UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE DEVELOPMENT OF FLUID EXTRACTOR IN DISMANTLING PROCESS FOR ELV

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical Technology and Engineering

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DEDICATION

I dedicate this to everyone who helped me during this project especially my parents and friends who had supported me from the beginning of the project.

ABSTRACT

Vehicle is one of the most important machines to humans. The vehicle will undergo a lifecycle from its production until it becomes unusable. After it had become unusable, it will be classified as End Life Vehicle where it will be recycled to be reused again the parts and materials in the vehicle. during the recycling of the vehicle, many steps and tools were used to make the recycling process easier. One of the tools is the Fluid Extractor. The current fluid extractor is used during the depolluting process and only been used by big companies due to its constrains in its design. To overcome this, new product needs to be developed in order to solve the rising problems with the current Fluid Extractor tool to make the depolluting process more efficient.

ABSTRAK

Kenderaan adalah salah satu mesin terpenting kepada manusia. Kenderaan itu akan menjalani kitaran hayat daripada pengeluarannya sehingga ia menjadi tidak boleh digunakan. Selepas ia tidak boleh digunakan, ia akan diklasifikasikan sebagai End Life Vehicle di mana ia akan dikitar semula untuk digunakan semula bahagian dan bahan di dalam kenderaan. semasa kitar semula kenderaan, banyak langkah dan alatan digunakan untuk memudahkan proses kitar semula. Salah satu alat ialah Pengekstrak Bendalir. Pengekstrak cecair semasa digunakan semasa proses pencemaran dan hanya digunakan oleh syarikat besar kerana kekangan dalam reka bentuknya. Untuk mengatasinya, produk baharu perlu dibangunkan untuk menyelesaikan masalah yang semakin meningkat dengan alat Pengekstrak Bendalir semasa untuk menjadikan proses penyahcemaran lebih cekap.

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ELV	-	End Life Vehicle

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Vehicles nowadays had become one of the most important tools in our daily life. Since the invention of the first automobile, the world had forever been thankful for this invention that makes previously cumbersome to travel distances become a daily routine in our lives especially with light vehicles such as cars and trucks. Other than help us to become mobile, vehicles also had unlocked new possibilities for humans to carry heavy load over a long distances. As many great things they had done, the vehicles eventually will fall into end of their service as the vehicles had become obsolete and categorised as End of Life Vehicle.

End Of Life Vehicle or ELV are vehicles that are no longer used or reached the end life cycle. When a vehicle had no longer a purpose to serve the user or involved in an accident that makes the car can't be fixed is the criteria of an end life vehicle. These vehicles are categorised as waste and pose a hazard to environment and human health. End life vehicle contains harmful chemicals in them such as lead and mercury. These chemicals can be accidentally released to the environment and contribute to air and soil pollution. The fluids in these vehicles also are poisonous to the human body and can be very harmful if it is contacted by the human body,

As for this reason, end of life vehicle must be disposed properly to minimize the waste that may be produced by these waste vehicles. currently, cars are one of the most attainable personal transportations to the most part of the world. The number of production of vehicles had steadily increased over the years, since the first mass-produced vehicle are manufactured during the 1940's as shown by the graph below(Rodrigue, 2020). This trend is concerning as the vehicles are being produce more and causes many vehicles to become unused and piling up in in the junkyard causing pollutions and waste of space to store them.

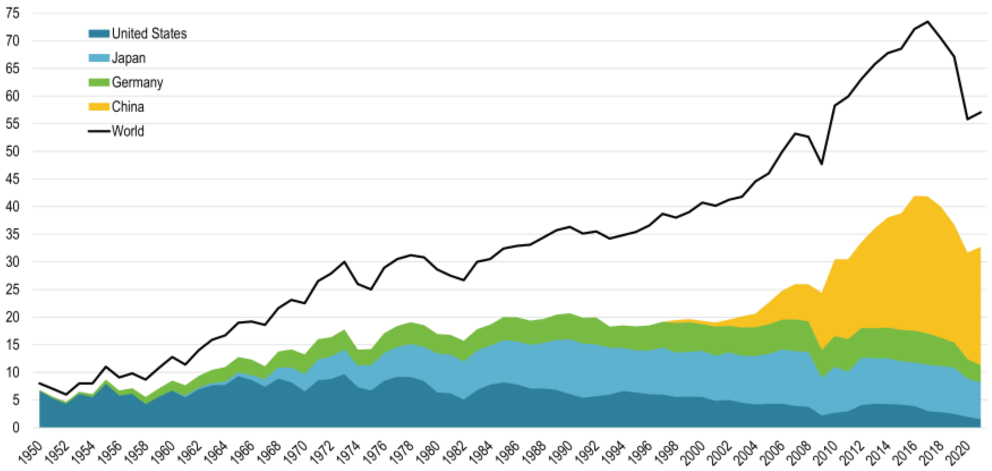


Figure 1.1 Number of Automobile Production 1940-2020

Source: (Rodrigue, 2020)

To combat these, some countries had taken measures to properly dispose these vehicles by many ways such as proposing a systematic system to recycle the vehicles, enforce laws around the practice of recycling end of life vehicle and develop tools that can be used to recycle these cars efficiently. The goal of this effort is to reduce the pollution caused by the end life vehicle and also reduce the wasted space that had taken to store these vehicles in the first place. Some countries also import end of life vehicle to their own country to reuse the parts in them and recycle the vehicles raw materials. These also reduces the burden of certain countries where end of life vehicle recycling process is less emphasized in their countries or lack of facilities to accommodate the recycling process.

The recycling process of ELV is a multi-stage process that requires dismantlers to properly disassemble the vehicle in order to thoroughly recycle the available materials inside the vehicle. To makes the process easier, some proprietary tools were developed to makes the dismantling process and the recycling process more efficient and easier to the dismantlers. With the usage of these tools, the recycling of ELV's will be safer and faster due to the help of the tools.

1.2 Problem Statement

End life vehicle undergoes multiple stages of process before the vehicle is recycled for their raw material and parts. One of the initial steps is the removal of fluids inside the vehicle such as engine oil, brake oil and transmission fluid. During this process, it is currently done manually by dripping all of the fluids into a drip pan to be stored.

This posed a problem as sometimes the fluid can be difficult to handle and causes some of the fluid to leak on the ground. The leaking of these fluids into the ground can make the ground become toxic and it may flow to underground water resources and may pollute them. Some of the fasteners used for the usual servicing of the fluids also can be cumbersome whether it is hard to remove or located in remote places in the vehicle. this also causes the recycling process of the vehicle less efficient and inconvenient to the person in charge. This factors also contributes to less companies willing to do the recycling of end-of-life vehicle and can further pollute the environment.

The current tool for this step is also not widely attainable as it is expensive and require proper garage to store them due to their design. This makes the use of the tool only widely used in the big dismantling companies and less used by the smaller ELV dismantling start-ups. These companies that don’t use the tool may cause the fluids to be released to the environment and causing pollution. The current tool also is less mobile due to their design mostly needed to be planted and this can reduce the efficiency of the process dismantling the vehicles.

1.3 Research Question

Based on the problem statement, three research questions can be founded which is:

a) What are the design parameters that the customer needs in fluid extractor in dismantling process of ELV.

b) How to propose and analyse the design parameters needed in fluid extractor.

c) How to develop the prototype of the fluid extractor.

1.4 Research Objective

The main objective of this research is to develop a device to properly extract fluids from ELV while the other objectives is as below:

a) To design and analyze fluids extractor tool in dismantling process of ELV

b) To develop the prototype of fluid extractor in dismantling process of ELV based on the analyzed design parameters

1.5 Scope of Research

The scope of research is as below:

a) Research the possible design for the technician to use during recycling process

b) Determine the container unit capacity to store the fluids

c) Do a survey for a possible vacuum pump unit.

d) Design a mobile overall machine to ease of use in the facility

1.6 Significance of the project

This project will reduce the inefficiency occurred during the extraction of the vehicle fluids and will reduce any spillage that may occurs during the recycling process and makes the fluids can be stored temporarily safely before sent to proper disposal facility.

The product also will reduce the fatigue to the technician to walk back and forth to dispose the waste fluids during the dismantling process.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Vehicle according to Cambridge Dictionary meaning a machine with wheels and an engine used for transporting people or goods. Vehicles such as cars plays a huge role in our daily lives as it is used widely in everyday life. Study by CEIC shows that almost 18 million vehicles are registered in Malaysia alone in the year of 2021(CEIC Data, 2021). This huge number of ownerships means that newer vehicle was registered and some of them are replacing the old vehicle of the individual. This rising number of vehicles raises concern due to the sustainability issue it would cause. One of the issues is when a vehicle is considered and End Life Vehicle – ELV. ELV is a deregistered car that will undergoes recycling process in order to reuse the material founded in a vehicle. ELV vehicles that are not recycled posed a few harms to the society and environment which is the chemicals may leak into the environment and causes severe pollution issue due to the poisonous chemical found in the fluids in the ELV. Other than that, unrecycled ELV also takes up space that can make storing them more costly and makes the use of space is not maximized. The effort of recycling ELV vehicle had been imposed for a long time overseas. One of the earliest is from Europe at the year 2000 with the introduction of The Directive on End-Of-Life Vehicle. This directive aims on the reduction of waste arise from the ELV. The directive had covered most of the vehicle existed on the road including passenger cars, light commercial vehicles, buses, motorcycles and commercial vehicles. in other countries such as Japan, the Automobile Recycling Law are enacted at the year 2005 to promote the proper recycling of auto parts.

In the law, it also stipulates the role of automotive manufacturers and related entities in the recycling of auto parts. In Malaysia however, there is currently no government-imposed law about the ELV recycling process. The recycling system of the ELV also are drafted in order to make the ELV recycling process more efficient and environmentally friendly. The general flow of recycling an ELV start with the dismantling process where dangerous fluids such as battery fluid, mechanical oils and refrigerant are extracted first from car to remove the presence of hazardous fluids in the vehicle. The process then continues with the collection of recyclable material such as engine and tires. The empty ELV is then send to the shredder to shred the scrap metal left from the vehicle in order to recycle them to be reused again.(Dissemination of IT for the Promotion of Materials Science (DoITPoMS) & University of Cambridge, n.d.)

2.2 End Life Vehicle

2.2.1 Definition, Concept and Philosophy

End Life Vehicle is vehicle that is out of use and to be discarded and recycled. A vehicle that is no longer been used and wanted to be discarded by the owner is the example of an End Life Vehicle. A vehicle also considered an ELV when the vehicle is damaged by accidents such as natural disaster and road accidents. The vehicles been considered an ELV as it is no longer can be used due to mechanical failure, stripped, or wrecked.(Green Vehicle Disposal, 2023)

The end-of-life vehicle is a concept that classifies vehicles that had no longer had purpose to their owner. These vehicles are then needed to be recycled by reusing the parts from the vehicle and scrapping the residue metal to be made into a new product to improve the sustainability of the environment. This can greatly reduce the emissions to make these parts or materials and can also reduce the cost for existing vehicle maintenance by reusing the used parts from the ELV vehicles.

2.2.2 Objectives of End Life Vehicles

Objectives of the End Life Vehicle concept is to prevent and limit waste production from end life vehicles from their component and material. ELV concept aims on up to 75% of the material and parts from the ELV to be recycled (Environmental Protection Agency, 2017). End life vehicle concept also implies on improve the environmental sustainability automotive industry to further maintain the preservation of the environment with the recycling process and the implementation of manufacturers make the vehicle easily to be dismantled and recycled through sustainable design.

2.3 Significance of End Life Vehicle for sustainability development.

2.3.1 Environment

End life vehicle played a huge role in environmental sustainability as the main idea of the end life vehicle is the recycling process of material from vehicles. Most of the material from the vehicle are needed to be reused or recycled during the process. These materials are dismantled then collected from cars before being reused or recycled to be made into new product. This greatly increases the sustainability of unused vehicle as the material that had been recycled can be used back in vehicle production. These materials such as metals are damaging to the environment if not been recycled and the process of extracting the ores are producing a lot of carbon emission that released to the environment (Watts Jonathan, 2019). With the recycling of the already used material, the industry also can rely less on mining new material and processing them that can greatly reduce the emissions produced. Other than that, the ELV also contains harmful substances and components that may harm the environment. The list of harmful chemicals and components are shown in the table below.(Molla et al., 2023)

Table 2.1 Harmful chemicals and its risks

Harmful chemicals / Components	Risk
Waste oil	Toxic and can contaminate water source and soil
Airbag	Can cause injury if accidentally detonated
Battery	Battery water contains acid that can corrode object and causes irritation if in contact with skin
Waste fuel	Can seep into the ground and contaminate the soil, Flammable
Air conditioning refrigerant	Causes greenhouse effect and thinning of ozone layer

2.3.2 Economic

Recycling of the end life vehicle greatly reduce the cost of manufacturing new vehicles. The materials such as metal didn’t need to be extracted and refined tin order to be used in the industry, and can reduce the cost of operation of manufacturers on building new vehicles. recycled material also needs less refinement from raw material and can cut the material processing time to make the process more efficient and cheaper to produce. The material that is commonly recycled from ELV’s are ferrous metal as it makes up the majority of the vehicle material. The figure below shows the breakdown of the materials from a car by its weight. Other than benefiting the manufacturers, it also can benefits to the owners of the vehicle that is almost classified as ELV. These vehicles still needed to be serviced and maintained so that it is not polluting the environment and can be function properly. By recycling the vehicle, not only the owner can get some compensation from their act, but also cut costs on the act of maintain the vehicle. Other than that, it also can remove the old unsafe cars from the roads of a country and reduces the number of accidents due to poor vehicle condition. This can reduce the fatality rate of vehicles accident that resulted in huge cost savings to the society and to the responsible bodies from the government as less cost is needed to repair the damaged infrastructure on the road due to the accident.

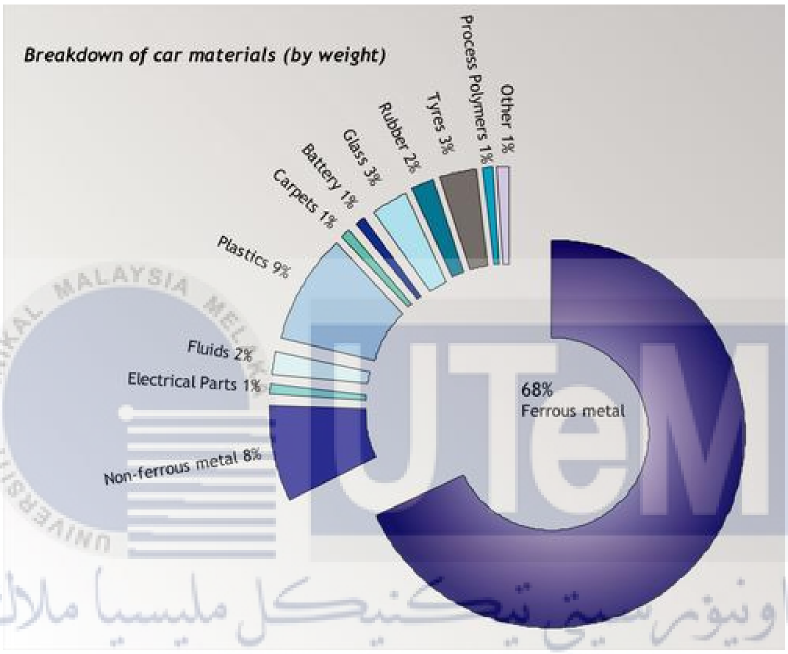


Figure 2.1 Material from a car

Source: (Dissemination of IT for the Promotion of Materials Science (DoITPoMS) & University of Cambridge, n.d.)

2.3.3 Social

ELV is a concept that heavily leaned towards the act of recycling, and the act itself is a very responsible act towards the society(Sitinjak et al., 2022). By recycling ELV's, it is benefiting to the society as it can minimize the pollution caused by ELV. By doing this, not only it will improve the environmental pollution that is steadily increasing, but also can make the society live in a safer and pollution free environment. Recycling ELV's also frees up the space used by the vehicles(www.scrapoto.com, n.d.) and the freed-up space can be used for other developments that can greatly benefits the society to make them more competent and can live an easier everyday life.

2.4 End life vehicle recycling system

ELV recycling is an extensive act that requires many steps and tools in order to correctly recycle them. Some countries had implemented guidelines for recycling ELV to make sure the recycling process does not release harmful chemical to the environment. In order to achieve this, some recyclers in their respective countries had implement systems to clearly state the steps needed in order to recycle the vehicle and also to make the recycling process more efficient and streamlined. Due to the regulations, each countries had similar steps to recycle the ELV but some requires further detail in some steps to properly remove and dispose the chemicals and efficiently recycle the waste materials.

2.4.1 Recycling system in Europe

Europe's ELV vehicle in the year 2014 alone reported around 6.15 million vehicles registered as ELV. This number is only the amount of ELV in the European union alone and not even the whole Europe. The figure below shows the number of reported ELV in Europe at year 2014.

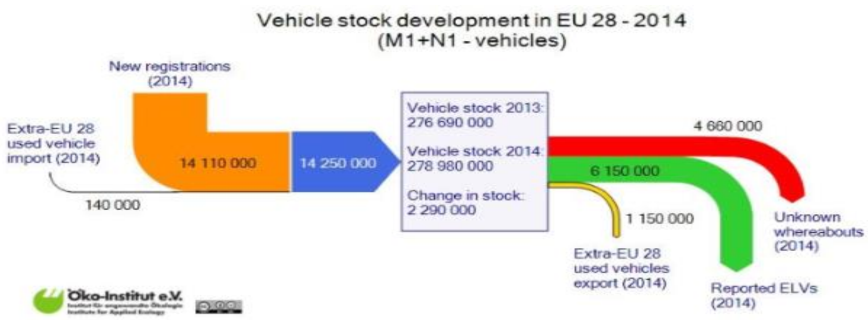


Figure 2.2 Reported ELV in Europe 2014

Source: (Baron, 2017)

EU-Directive 2000/53/EC on ELV states that state members must establish collection system from the waste of the vehicle and state members also needed to meet the target of "reuse and recovery" and "reuse and recycling" of 95% and 85% percenet respectively by 2015. Due to the stringent EU legislation, the companies who takes part in the ELV recycling were responsible for setting up a system for the collection and treatment of ELV. The processing system of the ELV were divided into several substages to further remove the components that can be reused recycled or recovered. The system drafted is schematically shown as below.

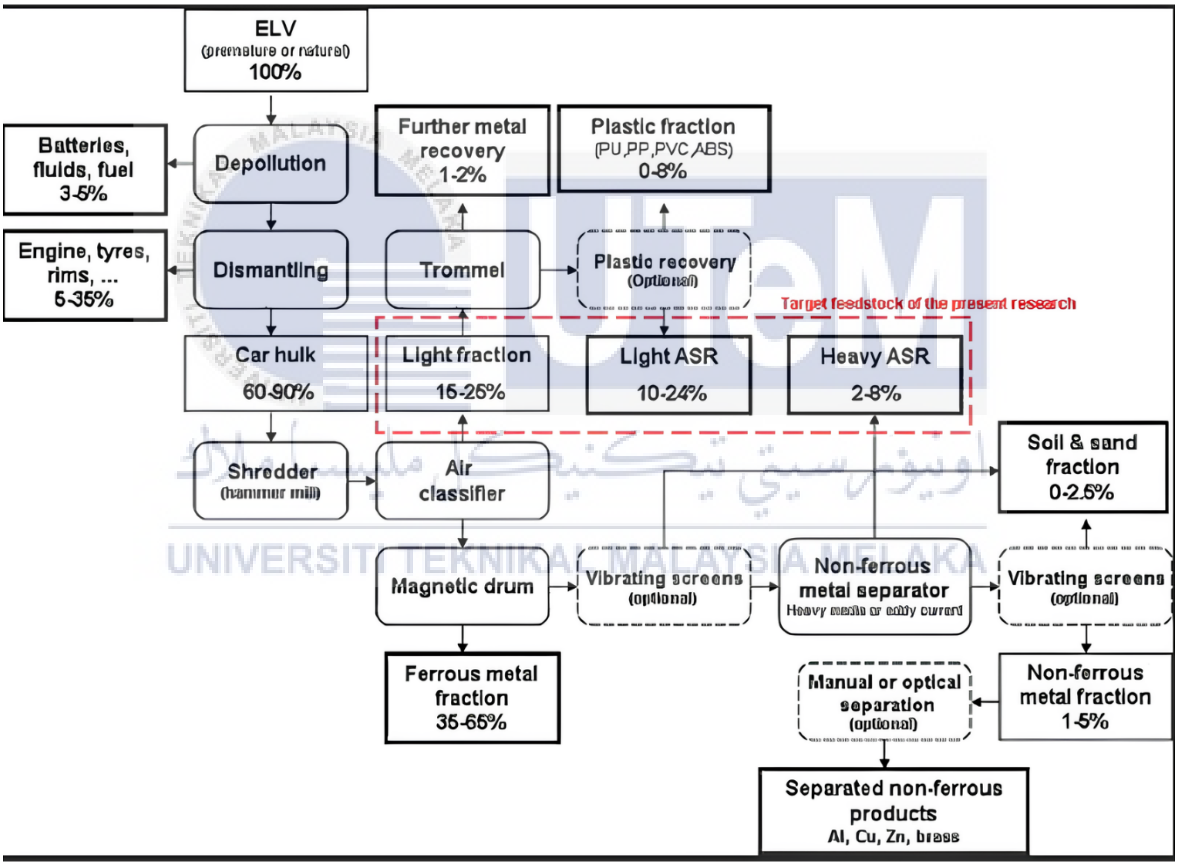


Figure 2.3ELV recycling system in Europe

Source: (Vermeulen et al., 2011)

The ELV firstly are depolluted by removing the harmful fluids found in the vehicle such as coolant, engine oil, battery fluid and fuel. This step is crucial in recycling ELV because it make sure the vehicle is free from hazardous chemicals so that the recycling process is less harmful to the environment and technician. After that, the vehicle is then dismantled. During this process, the vehicle parts that can be used is reused to be sell as parts or being recycled to form a new part. some of the parts that can be recycled are the tires, catalytic converters and bumpers. The number of parts dismantled depends on the condition of the vehicle and the labour needed to dismantle the parts and also the age of the vehicle. All left after the processes is the car hulk that is send to the shredder to shred the metal parts left from the vehicle. The shredder parts are then processed to separate the pure metal parts and non-metal parts before being classified as pure metal or non-metal used material.

2.4.2 Recycling system in Japan

As land resources is a scarce in Japan, the materials are needed to be recycled in order to maintain the useable materials in the country. Other than that, land space is also limited due to the geography of Japan itself(Zhao & Chen, 2011), thus increasing the price of landfills and reducing the size of new landfills to be open. Due to this, illegal dumping of ELV vehicle and inappropriate storage had risen. Thus, ELV recycling law was legislated to combat this in the year 2005(Kiyoshi Koshiba, 2006). This law stipulates the responsibilities of manufacturers, vehicle owners and vehicle processors and also create a proper recycling system to maximise the use or their resources. The Japanese ELV recycling system is shown below.

In Japan

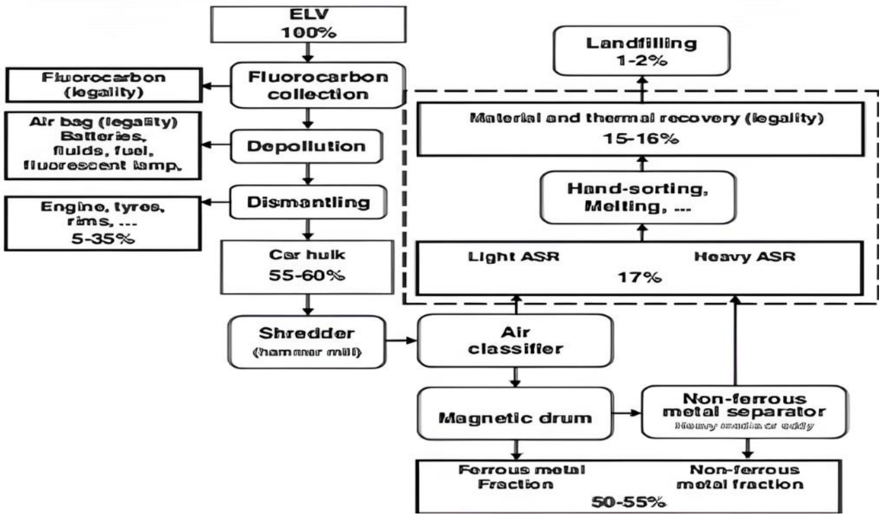


Figure 2.4 Japanese ELV recycling system

Source: (Sakai et al., 2014)

The system in Japan roughly the same as in the EU, with exception of the Fluorocarbon collection from the refrigerant is extracted first before the depollution process. The vehicle then is depolluted by removing the fluids and also the airbags before dismantled for reusing and recycling the parts from the vehicle. The difference here is that the car hulk is less thoroughly dismantled compared to the EU system due to the EU strict legislation. The car hulk is then sent to the shredder to be shredded before the shredded material are processed to extract the raw material form the vehicle.

2.4.3 Recycling System in Malaysia

In 2021 alone, almost 18 million vehicles are registered in Malaysia(CEIC Data, 2021) and were being estimated to keep increasing year after year. This will greatly impact the environment and needed solution to reduce the harm of these vehicles. thus, a proper recycling system is needed in this country to efficiently recycle the ELV’s in Malaysia.

Currently, ELV law in Malaysia currently has not been legislated by the government. But some manufacturer such as Proton is currently involved the ELV concept in response from the EU legislation that makes them changes the manufacturing and designing aspect of the vehicle to make the vehicle easier to recycle. Legislation on ELV had been proposed before in 2009, but later was withdrawn due to fierce rejection by the public. The legislation itself was done without proper research and has many loose ends that makes the public rejected them. In addition, Malaysia's GDP also is lower than in Japan or EU that makes the citizens here still uses old vehicles upward of 10 years old because of the high prices of the vehicles here. This lack of legislation results in low number of scrap rate in cars and high number of vehicle age active in Malaysia.(Azmi et al., 2010)

The recycling process of ELV in Malaysia also has not been drafted like in the EU or Japan. ELV recycling currently being done by small companies under Malaysia Automotive Recyclers Association (MAARA). They operate like normal workshops, and without a proper legislation makes the recycling process less environmental friendly as some chemicals may be released to the environment due to lack of enforcement. the system used currently to recycle ELV in Malaysia is as below.

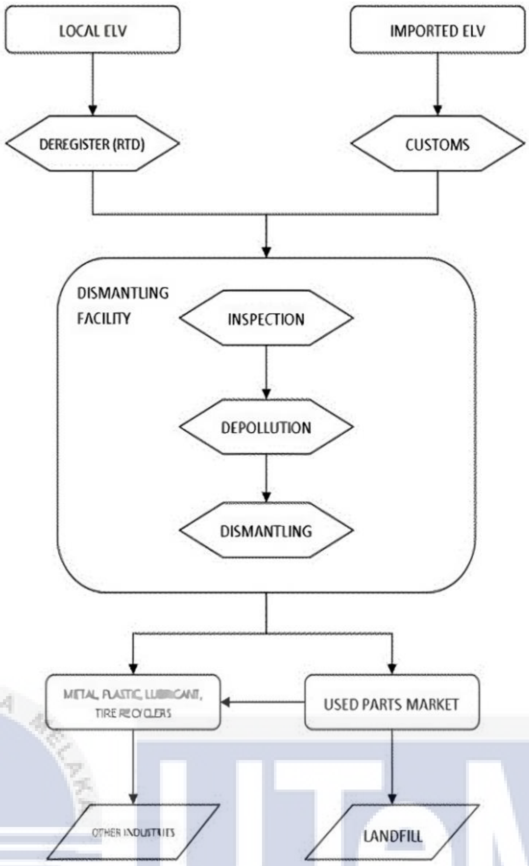


Figure 2.5Proposed Malaysian ELV recycling system

Source:(Azmi et al., 2010)

The recycling process of the ELV are done by small companies under the Malaysian Automotive Recyclers Association(Akram Khan et al., 2021). The workshop receives ELV's locally and imported to their shop. At their facility, the vehicle is first inspected and then depolluted before the dismantling job. This dismantling process does not clarify the final weight of the vehicle after dismantling before being sent to the landfill. In addition, the ELV also didn't shredded to further recycle the vehicle shell. The parts that can be used is sell as used parts and the rest is sent to the landfill.

2.5 Dismantling of ELV

2.5.1 Background of ELV dismantling

ELV dismantling is one of the steps in recycling the ELV. This step is the initial step in recycling ELV before sending it to the shredder. The dismantling process were systemically planned to efficiently remove the parts and recycling of materials with maintaining the safety of the technician during the process.

The dismantling process occurs after the acceptance of the vehicle and after being deregistered as shown in the figure below. The dismantling process is being done in different ways according to the region it is being dismantled in. In the EU, the vehicle is dismantled with using mechanised dismantling machine. In contrary, the Asian region still uses manual labour with the help of mechanical tools in order to dismantle the ELV. This trend is caused by the labour cost difference between these two regions.

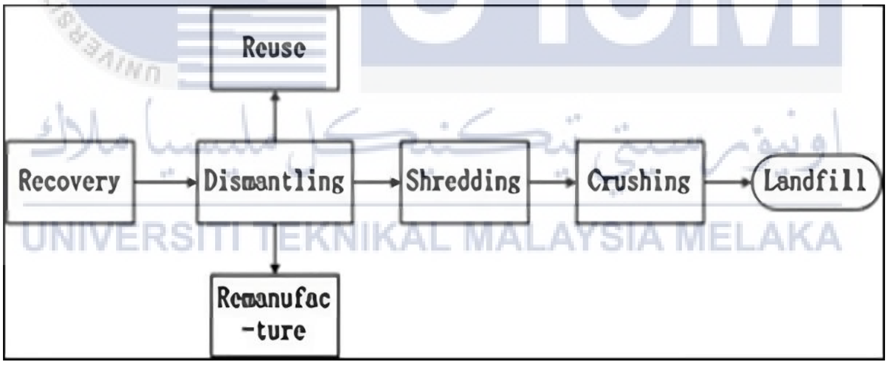


Figure 2.6General dismantling process

Source: (Tian & Chen, 2014)

But among all countries, the dismantling process in the United States is the most advanced with over 30 years of development in the ELV industry. In United states, these dismantled parts were remanufactured to be sold again and this has become one of the main profits of the ELV industry. During the dismantling process, mostly the parts that were dismantled were the parts that can be reused again in other vehicle as spareparts thus the logic behind the massive remanufacturing of the dismantled parts in the United States. In EU and Japan, the percentage of weight dismantled form the vehicle is different because of the stricter standard of the EU legislation. In Malaysia, the ELV imported to be dismantled here (Azmi et al., 2010) often become one of the sources of parts for the vehicles in this countries because many of the vehicle on the road are rebranded vehicles from other countries such as Japan. The parts dismantlers also had resorted to selling the parts because of the imported part's quality compared to locally available parts. Example of parts that are being reused after the dismantling are engines, wheels, compressors, water pump, body panels and steering wheels.

2.5.2 ELV Dismantling tool

The recycling of End life vehicle is a labour-intensive job as it is mostly done manually by individuals. In order to properly and efficiently dismantle the End life vehicle, tools are developed in order to increase the efficiency of the recycling process and indirectly reduce the labour costs of the workers in dismantling the vehicle. Currently, there are only a few specific tools to dismantle the end life vehicle. some of the tools needed in dismantling end life vehicle already been widely used such as hydraulic lifts and impact wrench. These tools are used to dismantle the vehicle after the detoxification process where the harmful chemicals are removed from the vehicle. After that, the vehicle is lifted to give easier access to the catalytic converter and to remove the wheels and tyres from the vehicle that uses hydraulic lift in order to lift the vehicle. Impact drill is also one of the most important tools in order to dismantle the vehicle as bolts is very common in a vehicle and using these pneumatic impact drill greatly reduces the time to dismantle the vehicle. Big recycling machine such as the vehicle scrapper compacted the vehicle to a smaller size to reduce the space taken by a vehicle. Some recycling plants also uses hydraulic press to further reduce the size of the vehicle. The compacted vehicle is then shredded by using a shredder machine to reuse the metal components in the vehicle(Kryaskov et al., 2015).

2.5.3 Tools used in ELV industry

Below are some of the tools used by the ELV industry in order to properly dismantle and recycle the ELV and the stage it was used with its function.

Tool	Name	Stage	Function
 (www.greencardepollution.com, n.d.-e)	Vehicle lift	Dismantling / Depolluting	Lift the vehicle in the air for easy dismantling
 (www.greencardepollution.com, n.d.-e)	Tyre Rim Punch	Dismantling	Separate the tyre from the rims of the vehicle
	Fuel extractor	Depolluting	Extract fuel from the vehicle and

 (www.greencardepollution.com, n.d.-c)			storing the fuel to avoid being ignited
 (www.greencardepollution.com, n.d.-b)	HVAC recovery unit	Depolluting	Safely recover and store refrigerant from the vehicle
 (www.greencardepollution.com, n.d.-a)	Airbag deployment unit	Depolluting	Safely detonate the airbag from a safe distance to safely remove it

 (Machinery Specialist, 2021)	Catalytic converter cutter	Dismantling	Efficiently remove the catalytic converter in vehicles to be recycled/reused
 (Kryaskov et al., 2015)	Vehicle manipulator	Dismantling	Used in Japanese ELV system to efficiently dismantle a vehicle to be recycled.
 (Wendt Corporation, 2024)	Vehicle shredder	Recycling	Used at the end of the dismantling cycle to shred the metals in vehicle to be recycled.

2.6 Multifluid Extractor

2.6.1 Introduction

Fluid extractor is a device used in the depollution stage of the vehicle. During this stage, the harmful fluids in the vehicle needed to be extracted out from the vehicle to properly depollute them and can be recycled safely. The fluid extractor uses pumps to extract the fluids inside the vehicle and stored them away safely to properly dispose the harmful fluids. The pumps are electrically powered and when operated, it transferred the fluids inside the vehicle into a separate container or tanks. The main objective of this tool is to separate the fluids from mixing with each other and provide a safe way to handle the fluids from being accidentally released to the environment. After the fluid container is full, the fluid is drained from the container and sent to be disposed. (European Commission, n.d.)

2.6.2 Current practice of depollution

Currently the process of depollution the ELV is done by hand with using a tool to properly extract the fluid. Overseas dismantling plants commonly uses these tools to extract the fluid while currently in Malaysia, some dismantling plants uses manual tools to drain the fluids. As ELV laws are not mandated yet, dismantling plants in Malaysia is consists of workshops that takes these ELV to recycle them for spare parts. these method proven to be labour intensive as a technician is needed to monitor the extraction process and only one fluid can be drained at a time which can causes inefficiency. With the rising of ELV in Malaysia, the industry needs a tool to efficiently remove the fluids from the vehicle while also easy to operate without costing a fortune to these ELV dismantling companies.

2.6.3 Current tool in Market

Model	Specification and features
 SEDA Mobile Drainage (SEDA, 2022)	• Air powered • 80L tanks • Modular • Distinct tank colour for fluids • Compact
 Vortex Mobile Oil and Coolant Tool (Vortex Depollution, 2023)	• Dual funnel to drain fluid simultaneously • Stainless steel tip to pierce radiator hose
 AutoDrain QuickDrain Compact (AutoDrain, n.d.)	• Compressed air operated • Flexible hoses • Fuel tank drill • Compact size

 Green Car Depollution Mobile Depollution System (www.greencardepollution.com, n.d.-d)	• Air Operated • Fuel extraction drill • Explosion proof storages

2.7 Design For Assembly

Design for assembly or DFA is a designing process which seeks the product to be simplified so the cost of assembly of the product can be reduced(Mital et al., 2014). The product needed to be analysed in terms of its design and make simplification of the current design. With the redesigned product, the assembly process can be simpler and cheaper because of the lesser parts needed in the product. This also can make the product more user friendly as it is easier to use and maintain the product. Companies had already started to implement DFA in their current product line and there is also some company that already practised DFA in their design before the practice is used often nowadays.

2.8 Quality Function deployment

Quality function deployment is a method of planning a product or service according to the customer needs and values. Quality Function Deployment is a method to defining the customer needs and demands and applying them into the product or service. Some approach to record the customers needs are such as surveys, interviews and observation to the customers(D.R. Kiran, 2017) .The needed parameters of the product were proposed to the customers through surveys, and the customer ranked the need statement according to their preferences. The obtained data from the survey were analyzed in the House of Quality

2.9 House of Quality

House of quality is a matrix diagram that is a combination of L and Roof matrices. It is used to translate and analyze the customer needs into technical characteristics (Robin Kent, 2016).The obtained data from the survey were plugged in into the House of Quality matrix to analyze the importance of the parameters to the customers. The highest ranking of the parameters were put into priority during the development of the product to cater to the customer priority needs.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Proper product development can ensure a well-built product and a systematic development to meet the needs of the objectives it was proposed to solve. Without using proper methods to develop the product, the product also will not be properly adequate with features and functionality to solve the problem. For this project, the Multifluid Extractor, several key factors need to be taken into account for designing an improved product compared to the existing product in the market such as the product designing, customer needs and the planning of the development itself. During the product planning, it must include the current situation of the product in industry and the background of the process which the product is needed for. Other than that, the customer needs also needed to be considered as this will be the main factors to contribute to the design of the product and will affect the satisfaction of the product when being used by the customer. With the use of Quality Function Development, the features needed by the customers will be analysed in the House of Quality for the final design features in the product. Finally, the product design phase will be taken into consideration of the requests and suggestions of the customers into the concept sketching and considerations will be taken with other constraints to select the appropriate concept to be finalised into a drawing.

3.2 Flow Chart of Project

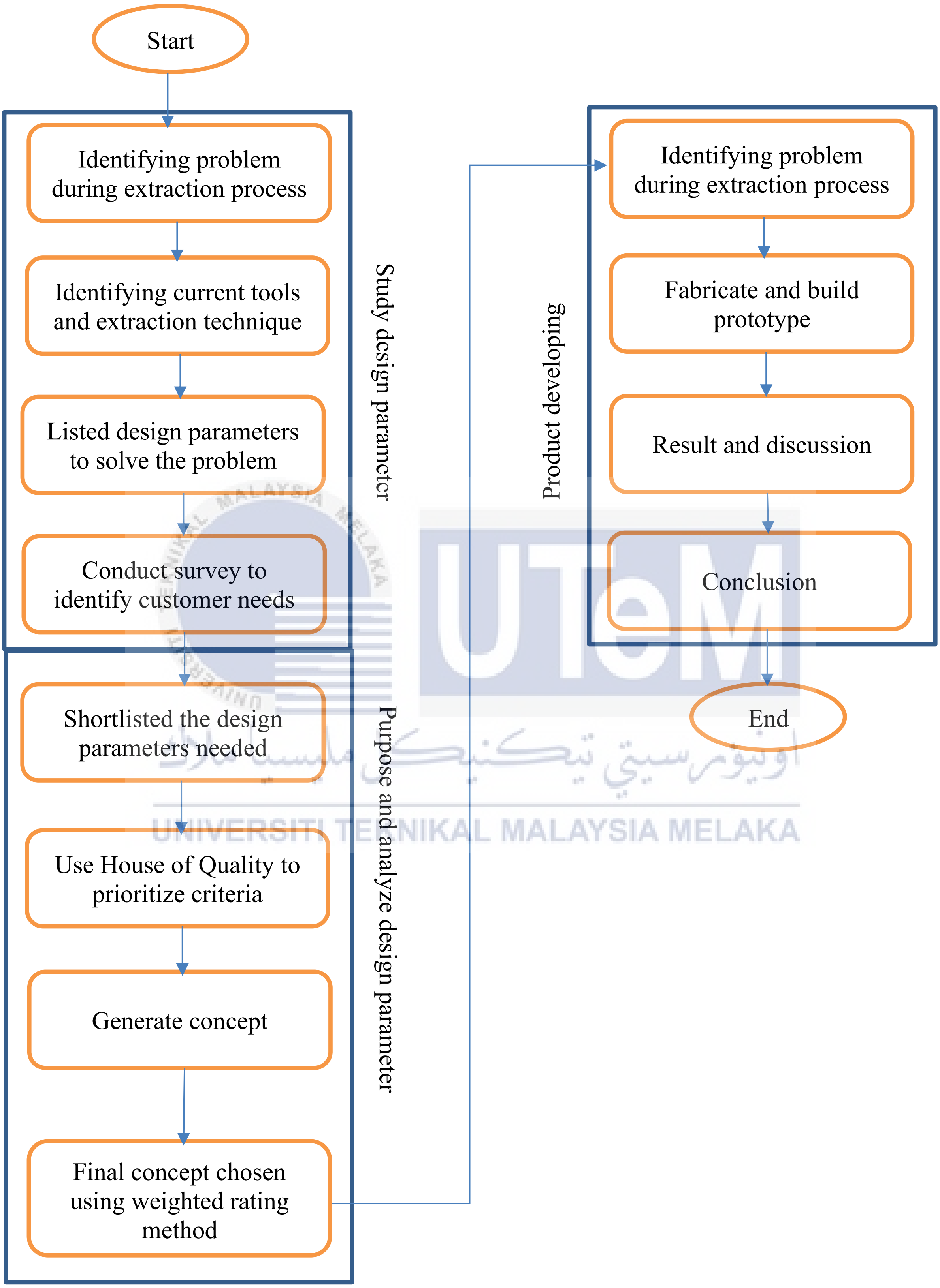


Figure 3.1 Project flowchart

3.3 Gantt Chart of Project

	PSM 1 GANTT CHART														
Activity	week														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SV Briefing	PSM 1 Briefing														
ELV Concept study															
Problem Identifying															
Project proposal															
Literature review															
Product Research															
Report writing															
Methodology															
Briefing															
Initial concept															
Report writing															
Survey															
Final Concept															
Report finalization															
Report submission															
Logbook submission															
Presentation															
Revised report submission															

Table 3.1 PSM 1 Gantt Chart

	PSM 2 GANTT CHART														
Activity	Week														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SV Discussion - PSM 1 progress discussion and PSM 2 briefing															
PSM 1 report correction															
Project dimensioning															
CAD Drawing development															
Component survey and costing															
Prototype Fabrication															
Final assembly															
E-Logbook Submission															
Thesis submission															
Presentation															

Table 3.2 PSM 2 Gantt Chart

3.4 Product Planning

Product planning is a process where decisions, steps and considerations are made in order to develop a product. These decisions include the design, features and the overall purpose of product are gathered and are implemented into the initial design of the product. To make the development successful, the product is developed in orderly steps to make the development more in orderly arrangements to detect the possible problem that might happen during the development. During the product planning also, considerations are made which mainly taken from the customers to include with the product itself. Other than that, product planning also can include the promotional marketing of the product and also the budget needed in order to make the product a reality. With the use of proper product planning, the product will achieve its production stage and will solve the problems that it had been designed for.

3.5 Customer Needs

3.5.1 Survey Questions

To finalize the customer needs in the product, a survey was conducted in order to recognise the feature and design elements of the product. The need statements were as below:

Number	Need Statement	Criteria	Importance
1	The machine must be easy to use	Usability	5
2	The machine is easy to move around	Mobility	5
3	The outside shell made from sturdy but expensive material	Design	3
4	The outside shell is made out of flimsy but cheap material	Design	3
5	The pumping mechanism has high flow rate pump but high in cost	Performance	5
6	Pumping mechanism has low flow rate but low in cost	Performance	5
7	Pumping mechanism is easy to be serviced	Usability	3

8	Fluid storage must be large in size but sacrifices mobility	Performance	4
9	Fluid storage adequate in size but sacrifices the capacity	Performance	4
10	Fluid storage easy to disassemble	Usability	5

Table 3.3 Survey questions and criteria

3.5.2 Summary of Customer Needs

The summary of the questions in the survey with their criteria and the targeted design parameters in the product.

Number	Criteria	Design Parameters
Question 1, 7, 10	Usability	Design a user friendly control interface and easy to make maintenance
Question 2	Mobility	Ergonomic design and easy to move the product
Question 3 , 4	Design	Use appropriate material to make the outer shell

Question 5 , 6 , 8 , 9	Performance	Make considerations on the sacrifice of performance to the mobility and cost
Question 3 , 4 , 5 , 6	Cost	Use affordable material and parts without sacrificing performance and mobility

Table 3.4 Summary of customer responses

3.5.3 Customer Survey Analysis

The survey asks the customer to rate the features in a linear scale and the highest scale rating of 4 and 5 responses were analysed and ranked.

Question NO.	No. Of Votes	Ranking	Criteria
1	20	1	Usability
2	19	2	Mobility
3	12	5	Design/Cost
4	12	5	Design/Cost
5	12	5	Performance/Cost
6	11	6	Performance/Cost
7	19	2	Usability
8	13	4	Performance
9	17	3	Performance
10	19	2	Usability

Table 3.5 Customer questions ranking

3.5.4 Design parameter

Criteria	Design Parameters
Usability	• Simple controls • Easy to disassemble
Mobility	• Include Wheels • Ergonomic height • Lower weight • Compact design
Design	• Material sturdiness • Simple design • Aesthetic design
Performance	• Pumping Flow rate • Capacity of storage
Cost	• Material type • Type of fluid pump

Table 3.6 Criteria and design parameters

3.5.5 Definition of customer needs criteria

3.5.5.1 Usability

The product is easy to use with simple control system to operate the product. The product itself is easy to service when a malfunction occurs and to make regular operating mechanism.

3.5.5.2 Mobility

The movement are not restricted by its design. The extra mobility can makes the product more user friendly and efficient when in working order.

3.5.5.3 Design

The choice of materials or the overall design of the product must be appropriate in for its function. Design plays a huge role in the cost and the overall form factor of the product that can attract interest to the customer.

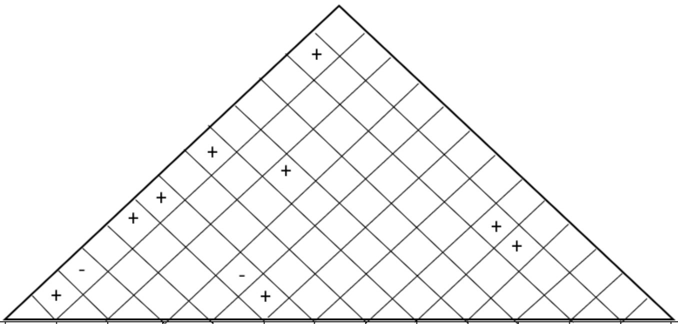
3.5.5.4 Performance

Performance is the main feature of the product because it effects the efficiency of the work done by the product. The performance must be taken into consideration with other factors such as cost and useability.

3.5.5.5 Cost

The cost of making the product must be affordable but without using cheap materials and parts that can sacrifices the product performance.

3.5.6 House of Quality



	Importance Weight	Simple Construction	Easy to Disassemble	Include Wheels	Ergonomic Height	Lower weight	Compact Design	Sturdy Material	Simple Design	Aesthetic design	High Flowrate	High-Capacity Storage	Material Cost	Fluid Pump Cost	Total
Improvement Direction															
Unit					MM	Kg					LPM	L	RM	RM	
Usability	5	9	9	9	3	9					1	3			
Mobility	4	1		9		9									
Design	3	9	9	9	9		3		3	9			1		
Performance	5					3		1			9	9	3	3	
Cost	5	9		9			3	9	9	3	9	9	9	9	
Raw Score		121	72	153	42	96	24	50	54	42	95	105	63	60	977
Relative Weight		12	7	16	4	10	3	5	6	4	10	11	6	6	100
Rank Order		2	6	1	12	4	13	11	10	9	5	3	7	8	

Figure 3.2 House of Quality for the parameters

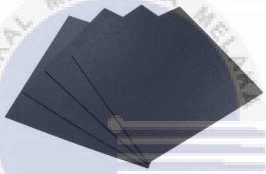
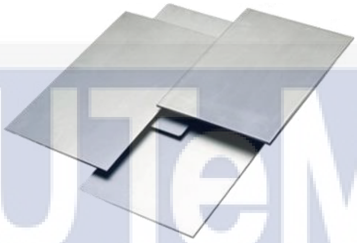
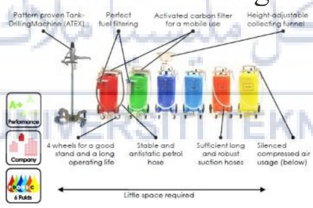
3.5.7 Final Specification

No.	Criteria	Remarks
1	Mobility	Include wheels in the design, lower weight
2	Usability	Simple controls to operate and simple construction
3	Performance	High flowrate pump and high-capacity storage
4	Design	Easy to disassemble and tough material

5	Cost	Affordable price with adequate performance

Table 3.7 Final chosen specification

3.6 Morphological Chart

Component	Solution 1	Solution 2	Solution 3
Type of pumps	Mechanical Pump 	Electrical Pump 	
Shell Material	ABS Plastic 	Mild Steel 	Aluminium 
Benchmark Design	Internal tank design 	External tank design 	Mix of internal and external 

3.7 Concept design

3.7.1 Concept Sketching

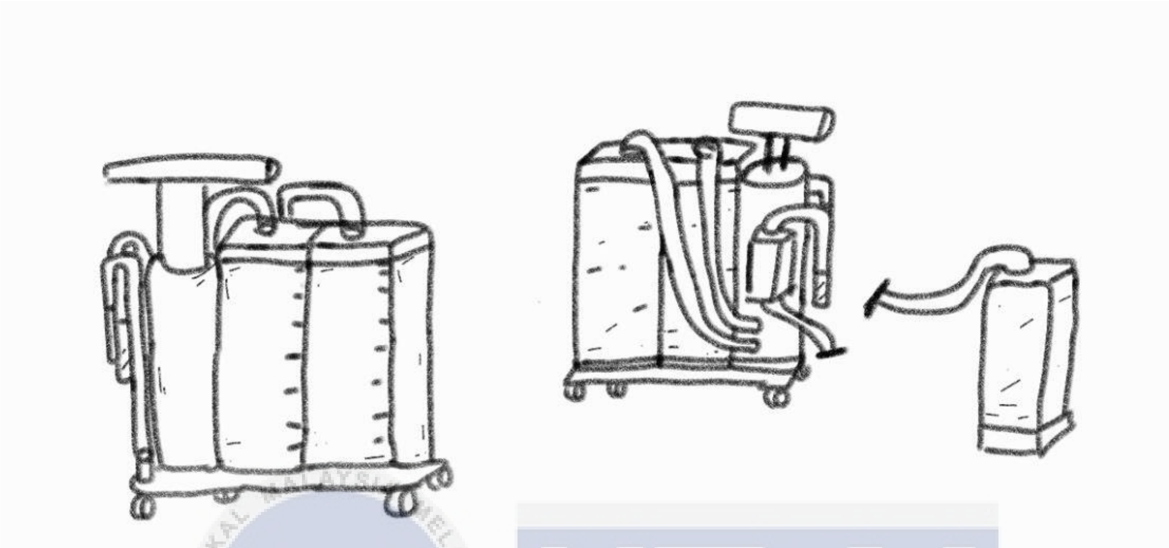


Figure 3.3 Figure shows the concept of the product with mixed storage tanks type and mechanical pump

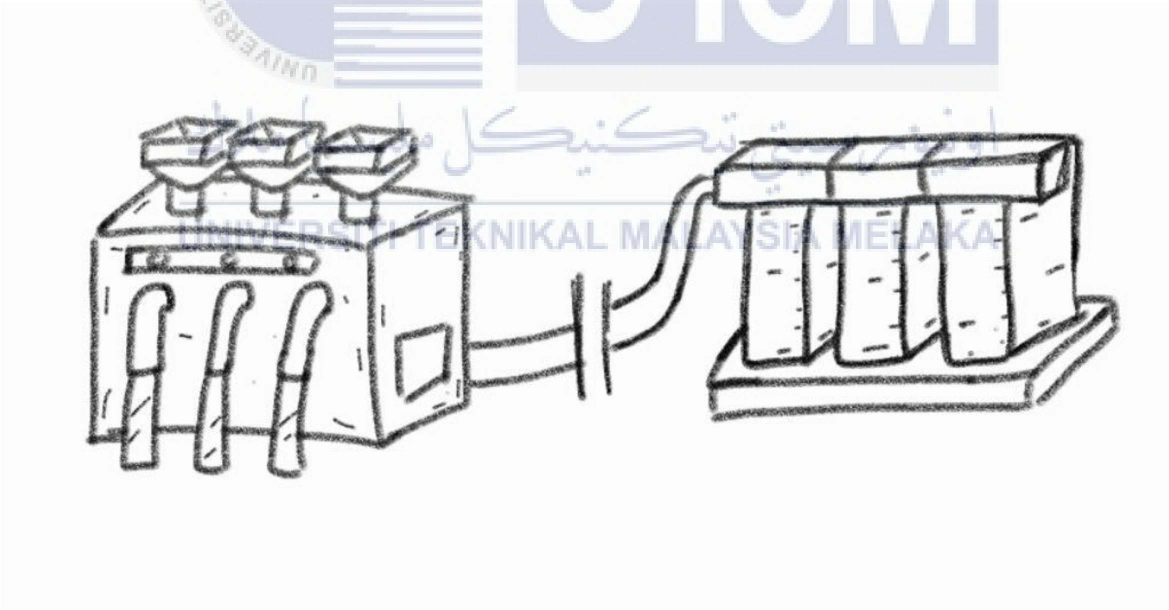


Figure 3.4 Figure shows the conceptual sketch with external storage tanks and electric pumps

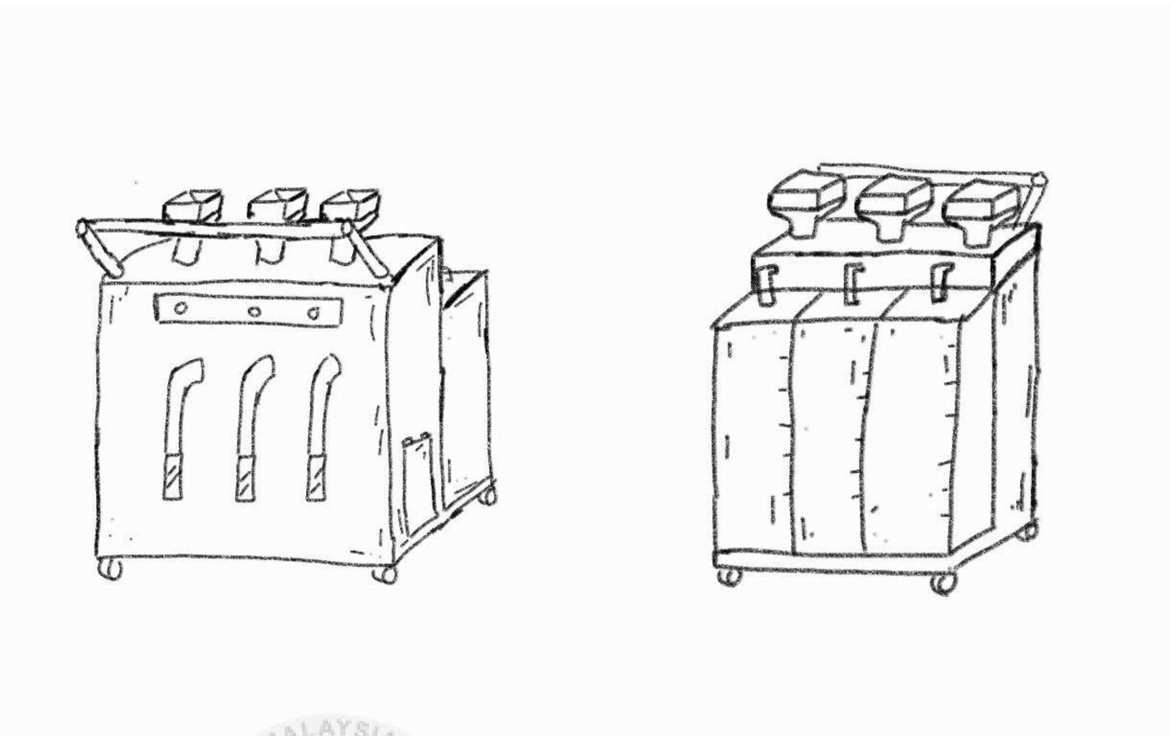


Figure 3.5 The figure shows the conceptual design of the product with internal storage tanks and electric pumps.

3.7.2 Concept selection

Table shows the concept features combinations of features from the concept.

		Concept Design		
		Concept 1	Concept 2	Concept 3
Features	Type of pump	Mechanical	Electric	Electric
	Shell material	ABS Plastic	Aluminium	Mild Steel
	Storage type	Mixed	External	Internal

Table 3.8 Features combination of concepts

The table belows the alternatives concept selection of the product

Alternative	Features		
	Pump type	Shell Material	Storage type
1	Mechanical	ABS Plastic	Mixed
2	Mechanical	ABS Plastic	External
3	Mechanical	ABS Plastic	Internal
4	Mechanical	Mild steel	Mixed
5	Mechanical	Mild steel	External
6	Mechanical	Mild steel	Internal
7	Mechanical	Aluminium	Mixed
8	Mechanical	Aluminium	External
9	Mechanical	Aluminium	Internal
10	Electric	ABS Plastic	Mixed
11	Electric	ABS Plastic	External
12	Electric	ABS Plastic	Internal
13	Electric	Mild steel	Mixed
14	Electric	Mild steel	External
15	Electric	Mild steel	Internal
16	Electric	Aluminium	Mixed
17	Electric	Aluminium	External
18	Electric	Aluminium	Internal

Table 3.9 Alternative concept selection of the product

Table shows weighted rating method for the final concept

		Concept Alternatives					
		Concept 1		Concept 2		Concept 3	
Criteria	Importance Weight	Rating	Weighted rating	Rating	Weighted rating	Rating	Weighted Rating
Mobility	25	2	0.5	3	0.75	4	1.0
Usability	20	2	0.4	4	0.8	4	0.8
Performance	25	2	0.5	4	1.0	4	1.0
Design	10	3	0.3	3	0.3	3	0.3
Cost	20	4	0.8	3	0.6	3	0.6
Total	100	NA	2.50	NA	3.45	NA	3.70

Table 3.10 Weighted rating method for the final concept

3.8 Final Concept sketch

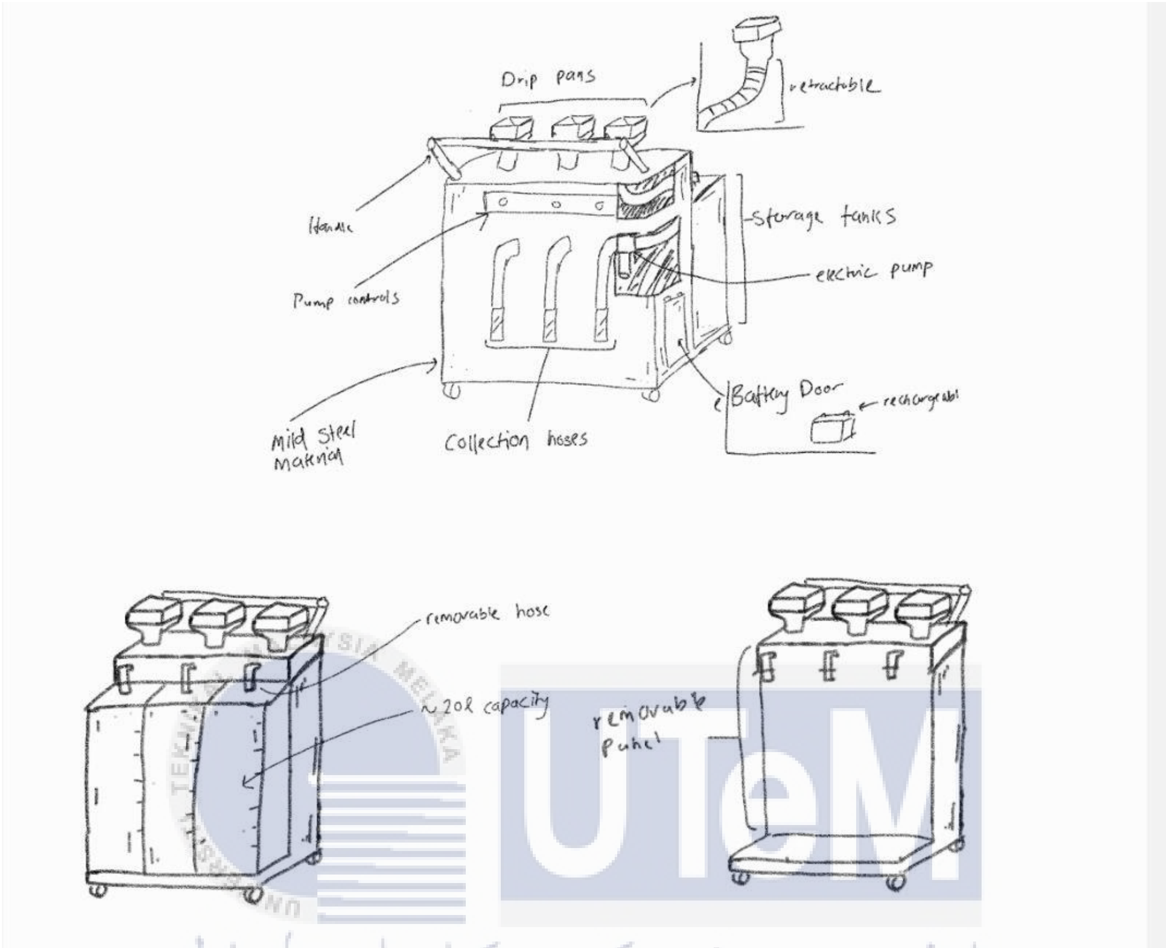


Figure 3.6 Final concept sketch

The figure above shows the final concept design of the product. This concept combines the best features to the product in order to fulfil the customer requirements. The pumps are using electrical pumps instead of mechanical pumps in order to make the product easier to use and increases its performance compared to mechanical pumps. The outside shell made out of mild steel will make the product more robust without sacrificing weight. The product uses integrated tanks to make the product easier to maintain and more efficient during the disposal of the fluids. The product also features wheels and handle to make the product easier to move from place to place.

CHAPTER 4
RESULT AND DISCUSSIONS

4.1 Overview

During this final chapter, the process is more focused on the final design of the product and the fabrication of the prototype product according to the selected design choices. This chapter will be divided into several parts that is Prototype Sketching and Dimensioning, CAD Model Development, Simulation Testing, Fabrication of Prototype, Bill of Material and Project Evaluation.

4.2 Prototype sketching and dimensioning

The selected concept sketching was chosen and the dimensions of the prototype were measure according to the available components to develop this product. The measurement of the prototype was based around the container of the fluids and the dimension of the electric pump. The figure below shows the dimensioning of the product and the chasis dimension. The chasis plays a main role in this product as it supports the whole product and needed to be sufficient to hold the fluids and need to use less material to reduce the cost.

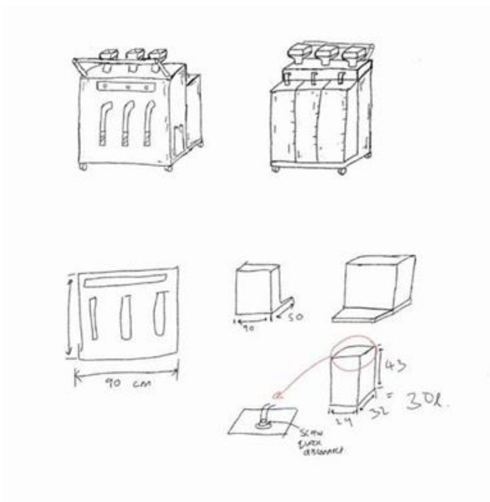


Figure 4.1 Dimension of fluid extractor

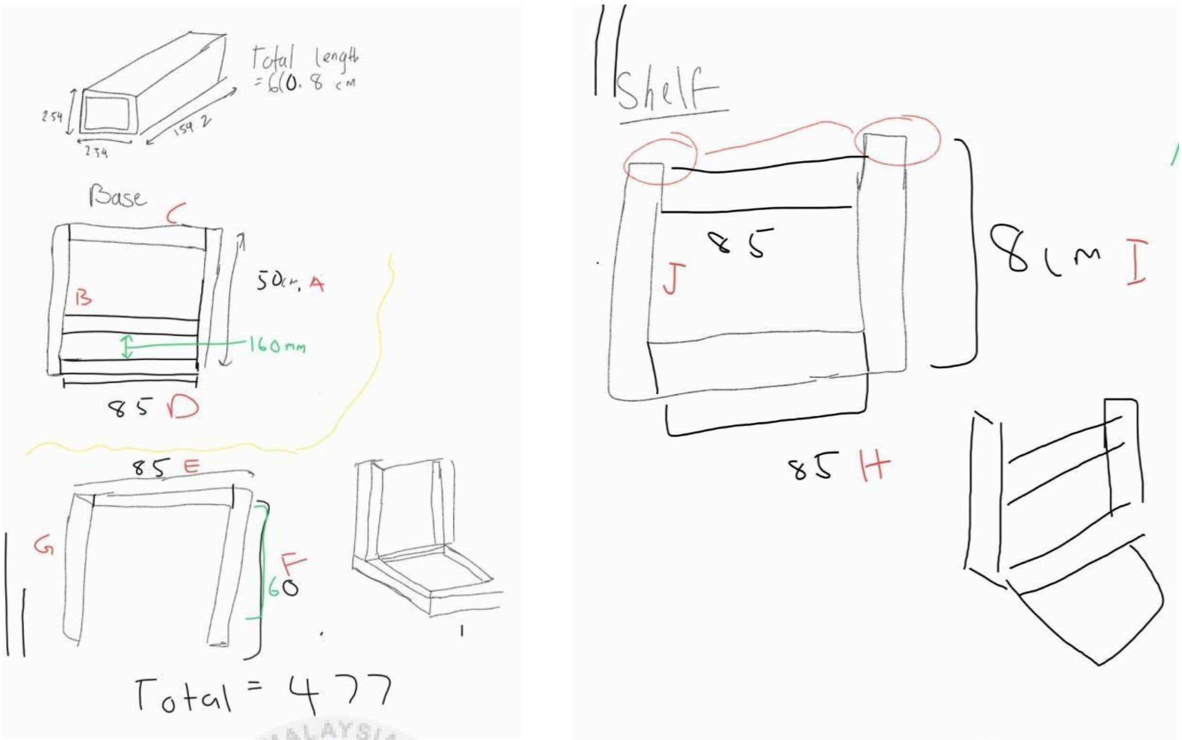


Figure 4.2 Chasis dimension

4.3 CAD model development

From the obtained dimension, the CAD model was drawn inside Catia V5 software. The drawn model were obtained as below.

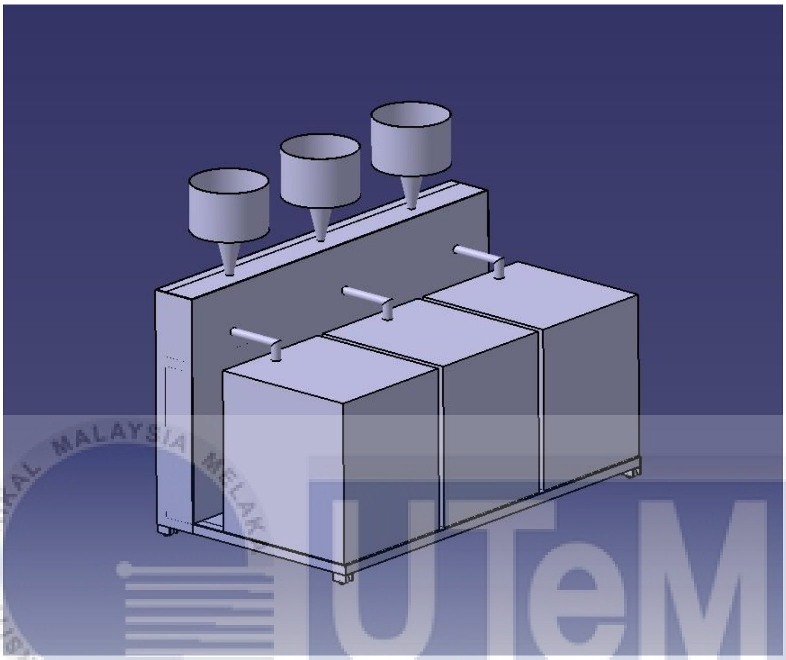


Figure 4.3Isometric view

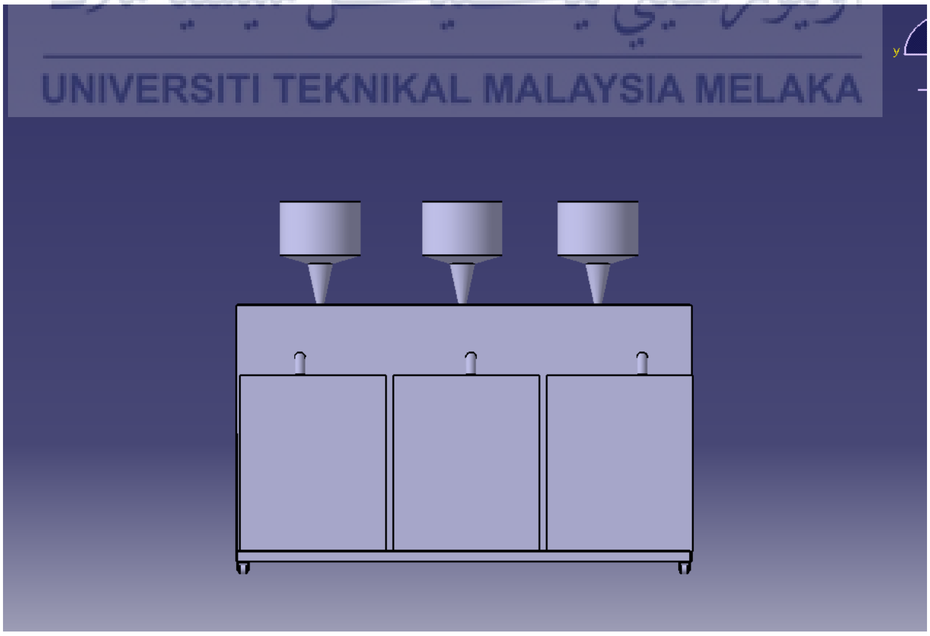


Figure 4.4Front view

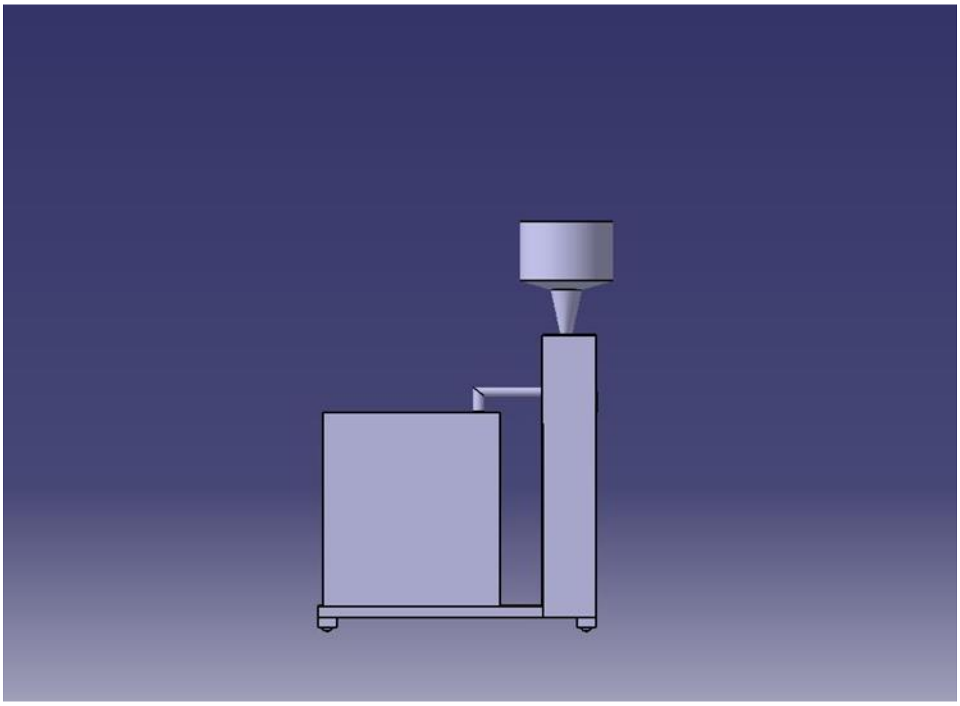


Figure 4.5Side view

4.4 Simulation testing

The chasis of the product were put to force similar of having to hold 90 litres of fluid. The analysis of the chasis is as below. The product were anchored around the base of the chasis and the force were applied evenly on the lower part of chasis.

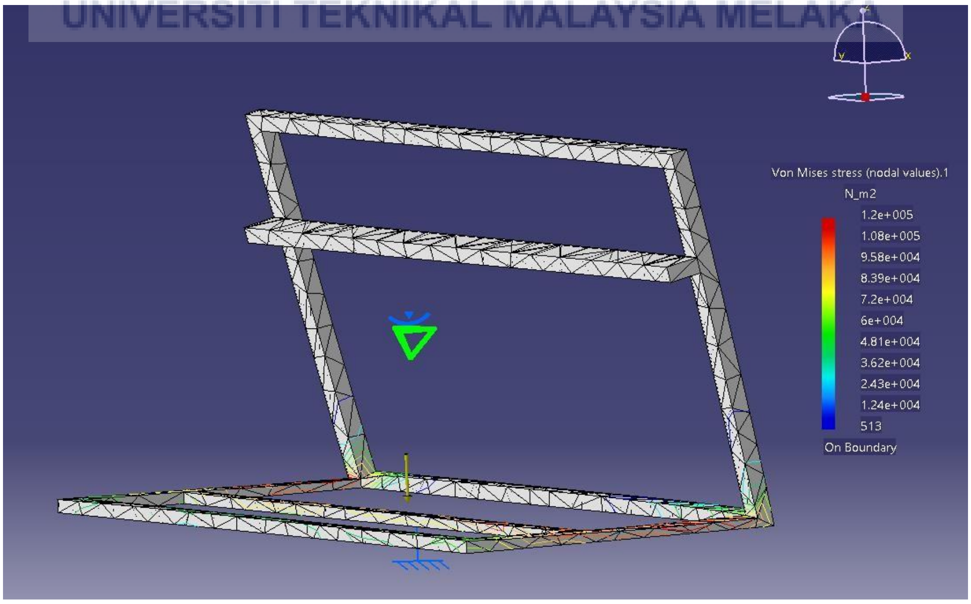


Figure 4.6 Von Mises Stress of the chasis

4.5 Prototype fabricating

After obtained the dimension of the product, the material were ordered and fabricated according to the CAD drawing. The process included during the fabricating were measuring, material cutting, welding and assembly.

4.5.1 Measuring

The material were marked according to the length desired according to the drawing. This is the first step of the prototype making. The markings must be accurate and uniform across the material. This step is important as it determines the cutting border of the material. During this process also, the available material were precisely calculated to extract most out of the material to produce less waste.

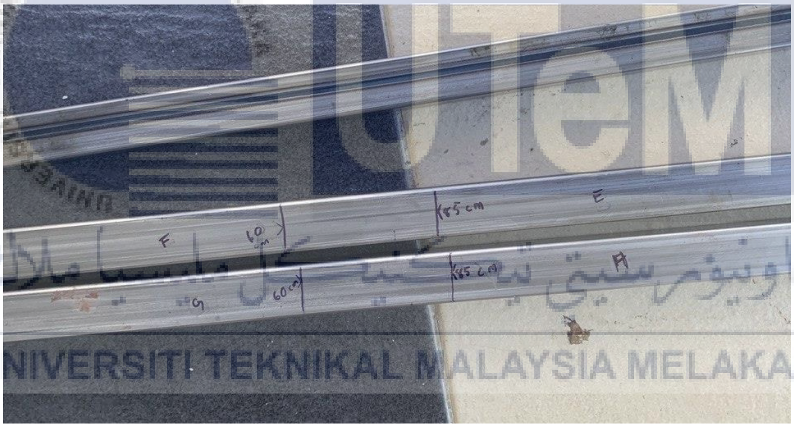


Figure 4.7 Measurement marking on the steel

4.5.2 Material cutting

The marked materials were cut using metal cutter. During this process, the cutting were taken into account of the thickness of the cutting disc. Protective equipment were worn during this time to avoid unexpected injury during cutting.

Figure 4.8 Material after cutting

4.5.3 Welding process

The cut material were welded together to form the chasis of the product. The type of welding machine that were used were MIG welding as the thickness of the material is not thick and may cause the material melt if the weld is too long.

Figure 4.10 Welding process

Figure 4.9 Welded chasis

4.5.4 Shell fabrication

The shell aluminium material were cut into shape and formed to the chasis of the product.

Figure 4.11 Product aluminium shell

4.5.5 Assembly

The product parts were assembled to the chasis such as the pump, drip pan, the container and the shell.

The pump assembly also been rewired to make it work through one single battery clamp.

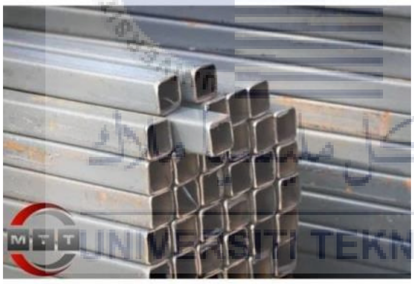
Figure 4.12 Pumps wiring

Figure 4.13 Handle and wheels installation

Figure 4.14 Final form of the prototype

4.6 Bill of material

The bill of material is the total listof parts and cost used in the project. Every parts used in this product were listed to calculate the cost.

No	Picture	Name	Price per unit	Total units	Total price
1		1 Inch x 1 Inch Mild Steel hollow Steel , 5 feet	RM 10.98	4	RM 43.94
2		1 Inch x 1 Inch Mild Steel hollow Steel, 100 cm	RM 6.50	2	RM 13

3		Electric Fluid Pump	RM 37	3	RM 112

4		Oil Funnel	RM 3.91	3	RM 11.73
5		Wheel	RM 2.00	2	RM 4.00
6		Automotive Wire	RM 8.50	1	RM 8.50
7		Handle	RM 1.79	1	RM 1.79
8		Aluminium Shell	RM 26 (3x8 Feet)	3 Feet	RM 9.75

		20L Container	RM 9	3	RM 27
		Screw set	RM 2.10	1	RM 2.10
Total			**RM 233.81**		

4.7 Product evaluation

In this section, the final prototype were tested for its capabilities in removing fluids and storing the fluids in a safe compartment before recycling the End Life Vehicle. The tested parameters were the:

a) Volume of liquid pumped

b) Storage capacity and disassembly

4.7.1 Volume of liquid pumped

From the provided spec sheet of the electric pump provided by the manufacturer, it can pump fluids up to 1.5L per minutes. The pump itself can be continuously run for 30 minutes straight without stopping. The average amount of engine oil used by car is around 4

– 6 litres per vehicle. From the provided numbers, we can calculate the time taken to remove engine oil is below.

4L/1.5L/min = 2.67 minutes

From the above calculation, the average car takes about 3 minutes to fully remove the engineoil in vehicle.

4.7.2 Storage tank capacity and disassembly

The storage capacity of the container is 20L. The amount of engine oil used for average car is about 4 litres. The total number of vehicles engine oil can be stored before emptying the container is as below.

20L/4L = 5

The total vehicles fluids can be stored before full is 5 vehicles.

After the container had been full, the container lid can be easily screwed off from thecontainer before emptying the container.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion from the project of The Development of Fluid Extractor In Dismantling Process For End Life Vehicle, the product development had been done and achieved its objective of developing the prototype of fluid extractor in dismantling process of ELV. The prototype created were using off the shelf items from the market and also using recycled containers to further reduce the cost of the product. For the final cost, the product only costs RM 233.81 which is far cheaper than the current tool used during dismantling process. The performance of the fluid extractor also can be seen as it can store 5 vehicle's worth of engine oil with only taking around 3 minutes for a full extraction. The storage container also is easily removable with using screw mechanism to empty the container of the fluids for recycling or proper waste management of the harmful fluids. So, it can be considered that it had reached the objectives required in use.

5.2 Recommendation

Throughout the project, there are some recommendations that can be implemented to the design of the product in order to make the product performs more efficiently during its use.

The first recommendation is to make the drip pan more wider while also making it adjustable in height to accommodate vehicles in air lift. The current product only had drip pan that is small in size and are not adjustable in height that make it less convenient during the extraction process.

Lastly, I would also recommended to improve on the handle of the product. The handle on the current product are too close to the chasis that makes it less comfortable to grip on the handle.

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APPENDICES

APPENDIX A ONLINE SURVEY QUESTIONNAIRE

Survey For Fluid Extractor

This survey is conducted to obtain the features that is needed by the customers in the final product. The product is a portable oil extractor for vehicle dismantling/servicing

The features is listed and the rating of importance of the features needed to be rated

* Indicates required question

1. Age *

   Mark only one oval.

   - 18 - 25
   - 26 - 30
   - 31 - 35
   - 36 - 40
   - Other: ______

2. Do you have any experience in vehicle dismantling or servicing? *

   Mark only one oval.

   - Yes
   - No

3. Do you have some knowledge on vehicle? *
   eg : The basics on vehicle engines

   Mark only one oval.

   - Yes
   - No

4. The machine must be easy to use *

Mark only one oval.

Disagree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Agree

5. The machine is easy to move around *

Mark only one oval.

Disagree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6. The outside shell made out of sturdy but expensive material *

Mark only one oval.

Disagree

1 ⬭
2 ⬭
3 ⬭
4 ⬭
5 ⬭

Agree

7. The outside shell is made out of flimsy but cheap material *

Mark only one oval.

Disagree

1 ⬭
2 ⬭
3 ⬭
4 ⬭
5 ⬭

Agree

Extraction and storage

Inside the extractor, it will uses a pumping mechanism to extract the fluids and stored inside a closed storage

8. The pumping mechanism has high flow rate pump but high in cost *

Mark only one oval.

Disagree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Agree

9. Pumping mechanism has low flow rate but low in cost *

Mark only one oval.

Disagree

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Agree

10. Pumping mechanism is easy to serviced *

Mark only one oval.

Disagree

1 ⬭

2 ⬭

3 ⬭

4 ⬭

5 ⬭

Agree

11. Fluid storage must be large in size but sacrifices mobility *

Mark only one oval.

Disagree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Agree

12. Fluid storage adequate in size but sacrifices the capacity *

Mark only one oval.

Disagree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Agree

13. Fluid storage easy to disassemble *

Mark only one oval.

Disagree
1 ◯
2 ◯
3 ◯
4 ◯
5 ◯
Agree