

# Analysis of the Effectiveness of Bagging Machines in Increasing Chicken Feed Production Capacity in the Bagging Off Process

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**Abstract** - The bagging machine is an essential component in the chicken feed production process. This machine functions to package livestock feed into bags with weights that meet specified standards. The machine can automatically weigh, fill, and seal feed bags with high speed and accuracy. This research aims to evaluate the performance of bagging machines in chicken feed production, focusing on increasing production capacity, reducing operational costs, and improving the quality of the final product. The study results indicate that using an automatic bagging machine significantly increases production capacity by up to 25% compared to previous manual methods, and operational costs decrease by 15% due to reduced downtime and improved labor efficiency. To determine the overall effectiveness of the machine, a calculation method is required to obtain values of availability, performance efficiency, and rate of quality, leading to solutions for optimizing the machine's effectiveness through proposing a more efficient layout. The results obtained after making changes are expected to increase production capacity to the optimal limit that the machine can produce.

**Keywords:** Bagging Machine, Livestock Feed, Production, Efficiency, Effectiveness.

## I. INTRODUCTION

Human daily food needs are often derived from animals. Therefore, the maintenance of livestock must be done properly to produce quality and safe animals for consumption. One way to produce good quality livestock is by providing quality feed. The feed production process involves many stages, from raw materials to finished feed. In this production process, various machines perform specific functions [1]. The feed production process includes intake, dosing, grinding, mixing, pelleting, and bagging. Each of these stages involves one or more machines. After completing the bagging stage, the product is distributed to farmers or sold to the public [2].

This study was conducted to determine the effectiveness level of the machine using the Overall Equipment Effectiveness (OEE) method. Additionally, the study identifies the dominant factors of the six big losses that affect the machine's effectiveness and determines the root causes using Fault Tree Analysis (FTA). Fault Tree Analysis is a method for identifying the relationships between cause factors, displayed in a fault tree involving simple logic gates to produce recommendations for overall productivity improvement [3]. In this study, FTA is used effectively to find the core problem to ensure that an undesirable event or loss does not originate from a single point of failure.

## II. RESEARCH OBJECT

The issues investigated in this study include calculating the Overall Equipment Effectiveness (OEE) of the bagging machine, identifying root causes using Fault Tree Analysis (FTA), and proposing improvements to increase production capacity during the bagging off process using the best layout design, considering all aspects [4].

Data collection in this study involves production data and bagging machine reports, including available time, breakdown time, setup time, cycle time, non-productive time, and planned downtime [5].

Bagging off is one of the final processes in chicken pellet feed production, where the feed is packaged after passing through various stages from raw materials to finished products, as shown in Figure 1. The packaging process plays an important role in maintaining product quality, ensuring product safety until it reaches the consumer, and enhancing product attractiveness and ease of use. It also provides an opportunity for producers to differentiate their brand and make it easy for customers to remember the products made [6].



Figure 1: Bagging machine

The OEE (Overall Equipment Effectiveness) value is a measure of the overall effectiveness of a machine. The OEE value is the product of availability, performance efficiency, and rate of quality. The availability value helps us know the percentage of machine effectiveness availability. To find the availability value, data on available time, planned downtime, breakdown time, and setup time are used. Once this data is available, it is processed using equation 1.

$$Availability = \frac{operation\ time}{loading\ time} \times 100\% \quad (1)$$

The next stage involves processing data to determine the machine's performance efficiency. Calculating performance efficiency requires data on cycle time, operation time, and total production. Performance efficiency can be calculated using equation 2.

$$Performance\ Efficiency = \frac{proceed\ amount \times Actual\ cycle\ time}{Operating\ time} \times 100\% \quad (2)$$

The following stage is calculating the rate of quality, used as a measure of equipment's ability to produce products that meet standards. Calculating the rate of quality requires production data such as good products and total rejects. The rate of quality can be calculated using equation 3.

$$Rate\ Of\ Quality = \frac{total\ good\ product - total\ broken\ product}{total\ good\ product} \times 100\% \quad (3)$$

The next stage is identifying the main factors of wastage/losses due to low machine effectiveness, represented by six big losses. These six big losses include breakdown losses, setup and adjustment losses, idling and minor stoppage losses, reduced speed losses, rework losses, and reject losses.

Breakdown losses occur due to sudden machine failures that prevent operation. Breakdown losses can be calculated using equation 4.

$$Breakdown\ Losses = \frac{breakdown\ time}{loading\ time} \times 100\% \quad (4)$$

Setup and adjustment losses are caused by setup and adjustment activities, including all setup times and adjustments. Setup and adjustment losses can be calculated using equation 5.

$$Set\ Up\ and\ Adjustment\ Losses = \frac{set\ up\ time}{loading\ time} \times 100\% \quad (5)$$

Idling and minor stoppage losses are caused by short machine stops, machine jams, and idle time. Idling and minor stoppage losses can be calculated using equation 6.

$$Idling\ Minor\ Stoppages\ Losses = \frac{non\ productive\ time}{loading\ time} \times 100\% \quad (6)$$

Reduced speed losses occur when the machine operates below its optimal speed. Reduced speed losses can be calculated using equation 7.

$$Reduce\ Speed\ Losses = \frac{operation\ time - (ideal\ cycle\ time \times total\ product)}{loading\ time} \times 100\% \quad (7)$$

Rework losses are caused by defective products that can still be repaired. Rework losses can be calculated using equation 8.

$$Rework\ Losses = \frac{(ideal\ cycle\ time \times rework)}{loading\ time} \times 100\% \quad (8)$$

Reject losses are caused by unused materials or raw materials. Reject losses can be calculated using equation 9.

$$Reject\ Losses = \frac{(ideal\ cycle\ time \times reject)}{loading\ time} \times 100\% \quad (9)$$

The next step involves root cause analysis of overall machine problems to identify the fundamental causes of losses due to breakdown loss factors, as shown in Figure 2.

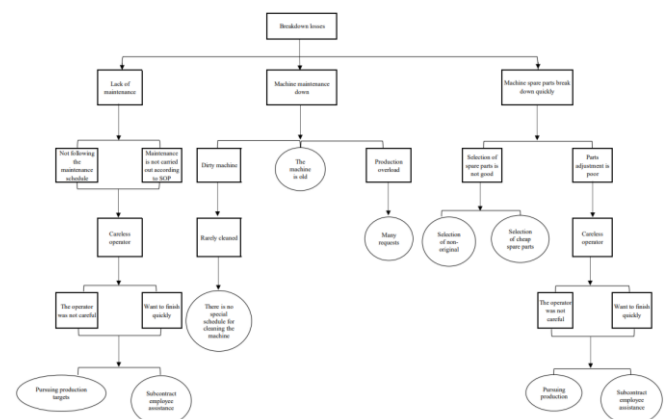


Figure 2: Fault tree analysis of breakdown loss

### III. DATA FOR ANALYSIS

The core of the calculation here is to calculate the OEE (Overall Equipment Effectiveness) value as a measure to determine the overall effectiveness of the machine. The OEE

value is the product of availability, performance efficiency, and rate of quality. The first step is calculating the availability value, as shown in Table 1, which shows the values of available time (a), planned downtime (b), breakdown time (d), and setup time (e). After processing the data, the calculated values of loading time (c), downtime (f), and operation time (g) are obtained, and finally, the Availability value calculated using the provided formula [9].

**Table 1: Bagging machine availability**

Month	(a) Available Time (minute)	(b) Planned Downtime (minute)	c = (a - b) Loading Time (minute)	(d) Breakdown Time (minute)	(e) Set Up (minute)	f = (d + c) Downtime (minute)	g = (c - f) Operation Time (minute)	g/c x 100% Availability (%)
September	30,200	1,440	28,760	6,684	360	7,044	21,716	75.51
October	31,320	960	30,360	5,113	660	5,774	24,586	80.98
November	30,640	960	29,980	3,837	510	4,347	25,633	85.50
December	31,640	960	30,680	4,577	450	5,027	25,653	83.61
January	31,640	1,440	30,200	3,498	630	4,128	26,072	86.33
February	31,200	960	30,240	1,561	540	2,101	28,139	93.05

To obtain the performance efficiency calculation results, multiply the total production value by the ideal cycle time, then divide the result by the operation time value. The total production and ideal cycle time values are obtained from field data collection where the bagging machine is located. The operation time is obtained from Table 1 calculations.

The final performance efficiency result is shown in Table 2. The Rate of Quality value involves the number of good production values and total broken values, as shown in Table 3.

**Table 2: Performance efficiency of bagging machine**

Month	Total Production (bag)	Ideal Cycle Time (minute)	Operation Time (minute)	Performance Efficiency (%)
September	12,445	0.0583	21,716	33.41
October	13,283	0.0583	24,586	31.49
November	12,987	0.0583	25,633	29.88
December	11,976	0.0583	25,653	27.21
January	12,593	0.0583	26,072	28.15
February	13,425	0.0583	28,139	27.81

**Table 3: Rate of quality product of bagging machine**

Month	Good Production (bag)	Total Broken (bag)	Rate of Quality (%)
September	12,122	326	97.31
October	13,014	269	97.93
November	12,674	313	97.53
December	11,811	165	98.60
January	12,436	157	98.73
February	13,291	134	98.99

After obtaining the calculation results of Availability, Performance Efficiency, and Rate of Quality, these three values are multiplied to find the final OEE (Overall Equipment Effectiveness) value, as shown in Table 4. To get the Six Big Losses value, calculate six key points: reduced speed losses, breakdown losses, idling and minor stoppages,

setup losses, rework losses, and reject losses. The calculated values are then tabulated in Table 5.

**Table 4: Overall equipment effectiveness of bagging machine**

Month	(a)	(b)	(c)	(a x b x c)
	Availability (%)	Performance Efficiency (%)	Rate of Quality (%)	OEE (%)
September	75.51	33.41	97.31	24.55
October	80.98	31.49	97.93	24.97
November	85.50	29.88	97.53	24.92
December	83.61	27.21	98.60	22.43
January	86.33	28.15	98.73	25.62
February	93.05	27.81	98.99	24.41

**Table 5: Cumulative percentage of bagging machine**

No.	Six Big Losses	Value (%)	Percentage (%)	Cumulative Percentage (%)
1.	75.51	23.07	43.78	43.78
2.	80.98	18.41	28.36	72.14
3.	85.50	12.82	25.35	97.49
4.	83.61	1.18	2.35	99.84
5.	86.33	0.05	0.08	99.92
6.	93.05	0.05	0.08	100

#### IV. RESULT AND DISCUSSION

Two factors prevent the bagging machine from reaching its ideal capacity: lost time and bottlenecks. Here are explanations of lost time and bottlenecks. Based on observations and interviews, lost time is divided into two based on occurrence frequency: definite lost time per shift and definite lost time per week. Lost time per shift is the time lost during one shift of the bagging off process. Data on lost time per shift is shown in Table 6. Lost time per week is the time lost in one workweek (Monday-Friday). Data on lost time per week is shown in Table 7.

**Table 6: Lost time data per shift**

Lost Time	Total Time (Minute)
Operator replacement	28
Production replacement	25
Sack Refill	56
Sewing machine lubrication	5
Sampling	9
Shift handover	15
Total duration	139

**Table 7: Lost time data per week**

Breakdown Type	Total Time (minute)
Routine maintenance	60
Praying	60
Total duration	120

Indefinite lost time is lost time whose frequency and duration are not precisely known. Indefinite lost time can occur suddenly and unpredictably. The frequency and duration

of indefinite lost time are obtained through interviews with production supervisors, shown in Table 8.

Table 8: Indefinite lost time data

Lost Time	Frequency Estimation per month	Duration Estimation
Jammed pallet machine	1-2	Depending on the damage
Jammet arm robotic machine	0-1	Depending on the damage
Electrical shutdown	0-1	2 – 4 hours
Peak load	0-1	2 – 4 hours
Empty bin bagging	12-60	10 – 30 minutes
Jammed conveyor	0-1	Depending on the damage
Jammed sewing machine	0-4	Depending on the damage
Stucked sack on conveyor	40-60	5 – 10 minutes

With lost time analysis, it is known that definite lost time per shift is 139 minutes or 2.31 hours, resulting in an effective working time per shift of 5.69 hours. Weekly definite lost time has a duration of 2 hours. Considering lost time in theoretical production capacity calculations, the production capacity with 5.69 hours per shift is 12,636 bags/shift. Comparing the initial output with the bagging off capacity under the adjusted working time, the bagging off process achieves 89.98% of its capacity. The remaining 10.02% of the maximum production capacity is confirmed by the company as indefinite lost time. This 10.02% will be used as an indefinite lost time factor in future proposals. The initial working time production capacity cannot meet the new bagging target of 13,400 bags/shift due to system lost time [10].

Besides lost time, bottlenecks also cause the bagging off process to not reach its maximum capacity. The bottleneck in the bagging off process occurs during the transfer of bags to the pallet. The robotic arm used to transfer bags to the pallet has a transfer capacity of 1,000 bags per hour. One robotic arm is operated for two bagging off lines, resulting in a transfer capacity of 500 bags per hour or 83 bags per minute per line. When compared to the ideal capacity of the bagging off process (926 bags per minute), the bag transfer to pallet process has a smaller capacity than the bagging off process itself [11].

The initial bagging off model was created using Promodel software, as shown in Figure 3. Several constraints were used in creating the model, such as resources and Path Network not being used since operators do not move while working. The entity modeled is the bag until it becomes a finished bag, and the inter-arrival time of the bag entity is set to 1 second.

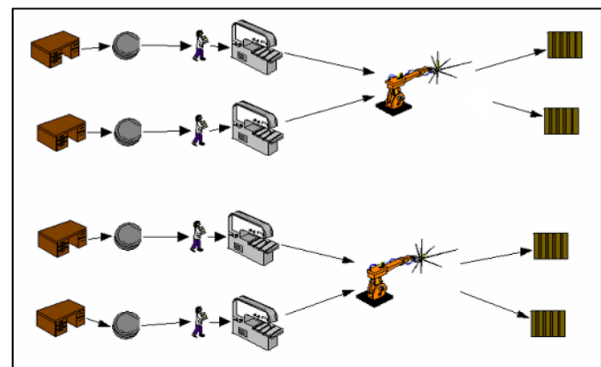


Figure 3: Initial bagging off process layout model

Run time is the duration a model performs a replication. The model was run for 569 hours according to the actual bagging off conditions, with 20 replications performed to test the adequacy of the replication.

Table 9: Replication adequacy test results

Lost Time	Output
N (Total Data)	20
S (Deviation Standard)	7.980
t (t table value)	2.093
K (accuracy degree)	0.05
X (data average)	11.301
N' (total replication)	0.000873789

Based on Table 9, the required number of replications (N) is 8,789 times. The number of replications used is greater than the required replications, indicating that the initial bagging off model meets the minimum number of replications [12].

To optimize production capacity, the first proposal is to add one robotic arm, as shown in Figure 4. Initially, the robotic arm had a transfer capacity of 83 bags per minute, whereas, according to theoretical calculations, the bagging off machine has a maximum capacity of 926 bags per minute. With this bottleneck issue, the maximum capacity of each bagging machine line is 83 bags per minute.

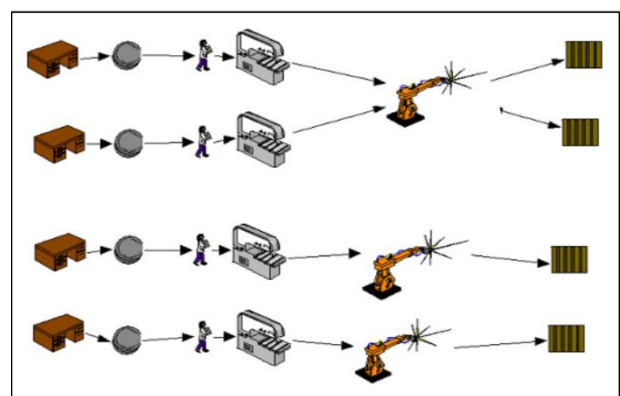


Figure 4: First proposal layout

The simulation of the first proposal results in an average output of 14,690 bags per shift. This output is under ideal conditions where no indefinite lost time occurs during the bagging off process. To adjust to actual conditions, the proposal output will be reduced by 10.02%, resulting in an average output of 13,218 bags per shift. With this proposal, the bagging off process can increase its output by 16.68% and the output of lines A and B by 14%. However, this proposal still does not meet the new bagging off target, so other proposals are needed [13].

The second proposal is to add a bagging off line, as shown in Figure 5. Currently, the bagging off system uses four bagging lines. Adding a bagging off line is necessary because adding sewing machines (machines with the longest processing time) cannot be realized, as one line can only use one machine. Adding a bagging off line involves setting up stations for preparing and sewing bags. The bag transfer to the pallet, usually done by the robotic arm, will be replaced by human labor with the help of a portable conveyor.

The simulation of the second proposal results in an average output of 16,758 bags per shift. This output is under ideal conditions where no indefinite lost time occurs during the bagging off process. To adjust to actual conditions, the proposal output will be reduced by 10.02%, resulting in an average output of 15,078 bags per shift. The second proposal can meet the target by increasing the output by 33.1%. With this proposal, the additional line utilization is 33% to reach the target of 13,400 bags/shift [14].

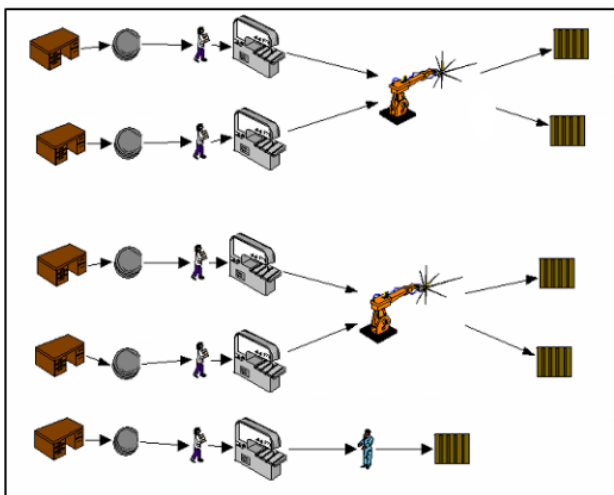


Figure 5: Second proposal layout

The third proposal is based on a combination of all previous proposals: using available time for 69 hours, adding one robotic arm, and adding one bagging off line, as shown in Figure 6.

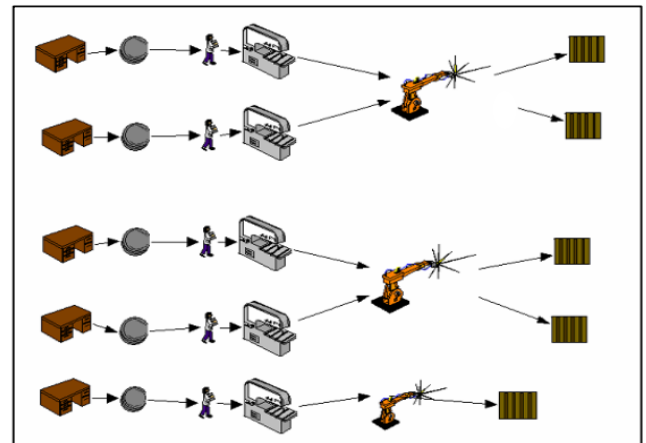


Figure 6: Third proposal layout

The simulation of the third proposal results in an average output of 17,647 bags per shift. This output is under ideal conditions where no indefinite lost time occurs during the bagging off process. To adjust to actual conditions, the proposal output will be reduced by 10.02%, resulting in an average output of 15,879 bags per shift. With this proposal, the bagging off process can meet the target and increase its output by 40.16% [15].

Cost calculation of proposals needs to be done to determine the cost of each proposal, helping the company choose the right proposal. Cost calculation is performed on proposals that can help the company meet the new bagging off target. The second proposal includes adding a Chronos bagging machine, a Newlong sewing machine, and a portable conveyor. The costs were obtained from Alibaba.com and Astar Machine. The company needs IDR 489,717,345 to realize the second proposal, as shown in Table 10. The cost of the second proposal does not include shipping, tax, installation, and technician costs.

Table 10: Cost calculation of second proposal

Machine Name	Total
Chronos Bagging Machine	IDR 278,434,550
New Long Sewing Machine	IDR102,566,495
Portable Conveyor Belt	IDR102,566,495
Total Biaya	IDR 489,717,345

The third proposal includes adding a bagging off line and a robotic arm, including a Chronos bagging machine, a Newlong sewing machine, and a MUYANG robotic arm. The costs were obtained from Alibaba.com and Astar Machine. The company needs IDR 826,787,200 to realize the third proposal, as shown in Table 11. The cost of the third proposal does not include shipping, tax, installation, and technician costs.

Table 11: Cost calculation of third proposal

Machine Name	Total
Chronos Bagging Machine	IDR 278,434,550
New Long Sewing Machine	IDR108,716,300
Muyang Robot Palletizer	IDR439,636,350
Total Biaya	IDR 826,787,200

### V. CONCLUSION

From the OEE (Overall Equipment Effectiveness) calculations on the bagging machine, the average Availability value is 84.16%, the Performance Efficiency value is 29.65%, and the Rate of Quality value is 98.18%, resulting in an OEE value of 24.41%. Based on the available data, the root causes of the problems include insufficient machine part maintenance, lack of machine lubrication, no specific cleaning schedule, pursuing production targets without considering other factors, using non-specification spare parts, and the old age of the machines. The optimization efforts for the bagging off process capacity used simulation methods to measure the effectiveness of the proposals. The third proposal, which involves adding a robotic arm and a bagging off line, should be implemented. The proposed model, compared to the validated initial model under actual bagging off conditions, shows increased output that meets the bagging off target.

### REFERENCES

[1] Aminata, R. N., Muhaimin, A. W., & Primaningtyas, D. N. (2015). Performance Analysis of Animal Feed Main Raw Material Suppliers (Specifically in the Animal Feed Agro industry Company PT. Japfa Comfeed Indonesia Gedangan Unit, Sidoarjo, East Java). Habitat, XXVI.

[2] Jaelani, A. (2021). Production Process and Physical Quality Testing in the Feed Industry. Banjar Baru: Zukzez Express.

[3] Hariyono, Miko. (2009). Evaluation of Machine Effectiveness with the Implementation of Total Productive Maintenance (TPM) at PT Hadi Baru. Final Undergraduated Project. The University of North Sumatra (USU).

[4] Uyun, Q. (2006). Proposed Use of the OEE Calculation Method in the Maintenance Department at PT. KHI Pipe Industry. Final Undergraduated Project. Industrial Engineering of Sultan Ageng Tirtayasa University.

[5] Gazpers, V. (2002). Analysis Methods for Quality Improvement. Gramedia Pustaka Utama. Jakarta.

[6] Bühler Group. 2016. "Innovations for a Better World: Bühler's Innovations Magazine."

[7] Hansen, R.C. (2001). Overall Equipment Effectiveness. First Edition. New York: Industrial Press Inc.

[8] Wulandari, T. (2011). System Failure Analysis using Fault Tree. Final Undergraduated Project. Indonesia University.

[9] Nakajima, S. 1988. Introduction to Total Productive Maintenance (TPM). Cambridge: Productivity Press.

[10] Wignjosobroto, S. (2008). Ergonomi, Motion and Time Studies: Analysis Techniques for Increasing Work Productivity. First Edition. Guna Widya, Surabaya.

[11] Vesely, W.E, (1981). "Bottleneck Handbook". Washington D.C.: U.S. Nuclear Regulatory Commision.

[12] Kumar, S. (2006). Production and Operation Management. New Age International Publisher, New Delhi.

[13] Rander, Berry and Jay Haizer.(2007). Principles of Operations Management. Salemba Empat, Bandung.

[14] Banks J, N. B. (2010) Discrete-event System Simulation (4th ed). NJ: Prentice Hall, Upper Saddle River.

[15] McCarthy, D and Rich, N. (2004). Lean TPM a Blueprint for Change. Burlington: Elsevier.

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