THE PRODUCTIVITY IMPROVEMENT OF HOME–MADE PRODUCTION LINE BY DEVELOPING OF SEMI-AUTO BATTER DISPENSING SYSTEM: KUIH BAHULU

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Abstract: The focus of this study is to improve the production system of a traditional food process. Specifically, by developing the semi-automated production line to improve the production rate of the current of kue bahulu process flow. In this study, Arena software is used to conduct the simulation towards the production line. First, identification of bottleneck problem related to the process flow of the production line. Second, development of dispensing system using SolidWorks software to design the semi-automated batter dispenser. Based on the simulation using Arena software, there were some improvement made and showed that the production line is significantly improved since the semi-automated batter dispensing installed in the system production line.

Keywords: Arena Simulation, Dispensing system, Kuih Bahulu, Solidworks

1.0 INTRODUCTION

Kuih bahulu or also known as mini egg sponge cake is a traditional food in Malaysia. This mini sponge cake, is traditionally, baked in the special mold. Kuih bahulu is mostly prepared for Malaysia’s festive occasions, such as Hari Raya Aidilfitri [1,2]. Therefore, the demand for kuih bahulu is going to increase in the market, especially during Malaysia’s festive seasons.

The facts, the kuih bahulu production is culturally made through manual processes, this home-made food product is increasingly popular to the Malaysian. However, the quantity of kuih bahulu available in the market still lower than users’ demands [2]. Therefore, the new ideas to increase and improve the home-made food of kuih bahulu were required to cope with the market [3]. Particularly, in the production line of the kuih bahulu related to the batter filling process. Since the kuih bahulu production processes were manually conducted by workers, there were also bottleneck problems found related to the line balancing. Figure 1 showed the kuih bahulu product and the mold.
2.0 RESEARCH METHODOLOGY

2.1 Actual versus Simulation
This study was carried out to improve productivity of the traditional food production system through direct visits to the home-made traditional industry. The purpose of the industrial visit is to explore and investigate the problems through the interview session with the owner and operators, besides in-place observation towards the process flow for the *kuih bahulu* production line.

![Figure 2. The Flowchart of the Kuih Bahulu Production](image)

Based on aforementioned, the focus of this study is to improve the production process of *kuih bahulu* related to the bottleneck problems. By developing a semi-automated batter dispensing system, the study also analyzed the implementation of the semi-automated batter dispensing system related to the productivity of production line.

![Figure 3. The Flow of Production Process the Kuih Bahulu](image)
Table 1: The Time Consumed of the Kuih Bahulu Production Process

| No | Process       | Time       | Remarks                          |
|----|---------------|------------|----------------------------------|
| 1  | Batter Mixing | 6.5 sec /pcs | 20 ~ 30 min /cycle / mould tray  |
| 2  | Oil Spreading | 17.79 sec  | average of 30 times data taken   |
| 3  | Dispensing    | 16.67 sec /pcs | 20 min / 6 tray or 20 min/ 72 units |
| 4  | Baking        | 3.46 sec   | average of 30 times data taken   |

By using Arena software to simulate the process, there were analysis conducted against the distributions of input data. Here, the data related to the batter dispensing and inspection processes were transferred into Arena software for the distribution analysis of each relevant process. Figure 4 shows the histogram of batter dispensing process time generated by using Arena input analyzer.

![Figure 4. The Histogram Ff Batter Dispensing Process Time Generated Using Arena Input Analyser](image)

Based on the measurement to the current production line performance, the generated kuih bahulu outputs of the Arena simulation were then compared to the real output of the kuih bahulu production line. The verification and validation of the simulation generated output were carried out to ensure the simulation model is closely done to the real system or not [4-6]. Figure 5 showed the simulation model of current kuih bahulu production line using Arena simulation software.
Figure 5. The Simulation Model using Arena Simulation Software towards Current Kuih Bahulu Production Line.

Table 2 showed the table of data verification and validation for real output and simulated output.

Table 2. The Data Verification and Validation for Real Output and Simulated Output.

| ITEM                  | REAL DATA | SIMULATED DATA | ACHIEVEMENT RATIO |
|-----------------------|-----------|----------------|-------------------|
| Number of output      | 462 units | 468 units      | 98.7%             |

2. 2. Design of Semi-Auto Batter Dispensing System

Theoretically, the production line improvement is not only related to the machine and scheduled/time allocation, however to the human involvement and allocation required [7]. In this study, since there was a strong correlation between the machine and the human involvement, there was an opportunity to develop the new design of batter dispensing system. This is due to the production of *kuih bahulu* that was only made manually using hands. Therefore, the design of battering process system using 3D computer aided design (CAD) model (SolidWorks 3D) towards *kuih bahulu* is utilized after the sketching of design.

The purpose of the development of semi-automated batter dispensing machine is to eliminate the detected bottleneck of the current production line. This bottleneck problem occurred due to the dispensing process conducted manually in the *kuih bahulu* production system. Figure 6 showed the semi-automated dispensing machine.
By analyzing the current production line, where the operator needs to use an ice-cream scooper (to pour up the batter and filled down one by one or manually into the baking mold), the study found that the problem occurred due to this activity. Based on this finding, the idea to make the process of batter dispensing faster is through the development of nozzle dispensing system that are able to reduce the batter dispensing process time. Figure 6 showed the design of multiple dispensing system for kuih bahulu batter dispensing machine.

![Figure 6. The Illustration of Design for SemiAutomated Kuih Bahulu Dispensing Machine](image)

Here, to control the batter flow on the dispenser system of kuih bahulu, it uses a simple hand crank mechanism. The hand crank mechanism of the batter dispensing nozzles uses two connectors and three connector pins. Figure 7 showed the mechanism of kuih bahulu batter dispenser. All of the dispenser nozzles will be pulled upward and opened when the hand crank was pulled downward. The batter will flow through the nozzles when the nozzles were being pulled upward by the hand crank. The batter nozzles will closed down when the hand crank returned to its standby position. Figure 8 and 9 showed the dispensing nozzles when the batter flow is open and closed.

![Figure 7. The Illustration of Multiple Nozzle System for Semi-Automated Kuih Bahulu Dispensing Machine](image)
Based on the dispenser semi-automated mechanism developed, the simulation model need the validation conducted towards the design based on given conditions. In this study, the motion study using SolidWorks Motion Analysis and Animation Simulation was carried out as an evidence to proof the designed mechanism of the dispensing system is workable or not [8-10].

3.0 RESULTS AND DISCUSSION

The virtual outcomes from Arena simulation software specify that the bottleneck problem of the kuih bahulu production system was the main cause of the problem in the kuih bahulu productivity and production line. The bottleneck problem of the production line was the batter dispensing process. By implementing the semi-automated batter dispensing system, the daily productivity of kuih bahulu production line will be increased.

The design of semi-automated batter dispensing system is using a multiple dispenser mechanism that contains 12 nozzles of batter in one shot. Based on the developed design, the data collected (the process time) were utilized into the next simulation model using Arena software to improve the kuih bahulu production line.

The simulation towards the production line was carried out and completed for 8 working hours. This study found that the output of kuih bahulu production line is 1140 units per-day, while the previous kuih bahulu production line is only 468 units per-day. Table 3 showed that the productivity improvement made using multi dispenser mechanism is 243.6%.
Table 3. The Number Output of Previous and Redesign Kuih Bahulu Production Line Generated by Arena Simulation Software

| PRODUCTION LINE | SYSTEM   | AVERAGE | IMPROVEMENT |
|-----------------|----------|---------|-------------|
| CURRENT         | Number   | 468     |             |
|                 | Out      |         |             |
| REDESIGN        | Number   | 1140    | 243.6%      |
|                 | Out      |         |             |

However, since the improvement required should consider the queue analysis for all of the processes related to redesigning kuih bahulu production line (which involved the processes in the batter mixing, batter dispensing, baking inspection, and batch process), the study found that the average waiting time for kuih bahulu towards the batter dispensing process is approximately 2.40 seconds compared to 31.88 seconds in the previous process. By ignoring the waiting time for mixing the batter for the dispensing process, the queue time can be reduced to zero (Table 4).

Table 4. The Queue Analysis of Current and Redesign Kuih Bahulu Production Line Generated Using Arena Simulation Software.

![Queue Analysis Screenshot](image_url)

In this sense, by implementing the semi-automated dispensing mechanism, the bottleneck problem in the kuih bahulu production line can be successfully eliminated. Besides, the waiting time and number of waiting for the batch queue is also reduced significantly. The average waiting time for the batch queued were reduced from 327.59 seconds to 137.5 seconds, whilst the average waiting time for inspection queue increased from 19.1 seconds to 19.21 seconds. Figure 5 shows the queue analysis of current and redesigned kuih bahulu production line generated by using Arena simulation software.

Table 5 showed that the percentage of improvement for the productivity of redesigned production line was about 143.6%. The number of output for semi-automated production line was enhanced significantly from 468 units to 1140 units of kuih bahulu.
### Table 5: The Improvement Results.

| ITEM                        | CURRENT MODEL | REDESIGN MODEL | IMPROVEMENT |
|-----------------------------|---------------|----------------|-------------|
| NUMBER OF OUTPUT            | 468 units     | 1140 units     | ↑ 243.6%    |
| WAITING TIME IN BATTER      | 2.4 secs      | 0.0 sec        | ↑ 240.0%    |
| DISPELLING QUEUE            |               |                |             |
| OPERATORS UTILIZATION       | 35.28%        | 13.83%         | ↑ 214.5%    |

### 4.0 CONCLUSIONS

In this study, to increase the output of the production line such as the home-made product (*kuih bahulu*) were examined through simulation using Arena software. In this study, the problem in the production line of *kuih bahulu* production is related to the queue time of pouring the batter into mold (batter dispensing). The average of waiting time for batter dispensing process queue was approximately 2.40 seconds, while the highest waiting time in the batter dispensing process queue was about 31.88 seconds or half a minute for one *kuih bahulu*.

The solution for bottleneck problem in the *kuih bahulu* production line was by implementing a semi-automation in batter dispensing process. Here, the study developed and proposed a design of semi-automated batter dispensing machine. The proposed design consists of multiple dispensing system with 12 batter dispenser nozzles mechanism. Before assembling and manufacturing the machine, the study conducted the validation towards the mechanism of the batter dispensing machine using Solidworks motion study and animation.

In conclusion, the implementation of semi-automated *kuih bahulu* batter dispensing system can eliminate the bottleneck problem of the production line and enhance the daily productivity of the *kuih bahulu* production line. However, there are still a lot of improvement required in future research if there is a need to increase the production and the output based on customer demand, such as the mixing of batter (batter mixing), backing, and packaging, besides the production system related to facility layout, movement, workmanship, and so on.

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