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PLASTIC PACKAGING WASTE MANAGEMENT THROUGH FILLING MACHINE WITH AGILE REENGINEERING PROJECT MANAGEMENT APPROACH

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Abstract In Indonesia, the number of plastic wastes has reached 66 million tons per year in which 50% of them come from plastic packaging waste. Meanwhile, the recycling of plastic packaging waste only reaches 14%. Hence, it is highly urgent to be aware of plastic packaging waste management in order to tackle this issue. The research discussed the capability and potential of applying digitalization and automation to Smart Retail Technology which focuses on filling machines to manage plastic packaging waste management and increase the competitive advantage. This research uses two main approaches, namely Business Process Reengineering and Agile Project Management to recommend a new business process on ongoing project. The result of the study suggests the urgency to take advantage of the QR Code and Human Machine Interface to maximize the effectiveness and results of implementing the business process. By using simulation, this effort is expected to reach up to 334 consumers each day with up to 42.14% of machine utilization.

Keywords: Plastic Packaging Waste Management, Smart Retail Technology, Filling Machine, Business Process Reengineering, Agile Project Management

1. Introduction

The company is one of the manufacturing companies in Indonesia focusing on the beauty industry. Nowadays, the company faces several challenges in its supply chain process, such as more than 1.400 Stock Keeping Units (SKU), 1.100 raw materials, 4.000 packaging materials, 200 New Product Developments (NPD) each year, and 500 supplier networks which are spread over several parts of the world, as well as unpredictable demand change. SKU handling plays a major role in saving space, time and inventory transportation costs [1],[2]. Handling NPD plays a major role in supply chain capability, the effectiveness of new product introductions, and the development of company performance [3]. The high amount of raw material, packaging, and new product development results in higher plastic production that highly impacts sustainable development. Even Ali, Sara, & Rahman (2021) stated that until 2016, plastic production in the world had reached 311 megatons (Mt) and expected to reach 1,1 billion tons in 2050 [4]. Due to its difficult parsing, only 9% of plastic is recycled, 12% is burned, and 79% is dumped in landfills. This fact is certainly very dangerous for food safety and the welfare of living things.

One of the most important contributors to plastic waste is product packaging [5]. The number of single-use plastic packaging usage will only result in more plastic production [6]. Since 2015, plastic packaging has accounted for almost 50% of the total plastic waste in the world, where most of them do not get proper treatment. Fast Moving Consumer Goods (FMCG) industry is the largest plastic waste contributor in the world. Based on data provided by Forbes (2020), the largest amount of plastic packaging waste generated by FMCG companies reached 2.900.000 tons in 2020 [7]. The plastic packaging waste treatment was even still very inappropriate, only 14% of plastic packaging waste was recycled.

The company also produces its products with packaging that is dominated by plastic. Moreover, the company is trying to expand its business in the personal care area. Therefore, wise plastic packaging waste management is needed to increase sustainability and benefits for the environment. It is getting more important because as the consumer needs and demands for

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high-quality products are getting higher, the level of competition will be as well. Several previous research deals with plastic waste management by using bioplastic bags combined with carbon taxes and sustainable development [4], reusable and refillable system with lightweight materials, and guarantee return system for the bottle [8].

Developing process efficiency and effectiveness can be achieved by utilizing appropriate technology. In Industry 4.0, many manufacturing companies are starting to plan to implement digitalization and automation in their business processes. To support Industry 4.0, several aspects that can be developed are BlockChain (BC), Cloud Computing (CC), Big Data Analysis (BDA), Additive Manufacturing (AM), and the Internet of Things (IoT) which are used to collect, analyze, and make decisions from big data in real-time[9]. Companies can utilize a combination of these aspects to create new business models that can access and share customized product information in real-time to minimize several wastes, namely waiting, transportation, and overprocessing[10], [11]. The use of this model is considered to be able to help companies evaluate various scenarios related to the implementation of new business models before applying them in real conditions [12]. In fact, future supply chains have started to use BC technology to handle information more transparently to minimize disruption and improve customer service[13]. Apart from that, the application of automation will also help minimize human errors and increase the accuracy of forecasting and calculations [14].

By looking at this current situation, the company decided to initiate Smart Retail Technology (SRT) in some of its independent stores. The SRT would focus on filling machines to minimize the amount of plastic packaging used in its products with the principles of refill and reuse. SRT is considered an innovation that is suitable for increasing users' awareness of plastic waste management efforts [15]. Quoted from Greenpeace (2021), the reuse principle was considered appropriate to be applied in Indonesia to overcome the plastic waste problem, not only from the symptoms but also the root cause [16]. Meanwhile, this principle also benefits the company and consumers through production and product purchase cost savings. This research aims to identify, evaluate, and analyze the supply chain business process in the current research object, as well as propose suggestions for business process improvements related to the filling machine implementation based on the Business Process Engineering approach.

2. Methods

The data collected consists of qualitative data (derived from the interview and observation results) and quantitative data (derived from the observation and documentation of the company's actual conditions and expert judgment). Qualitative data collection is intended to obtain information from research targets at the Supply Chain Management Directorate and Project Manager Division related to the supply chain business process of the current research object which involves the use of plastic packaging and the flow of filling machine implementation in other Fast Moving Consumer Goods (FMCG) companies. This data is collected through interview sessions with the employees and through other company websites.

Quantitative data collection involves the assessment of several proposed to-be business processes. This assessment score (weighting) is collected by the Manufacturing Excellence Division team of 3 people and the researcher itself through joint discussions. Business Process Reengineering is a critical technique for building or increasing process efficiency, and it entails redesigning the company (in whole or in part) to produce major gains in quality, productivity, customer happiness, and speed to market [17]. The proposed to-be business processes are developed by improving the flow of filling machine implementation in other FMCG companies, added with some technology implementations. Here are some of the considered categories[18], [19]:

a. Cost, the number of investment costs required to buy the material or equipment that the company has not owned yet.
b. Cycle time, the amount of time and steps required by consumers to fill the product in the filling machine.
c. User experience, the level of attractiveness and functionality of each alternative.
d. Reliability, the ease of doing maintenance and repairs.
e. Automation, the increase of business process effectiveness and efficiency.
f. Innovation, the uniqueness and differentiation of business process from the

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existing process in other companies (the usage of a button that must be pressed and held by a consumer).

g. Compatibility, the ability to adjust the net product to the bottle size provided by the company.

Table 1 provides a detailed explanation for each category using a Likert Scale which is universally known. Hence, choosing the Likert Scale is aimed to give the same understanding of the explanation for each assessor.

The next stage is data analysis. The data analysis technique is carried out through quantitative calculations using the AHP method (Expert Choice software) and validated with Fuzzy AHP (Microsoft Excel) to determine the most suitable business process to be implemented. Fuzzy Analytical Hierarchy Process (Fuzzy AHP) to minimize uncertainty in real problems [20], [21]. Table 2 shows the calculation base of Fuzzy AHP.

The selected business process is then modeled using Promodel software to find the estimated supporting indicators, such as the number and duration of queue, cycle time, and the number of outputs [22]. The efforts needed to monitor the to-be business process refer to the Critical Success Factor (CSF) and project management principles using the Scrum framework which involves several sprints for the whole development period[23]. The Critical Success Factors (CSF) in implementing SRT in the future (can be seen in Table 3).

Table 1. Weighting Categories of Business Process Alternatives

Category	Scale				
	1	2	3	4	5
Cost	> IDR 2 Mio	IDR 1 – 2 Mio	IDR 0,5 – 1 Mio	IDR 0,1 – 0,5 Mio	< IDR 0,1 Mio
Cycle Time	Involves QR Code with > 9 steps	Involves QR Code with 5 – 7 steps	Involves QR Code with 3 – 5 steps	Involves button with 3 – 5 steps	Involves button with < 3 steps
UX	Very low	Low	Neutral	High	Very high
Reliability	Very low	Low	Neutral	High	Very high
Automation	No automation	Involves button only	Involves button and QR Code	Involves button, QR Code, and HMI	Involves QR Code and HMI
Innovation	Not different yet not unique	Less different, but not unique	Less different and unique	Different and unique enough	Very different and unique
Compatibility	Not suitable	Less suitable	Neutral	More suitable	Very suitable

Table 2. Fuzzy AHP Method (Fuzzy Triangular)

	Saaty Scale	Fuzzy Triangular		
1	Equally Important	1	1	1
3	Weakly Important	2	3	4
5	Fairly Important	4	5	6
7	Strongly Important	6	7	8
9	Absolutely Important	9	9	9

Table 3. Critical Success Factor (CSF)

Type	Aspect
General	Safety – The machine is safe to be used by consumers
	Quality – The filling and interface qualities are very good
	Cost – The machine installation cost is worth the machine quality
	Delivery – The machine can be designed and delivered within 5 months (February – July 2022)
	Hygiene – The bulk storage system and product dispensing are hygienic
	Morale – Consumers' integrity can be increased because the machine can only be activated by using QR Code
	Environment – The machine does not produce emission which harms the environment

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Table 3. Critical Success Factor (CSF) (Continue)

Type	Aspect
Software	QR Code is integrated with consumer data on WebApps
	QR Code and label can be printed from the operator's PC or computer and can be read (no blurry or truncated information)
	QR Code can activate the filling machine
	The information on the number of bottles used appears on WebApps
	Consumers have access to their accounts to be informed to the operator under certain conditions
	The operator can access WebApps and input consumer data completely
	The operator can successfully scan QR Code and is immediately directed to WebApps
	HMI can display the information clearly
	The HMI touchscreen can work well
Machine	The "Start" button can automatically eject the product or fluid while being touched
	The machine can dispense product or fluid with a net product accuracy of about 250 ml and an error of less than 3%
	The machine can detect the minimum product limit in the tank to issue a marking signal
	The filling speed is ±200 ml/minute
	QR Code and label can be printed from the printer
	The machine can be successfully activated by scanning the QR Code
	The machine stops after dispensing the right amount of product net
Label	QR Code and label can be read clearly

3. Results and discussion

There are 2 (two) main research results, namely as-is business process (covering supply chain business process related to waste management in the company and the flow of Smart Retail Technology implementation from other FMCG companies) and the results of experts' business processes weightings.

3.1 As-Is Business Process

In its supply chain, the company has a business process like the general supply chain process, starting from raw material supplies, production, until the product arrives in the consumer's hand (can be seen in Figure 1). Based on the figure 1, the major use of plastic packaging comes from suppliers and packaging processes (primary and secondary).

In addition to the supply chain business process related to waste management within the company, this research also focuses on the flow of filling machine implementation by other FMCG companies as benchmarking material in the to-be business processes design as shown in Figure 2. In general, the usage of filling machines is considered able to increase public awareness of plastic waste management, reduce plastic material production costs, and minimize the potential for natural disasters due to recklessly handled waste [24]–[26].

Based on the figure 2, some activities are considered possible to be eliminated, such as the bottle weighting and masses difference calculation. Apart from that, some activities are also possible to be automated with the technology implementation, such as the product filling and final bottle weighting processes.

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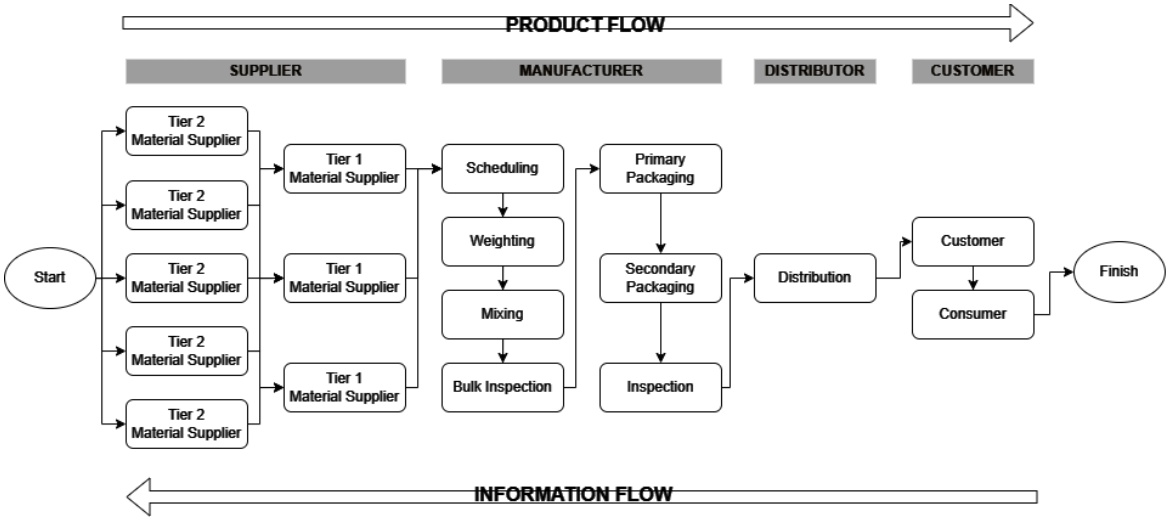

Fig 1. As-Is Business Process in the Company

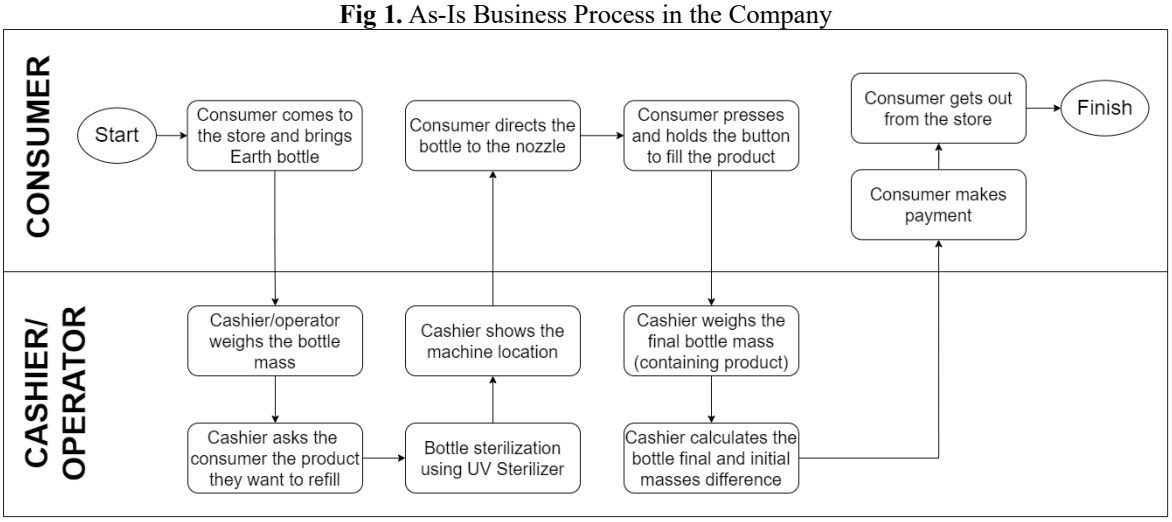

Fig 2. The Flow of Filling Machine Implementation by Other FMCG Companies

3.2 Business Process Weightings

Business process weightings are done by using the AHP method (Figure 3). In this method, the assessors must prioritize which weighting category is the most important and which one is less important. Then, the assessors give some scores for each business process alternative to know the best. The weightings are also done by using the Fuzzy AHP method (Table 4). The weighting results show that alternative 2 is the most suitable to be implemented due to the highest score. However, a future plan is needed to improve the reliability score of this business process.

3.3. Business Process Evaluation

As-is business process evaluation focuses on activity or task analysis which may increase the plastic packaging usage of as-is business process in the company as well as the non-value-added ones, as explained in Figure 4. The figure 4 shows that the major use of plastic packaging comes from suppliers and both packaging processes. Meanwhile, the flow of filling machine implementation in other FMCG companies has some non-value-added activities which can be eliminated, such as the bottle weighting and masses difference calculation. Apart from that, some activities can also be automated with the technology implementation, such as the product filling and final bottle weighting processes.

3.4 To-Be Business Process

To-be business process is designed regarding the implementation of the filling machines that aim to assist consumers in filling the products in the company independently into an environmental-friendly refill bottle (Earth bottle) in a size of 250 ml. In this industry 4.0 era, the suggestion of new business process

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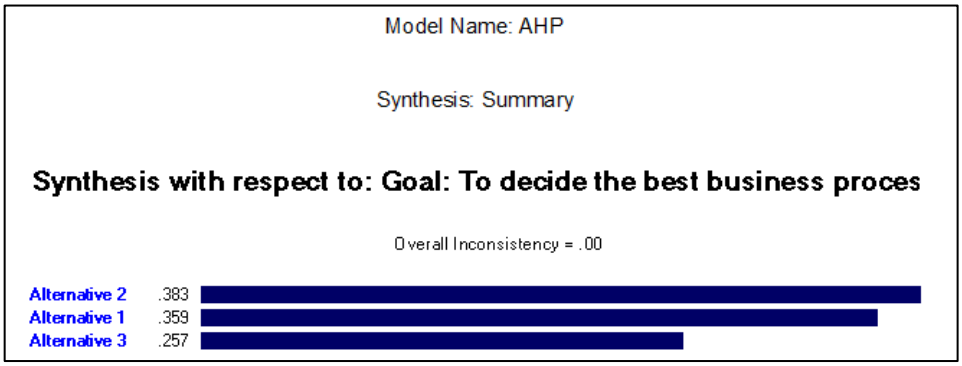
design is integrated with digitalization and process automation, that is implementing the Internet of Things (IoT) in a form of a QR Code. QR Code plays a role in the collection process of consumer data, bottle usage, product information, and filling machine usage. QR Code will be attached to a label that contains important information for the consumers and operator, such as bottle code, product name, and product expiration date. The label and QR Code will always be replaced for each purchase to update the information in it. The to-be business process design is adjusted to the real situation in the company which has no experience in operating filling machine systems and implements digitalization gradually so that the human role (operator) is still needed for collecting consumer data.

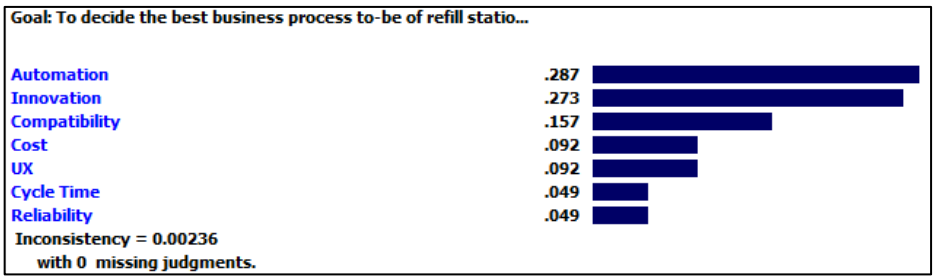
There are 3 (three) types of new business process design scenarios or alternatives with the main differentiation in the filling machine usage process:

a. The Usage of QR Code and Button

In the first alternative, the QR Code can be used by the consumer to activate the filling machine by scanning it on QR Scanner at the machine. The first alternative only allows the consumer to fill the product in a size of 250 milliliters (the bottle size) so that the provided button at the machine is only the "filling" button. Figure 5 shows the flow of the first scenario or alternative implementation. The first to-be process is designed with several technology implementations, but not as much as the second to-be process. While the other activities are referred to as the as-is process.



(a)



(b)

Fig 3. Business Process Weightings (AHP)
(a) Business Process Alternatives ; (b) Category

Table 4. Business Process Weightings

	Alternative 1	Alternative 2	Alternative 3
Cost	0.03565082	0.00431716	0.03271049
Cycle Time	0.0106954	0.0106954	0.0106954
UX	0.02928434	0.03480735	0.00858895
Reliability	0.00840473	0.00348412	0.02032036
Automation	0.08820699	0.21383177	0.03686831
Innovation	0.11486685	0.11486685	0.04079878
Compatibility	0.06030198	0.06030198	0.06030198
Total	**0.34741111**	**0.44230463**	**0.21028426**

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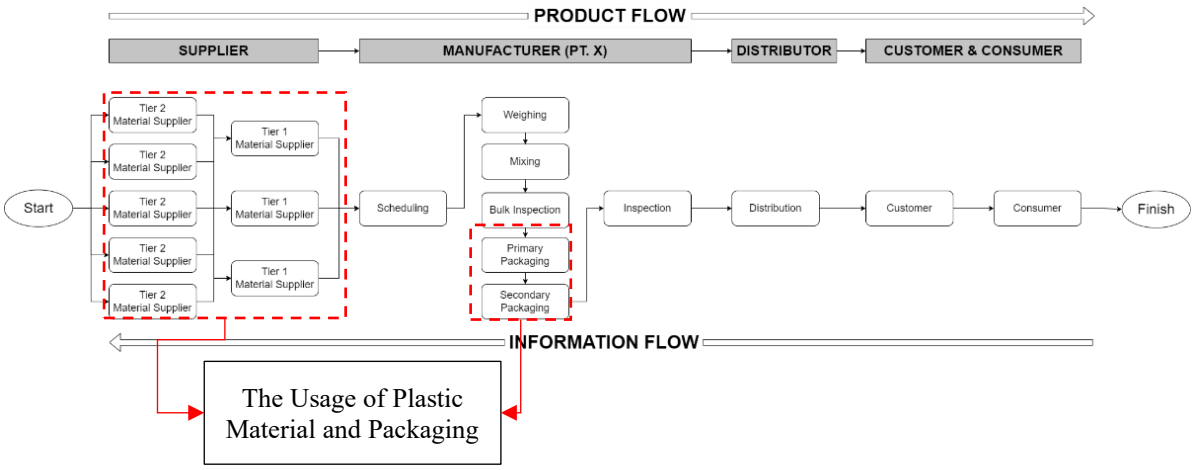
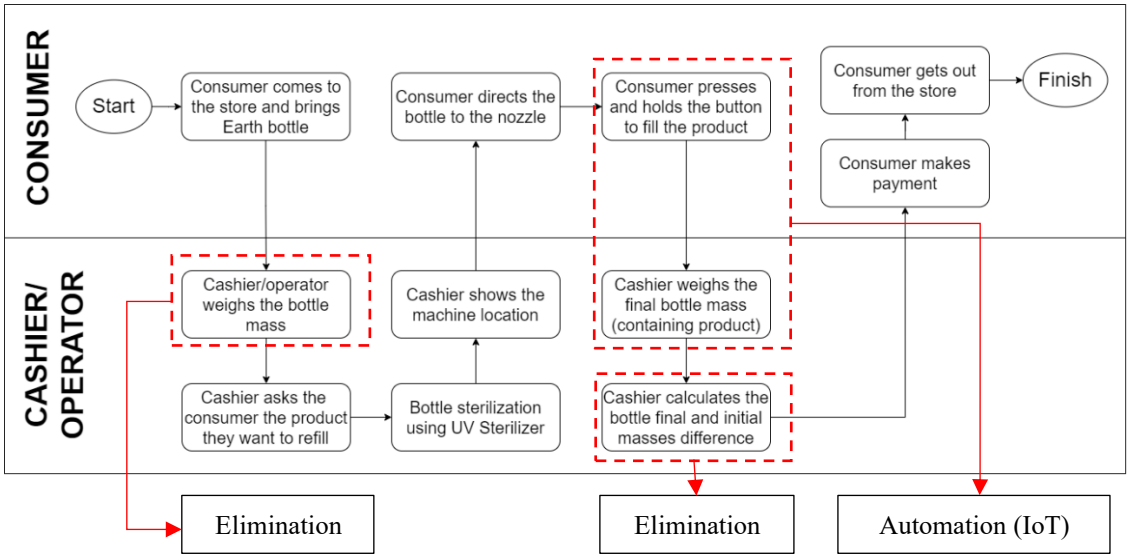


(a)



(b)

Fig 4. As-Is Business Process Evaluation
(a) The Company ; (b) Other Companies

b. The Usage of QR Code and HMI

In the second alternative, the usage of QR Code is like the first one which is to activate the filling machine. Meanwhile, Human Machine Interface (HMI) is used in the form of a touchscreen to show the product information and touchable filling icon, therefore HMI replaces the function of the button in the first alternative. Figure 6 shows the flow of the second scenario or alternative implementation.

The second to-be process is designed based on what kind of technologies can be used to automate the as-is process. The budget needed may be higher than the other to-be processes, but this process focuses more on the automation and the innovation. While the other activities are referred to as the as-is process.

c. The Usage of Buttons

In the third alternative, the usage of the filling machine depends on the buttons. There are several types of buttons in this alternative, such as 1 (one) machine activation button and 3 (three) filling buttons which consist of small (50 ml), medium (150 ml), and large (250 ml) buttons. Therefore, this alternative allows the consumers to choose the product net they want to refill. Figure 7 shows the flow of the third scenario or alternative implementation.

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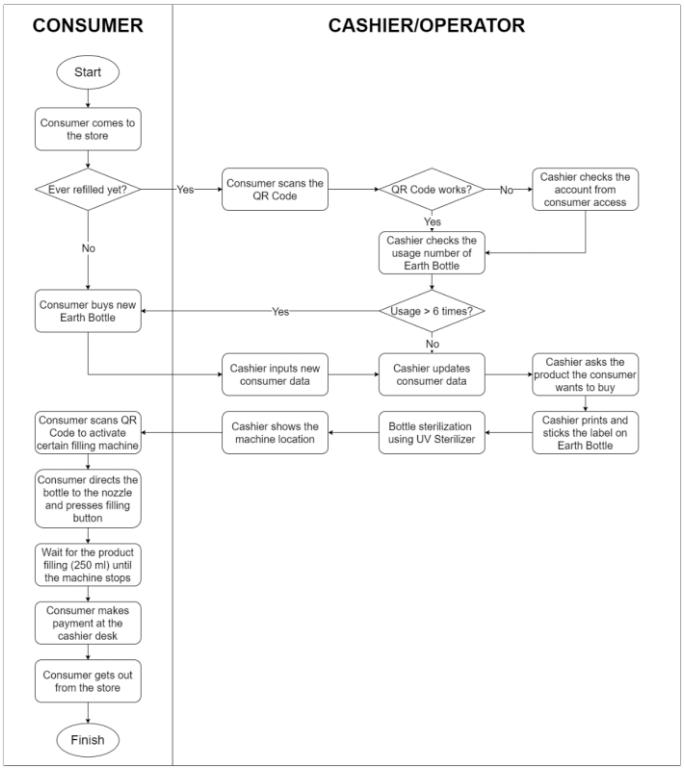

Fig 5. The First To-Be Process Design

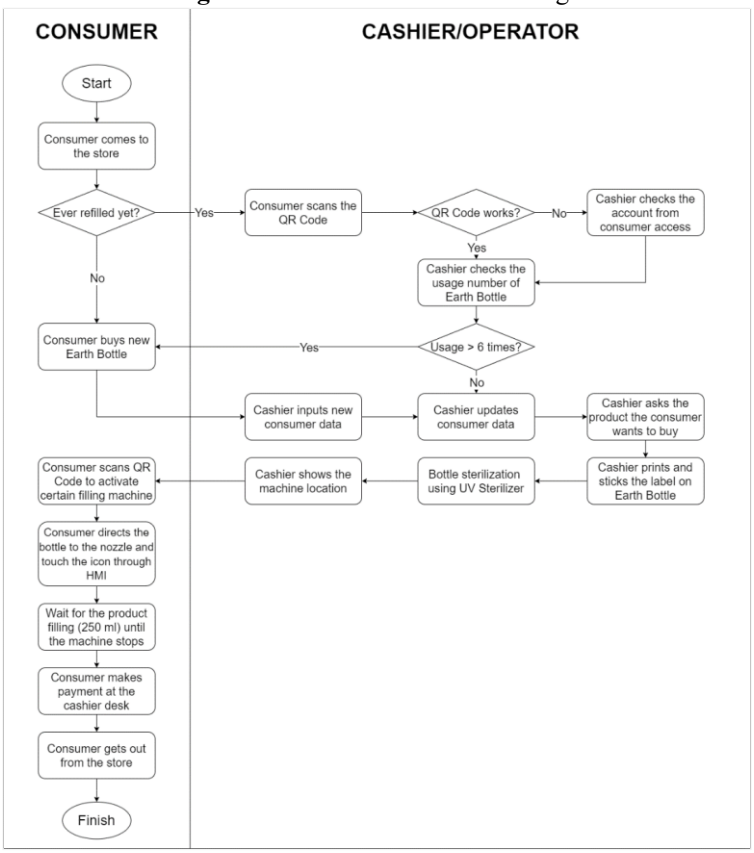

Fig 6. The Second To-Be Process Design

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The first to-be process is designed to be as simple as possible with less technology implementation to press the budget needed. While the other activities are referred to as the as-is process. Based on the data analysis before (Figure 3 and Table 3), the most suitable business process alternative to be implemented in the company is the second alternative (the usage of QR Code and HMI) because of the highest weighting score. This result has been approved by some related parties in the company.

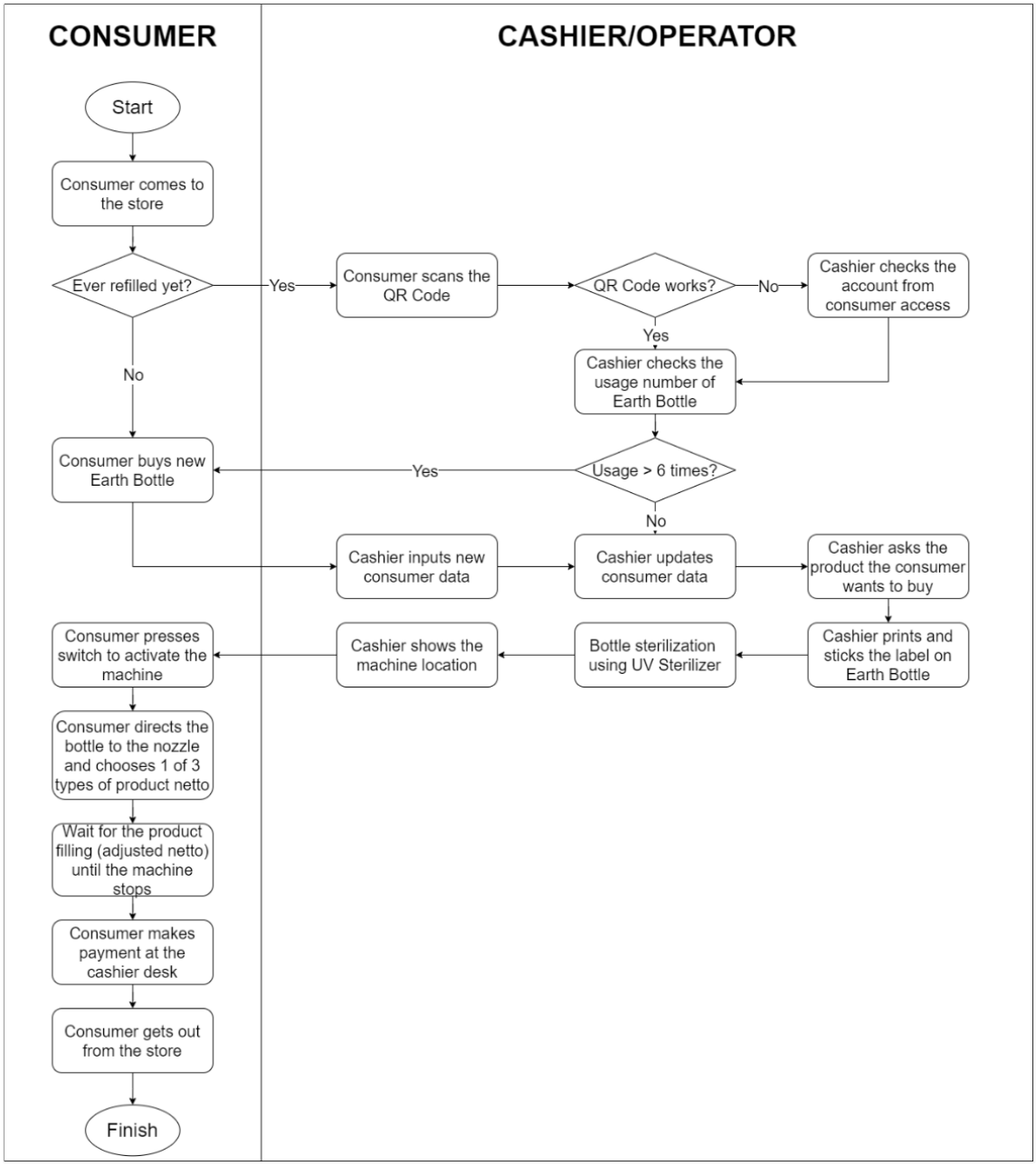

Fig 7. The Third To-Be Process Design

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3.5 Simulation Modeling

Simulation modeling is used to analyze the predicted result for the company if the to-be business process is implemented, as the company has not entered the implementation stage in the actual condition. There are several assumptions in the simulation modeling, such as:

a. The layout of the cashier desk and filling machines are randomly arranged.
b. There are 6 (six) filling machines determined as the company planned.
c. The amount of time needed by the consumer to do the task or activity is rationally set, but still not precise with the actual condition.
d. The total duration of the simulation is set to 7 (seven) hours.
e. All the potential risks are ignored.

Figure 8 is the simulation interface done to the chosen to-be business process. In the simulation model above, blue circle indicates the entry and exit door in the store for consumers. Barrels indicate the earth bottle sold in the store. The ladder indicates the user's flow after entering the door and making the payment in the cashier area. The woman in blue and brown table indicates the cashier area. Six machines indicate the filling machines.

In the simulation model above, blue circle indicates the entry and exit door in the store for consumers. Barrels indicate the earth bottle sold in the store. The ladder indicates the user's flow after entering the door and making the payment in the cashier area. The woman in blue and brown table indicates the cashier area. Six machines indicate the filling machines.

The simulation shows that each store can possibly serve up to 243 customers who successfully enter and exit the store within the assumptions given, with the balanced utilization of each machine. The utilization is still quite low which impacts in higher idle time. Hence, there is a room for improvement in the future.

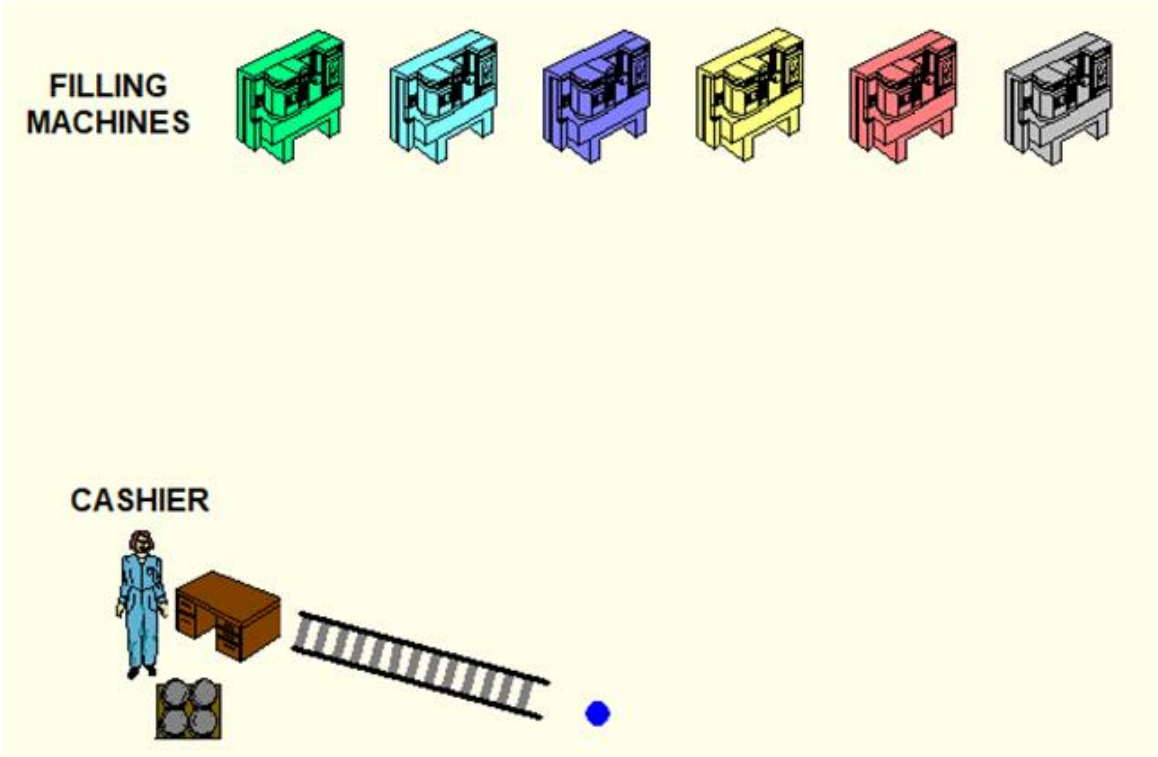

Fig 8. Simulation Model

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Locations for refill station simulation

Name	Scheduled Time (MIN)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
L CashierDesk	420.00	1.00	490.00	0.75	0.87	1.00	0.00	87.38
L Machine1	420.00	1.00	42.00	3.23	0.32	1.00	1.00	32.31
L Machine2	420.00	1.00	40.00	3.31	0.32	1.00	0.00	31.56
L Machine3	420.00	1.00	35.00	3.33	0.28	1.00	0.00	27.77
L Machine4	420.00	1.00	46.00	3.29	0.36	1.00	1.00	36.00
L Machine5	420.00	1.00	39.00	3.30	0.31	1.00	0.00	30.64
L Machine6	420.00	1.00	44.00	3.31	0.35	1.00	0.00	34.69
L Machine	2520.00	6.00	246.00	3.29	0.32	4.00	2.00	32.16
L EarthBottle	420.00	999999...	0.00	0.00	0.00	0.00	0.00	0.00
Loc1	420.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Loc2	420.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
L Conveyor	420.00	999999...	250.00	5.03	2.99	3.00	3.00	89.38
L Door	420.00	999999...	1000242.00	419.84	999871.86	999998.00	999749.00	99.99

(a)

Location States Single/Tank for refill station simulation

Name	Scheduled Time (MIN)	% Operation	% Setup	% Idle	% Waiting	% Blocked	% Down
L CashierDesk	420.00	87.38	0.00	12.62	0.00	0.00	0.00
L Machine1	420.00	14.89	0.00	67.69	0.00	17.42	0.00
L Machine2	420.00	14.29	0.00	68.44	0.00	17.27	0.00
L Machine3	420.00	12.50	0.00	72.23	0.00	15.27	0.00
L Machine4	420.00	16.43	0.00	64.00	0.00	19.57	0.00
L Machine5	420.00	13.93	0.00	69.36	0.00	16.71	0.00
L Machine6	420.00	15.71	0.00	65.31	0.00	18.98	0.00
L Machine	2520.00	14.62	0.00	67.84	0.00	17.54	0.00
Loc1	420.00	0.00	0.00	100.00	0.00	0.00	0.00
Loc2	420.00	0.00	0.00	100.00	0.00	0.00	0.00

(b)

Entity Activity for refill station simulation

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Wait For Res (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
E Consumer	243.00	999756.00	210.70	0.43	0.00	6.40	203.86

(c)

Fig 9. Simulation Report
(a) Spread of Entity in Each Location (b) Percentage of Activities in Each Location
(c) Maximum Number of Entity Served

3.6 Benefit Analysis

By implementing the to-be business process, the company will be able to escalate its competitive advantage through digitalization and automation implementation in the industry 4.0 era increase brand awareness in consumers' views, as well as overcome the sustainability development goal through single-use plastic packaging waste management.

3.7 Implementation of Agile Project Management

This research will surely not go well without the role of project management, that is Agile Project Management which involves the Scrum framework. The agile method is chosen because the SRT project has never been implemented yet in the company so it will need a lot of adjustments during the project. Apart from that, by implementing the agile method, each iteration can be evaluated for improving the next iterations (through user feedback). The researcher uses software owned by the company to design the backlogs and iterations (sprints) needed to support the research. In addition, the usage of this software also assists the researcher in monitoring the progress of the project through Gantt Chart to monitor the works that will be, are currently, or have been done.

The filling machine implementation project is still a new project for the company and surely

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involves a lot of adjustments during the project, starting from business process design to the Minimum Viable Product (MVP). Therefore, the agile technique is considered appropriate to be applied in the project. Figure 9 is the results of implementing the agile technique. During the development of filling machine, Gantt Chart is used to divide the process into several sprints in which every output of each sprint is evaluated and revised on the next sprint. Using Gantt Chart results in more efficient development processes and more organized resource allocation.

4. Conclusion

This research discusses the huge usage of plastic material in terms of packaging which needs wise waste management through Business Process Reengineering. Alongside with the advanced technology in this era, the suggested business process through filling machines involves the implementation of digitalization and automation, including QR Code and Human Machine Interface which is considered capable of providing qualitative and quantitative benefits for related stakeholders. However, some optimization plans are needed as well for future implementation of filling machines. Before implementing the usage of filling machines, a study must be conducted to analyze the consumers' most wanted refilling products and the bottle materials (e.g., aluminum for the ease of recycling and long-term usage). To engage more consumer segmentations, a marketing effort to optimize the spread of discount information on WebApps or social

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