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Design of inspection plan simulation for material packaging activities in the baby milk industry

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Abstract. One of the main activities that has an important impact to ensure good packaging material quality to be used in the production process is the inspection activity. In the inspection process, dynamic situations always arise. This study is conducted to simulate the design of packaging material inspection plan activities. Model simulations are performed using the Plant Simulation software. The models that are simulated are the existing model running under current conditions as well as models sampled using the MIL STD 1916 method. The results of this study show that with the existing model, 1,096 samples can be completed by 5 inspectors working in 1 shift, whereas with the model using the MIL STD 1916 sampling method, 2,120 samples can be completed by 6 inspectors working in 3 shifts.

Keywords. Inspection plan, inspection standard time, number of inspectors, packaging materials, quality, simulation, total sample.

1. Introduction

Maintaining the quality level of products and services is a vital endeavor for the success of organizations. Quality assurance measures including inspection plans play an important role to ensure that products and services are in accordance with customer needs [1].

For good inspection, an effective inspection plan is required. Inspection is the way how surveillance is conducted. A problem that often arises as a result of ineffective inspection plans is product defects going undetected and eventually making it into the market. Therefore, to obtain a real picture of the planning of inspection plans, a visualization through simulation needs to be created. This simulation shows the inspection plan activities and creates a number of scenarios and potential improvements that could be made.

Production process simulation is a way to determine or analyze the production process [2]. Through this, the ways in which problems occur in the production process can be simulated to understand production conditions. Simulation is a way to design a model that represents actual conditions to identify bottlenecks and improve system performance [3]. By using a valid simulation model, advantages such as creating better manufacturing processes to improve the performance of manufacturing activities may be gained.

Based on available literature, research on inspection plans continues to evolve using different acceptance sampling methods depending on the needs of the users of the inspection plan. There are several methods that in recent times are often used to determine the appropriate number of samples, such as the Mixed Sampling Plan, Repetitive Group Sampling, Military Standard 105D, Military Standard 1916, and other methods.



Various studies regarding inspection plans have been conducted, given the importance of the acceptance sampling plan. Research on acceptance sampling plans/inspection plans always aims to minimize sample size as this will ultimately reduce the cost of inspection [4–11]. The base of this research is a previous study conducted on the design of inspection plans and labor measurement of packaging material inspection activities in the dairy industry [12].

Based on the aforementioned research, an inspection plan is obtained which is equipped with labor measurement and planning results of previously set inspection activities whose output is the sample size, the standard time of inspection, and the number of inspectors.

The inspection plan model currently running and the inspection plan model using MIL STD 1916 have never been simulated before, so the simulated results obtained visually as well as the scenarios that can be created in order to improve productivity are yet to be known.

Simulation is a way to describe the appearance and characteristics of a real system. The initial idea of simulation is to replicate the real-world situation mathematically, study its characteristics, and ultimately make conclusions based on the results of the simulation.

This research is conducted on the activities of packaging material inspection within the baby milk industry and continues previous research. In this research, modeling is done by dynamically taking into account the number of samples, the number of inspectors, and inspection work time.

2. Research methodology

2.1. Simulation data processing

Data processing using simulation begins with a preliminary analysis to identify problems, creation of simulation designs, verification, validation, and creation of scenarios. Finally, conclusions can be drawn from the results.

2.2. Data collection

This research begins with the collection of data in the form of secondary data of packaging material inspection historical data in 2014.

Table 1 presents the types of packaging material, the number of units per lot, the average arrival of goods per day, the number of samples in the current condition (A), and the number of samples using MIL STD 1916 (B).

Table 1. Type of packaging material, lot size, and sample size.

Type of Packaging Material		Lot Size	Arrival of Goods/Day	Total Sample Size (A)	Total Sample Size (B)
Folding Box	200 grams	19.200	140.242	90	224
Folding Box	400 grams	14.400	140.242	90	224
Folding Box	2 x 900 grams	3.000	140.242	90	224
Can	800 grams	748	8.933	12	114
Can	900 grams	680	8.933	12	114
Can	400 grams	1.694	8.933	12	114
Scoop	-	450	67.295	36	8
Outer Carton	Can	1.000	1.305	-	44
Outer Carton	Box	600	1.305	-	44
Lid	-	450	1.905	10	8
Bottom End	-	9.600	1.905	10	12

The standard times required by an inspector to conduct inspection activities on each piece of each type of packaging material can be seen in table 2.

Table 2. Type of packaging material, lot size, and sample size.

Inspection Activity	Standard Time (seconds)
Folding Box	57
Outer Carton	36
Can	45
Lid	71
Scoop	48
Bottom End	71
Total	328

The number of inspectors who work every day in the current condition is one person working in one shift. The number of inspectors currently being run in the calculation is 5 people, while the number of inspectors with the MIL STD 1916 sampling method is 9 people.

2.3. Data processing

Once the data is obtained, it is processed using the Plant Simulation software. A preliminary analysis is conducted to identify the problem, then simulation model designs are created. Once the design of the simulation model has been formulated, verification and validation of the model is performed. Once the models are verified and valid, the final step is to create scenario models.

To complete the inspection of goods that arrive every day, several sampling cycles need to be done per lot size. The cycles of each type of packaging material are as follows: folding box 4 times, outer carton 6 times, can 22 times, scoop 3 times, lid 5 times, and bottom end 1 time.

The time required to perform inspection of an entire sample of goods coming every day is the product of the standard time for inspection of each type of packaging material and the daily total sample. From the results of these calculations, it is obtained that the total packaging material inspection time with the sample size of the current running condition is 58.346 seconds or 16 hours, 12 minutes, and 26 seconds. Meanwhile, the time to conduct inspection of the sample size obtained using the MIL STD method is 102.240 seconds or 28 hours and 24 minutes.

The next step is formulating a model. The model that is currently running with 1.096 samples is completed by one inspector who works in one shift. This model is shown in figure 1.

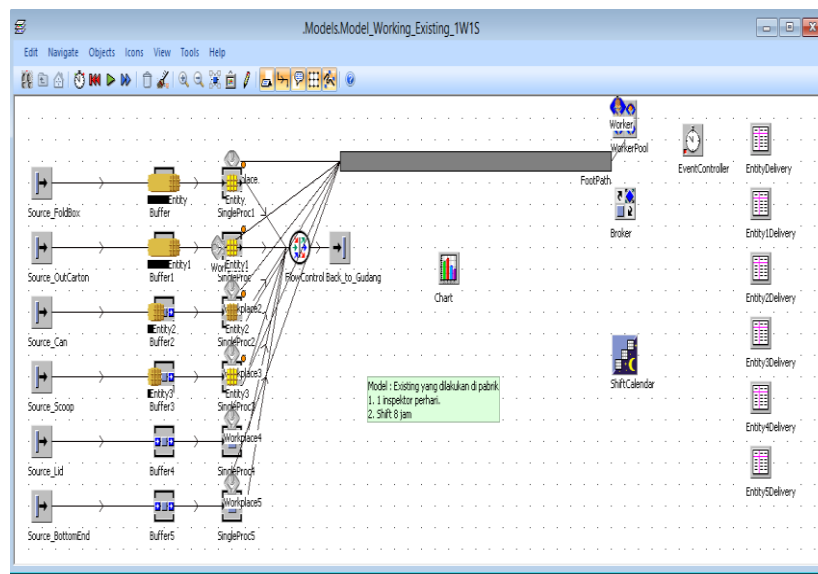
**Figure 1.** Existing model (1 inspector, 1 shift).

Figure 1 illustrates the simulation model of the current running condition. The result obtained from the above simulation is that the total time required to complete the process with 1.096 units of samples using existing resources is 57.269 seconds or 15 hours, 54 minutes, and 29 seconds.

Once the model has been successfully created, the next step is verification and validation.

Verification of the model is a method to ensure that the simulation model has been created properly and in accordance with the desired conditions. By comparing the conceptual logic with the logic of the results of running the simulation as well as the display of the running logic event debugger, it can be concluded that this model has been verified.

Validation of the model is a method to ensure that the model created is in accordance with the conditions that occur in the field. The total inspection time obtained in the simulation result is 15 hours, 54 minutes, and 29 seconds while the yield in the actual condition is 16 hours, 12 minutes, and 26 seconds. With the simulation results being similar to the actual results and the difference being only 1,8%, this indicates that the simulation is valid.

3. Results and discussion

The total throughput as a result of the simulation that is currently running with the resource being one inspector working one shift per day is 507 sample units out of a total sample of 1.096 units. Therefore, scenario models are created to obtain a model that can complete all the inspection activities daily. The scenario consists of three models, namely a model of the current condition with 5 inspectors working 1 shift, a model using the MIL STD 1916 sampling method with 9 inspectors working 3 shifts, and a model using the MIL STD 1916 sampling method with 6 inspectors working 3 shifts.

Results of the model simulation of the current condition with 1 shift a day and with inspection activities being carried out by 1 inspector compared with 5 inspectors can be seen in figure 2.

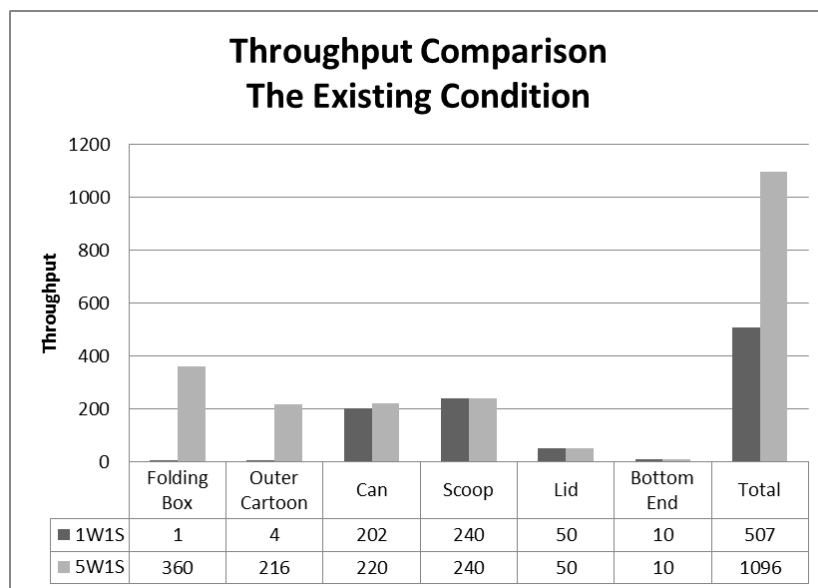


Figure 2. Comparison between simulation results (existing condition with 1 inspector and with 5 inspectors working 1 shift per day).

Figure 2 illustrates the comparison of results obtained from the simulation. Total throughput obtained with 1 inspector is 507 sample units, whereas with 5 inspectors is 1.096 sample units. With 5 inspectors, inspection of all samples of packaging material can be completed each day.

Results of the model simulation using the MIL STD 1916 sampling method with 3 shifts a day and with inspection activities being carried out by 9 inspectors compared to 6 inspectors can be seen in figure 3.

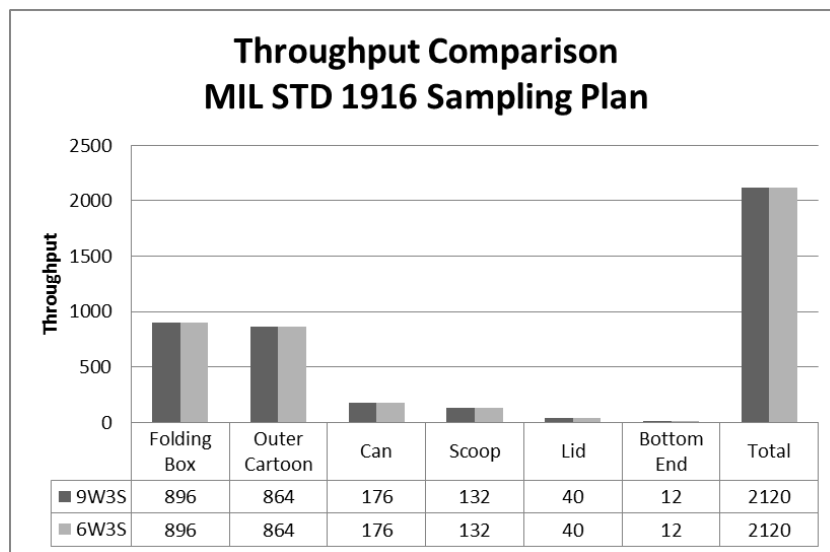


Figure 3. Comparison between simulation results (simulation model using MIL STD with 9 inspectors and with 6 inspectors working 3 shifts per day).

Figure 3 illustrates the comparison of results obtained from the simulation. Total throughput obtained with 9 and 6 inspectors who work 3 shifts each day together amount to 2.012 sample units. With 6 inspectors working 3 shifts per day or 2 people per shift, inspection of all samples of packaging material can be completed per day.

The model simulation with the number of samples in the existing condition, with the number of inspectors being 5 inspectors working 1 shift, and with inspection requirements being 1.096 sample units in one shift per day, results in a total time of 5 hours and 52 minutes.

The model simulation using the MIL STD 1916 sampling method, with inspection requirements being 2.120 sample units, and inspection being carried out by 9 inspectors in 3 shifts every day (or 3 inspectors per shift) results in a total time of 19 hours and 48 minutes.

The model simulation using the MIL STD 1916 sampling method, with inspection requirements being 2.120 sample units, and inspection being carried out by 6 inspectors in 3 shifts each day (or 2 inspectors per shift) results in a total time of 19 hours and 21 minutes.

4. Conclusion

Based on the results of the analysis, several conclusions can be drawn from this model simulation of an inspection plan that takes into account the number of samples, the number of inspectors, and the time of the work done concerning the amount of resources needed to complete daily inspection requirements. These conclusions are:

- within the scenario of the existing condition currently running, 1 inspector working in 1 shift cannot finish the inspection of 1.096 sample units;
- within the scenario using the MIL STD 1916 sampling method, 9 inspectors working in 3 shifts can complete inspection of 2.120 sample units;
- within the scenario to overcome the problem faced in the current condition, 5 inspectors working in 1 shift can complete inspection of 1.096 sample units;
- within the improved scenario using the MIL STD 1916 sampling method, 6 inspectors working in 3 shifts can complete inspection of 2.120 sample units.

The limitation of these simulation models is the absence of data of defective products. Further research should take into account defective products so as to obtain more significant improvement.

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