINE STANDBY LOW TEMPERATURE FRESH WATER PUMP	-	2
R1	MAIN ENGINE FRESH WATER COOLER	-	2
V1	GATE VALVE	125	2
V2	STOP-CHECK VALVE	125	2
V3	STOP-CHECK VALVE	100	2
V4	GATE VALVE	100	8
V5	GATE VALVE	40	1
V6	STOP VALVE	15	1

4.3. Create 3D Modelling

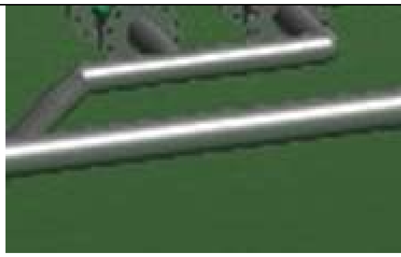
In this phase consists of creating the assets of the virtual environment using Blender application. The 3D models are drawn in Blender, which is a free and open-source 3D computer graphics software used for creating 3D models, visual effects, 3D interactive application, etc. The model is finalised to be as close as the actual object. The requirements for some assets can be precise from earlier phases of the analyses or even from the scenario draft. There are two main 3D models, such as ship deck with all the environment and fire fighting equipment 3d model.

4.3.1. Cooling Systems Equipment Model

Table 0.3 Cooling System Equipment 3D Model
Source: By Author

Description	Actual Model	3D Model
MAIN ENGINE COOLING SEA WATER PUMP		
MAIN ENGINE LOW TEMPERATAURE FRESHWATER PUMP		
MAIN ENGINE FRESH WATER COOLER		

GATE VALVE		
STOP-CHECK VALVE		
THREE-WAY VALVE		
STRAINER		

PIPE		

4.3.2. Ship Engine Room Model

This engine room model was created using a blender application that produces parts that complement the engine room such as main engine, double bottom, stairs, gear box, and flooring. all these parts are modeled in such a way that they have the same appearance as in the real world to make it look smoother and more real when the application is played. then all parts will be combined into one using the unity application.

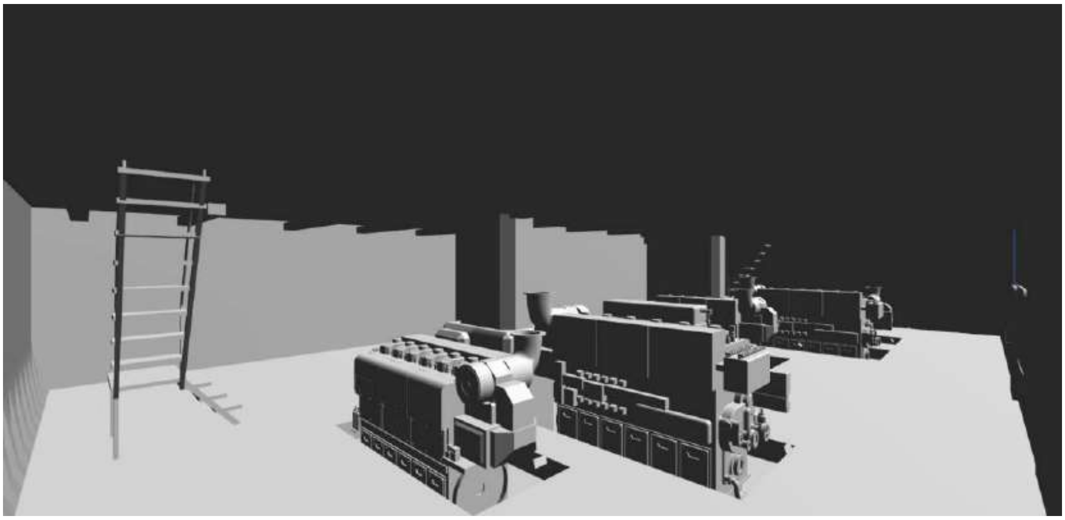


Figure 0.3 First Look of The Engine Room Model
Source: By Author

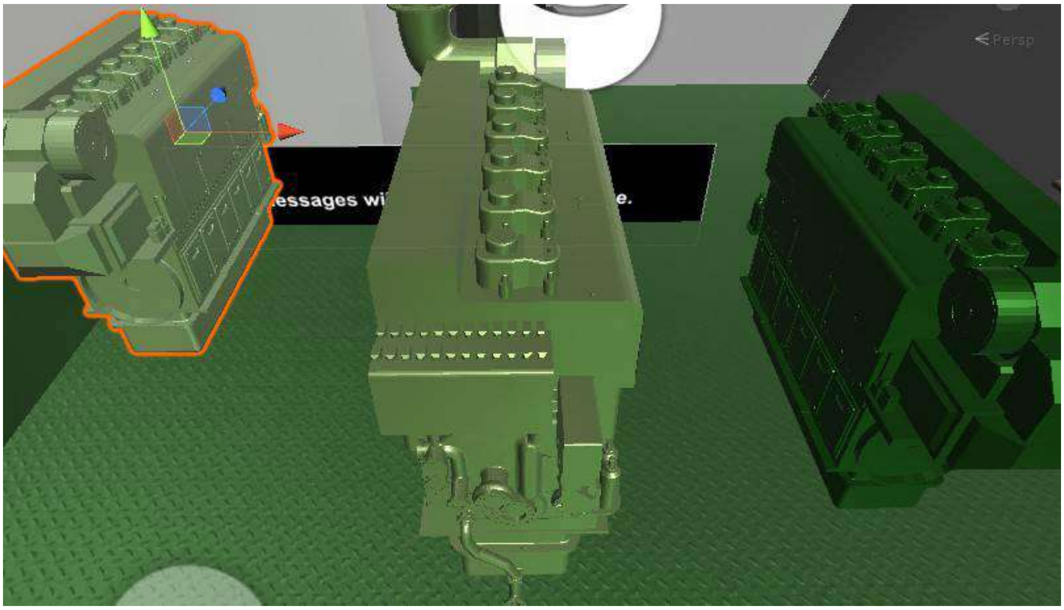


Figure 0.4 Main Engine
Source: By Author

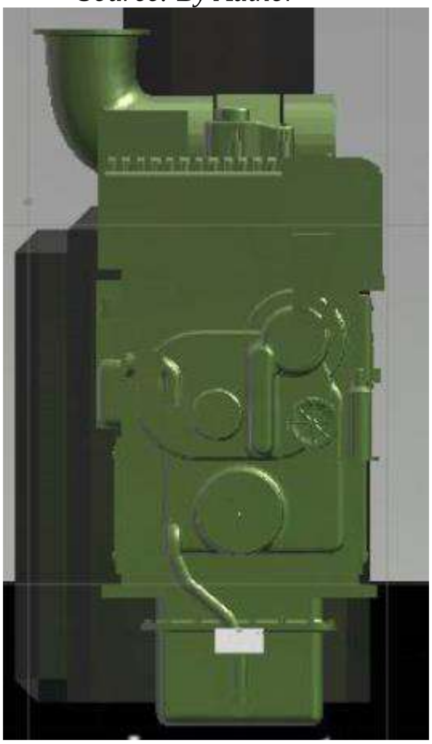


Figure 0.5 Main Engine (front view)
Source: By Author

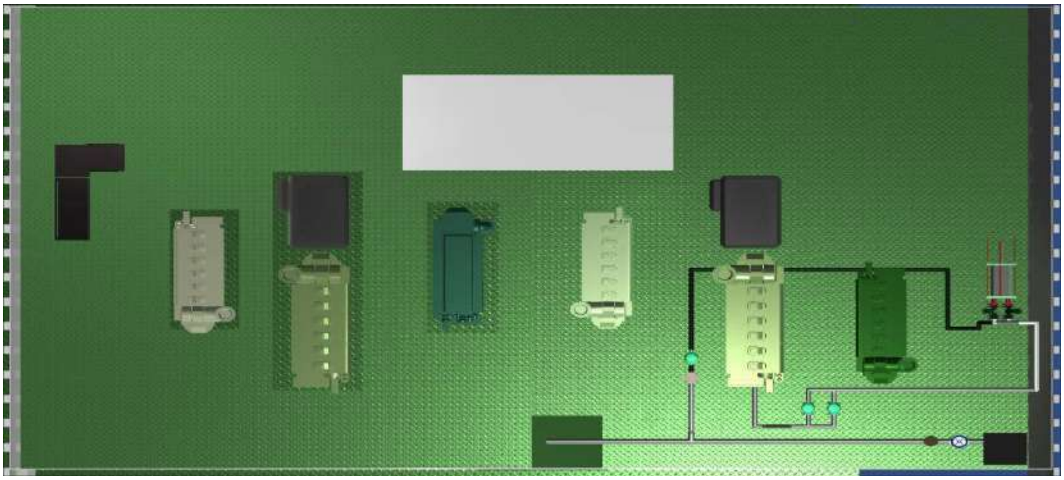


Figure 0.6 Engine Room Top View
Source: By Author

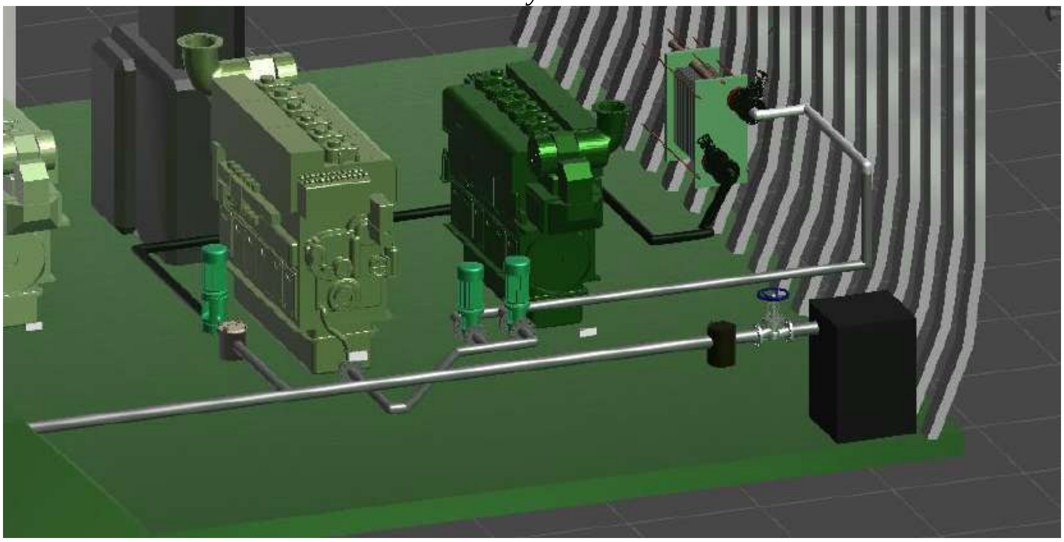


Figure 0.7 Engine Room with Cooling Systems installed
Source: By Author

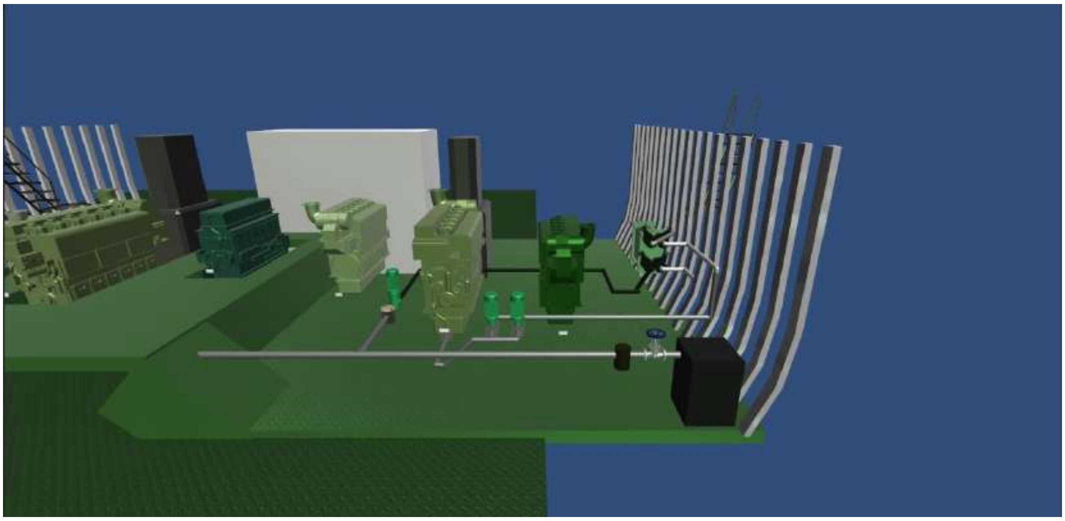


Figure 0.9 Engine Room
Source: By Author

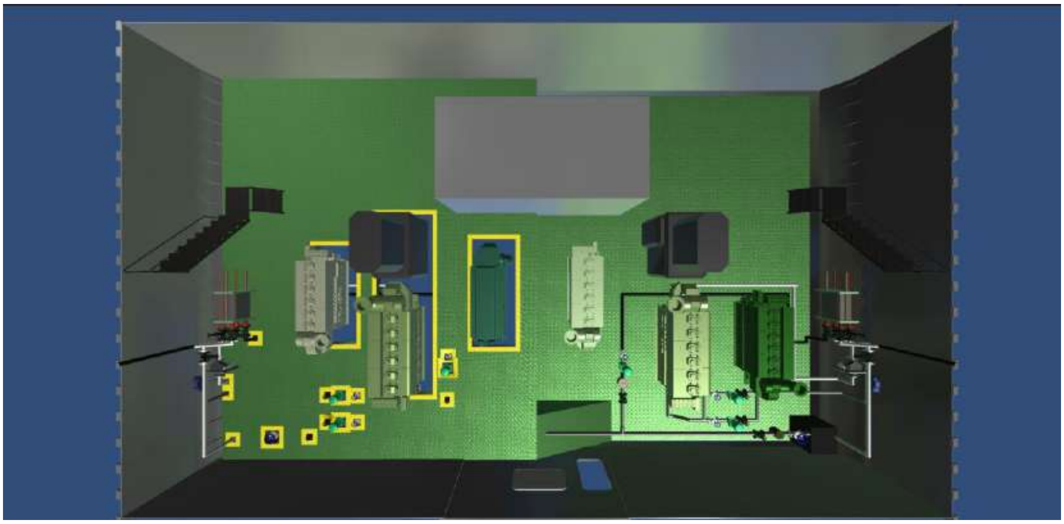


Figure 0.10 Engine Room (top view)
Source: By Author

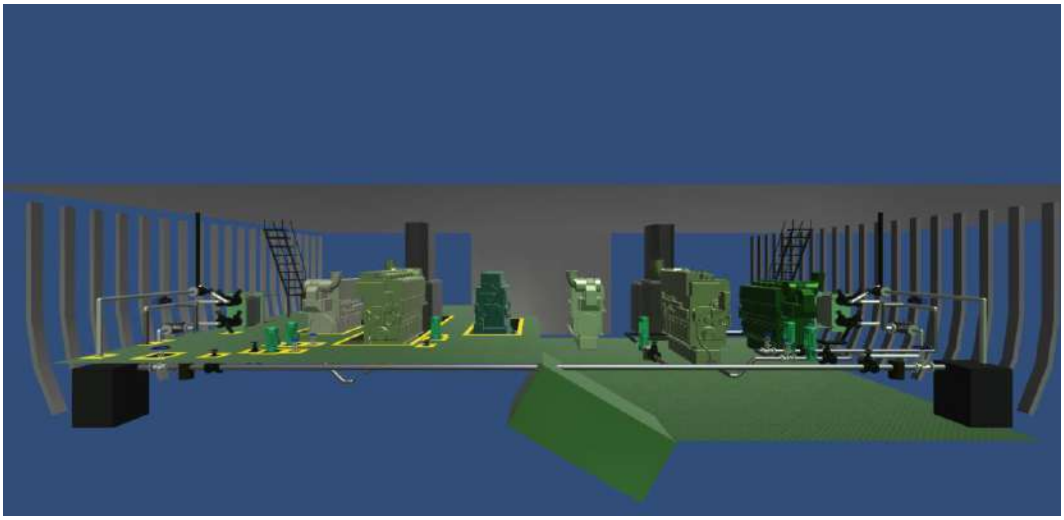


Figure 0.11 Engine Room (front view)
Source: By Author

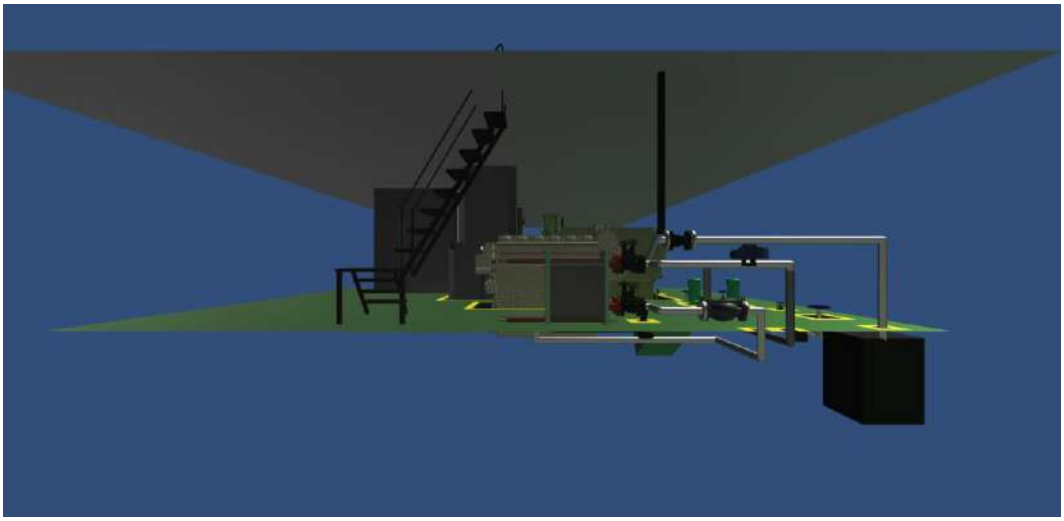


Figure 0.11 Engine Room (side view)
Source: By Author

4.4. User Interface

The user interface is a visual part of virtual reality application that ensures how a user interacts with the VR application and how information is displayed on the screen, in the other ways is a communication mechanism between user and the application system.

The design of the user interface is indeed fundamental because it will determine how a person interacts with the application.

Figure 0.12 Application Logo
Source: By Author

This application starts with a logo that appears on the main screen. Then proceed with the start button which will direct the user to a page that contains an introduction to the cooling system contained in the ship. This introduction material contains the basic understanding of the cooling system, the types of cooling systems, the fluid used, and an explanation of each type of cooling system circuit.

The introduction material:

“

INTRODUCTION

One of the essential system onboard in a ship is engine cooling system. This system is used to control the temperature of the engine. Jacket water cooling system is the one that cool the engine through cylinder liner. The discharge temperature of jacket water cooling is around 90 C so that this system may be called High Temperature Cooling (HT), supply water that used in this jacket cooling is fresh water which supplied from expansion tanks. Jacket water cooling circulated water needs to be cooled after out from engine. Temperature requirement for jacket water cooling before inlet is around 80 C, so it must be cooled from 90 to 80 C. That is why it requires central cooling system. This central cooling system not only cool HT but also cool lubricating oil. Central cooling system may be called Low Temperature Cooling (LT). LT got water supply from expansion tanks too. Moreover, the central cooling system must be cooled by another system which called seawater cooling system. This last system used sea water as the supply water.

DESCRIPTION

In the engine cooling system, there are 3 main components that should be cooled, such as :

4. Engine block / jacket
5. Air inlet to engine (turbocharger)
6. Lubricating oil

In the combustion process, there are some heat which is left in the part of engine. Those heat should be cooled by cooling system in order to maintain the operating temperature that required by engine maker. But, noticed the water temperature couldn't be so cool to prevent the thermal stress that might be happened during the process of cooled the engine.

Combustion process needs three main factor, heat, air and fuel. The temperature of air income to engine should be keep cool for getting high density, so the volume is greater. It is cooled by after cooler or intercooler. When the exhaust gas turn the turbines and the compressor, so the incoming air become a rather hot, so that the inlet temperature in scavenge air cooler is maintain as low as possible to get the minimum consumption of the fuel oil.

Lubricating oil is used to lubricate, cleaning, protecting, and cooling. As a cooling of moving part in engine, lubricating oil absorb heat from material (crankshaft, camshaft, timing gears etc.). It cause the temperature of lubricating oil become higher and reduce the viscosity, so that lubricating oil is needed to be cooled to getting back the viscosity required.

Cooling system based on cooler media is divided by two system, can be described as follow:

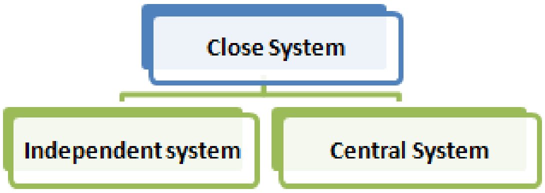
c. Air media cooling systems

Cooling system which use air for cooler media usually use in car and bike cycle cooling system, we call this system is Air Radiator.

d. Water media cooling systems

This system is directly used sea water to cooled the needed component. Water media cooling system call open system if the cooler media is direct touch with fresh air.

This system is used fresh water to circulate in the close system to cooled the needed component. Then the fresh water is cooled by sea water, those fresh water is circulating back to cooled the component. This close system is divided into two, those are :



- Independent systems

Fresh water is used to cool every component separately, not by one heat exchanger.

- Central systems

Fresh water that used to cool the component is collecting to be cooled in one heat exchanger. Heat exchanger in central cooler use sewater to cool fresh water. So, the equipment that directly related to sea water is not much and the problem of corrosion could be reduced.

This close system is divided into two circuit, these are :

3. Sea water circuit

Sea water as the fluid which used to cooled central cooler. Sea water is taken from sea chest using a sea water pump. The output is directly dispose to overboard.

4. Fresh water circuit

Fresh water as the fluid which cooled by sea water used to cooled the component needed. This fresh water circuit is divided into two again, these are :

- High temperature circuit

Fresh water is used to cool the jacket water cooler and supplied by the jacket water pump, and the remains of evaporation processed on de-aerating tank is to be reused for cooling.

- Low temperature circuit

Fresh water is used to cooled the lubricating oil and charge air cooler (scavenge air)."

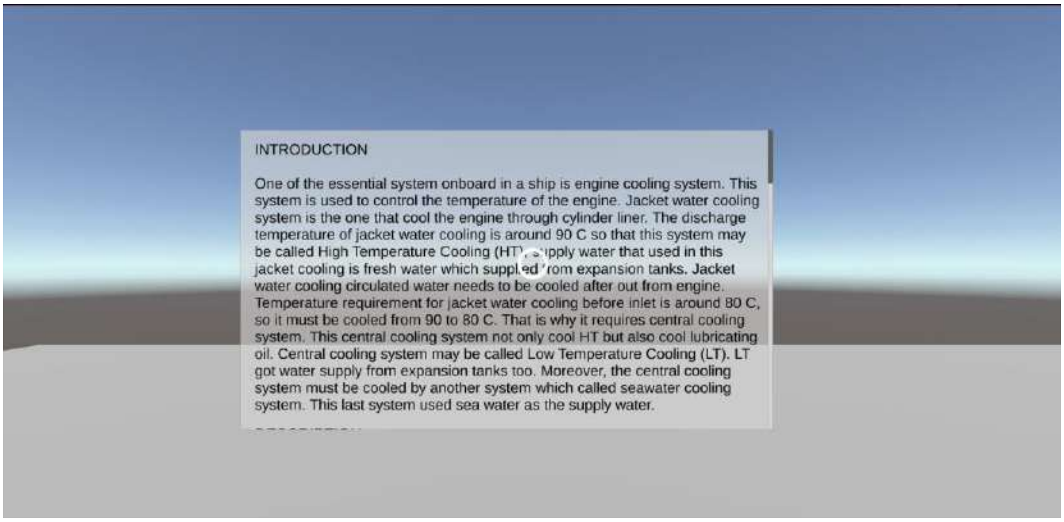


Figure 0.13 First page of cooling systems introduction
Source: By Author

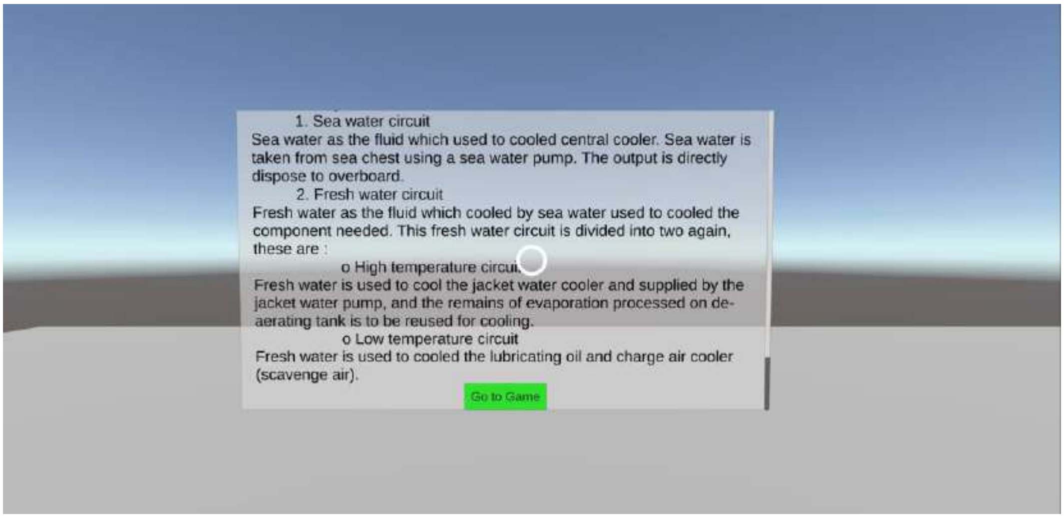


Figure 0.14 second page of cooling systems introduction
Source: By Author

After the user understands the basics of what is needed to design and make a cooling system installation on the ship, the user will be delivered on a page that will show the design of the cooling system that has been installed on the ship in the form of a 3D view. Users will be able to explore the engine room area and see what objects are installed in a series of ship cooling systems.

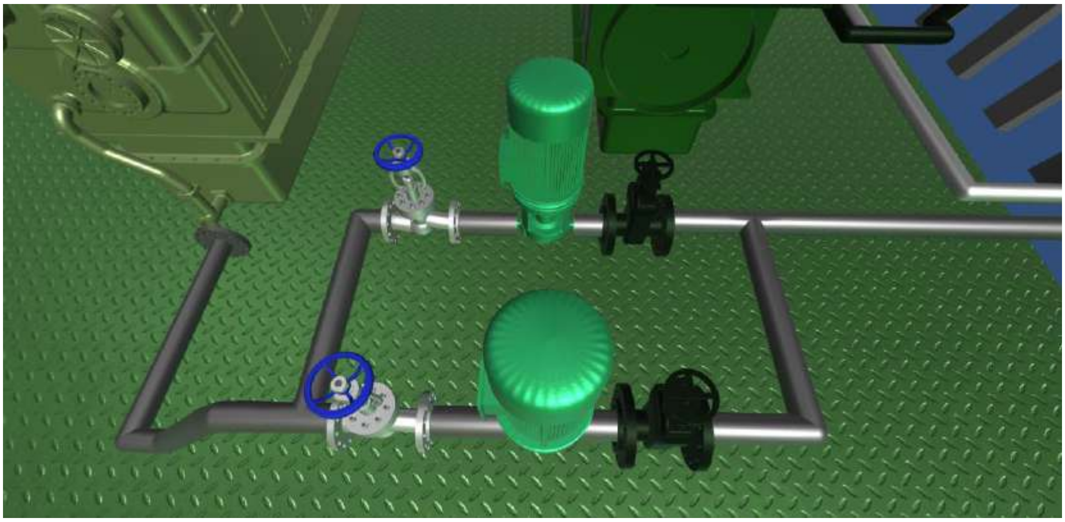


Figure 0.15 user view on engine room
Source: By Author

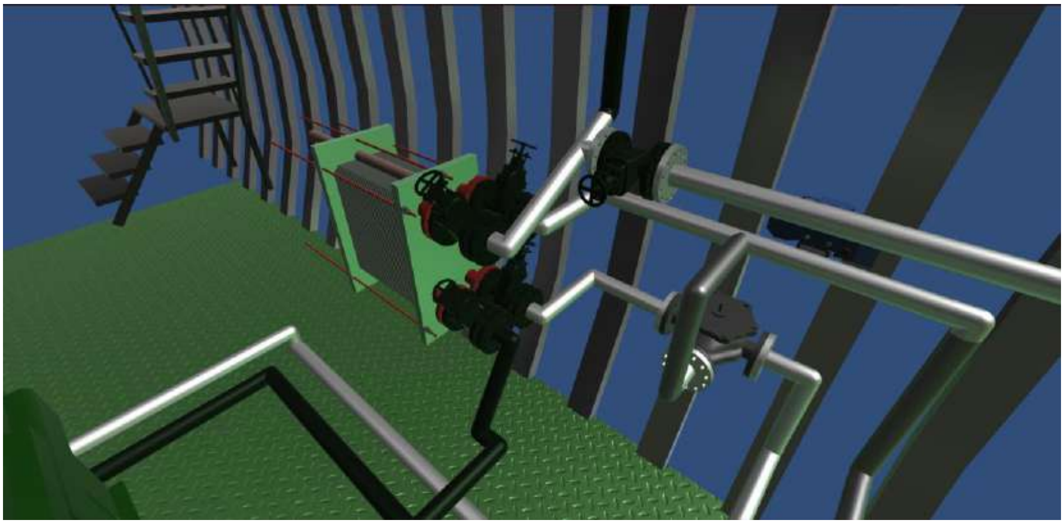


Figure 0.16 user view on engine room
Source: By Author

To better understand how to install cooling systems on ships more accurately, this application also features features that can display P&ID or design of installed ship pending systems. in the P&ID there is a picture of the whole series that is equipped with names and numbers on each device installed in the system. For certain parts, there are also specifications and basic ingredients of these tools. this feature was added to make it easier for users to interpret a P&ID to be implemented in the original system.

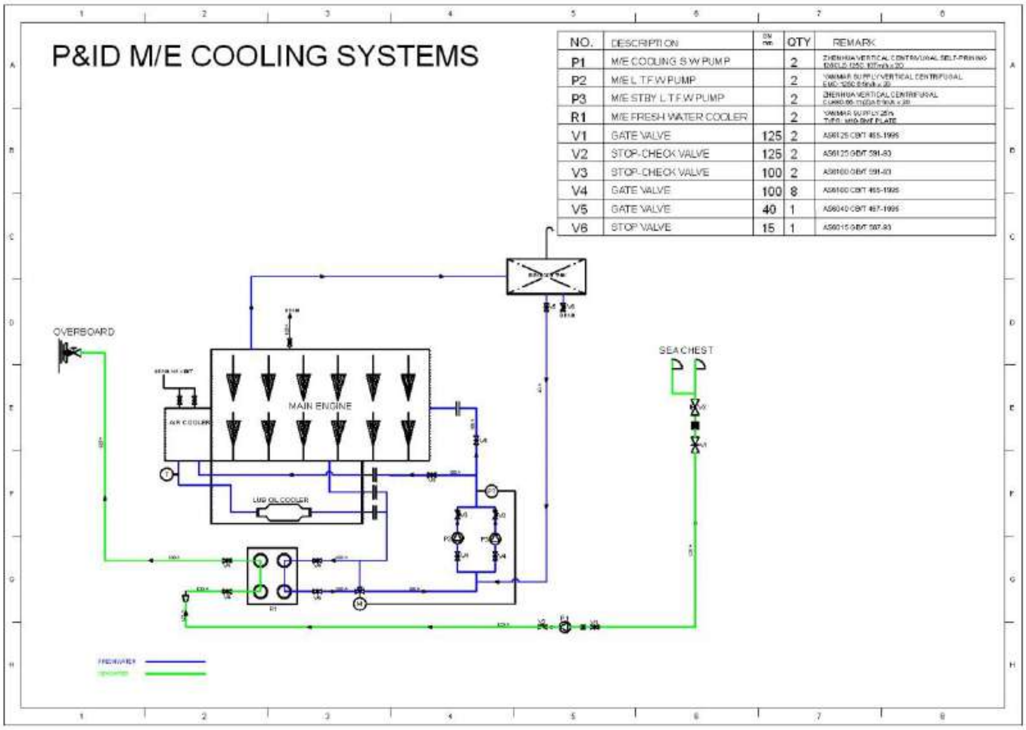


Figure 0.17 P&ID of M/E Cooling systems
Source: By Author

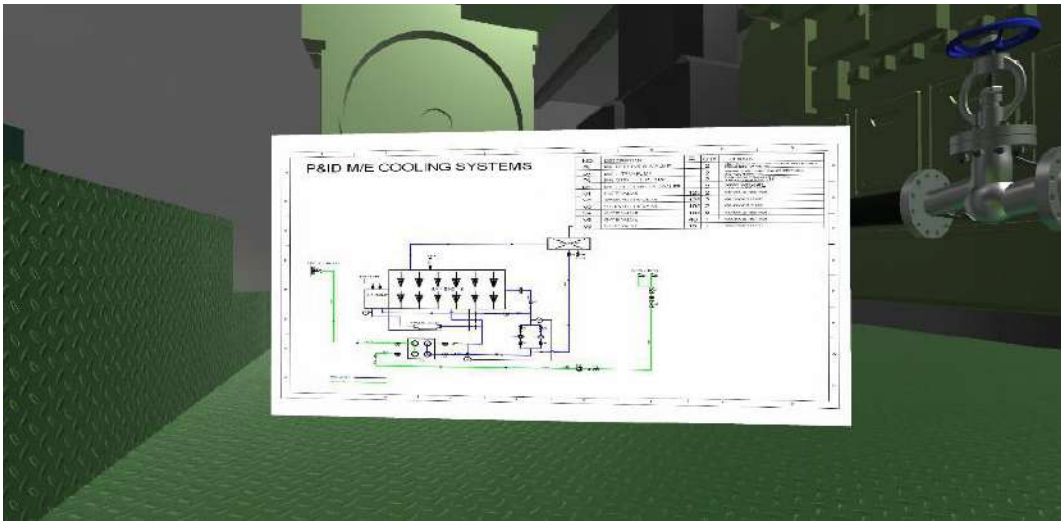


Figure 0.18 P&ID of M/E Cooling systems in application
Source: By Author

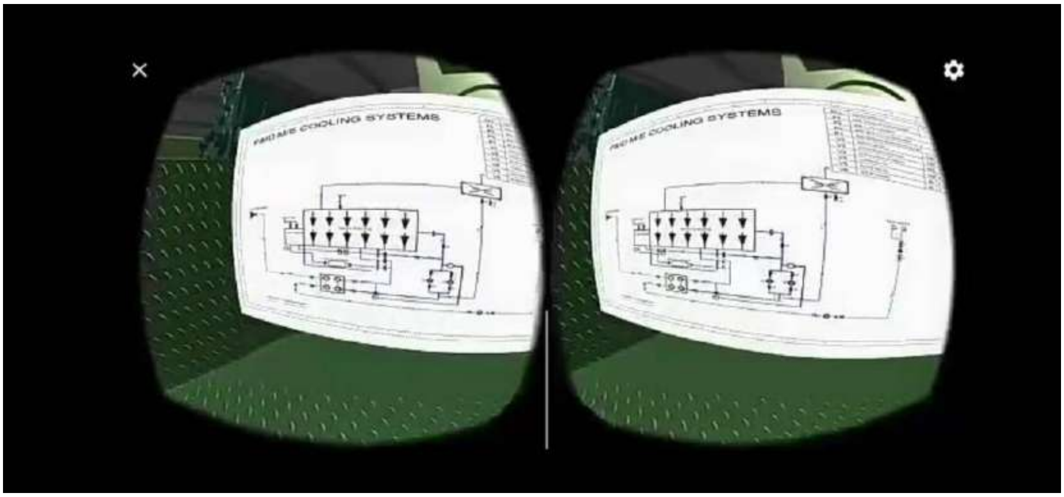


Figure 0.19 P&ID of M/E Cooling systems on VR view
Source: By Author

The ship's cooling system used in this application is designed based on ABS class. This application also shows the rules that must be considered when designing a ship's cooling system based on ABS class. There are several different slides with one rule on each slide. this is done so that users get easy to understand the rules applied.

As for the rules used:

“

No.	Key Equipment	Reference	Parameter Design
1.	Main Pump	ABS Rules, Part 4, Chapter 6, Section 5 (7.3.1)	Cooling water pumps of propulsion gas turbine and associated reduction gear and cooling water pumps of propulsion diesel engines with bores greater than 300 mm and associated reduction gears are to be certified in accordance with 4-6-1/7.3. Pumps supplying cooling media other than water are to be subjected to the same requirements.
2.	Cooler	ABS Rules, Part 4, Chapter 6, Section 5 (7.3.2)	a. Water and air coolers having either of the following design parameters are to be certified by ABS: - be certified by ABS: • Design pressure > 6.9 bar (7 kgf/cm2, 100 lb/in2) on either side

			-	Design pressure > 1 bar (1 kgf/cm2, 15 lb/in2), internal volume > 0.14 m3 (5 ft3), and design temperature > 149°C (300°F) on either side.
			b.	Charge air coolers. Charge air coolers are not subject to 4-6-5/7.3.2(a). They are to be hydrostatically tested on the water side to 4 bar (4.1 kgf/cm2, 57 psi), but not less than 1.5 times the design pressure on the water side, either in the manufacturer's plant or in the presence of the Surveyor, after installation onboard the vessel.
3.	Sea Chest	ABS Rules, Part 4, Chapter 6, Section 5 (7.5)		At least two sea chests, located below the lightest waterline, as far apart as practicable and preferably on opposite sides of the vessel, are to be provided. Each of the sea chests is to be capable of supporting the cooling of propulsion and auxiliary machinery and other services drawing sea water from the same sea chest.
4.	Standby Pump	ABS Rules, Part 4, Chapter 6, Section 5 (7.7.1a)		There are to be at least two means to supply cooling water or other medium to propulsion and auxiliary engines, air compressors, coolers, reduction gears, etc. The capacity of each means is to be sufficient for continuous operation of the propulsion unit and its essential auxiliary services at rated power.
5.	Strainer	ABS Rules, Part 4, Chapter 6, Section 5 (7.7.2)		Where sea water is used for direct cooling of the engines, suitable strainers are to be fitted between the sea valve and the pump suction. The strainers are to be either of the duplex type or arranged such that they can be cleaned without interrupting the cooling water supply.

6.	Overpressure Protection	ABS Rules, Part 4, Chapter 6, Section 5 (7.7.4)	The cooling water system and all jackets are to be protected against over pressurization, in accordance with 4-6-2/9.9.

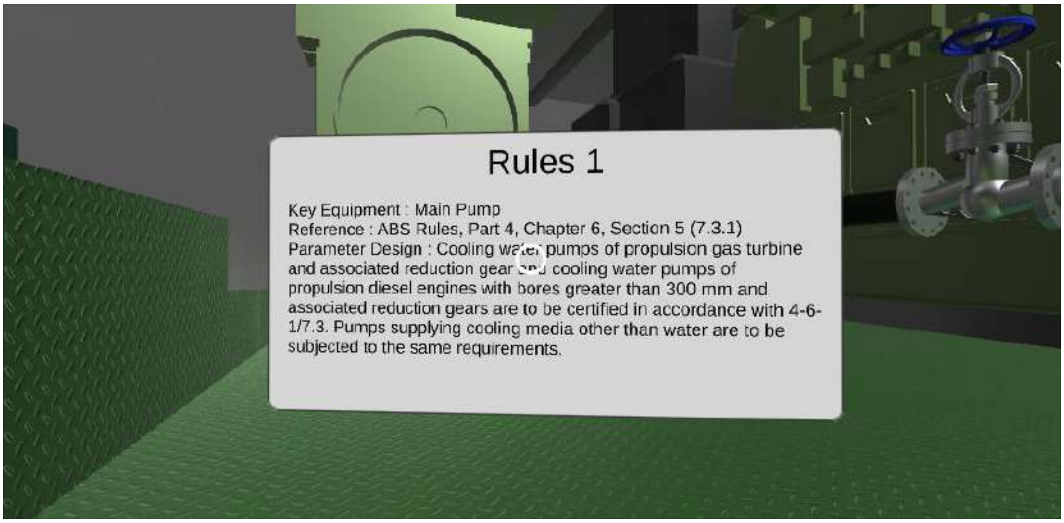


Figure 0.20 Rules of ABS class
Source: By Author

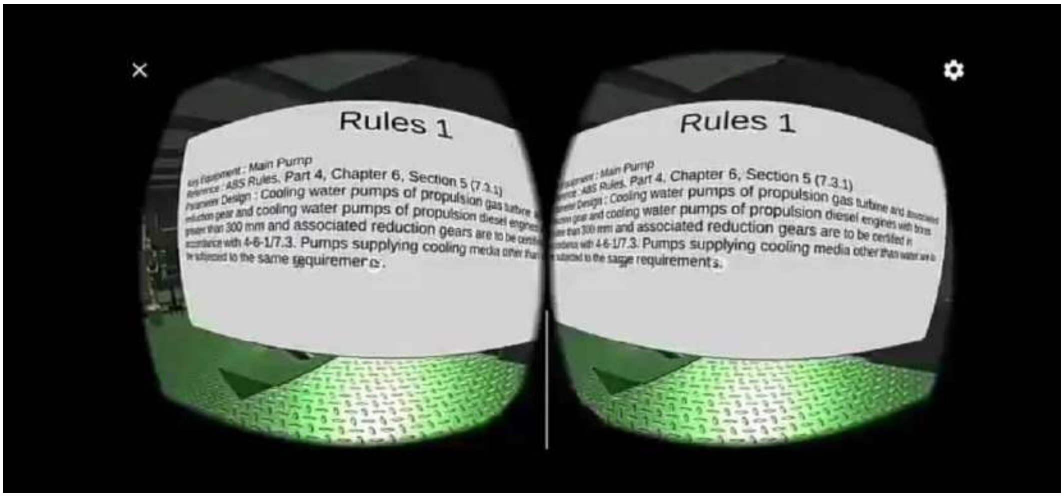


Figure 0.21 Rules of ABS class on VR view
Source: By Author

4.5. User Assessment Questionnaire Form

To find out the weaknesses and strengths in this application, we need a test in the real world. In this test it can be seen that this application meets the expected goals or not. And can find out what improvements can be made to improve this application.

This test is carried out using the questionnaire method given to test subjects after using the application. This test is carried out on 10 test subjects, with each subject being told to use the application with VR glasses within 10 minutes. Then the test subjects are presented the questionnaire listed in the link *www.bit.ly/ShipCoolingSystemsVR*.

In this questionnaire there are 10 questions related to the use of the application. Subject tests must provide points on each question as answers after using the application. The choice of points provided is in the form of numbers ranging from 1 (one) to 5 (five). The excellent score is 5, and the lousy score is 1. The question is:

1. Is the display in this application convenient to understand?
2. Are the features in this application easy to use?
3. Do all the features available in this application function properly?
4. When using VR glasses, is the VR application comfort to used?
5. Is the system installed in this application in accordance with the design shown in this application?
6. Do the tools installed on this system match the original objects in the ship?
7. Does the display in this application describe the ship's main engine cooling system?
8. Do the features provided in this application help in learning how to make a ship engine cooling system installation?
9. is learning to use VR more helpful compared to going to the field directly?
10. If you are an engineer, is this application able to assist you in learning and understanding your task in making the main engine cooling system of the ship?

4.5.1. Questionnaire Results

These following are the total results of collecting data from each answer from ten respondent that filled the questionnaire online or paper-based; it can be seen in Table 4.8 below.

Table 0.4 Questionnaire Results

No	Criteria	Respondent					Total
		1	**2**	**3**	**4**	**5**	
1	Is the display in this application convenient to understand?	0	0	0	3	7	10
2	Are the features in this application easy to use?	0	0	0	0	10	10
3	Do all the features available in this application function properly?	0	0	0	2	8	10
4	When using VR glasses, is the VR application comfort to used?	0	0	2	7	1	10
5	Is the system installed in this application in accordance with the design shown in this application?	0	0	0	0	10	10
6	Do the tools installed on this system match the original objects in the ship?	0	0	4	6	0	10
7	Does the display in this application describe the ship's main engine cooling system?	0	0	0	9	1	10
8	Do the features provided in this application help in learning how to make a ship engine cooling system installation?	0	0	1	7	2	10
9	is learning to use VR more helpful compared to going to the field directly?	0	0	4	5	1	10
10	If you are an engineer, is this application able to assist you in learning and understanding your task in making the main engine cooling system of the ship?	0	1	5	3	1	10

4.5.2. Questionnaire Results Analysis

From the results of questionnaire data collection, a score and percentage calculation can be made for each question given. To find the percentage of each answer to the questionnaire used the Likert scale formula as follows:

$$P = \frac{S}{Ideal\ Score}\ x\ 100\%$$

The description of the formula for calculates score and percentage value of the questionnaire answers can be seen in the following table 4.9.

Table 0.5 Formula Description

Name	Description
P	Percentage value.
S	The number of times the frequency is multiplied by the score in the answer.
Ideal Score	Highest score multiply by the number of samples
Highest Score	5
Sample	10 Respondent
Ideal Score	5 x 10 Respondent = 50

So these below is score and percentage calculation from each answer, As for the explanations as follows:

1. Is the display in this application convenient to understand?

Table 0.6 Question No.1 Calculation

Score	Respondent	Total Score
5	7	35
4	3	12
3	0	0
2	0	0
1	0	0
Total	10	47
Average Score		4,7

Then the calculation is as follows :

$$P = \frac{47}{50}\ x\ 100\% = 94\%$$

Then we can conclude that the VR application is quite easy to understand. some test subjects felt that they did not understand because they were not equipped with good graphics on each picture.

2. Are the features in this application easy to use?

Table 0.7 Question No.2 Calculation

Score	Respondent	Total Score
5	10	50
4	0	0
3	0	0
2	0	0
1	0	0
Total	10	50
Average Score		5,0

Then the calculation is as follows :

$$P = \frac{50}{50} x\ 100\% = 100\%$$

We can conclude that this application is easy to use because it implements commands and features that are simple and easy to understand.

3. Do all the features available in this application function properly?

Table 0.8 Question No.3 Calculation

Score	Respondent	Total Score
5	8	40
4	2	8
3	0	0
2	0	0
1	0	0
Total	10	48
Average Score		4,8

Then the calculation is as follows :

$P = \frac{48}{50}\ x\ 100\% = 96\%$

We can conclude that the features contained in this application function quite well. some test subjects stated that the features offered were still simple, so they still needed enhancements.

4. When using VR glasses, is the VR application comfort to used?

Table 0.9 Question No.4 Calculation

Score	Respondent	Total Score
5	1	5
4	7	28
3	2	6
2	0	0
1	0	0
Total	10	39
Average Score		3,9

Then the calculation is as follows :

$P = \frac{39}{50}\ x\ 100\% = 78\%$

We can conclude that this application is quite convenient to use when the test subjects use VR glasses. some test subjects feel uncomfortable because this application does not yet have the feature of adjusting the resolution and adjusting the screen distance to the eye, so that further development can be done.

5. Is the system installed in this application in accordance with the design shown in this application?

Table 0.10 Question No.5 Calculation

Score	Respondent	Total Score
5	10	50
4	0	0
3	0	0
2	0	0
1	0	0
Total	10	50
Average Score		5,0

Then the calculation is as follows :

$$P = \frac{50}{50} \, x \, 100\% = 100\%$$

We can conclude that the system displayed in this application is in accordance with the existing design in the application.

6. Do the tools installed on this system match the original objects in the ship?

Table 0.11 Question No.6 Calculation

Score	Respondent	Total Score
5	0	0
4	6	24
3	4	12
2	0	0
1	0	0
Total	10	36
Average Score		3,6

Then the calculation is as follows :

$$P = \frac{36}{50} \, x \, 100\% = 72\%$$

We can conclude that the object contained in this application is close to the original object. some test subjects stated that the details of each object could still be improved to make it look more real.

7. Does the display in this application describe the ship's main engine cooling system?

Table 0.12 Question No.7 Calculation

Score	Respondent	Total Score
5	1	5
4	9	36
3	0	0
2	0	0
1	0	0
Total	10	41
Average Score		4,1

Then the calculation is as follows :

$$P = \frac{41}{50}\ x\ 100\% = 82\%$$

We can conclude that the system shown in this application has described the main engine cooling system of the ship because it has applied every component in the main engine cooling system of the ship.

8. Do the features provided in this application help in learning how to make a ship engine cooling system installation?

Table 0.13 Question No.8 Calculation

Score	Respondent	Total Score
5	2	10
4	7	18
3	1	3
2	0	0
1	0	0
Total	10	31
Average Score		3,1

Then the calculation is as follows :

$$P = \frac{31}{50}\ x\ 100\% = 62\ \%$$

We can conclude that this application is quite helpful in learning about how to make the ship's main engine cooling system. some test subjects stated that there was still a need to improve the image quality and display accuracy.

9. is learning to use VR more helpful compared to going to the field directly?

Table 0.14 Question No.9 Calculation

Score	Respondent	Total Score
5	1	5
4	5	20
3	4	12
2	0	0
1	0	0
Total	10	37

Average Score	3,7

Then the calculation is as follows :

$$P = \frac{37}{50}\, x\ 100\% = 74\%$$

We can conclude that VR is quite helpful when compared to going directly to the field by considering the risks that occur. Some test subjects said that VR cannot completely replace training with the direct downward spaciousness method until the graph and appearance look more real with the conditions in the field.

10. If you are an engineer, is this application able to assist you in learning and understanding your task in making the main engine cooling system of the ship?

Table 0.15 Question No.10 Calculation

Score	Respondent	Total Score
5	1	5
4	3	12
3	5	15
2	1	2
1	0	0
Total	10	34
Average Score		3,4

Then the calculation is as follows :

$$P = \frac{34}{50}\, x\ 100\% = 68\%$$

Then we can conclude that Virtual Reality application was very helpful for training purposes.

Table 0.16 Total Question Score

Question No.	Percentage Value	Total Score
1	94%	47
2	100%	50
3	96%	48
4	78%	39
5	100%	50
6	72%	36

7	82%	41
8	62%	31
9	74%	37
10	68%	34
Total score		413
Total Average Score		4.13

To assess the results of the respondent's overall assessment of the quality of the application, the steps are:

1. Determine the maximum score, which is the largest answer score multiply by total questions, multiply by the total respondent.

5 x 10 x (10 respondent) = 500

2. Determine the minimum score, which is the smallest answer score multiplied by total questions, multiply by the total respondent.

1 x 10 x (10 respondent) = 100

3. Determine the median value, with the sum of the maximum total score with a minimum total score divided by two.

$$\frac{(500 + 100)}{2} = 300$$

4. Determine the quartile I value , with the sum of the minimum total score with a median divided by two.

$$\frac{(100 \ + 300)}{2} = 200$$

5. Determine the quartile III value, which is the sum of the maximum scores with the median divided by two

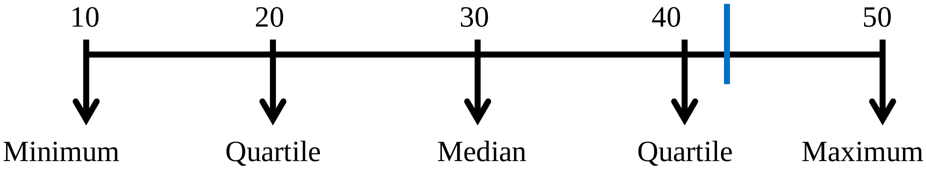
$$\frac{(500 + 300)}{2} = 400$$

Table 4.20 is an assessment categorized based on the value of the maximum score, quartile III, median, quartile I and the minimum score that calculated above.

Table 0.17 Category of overall application assessment

Excellent	Quartile III ≤ x ≤ Maximum Score	400 – 500
Good	Median ≤ x < Quartile III	300 – 400
Enough	Quartile I ≤ x ≤ Median	200 – 300
Bad	Minimum Score ≤ x ≤ Quartile I	100 – 200

413 or 82,6%



Based on the questionnaire given to the test subjects, a score of 413 was obtained, which was in the range of 400 and 500 (maximum score) and included in the excellent category.

CHAPTER 5

CONCLUSION AND SUGGESTION

5.1. Conclusion

Based on the problems and objectives made, this application can be a solution for implementing virtual reality technology as a training method for installing cooling systems on ships. This application is also able to describe the real condition of the ship's cooling system installation in the form of a 3D model that matches the dimensions of the ship. Based on the questionnaire given to the test subjects, a score of 413 was obtained, which was in the range of 400 and 500 (maximum score) and included in the excellent category. This application can still be developed by improving image quality and image details to better suit the real conditions that exist in the cooling system on the ship.

5.2. Suggestion

The suggestion of this thesis are :

1. There must be developments in the quality of high resolution and fine detail to be closer to real-world conditions.
2. There must be developments in the application to be more flexible in its use and can be used in a variety of electronic devices.
3. there must be an improvement in the application's features so that it is easier to implement it as a training method for engineers.

"This page is intentionally left blank."

REFERENCE

Abshire K.J and Barron M.K IEEE Proceedings Annual Reliability and Maintainability [Journal]. - 1998. - Virtual maintenance: Real World Applications.

Bricken and Winn & Designing virtual worlds for use in mathematics education [Journal]. - [s.l.] : Educational Technology, 1992. - The example of experiential algebra.

CMID Common Marine Inspection Document [Report]. - 2016.

Gomes de Sa A and Zachmann G Computers and Graphics [Journal]. - 1999. - Virtual reality as a tool for verification of assembly and maintenance processes.

Haufmann H Construct3D: A Virtual Reality [Journal]. - [s.l.] : Education and Information, 2000.

Inc Can Stock Photo Fire Hose [Online] // canstockphoto.com. - 09 12, 2019. - https://www.canstockphoto.com/fire-hose-14104908.html.

Kalawsky R. S. The Science of Virtual Reality and Virtual Environments [Journal]. - 1993.

Neil M. J Architectural Virtual Reality Applications [Journal]. - 1996. - Computer Graphics.

Onyesolu Moses Okechukwu and Eze Felista Udoka Understanding Virtual Reality Technology: [Journal]. - Nigeria : InTech, 2011. - Vol. 4.

Shin Junho A PROTOTYPE VIRTUAL REALITY SYSTEM THROUGH IDEF MODELING FOR [Journal]. - Republic of Korea : International Journal of Industrial engineering.

Smith S and Lee S A pilot study for integrating virtual reality into an introductory [Journal]. - [s.l.] : Journal of Industrial Technology, 2004.

TheFreshUK History Of Virtual Reality [Online] // www.vrs.org.uk. - The Virtual Reality Society, 2017. - https://www.vrs.org.uk/virtual-reality/history.html.

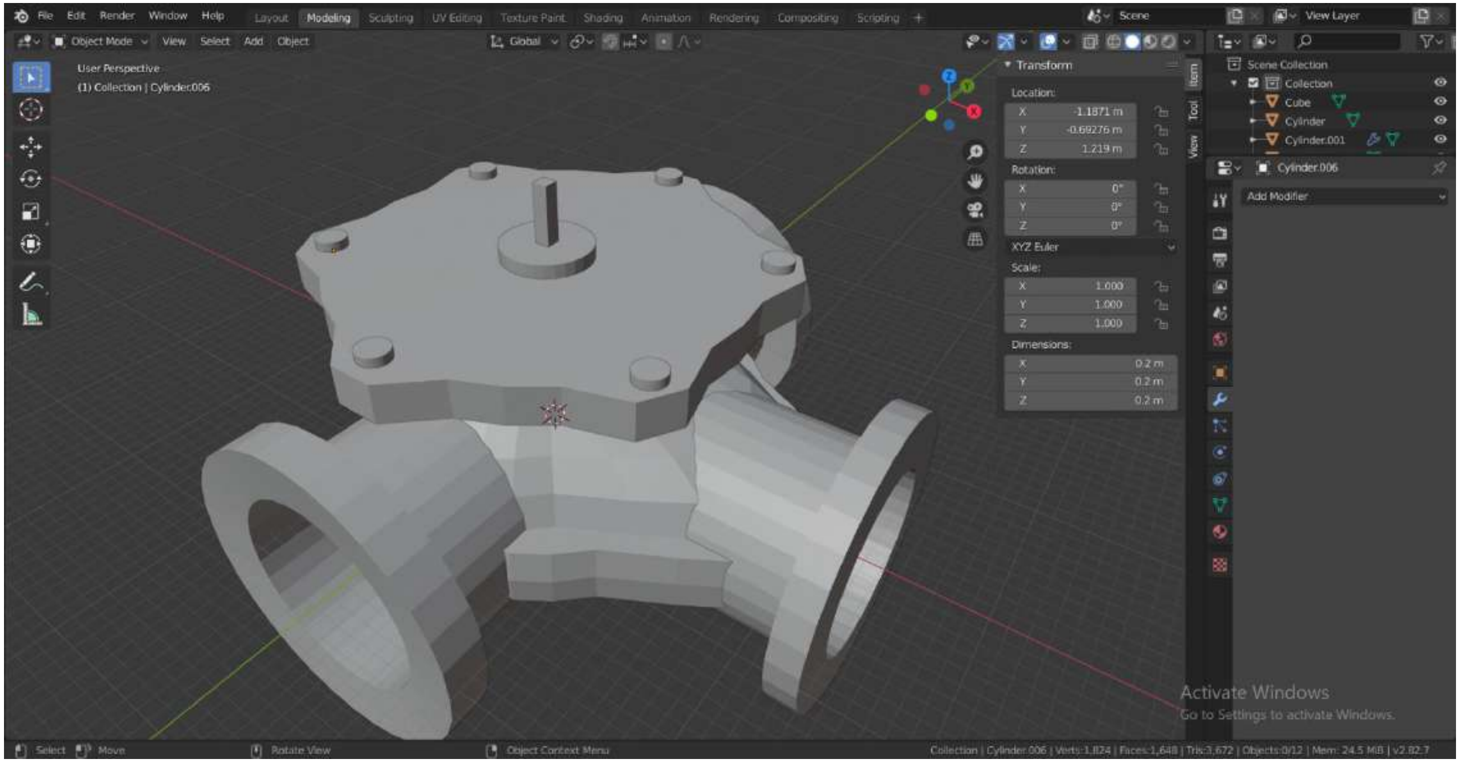
Tumey David M. BRAIN ACTUATED CONTROL OF AN E-COMMERCE APPLICATION [Online] // https://patents.justia.com. - January 11, 2018. - https://patents.justia.com/patent/20180204276.

Wittenberg G Assembly Automation [Journal]. - 1995. - Training with virtual reality.

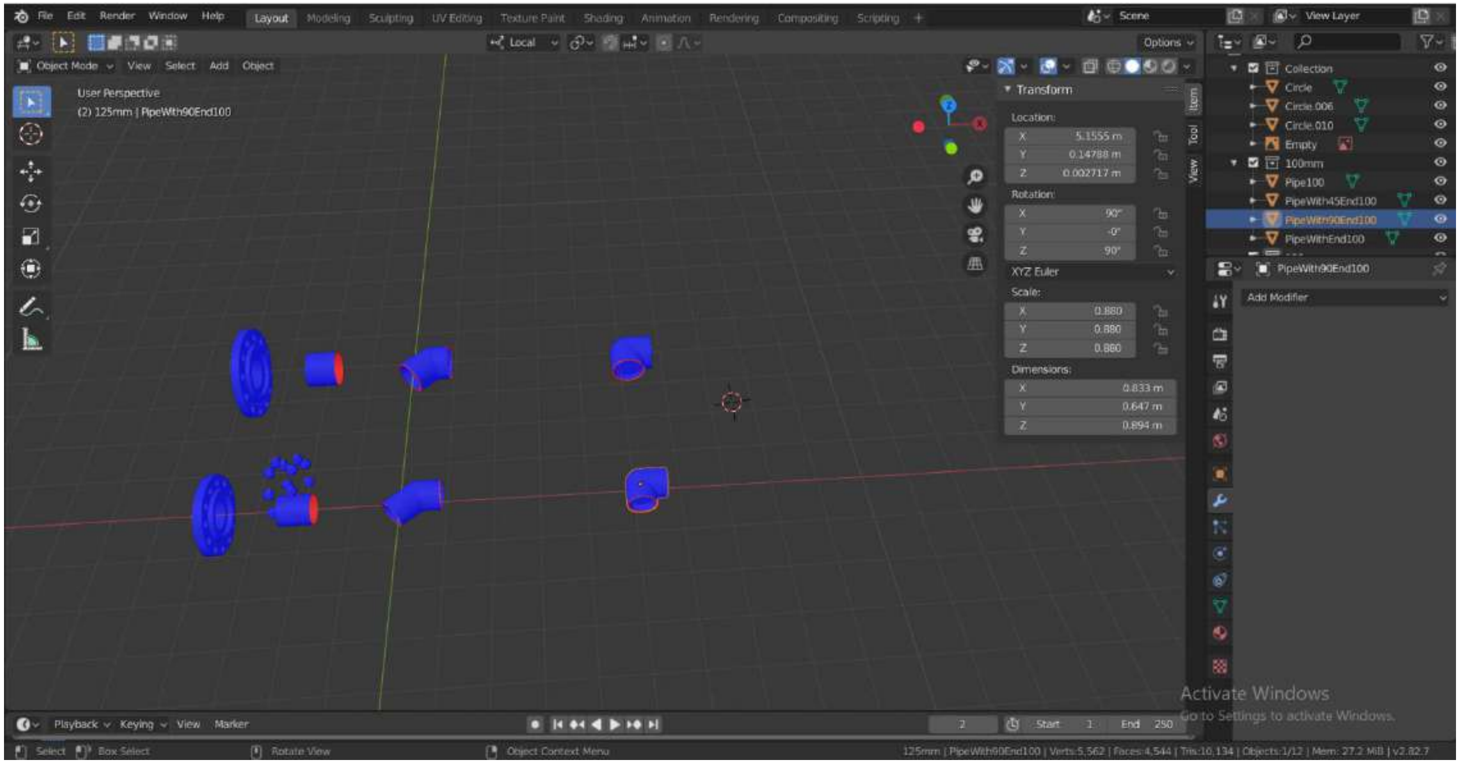
APPENDIX

"This page is intentionally left blank."

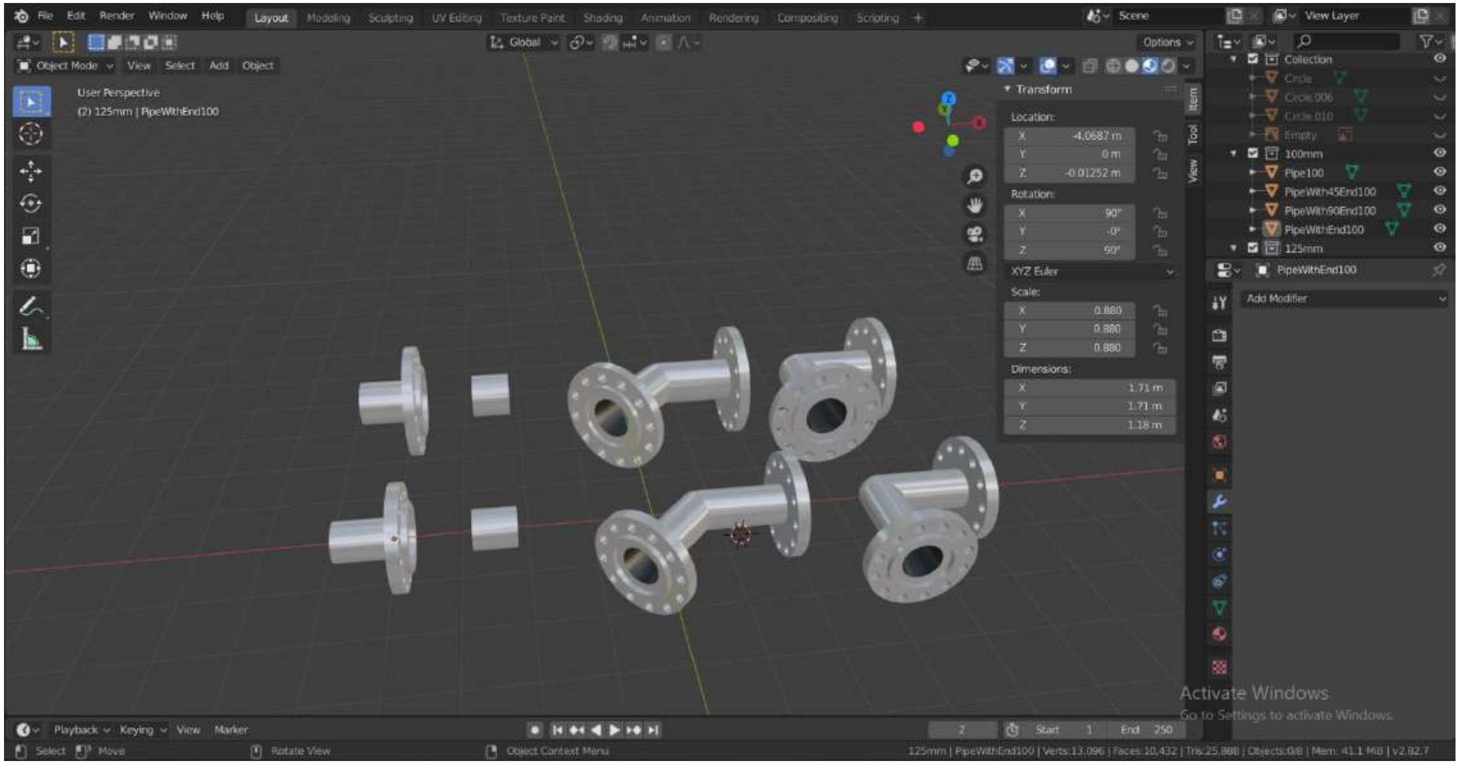
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



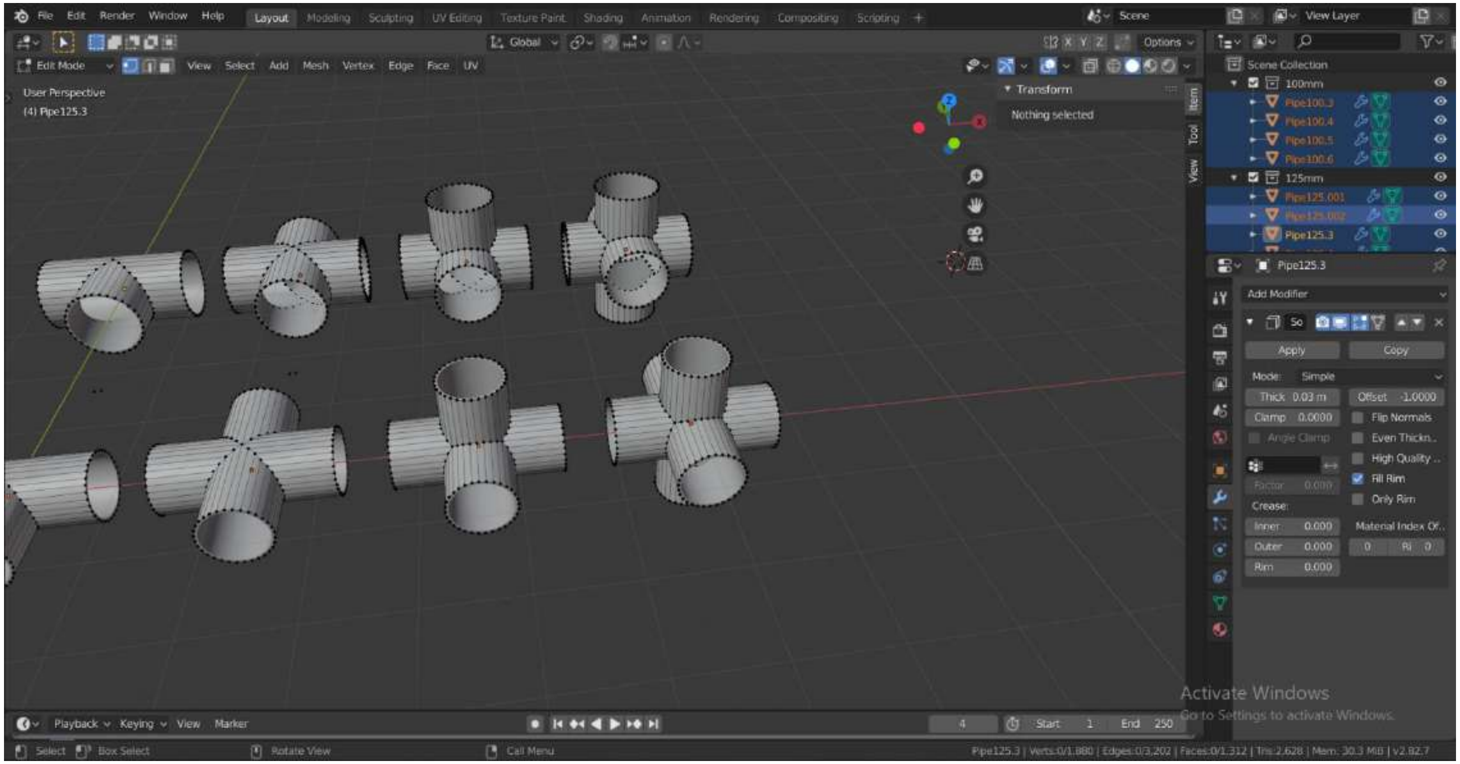
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



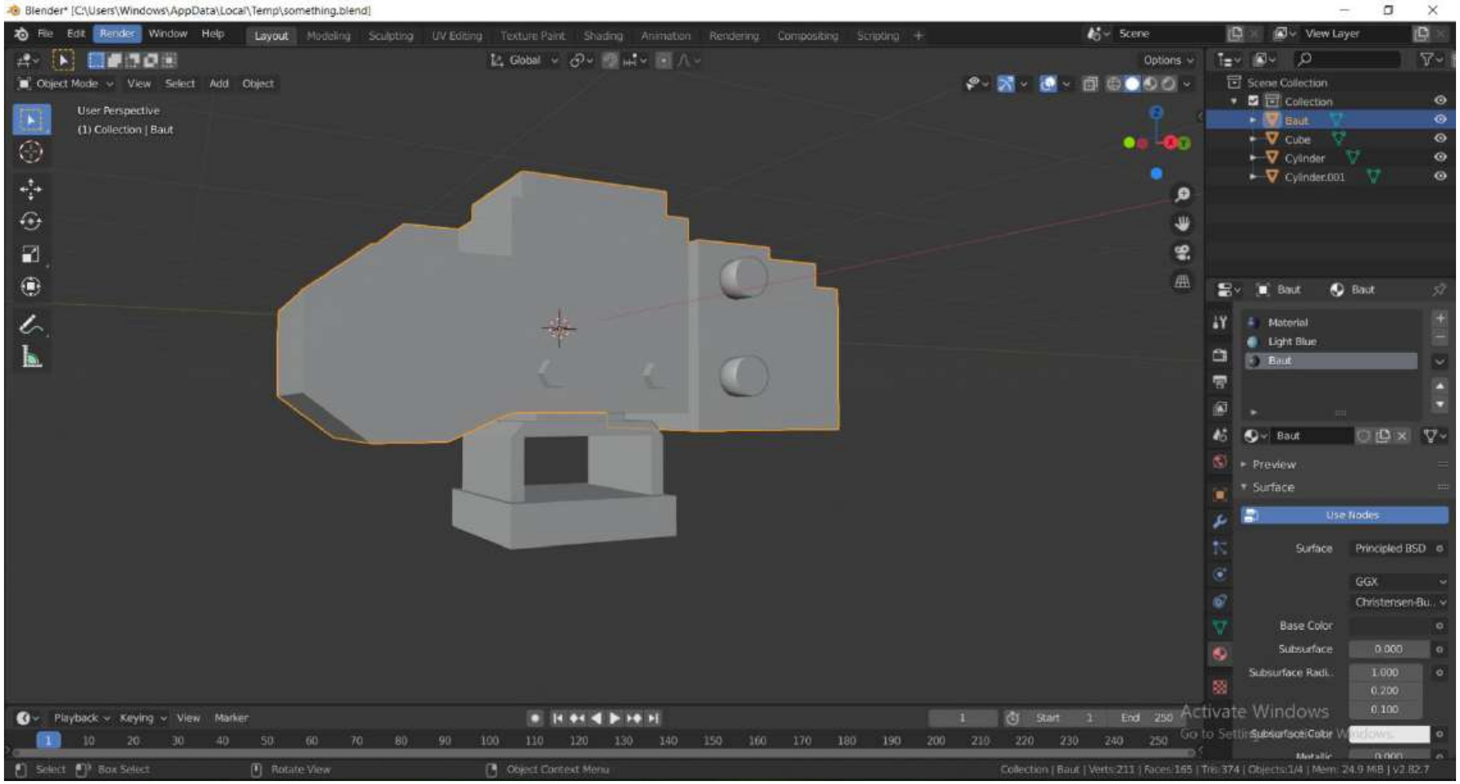
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



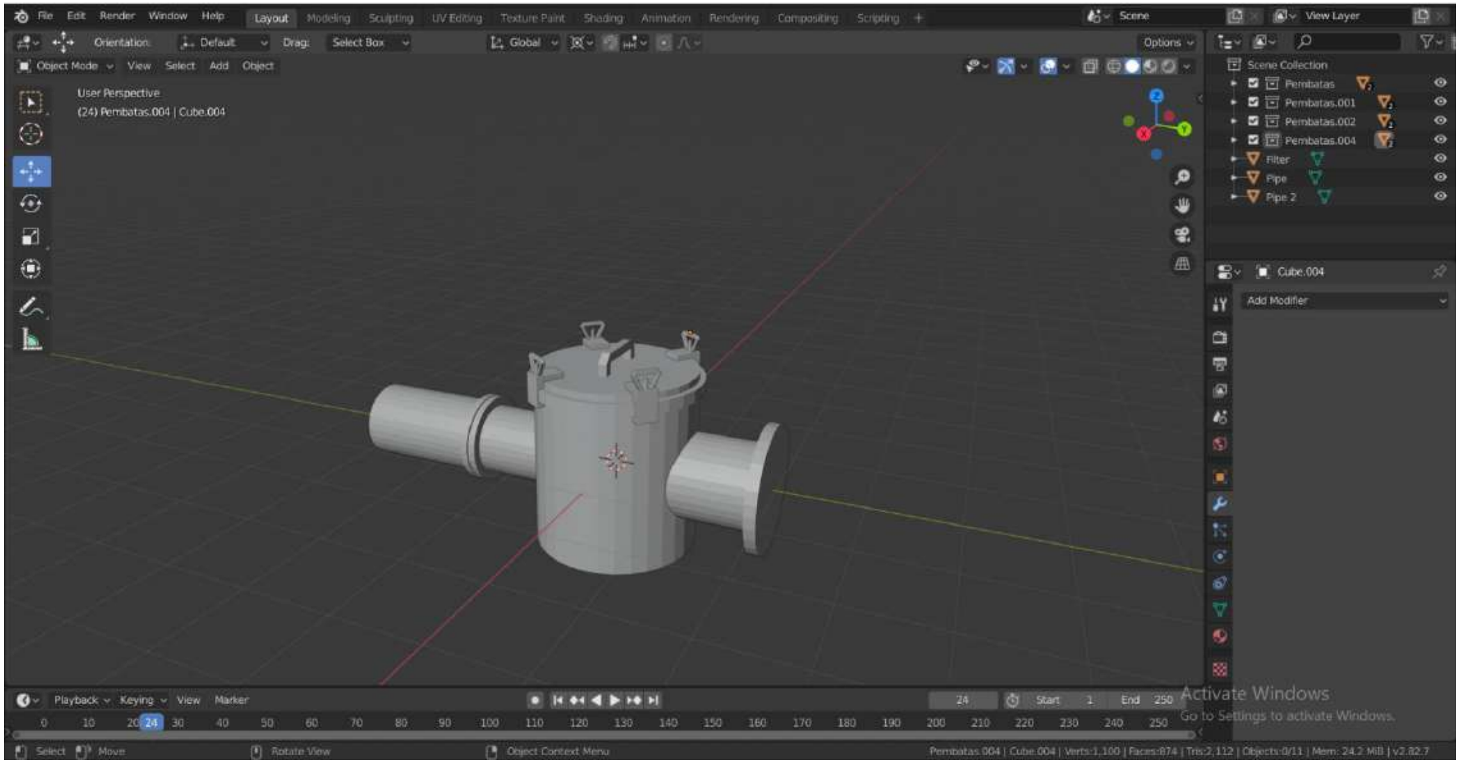
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



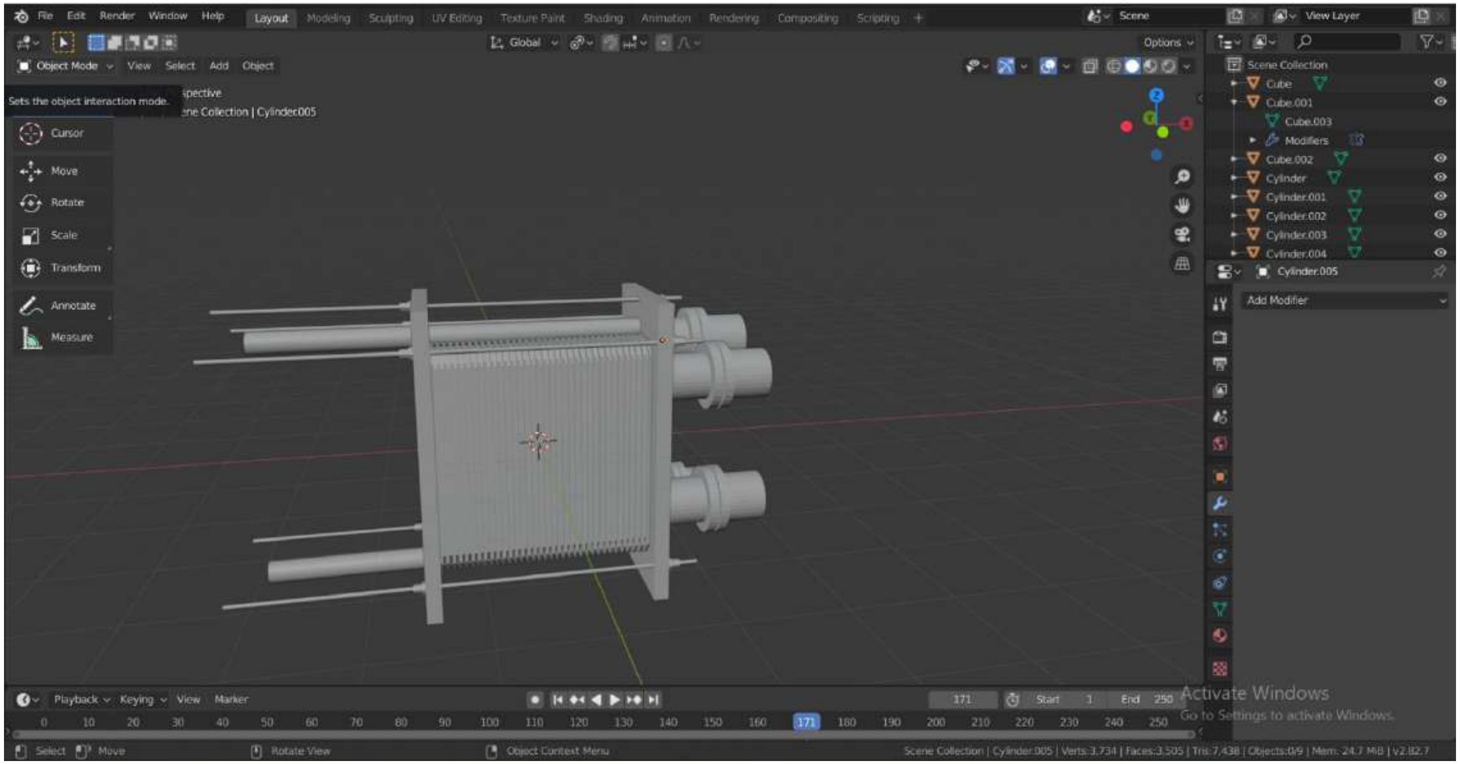
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



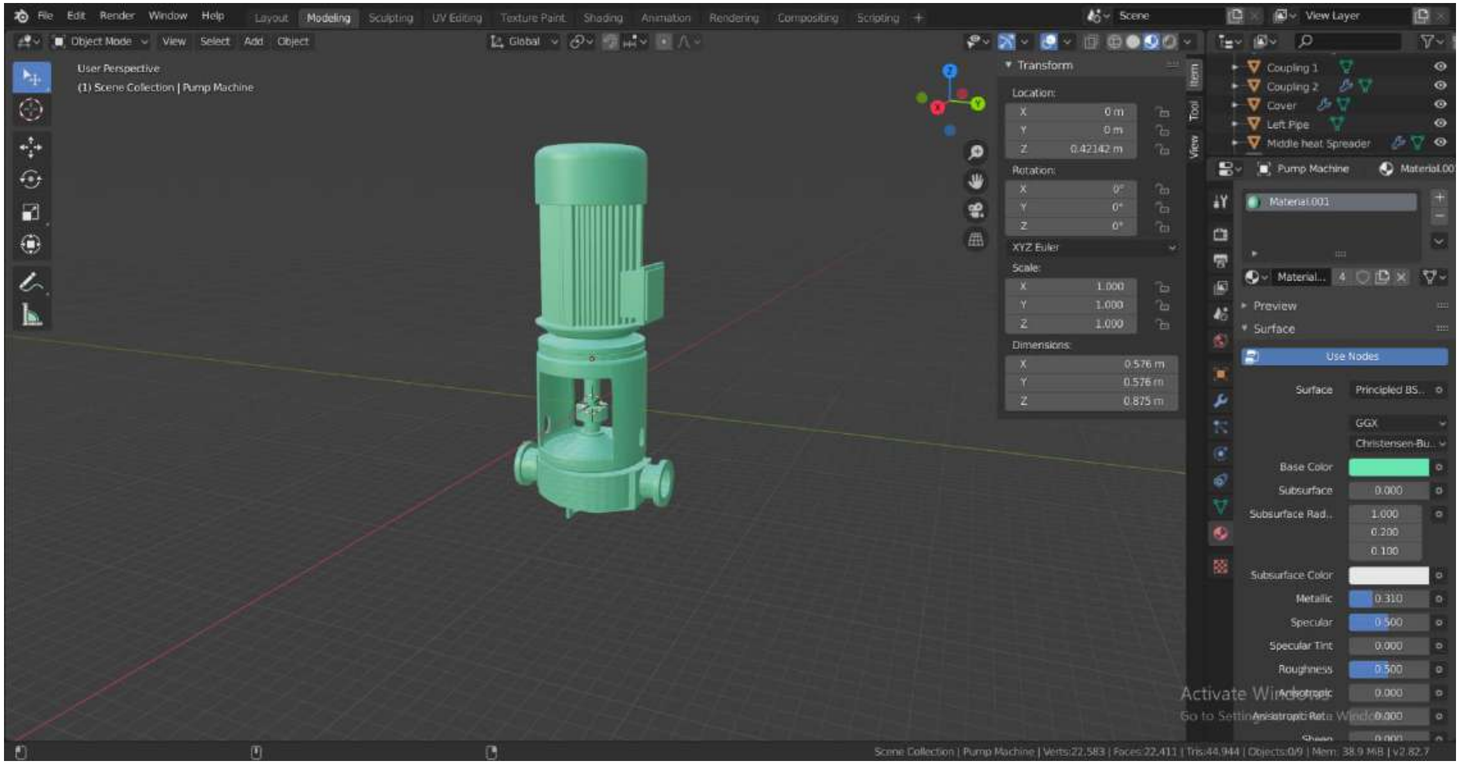
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



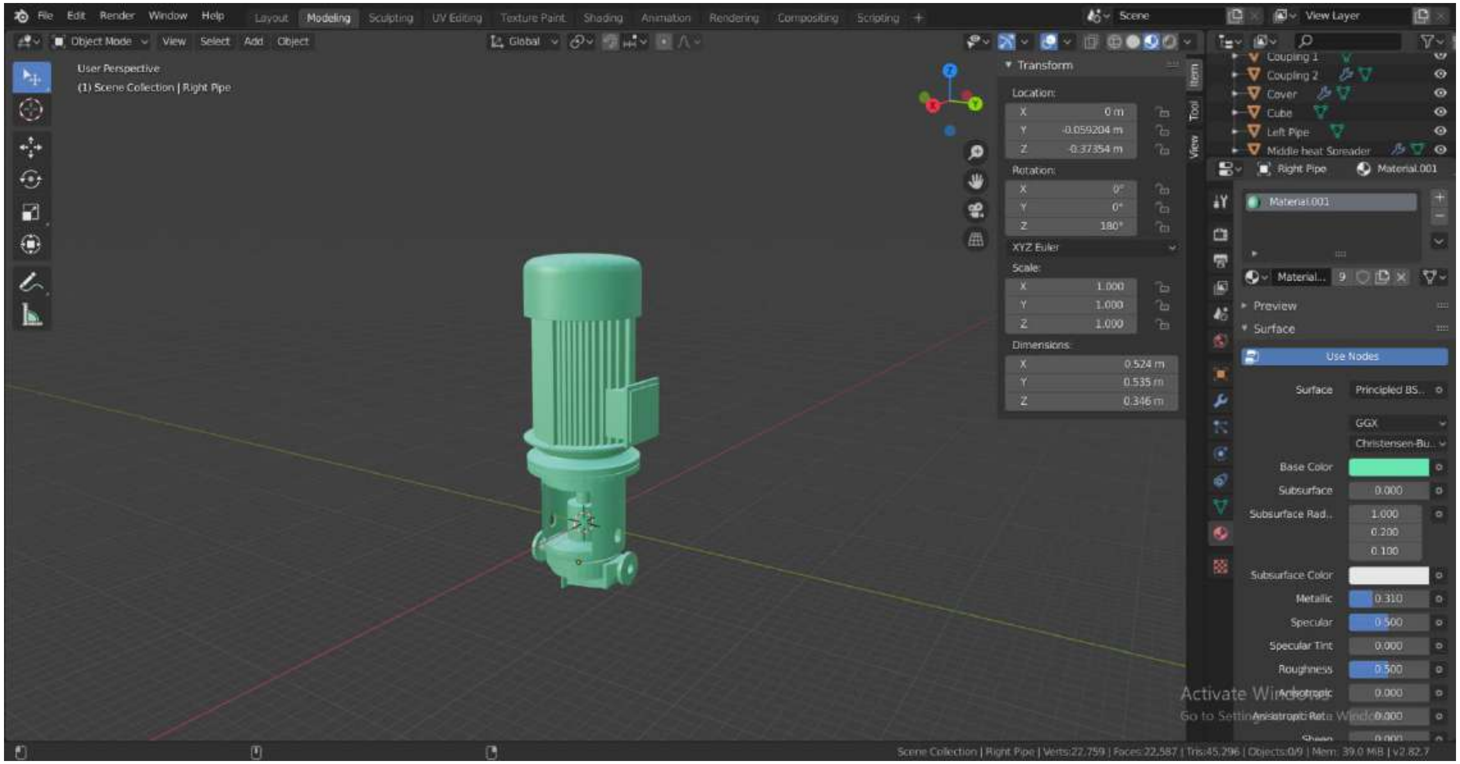
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



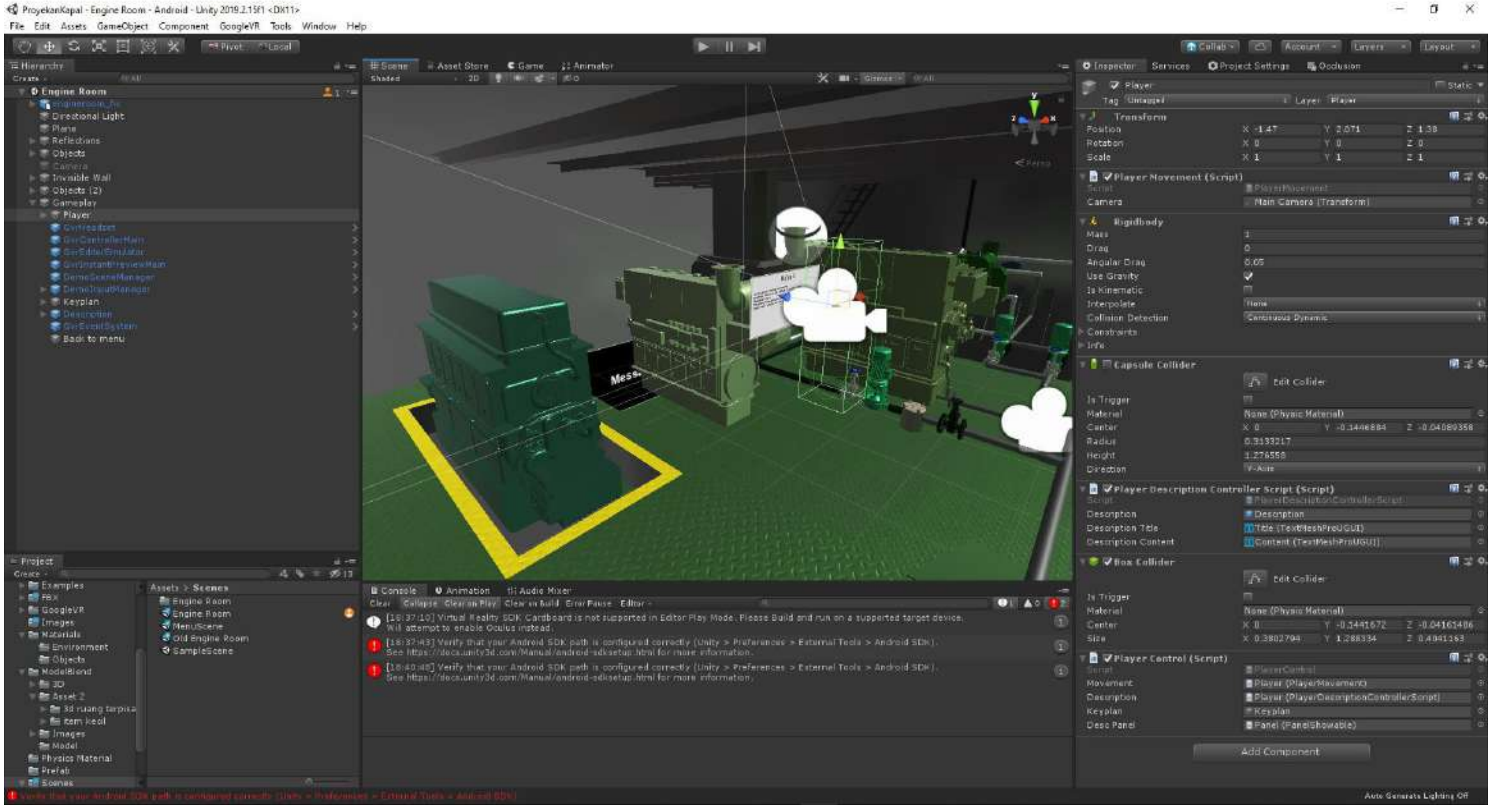
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



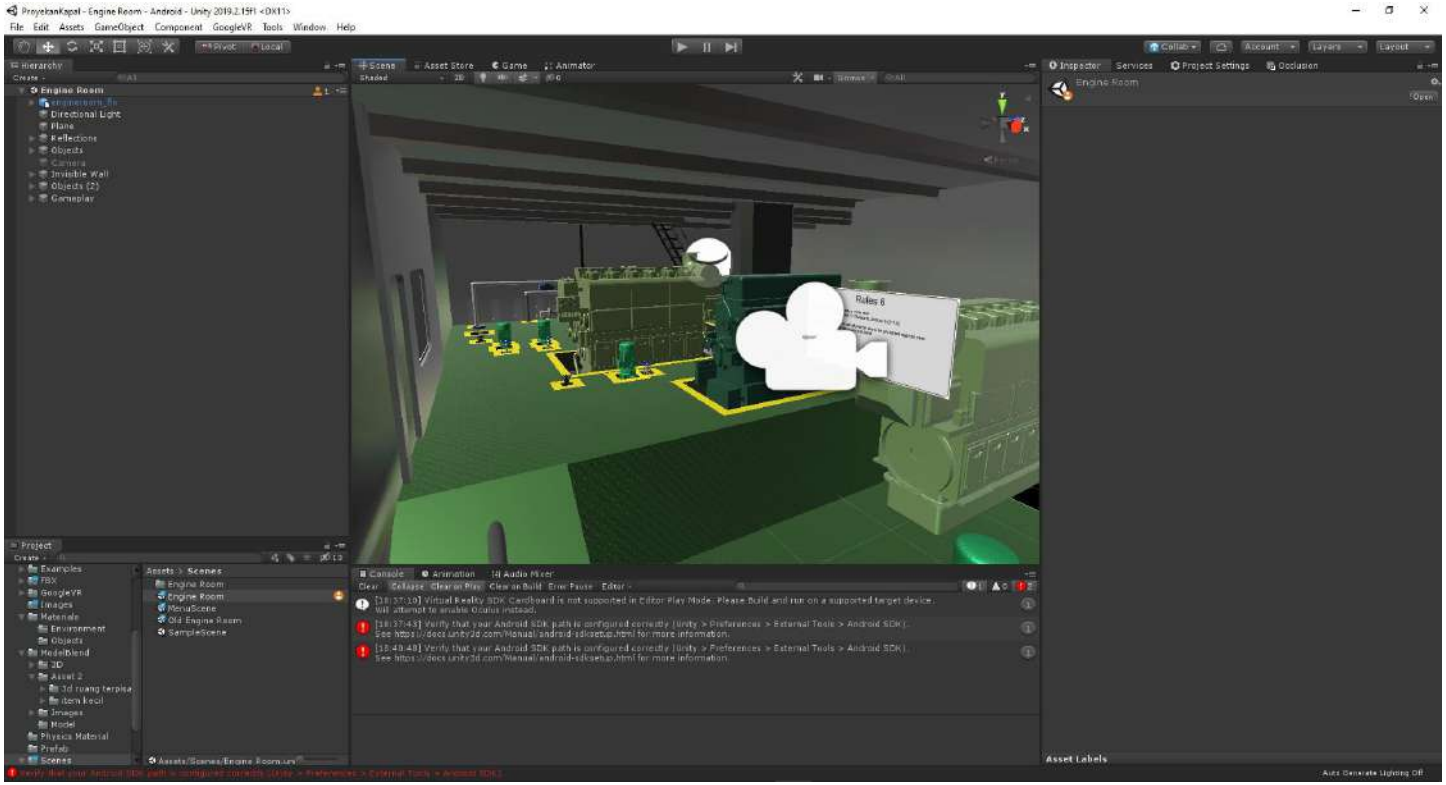
BLENDER APPLICATION FOR DESIGNING 3D OBJECT MODEL



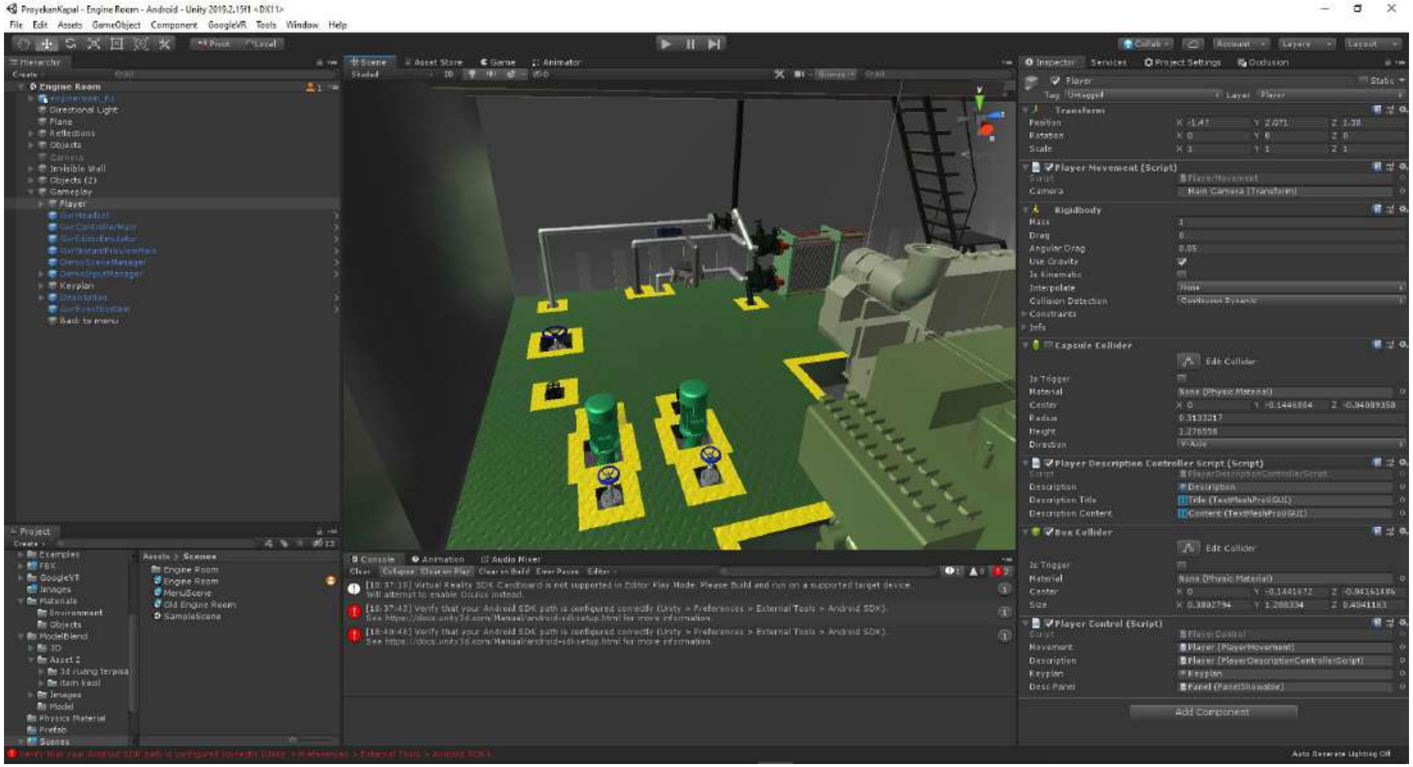
UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION



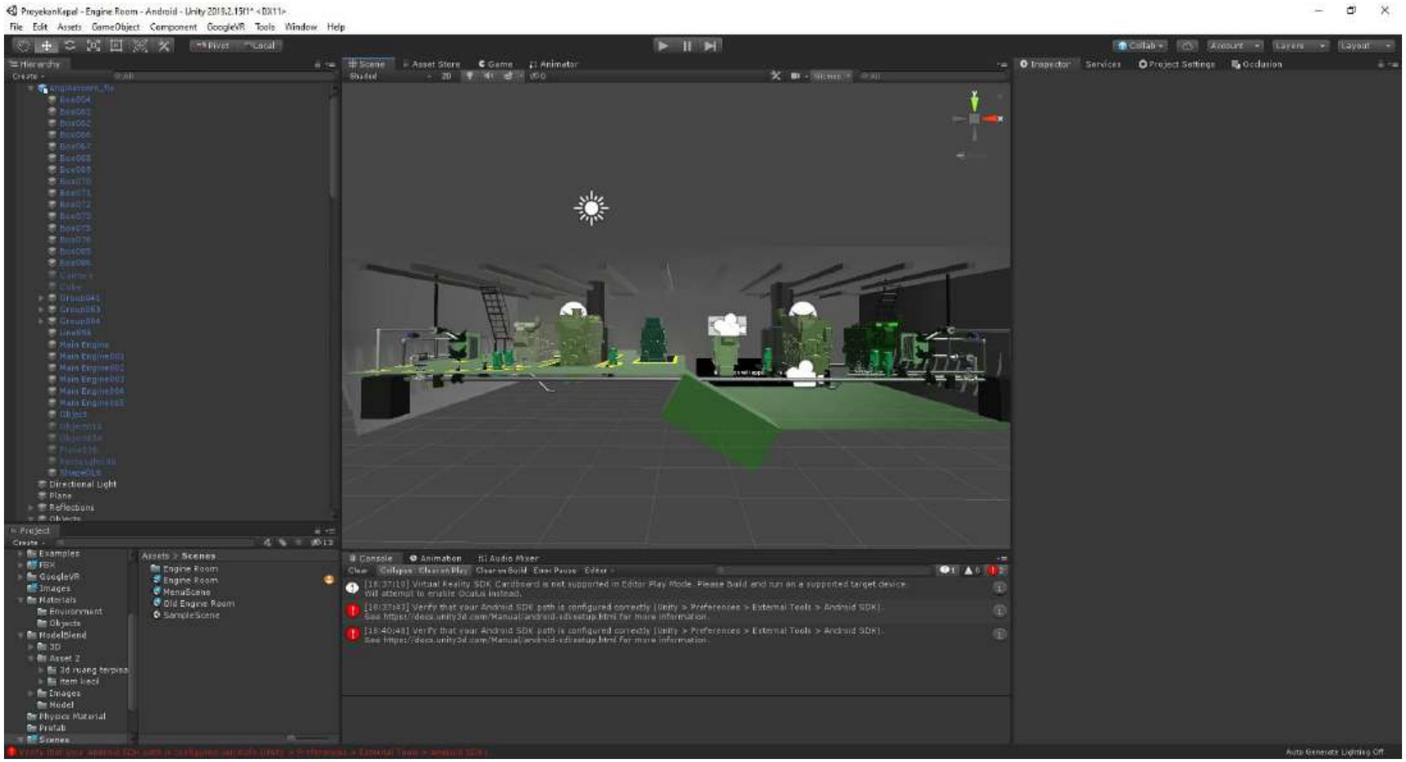
UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION



UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION

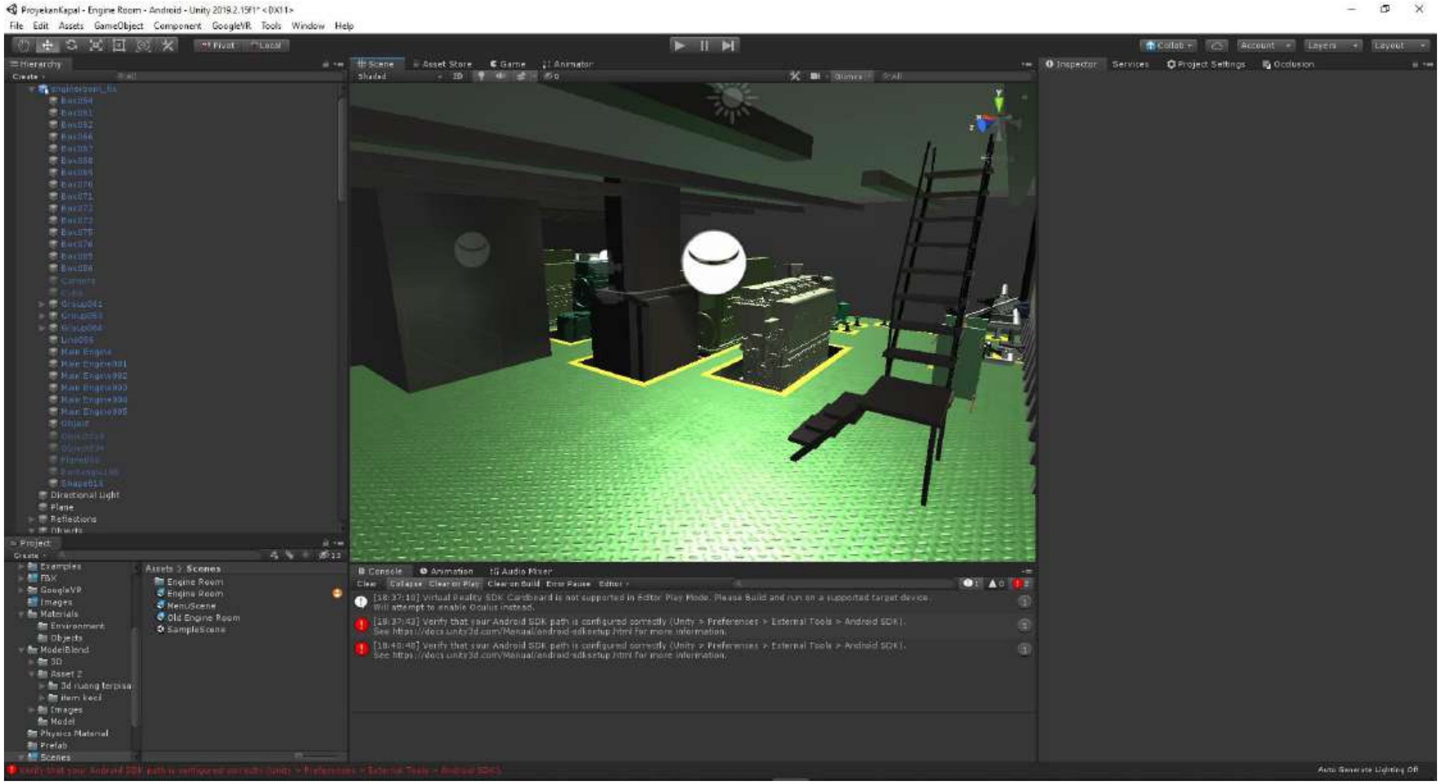


UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION

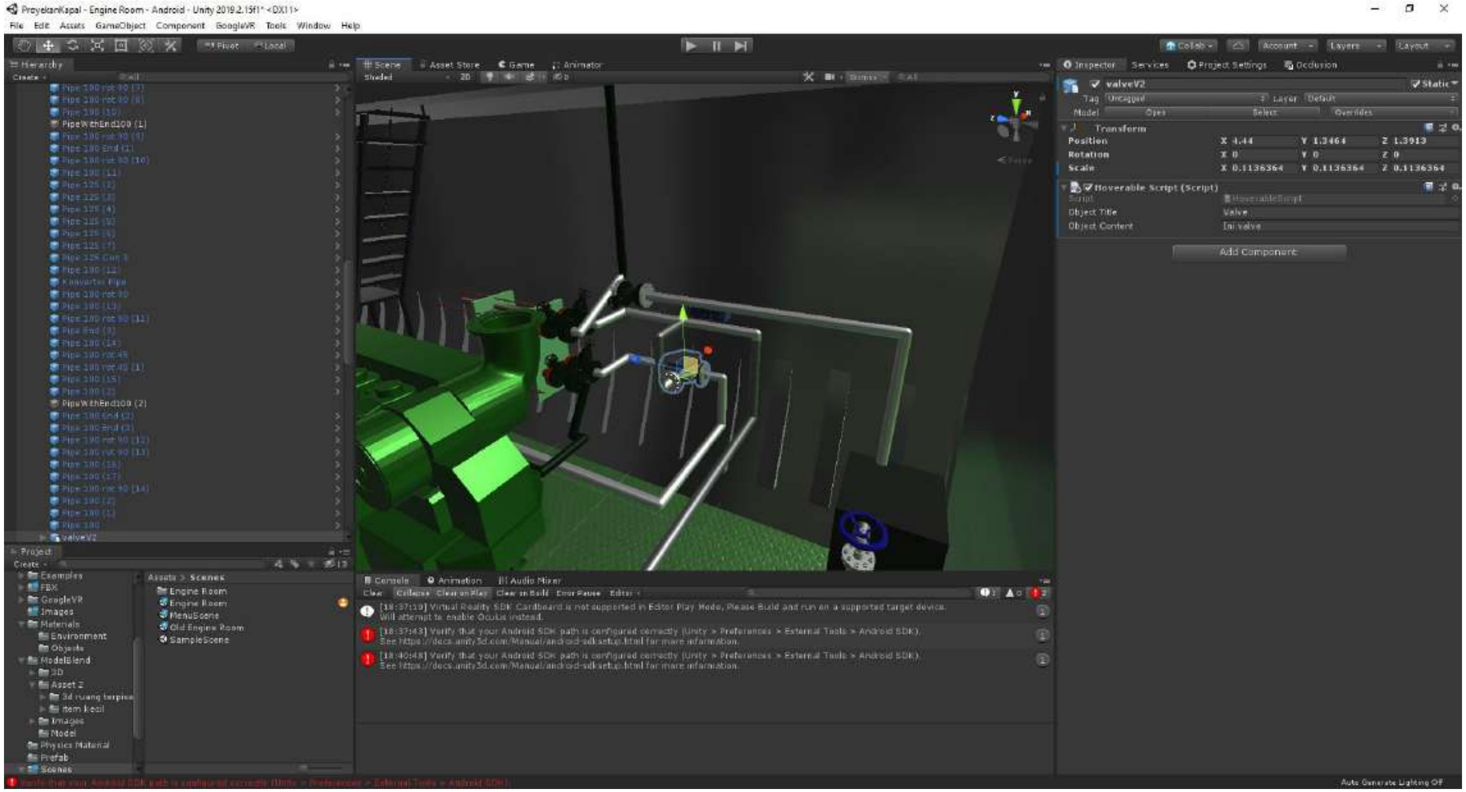


UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION

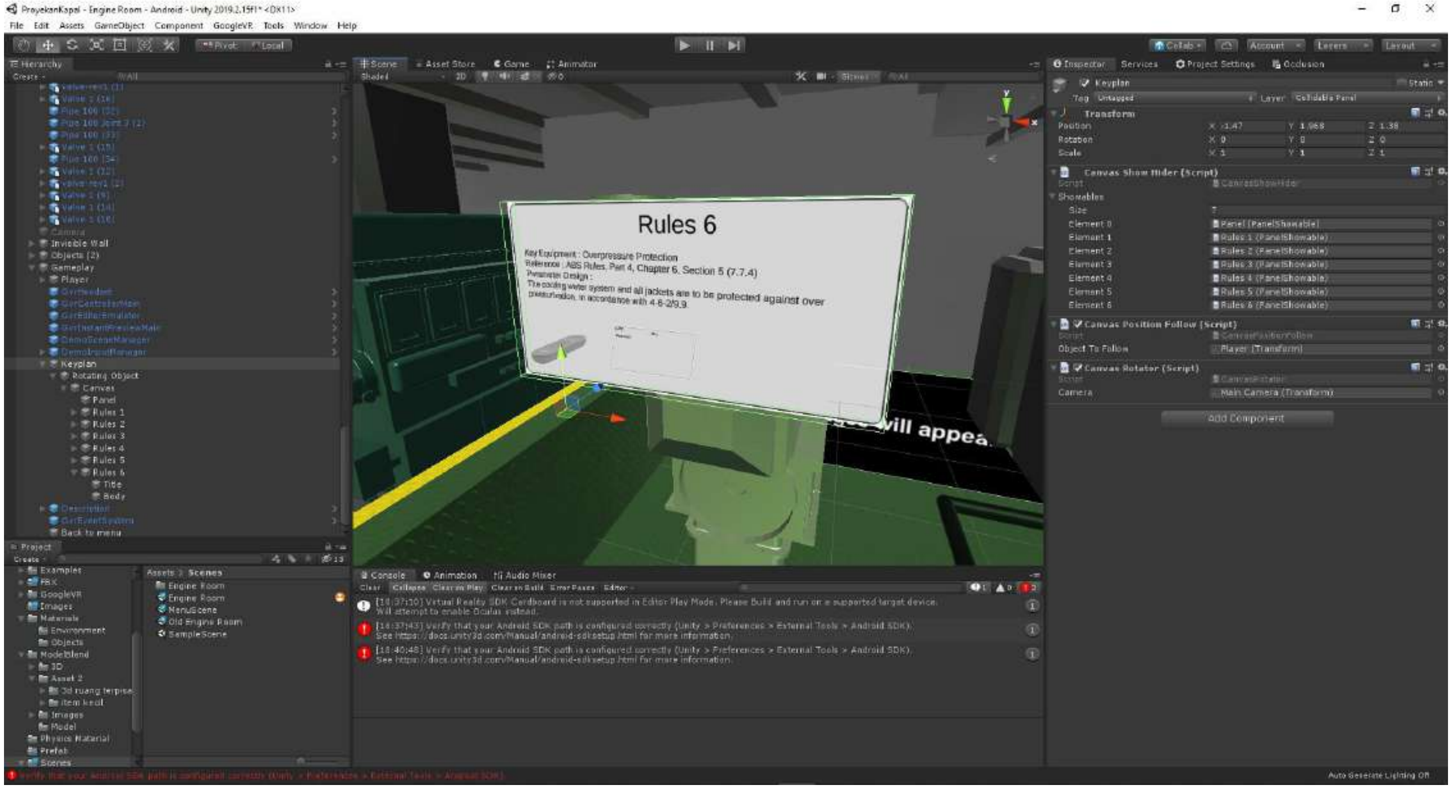
UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION



UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION



UNITY APPLICATION FOR CREATING VIRTUAL REALITY APPLICATION



"This page is intentionally left blank."

The author's name is Tito Satria Buwana, born on 19th October 1997 in Surabaya, Indonesia. Author is the oldest child from 3 siblings. Author is derived from a family with father named Dwi Sukartowo S.E.,M.M. and mother named Susanti S.E.. The author was raised in the Blitar citiy. The author had formal studies at SD Negeri Bendogerit 1 Blitar (2003-2009), SMP Negeri 1 Blitar (2009-2012), and SMA Negeri 1 Blitar (2012-2015). In 2016, the author went to Surabaya in order to continue the study at Department of Marine Engineering (Double Degree Program with Hochschule Wismar), Faculty of Marine Engineering, Institut Teknologi Sepuluh Nopember Surabaya specialized in Marine Operation and Maintenance. During the study period, the author did activities in campus and out campus organizations, e.g., UKAFO, Mahasiwa Teknik Sistem Perkapalan FTK ITS, and also as a member of MOM Laboratory of Marine Engineering. The author also has work experiences in two companies as engineering student intern e.g., PT. Yasa Wahana Tirta Samudera (2018) and PT. Pertamina Hulu Energi (2019). For further discussion and suggestion regarding to this research, the author can be reached through email stated as below.

Tito Satria Buwana
Tito.satria.b@gmail.com