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RESEARCH PAPER

Automated Packaging Machine Analysis with The Overall Equipment Efficiency Method

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ABSTRACT
This research aims to identify the initial OEE (Overall Equipment Efficiency) values on automated packaging machines with a 2d barcode track and trace system. Quantitative research methods used to obtain the OEE value, analysis of factors affecting the OEE values, developing a strategy to make improvements, and evaluate these strategies on the level of machine productivity. The importance of the subject lies in the need to improve the efficiency and productivity of pharmaceutical packaging processes. The pharmaceutical industry is facing increasing pressure to optimize operations and reduce waste. Implementing effective performance measurement tools such as Overall Equipment Effectiveness (OEE) can help identify areas for improvement and enhance productivity. This study found that the track-and-trace system was below the company's standard, indicating room for improvement. Then, countermeasures were implemented to increase productivity and machine effectiveness, and the initial OEE value of the automated packaging machine with 2D barcodes improved. Thus, this study demonstrated the effectiveness of the proposed framework in evaluating and improving OEE in pharmaceutical packaging processes, highlighting the significance of digitalization and automation technologies in enhancing productivity.

KEYWORDS: *Machine productivity; Machine learning; Overall equipment efficiency; Packing machine; Track and trace system.*

1. Introduction

The digitalization of the system and manufacturing process endeavor to improve flexibility, product quality, and productivity; it creates an effective and efficient production process [1]. Due to increasing environmentally-sharing power, industrial companies now have to meet their consumer demands in terms of quality, price, flexibility, and delivery period [2]. As a result, business has to develop plans to improve their flexibility and the effectiveness of operations. Smart technology, analytic data, and related tools help manufacturers increase efficiency, productivity, and accuracy. The producer's capacity to increase reactivity and dexterity in response to changing market conditions and consumer needs is a major factor driving digitalization. The producers can reduce the waste and dissatisfaction of the customers by matching their production cycle with the demand throughout the line [3].

The integration of information technology in the manufacturing sector has given rise to smart factories that boast improved ergonomics, adaptability, and resource efficiency [4]. It has led to a significant transformation in the industry, enabling manufacturers to streamline and optimize their operations in various ways, such as Digitalization. Digitalization changes the way the chain eye operates. It increases productivity significantly. However, with increased investments in technical advances, Digitalization of production brings benefits and difficulties [5]. To get significant market profit growth, industrial organization increase their productivity. Equipment manufacturing is an essential

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component of the system, effectiveness and a direct impact on the quality and product cost, which help increase productivity [6]. The level of machine performance can be decreased through improper machine management and maintenance, reducing the machine's efficiency and output [7], [8].

The Total Productive Maintenance (TPM) method is a crucial procedure for improvement that emphasizes a maintenance-oriented approach to equipment. Many industries have been able to boost responsiveness to increase productivity due to the favorable impact [6], [9]. In TPM, a fundamental quantitative statistic to measure the performance of productive systems is known as Overall Equipment Effectiveness (OEE), one of the most useful methods in the industrial sector for analyzing the performance of one or more machines [10]. OEE consists of performance levels, availability, and quality levels, which measure equipment losses [6]. OEE indicators quickly provide information about the potential and use of machines and the effectiveness of production processes [11], [12]. The OEE plan will enhance product quality and decrease equipment breakdowns, idle time, accident rates, excess inventory, product scrap, and flaws in manufacturing businesses.

OEE has been modified due to its inadequacy as an indicator [13]. Many companies have customized it to suit their particular requirements. Models have been created for areas like sustainability, line manufacturing, assets, resources, transport, and ports based on the OEE framework [14]–[18]. This research applies the OEE method to provide alternative solutions that may be useful for companies to increase the effectiveness of conveyor machines. OEE is the most important performance measurement in modern manufacturing facilities. The TPM method's efficacy can be measured against OEE requirements. It is demonstrated by making the most of machine performance while manufacturing activities are being completed.

In order to enhance the analysis in this research, the researcher used several previous researches. Chikwendu et al. [6] proved that the implementation of a well-designed TPM will not only bring significant improvements in other fields but will also increase efficiency and improve equipment, thereby increasing the profitability of manufacturing companies. Dobra and Josvai [18] outline the stages of the OEE life cycle, their features, and how they affect production costs for semi-automated assembly lines in the real world. Research by Zubair et al. [19] demonstrates that OEE is a crucial tool for locating potential bottlenecks in a manufacturing line and covers three key categories: equipment availability, performance, and output quality. Facchinetti and Citterio [20] find the application of transforming OEE into a target that drives improvement by identifying areas of loss in the production process. Ginste et al. [21] emphasize the value of flexibility in equipment effectiveness measurement to support the mass customization paradigm and strive for continual improvement towards a resilient manufacturing system. In this research, OEE will be applied to identifies the initial value of OEE on automatic packaging machines with a barcode system 2d track and trace.

After getting an OEE score, an analysis of the factors affecting the value of the OEE is performed. The next step is to develop a strategy to improve the problem and evaluate that strategy at the engine's productivity level. Further, the replacement performed based on the OEE value of the machine has yet to reach the standard minimum target of 85%. Availability values obtained from other OEE components have been reduced. It is necessary for further analysis and correction of the cause of downtime or breakdown, among other things: changes in batch time. Since the machine processes two batches per day, thus, there is downtime used for the clear and check process from the first batch to the second batch. In addition, this automatic packing machine is connected to the 2d barcode track and trace system, so the internet network's stability becomes a decisive factor in starting the packaging process.

2. Methodology

This research design used a quantitative approach. In testing the productivity level, analysis is used with the OEE method as an indicator of machine performance. OEE is a collaboration between an organization’s production and maintenance functions that consistently directs the plant's attention to zero waste [22]. This research was conducted at a pharmaceutical company. The object of this research is an automatic packaging machine equipped with a 2D barcode track and trace system, starting from the labelling stage to cartooning. The product used is the COVID-19 vaccine. Primary data is obtained by digging for information or directly observing the object to be studied and carried out by the researcher concerned. Observations are made, such as observing the packaging process, machine maintenance processes, and others. Sources of information supplied by other parties are used to gather secondary data. In this case, the researcher conducted a literature study using books, newspapers, websites, research journals, company documentation, and other sources of information. After the necessary information has been gathered, an initial OEE calculation is performed, and then a fishbone diagram is used to analyze the elements that affect the OEE value. From these results, an analysis is conducted to determine steps to overcome/repair the problems. The last stage of this research is to draw conclusions and make recommendations that can be given to the company.

Further, this study applied the OEE method because there are several reasons such as OEE provides a comprehensive, standardized measurement framework that combines three key performance indicators: availability, performance rate, and quality rate. This holistic approach allowed for a more accurate assessment of the overall effectiveness of the device and identified specific areas for improvement. Besides, OEE identifies losses and inefficiencies in the production process. By analyzing downtime, speed reduction, and quality loss using an OEE matrix, companies can identify the root causes of low OEE and implement targeted improvement strategies.

Additionally, OEE facilitates benchmarking and performance comparisons between different machines, production lines, and facilities. This enables companies to identify the best practices, set realistic goals, and drive continuous improvement initiatives. Thus, the OEE approach provides a structured, systematic approach for measuring, analyzing, and improving system effectiveness.

Primary and secondary data were gathered as part of the data collection strategy for this study. Primary data is information that researchers have gathered by personally visiting production sites. The steps of the packing process, the kind of machine utilized, the machine's capacity, and the kind of product produced were all noted. Secondary data is information that researchers have gathered from published works and business records. The following information was gleaned from machine records that company technicians and machine operators directly examined:

- Data running time is overall time that shows the number of working hours used in production process.
- Data downtime (breakdown) occurs when the machine stops production due to unforeseen circumstances. This situation relates to machine and non-machine problems, such as power outages, malfunctions, and setup.
- Planned downtime data is the scheduled time for the production process to stop during working hours, such as breaks, gymnastics, prayers, etc.
- Data loading time is the net time available for running the production process.
- Data operation time is the time used to run the production process without considering downtime.
- Data on the number of output products produced.
- Data on the number of failed or defective products (rejects).

2.1. Data processing method

According to Agustiady and Cudney [23], Equations (1)–(3) are used to calculate the availability rate, performance efficiency, and quality rate (%).

- Availability (AV)

  First, calculate the loading time and operation time every month, then calculate the availability [24].

$$\text{Availability (AV)} = \frac{\text{Operating time}}{\text{Loading time}} \times 100\% \tag{1}$$

- Performance Rate (PE)

  The data used to calculate the performance rate is the operational time data per month, the actual data production output per month, and the standard value of output that the machine is capable of producing in 1 minute [24].

$$\text{Performance rate (PE)} = \frac{\text{Actual output}}{\text{Operation time x Output standard}} \times 100\% \tag{2}$$

- Rate of Quality (RQ)

  The data used to calculate the rate of quality is data on the total production output in one month and data on failed or defective products rejects [24] .

$$\text{Rate of quality (RQ)} = \frac{\text{Actual output} - \text{Reject product}}{\text{Actual output}} \times 100\% \tag{3}$$

- Calculating machine OEE values, which take into account availability, performance rate, and rate of quality, OEE is a TPM measurement that determines the real efficacy of a piece of machinery or a production line.
- The formula for calculating OEE, namely making comparisons with OEE value categories, makes OOE matrix analysis based on the big six losses, makes fishbone diagram

analysis, and develops problem-solving strategies.

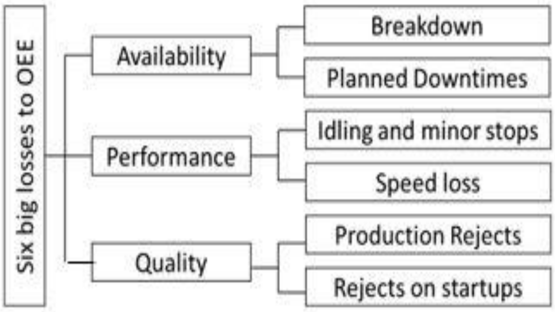

Fig. 1. Six big losses

Meanwhile, there are several troubleshooting analysts as follows:

- OEE analysis.
- OEE matrix analysis based on the big six losses.
- Analysis of fishbone diagrams.
- Problem analysis and proposed countermeasures/improvements.

In addition, there are three strategies for compilation of proposed countermeasures/remedies as follows:

- Create coping or improvement strategies for problems that occur.
- Carry out countermeasures or repairs.
- Evaluate the results of the condition of the machine after the countermeasures or repairs have been carried out.

3. Results and Discussion

3.1. Production process

This research focuses on one of the routinely used machines, an automatic packaging machine with a Track and Trace 2D barcode system. This packaging machine uses a PL1 labelling machine for the labelling process and a PL1 cartooning machine for the inline packing process. This automatic packaging machine is only used for biological products implementing the Track and Trace 2D barcode system in primary, secondary, and tertiary packaging. One of the products that is the object of research is the COVID-19 vaccine, with a batch size of 15,000 vials. The vaccine was newly developed and successfully launched commercially a few months ago. The product is new, thus the effectiveness of the machine in the packaging process will be analyzed using the OEE calculation, which is utilized as a tool to assess the effectiveness of the production system.

3.2. Initial OEE calculation

3.2.1. Availability (AV)

In calculating the availability, the first step is calculating the loading time on the automatic packaging machine shown in Table 1. After obtaining the loading time values for each period, the required operation time is calculated to calculate the availability. It can be shown in Table 2. After obtaining the value of the operation time for each period, the availability calculation is then carried out. Availability calculation requires loading time data in Table 1 and operation time in Table 2. The calculation of automatic packaging machine availability is shown in Table 3.

Tab. 1. Calculation of the automatic packing machine loading time

Batches	Working hours (minutes)	Planned downtime (minutes)	Loading time (minutes)
1	540	110	430
2	540	110	430
3	540	110	430
4	540	110	430
5	540	110	430
6	540	140	400

Tab. 2.Calculation of the automatic packaging machine operation time

Batches	Loading time	Downtime/	Operation time

	(minutes)	Breakdown (minutes)	(minutes)
1	430	0	430
2	430	0	430
3	430	0	430
4	430	0	430
5	430	0	430
6	400	0	400

Tab. 3.Calculation of the availability of automatic packaging machines

Batches	Loading time (minutes)	Downtime / Breakdown (minutes)	Operation time (minutes)	Availability (%)
1	430	0	430	100
2	430	0	430	100
3	430	0	430	100
4	430	0	430	100
5	430	0	430	100
6	400	0	400	100

3.2.2. Performance rate

The data needed to calculate the performance rate are monthly operation time, production data per month, and standard output. Operation time data is obtained from the calculations in Table 2, production data is obtained from company documentation, and the standard output that a machine can produce in a unit of time is 100 units per minute. The calculation of the packaging machine performance rate is shown in Table 4.

Tab. 4. Calculation of the packaging machine performance rate automatic

Batches	Production actual output (vial)	Operation time (minutes)	Performance rate (%)
1	14063	430	32.70
2	13913	430	32.36
3	14286	430	33.22
4	15691	430	36.49
5	16020	430	37.26
6	15426	400	38.57

3.2.3. Rate of quality (RQ)

Data on production output and the number of failed or defective products (rejects) are obtained from company documentation in the form of production records while calculating the automatic packing equipment quality rate described in Table 6. After receiving the availability value in Table 3, the performance rate in Table 4, and the quality rate in Table 5 for each period, the OEE calculation is performed. The summary of the calculation results for the OEE value of the packaging machine is in Table 6. In addition, the following average OEE values can be seen in Figure 2.

Tab. 5. Calculation of the rate of quality for automatic packaging machines

Batches	Actual production output (units)	Number of rejects (units)	Good output (units)	Rate of quality (%)
1	14,063	2240	11,823	84
2	13,913	1680	12,233	88
3	14,286	2240	12046	84
4	15,691	1680	14011	89
5	16020	2240	13,780	86
6	15,426	1680	13,746	89

Tab. 6. OEE recapitulation of automatic packaging machines

Batches	Availability (%)	Performance rate (%)	Rate of quality (%)	OEE (%)

1	100	32.70	84	27.50
2	100	32.36	88	28.45
3	100	33.22	84	28.01
4	100	36.49	89	32.58
5	100	37.26	86	32.05
6	100	38.57	89	34.37
Average	100	35.10	86.79	30.49
SD	0	2.25	1.96	2.42
Average ± 2SD	100	30.60 – 39.60	82.86 – 90.72	25.65 – 35.34

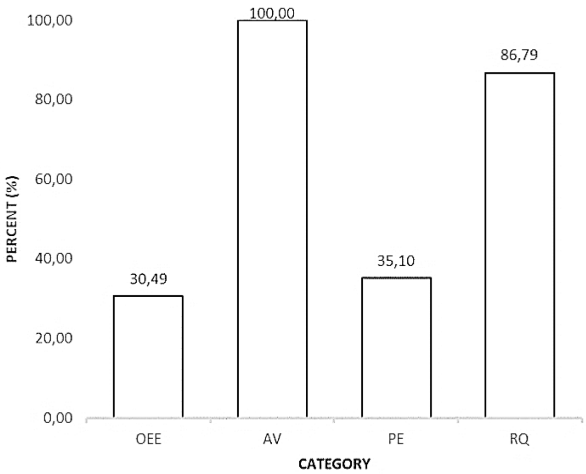

Fig. 2. The average achievement of the OEE value of automatic packaging machines

The calculated OEE value is 30.49%; this value is compared to the goal OEE value, which is at least 85% and is based on international standards. Park and Zhu [25] also explained that achieving an OEE value of 85% is an ideal condition for a machine to be said to be operating properly. The achievement of automatic packaging machine performance based on the OEE value obtained still needs to meet the targets set by the company because it causes significant economic losses, and the company's competitiveness could be much higher than it.

3.3. OEE outcome analysis

OEE is an effective method for locating and eradicating manufacturing losses in terms of performance, availability, and quality rate [26]. Based on Figure 1, it can be seen that the calculation of the average d OEE value for automatic packaging machines has not reached the established standard (OEE of at least 85%), and the value that most significantly affects OEE is the value of performance (PE). It can be seen from the average performance value of 35,10%, which is lower than the average availability (AV) value of 100% and the average quality rate (RQ) of 86.79%. In Figure 2, it can be seen the OEE matrix for analyzing losses that significantly affect the OEE value. With the six big losses method, the value of the main losses that occur and the most dominant they affect OEE achievements in automatic packaging machines will be known. This result is in accordance with previous research that has been done [26].

TPM first identified six major production losses and their underlying causes, including downtime losses brought on by equipment failure and changes, speed losses resulting from idling, minor stops, speed dips, and defect losses brought on by process flaws and lower yields. According to Agustiady and Cudney [23], six significant losses that fall into three categories have an impact on the effectiveness of OEE as follows:

- Downtime losses that have an impact on availability.
- Speed reductions that lower performance rates.
- Quality losses that influence the rate of quality.

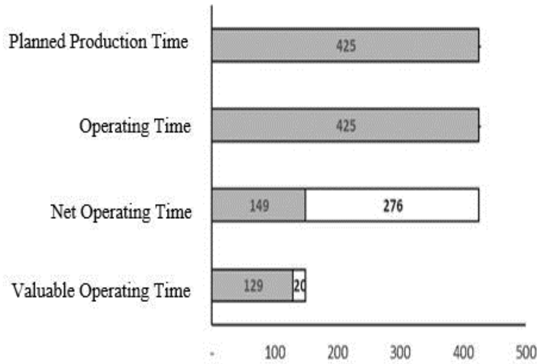

Fig. 3. OEE matrix using average actual working hours

Tab. 7. Six big losses in automatic packaging machines

Six Big Losses	Total Losses (minutes)	Percentage (%)	
Downtime losses	Equipment failure Setups and adjustments	0	0%
Speed losses	Minor stoppage Reduced speed	276	93.24%
Quality losses	Defects in process and rework Startup losses	20	6.76%
Total	296	100%	

OEE matrix can be seen in Figure 3 and Table 7 that the average planned working time in that period was 425 minutes. In that period, there was no breakdown of the machine. From the average time used for the packaging process, there are losses of the type of idle losses, minor stoppages, and a reduced speed of 276 minutes. The average wasted time caused by losses due to idling, minor blockages, and the reduced rate is obtained from the difference between the average operating time used for production and the average time required for packaging in each period, based on the number of products in each period referring to the ideal run time. The time for good product packaging is 129 minutes, and losses reduce yield, which has units of vials, which, if converted into units of minutes, will produce a value of 20 minutes. This research is in accordance with Benyathiar et.al [27].

When grouped into six big losses, the very low PE value is due to idling losses, minor stoppages, and reduced speed. Reduced speed is a condition in which a machine is operated at a speed that does not match the design (ideal) speed of the engine (usually, the actual speed is lower than the ideal speed) due to the small batch size of the product; the machine is old, including losses idling and minor stoppages when there is a stop or jam at certain points of the device. An in-depth analysis is needed regarding the causes of idling, minor stoppage losses, and reduced speed so that improvements can be made to the problems that affect the OEE value.

Based on the calculation of the OEE on the automatic packaging machine, it was found that there were losses that most significantly affected the OEE, namely idling and minor stoppage losses and reduced speed. Meanwhile, an analysis was carried out using the Fishbone diagram method in Figure 4. It is used to identify the highest cause of failure in idling, minor stoppage losses, and reduced rate. The main reasons for losses are the main causal factors in materials, techniques, machines, and humans [28]. After analyzing the possible causes of the highly reduced speed problem, an examination of the actual conditions in the automatic packaging machine is carried out, including the factors in the diagram above. The results of the analysis are seen in Table 8. It is similar with the Kuric et.al's research [29].

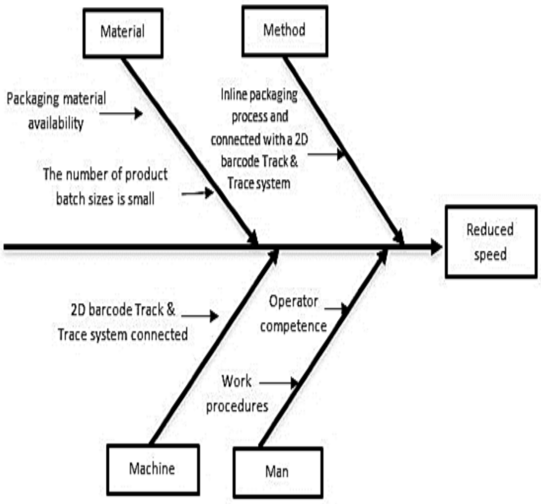

Fig. 4. Fishbone diagram reduced root cause analysis speed on an automatic packaging machine

Tab. 8. Analysis of the actual condition of automatic packaging machines

Factor	Conditions that should have happened	The actual conditions that occurred	Evaluation Method	Information
	Packaging materials are available on time	Packaging materials are available on time	Genba and observation	Qualify
Material	Packaged product batch size	The batch size of the product is 15000 vials, which is smaller than the batch size of the machine's capacity	Packing scheduling by increasing the number of batches packed in one day (from 1 batch to 2 batches)	Not eligible
Method	Integrated 2D barcode Track & Trace system with in-line packaging process.	According to the method, the packaging process is integrated with the 2D barcode Track & Trace system.	Genba and observation	Qualify
Machine	The machine runs fine	The machine runs fine	Genba and observation	Qualify
	The Track & Trace system link for 2D barcodes functions well.	The Track & Trace system link for 2D barcodes functions well.	Genba and observation	Qualify

Factor	Conditions that should have happened	The actual conditions that occurred	Evaluation Method	Information
Man	Operators are competent enough.	Operators are familiar with the upkeep and use of automatic packing equipment.	Trial training and practice	Qualify
	Operators are familiar with work processes.	The operator is aware of the machine's specified operating instructions.	Trial training and practice	Qualify

One factor contributing to the machine's lowered speed is the batch size of the items processed by the packing process, which is lower than the optimal machine capacity, as indicated in Table 8. The issue is resolved by planning the packaging and increasing the number of processed product batches. With the addition of the packaging schedule, it can be done in stages, from 1 to 2 sets per day. It is similar with two previous studies [30], [31].

By bringing actual production capacity closer to the ideal runtime, i.e., scheduling two batches of packaging per day, efforts to increase productivity and machine effectiveness are carried out. It is accomplished by being aware of the OEE figures and the investigation outcomes into the variables generating the subpar OEE levels still present. The strategy is practical and realistic for the business. The results of OEE calculations after repairs were carried out for one week (6 days) obtained data on running time, downtime, planned downtime, loading time in Table 9, operation time in Table 10, the number of output products produced, the number of failed/defective products (reject). It is similar with the previous studies [32]. The calculation results for each period in the OEE category from availability (AV), performance rate (PE) and rate of quality (RQ). It can be seen in Table 11, Table 12 and Table 13. Meanwhile, an OEE value after countermeasures/repairs is 67.67%. It can be proven in Table 14.

Tab. 9. Calculation of automatic packaging machine loading time

Batches	Working hours (minutes)	Planned downtime (minutes)	Loading time (minutes)
7, 8	540	110	430
9, 10	540	110	430
11, 12	540	110	430
13, 14	540	140	400
15, 16	540	110	430
17, 18	540	110	400

Tab. 10. Calculation of automatic packaging machine operation time

Batches	Loading time (minutes)	Downtime / Breakdown (minutes)	Operation time (minutes)
7, 8	430	60	370
9, 10	430	105	325
11, 12	430	60	370
13, 14	400	60	340
15, 16	430	90	340
17, 18	400	60	370

Tab. 11. Calculation of the availability of automatic packaging machines

Batches	Loading time (minutes)	Downtime/ Breakdown (minutes)	Operation time (minutes)	Availability (%)
7, 8	430	60	370	86.05
9, 10	430	105	325	75.58
11, 12	430	60	370	86.05
13, 14	400	60	340	85.00
15, 16	430	90	340	79.07
17, 18	400	60	370	86.05

Tab. 12. Calculation of packaging machine performance rate automatic

Batches	Production actual output (vial)	Operation time (minutes)	Performance rate (%)
7, 8	31,450	370	85.00
9, 10	31,950	325	98.31
11, 12	32,220	370	87.08
13, 14	31,500	340	92.65
15, 16	30,570	340	89,91
17, 18	31,110	370	84.08

Tab. 13. Calculation of rate of quality for automatic packaging machines

Batches	Actual production output (units)	Number of rejects (units)	Good output (units)	Rate of quality (%)
7, 8	31,450	3,360	28,090	89
9, 10	31,950	2,800	29,150	91
11, 12	32,220	3,920	28,300	88
13, 14	31,500	2,800	28,700	91
15, 16	30,570	3,360	27,210	89
17, 18	31,110	3,360	27,750	89

Tab. 14. Repopulation of OEE of automatic packaging machines

Batches	Availability (%)	Performance rate (%)	Rate of quality (%)	OEE (%)
7, 8	86.05	85.00	89	65,33
9, 10	75.58	98.31	91	67,79
11, 12	86.05	87.08	88	65,81
13, 14	85.00	92.65	91	71.75
15, 16	79.07	89,91	89	63,28
17, 18	86.05	84.08	89	64,53
Average	83,17	90.76	89,87	67,67
SD	4.13	4.88	1.20	2.75
Average ± 2SD	74.91 – 91.43	80.99 – 100.53	87.47 – 89.87	62.18 – 73.16

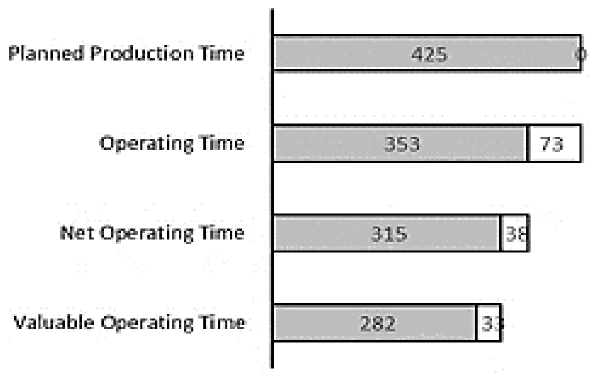

Fig. 5. The OEE matrix using the actual average working hours after countermeasures

The efforts to increase the productivity and effectiveness of the machine's packaging process machine by setting a packaging schedule of two batches in one day to bring the actual production capacity closer to the ideal runtime. The results of the OEE matrix analysis after solving the problem are shown in Figure 5 above. OEE matrix after countermeasures average planned working time in that period was 425 minutes. It can be seen in Figure 5. The packaging process is 353 minutes, and the average breakdown and set-up time is 73 minutes. In the average time used for the packaging process, there are losses from idle and minor stoppages and a reduced speed of 38 minutes. The average wasted time caused by losses due to idling, minor jams, and reduced rate is obtained from the difference between the average operating time used for production and the average time required for packaging in each period based on the number of products in each period regarding the ideal run time. While the time used for good product packaging is 282 minutes, losses reduced yield, which has units of vials, if converted into minutes, will produce a value of 33 minutes. The results of comparing OEE values before and after countermeasures/repairs are shown in Figure 6. This results similar with previous studies [33], [34].

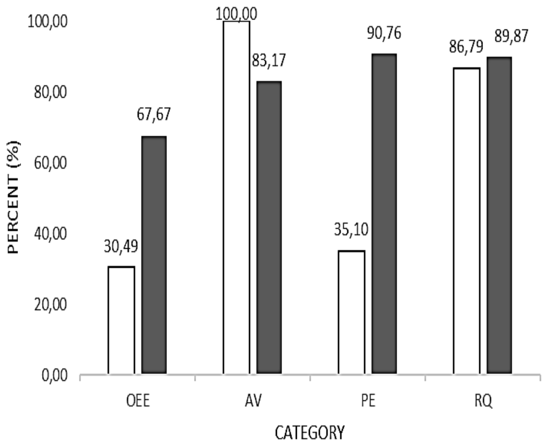

Fig. 6. Comparison of the average achievement of the OEE value

4. Conclusions

The results of this study show that the initial overall equipment effectiveness (OEE) of automated packaging machines equipped with 2D barcode tracking systems is lower than that of company standards. Analysis of losses using the OEE matrix showed that idling, minor stops, and reduced speed were the main reasons for lower OEE. These losses were further analyzed using fishbone diagrams, identifying factors such as material availability, machine performance, and operator skill as key causes.

Based on the explanation above, it can be concluded that the initial value of OEE on automatic packing machines with track and trace 2d barcode system is 30.49 %. This value is still far below the company standard of 85%; although the availability value (av) and the rate of quality (rq) are quite high, the performance rate (pe) still needs to be higher, so the OEE value is low. Based on analysis of six big losses, the biggest factor that causes the low OEE value is reduced speed, where the machine is operated at a speed that does not correspond to the design speed (ideal) of the machine (usually the actual speed is lower than the ideal speed) which can be caused due to the small batch size of the product. By determining and analyzing the root problem using the method of fishbone diagrams, problem response proposals are done by adding a batch number to the packing process. Based on the OEE, count average after-problem response is 67.67 %. An increase in value gained by 37.18 % from the previous value achievement. With that response, these changes also affect the price component of the sale point, one of them costing immediate labor (back) and increased productivity.

In conclusion, this study provides valuable insights into the evaluation and improvement of OEE in pharmaceutical packaging. These results highlight the importance of addressing factors, such as idle time, minor downtime, and speed reduction, to improve productivity. Implementing countermeasures and using digital and automation technologies can significantly improve the OEE and overall process efficiency.

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