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Analysis of the Application of Green Manufacturing with the Concept of Water Recycle System to Reduce the Use of Clean Water at Pt. Karton Cikarang

Ali Hanafi[1]; Fibi Eko Putra[2]; Putri Anggun Sari[3]
Pelita Bangsa University, Industrial Engineering Study Program,
Faculty of Engineering, Bekasi Regency, West Java (17530)

Abstract:- The carton packaging industry has potential and advantages that can be used to maintain and develop business operational activities, one of the potentials is liquid waste left over from the production process, as an efficiency measure and a long-term business, sustainable energy is needed as an effort to apply efficiency and effort for the survival of mankind. The purpose of this research is to find the root cause of the high use of clean water in the production process and design the reuse of recycled water in the production department so that it can reduce the use of clean water, and can implement the concept of green manufacturing at PT. Karton Cikarang. This research is quantitative using the Failure Mode and Effect Analysis (FMEA) method which allows to identify and prevent the occurrence of problems in products and processes. Based on the research conducted, it is known that the percentage of clean water use in the production department is divided into 3 parts, namely converting machines (57%), corrugator machines (27%) and finishing machines (16%) which means that the use of clean water is mostly used by converting machines and the least water use is used by finishing machines. PT. Karton Cikarang has complied with wastewater quality standards set by the government, management and monitoring efforts are also carried out to create environmental protection for humans and life in the future.

Keywords:- *Sustainable Energy, Waste Management, Green Manufacturing.*

I. INTRODUCTION

The packaging industry is one of the important things for the sustainability of products on the market, among the various types of packaging on the market, cardboard / cardboard packaging is one form of product packaging that is commonly found in every product product. Carton box companies have a great opportunity in carrying out their operational activities, because almost all products have packaging on the outside such as food products, beverages, electronics and even vehicle engines. Among the opportunities possessed by carton box manufacturing companies, it needs to be realized that many production lines produce waste from production that needs to be addressed systematically, carefully and seriously.

One of the reuses of industrial waste is to use liquid waste that has been processed / water recycle derived from the rest of the production process to be re-used in the production process, this is in line with the purpose of implementing green manufacturing in carton box manufacturing companies, green manufacturing plays a major role in companies and the environment in order to protect and continue the environment of mankind, Although the company already has a wastewater disposal permit (WWTP) that is in accordance with quality standards and contained in UKL-UPL (Environmental Management Efforts and Environmental Protection Efforts), the disposal of liquid waste directly into river bodies needs to be minimized, reuse of waste for production needs is a solution that can be taken.

This is in line with the Sustainable Development Goals (SDGs) program which is a long-term world program to optimize all the potential and resources owned by each country (Irhamsyah, 2019). The purpose of the research in this final project is to find out the main causes of waste of clean water use that occurs in the production department, provide an overview and advice to companies to be able to reuse the great potential contained in water recycle from liquid waste treatment because it can reduce the number of clean water use which can directly reduce the company's capital costs in the field of water energy and participate in providing overview and advice For companies to be able to apply the concept of green manufacturing in the implementation of company operational activities.

II. LITERATURE STUDY

A. Sustainable Energy

Sustainable energy is the provision of sustainable energy that meets current needs without sacrificing the ability of future generations to meet the needs of mankind in the future, sustainable energy sources come from energy used today such as water, heat, natural gas and so on, but can be used and managed properly for the survival of

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mankind. Some technologies that participate in building and supporting sustainable energy are renewable energy technologies, such as hydroelectric power plants, air power generation technology, solar energy, geothermal energy, artificial photosynthesis, artificial tidal energy and energy made with the aim of increasing energy efficiency. Sustainable energy is a source derived from operational resources used today, without jeopardizing the energy needs or climate of future generations (J. University, 2021).

Sustainable energy has benefits to continue to be used and utilized by mankind in the future, by applying sustainable energy the manufacturing industry sector contributes to savings / power savings for mankind in the future, this is a good thing for business, because it also supports the continuation of business and economy based on resources found in the environment.

B. Waste Management

Waste management is an activity that includes confinement, storage, collection, transportation, utilization, management and/or landfill (Ministry of Environment and Forestry, 2022). The management of 10 wastes is one of a series of activities that include storage, collection, utilization and processing of the waste itself. The characteristics of waste that are the rest of the process make waste management need to be taken seriously, because its existence is supervised by regulations and laws and regulations in Indonesia. Wastewater is water that comes from a process in an activity (Ministry of Environment and Forestry, 2022). Toxic and hazardous waste, hereinafter referred to as B3, is the remainder of a business and / or activity containing B3 (Minister of Environment and Forestry, 2021). B3 waste treatment is a process to reduce and/or eliminate hazardous and/or toxic properties (Minister of Environment and Forestry, 2021).

C. Green Manufacturing

Manufacturing is a word derived from Latin, namely manus factus which means made by hand. While the word manufacture first appeared in 1576, and the word manufacturing appeared in 1683 (Supriyanto, 2020). Green Manufacturing is a production process that uses inputs with relatively low environmental impact, and produces little or no waste or pollution, Green Manufacturing leads to the design of an environmentally friendly manufacturing system by changing raw material processes, production processes, energy use and can reduce adverse environmental impacts. Green Manufacturing is also considered an innovative process because of its potential and reasons that can be useful in reducing waste, pollution prevention, energy conservation (Mustakim et al., 2021).

D. Water Recycle

Water recycling is a water treatment system that is inappropriate or dangerous into reusable water. The use of recycled water products in Indonesia is still more intended as a source of clean water for non-domestic, especially recycled water derived from industrial activities (Priyandes, 2018). In language, water recycle has two word affixes derived from English, water which means water and recycle which means recycling which means the reuse of unused materials into raw materials that can be reused.

E. Clean Water

Clean water is an environmental health quality standard for water media for sanitary hygiene purposes including physical, biological, chemical parameters of which 12 can be mandatory parameters and additional parameters (Pontororing et al., 2019). Water is one of the main elements in life, water plays an important role in the sustainability of living things. Industrial activities can have a direct impact in addition to indirect impacts. It is said that the direct impact if industrial activities can be directly felt by humans. Direct positive impacts are expected, but direct negative impacts that reduce the quality of human life must be avoided and reduced. Industrial activities can disrupt the balance of the environment, if the balance of the environment is disturbed the quality of life will change. The direct negative impact due to industry can be seen from the occurrence of air pollution problems, water pollution, and land pollution (Achmad Fauzi et al., 2018).

F. Failure Mode and Effect Analysis (FMEA) Method

Failure Mode and Effect Analysis (FMEA) method is a technique used to improve the reliability and safety of a process by identifying potential failures - or so-called failure modes - in the process. Each failure mode will be assessed using three parameters, namely severity (S), probability of occurrence (O), and probability of failure detection (D). The three parameters were then combined to determine the criticality significance (FMECA) of each failure mode. The combination of these three parameters is known as the Risk Priority Number (RPN) (Alijoyo et al., 2020). FMEA was first developed by the United States military, through the military procedure MIL-P-1629 November 9, 1949 entitled "Procedure for Performing a Failure Modes, Effect and Ccritically Analysis". The FMEA method is generally used to identify and analyze failures. FMEA identifies three things as follows:

- Potential causes of failure of systems, designs, products and processes during their life cycle.
- Effects resulting from such failures.
- The criticality of the effect of failure on system function, design, products and processes.

III. RESEARCH METHODS

This study used a quantitative research design. What is meant by quantitative research here is a method used to answer research problems carried out using a series of numbers, statistical data processing, structure and control experiments. The method used in this study is the FMEA method. The purpose of this study is to determine the cause of the high use of clean water and design the use of green manufacturing in the company PT. Carton Cikarang.

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In a study, data collection techniques are an important factor that must be done for the success of the study. It deals with how to collect data, who and what the source is, and the tools or methods used. The types of data used in this study are divided into 2, namely:

A. Primary Data

Primary data is data obtained directly from the object of research. In this study, primary data were obtained in the following ways:

➢ *Focus Group Discussion (FGD)*

FGD is carried out by gathering experts and experienced employees from the production, maintenance, HRD & GA departments and WWTP divisions to obtain direct information which is the most important part of research. In this study, FGD was conducted with department leaders and division leaders of PT. Karton Cikarang which is the most authorized party in the company's operational and production activities.

➢ *Observation*

Observation is a data collection technique by making direct observations at the research site and taking research data based on a checking form that is carried out in stages for 2 hours.

B. Secondary Data

Secondary data in this study is obtained through literature studies obtained from companies, scientific books, research journals and other scientific documents that support the research to be carried out.

To find out the stages of research, it is stated in figure 1 as follows:

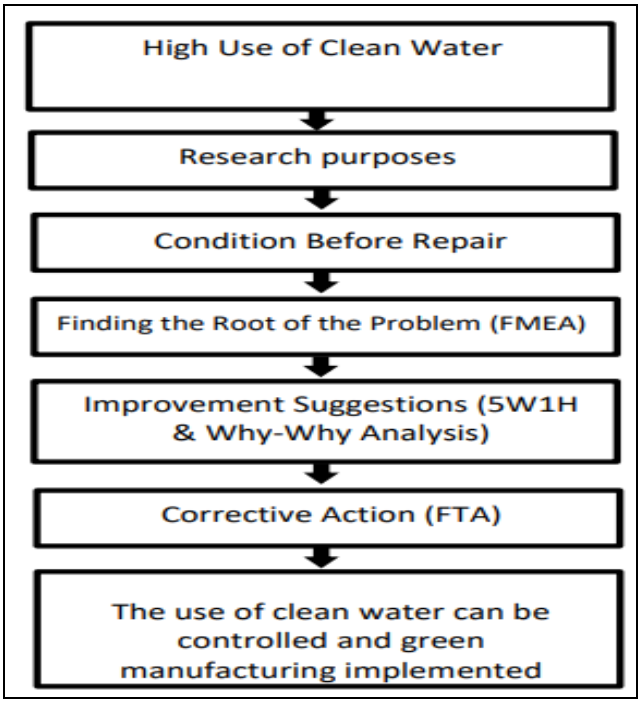

Fig 1: Stages of Research

IV. RESULTS AND DISCUSSION

PT. Karton Cikarang focuses its business on the manufacturing industry, namely the process of making packaging made from cardboard. PT. Cikarang Cardboard carries out its entire production process within the company area. The production process carried out at PT. Karton Cikarang starts from the corrugated process operated on a corrugator machine with the results of products in the form of plain cardboard that does not yet have patterns and images, the next process is the printing process operated on a flexo converting machine where the result of the process is a cardboard product that already has patterns and images but does not have adhesive to connect the box, the final process occurs in the finishing process where a series of cartons that already have pictures and patterns are glued Using glue or *stich* wire that glues the carton box.

The first step in this study is direct observation in the field involving representatives of the printing production department and representatives of the WWTP department which is the focus of research to determine the flow of the clean water distribution process to the production department using FGD.

Table 1: Focus Group Discussion (FGD) Team

	Age	Work Experience (Years)	Position	Skills	Information
FGD-A	48	25	Production Manager	Production and Techincal Engineering	Internal Company
FGD-B	44	25	Printing Supervisor	Production	Internal Company
FGD-C	34	15	Engineering Manager	Technical Engineering	Internal Company
FGD-D	43	20	Manager HRD&GA	HRD&GA	Internal Company
FGD-E	23	5	General Affairs Leader	Building &; Clean Water	External Company

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The next step is to determine the problem of high use of clean water at PT. Karton Cikarang is by using the Failure Mode and Effect Analysis (FMEA) method and collecting data on the use of clean water in the company. The data collected is in the form of data on the amount of production, allocation of clean water use and the amount of clean water use.

Data on the amount of production of PT. Karton Cikarang in the form of partition data, finished cartons and plain cartons used are data for the period 01 December 2022 – 28 February 2023. Includes production data in the corrugator, converting and finishing machine area that is accumulated and recorded when entering the storage warehouse area. Data on the amount of production collected can be seen in the following table.

Table 2: Production Quantity Data

Moon	Department	Machine Name	Total Production (kg)
December 2022	Production	Corrugator, Converting & Finishing	32.000
January 2023	Production	Corrugator, Converting & Finishing	31.500
February 2023	Production	Corrugator, Converting & Finishing	30.000
Sum			**93.500**

After direct observation in the production area, there are 3 allocations of clean water use needed in the production process, in calculating the use of clean water using a *flow water meter*. The allocation of clean water use can be seen in the following table.

Table 3: Allocation of Clean Water Use

No.	Process Name	Machine Name	Water Use Allocation	Quantity (m^3)
1	Printing	Converting	For ink mixing media	3.350
2	Corrugated	Corrugator	To clean spare parts and machine body	1.585
3	Finishing	Insun	For glue mixing media	950

After knowing the allocation of clean water usage needs, then data collection of the amount of water use is carried out based on recording water use carried out for 2 hours and recorded using a flow water *meter tool*. Data on clean water usage can be seen in the following table.

Table 4: The Amount of Clean Water Usage

No.	Moon	Machine Name	Usage (m^3)
1	December 2022	Corrugator, Converting & Finishing	2.100
2	January 2023	Corrugator, Converting & Finishing	1.900
3	February 2023	Corrugator, Converting & Finishing	1.885
Total			**5.885**

After the data is obtained, data processing is carried out using the Failure Mode and Effect Analysis (FMEA) method as follows:

A. Identify Failure Mode

The identification process through cost percentages and cumulative percentages is then analyzed with a pareto chart, the type of failure to be analyzed is seen based on the pareto chart in the following table and figure.

Table 5: FMEA Total Clean Water Use PT. Carton Cikarang

No.	Machine	Usage Allocation	Number of Uses ($m^{3)}$	Price (Rp/m3)	Water Cost	%Cumulative
1	Converting	Print Printing	3.350	63.650.000	57%	68%
2	Corrugator	Machine Maintenance	1.585	30.115.000	27%	24%
3	Finishing	Glue mixture	950	18.050.000	16%	8%
Total			5.885	111.815.000	100%	100%

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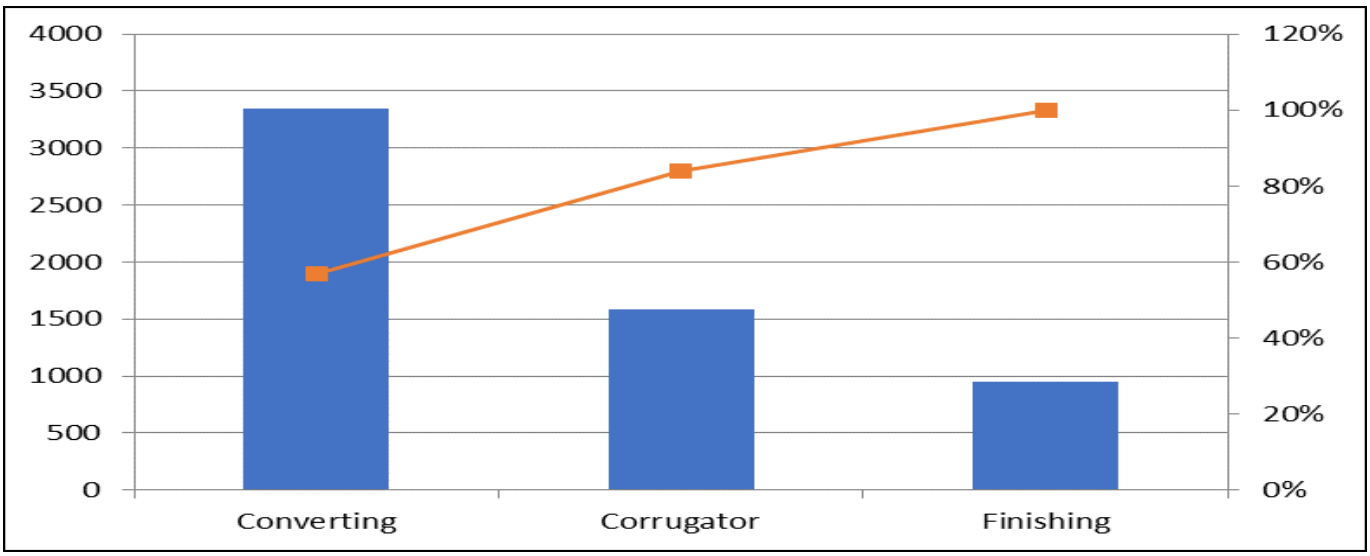

Fig 2: Pareto Diagram of the Percentage of Clean Water Usage

Based on data processing using the pareto concept, the process that uses the largest clean water is in the converting and corrugator processes, so it is described in the following explanation:

- *Effect of Failure from Converting and Corugator Processes.*

The effect obtained from the printing process and machine maintenance is the high use of water and the costs that must be incurred by the company.

- *Cause Failure of the Converting and Corrugator Process.*

At this stage, we will identify what factors can make water use high, using *seven tools* in the form of *Why-why analysis* and 5W1H which are described in the following table:

Table 6: Why-Why Analysis

	Problem	**Why-1**	**Why-2**	**Why-3**	**Why-4**	**Why-5**
Action	High consumption of clean water leads to huge costs	The use of water is allocated for the process of mixing ink, cleaning the machine and mixing glue	The use of clean water is needed in the printing process because each machine processes 6 articles / shift	Mixing water in ink and glue is often done because in 1 shift there is an ink consumption of 10 pail / machine	Water mixing is needed in the process because for 1 pail of ink / glue it takes 1/2 pail of clean water so that the ink and glue become diluted	Clean water is also needed for machine cleaning and machine spare parts
Repair					Mixing ink using water from the recycle process	Machine cleaning and spare parts using recycled water process
Prevention					Optimal and consistent *distribution of recycled* water	Consistent engine cleaning

Based on the results of the *why-why analysis method*, it is known that the cause of the high use of clean water at PT. Karton Cikarang is the use of water for the needs of mixing water as a medium for diluting ink in the printing process, glue dilution media in the finishing process and cleaning of factory machines when the production process occurs and the machine maintenance process occurs.

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Table 7: 5W1H Analysis

5W1H Analysis			Answer
1	What	What causes the high use of clean water in the production department at PT. Karton Cikarang?	Because in the converting production process, water is needed as an ink dilution medium, in the finishing production process, water is needed as a glue mixing medium and in the corrugator production process there is water integrity for cleaning and machine maintenance.
2	Who	Who are the users of clean water in the production department at PT. Karton Cikarang ?	In general, the use of water in the production area is used for the production needs of corrugator machines, converting, finishing and sanitation needs.
3	Where	Where the use of clean water on the largest and smallest scale in the production department at PT. Karton Cikarang?	The largest use of clean water is used by converting machines with an average usage of 3,350 m^3 and the smallest in finishing machines with an average usage of 950 m^3
4	When	When clean water usage data is taken at PT. Karton Cikarang?	Clean water usage data is taken in the period December 2022 – February 2023 using a *flow water meter* recording system for 2 hours
5	Why	Why does the use of clean water need to be controlled and why does *the green manufacturing* system need to be applied?	Because water is a primary need in the company's production system that has the potential to increase production costs and *green manufacturing* systems need to be implemented to achieve the goals of green industries and maintain sustainable energy for the next generation
6	How	How to control the use of clean water and *green manufacturing* systems can be applied at PT. Karton Cikarang?	By reusing waste treatment water called *water recycle* so that the need for mixing ink, glue and cleaning and machine maintenance needs can use *water recycle* and can indirectly reduce the discharge of treated wastewater into the environment and contribute to protecting the environment

After analysis through the 5W1H approach, it is known that the cause of the high use of clean water at PT. Kartoon Cikarang, the location of the highest and lowest use of clean water and control of clean water use through a green manufacturing system that can minimize the disposal of treated liquid waste directly into the environment but reused for water needs in the production area.

B. Value of Risk Priority Number (RPN)

After identifying the failure mode, effect of failure, cause effect, the next stage is setting the severity rating value, setting the occurance rating value, determining the current control, setting the detection value, and calculating the Risk Priority Number (RPN).

RPN = severity rating x occurance rating x detection rating (1) = S x O x D

The RPN table can be seen in the following table.

Table 8: Risk Priority Number (RPN)

Process Name	Failure Mode	Effect of Failure	Cause of Failure	Current Control	Existing Condition			
					S	O	D	RPN
Printing on converting machines	There is high use of clean water for the needs of mixing ink, cleaning and machine maintenance in converting machines	High water use and wastage	The existence of cleaning, machine maintenance and ink mixing processes	The use of water recycle as a substitute for clean water	4	3	5	60
Cleaning in corrugator machines	There is a high use of clean water for machine cleaning and machine maintenance needs	Water use is quite high and waste occurs	The existence of a cleaning process and machine maintenance	The use of water recycle as a substitute for clean water	3	3	4	36
Mixing glue in finishing machines	There is the use of clean water for machine cleaning and glue mixing needs	There is waste	The existence of cleaning, machine maintenance and glue mixing processes	The use of water recycle as a substitute for clean water	2	3	3	18

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Based on the problems that have been found above, the root cause of the problem is sought using *Faulth Tree Analysis* (FTA) which is described in the following figure.

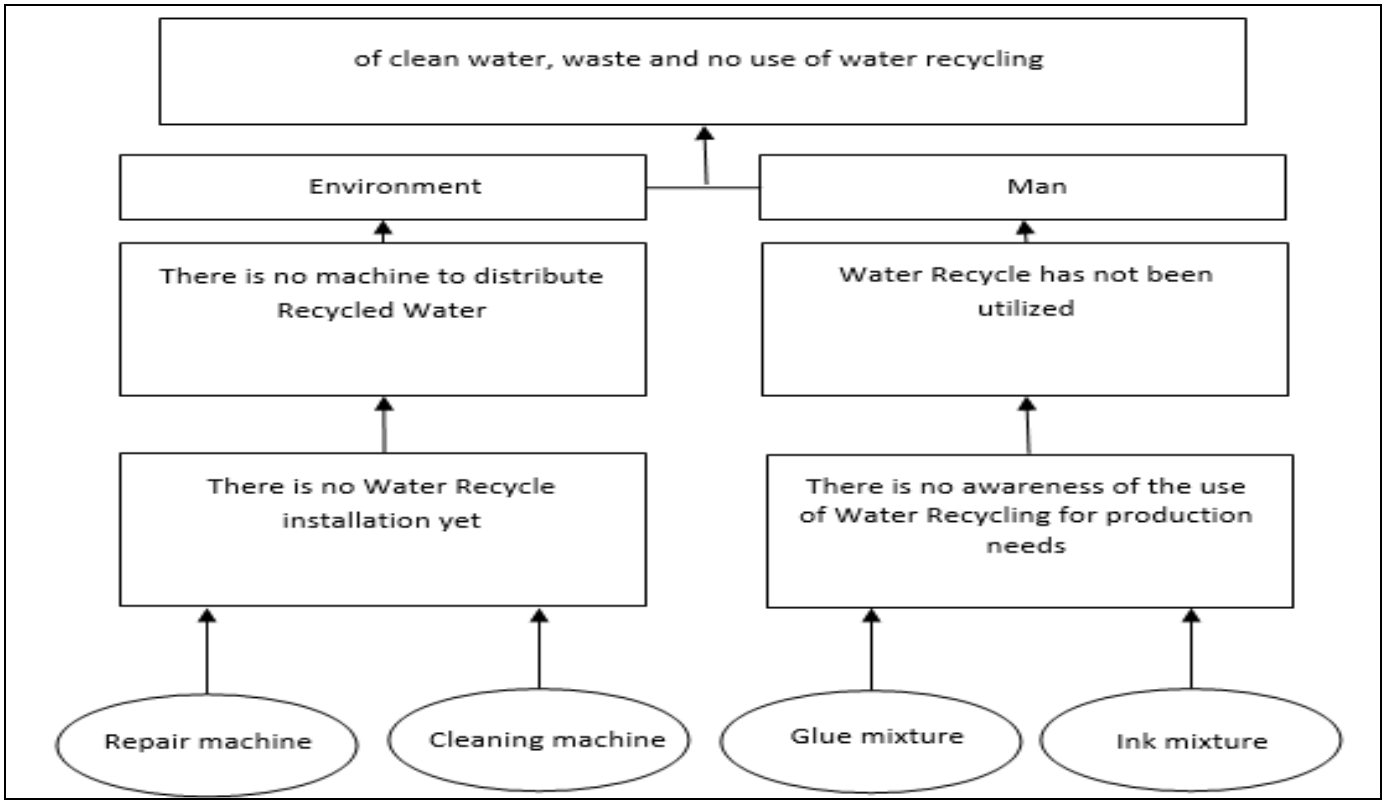

Fig 3: Faulth Tree Analysis

C. Implement Water Recycle Usage Design

Based on the data that has been collected, it was found that the results were in the form of high use of clean water in the production department of PT. Karton Cikarang is caused by the average usage on the Converting machine of 3,350 m3, the average corrugator machine of 1,585 m3 and the smallest on the finishing machine with an average use of 950 m3, then a discussion was carried out through a focus group discussion (FGD) which was attended by experts and employees who have experience in the field of production to propose an installation design for the use of water recycle for the needs of the production department.

In order to provide an overview of the causes of the high use of clean water and suggestions for improvements that can be made by PT. Karton Cikarang, then poured in the fishbone diagram in the following picture.

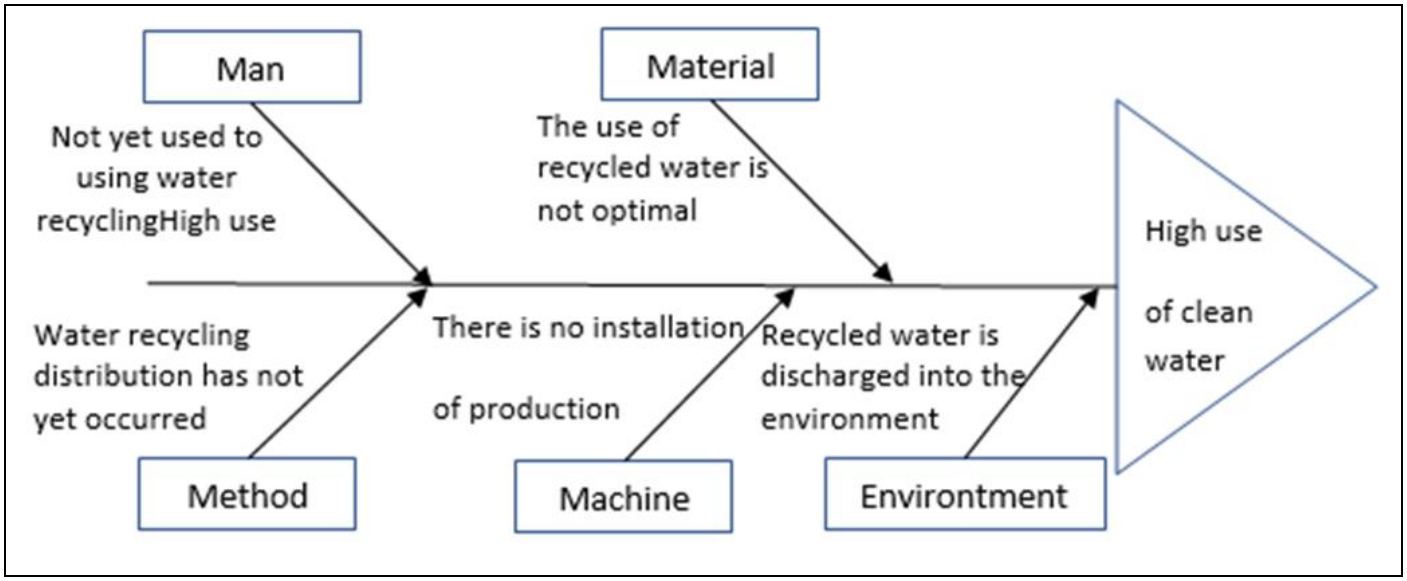

Fig 4: Fish Bone Diagram

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In its implementation, there are several material needs that need to be prepared before the water recycle installation process is carried out, the estimated needs are based on the distance and area of the work area which includes 3 machines, namely corrugator, converting and finishing. Some material suggestions needed in the process of installing water recycle are outlined in the following table:

Table 9: Installation Material Requirements Advice

No	Tool Name	Sum	Allocation
1	PVC Pipe 1/2 Inch	2 Bars	Water recycle *installation media needs*
2	2 Inch PVC Pipe	30 Bars	Water recycle *installation media needs*
3	Elbow PVC ½ Inch	6 Pcs	Water recycle *installation media needs*
4	Tee PVC ½ Inch	2 Pcs	Water recycle *installation media needs*
5	Elbow PVC 2 Inch	13 Pcs	Water recycle *installation media needs*
6	Elbow PVC 2 Inch	8 Pcs	Water recycle *installation media needs*
7	3 Phase Water Pump	2 Units	Water recycle *installation media needs*
8	Toren Water Storage Capacity 1,500 Liters	1 Unit	The need for shelter before being flowed into production
9	Automatic Water Buoy Radar	1 Set	To adjust the water level in the toren so that use can be done automatically
10	Electrical Devices (MCB, Cables and Stackers)	1 Set	For electrical needs of *water recycle installation*

To provide a visual overview of the *water recycle* installation at PT. Cikarang Carton is then poured in the following draft picture:

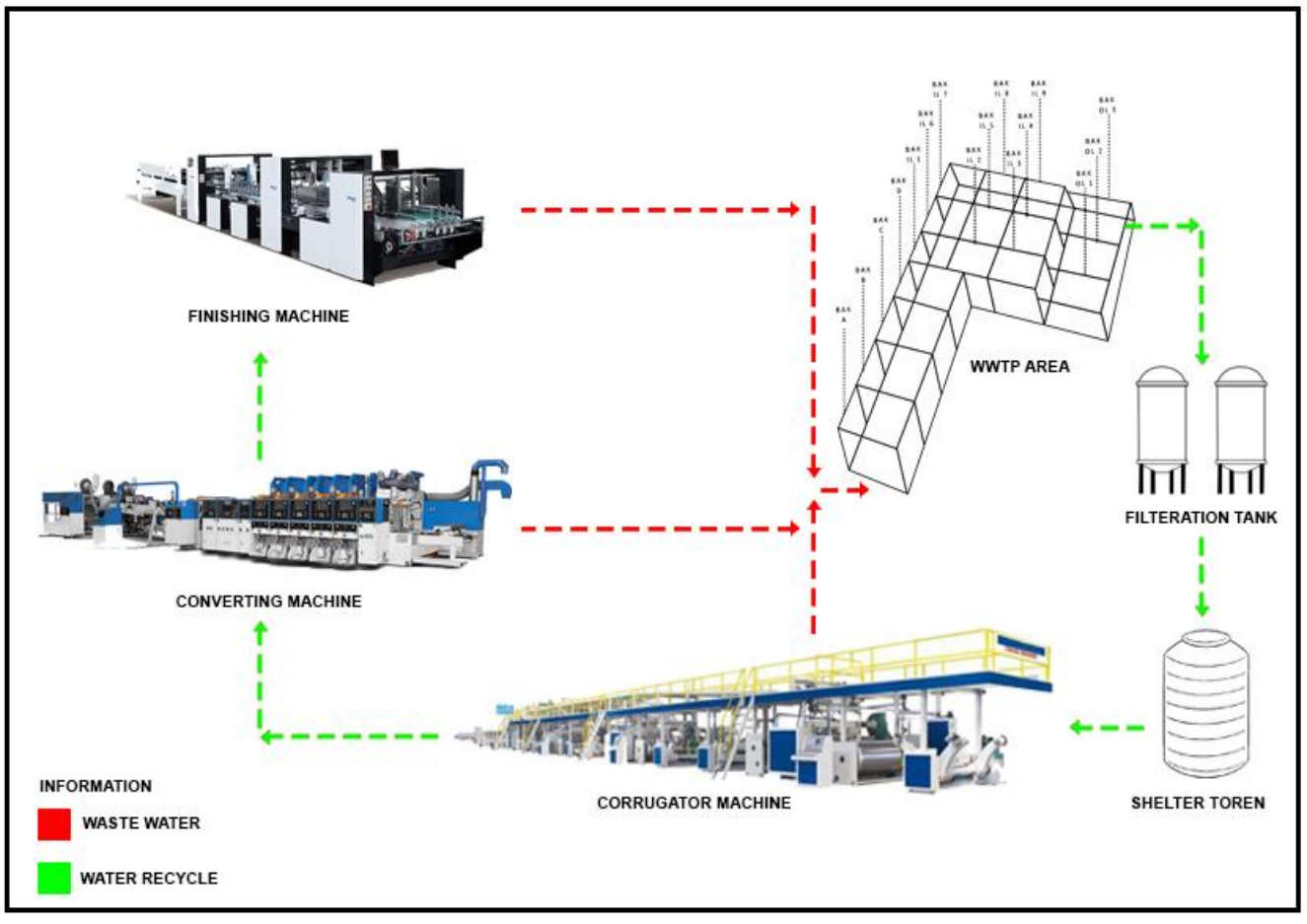

Fig 5: Water Recycle Installation Suggestions

In the picture, the water recycle distribution line uses a green line that crosses the WWTP area, a filtering tank, a storage toren and then distributed to corrugator machines, converting machines and finishing machines, and there is a liquid waste disposal line which is denoted using a red line, the liquid waste produced is then processed in the WWTP area.

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V. CONCLUSION

➢ *From the Results of Research Conducted at PT. Karton Cikarang, can be Concluded Several Things as Follows:*

- Based on calculations using the FMEA method, it is known that the percentage of clean water use in the production department is divided into 3 parts, namely converting machines (57%), corrugator machines (27%) and finishing machines (16%) which means that the most clean water use is used by converting machines and the least water use is used by finishing machines. The allocation of water use in converting machines is influenced by the need for water mixture with ink, engine cleaning and machine repair, corrugator machine needs are influenced by the need for machine cleaning and machine maintenance, while finishing is influenced by the need for mixing glue with water, machine cleaning needs and machine maintenance and all use is recorded through a flow water meter which is documented every 2 hours.
- Based on the data that has been collected, results were found in the form of high use of clean water in the production department of PT. Karton Cikarang is caused by the average usage on the Converting machine of 3,350 m3, the average corrugator machine of 1,585 m3 and the smallest on the finishing machine with an average use of 950 m3, then a discussion was carried out through a focus group discussion (FGD) which was attended by experts and employees who have experience in the field of production to propose an installation design for the use of water recycle for the needs of the production department. In its implementation, there are material needs that need to be prepared before the water recycle installation process is carried out, the estimated needs are based on the distance and area of the work area which includes 3 machines, namely corrugator, converting and finishing.

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