CHAPTER I INTRODUCTION

I.1 Background

Drinking water is one of the most essential things that people needed for life. Without mineral water, human body will have dehydration and it can create and effect to disorders and infections to the urinary tract. Water that is safe and easily accessible is essential for public health, whether it is used for drinking, domestic use, food production, or recreation. Improved water supply and sanitation, as well as better water resource management, can boost countries' economic growth and contribute significantly to poverty reduction. The Guidelines define safe drinking water as not posing any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Infants and young children, the elderly, and the disabled are the most vulnerable to waterborne disease, especially when living in unsanitary conditions. Those who are generally at risk of waterborne illness may need to take additional precautions, such as boiling their drinking water, to protect themselves from waterborne pathogens. All normal domestic purposes, such as drinking, food preparation, and personal hygiene, require safe drinking water. The Guidelines apply to packaged water and ice meant for human consumption. However, higher quality water may be required for some special purposes, such as renal dialysis and contact lens cleaning, or for specific purposes in food production and pharmaceutical use. The Guidelines may not be appropriate for aquatic life protection or for certain industries. Based on Indonesian’s Minister of Health regulations, the water can be drink if it is through processing or without processing that meets health requirements and can be drunk directly.

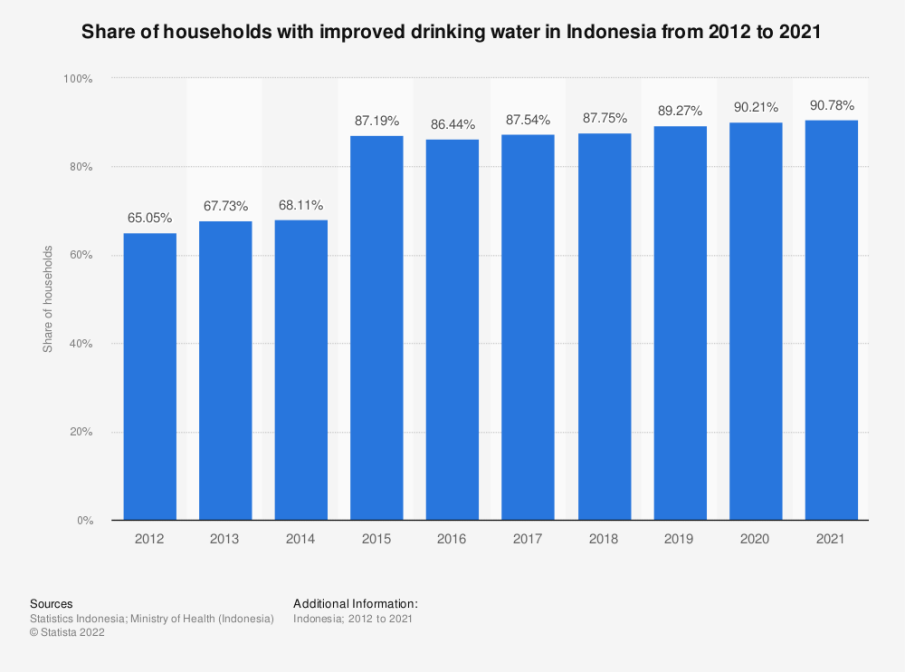

Figure I. 1 Share of households with improved drinking water in Indonesia from 2012 to 2021

As it can be seen by the table above, the share of households drinking water is improving by year-to-year, from 2012 at 65,05% to 2021 at 90,78% and it is a huge improvement that has been created for nine years. However, it is still included both of the rural and the urban condition which is different from each other.

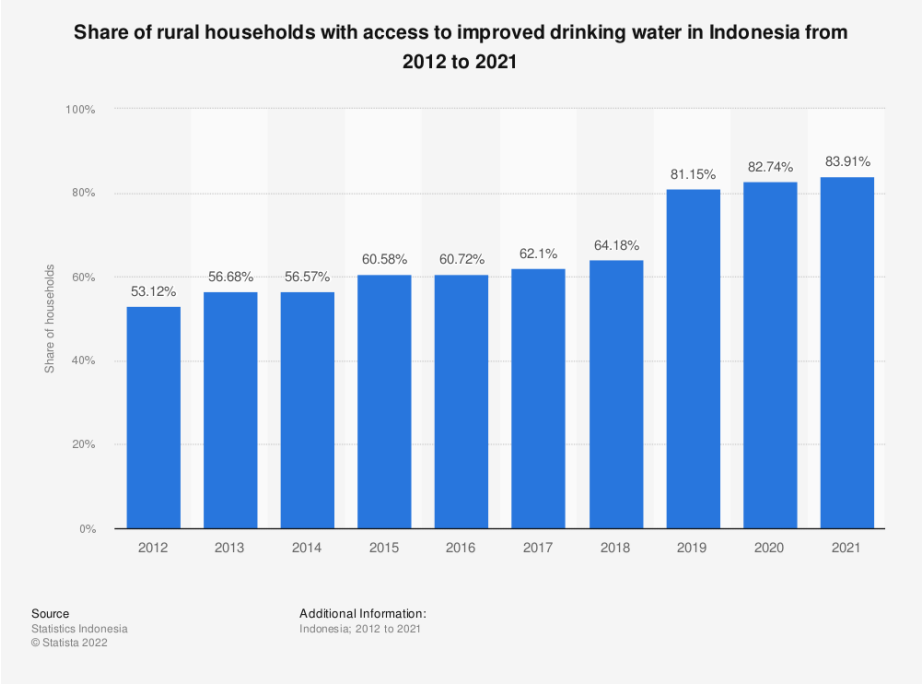

Figure I. 2 Share of rural households with access to improved drinking water in Indonesia from 2012 to 2021

The percentage of rural households with improved drinking water is also rising significantly, especially from 2018 to 2019, when it increased by 16,97%. Even though there has been improvement over the years, more must be done to maximize the existence, particularly given that Indonesia is a country with abundant water resources. The true situation, where poor water quality exists regardless of socioeconomic circumstances, can be seen in the field. Therefore, there is still a major problem with access to clean water in Indonesia, particularly in rural and slum areas. These barriers are characterized by their proximity, expense, accessibility issues, and methods for assessing the water quality.

In Indonesia, different varieties of drinking water are available for purchase by the public and are a necessity for daily life. For instance, there are bottles with capacities of 250 ml, 600 ml, etc., and a jug with a 19 L or even smaller capacity. People purchase these in accordance with their needs, and the majority of households require a shared drinking water container. The jug is empty after the water is used for drinking, and it can be filled again for the same household or a different one. However, this is where the issues are identified. There are some jugs that fall under the minor defect and major defect categories and are not classified

for reuse. The jug's minor flaw is that it can still be used after a few polishes using the chosen procedure. For instance, a crack that is smaller than the designated size or a dirty jug. The jug's major flaw, however, prevents it from being used any longer because it goes against the explicitly stated company policies. For instance, a crack that is larger than the desired size or a used jug that has typically been in use for more than five years.

PT. Tirta Investama is a company that is engaged in the manufacturing of the AQUA drinking water, which is technically be the subsidiary of PT. Danone, that is known as the first and biggest mineral water drink in Indonesia. One of PT. Tirta Investama branch is located in Subang, West Java, that is assisting in the production of the 600 ml bottle and 19 L jug packaging. The jugs are treated before being re-distributed to the public in accordance with the drinking water policies already established by PT. Danone.

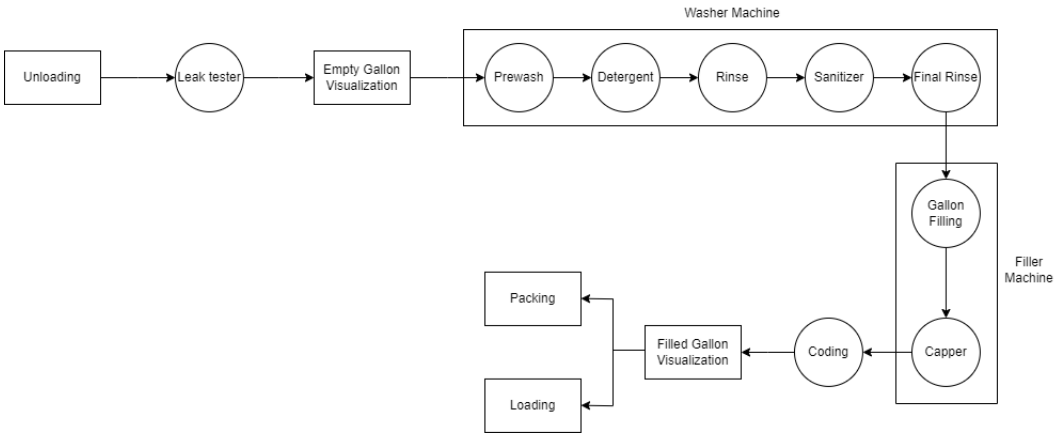

Figure I. 3 Steps for Jug Cleaning in PT. Tirta Investama (AQUA) Subang

The treatment steps that have been decided upon for the treatment of the jug are shown in the chart below. There are several procedures that must be completed before the filling can begin, including leak detection, empty gallon visualization, and washer machine with five steps inside. These steps are required to make sure the jug is safe enough to be used for drinking water once again. The following jugs, which are specifically listed in the empty gallon visualization step, are not acceptable in any step: dirty jugs with difficult-to-remove stains; cracked jugs; jugs with unknown objects inside; odorous jugs; and jugs with failures that are noted on

the label. When the jug is being replaced or can receive a special treatment, these criteria are once again chosen before it reaches the final decision.

Currently, a machine that was self-built to help clean the dirty jug in a matter of seconds is the main focus. However, the machine still needs to be improved in order to accommodate anthropometric measurements and human concerns, which will also help the workers feel comfortable while using the machine.

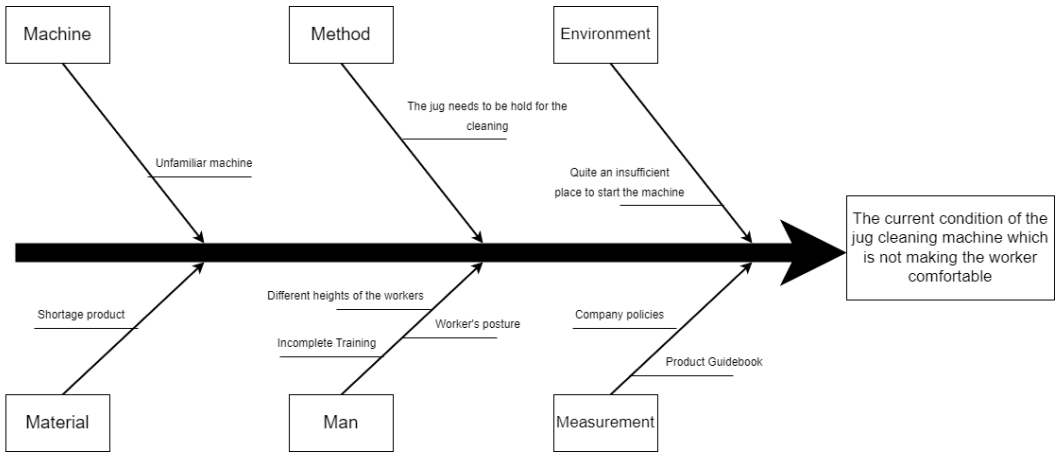

Figure I. 4 Fishbone for Jug Cleaning

From the fishbone above, it can be described that there are quite problems that are around the machine, material, method, man, measurement, and environment. The following problems are in the machine, the problem is unfamiliar machine. Next, in the material, the problem is shortage product. Third, in the method, the problem is the jug needs to be hold for the cleaning. After that, in the man, there are different heights of the workers, worker's posture, and incomplete training for the workers. Next, in the measurement, there are company policies and product guidebook. And the last, in the environment, there is quite an insufficient place to start the machine.

The process for cleaning the jug is only required for about five until twelve seconds, but it is not including the jugs that are coming from the visualization where is not selected to be continue on the main process. There are approximately two jugs per-fifteen seconds that is not required to be continue and it continuously moving on the track when it is shifted. Hence, the jug cleaning machine holds an important

process, and it needs to be improved which will affect the input and output of the production.

If the incoming gallon is defective, the gallon will undergo a variety of treatments. The issue here is that it only includes the pre-treatment area, which has a cleaning machine on the jug in the below-displayed picture:

Figure I. 5 Criteria for Pre-Treatment Empty Jug

The picture above explains the standards by which empty gallon pre-treatment and other processes are accepted or rejected. The pre-treatment process is represented by the blue color, which also contains the following elements: foreign object, light smell, light dirtiness, light moss, light blur, and heavy mud. Before moving on to the washer machine and another refill, the gallon must go through the pre-treatment process where it is cleaned.

Figure I. 6 Operator cleaning on the machine (before)

Operators for the pre-treatment were feeling sore, especially for the wrist and waist because of the time for the jug cleaning that is filled of mose that practically makes the cleaning came difficult, and as it is done per-shift, the operators must seat down approximately five hours until the shift changed. This is inversely through the ergonomic rules, and it must be fixed. Besides the ergonomics rules, the safety, quality, cost, delivery, motivation, and environment also affected the improvement.

Figure I. 7 Operator's environment (Before)

Figure I. 8 Pre-Treatment's environment (Before)

Table I. 1 SQCDME Table (Before)

No	Risk	Analysis
1	Safety	Pre-treatment operators affected by the chemical reaction from the cleaning water.
2	Quality	The checking for the jug cleaning is done in minimum seen.
3	Cost	Time for the jug cleaning takes too long for around 4-6 minutes.
4	Delivery	Jug that already washed turned down at the empty visual control.
5	Motivation	Area for the pre-treatment is inconvenient and the workstation is not fully secure.
6	Environment	Waters that have been used for the cleaning is around six tub (50 liters) per-shift and the chemical reaction is around 3 liters per-shift.

Figure I. 9 New machine for Pre-Treatment

The jug machine is called GOEL, an automatic cleaning jug tool that is designed to make cleaning faster and more efficient than before. GOEL machine was made because of the previous pre-treatment washing has been done manually.

The machine was already going through the fulfil treatment with the risk analysis around the safety, quality, cost, delivery, motivation, and environment. Here is the result of the risk analysis after the machine was made:

Figure I. 10 Operators trying the new machine

Table I. 2 SQCDME Table (After)

No	Risk	Analysis
1	Safety	1. Put of the eyewashes around the pre-treatment area 2. Placement of the secondary tub 3. Training for the pre-treatment employee for the chemical handling
2	Quality	Additional of the light
3	Cost	The unclean jug is cleaned by the jug cleaning machine

4	Delivery	Employees are given more caution for the checking of the pre-treatment jug
5	Motivation	Placement of the workspace
6	Environment	Using recycle water to reduce the water and chemical usage

Even though the cleaning process for the jugs was renewed, there are still things that can be improved based on what was observed on the field and how the workers stated from the interview that was conducted. It provided an opportunity to conduct a brief interview with two operators who were working in one shift and cleaning the jug. The following questions and answers have been recorded:

Table I. 3 Interview with operator (1)

Operator's name: Tono	
Question	**Answer**
When do you use the product?	It started from the company's policy to improve the step for jug cleaning. The workers were complaining about how their back hurts when cleaning on the jug.
What do you like about the existing product?	The amount of the clean jug increased, quality improved, the job becoming easier, and becoming more ergonomic.
What do you dislike about the existing product?	It is still a dangerous thing that the electricity way is still far away from safety and the chair is not comfortable enough.
What improvements would you make to the product?	Think about the safety for the operators for changing on the

	electricity way for the machine and improve more comfort.

Table I. 4 Interview with operator (2)

Operator's name: Kukus	
Question	**Answer**
When do you use the product?	From the company that is pulled out the product for the pre-treatment of the jug cleaning.
What do you like about the existing product?	It is faster and cleaner than the previous process.
What do you dislike about the existing product?	The moss still difficult to be cleaned as the garbage bin is far away from the machine, the chair is still not comfortable and need more improvement for the comfort, and the machine needs maintenance.
What improvements would you make to the product?	Improving the comfort of the chair and adding on garbage bin that is near on the machine.

According to the operators' comments during the interview, the machine still has room for improvement. A few examples include making the operators' seats more comfortable while using the machine, changing the way the electricity is run to increase safety, and adding extra components like a garbage can to the machine. With a precise brush for cleaning the inside of the jug, the moss can also be removed more easily.

Following the interview with the operators, the pre-treatment area's surroundings were also examined and recorded based on field observations and the operators' feedback on the newly-being-developed machine. An observation checklist was

created to list the assertions that are visible to the unaided observer in order to create a basic resume about the observation. An observation checklist is a crucial tool for keeping track of field notes and is a means of gathering data for research projects by watching what is happening and why. Therefore, the observation checklist has been concluded:

Table I. 5 Observation Checklist

OBSERVATION CHECKLIST				
NAME OF THE RESEARCH: Checking on the pre-treatment workers for the jug cleaning machine				
Date: July 13th, 2023				
Observer: Shafa				
No	**Criteria**	**Yes**	**No**	**Observations**
1.	The workspace has a good placement.		✓	The placement for the pre-treatment is near of the visualizer and to the primary washing machine. However, the place is quite not suitable and safe.
2.	The workspace has a sufficient light	✓		The pre-treatment area has a sufficient light to help the workers on the process.
3.	The process using a recycle water and reducing the water needs.	✓		The pre-treatment area uses a recycle water for the process.
4.	The jug cleaning machine has a sufficient machine for the pre-treatment process.		✓	The jug is still everywhere which is waiting to be cleaned by only two employees per-shift.
5.	The jug cleaning machine can clean the jug fast.	✓		The jug cleaning machine cleans the jug fast, faster than before the machine created.
6.	The jug cleaning workspace has a comfort that is given to the employees.		✓	The employee's posture did not show that their comfortable with the state.
7.	The jug cleaning machine is according on the safety measurement.	✓		The employee operates the jug cleaning machine safely.

Figure I. 11 Operators cleaning on the jug

Based on the observations, the workspace for the pre-treatment area can be improved with appropriately placed in the space. Aside from that, the ergonomics factor for the operators can still be improved, as the operators stated that the chair is not comfortable enough to sit in for a five to six hour per-shift. Following the conclusion of the observation and interview, the workspace and equipment can be upgraded to support the operators' comfort and health, with an overall focus on the jug cleaning workstation to enable the operators to exert maximum effort in cleaning the pre-treatment's jug. After the observations and interviews, a NASA-TLX questionnaire was spread to support the mental load data for the workers.

NASA-TLX is one of the applicated method for collecting on the workers need. NASA-TLX has its own form to proceed the data that has been collected from the workers about the ergonomics statements depends on the six factors: mental demand, physical demand, temporal demand, frustration level, performance, and effort. Before operating the NASA-TLX with the calculation, a hierarchical task analysis was determined to check in the tasks that the employees do for the jug cleaning process. Hence, the hierarchical task analysis determined below:

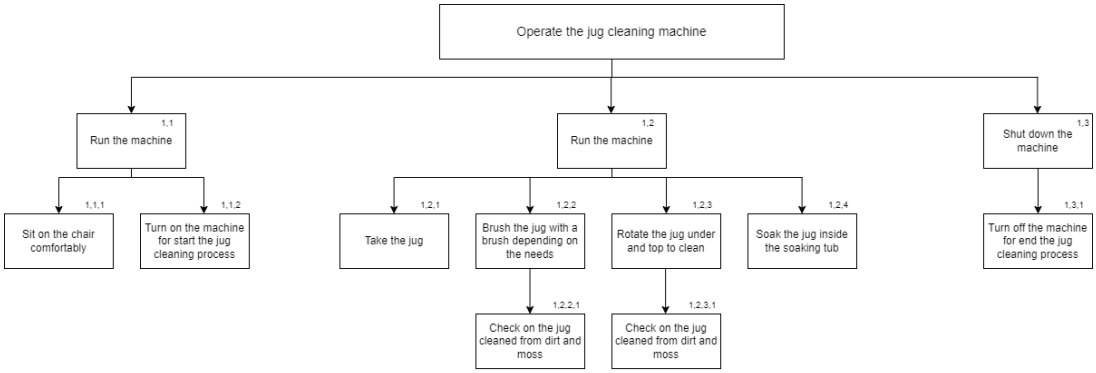

Figure I. 12 Hierarchical Task Analysis

After the hierarchical task analysis has been determine, the NASA-TLX will be continue to calculated. The weighting of the analysis for mental workload of NASA-TLX described in the table below:

Table I. 6 NASA-TLX Weighting Indicator

Weighting Indicator		
Mental Demand (MD)	Or	Physical Demand (PD)
Mental Demand (MD)	Or	Temporal Demand (TD)
Mental Demand (MD)	Or	Performance (OP)
Mental Demand (MD)	Or	Effort (EF)
Mental Demand (MD)	Or	Frustration Level (FR)
Physical Demand (PD)	Or	Temporal Demand (TD)
Physical Demand (PD)	Or	Performance (OP)
Physical Demand (PD)	Or	Effort (EF)
Physical Demand (PD)	Or	Frustration Level (FR)
Temporal Demand (TD)	Or	Performance (OP)
Temporal Demand (TD)	Or	Effort (EF)
Temporal Demand (TD)	Or	Frustration Level (FR)
Performance (OP)	Or	Effort (EF)
Performance (OP)	Or	Frustration Level (FR)

Effort (EF)	Or	Frustration Level (FR)

Here is the data that has been collected for the NASA-TLX data collecting based on the six employees that is willing to fill in the form:

Table I. 7 NASA-TLX Data Collecting (1)

Name:	Tono
Weighted Analysis	
Question 1	Mental Demand
Question 2	Physical Demand
Question 3	Performance
Question 4	Effort
Question 5	Frustration Level
Question 6	Temporal Demand
Question 7	Physical Demand
Question 8	Physical Demand
Question 9	Frustration Level
Question 10	Temporal Demand
Question 11	Temporal Demand
Question 12	Temporal Demand
Question 13	Performance
Question 14	Performance
Question 15	Frustration Level
Scale Given	
Mental Demand	50
Physical Demand	50
Temporal Demand	50
Performance	50
Effort	80
Frustration Level	40

Table I. 8 NASA-TLX Data Collecting (2)

Name:	Engkus
Weighted Analysis	
Question 1	Mental Demand
Question 2	Temporal Demand
Question 3	Performance
Question 4	Effort
Question 5	Mental Demand
Question 6	Temporal Demand
Question 7	Physical Demand
Question 8	Physical Demand
Question 9	Physical Demand
Question 10	Temporal Demand
Question 11	Temporal Demand
Question 12	Temporal Demand
Question 13	Performance
Question 14	Performance
Question 15	Effort
Scale Given	
Mental Demand	50
Physical Demand	100
Temporal Demand	50
Performance	50
Effort	50
Frustration Level	50

Table I. 9 NASA-TLX Data Collecting (3)

Name:	Giwa
Weighted Analysis	
Question 1	Physical Demand
Question 2	Temporal Demand
Question 3	Performance
Question 4	Effort
Question 5	Mental Demand
Question 6	Temporal Demand
Question 7	Performance
Question 8	Physical Demand
Question 9	Physical Demand
Question 10	Performance
Question 11	Effort
Question 12	Effort
Question 13	Effort
Question 14	Frustration Level
Question 15	Effort
Scale Given	
Mental Demand	65
Physical Demand	60
Temporal Demand	80
Performance	70
Effort	70
Frustration Level	80

Table I. 10 NASA-TLX Data Collecting (4)

Name:	Proy
Weighted Analysis	
Question 1	Physical Demand
Question 2	Mental Demand
Question 3	Performance
Question 4	Effort
Question 5	Frustration Level
Question 6	Temporal Demand
Question 7	Performance
Question 8	Effort
Question 9	Physical Demand
Question 10	Performance
Question 11	Temporal Demand
Question 12	Temporal Demand
Question 13	Effort
Question 14	Performance
Question 15	Effort
Scale Given	
Mental Demand	70
Physical Demand	75
Temporal Demand	70
Performance	60
Effort	65
Frustration Level	70

Table I. 11 NASA-TLX Data Collecting (5)

Name:	Dedi
Weighted Analysis	
Question 1	Physical Demand
Question 2	Temporal Demand
Question 3	Performance
Question 4	Frustration Level
Question 5	Frustration Level
Question 6	Temporal Demand
Question 7	Performance
Question 8	Effort
Question 9	Physical Demand
Question 10	Temporal Demand
Question 11	Effort
Question 12	Temporal Demand
Question 13	Effort
Question 14	Performance
Question 15	Frustration Level
Scale Given	
Mental Demand	70
Physical Demand	65
Temporal Demand	60
Performance	55
Effort	60
Frustration Level	70

Table I. 12 NASA-TLX Data Collecting (6)

Name:	Wildan
Weighted Analysis	
Question 1	Physical Demand
Question 2	Temporal Demand
Question 3	Mental Demand
Question 4	Effort
Question 5	Frustration Level
Question 6	Temporal Demand
Question 7	Performance
Question 8	Effort
Question 9	Physical Demand
Question 10	Temporal Demand
Question 11	Temporal Demand
Question 12	Effort
Question 13	Performance
Question 14	Performance
Question 15	Frustration Level
Scale Given	
Mental Demand	60
Physical Demand	55
Temporal Demand	60
Performance	70
Effort	60
Frustration Level	70

The data collecting has been through from the questionnaire that is being spread to the workers for the jug cleaning. Firstly, the data need to be calculated.

From the data collecting of the NASA-TLX that is taken from the operators. The company has a total of eight pre-treatment operators, six of which are available for

data collection. Here is the recap and calculation according from the method of NASA-TLX scoring:

Table I. 13 NASA-TLX Scoring Result

No	Name	Aspect	Rating	Weighted	WWL	Score	Indication
1.	Tono	MD	50	1	750	50	High
		PD	50	3			
		TD	50	4			
		PO	50	3			
		EF	80	1			
		FR	40	3			
2.	Engkus	MD	50	2	900	60	High
		PD	100	3			
		TD	50	5			
		PO	50	3			
		EF	50	2			
		FR	50	0			
3.	Giwa	MD	65	1	1045	70	High
		PD	60	3			
		TD	80	2			
		PO	70	3			
		EF	70	5			
		FR	80	1			
4.	Proy	MD	70	1	930	62	High
		PD	75	2			
		TD	70	3			
		PO	60	4			
		EF	65	4			
		FR	70	0			
5.	Dedi	MD	70	0	915	61	High
		PD	65	2			
		TD	60	4			
		PO	55	3			
		EF	60	4			
		FR	70	2			
6.	Wildan	MD	60	1	940	63	High
		PD	55	2			
		TD	60	4			
		PO	70	3			
		EF	60	3			
		FR	70	2			

According to the data obtained, six employees scored 'High', indicating that quick action is required to be proceed.

I.2 Formulation of the Problem

Based on the background that has been explained, the problems definition can be formulated:

1. How to improve the suitable jug cleaning machine to be used for the people who use it?

2. How to re-design the jug cleaning machine to help the workers to have a comfortable seat by the process?

I.3 Research Objectives

The objectives are concluded as follows:

1. Improve the suitable aspects of the jug cleaning machine for the workers.

2. Re-design the machine to improve the comfortable state process for the workers.

I.4 Research Benefits

The benefits are concluded as follows:

1. For Students

Can apply the Industrial Engineering science that has been learned during lectures that can help the problem that occur in the society.

2. For Company

Can create an efficient output from improving the quality of the product by start from improving the new jug cleaning machine especially in maintaining a healthy and safe working habits.

3. For Related Workers

Can help the workers to reduce the risk and unsafe gesture to avoid the working accidents in cleaning the jug.

I.5 Writing Systematics

The following is the writing systematics for the research:

Table I. 14 Writing Systematics

Chapter I	**Introduction**

	This chapter discusses the background of the ongoing process and the events that occurred before the problem was identified. It also includes the problem, goals, advantages, and writing systematics of the report.
Chapter II	**Literature Review** This chapter includes the reference of the literature that will be use in break-down the project. All of the studies that has been concluded from the research or books and also selecting the literature that will be use in the furthermore.
Chapter III	**Problem Solving Methodology** This chapter includes a detailed explanation of the research process that serves as a manual for gathering data and processing it from beginning to end in order to solve the problem.
Chapter IV	**Data Collection and Processing** This chapter describes about how to obtain the data from the investigations, observations, and interview from the workers. The data is being processed and tested to reach the validation and verification that will be carried out to make the analysis.
Chapter V	**Analysis** This chapter includes the analysis from the data that has been collected for the suggested tool design, includes in the Kansai Engineering approach.
Chapter VI	**Conclusion and Suggestions** This chapter concludes the report and add a comparison that is done and commentary opinion about the future judgement to the company to be conducted.