Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023
DOI : https://doi.org/10.33395/sinkron.v8i4.12953
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Automatic OEE Data Collection and Alert System for Food Industry

Ruly Sumargo[1)]*, Amelia Makmur[2)]
[1)]Pradita university, Tangerang, indonesia
[1)]ruly.sumargo@student.pradita.ac.id, [2)] amelia.makmur@pradita.ac.id

Submitted : Aug 31, 2023 | **Accepted** : Sep 15, 2023 | **Published** : Oct 1, 2023

Abstract: The constant demand for food and beverages to sustain human life drives fierce competition among manufacturers, focusing on product excellence in terms of timeliness, quality, and pricing. The key to competitiveness depends in optimizing manufacturing processes by efficiently utilizing company resources. To ensure the overall optimization and reliable flow of manufacturing processes, a systematic evaluation process must be used, Overall Equipment Efficiency (OEE) stands out as a prominent performance measurement metric in manufacturing process efficiency. OEE serves as a valuable diagnostic tool, exposing areas for improvement and losses transparently. Accurate OEE measurement necessitates the implementation of an automated data collection system with minimum human dependencies, human intervention, and conducting on-the-fly calculations to informed the stakeholder/user. Data quality and accuracy in OEE measurement is very critical. Low quality and accuracy data could lead to false decision. OEE categorizes losses into six groups loss to pinpoint significant factors for potential improvement. Once OEE could be maintain at high level with high data accuracy and right improvement point, an optimum manufacturing process, and cost effective in manufacturing expenses will be achieve. Base on the result comparison for OEE result before and after the system implementation, positive improvement in OEE could reach 8.06%. This scenario be adopted by other company, and could become a model for 1st phase journey in company digital transformation.

Keywords: Automated Data Collection; Food and Beverage; Optimizing Manufacturing Processes; Overall Equipment Efficiency (OEE); Six Groups Loss

INTRODUCTION

Humans will always have a huge demand on food and beverages to support their lives, which pushing the competition among industries or manufacturers to produce competitive products which excel in terms of time deliverable, quality, and pricing. Optimizing the manufacturing process through optimum utilization of the company resources, becomes the key success factor on the competition (Cahyono et al. 2020; Haddad et al., 2021).

Nowadays an automated machine in the manufacturing area mostly were using a Programmable Logic Controller (PLC) as the main controller (Hudedmani et al., 2017; Khairullah & Sharkawy, 2022). Even though the machine were already automatic and using latest technology, the machine performance will be degraded upon time and potentially will affecting the product quality which produce using this machine (Karmilawati et al., 2021). To ensure the product quality were maintained, the maintenance activity to the machine must be performed regularly, analyzing listed error which occur, and potential improvement points (Wiyatno, et al., 2018; Hamda, 2018).

*Ruly Sumargo

SinkrOn
JURNAL & PENELITIAN TEKNIK INFORMATIKA
Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023
DOI : https://doi.org/10.33395/sinkron.v8i4.12953
e-ISSN : 2541-2019
p-ISSN : 2541-044X

To ensure the overall manufacturing process is optimized correctly and has a reliable flow, evaluation process must be performed in a good manner using specific tools and methods. The most popular performance tool in the manufacturing process efficiency is Overall Equipment Efficiency (OEE) (Rasib & Ebrahim, 2017; Iannone & Nenni, 2015). OEE is a good tool to diagnose the manufacturing process, reveal the area for improvement and losses area more transparently. To perform an accurate OEE measurement, an automated data collecting system (data mining) from all related equipment must be implemented. It should be able to collect a large amount of real time data and perform a real time calculations for decision making (Iannone & Nenni, 2015). Data quality and accuracy for OEE measurement were very crucial, it should have a low human dependency and intervention. OEE could be considered effective and ideal at level of 85% (Suliantoro et al., 2017). In OEE method we could classify losses into 6 groups, to make users see the most significant factor which affecting the OEE and potential improvement point (Hedman et al., 2016; Suliantoro et al., 2017). Once an accurate data for OEE being collected, it could lead to produce a good improvement point and focused decision (Prasetio & Sulistriadi, 2019).

Considering the importance of data accuracy for performance measurement and classifying the data to support a good decision being taken on the manufacturing area, authors intend to design a data mining system which able to collect and automatically calculate the OEE of packaging machines. It will utilizing a direct machine-to-machine (M2M) communication between PLC controllers (Imam et al., 2011), direct data sharing PLC controllers to database, fault tree analysis for losses and automatic alert system to management on suppressing the down time. By performing direct data sharing, it could ensure the data accuracy will be higher than 90%. This method could be use as 1st phase of journey in digital transformation in manufacturing area, conducting a data driven decision, achieve an optimum manufacturing process, and cost effective in manufacturing expenses.

LITERATURE REVIEW

Overall Equipment Effectiveness (OEE) is a matrix or assessment method to know the effectiveness of a machine or production. The result could use as a performance indicator for machine or production line. OEE could be calculated using equation:

$$OEE\ (\%) = Availability\ (\%)\ x\ Performance\ Efficiency\ (\%)\ x\ Rate\ of\ Quality\ Product\ (\%) \quad (1)$$

$$Availability\ (\%) = \frac{Operating\ Time}{Loading\ Time}\ x\ 100\% \quad (2)$$

$$Loading\ time = available\ time - planned\ downtime \quad (3)$$

$$Loading\ time = available\ time - (maintenance + break\ time) \quad (4)$$

$$Operating\ time = Loading\ time - unplanned\ downtime \quad (5)$$

$$Performance\ Efficiency\ (\%) = \frac{Actual\ Capacity\ Production}{Ideal\ Run\ time}\ x\ 100\% \quad (6)$$

$$Actual\ Capacity\ Production = \frac{Total\ Production\ Quantity}{Operation\ Time} \quad (7)$$

$$Performance\ Efficiency\ (\%) = \frac{Total\ Production\ Quantity}{Operation\ Time\ x\ Ideal\ Run\ time}\ x\ 100\% \quad (8)$$

$$Rate\ of\ Quality\ product\ (\%) = \frac{(Total\ Production\ Quantity - Defect\ Quantity)}{Total\ Production\ Quantity}\ x\ 100\% \quad (9)$$

Equation (1) parameters has been explained by Japan Institute of Plant Maintenance (Nakajima, 1988; Iannone & Nenni, 2015). Availability depicts the condition of a machine being ready to produce a product within a specific timeframe. Availability (2) is calculated by dividing the operational time of the machine to produces products by the total loading time. Performance efficiency (8) reflects the machine's condition when producing products, whether it aligns with the intended quantity of products produced within a designated time, based on the initial design of the machine's maximum capacity. Rate

*Ruly Sumargo

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023
DOI : https://doi.org/10.33395/sinkron.v8i4.12953
e-ISSN : 2541-2019
p-ISSN : 2541-044X

of Quality Products (9) portrays the percentage of good products compared to the total products produced. Nakajima on his book explain ideal OEE parameter as shown below (Nakajima, 1988)

- Availability > 90%
- Performance Efficiency > 95%
- Quality Product > 99%

Ideal OEE (%) = 90% x 95% x 99% = 85% *(Good Criteria)*

Base on the three related element in OEE calculation, 6 group of losses could be classified and monitored for the correlation with action related with OEE improvement (Hedman et al., 2016). To ensure the calculation could be done smoothly, the 6 group of losses were distributed as shown in Figure 1.

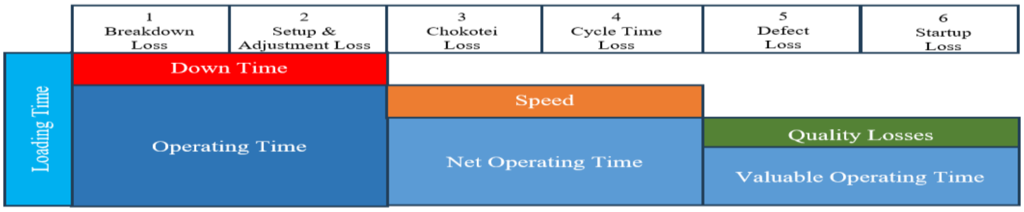


Fig. 1 OEE and 6 Big Losses Classification

In a study conduct by (Hedman et al., 2016), inaccurate data which collected manually for OEE calculation, such as log book in production, could easily manipulated and losses classification will become bias, in example the data record for machine stop time and duration of production activities will lead to false OEE calculation and analysis. The collateral damage due to this condition will lead to wrong decision or improvement action items on the machine, and in the end will affecting to unnecessary cost from wrong decision.

METHOD

This research arranged through systematic flow on identifying the problems, collecting the information, perform investigation, and developing the final solution (Kothari, 2004; Adams & Lawrence, 2019), as shown in Figure 2.

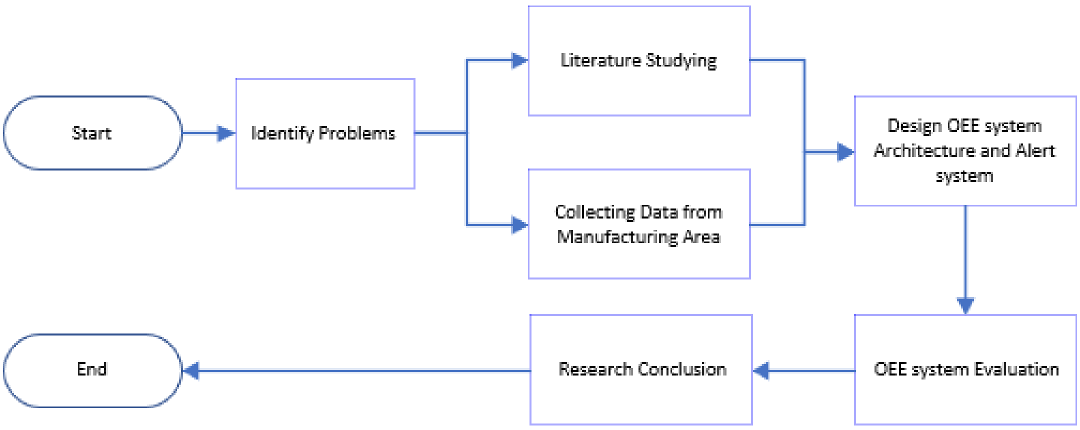


Fig. 2 Research Flow Chart

In the system, Microsoft SQL Server 2019 were use as the database storage of the system, the custom dashboard and platform were built under ASP.NET. Specific ethernet port (TCP/IP) number 1433 were being open and used for the database connection services. A specific PLC in this system were use as a data collector and controller bridging between Information Technology system (IT) and Operational Technology system (OT). Figure 3 shown the flow process of OEE system. In most of OEE system, it did not integrate with automatic alert function for the stakeholder in manufacturing operation.

*Ruly Sumargo

SinkrOn
JURNAL & PENELITIAN TEKNIK INFORMATIKA
Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023 e-ISSN : 2541-2019
DOI : https://doi.org/10.33395/sinkron.v8i4.12953 p-ISSN : 2541-044X

This condition has caused a slower response time during the problem-solving period. It is become the background for implementing the automatic alert function in the new OEE system.

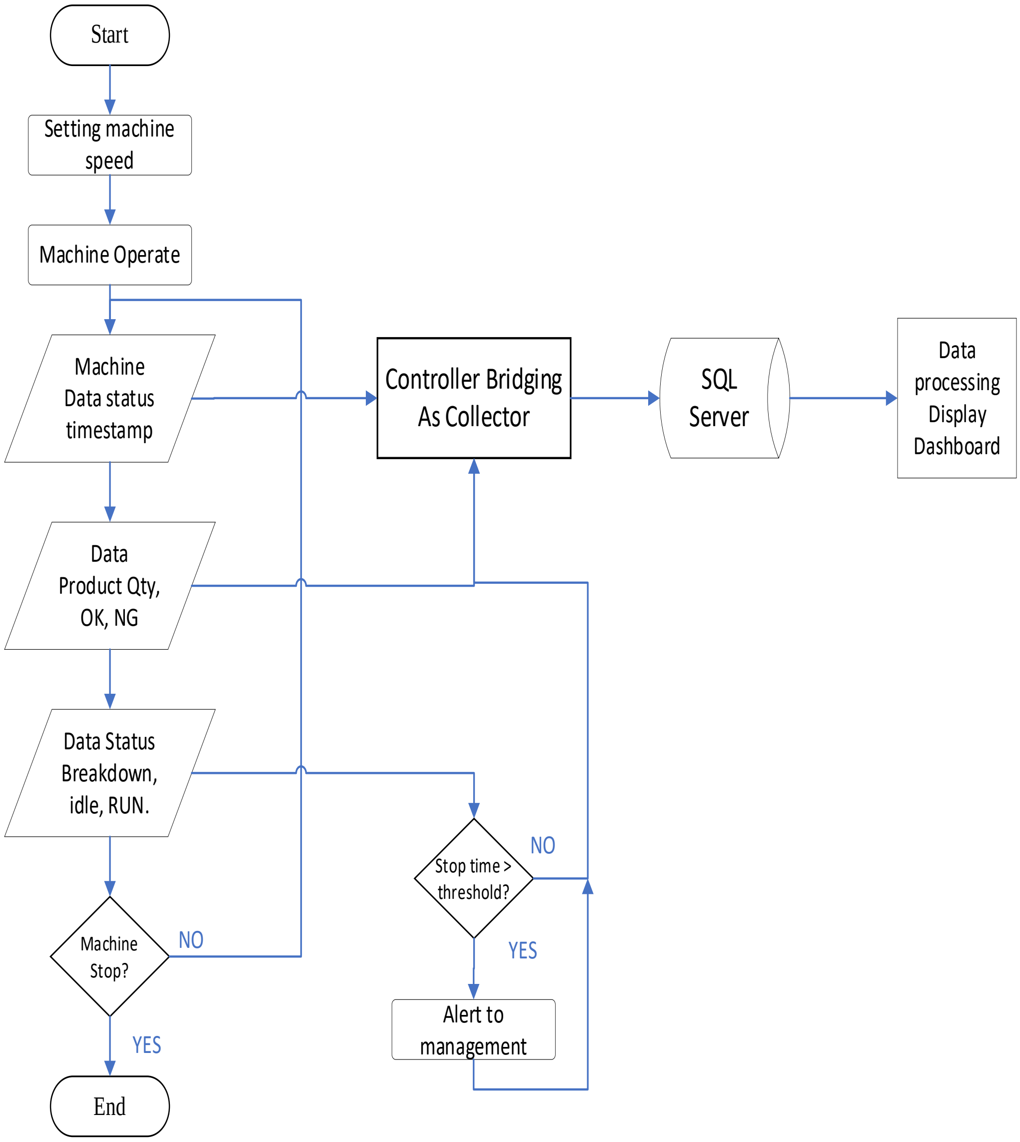


Fig. 3 System Flow Chart

In a study conduct by (Imam et al., 2011) found, sharing data from one machine to another can be achieved by utilizing communication protocols available in the PLC such as Ethernet IP, TCP/IP, MODBUS TCP, and others. For storing the shared data from the PLC into a database, the DB Connection service is used through the TCP/IP protocol. Through this way, the data collected from each machine unit will be automatically stored in a database. Subsequently, it will be displayed on a dashboard. In this study after the losses being classified, the specific alert system will be triggered to inform management team once it has pass time limit on the occurred losses. By implementing this, OEE could significantly improve and become good evidence for digital transformation implementation at the beginning phase

This system performing automatic data mining directly from the machine, it will ensure the data accuracy could be guaranteed and real time data being collected properly, which not easy to be manipulated by human. The collected data directly obtained from the machines by utilizing signals from sensors and existing inputs as signals for categorizing the six major losses, Table 1 shown the big losses classification with correlation to the losses root cause, error code, and OEE measurement category.

.

*Ruly Sumargo

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023 e-ISSN : 2541-2019
DOI : https://doi.org/10.33395/sinkron.v8i4.12953 p-ISSN : 2541-044X

Table 1 Big Losses Classification for OEE Measurement (Azizah & Rinaldi, 2022)

Loss Category	OEE Measure	Reason for Loss	Error Code
Breakdown Loss	Availability	• Major component failure/ Cutting Blade Change • Breakdown	1 2
Setup & Adjustment Loss	Availability	• Planned maintenance • Material availability • Labor shortage/Break Time • Changeover • Measurement Adjustment	3 4 5 6 7
Chokotei Loss	Performance	• Fallen product and Cleaning • Blockages/Process Failure • Misalignment • Minor Stoppage	8 9 10 11
Cycle Time Loss	Performance	• Running lower than nominal speed • Untrained operator not able to run at nominal speed	12 13
Defect Loss	Quality	• Product out of spec • Scrap	14 15
Startup Loss	Quality	• Product out of spec at process start of run • Damage product after maintenance activity	16 17

Figure 4 shown the high-level system architecture for the packaging line data mining. Ethernet IP communication directly between PLC to the database has push down human intervention and improve the data accuracy. OPC UA and Modbus TCP were used to accommodate the data sharing among PLC and server in the system. Several Application Program Interface (API) were deployed to ensure the system could communicate with ERP system in the factory and the maintenance scheduling software.

This OEE dashboard system were required to be accessible by management team from outside the company. Considering the feasibility of cyber threat, firewall and also the redundant server were implemented in this system. Automatic backup process for the database were set automatically in weekly basis, as an additional prevention of data lost.

Several gadgets (tablet PC) were provided and connected to the system and enabling the packaging machine operator for giving feedback on several condition which not covered by sensors, during manufacturing activity, such as giving acknowledge when break time coming, perform cleaning process, or trigger a feedback on material availability issue.

*Ruly Sumargo

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023
DOI : https://doi.org/10.33395/sinkron.v8i4.12953
e-ISSN : 2541-2019
p-ISSN : 2541-044X

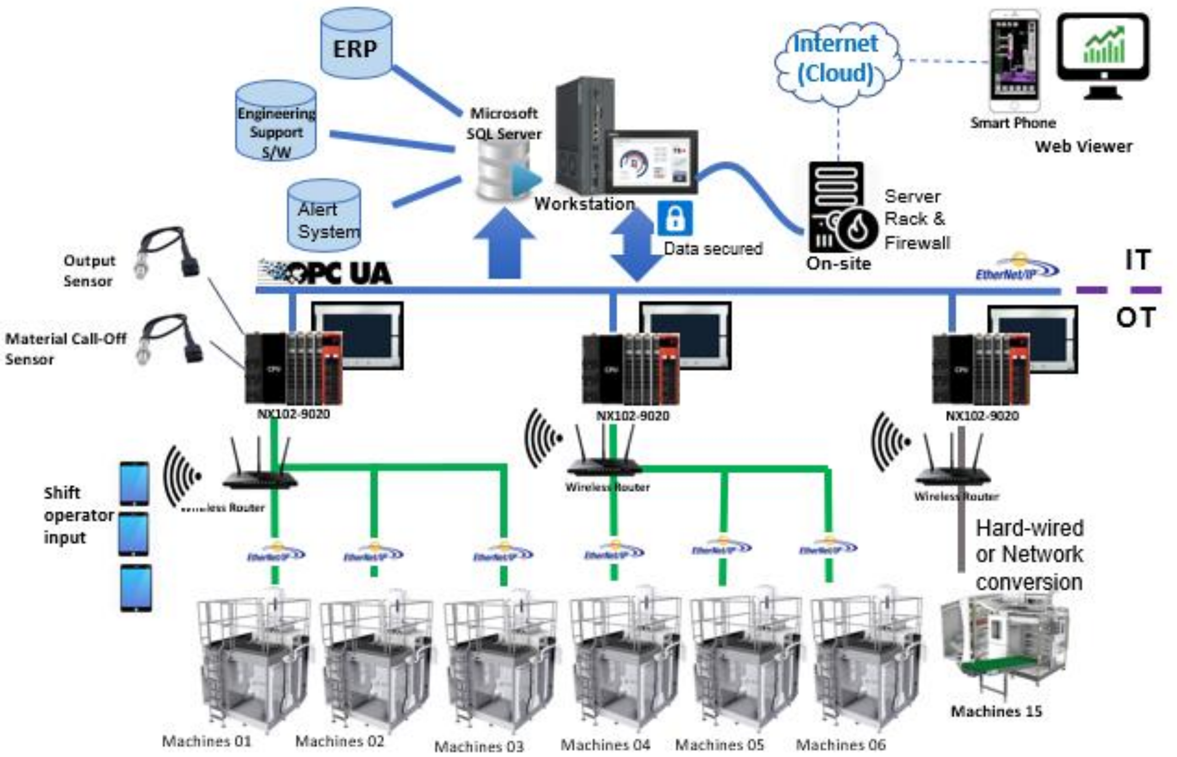


Fig. 4 System Architecture for Packaging Line Data Mining

Figure 5 shown the criteria to counting time for recognize issue which being agree by stakeholder and define the error code classification base on the root cause in production. The error coded list which used were align with data classification shown in Table 1. Once the data available from the production machine, OEE system will be automatically calculated by the system, time losses classification for fault tree analysis processed.

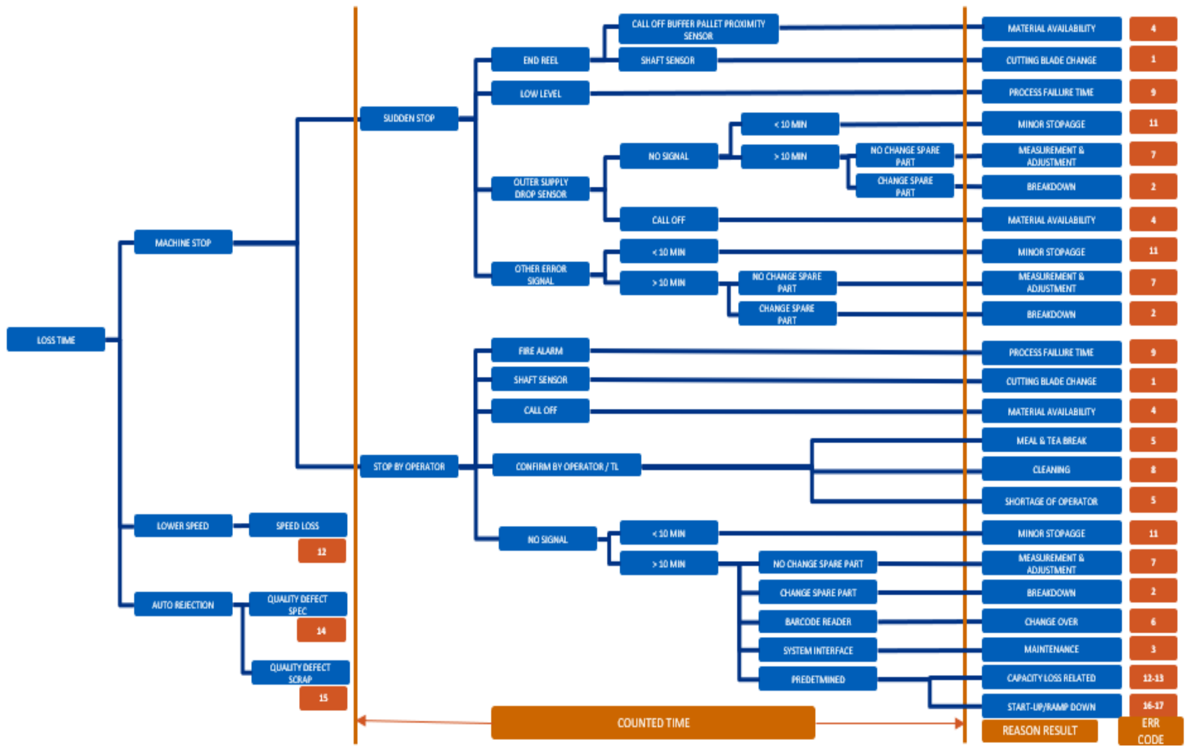


Fig. 5 Time Losses Classification for Fault Tree Analysis

*Ruly Sumargo

DOI : https://doi.org/10.33395/sinkron.v8i4.12953
e-ISSN : 2541-2019
p-ISSN : 2541-044X

To ensure the time losses could be suppressed, an alert system for management team (operational, engineering, and supply chain) will be triggered gradually each time losses occur and over the define time limit as shown in Table 2. The alert will be triggered through telegram and email to the respective person in the company. Specific API program were developed to accommodate this feature and all stake holder were properly informed and trained for the operational purposes.

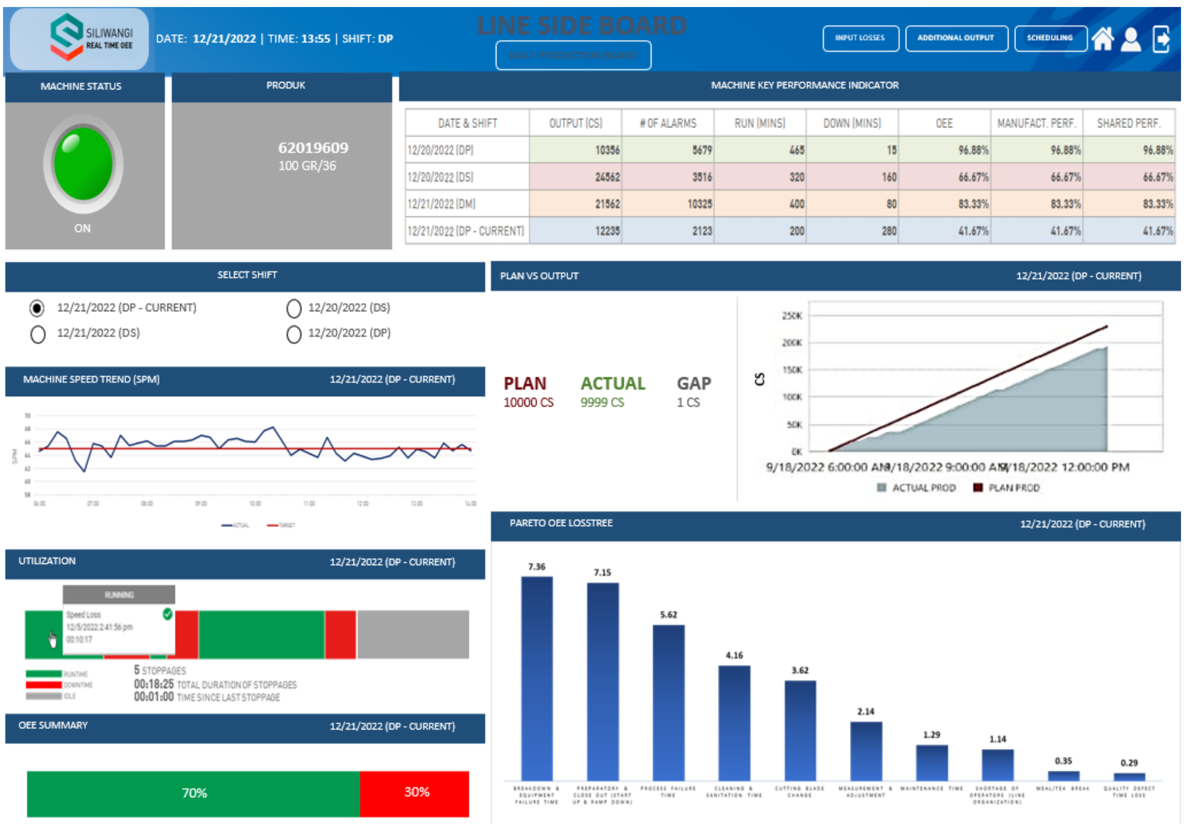
Table 2 Auto alert system to management

No	Time Losses Duration Limit	Management Level
1	15 minutes < Time Loses ≤ 1 hours	Supervisor
2	1 hour < Time Loses ≤ 2 hours	Manager
3	2 hours < Time Loses ≤ 3 hours	Division Head
4	Time Loses > 3 hours	Plant Director

To evaluate the effectiveness of the new system, comparison of OEE data before implementation and after implementation will be performed. Potential factor which affecting the result shall be analyze. Considering the 2021 is highly affected by Covid-19 which causing production activity low, OEE data from 2020 will be use, considering it is at beginning stage of pandemic and no much impact. This condition was considered similar to 2022 (when the new OEE system implemented), when the recovery from pandemic were started in 1st semester and back to normal in 2nd semester.

RESULT

In this section, the result of implementing overall OEE system were explained. Figure 6 shown the dashboard of OEE system, with losses classification, line performance and machine performance in the food packaging line. The dashboard could show the pareto OEE loss tree and other important data which has been define by stakeholder.



*Ruly Sumargo

SinkrOn
JURNAL & PENELITIAN TEKNIK INFORMATIKA
Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023 e-ISSN : 2541-2019
DOI : https://doi.org/10.33395/sinkron.v8i4.12953 p-ISSN : 2541-044X

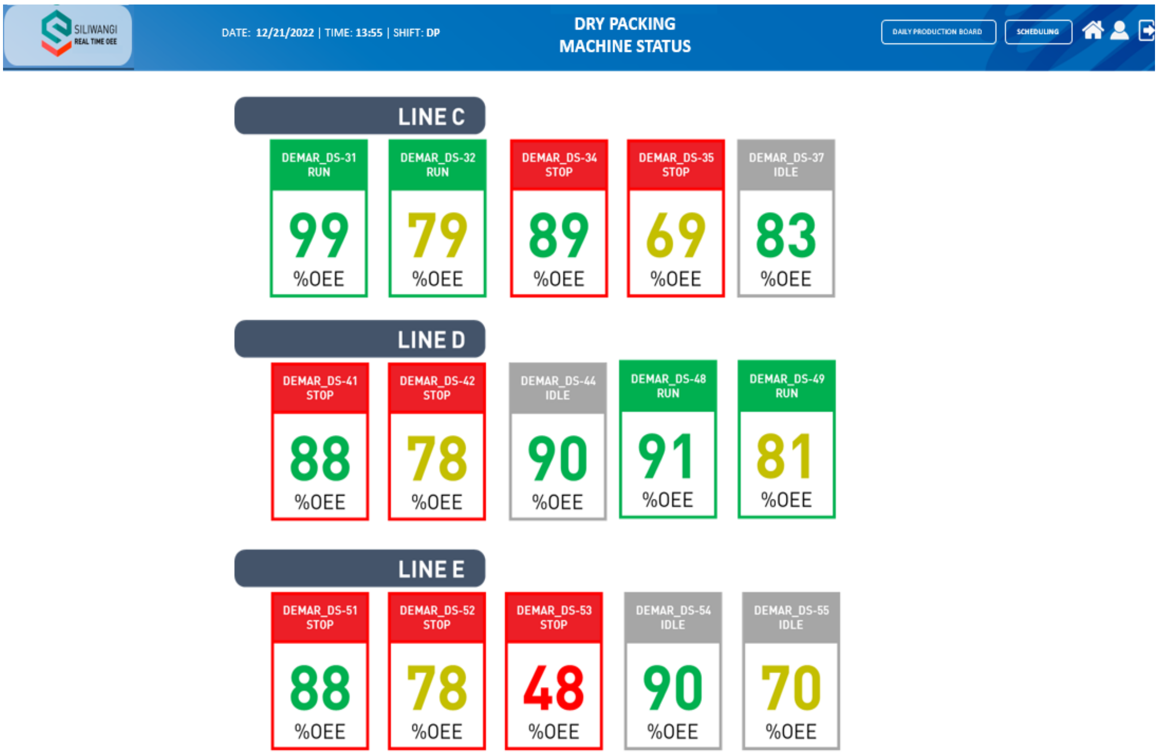


Fig. 6 OEE Line Side Dashboard and Machine Status Dashboard

Current OEE system were assign to handled 15 packaging machines as shown by Figure 6 above. By using averaging method on the OEE data from15 packaging machines, before and after the implementation. the annual performance for the food packaging line could be seen in Table 3. As mention in the research method, performance in year 2021 will only use as references, due to it is during pandemic period which have some unexpected condition, production activity low, shortages for material and manpower relatively high. This could be observed from Table 3 the availability value in 2021, and also material availability in Table 4.

Table 3 Average Food Packaging Machine OEE Data

	Years		
	2020	**2021**	**2022**
Availability (%)	71.49%	56.47%	74.85%
Performance (%)	91.52%	90.29%	98.09%
Quality (%)	98.91%	98.95%	99.11%
OEE (%)	64.71%	50.45%	72.77%

The results in year 2022 were reflecting the condition after the automatic OEE and alert system were implemented in the production line. It shows a significant improvement in 2022 (+8.06%) for the OEE measurement result, compared to the year 2020 result. The dashboard design which is simple, could give sufficient information to the user, and it gives a positive impact on the OEE improvement. And the automatic alert function for stakeholders were also played an important role in this improvement, as shown in Table 4 for the category "Accumulated time losses > 1 hour". It shows the losses were reduced by around 4.8% from 9.02% (2020) to 4.22% (2022). Most of the loss root cause factors were improve, after the implementation done.

*Ruly Sumargo

Table 4 Ratio Big Losses Classification for OEE Measurement

		Before		After
OEE Measure Category	**Reason for Loss**	**2020**	**2021**	**2022**
Availability	Major component failure/Cutting Blade Change	0.79%	0.77%	0.71%
	Breakdown	0.45%	0.94%	0.38%
	Planned maintenance	35.09%	34.48%	39.78%
	Material availability	10.12%	12.16%	3.19%
	Labor shortage/Break Time	36.74%	36.85%	37.87%
	Changeover	14.62%	12.65%	16.58%
	Measurement Adjustment	2.19%	2.15%	1.49%
Performance	Fallen product and Cleaning	7.94%	10.09%	31.47%
	Blockages/Process Failure	67.46%	63.60%	25.76%
	Misalignment	6.35%	8.77%	14.56%
	Minor Stoppage	6.08%	3.95%	11.65%
	Running lower than nominal speed	8.99%	8.77%	13.44%
	Untrained operator not able to run at nominal speed	3.17%	4.82%	3.14%
Performance	Product out of spec	44.24%	41.90%	44.17%
	Scrap	5.48%	5.71%	5.28%
	Product out of spec at process start of run	44.24%	46.10%	44.58%
	Damage product after maintenance activity	6.03%	6.29%	5.97%
Accumulated time losses > 1 hour		9.02%	3.40%	4.22%

From the result in Table 4, it shows the system has made some significant improvements on the OEE result in the food packaging line. The improvement journey was already in the right path, to close the gap on reaching the ideal OEE target for the manufacturing process.

CONCLUSION

This automatic OEE data collection and alert system has simple, user-friendly outlook, and yet it is powerful enough to support OEE improvement in the food packaging line. It has shown from OEE result in 2022 which could reach 72.77%, positively improving 8.06% compared to year 2020 OEE result. The additional alert system, were an effective catalyst to suppress the long period unsolved issue/losses in the manufacturing area, which could reduce 4.8% from the 2020 result. For further research, additional aspect such as auto alert, spare part stock order, and predictive maintenance could be added.

REFERENCES

Adams, K., & Lawrence, E. (2019). *Research Methods, Statistics, and Applications Second Edition.* Los Angeles: SAGE.

Azizah, F. N., & Rinaldi, D. N. (2022). Effort to Improve Overall Equipment Effectiveness Performance with Six Big Losses Analysis in the Packaging Industry PT BMJ. *Indonesian Journal of Industrial Engineering & Management*, 26-34. Retrieved from https://publikasi.mercubuana.ac.id/index.php/ijiem/article/view/13508/0

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 7, Number 4, October 2023 e-ISSN : 2541-2019
DOI : https://doi.org/10.33395/sinkron.v8i4.12953 p-ISSN : 2541-044X

Cahyono, S. D., Handoko, F., & Budiharti, N. (2020). Penerapan Efektivitas Mesin Debarker Menggunakan Overall Equipment Effectiveness. *Jurnal Teknologi dan Manajemen Industri, 6*, 12-17.

Haddad, T., Shaheen, B. W., & Nemeth, I. (2021). Improving Overall Equipment Effectiveness (OEE) of Extrusion Machine Using Lean Mafucaturing Appra. *Manufacturing Technology, 21*, 56-64. doi:10.21062/mft.2021.006

Hamda, P. (2018). Analisis Nilai Overall Equipment Effectiveness (OEE) Untuk Meningkatkan Performa Mesin Exuder Di PT Pralon. *Jurnal Ilmiah Teknologi dan Rekayasa Volume 23 No. 2*, 112-121.

Hedman, R., Subramaniyan, M., & Almstrom, P. (2016). Analysisi of Critical Factor For Automatic Measurement of OEE. *Procedia CIRP 57*, 128-133.

Hudedmani, M. G., Kabberalli, S. K., & Hittalamani, R. (2017). Programmable Logic Controller (PLC) in Automation. *Advanced Journal of Graduate Research, 2*(1), 37-45. doi:https://doi.org/10.21467/ajgr.2.1.37-45

Iannone, R., & Nenni, M. E. (2015). Managing OEE to Optimize Factory Performance. *INTECH Open Science*, 31-50. doi:http://dx.doi.org/10.5772/55322

Imam, G. K., Taufiqurrahman, S., W. T., & Tjatur, W. R. (2011). Perancangan Komunikasi Data Terintegrasi Pada Programmable Logic Controller Via Contoller Link Network Dan Ethernet Device. *Electronics Engineering Polytechnic Institute of Surabaya : Industrial Electronics Seminar* , 1-6.

Karmilawati, E., Mulyono, K., & Nugroho, S. (2021). Pendekatan OEE (Overall Equipment Effectiveness) Untuk Mengurangi Losses. *Jurnal Optimasi Teknik Industri, 03*(02), 46-48. Retrieved from https://journal.lppmunindra.ac.id/index.php/JOTI

Khairullah, S. S., & Sharkawy, A. N. (2022). Design and Implementation of a Reliable and Secure Controller for Smart Home Applications Based on PLC. *Journal of Robotics and Control (JRC), 3*(5), 614-621. doi:10.18196/jrc.v3i5.15972

Kothari, C. (2004). *Research Methodology Methods & Techniques.* New Delhi: New Age International Publisher.

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

Prasetio, D. E., & Sulistriadi, O. (2019). Perbaikan Overall Equipment Effectiveness (OEE) Pada Line Assembly 3 Di Pt. Mesin Isuzu Indonesia. *Jurnal Baut dan Manufaktur, 01*(01), 7-16.

Rasib, A. A., & Ebrahim, Z. (2017). Unnecessary Overtime As A Component Of Time Loss Measures In Assembly Processes. *Journal Of Advanced Manufacturing Technology (JAMT), 11*, 37-47.

Suliantoro, H., Susanto, N., Prastawa, H., Sihombing, I., & M., A. (2017). Penerapan Metode Overall Equipment Effectiveness (OEE) dan Fault Tree Analysis (FTA) Untuk mengukur Efektifitas Mesin Reng. *J@ti Undip: Jurnal Teknik Industri, 12*(2), 105-118.

Wiyatno, T. N., Fatchan, M., & Firmansyah, A. (2018). Sistem Informasi Produktivitas Mesin dengan Metode Overall Equipment Effectiveness (OEE). *Jutikomp Vol. 1 No. 2*, 205-2014. doi:https://doi.org/10.34012/jutikomp.v1i2.245