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Integration of Ergo-Manufacturing and Simulation to Minimise Waiting Time for Cracker and Kemplang Production Process Flow (Case Study of PT. Belimo Food Industry)

Heri Setiawan[1], Sani Susanto[2*], Micheline Rinamurti[3], Achmad Alfian[4],

[1] Industrial Engineering Study Program, Musi Charitas Catholic University, Jl. Bangau 60 Palembang, South Sumatera, Indonesia

[2] Industrial Engineering Study Program, Parahyangan University, Jl Ciumbeleuit No. 94, Bandung, West Java, Indonesia

[3] Management Study Program, Musi Charitas Catholic University, Jl. Bangau 60 Palembang, South Sumatera, Indonesia

[4] Industrial Engineering Study Program, Musi Charitas Catholic University, Jl. Bangau 60 Palembang, South Sumatera, Indonesia

* Corresponding author: ssusanto@unpar.ac.id

Abstract. Belimo Food Industry factory is engaged in the production of crackers and kemplang with the Belimo brand. Observations made at the packing workstation, there is still a buildup or bottleneck in the press machine that is not optimal and performance is not efficient because it violates many ergonomic principles in the manufacturing industry (Ergo-Manufacturing). This research explores the integration of Ergo-Manufacturing concepts with simulation. The research aims to improve performance and reduce process lead time. The research method used is quantitative-descriptive with primary data. Data processing uses the integration method of the Ergo-Manufacturing concept with Arena software-based simulation so as to provide solutions that can optimise the performance of process waiting time, improve efficiency, work comfort, and production capacity at the packing workstation. The results of the study after applying Ergo-Manufacturing with work environment settings can minimise the waiting time of the initial condition process with a process time of 58.273 minutes. Under the conditions of improvement scenario 1, the process waiting time of 26,830 minutes can reduce the process time by 60%, under the conditions of improvement scenario 2, the process waiting time of 14,562 minutes can reduce the process waiting time by 80% and under the conditions of improvement scenario 3, the process waiting time of 12,483 minutes can reduce the process time by 85%. The results of the BEP decision analysis for scenario 1 were selected by adding 1 press machine to 2 press machines which can increase production capacity by 128 products and reduce overtime costs incurred by the company for 1.5 hours by IDR 40,500 and BEP investment in press machines takes 3 years.

Keywords: Bottleneck, ergo-manufacturing, simulation, process time, Arena Software

INTRODUCTION

The synergy of the ergonomics approach in the manufacturing industry (Ergo-Manufacturing) and simulation to minimise production process time can simulate real situations and conditions of inefficient production processes combined with an approach to ergonomic principles can prevent and reduce the potential for occupational injuries and

diseases, reduce physical and mental stress, which in turn will have an impact on improving the performance of organisations and management of industrial companies, especially the aspect of productivity in the manufacturing industry (Didik Hadiyatno, 2024; Lamers & Zelik, 2021). Consideration of production trajectory in a production process to get the best quality is one of the focuses of the manufacturing industry in winning the competition (Huda Nur Qodzbari & Andesta, 2023). Efforts that can be made are to improve the performance of the production line system in the company, where improving system performance can be done by increasing production output or making efficiency on the production line. In a manufacturing company engaged in food production, PT Belimo Food Industry also needs to implement these efforts so that it can survive and compete with other companies.

The production activities of a manufacturing industry must normally take place well with the production process that has been designed so as not to cause problems during the continuity of the production process. Queues occur because service needs are beyond capacity, causing or service. Queuing is a situation of waiting to receive service from customers waiting to get service (Iqbal Alfarizi & Andesta, 2023; Situmorang & Matondang, 2020). Queuing system in the production process is a method used to organise the order and production time of various elements or stages in a limited facility manufacturing operation. The purpose of this queuing system is to increase efficiency, reduce waiting time, and maximise resource usage (Yaqin et al., 2022).

PT Belimo Food Industri is one of the companies engaged in food processing. The products produced are raw crackers and kemplang which are still not fried using tapioca flour as the main raw material.

Figure 1. Stacking of Packing Station

From Figure 1 above, it shows that there is a buildup at the packing workstation in its operation, the buildup causes a bottleneck which results in a long process time. The number of incoming orders and the ratio of the number of machines that are not balanced, causes a buildup or queue of work. The occurrence of the buildup is due to the capacity of the machine

owned by only 1 press machine so that the arrival of products to be packed becomes piled up, and lengthens the product process.

As a result of the queues that occur, PT Belimo Food Industry is often late in the production process which makes the company have to increase overtime, delay delivery time and customer complaints about the long wait when picking up goods. From the long process time the company lost 3 customers which resulted in a loss of opportunity for profit and loss of trust in the company. Queues are related to constraints. Based on the *Theory of Constraints* (ToC), ToC is a *continuous improvement* activity that focuses on identifying and managing constraints in the company, so as to optimise the use of these constrained resources to achieve ToC goals (Lidberg & Ng, 2024; Urban & Rogowska, 2020; Inayati & Wahyuningsih, 2018).

The Ergo-Manufacturing integration approach and Arena Software-based simulation have the advantage of improving workstations and workers who are not yet ergonomic and the ability of the model to represent the real system quite accurately, so that bottlenecks can be identified and can be optimised properly. The experimental design is made like the real thing and then observe what will happen to the production process of PT Belimo Food Industry to minimise the process time which will affect the buildup (Rahmawati & Donoriyanto, 2023; Dohale et al., 2021). The purpose of this research is to apply Ergo-Manufacturing by regulating the work environment, minimising process waiting time and determining the simulation of balancing model parameters to be used and forming an improvement model as an appropriate proposal scenario to increase output (Dube & Gupta, 2023).

METHODS

The stages of this research are as follows: field studies and literature studies, problem identification, problem formulation, determination of objectives, data collection (work environment data, time data between each production process, data on the number of existing machines, and data on the choice of machine direction), data processing (improving the work environment with the Ergo-Manufacturing approach, determining system boundaries and assumptions, performing distribution fitting, developing conceptual models with Activity Cycle Diagrams, problem solving with ToC, building system models with Arena software, determining the number of replicas and running simulations and verifying and validating simulation models), formulation and selection of alternatives for improving the physical environment based on Ergo-manufacturing and Arena software, analysis and discussion, and

conclusions (Setyaningrum & Sari, 2023; egral Ergo-Value Stream Mapping in a Metal-MechaDomínguez-Alfaro et al. , 2023). This research focuses on the production process of crackers and kemplang; 1 storage warehouse, 1 inventory, and 5 workstation sequences according to the work order.

DISCUSSION

The Ergo-Manufacturing approach improves workplace design, product, and system innovation to suit users. Ergo-Manufacturing aims to provide a comprehensive overview of ergonomics practices in manufacturing, highlighting the importance of ergonomics practices in improving worker well-being and increasing operational efficiency (Mohammed et al., 2024; Erwanda, 2023). Ergo-manufacturing focuses on applying ergonomic principles in the design of production systems to minimise the risk of injury and improve work comfort, while Arena is a simulation software used to analyse and optimise production systems through process modelling and simulation. The application of Ergo-manufacturing at PT Belimo Food Industry, a manufacturer of crackers and kemplang, has an impact in increasing efficiency and productivity, in this case, production capacity. Ergonomic workplace design through work environment settings; additional light with a transparent roof and some additional lights and additional air ventilation in the production process area (Aulia Chafifah Wulandari et al., 2023).

Goodness of fit test results for determining the distribution of time data for each process with the help of fit-all in Arena software and distribution fitting results using input analyzer are presented in Figure 3 (Mohammed et al., 2024) (Javadi et al., 2023).

Table 1. Doughing Process Time

Waktu Penggadonan (Menit)									
1	2	3	4	5	6	7	8	9	10
11	13	13	11	12	11	11	13	11	11
12	12	11	12	11	11	13	12	13	11
11	13	12	11	12	13	11	13	11	13
11	11	12	11	13	11	13	11	12	11
12	11	13	13	12	12	11	12	11	13

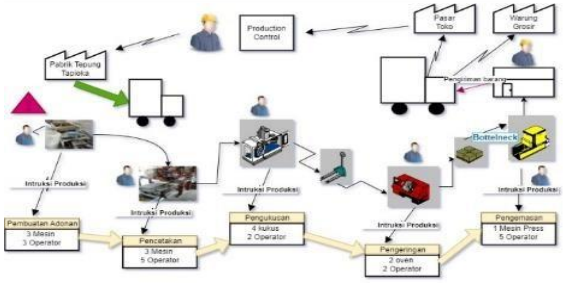

Figure 2. Current State Mapping Production Process of PT Belimo Food Industri

Table 2. Packing Process Time

Waktu Packing (Detik)									
1	2	3	4	5	6	7	8	9	10
6	5	9	6	9	5	5	6	9	7
7	5	7	5	5	3	4	5	4	6
3	6	3	3	4	4	8	7	5	10
4	5	6	5	7	6	7	6	5	3
4	6	10	8	6	5	4	4	3	5

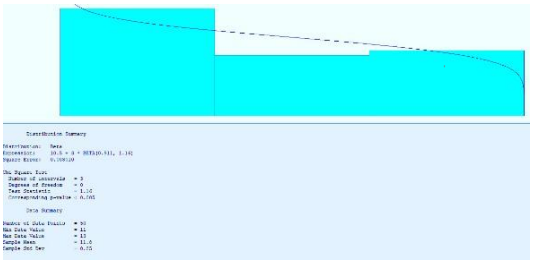

Figure 3. Distribution Fittings

From the results of the distribution fitting results using input analyser, it can be seen that the data is UNIF(11,13.8) distributed.

The conceptual model of Activity Cycle Diagram (ACD) and simulation modelling on several processes of making crackers and kemplang, namely kneading, moulding, steaming, drying, and packing processes can be seen in Figures 4 and 5. The following (egral Ergo-Value Stream Mapping in a Metal-MechaDomínguez-Alfaro et al., 2023; Ramawisari et al., 2023; Dina Rachmawaty, 2021).

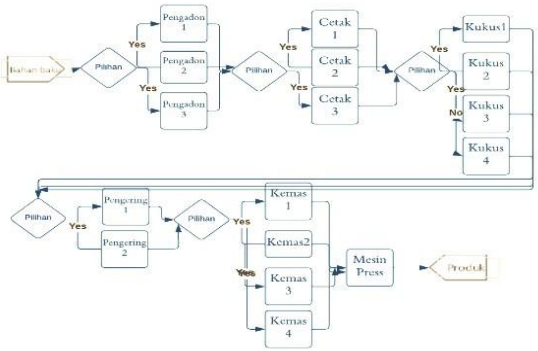

Figure 4. Activity Cycle Diagram Cracker and Kemplang Production Process

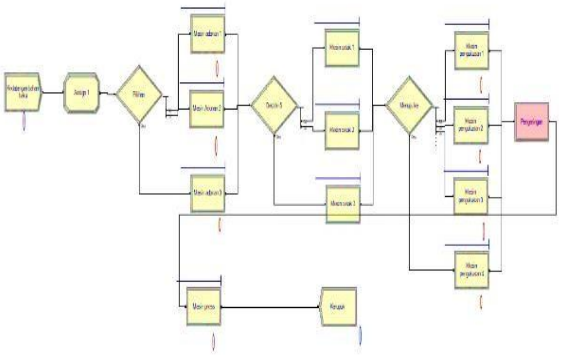

Figure 5. Process Arena Model

Problem solving with ToC, identification of constraints is characterised by the presence of overtime hours at the workstation of the cracker and kemplang production system (Kisanjani et al., 2023; Dube & Gupta, 2023). The constraints that occur at the packing workstation are caused by a lack of capacity where the machine used is only 1 press machine which makes the product accumulate. 3) Subordination of constraints. At this stage perform bottleneck workstation optimization by performing several alternative solutions, namely: bottleneck workstation optimization with the first solution adding 1 press machine and the second solution adding 2 press machines + 1 labour, so that the waiting time of the process can decrease. Bottleneck workstation optimisation by increasing the work shift from 1 shift to 2 shifts, so that production capacity increases (Rohmawati, 2023; Daffa' Muhammad Amjad et al., 2023; Suwandi et al., 2022).

Furthermore, the determination of replication calculates the standard error and percentage as follows standard error = 2.693 and percentage error = 4.621%. Based on Arena software simulation running, the number of replications of 5 is sufficient because it does not exceed the *error* limit of 5%. The improvement scenario used in improving performance with the initial condition of a buildup with a process time of 58,273 minutes from the service system consists of 3 improvement scenarios which will be explained as follows: (1)

improvement scenario 1 can be done by adding 1 press machine with a process waiting time of 26,830 minutes capable of reducing the process time by 60%, (2) improvement scenario 2 can be done by adding 2 press machines to 3 by adding more, the process can be accelerated properly with a process waiting time of 14,562 minutes capable of reducing the process waiting time by 80%, (3) improvement scenario 3 can be done by combining scenario 2 with scenario 3 adding 1 number of employees in the packaging section because the worker's utility is very busy so that adding 1 can also speed up the process waiting time with a process waiting time of 12,483 minutes capable of reducing the process time by 85%. The results of the BEP decision analysis for scenario 1 were selected by adding 1 press machine to 2 press machines which could increase production capacity by 128 products and reduce overtime costs incurred by the company for 1.5 hours by IDR 40,500, if the number of products produced in one month is 8000 packs, then according to the calculation of the break-even point of BEP investment in a press machine it takes 3 years to be able to recover investment costs (Fauzi et al., 2024; Ibrahim & Djamaludin, 2022; Nabilasari et al., 2022). and the application of Ergo-Manufacturing carried out is the regulation of the work environment. The increasing awareness of ergonomics in the workplace of the manufacturing industry of kerupuk and kemplang producers has led to the emergence of specialised manufacturing practices aimed at improving worker comfort, safety and productivity (Nizam & Ramlee, 2024; Flor-Unda et al., 2023; Mellasanti Ayuwardani, 2022).

CONCLUSION

Based on the results of the research that has been done, the following conclusions are obtained: (1) the simulation model of the production process and the packing process is made with a conceptual model using an ACD diagram. (2) The results of the simulation of the production process of queues that occur are found at the packing process workstation in the initial condition there is a buildup with a waiting time of 58.273 minutes with 63 products produced. From the proposed scenario given changes to the 3 improvement scenarios carried out can reduce the waiting time of the largest process in the condition of improvement scenario 3 by 85%, the condition of improvement scenario 2 by 80%, and the condition of scenario 1 waiting time process by 60%. (3) Based on the results of the analysis of the BEP calculation, the right decision is in scenario 1, a change is made by adding 1 press machine to 2 press machines, which can initially be processed 58.273 minutes to 26.830 minutes, which can reduce the process waiting time by 60%. With the application of scenario 1 improvements, there is an increase in production capacity of 128 products produced and

reduces overtime costs incurred by the company for 1.5 hours by IDR 40,500. BEP investment in press machines takes 3 years to be able to recover investment costs, and (3) the application of Ergo-Manufacturing carried out is the regulation of the work environment through the installation of a transparent roof and the addition of lights and the addition of air vents in the production process room. The increasing awareness of ergonomics in the workplace of the manufacturing industry of crakers and kemplang producers has led to the emergence of specialised manufacturing practices aimed at improving worker comfort, safety and productivity.

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