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Improvement Design of Packaged Juice Production Process using Business Process Reengineering

Novandra Rhezza Pratama[1*], Putri Amaliyah Agustin[1]

[1]*Department of Industrial Engineering, Faculty of Engineering, Universitas Indonesia, 16424, West Java, Indonesia*

Abstract. Process efficiency is required in packaged juice production to meet the greater demand for its product. The manual production process causes time loss, poses a bottleneck, and results in waste due to the time-consuming process. This study aims to design an improvement in the production process of packaged juice by eliminating the waste that occurs to increase the productivity and efficiency of processing. Process Activity Mapping and Waste Assessment are used to map the activities and identify waste. The improvement design is executed using a Business Process Reengineering (BPR) through implementing a combination of BPR best practices and simulation using iGrafx software. Process improvement involves the entire production process that consists of three stages, namely the puree-making stage, production stage, and packaging stage. This research resulted in designs of improvement solutions. The models of the improvement solutions are then simulated and produce an improved production process time. This solution resulted in a 34.9% reduction in distance traveled and a 50.54% reduction in total processing time.

Keywords: Business process reengineering; Packaged juice production; Process activity mapping; Waste; Waste assessment

1. Introduction

In 2020, Indonesia continued the trend of increasing fruit production by recording an increase of 10.46% from production in 2019 (BPS, 2020). However, the abundance of fruit production in Indonesia is not in line with the level of fruit consumption of the Indonesian population. Until 2020, the reality of the average consumption of fruits and vegetables in Indonesia was only 89gr/Cap/Day, far below the WHO's recommended RDA of 150gr/Cap/Day (BPS, 2021). Currently, packaged juice as one of the processed products derived from the fruit is often an alternative and a good approach to increase fruit consumption (Mushtaq, 2018). The continuous increase in consumer demand for packaged fruit juice presents opportunities for players in the Indonesian food and beverage industry to meet consumer needs, improve food security, and achieve Sustainable Development Goals (SDGs) (Berawi, 2019).

PT API is a food and beverage industry company specializing in packaged fruit juice drinks. One of PT API's production lines, namely packaged juice with the "Signature" label, has continued to increase in demand every month since the beginning of 2021. Given this projection, the current daily production capacity for "Signature" products may not be

*Corresponding author's email: novandra@ui.ac.id, Tel.: +62-21-78888805
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sufficient due to several constraints. These include the manual nature of the production process, which is time-consuming, lacks accuracy, and requires a significant number of workers. Due to these production problems, corrective steps needed to be taken by the company in the "Signature" production process to improve the business process and assess the waste problems.

Business processes can be stated as the formality of operations and process behavior of activities in an organization (Saragih, Dachyar, and Zagloel, 2021). The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed (Kyfyak and Lopatynskyi, 2018; Dumas *et al.,* 2018; Gunasekaran, and Kobu, 2002). Business Process Reengineering (BPR) is a philosophy of improvement (Towill, 2001) that aims to improve process performance (Mansar, Reijers, and Ounnar, 2009) by redesigning the processes an organization operates (Al-Shammari, M., 2009), maximizing value-added activities, and minimizing other activities (Martonová, 2013). There are 5 BPR steps (Mudiraj, 2014; Guimaraes and Paranjape, 2013): Prepare for BPR, Map & Analyze As-Is Process, Design To-Be Processes, Implement Reengineered Process, and Improve continuously. There are 10 best practices that can be applied in BPR (Kumar and Bhatia 2012; Mansar and Reijers, 2007), that is task elimination, task composition, integral technology, empower, order assignment, resequencing, specialist generalist, integration, parallelism, dan numerical involvement.

Lean Manufacturing (LM) is a method that helps companies identify and eliminate waste (Gupta and Jain, 2013; Wahab, Mukhtar, and Sulaiman, 2013) to increase value (Driouach, Zarbane, and Beidouri, 2019), improve quality (Anvari, Ismail, and Hojjati, 2011), increase production output (Singh, Singh, and Singh, 2018), and reduce lead time and production costs (Ahmad *et al.,* 2019; Satao, 2012). There are eight types of manufacturing waste (Liker, 2004): Overproduction, Excessive Inventory, Defect, Unnecessary Motion, Transportation, Overprocessing, Waiting, and Non-Utilized Resources. Waste can be divided into two categories (Gaspersz, 2007), namely non-value-added activities (NVA) and necessary but non-value-added activities (NNVA).

To describe the production process in detail from each activity, Process Activity Mapping (PAM) can be used (Amrina and Andryan, 2019; Zuting *et al.,* 2014; Pude, Naik, and Naik, 2012). PAM involves simple steps, first, analyzing the production process which is carried out sequentially from the beginning, followed by a detailed recording of all items needed in each process and conducting waste assessment (Mikkelsen, Lydekaityte, and Tambo, 2021; de Bucourt *et al.,* 2012; Teichgräber and De Bucourt, 2012). The waste assessment is used to identify critical waste that occurs throughout the manufacturing process (Singh, Ramakrishna, and Gupta, 2017; Rybicka *et al.,* 2015; Moinuddin, Collins, and Bansal, 2007) by distributing questionnaires to expert practitioners (Ekanayake and Ofori, 2004). The questionnaire was conditioned based on the Borda Count Method (BCM) (Emerson, 2013). BCM is one of the methods used to determine an alternative with the highest preference from several alternatives to be selected (Orouskhani, Teshnehlab, and Nekoui, 2019; Albanna and Karningsih, 2018; Van Erp and Schomaker, 2000).

This study discusses how we overcame technical problems, such as manual processing, bottlenecks, and long production times, as well as waste problems, including identifying the waste generated and how we overcame it. We improved our company efficiency and productivity by using the methods mentioned above. Through this research, we were able to determine the required production process tools, identify and eliminate waste, and design process improvements. We aspired that this research would contribute to enhancing the science of BPR and LM application in manufacturing processes.

2. Methods

The research was carried out at the PT API central factory in Indonesia from September to November 2021. Information regarding the product, production process, and production floor layout was obtained through observations and interviews with related parties. From that information, the authors created PAM to conduct a waste assessment using BCM. Then the authors designed an as-is model and simulated them using IGrafx software to calculate the cycle time, work time, and waiting time of each process. After that, the authors analyzed the process using BPR best practices and proposed to-be process design as a process improvement. A flowchart of the research methodology can be seen in Figure 1.

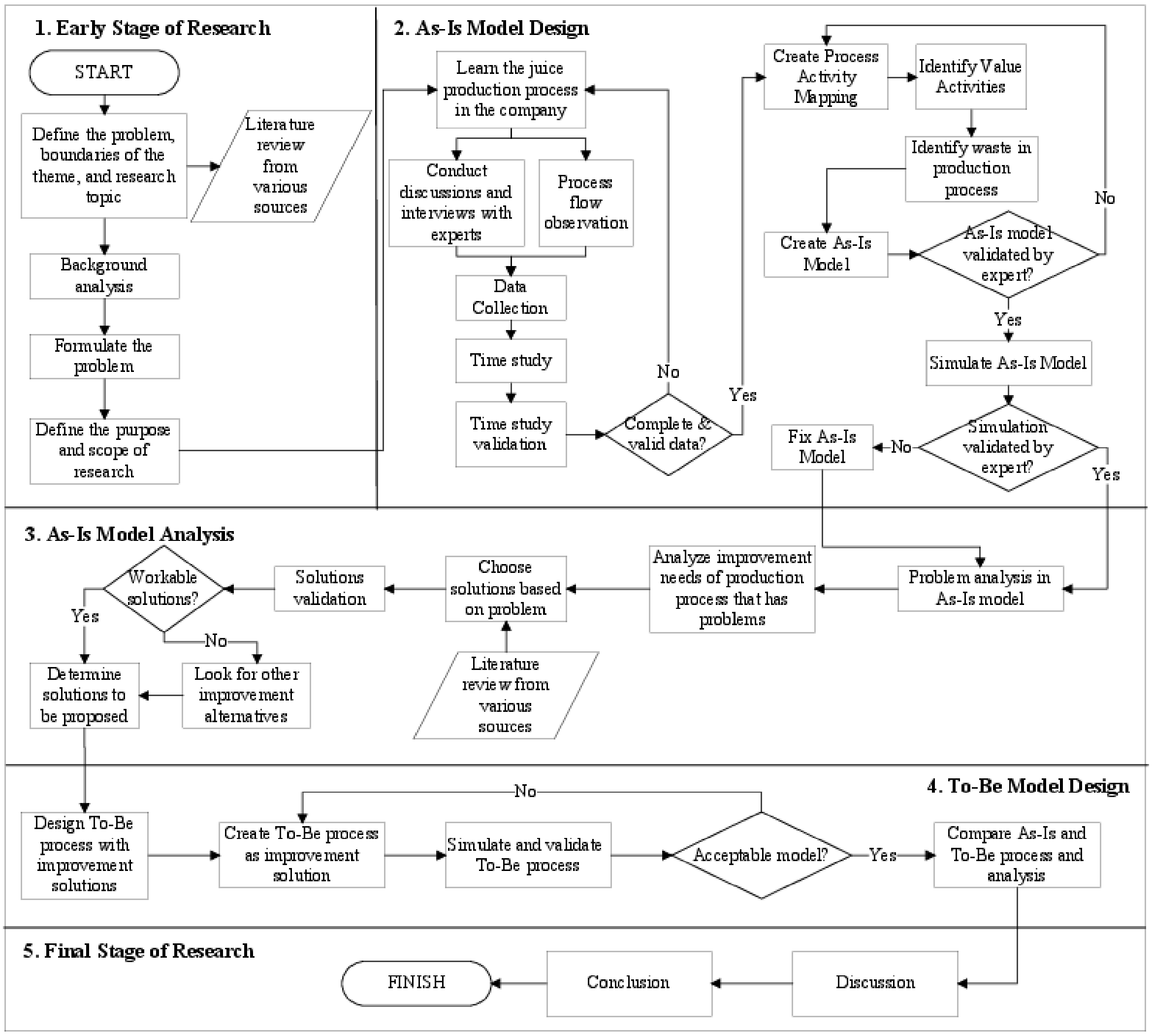

Figure 1 Methodology of this Research using combination of BPR and PAM

3. Results and Discussion

3.1. Overview of "Signature" Production Process

The activities carried out in the "Signature" production process are divided into three stages, namely, the stage of making semi-finished materials (puree), the production stage, and the packaging stage. The puree-making stage is the process of processing raw materials into semi-finished materials. The production stage is an advanced stage that processes semi-finished materials into finished products. In the production phase, there are five process phases, namely the preparation phase, pre-mixing and mixing, then pasteurization, filling, and cooling. After the production stage is complete, the last stage is packaging which consists of three process phases, namely the formation of packaging cartons, shrink/seals, and labeling. The divisions involved in the "Signature" production process are the production, QC, and warehouse departments, with the actors involved being workers from each of these divisions. The entire production process is carried out in seven places, namely the warehouse for raw materials and additives, puree making room, RTD room, washing room, QC room, finished goods warehouse, and production room. The as-is production floor layout is shown in Figure 2.

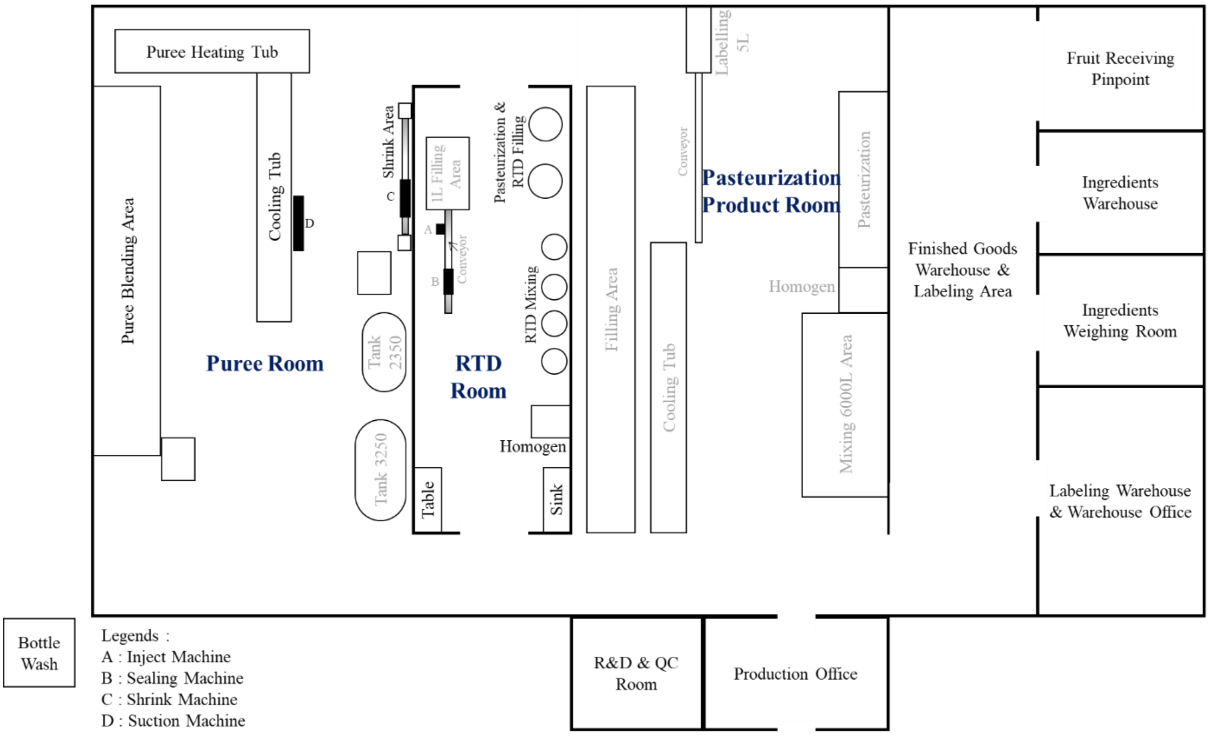

Figure 2 As-is Production Floor Layout

3.2. Current Process Activity Mapping

The identified activities are mapped into PAM with the following Table 1 and Table 2. Overall we can see that the production process consists of 76 processes, a total distance traveled of 195 m, and a total number of workers of 19 workers, with a total production time of 24 hours 51 minutes 5 seconds.

Table 1 Number of processes, the distance of movement, and the number of workers in the current PAM

Process	Puree Making	Production	Packaging	Total Process
Operation	9	18	18	45
Transportation	3	11	4	18
Inspection	0	4	2	6
Delay	1	4	1	6
Storage	1	0	0	1
Total Process	14	37	25	76
Distance Traveled (m)	45	96.6	54.14	195
Total Number of Workers	5	6	8	19

3.3. Critical Waste Identification

Questionnaires were distributed to experts to rank the types of waste that occur in the production process. Experts were asked to rate the types of waste with a rank of 1 to 8, then processed using BCM. Table 3 shows the result of the waste score.

Table 2 Overall Production Process based on Current PAM

Value Category	Total	Percentage	Time (hh:mm: ss)	Time Contribution
VA	34	44.7%	14:10:23	57.00%
NVA	7	9.20%	01:02:33	4.20%
NNVA	35	46.10%	09:38:09	38.80%
Total	76	100.00%	24:51:05	100.00%

Table 3 Result of Waste Score with Borda Count Method (BCM)

Waste	Total	Percentage	Rank
Waiting	37	25.34%	1
Transportation	27	18.49%	2
Unnecessary Motion	22	15.07%	3
Defect	19	13.01%	4
Overprocessing	13	8.90%	5
Excessive Inventory	10	6.85%	6
Non-Utilized Resource	9	6.16%	7
Overproduction	9	6.16%	8

From this score, it can be concluded that along the production line, the three largest contributing wastes are: waiting, transportation, and unnecessary motion. Waiting time between processes is mostly caused by machine set-up processes and separate processes between workstations. According to PAM, transportation is the second highest number of processes after an operation. This was deemed too frequent and a cause for concern with current production floor layout arrangements, requiring workers to carry out more transporting activities. Unnecessary Motion occurs due to the unnecessary movement of workers during the production process, which can be caused by transportation and over-processing. The authors focused on solving these problems in the next steps, as these already covered more than half of the total score.

3.4. Determination of Process Improvement Solutions

Based on as-is process analysis, we proposed solutions based on BPR Best Practices. The Business Process Improvement Plan is shown in Table 4. A solution was designed based on the proposed implementation of two technologies, namely an automatic labeling machine and 3 in 1 integrated filling machine, to assist the production and packaging stages. The implementation of this machine is proposed because, based on the As-Is model, the packaging stage is the process that takes the longest time because the labeling on the product packaging is done manually. With the implementation of this machine, more precise labeling can be achieved in less time. The automatic labeling machine can reduce the possibility of defects caused by damaged labels due to worker errors. This, in turn, ensures that the use of resources in the form of sticker labels is in line with the production plan and does not require additional goods requests. Figure 3 shows the proposed To-be production floor layout.

With the addition of a 3 in 1 machine, the process of bottle washing, filling, and bottle closing can be carried out in one machine, thus speeding up processing time and shortening process stages. This machine is needed to balance the speed of the automatic labeling machine so that starving does not occur. With the implementation of the 3 in 1 Integrated Filling Machine, there is no need for a bottle-washing workstation because the bottle-washing phase is carried out directly on the proposed 3 in 1 machine. Using these solutions, we can reduce the total processes in the future PAM (Tables 5 and 6). Comparing Table 5 with Table 1, we can see that the total process is reduced from 76 to 48, the total distance traveled is reduced from 195 m to 127 m, and the total number of workers is reduced from 19 workers to 8 workers. Comparing Table 6 with Table 2, we can also see that total production time is reduced from 24 hours 51 minutes 5 seconds to 12 hours 17 minutes 29 seconds, amounting 50.54% decrease in total time.

Table 4 Business Process Improvement Plan.

Waste	Problem	Solution	BPR Best Practices
Process Efficiency and Accuracy	The production process is done manually, and there are no accurate measuring tools in the process, so the process takes a long time and produces a lot of waste	Automate processes by implementing automated machines to reduce process work time, increase the accuracy of resource use, and eliminate waste that occurs along the production line	Integral Technology, Task Elimination, Parallelism
Integration	The implementation of each phase in a process often changes places so that the flow between processes is stagnant and intermittent	Re-layout on the production floor, which also requires process resequencing	Resequencing, Task Elimination

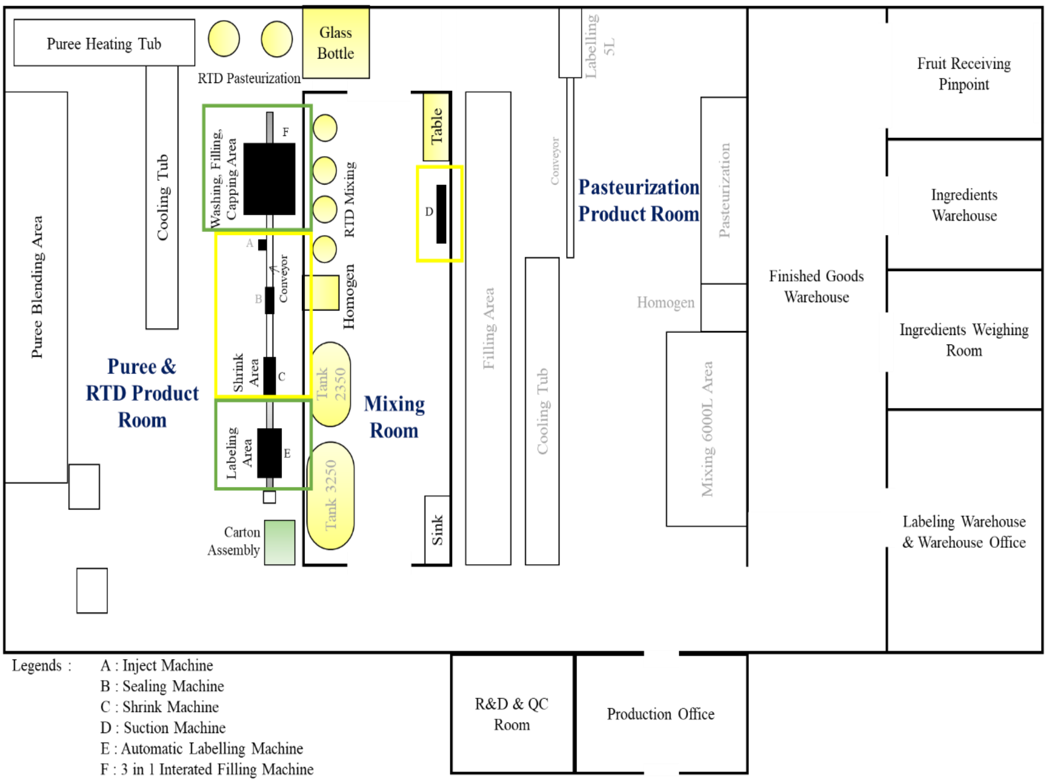

Figure 3 Production Floor Layout for To-be Process. Yellow marked are layout changes, and green marked are additional areas

The To-be model is mapped with BPMN based on the As-is model. Figure 4 shows the To-be model of Puree Making stage, Figure 5 shows the Production stage, and Figure 6 shows the Packaging stage of the "Signature" Production Process. Processes marked in red are eliminated, yellow indicates a change in processing time, green indicates a change in the sequence of processes, and purple represents new processes that were added. There were no changes in the Puree-making stage.

Table 5 Number of processes, the distance of movement, and the number of workers of future PAM.

Process	Puree Making	Production	Packaging	Total Process
Operation	9	14	6	29
Transportation	3	6	1	10
Inspection	0	4	1	5
Delay	1	2	0	3
Storage	1	0	0	1
Total Process	14	26	8	48
Distance Traveled (m)	44.71	69.54	13.24	127
Total Number of Workers	4	2	2	8

Table 6 Overall Production Process of Future PAM.

Value Category	Total	Percentage	Time (hh:mm:ss)	Time Contribution
VA	37	77.10%	10:36:56	86.40%
NVA	0	0.00%	0:00:00	0.00%
NNVA	11	22.90%	1:40:33	13.60%
Total	48	100.00%	12:17:29	100.00%

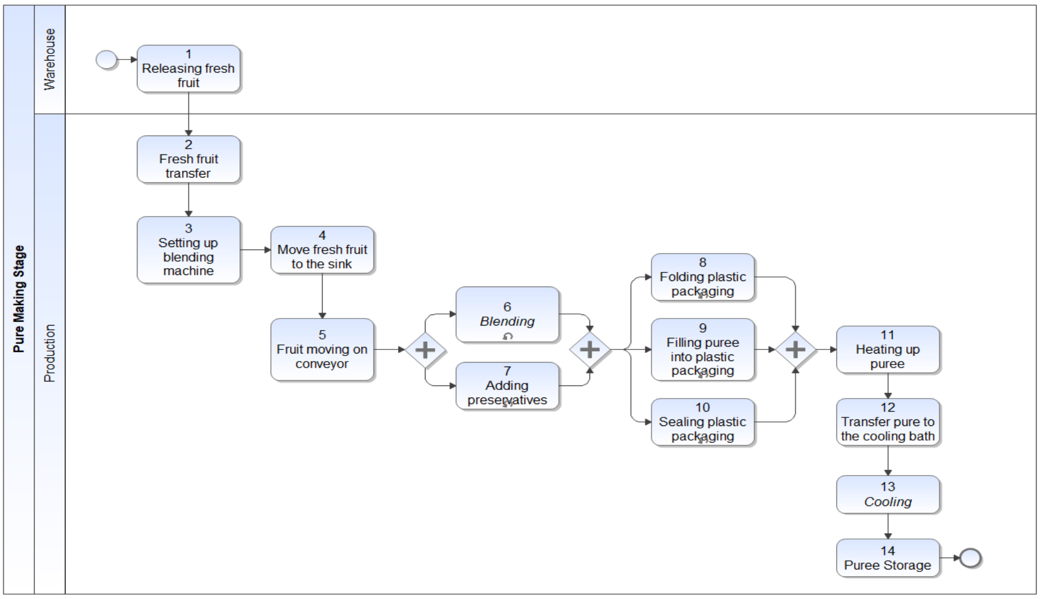

Figure 4 To-be model of Puree Making Stage, include Process No. 1-14

3.5. Discussions

The implementation time of this solution takes around 3-5 days. Comparing Tables 1-2 and Tables 5-6, this solution is able to solve the NVA problem, reducing the total time from around 24 hours to just around 12 hours, reducing labor use from 19 workers to 8 workers, reducing the distance traveled from 195 m to 127 m amounting to 34.9% decrease of distance traveled, and reduce total production time from 24 hours 51 minutes 5 seconds to 12 hours 17 minutes 29 seconds amounting 50.54% decrease of total time. The automatic labeling machine has approximately 2.8 × 1.6 × 1.5 meters, and the 3 in 1 integrated filling machine has dimensions of 2.1 × 1.7 × 2.35 meters (Zhang and Li, 2015). The cost of procuring these machines may vary, depending on the capacity. In this case, with the production speed of 2,000 bottles per hour, the additional cost will be around $4,000 for the automatic labeling machine and $3,500 for 3 in 1 integrated filling machine.

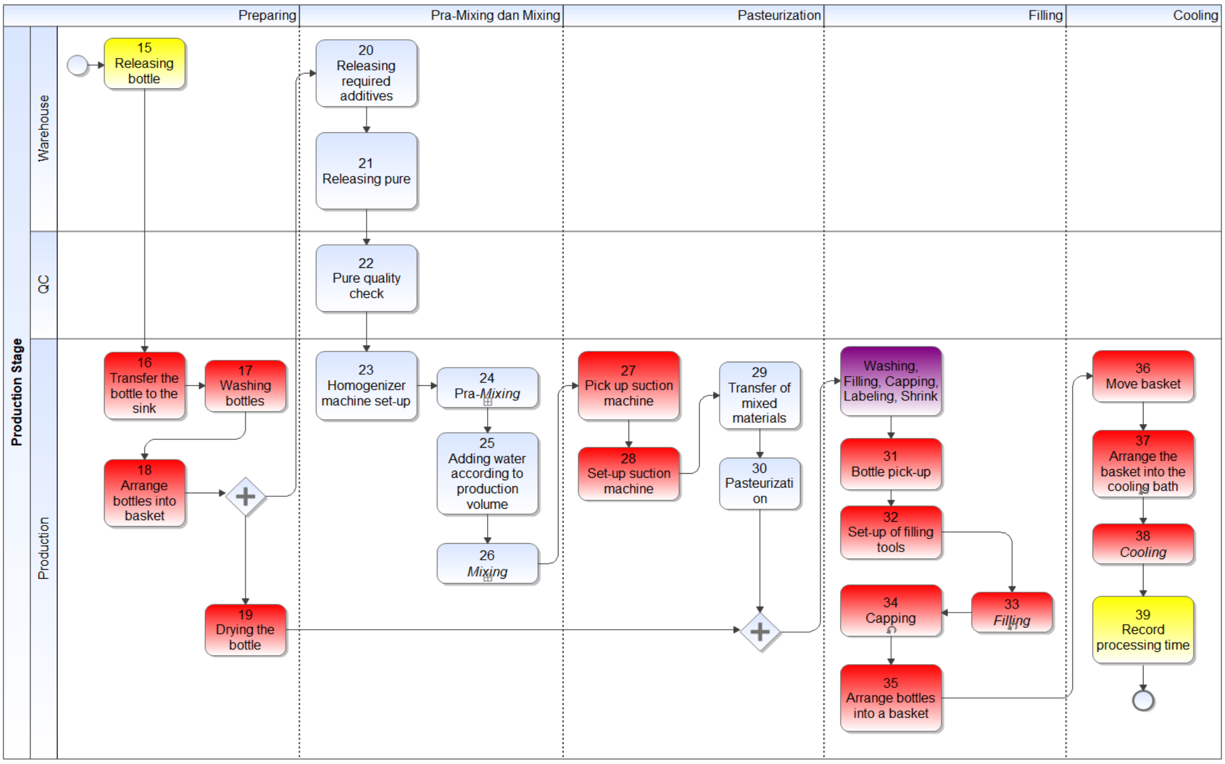

Figure 5 To-be model of Production Stage, include Process No. 15-39

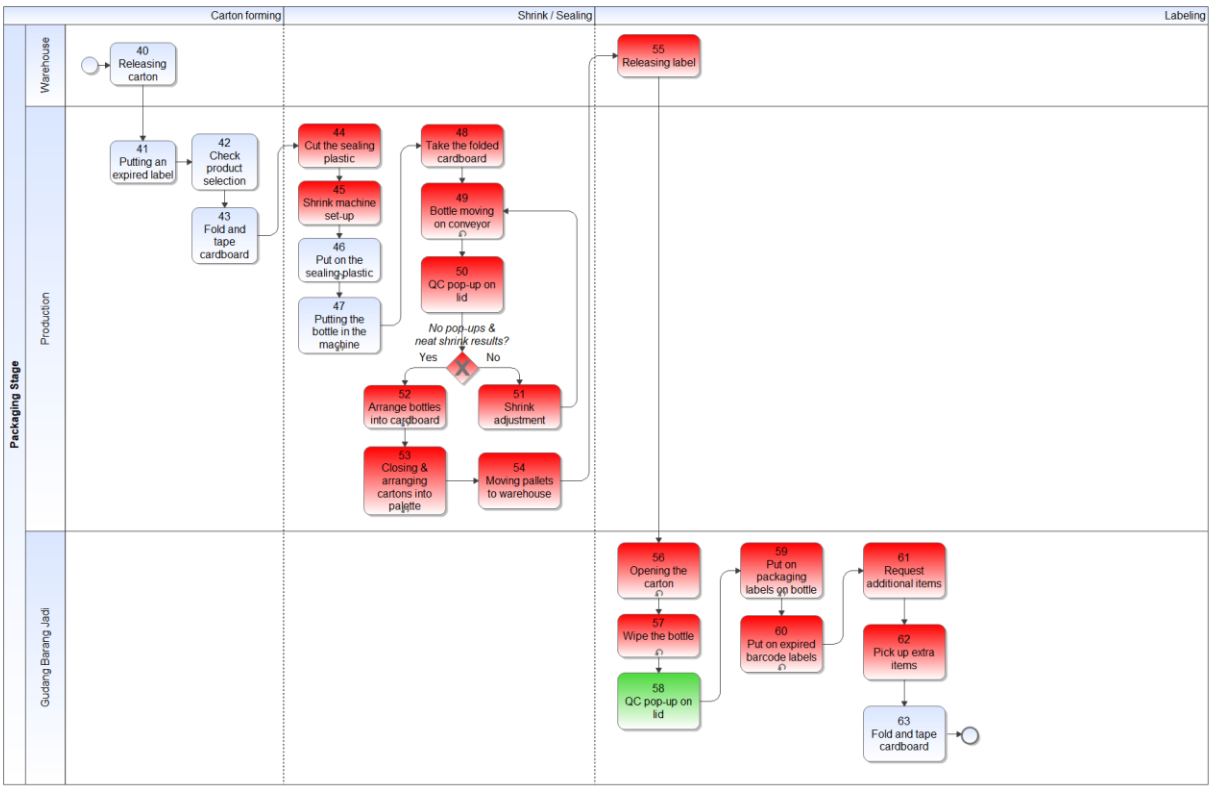

Figure 6 To-be model of Packaging Stage, include Process No. 40-63

4. Conclusions

In this research, we improved the business process of the "Signature" production process and assess the waste problems. Based on the discussion of the analysis that has been carried out previously, the proposed process improvement results in the following conclusions: Improvement solutions to improve process efficiency are designed by combining the implementation of BPR best practices, namely integral technology, task elimination, parallelism, and resequencing. To implement the solutions, we changed the production floor layout, eliminated, parallelized, and resequenced the production process, automated the bottle labeling process by installing an automatic labeling machine, and combined and automated the bottle washing, filling, and capping processes by installing a 3-in-1 integrated filling machine; These solutions resulted in a 34.9% reduction in distance traveled and a 50.54% reduction in total processing time. This research only provides the potential solutions for the improvement that needs to be tested and selected. Further research can be done by selecting a solution through a feasibility analysis. Research on problems and improvements in other production lines also needs to be done, considering that PT API is not a company that produces a single product but a multi-product. Future research can also combines more detailed aspects of facilities planning, such as facilities location and systematic layout planning.

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