Indonesian Journal of Community Engagement
Jurnal Pengabdian kepada Masyarakat
Vol. 10, No. 4, December 2024, Page. 204-209
DOI: http://doi.org/10.22146/jpkm.93563

The Development of an IoT-Based Palm Solid Waste Counting System for Empty Fruit Bunches in the Palm Oil Industry

Emil Salim Parhimpunan Siregar[1]*, Meutia Mirnandaulia[1], Poltak Evencus Hutajulu[1], Tengku Rachmi Hidayani[1], New Vita Mey Dessty Marbun[1], Irwan Rachmiadji[1], Oksya Hikmawan[1], Hariyanto[1], Enda Rasilta Br. Tarigan[1], Andreas Rumata Simanjuntak[1], Miftahul Falah[1], Erwin Pardede[1], Donda[2], Evi Christiani Sitepu[3]

[1]Study Program of Agribisnis Kelapa Sawit, Politeknik Teknologi Kimia Industri (PTKI) Medan, Medan, Indonesia
[2]Study Program of Chemical Engineering, Politeknik Teknologi Kimia Industri (PTKI) Medan, Medan, Indonesia
[3]Study Program of Mechanical Engineering, Politeknik Teknologi Kimia Industri (PTKI) Medan, Medan, Indonesia

Submitted: January 25th 2024; Revised: September 10th 2024; Accepted: October 01st 2024

Keywords:
Empty fruit bunches
Fruit counting system
Internet of things
Palm oil mill

Abstract The recent application of palm empty fruit bunches as solid waste directly on soil or as organic fertilizer has enhanced palm farms. Moreover, the co-products of this palm oil mill constitute a dependable metric for assessing mill processing performance, specifically regarding quantity and weight. The quantity of palm empty fruit bunches is usually ascertained through manual counting using a hand counter during processing. The imprecision in calculating palm empty fruit bunches is a limitation of this method, as operators sometimes perform erroneous calculations, overlook quantities, and produce contradictory results for mill management. To address this issue, the sector requires enhanced execution of a monitoring and counting system methodology. The aim of this community service project is to create an empty fruit bunches count station using an IoT-based palm solid waste counting system for use in palm mills. The Ministry of Industry - Politeknik Teknologi Kimia Industri (PTKI) Medan will engage in and oversee the advancement of Industry 4.0 within the industrial sector. The initiative was executed at Tanah Gambus Estate in Batubara Regency, North Sumatra. Assistance was provided by a palm mill partner associated with PT. Socfin Indonesia. The implementation of the empty fruit bunches palm oil counting system was conducted efficiently, facilitating optimal operations, real–time online monitoring, uninterrupted functionality exceeding 24 hours daily, swift assessment of the empty fruit bunches volume, immediate identification of traditional counting inaccuracies by operators and management, and its station provides benefits to the palm industry.

1. INTRODUCTION

Palm fresh fruit bunches (FFB) undergo processing in palm mills to produce crude oil, along with palm oil mill effluent (POME) and palm solid reject. Palm solid wastes (PSW), comprising kernel shell, fibre, and empty fruit bunches (EFB), have the capacity to enhance the potential of palm solid waste as a composting organic material for soil improvement and plantation (Januari & Agustina, 2022). In addition to mitigating environmental pollution, PSW offers three other advantages: enhancing soil characteristics, improving the quality of FFB crop yields, and substantially increasing the supplementary income of palm mills (Anyaoha et al., 2018).

The demand of EFB solid wastes is becoming a challenge for palm oil plantations with increasing the organic composting demand and reducing the inorganic fertilizers consumption due to the adverse effects of its

ISSN 2460-9447 (print), ISSN 2541-5883 (online)
*Corresponding author: Emil Salim Parhimpunan Siregar
Study Program of Agribisnis Kelapa Sawit, Politeknik Teknologi Kimia Industri (PTKI) Medan, Jl. Medan Tenggara VII, Medan 20228, Indonesia
Email: emilsalim@kemenperin.go.id

continuous usage on crops and land, as well as the high price of synthetic fertilizers causes the palm estate to prefer available organic waste (Januari et al., 2020). The current practice of application by spreading EFB into land applications directly or mixing it with POME as composting (Baron et al., 2019). Efforts to use EFB and POME as a direct fertilizer or mixing both wastes is also gaining attention as an organic fertilizer.

The boiling of FFB is followed by a threshing procedure in the palm mill, which results in the production of empty fruit bunch. Upon reaching the thresher station, the fruit bunches are transported to the next stage, while the solid waste from the EFB is transferred to the designated EFB storage area (John et al., 2019). The efficiency of palm oil mills is determined by the ratio of EFB to the number of fruit bunches that still include loose fruit, also known as unstripped bunches (USB). Therefore, the detection of EFB is crucial for quantifying the losses in crude palm oil production. Thus far, the detection of the quantity of EFBs has been carried out using traditional techniques, namely manual counting using a hand counter, which is quite disregarded. Due to adding extra workforce–operators, working hours longer, the detecting requires a better monitoring and counting system approach to be applied (Aji et al., 2022).

Inconsistent reports from operators to mill management and frequent instances of manual miss-counting were discovered. The discrepancy in counting has been quantified and compared between the amount of processed FFB and the produced EFB, therefore revealing an inherent error in the measurement of mill processing efficiency. To resolve this deviation problem, it is necessary to construct a continuous and automated EFB count monitoring system as the initial initiative in establishing EFB stations.

Currently, demand for the Internet of Things (IoT) continues to increase as part of the I4.0 development in palm industry. some applications include: application of IoT to communication equipment in oil palm plantation areas (Adiono et al., 2018), harvesting and FFB collection (Chyan, 2018), USB detection based on R–CNN (Aji et al., 2022), and other application.

The community service team from the Ministry of Industry, Politeknik Teknologi Kimia Industri (PTKI) Medan, contributed to the development and implementation of Industry 4.0 in the palm industry by establishing an Internet of Things (IoT) – based EFB monitoring station. The objective of the community service initiative was to create a solid waste counting system for empty fruit bunch palm oil using IoT-based sensors for the palm oil sector. This initiative was undertaken as a means of polytechnic involvement in the development of sector 4.0. An anticipated advantage of this industrial community service initiative was the provision of an empty fruit bunch palm oil counting station equipped with IoT-based sensors in palm oil manufacturing facilities. Therefore, the absence of operator errors in the calculation and reporting of the number of EFBs enables management to effectively monitor mill process production.

2. METHOD

2.1 Location

The industrial partner of this program was PT. Socfin Indonesia (Socfindo). Socfindo is an oil palm and rubber plantation company with its operations in Sumatra Utara and Aceh Provinces and its head office in Medan, Sumatra Utara, Indonesia. This program was conducted in Palm Oil Mill – Tanah Gambus Estate. More precisely, this program area is located in Tanah Gambus Village, Sub District of Lima Puluh, District of Batubara, Province of Sumatera Utara, Indonesia (Latitude N 03o 12’ 14"; Longitude E 99o 24’ 16") (SOCFINDO Sustainability Report 2022).

2.2 The program

This community service program was a sustainable initiative focused on developing Industry 4.0 (I-4.0) for the palm oil industry. It consisted of industrial community service, research, and mentorship activities for PTKI’s student community service in the palm oil sector. Additionally, the results of this program were used as a TVET 4.0 assessment for polytechnics, which are educational units under the Ministry of Industry, responsible for the development and implementation of I-4.0 in the industry. The goal of the Industrial Human Resources Development Agency (IHRDA) in this assessment was to measure the level of TVET 4.0 implementation and provide continuous I-4.0 education within the industry (Ministry of Industry – Industrial Human Resources Development Agency, 2021).

The program was implemented by developing a palm oil waste counting system, specifically an empty fruit bunch (EFB) counter station with IoT-based sensors. The initial discussion and explanation of the benefits of this industrial community service program were held on September 7, 2023. The development of the station was carried out in collaboration with the electrical and instrument control workshop at the Palm Oil Mill – Tanah Gambus.

The establishment of this station began with an extensive literature review on the threshing fruit process and the generation of solid palm oil waste at the thresher station of the palm oil mill. Based on this, an appropriate method was determined to help operators and palm mill management efficiently monitor the volume of empty fruit bunches (EFB) via an LCD monitor mounted at the station. This surveillance system was accessible through the internet and mobile phones. The team then created a prototype and gained insights into the optimal operation of sensors, the Raspberry Pi single-board computer, and the software. After completing the prototype, a subsequent discussion regarding authorization to build the station took place on November 14th with the general manager at PT. Socfin Indonesia headquarters in Medan, North Sumatra. The construction of the stations started at the workplace on November 18–19, 2023. This date was chosen because the palm oil mill was non-operational at the time, allowing for maintenance and troubleshooting of the processing units.

2.3 Creating an EFB counting station

The station builder began by preparing a panel box for raspberry Pi web server (Figure 1). We use the Flask to control GPIO (General Purpose Input/Output) digital signals. The Flask is a Python microframework for installing web servers on built computing systems. The EFB count sensor system's main hardware is the single – board computer with Raspberry Pi 4 Model B, Processor Broadcom-Quad core Cortex-A72, 64-bit at 1.5 GHz processor and 4 GB RAM as a microprocessor to control it system (Raspberry Pi, 2021). The other product's key features include a Bluetooth 5.0, Gigabit Ethernet, dual-band 2.4/5.0 GHz wireless LAN, and the PoE capability.

In hardware system is an "Always On" mode, it was powered by a Voltaic Systems V15 USB battery (5000 m A h). Some other hardware and electrical prepared includes the secure digital (SD) card, a WiFi dongle, the breadboard; a liquid crystal display (LCD) monitor and a jumper wires.

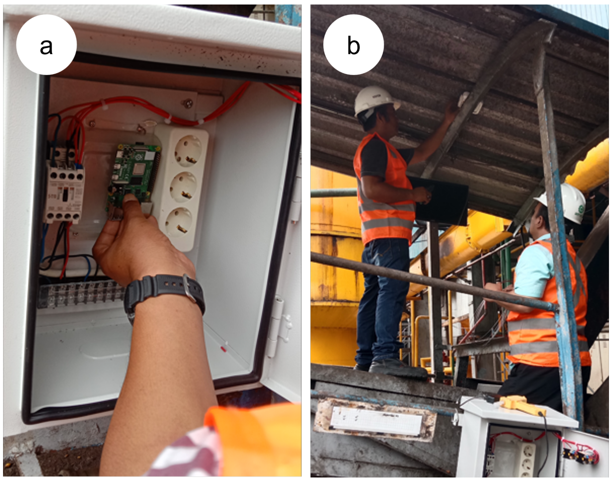

Figure 1 . The installation of EFB count station creation: (a) Preparing a panel box for Raspberry Pi web server; (b) Installation of infrared sensors at the ends of the connecting plates between conveyors

3. RESULT AND DISCUSSION

3.1 Palm oil mill-thresher station

The palm oil milling process used in Tanah Gambus mill was broadly similar to standard procedures. The process involved the following stages: transportation of the fresh fruit bunches (FFB), sterilization, threshing, digestion, pressing, clarification, nut/fiber separation, nut conditioning, nut cracking, mixture separation, and kernel drying.

The initial stage involved transporting mature fruit bunches from the plantation to the mill. Upon arrival, the fresh fruit bunches underwent multiple processing steps to yield the final products, including crude palm oil (CPO) and palm kernel (PK). A sterilizer, a high-pressure vessel, was used to boil, heat, and temper the FFB with steam, facilitating the sterilization process. The steam sterilization procedure enhanced the segregation and liberation of the fruits from the bunches. After sterilization, the fruit bunches were sent to the thresher station for separation from the stalks (John et al., 2019).

The thresher station, as shown in Figure 2, can be described as a large-diameter rotating mesh drum, which rotates at a fixed speed of around 25 rpm (Shanti Faridah et al., 2019). During rotation, the sterilized FFB were continuously fed into the drum at one end. As the drum rotated, the fruits were separated from the bunches, while the empty fruit bunches passed out continuously at the other end.

Figure 2 . Thresher station

Next, the fruits detached from the bunches were conveyed to the digestion station, while the empty fruit bunches (EFB) were transferred to the Horizontal EFB Conveyor (HEFBC), then to the Inclined EFB Conveyor (IEFBC), where they were taken to the EFB holding area. During the transfer, larger bunches could get stuck inside the conveyor, causing the thresher station and the entire mill system to stop during operation. To prevent delays during threshing, the rotating drums and conveyors had to be handled with care and quick action. The operator played an important role in ensuring the smooth exit of the EFB from the thresher drum, grading the USB from the EFB, and counting the number of EFB on the horizontal EFB conveyor.

3.2 The community service team

To accomplish a successful and productive development of the EFB count station, we assigned the team members into groups. The work procedure was completed within two weeks. Preparations for establishing an EFB count station involve team division, presentations and discussions with the General Manager of the palm mill, formulation of a Memorandum of Understanding (MoU) between the vocational polytechnic and industry, scheduling of station assembly, communication with the recipients of the palm mill-industrial community, and handover of reports at Tanah Gambus Estate, Batubara Regency, Sumatra Utara.

The division of work teams are: (1) Relationship team between polytechnics and industry, directly responsible for relations with industry, communications, MoU, counseling and presentations to industry, (2) process and electrical team; responsible for procurement of equipment, assembly and building the station, (3) programming team, responsible for sensors, network programs and IoT devices.

3.3 Creating an Internet of Thing system (IoT)

In this program, the Raspberry Pi 4 Model B was used as the single-board computer (SBC) to receive input signals, process them, and control the output devices. To ensure accurate counting of the empty fruit bunches (EFBs), an infrared-count sensor was employed. The sensor was chosen for its fast response to the shape and acceleration of objects passing through it, as well as its small size, which facilitated easier installation. The sensor's signal operation is shown in Figure 3.

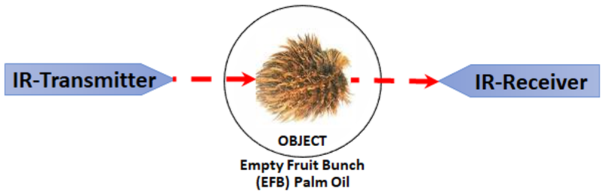

Figure 3 . IR-sensor signal working

The infrared transmitter sensor emitted infrared light, and when an object passed through it, the light was reflected back and captured by the receiver sensor. The received light was then converted into a numerical signal by the SBC, and the LCD monitor automatically displayed the count of EFBs.

To prevent overlap of the bunches and increase the speed at which the EFBs moved from the HEFBC to the IEFBC, the connecting plate between the conveyors was set at a 45° slope (Figure 4 (a)). The infrared sensor was fixed at the end of this connecting plate to ensure accurate counting of the EFBs (Figure 4 (b)). As an EFB exited the HEFBC, it was placed on the connecting plate (Figure 4 (c)), where it passed through the sensor unit. The sensor detected the EFB and updated the LCD monitor to display the current count. After passing through the sensor, the EFB was then fed onto the IEFBC conveyor belt, which transported it to the EFB collection area.

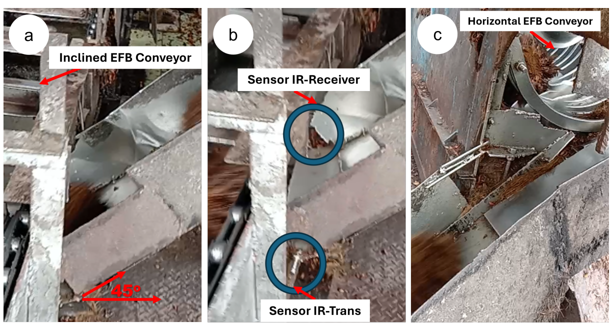

Figure 4 . Sensor system and EFB work area: (a) the connecting plate angle (45° slope) between the conveyors; (b) Complete sensor set-up; (c) EFB throughput on Horizontal Conveyor

The Raspberry Pi single board computer programming is very flexible in customized system for programmers to take advantage of the processor's hardware and the EFB count software system operations. The single-board computer (SBC) is connected to the Infrared – counter proximity sensor via the GPIO port. The Raspbian is a Linux software-based operating system that runs on an Infrared (IR) sensor system, and the python core is used as the primary programming language to command the sensor system to capture objects on the real-time counting.

First of all, the program was coded with a command script to automatically adjust for objects passing through the sensor. One EFB passing through the sensor was counted as one object. The detection of this object was influenced by its acceleration, shape, and the variable number of EFBs. Next, the program was connected to the internet through an IoT application, which is capable of collecting and transferring data over a wireless network with minimal human intervention (Shafiq et al., 2022). The IoT-enabled portable device operated when the EFB passed through the infrared sensor. The count was synchronized with the signal time detecting the object. Each captured EFB unit was converted on the Raspberry Pi device, recorded as a program script on the "SOCFIN-PTKI" webpage, saved as a file on the SD card, and connected to the IoT cloud. The data was then visualized on the LCD monitor, forwarded, and also implemented into devices via Android smartphones, as shown in Figure 5.

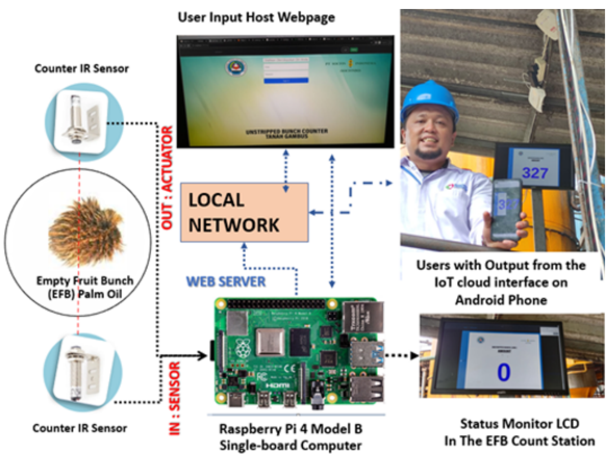

Figure 5 . The Internet of Things–monitoring a Raspberry Pi EFB counter over internet and smartphone

3.4 Evaluation of systems and station

The EFB count station and sensor systems was installed in the mill, starting from 18 to 19 November 2023; On November 22, 2023, the team tested system reliability and evaluated station performance. Next, the team carried out counseling and training to operators and mill management. It's relating to technology and operation of the IoT system and EFB count stations.

In the palm mill environment, the EFB count station had achieved good performance. The system was not affected by temperature, rain, or weather changes. Furthermore, in an industrial vibration environment of 60–80 Hz, especially in the thresher station area and loading ramp station, the EFB count station was able to upload EFB count information to the IoT cloud, enabling real-time information monitoring.

The EFB count station worked continuously for more than 24 hours per day, enabled real-time online monitoring, and facilitated the fast diagnosis of conventional counting errors by operators and management. The station provided significant benefits to the palm oil industry.

4. CONCLUSION

The industrial community service program at the Tanah Gambus palm oil mill, located in the Sub-district of Lima Puluh, District of Batubara, Province of Sumatera Utara, Indonesia, was successfully conducted with the support of the head office of PT. Socfin Indonesia and the enthusiasm of the target parties, including processing operators and palm mill staff. The installation and assembly of the IoT-based EFB counting system proceeded smoothly, and the station was fully operational. It was able to function continuously for more than 24 hours a day. This industrial community service program provided significant assistance to the palm oil mill industry. Operators and management gained valuable knowledge and experience in IoT systems, technology, and the operation of the EFB count station. With the new station, the palm mill industry was able to empower operators across other units, reduce labor requirements, shorten the time needed to determine mill processing efficiency indicators, and quickly monitor processing quality.

ACKNOWLEDGMENT

The authors would like to express their gratitude to various parties involved in the implementation of the research and industrial community service activities. This includes the Head Office of PT. Socfin Indonesia for granting approval for the program, The Palm Oil Mill Socfindo – Tanah Gambus Estate for supporting the availability of facilities, data, and information needed, and the Director and Head of the Research and Community Service Unit at Politeknik Teknologi Kimia Industri (PTKI) Medan for entrusting the team with the responsibility of carrying out this program.

CONFLICT OF INTERESTS

This program was supported and funded by the Ministry of Industry, Industrial Human Resources Development Agency (IHRDA), Politeknik Teknologi Kimia Industri Medan (decision number : 348/BPSDMI/PTKI/Kep/X/2023). The authors declare there is no conflict of interest.

REFERENCES

Adiono, T., Dawani, F., Rifai, A., Fuada, S., & Purwanda, I. G. (2018). Functionality test of communication systems based on LoRa technology in oil palm plantations area. *International Conference on ICT for Rural Development (IC-ICTRuDev)*, 18-22. https://doi.org/10.1109/ICICTR.2018.8706854

Aji, W. S., Hawari Bin Ghazali, K., Akbar, S. A. (2022). Oil palm unstripped bunch detector using modified faster regional convolutional neural network. *IAES International Journal of Artificial Intelligence (IJ-AI), 11*(1), 189-200. http://doi.org/10.11591/ijai.v11.i1.pp189-200

Anyaoha, K. E., Sakrabani, R., Patchigolla, K., & Mouazen, A. M. (2018). Critical evaluation of oil palm fresh fruit bunch solid wastes as soil amendments: Prospects and challenges. *Resources, Conservation and Recycling, 136*, 399-409. https://doi.org/10.1016/j.resconrec.2018.04.022

Baron, V., Saoud, M., Jupesta, J., Praptantyo, I. R., Admojo, H. T., Bessou, C., & Caliman, J-P. (2019). Critical parameters for integrating co-composting of POME and EFB into life cycle assessment models of palm oil production. *IJoLCAS: Indonesian Journal of Life Cycle Assessment and Sustainability, 3*(1). https://doi.org/10.52394/ijolcas.v3i1.72

Chyan, T. J. (2018). *Design of an audio-based machine learning algorithm to detect oil palm fresh fruit bunches harvesting* [Thesis]. Universiti Tunku Abdul Rahman. http://eprints.utar.edu.my/2924/

Januari, A. D., & Agustina, H. (2022). Palm oil empty fruit bunches and the implementation of zero waste and renewable energy technologies. *IOP Conf. Series: Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/1034/1/012004

Januari, A. D., Utomo, S. W., & Agustina, H. (2020). Estimation and potential of palm oil empty fruit bunches based on crude palm oil forecasting in Indonesia. *E3S Web Conf., 211*, 05003. https://doi.org/10.1051/e3sconf/202021105003

John, I., Magdalene, A. M., Tarmizi, S. S. S., & Shirley, J. T. (2019). A model to manage crude palm oil production system. *MATEC Web of Conferences, 255*, 02001. https://doi.org/10.1051/matecconf/201925502001

Ministry of Industry – Industrial Human Resources Development Agency (2021). *Global standard industrial vocational development towards corporate university*. BPSDMI Press.

Raspberry Pi. (2021). Raspberry Pi 4 computer model B getting started guide. *Raspberry Pi*. Retrieved November 17, 2023, from http://www.raspberrypi.org/downloads

Shafiq, M., Gu, Z., Omar, C., Wajdi, A, & Hamam, H. (2022). The rise of "Internet of Things": review and open research issues related to detection and prevention of IoT – based security attacks. *Wireless Communications and Mobile Computing, 2022*, e8669348. https://doi:10.1155/2022/8669348

Shanti Faridah, S., Shareena, S., Khairuddin, S., Afrasyab, K., Robiah, Y., Marini, S., Nordiana, R., Norzafirah, A. M. F., & Muhammed, H. A. (2019). Mathematical modelling and simulation of thresher operation in palm oil mill. *Journal of Sustainable Science and Management, Universiti Malaysia Terengganu, 14*(5), 43-54.

Socfindo. (2022). Socfindo sustainability report 2022. *Socfindo*. Retrieved November 24, 2024, from https://www.socfindo.co.id/documents/eng/Socfindo-Sustainability-Report-2022.pdf