International Journal of Social Science, Educational, Economics, Agriculture Research and Technology (IJSET) | ISSN (e) : 2827-766X
Volumes 4 No. 8 (2025)

DESIGN AND IMPLEMENTATION OF AUTOMATIC SLUDGE PUMPING SYSTEM USING SUBMERSIBLE PUMP AND STRAINER WITH FLOAT LEVEL SWITCH OIL IN CARRIGE TIPPLER TRANSFER POND IN SEMILAR PALM OIL FACTORY

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Received	: 29 May 2025	Published	: 31 July 2025
Revised	: 10 July 2025	DOI	: https://doi.org/10.54443/ijset.v4i8.1047
Accepted	: 17 July 2025	Link Publish	: https://www.ijset.org/index.php/ijset/index

Abstract

In the wastewater management process at Semilar Palm Oil Mill, sludge accumulation in the carriage tippler transfer pit often obstructs flow to subsequent treatment units. To address this issue, an automatic sludge pumping system was designed and implemented using a submersible pump, strainer, and float level switch. This system is engineered to operate automatically based on sludge level, eliminating the need for manual operation by workers. The design involved selecting a submersible pump suitable for sludge characteristics and required flow rate, installing a strainer to prevent large solid particles from entering and clogging the pump, and using a float level switch with dual-point control (high and low levels) to automate the pump's start-stop cycle. The system was installed directly in the transfer pit and calibrated for stable performance in a muddy and corrosive environment. Implementation results show that the system significantly reduced the pit drainage time and minimized downtime due to clogging. During the trial period, the system operated reliably, responded effectively to sludge level changes, and improved operational efficiency by reducing manual intervention. This system provides a reliable and practical solution for sludge handling in palm oil mills while supporting more efficient and environmentally friendly waste management practices.

Keywords: ***sludge, submersible pump, float level switch, strainer, automation, carriage tippler, palm oil mill***

INTRODUCTION

Industrial waste management has become a global concern, particularly in the palm oil-based agricultural sector, which produces large amounts of organic waste. Amid growing awareness of the importance of sustainable production, the palm oil industry faces the challenge of streamlining operations while minimizing environmental impacts. Indonesia, the world's largest palm oil producer, produces millions of tons of liquid waste known as Palm Oil Mill Effluent (POME) annually. One of the main components of POME is sludge—a mixture of water, oil, and suspended solids—which is acidic and rich in organic matter. If not handled properly, sludge can pollute the environment, damage mill systems, and cause the loss of valuable oil. Palm oil mills (PKS) in various regions, including Semilar, face common problems in handling sludge in transfer ponds, particularly in the tipper carriage area. The manual sludge transfer process often leads to spills, delays, and equipment damage. Therefore, mechanical and automated solutions are essential to improve system efficiency and safety. One technical solution that can be adopted is the use of submersible pumps capable of working directly in liquid sludge. However, the success of this system depends heavily on protecting the pump from solid particles with a strainer, as well as precise pump operation with an oil float level switch. With this combination, the sludge pumping process can be automated according to the liquid level, reducing manual intervention and the risk of damage. Several studies, such as those by Fadhilah et al. (2021), show that optimizing sludge separation systems can significantly reduce oil loss. However, a review of the past five years shows that most studies still focus on aspects of biochemical waste treatment (Ismail et al., 2024; Pandia et al., 2021), temperature control (Darma, 2023), or sludge utilization (Linda & Mardaleni, 2023). There has been no in-depth study that technically and integratedly discusses the automated sludge pumping system that uses a combination of pump, sensor, and filter technology, as in this study. With reference to these conditions, this study focuses on the design and implementation of an automated sludge pumping system using a submersible pump and strainer with a float level switch oil in the transfer pond of the Semilar PKS tippler carriage. The goal is to create an efficient, low-maintenance, and environmentally friendly pumping system as a tangible contribution to supporting the sustainable palm oil industry. The author chose this title because he observed frequent problems at the Semilar Palm Oil Mill (PKS) related to overtime and an ineffective manual cleaning system that potentially leads to operational losses. This automated system is expected to provide a more efficient and reliable solution, helping to improve productivity and operational sustainability in the palm oil industry.

METHOD

A. Place and Time of Implementation

This research was conducted from February to June 2025. The research was conducted at PT. Tapian Nadenggan – Semilar Mill, which was established in 2008 and is located in Ruangau Raya Village, Danau Seluluk District, Seruyan Regency. This factory is located in the Semilar Estate area and was established by PT. SMART Tbk.

B. Implementation Steps

1. System Requirements Identification

The first step in implementing an automatic submersible pump system is to identify system requirements based on operational conditions at the Semilar Palm Oil Mill (PKS). This identification includes:

a. Determine the capacity of the Submersible pump that corresponds to the volume of liquid that needs to be transferred from the carriage transfer pool in the TIPPLER.
b. Analyze fluid characteristics, including viscosity, oil content, and potential for clogging due to dirt.
c. Determine the type of strainer that is effective in filtering impurities before the liquid is pumped.
d. Determine the specifications of the Float Level Switch oil to ensure automatic control of the liquid level.
e. Analyze the electrical power requirements and energy efficiency required for the system to operate optimally.
f. Identify operational risks, such as the possibility of blockages or damage due to extreme working conditions.

2. System Design

Once the system requirements are identified, the next stage is system design which includes:

a. Determine the layout of Submersible pumps, strainers, and Float Level Switches within the transfer basin to ensure efficient fluid flow.
b. Designing an automation system using an oil Float Level Switch to control pump operation in real-time.
c. Designing an electrical circuit that connects the Float Level Switch to the pump control panel, ensuring the system works without the need for manual intervention.
d. Prepare a flow diagram of the overall system work process to ensure smooth operations.
e. Determine the type and material of strainer that can be used to filter coarse particles without hindering pump performance.
f. Calculate the electrical power capacity required so that the system can work optimally without wasting energy.
g. Ensure the system design has protective mechanisms against abnormal conditions, such as electrical voltage leaks or surges.

3. Component Procurement

At this stage, the designed components will be prepared and procured. Procurement is carried out with attention to component quality and compatibility with system requirements. The main components procured include:

a. Submersible pump with capacity according to calculated needs and resistance to oily fluid environments.
b. Float Level Switch Oil which has high sensitivity to oil-mixed liquids to ensure accurate liquid level control.
c. Strainer with appropriate hole size so as not to cause pump blockage and maintain smooth fluid flow.
d. An automatic control panel that allows integration between sensors and pumps and features protection against electrical disturbances.

e. Alarm system and visual indicators to provide warning in case of system disturbance or failure.
f. Waterproof cables and connectors suitable for industrial environments to ensure the system operates safely and efficiently.

4. System Implementation

The implementation phase includes the installation and integration of all components in the system. The implementation steps include:

a. Installation of the Submersible pump in the transfer pond in an optimal position to ensure maximum suction power.
b. Installing a Float Level Switch oil in a strategic position to detect the liquid level accurately and prevent dry running of the pump.
c. Installing a strainer at the pump inlet to filter out dirt before the fluid is pumped to prevent blockages that can damage the system.
d. Wiring and integration of the sensor system with the automatic control panel to ensure the system can operate automatically as designed.
e. Configure the control panel to detect changes in fluid levels and provide a quick response to conditions that occur.
f. Installation of visual indicators and alarm systems to monitor system performance in real-time and provide early warning if problems occur.
g. Initial system test to ensure that all components are installed correctly and functioning as intended.

5. Testing and Validation

After the system is implemented, testing is performed to ensure that the system performs according to the designed specifications. The testing procedure includes:

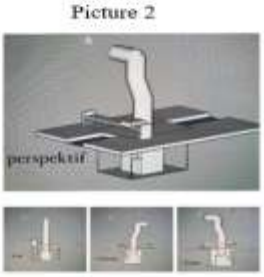
a. Operational testing: Running the system under normal operational conditions to evaluate the performance of pumps, sensors, and strainers.
b. Extreme condition testing: Testing the system under very high and very low fluid level conditions to ensure the system can respond correctly.
c. Automation validation: Ensures that the oil Float Level Switch automatically activates and stops the pump according to the predetermined liquid level.
d. Efficiency evaluation: Measures energy efficiency and pumping performance compared to previous systems, including power consumption and fluid transfer rates.
e. Component durability testing: Operating the system for a long time to see how well the pump and sensors can withstand harsh environmental conditions.
f. Electrical safety test: Ensures all cables and connectors are safe to use and the system has protection against electrical disturbances such as short circuits.
g. Emergency condition simulation: Tests the system's response to disturbances such as strainer blockages, electrical failures, and sudden surges in fluid volume.

After all testing has been successfully completed and the results meet the expected standards, the system is declared ready for full operation at the Semilar Palm Oil Mill (PKS). Periodic evaluations will be conducted to ensure optimal system performance and to identify potential future improvements.

RESULTS AND DISCUSSION

A. Tool Design and Manufacturing

Initially, observations were made of the condition of the transfer carriage tipper, which revealed a buildup of oil in the transfer basin. To date, the plant has not yet established a definitive system for managing the waste oil. As a solution, a tool and system were designed to handle the stagnant oil in the area. This system utilizes a submersible pump that drains the oil into a recovery pit, allowing it to be reprocessed as POME oil and thus gain market value. The system design was then prepared and submitted to local leaders in the form of the following engineering drawing:



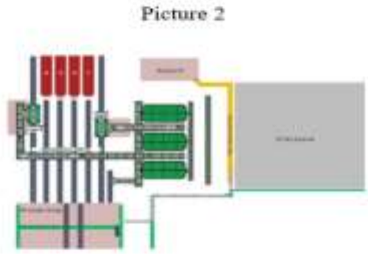


Figure 1. Pump System Manufacturing Technique and Figure 2. Sludge Pipeline Design

The initial design described above received approval from local leaders. However, after considering the conditions on site, it was discovered that the factory lacked concrete cutting tools (snippers) for the floor drilling. Based on these constraints, adjustments were made to the initial design and a new one was created, as shown below:

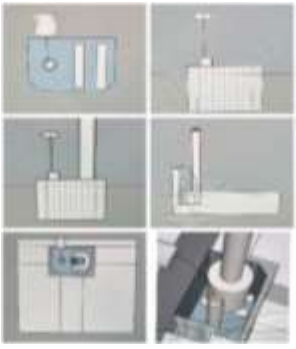


Figure 3. Engineering Drawing of Pump System

The second design was then resubmitted to the local leader and approved based on the technical considerations presented. With this design approved, the tool manufacturing process could begin immediately, following the adjusted design. Next, collaboration with the Workshop Department was carried out to carry out the work, which included the construction of the strainer, the drilling of the floor in the transfer carriage area, and the construction of the pump hanger, all in accordance with the previously established design.

After the strainer manufacturing process was complete, an initial test was conducted by inserting the strainer into a pre-drilled hole. Observations revealed that the strainer only sank to a depth of 23 cm, as shown in the following image:

Figure 4. Strainer before being immersed and Figure 5. Strainer after being immersed

The depth of the strainer has not yet reached the planned depth for optimal pump operation. Therefore, it was decided to carry out further drilling to achieve a depth that meets the design specifications, namely 50 cm. The following image is after the second drilling. After the strainer was successfully adjusted to the planned design, a pump mount was added inside the strainer to maximize absorption by the pump. This addition aims to ensure the pump position remains stable and at an optimal point for sucking oil from the bottom of the transfer pond, as shown in the following image:


Figure 6. Installing the Pump Mount on the Strainer and Figure 7. Cleaning the Strainer

After all parts of the pumping system are completed, the process continues with the assembly of the piping line as the pump outlet. This line is designed to efficiently and safely channel the extracted oil to the recovery pit, in accordance with the system flow specified in the initial design. The next stage is the electrical work, namely the creation of an electrical circuit to support pump operation. At this stage, a complete electrical system is designed with a control panel, including the installation of an automation system on the pump to ensure the pump can operate efficiently based on the liquid level conditions in the transfer basin. This automated system also aims to optimize energy consumption and minimize the risk of damage due to improper manual operation. The circuit diagram is as follows:

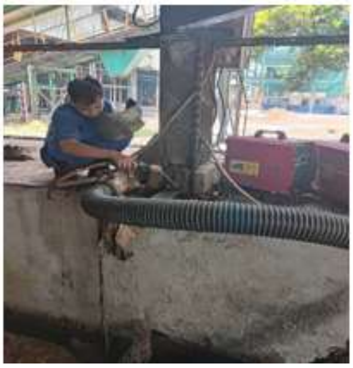



Figure 8. Electrical Installation and Figure 9. Installation of Float Level Switch

After all work, both mechanical and electrical, is completed, an observation phase is conducted to evaluate the overall performance of the equipment. This observation aims to ensure the system operates according to its designed function and to identify potential improvements in terms of oil absorption efficiency and pump operational reliability.

B. Tool performance

1. Effectiveness

*Effectiveness*The sludge pumping system is measured using the actual power calculation method used by the pump compared to the fluid transfer capacity (Flowrate) based on the test results. Based on the calculations contained in the technical document of the Tsurumi KTZ 47.5 pump, with a pump power of 11 kW, a total head of 30 meters, and a fluid density of approximately 994 kg/m³, the system effectiveness is approximately 73%. This shows that this system is effective enough to be used in industrial operations with heavy loads such as in the transfer pond of the tippler carriage.

1. Flowrate measurement based on tool calibration using the formula:

$$Q = \frac{P \times \eta}{\rho \times g \times H}$$ ....(Formula 1)

Description: 1. Q: Flowrate ($\frac{m^3}{s}$)

2. P: Pump Power (Watts)

3. η: Pump efficiency
4. ρ :Fluid Density$\left(\frac{kg}{m^3}\right)$
5. H : Total Head (m), for this type has a head of 30.

2. Find the density of the fluid contained in the holding pond

$\rho\ Minyak = 850\ (\frac{kg}{m^3})$............(Çengel & Boles,2020)

$\rho\ Air = 1000\ \left(\frac{kg}{m^3}\right)$................(Çengel & Boles,2020)

$\rho\ Emulsi = 950\ \left(\frac{kg}{m^3}\right)$............(McClements, 2020)

$\rho\ Sludge = 1100\ \left(\frac{kg}{m^3}\right)$..........(Metcalf & Eddy 2020)

With lab test results, the mixture consists of 6% oil, 12% emulsion, 68% water, and 12% slide.
So$\rho\ campuran = (\ 0{,}06\ x\ 850\ ) + (\ 0{,}12\ x\ 950\ ) + (\ 0{,}68\ x\ 1000\ ) + (\ 0{,}12\ x\ 1100\ )$
= 54 + 114 + 680 + 132 = 980$\left(\frac{kg}{m^3}\right)$

3. Finding Pump Effectiveness

$\eta = \frac{Q.\rho.g\ .H}{P\ .1000}$..........(Formula 2)

Information : 1.Q : Flowrate (, Average Flow from the pump$\frac{m^3}{s}$)
87 $(\frac{m^3}{jam})$
2. P: Pump Power (7500 Watt / 7.5 kW)
3. η: Pump efficiency
4. ρ :Fluid Density
5. H : Total Head (m), for this type of pump has a head of 30 m.
6. g : Gravity (9.81$\frac{m}{s^2}$)

$$\eta = \frac{Q.\rho.g\ .H}{P\ .1000}$$

$$\eta = \frac{0.02417\ .\ 980\ .9.81\ .\ 30}{7{,}5\ .1000}$$

$$\eta \approx \frac{6971}{7.500}$$

$$\eta \approx\ 0.929\ Atau\ 92{,}94\ \%$$

So Flowrate =$Q = \frac{P\ x\ \eta}{\rho\ x\ g\ x\ H}$

$$Q = \frac{7{,}5\ x\ 1000\ x\ 0.929}{980\ x\ 9.81\ x\ 30}$$

$$Q = \frac{6967}{288.414}$$

$$Q = 0.02415\ \left(\frac{m^3}{s}\right) Atau\ 0.02417\ x\ 3600 = 86{,}94\ \left(\frac{m^3}{h}\right)$$

4. Finding Flowrate from comparison

From direct calculations using the ratio between the cubic capacity of the fluid reservoir and the time required to empty it. Find the volume of the fluid reservoir.

a Finding the volume of a triangular prism

120 cm

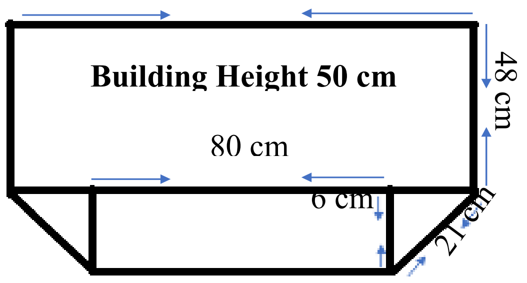


Figure 10. Triangular Prism

$Volume\ Prisma\ segitiga = 2\ x\ \left(\frac{1}{2}\ x\ a\ x\ t\right) x\ T$.......(Formula 3)

Description: a: hypotenuse of a triangle
t : height of triangle
T: height of the prism

$$Volume\ Prisma\ segitiga\ = 2\ x\ \left(\frac{1}{2}\ x\ a\ x\ t\right) x\ T$$

$$Volume\ Prisma\ segitiga = 2\ x\ (\left(\frac{1}{2}\ x\ 20\ x\ 6\right) x\ 50\ )$$

$$Volume\ Prisma\ segitiga = 6.000\ cm^3$$

b Finding the volume of cuboid 1

$Volume\ Balok = P\ x\ L\ x\ T$..........(Formula 4)

Description: P: Length of the beam
L : Width of the beam
T : height of the beam

$$Volume\ Balok = P\ x\ L\ x\ T$$
$$Volume\ Balok = 80\ x\ 6\ x\ 50$$
$$Volume\ Balok = 24.000\ cm^3$$

c Finding the volume of cuboid 2

$$Volume\ Balok = P\ x\ L\ x\ T$$
$$Volume\ Balok = 120\ x\ 48\ x\ 50$$
$$Volume\ Balok = 288.000\ cm^3$$

So the total volume = volume of the triangular prism + volume
Block 1 + volume of Block = 6,000 + 24,000 + 288,000 = 318,000 cm^3 or 0.318 m^3

After suction for 5.54 seconds and the height of the fluid pool in the container is 21 cm, the volume of fluid with a pool height of 21 cm is 0.1323 m^3

Then Flowrate =$Flowrate = \frac{volume\ fluida}{waktu}$......(Formula 5)

$$Flowrate = \frac{0.1323}{5.54\ detik}$$

$$Flowrate = 0,02388\ \left(\frac{m^3}{s}\right) Atau\ 85.97\ (\ \frac{m^3}{h}\ )$$

$$\text{So Tool Efficiency}\quad \frac{85.97\left(\frac{m^3}{h}\right)}{86.94\left(\frac{m^3}{h}\right)}\ X\ 100\% = 98.88\%$$

So far the tool has been working for 2.7 hours since the tool was made on April 24, 2025. Thus we can calculate the cubic capacity of sludge that we collect in the transfer pool.

With the formula = Pump flow rate x working time.....(Formula6)

$= 85.97\left(\frac{m^3}{h}\right)$x 2.42 h

$= 208.04m^3$

So with this pump in the transfer carriage we can draw as much as 208.04 liters of oil.m^3 within 40 days. And this oil can be sold as POME (Palm Oil Mill Effluent) / HFE. From this calculation, we also get a daily sludge volume of ± 5.20m^3/ day . So from 5.20m^3 with an oil content of 6% to 0.312m^3/day

2. Efficiency

The efficiency of the system is evaluated based on the average results of sludge removal successfully carried out by the system in a certain time and its effect on reducing operator overtime hours.

a. The Influence of Tools on Employee Overtime

Table 1. Average Overtime

Month	**Average Overtime (hours)**	**Information**
March 2025	6.71	Before the implementation of the automated system
April 2025	5.00	After the implementation of the automated system

Based on observation data and documentation of employee overtime during March and April 2025, there was a decrease in average overtime hours from 6.71 hours in March to 5.00 hours in April. This decrease indicates that the automated pumping system has helped speed up work processes and reduce manual workloads, significantly improving operational efficiency at the carriage tippler station.

Average Overtime Summary:

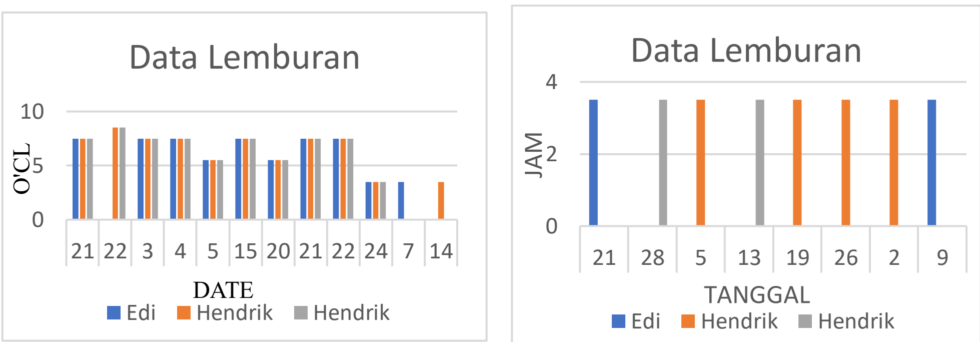


Figure 11. Average Overtime Diagram from February to June

b. The Influence of Tools on Cleanliness in Transfer Pools

The efficiency of the automatic sludge pumping system can also be seen clearly in the improved cleanliness of the carriage tipper transfer pond. Prior to the system's installation, the pond tended to experience large amounts of sludge buildup due to manual and poorly scheduled transfers. This resulted in a dirty, smelly environment, and the risk of contaminating the work area and causing operational disruptions. After implementing a submersible pump system automatically controlled by a float level switch, sludge transfer can be carried out more routinely and controlled. As a result, the transfer pond is cleaner, there are no longer any long-standing sludge pools, and the wastewater flows more smoothly to the next process. This condition also helps create a more hygienic and safe working environment for operators, as well as supporting overall process efficiency.

Figure 12. Before installing the tool

Figure 13. After installing the tool

a. Break Even Point (BEP) Analysis and Its Benefits

This document contains the Break Even Point (BEP) calculation and profit estimation from the implementation of automatic sludge pumping equipment in the tippler carriage transfer pond at the Semilar Palm Oil Mill.

1. Basic Data

Table 2. BEP Basic Data

COMPONENT	MARK
Total investment cost (initial capital)	Rp. 59,000,000
Quantity of oil collected per day	0.312 tons = 312 kg
Selling price of oil per kg	Rp. 8,500
Duration of operation	40 days

2. BEP Calculation

Break Even Point is the point at which total revenue equals total costs incurred.
Income per day = 312 kg x Rp. 8,500 = Rp. 2,652,000
Break Even Point (BEP) in days = Rp. 59,000,000 ÷ Rp. 2,652,000 = 22.3 days

Table 3. Estimated Profit for 40 Days

COMPONENT	MARK
Total income (40 days)	Rp. 106,080,000
Total investment cost	Rp. 59,000,000
Net profit	Rp. 47,080,000

Based on the calculations above, the machine reached break-even point (BEP) on day 23. After that, it began generating net profits. Total profits earned during the 40 days of operation reached Rp 47,080,000.

3. Reliability

The reliability of this automatic sludge pumping system was analyzed through three main aspects: availability, maintainability, and durability. The evaluation was based on the results of 10 tests, daily operational observations, and input from operators and technicians in the field.

a **Availability**
The system demonstrated high availability, operating automatically and immediately upon request, without delay or start-up failures. During testing and simulation, no issues such as start-up failures, power outages causing pump failures, or float switch failures were encountered.

b **Ease of Maintenance (Maintainability)**
The system is designed with a simple DOL (Direct On Line) control circuit and easily accessible components. The submersible pump can be easily removed from its mounting when maintenance is required, while the strainer has an open design for easy cleaning. Indicators such as hour meters also facilitate scheduling of periodic maintenance without the need for system dismantling.

c **Durability**
The Tsurumi KTZ 47.5 pump features abrasion-resistant cast iron, an internal cooling system, and dual mechanical seals. During testing and initial use, no signs of performance degradation, overheating, or component wear were observed. This demonstrates the system's robustness in extreme working environments such as palm oil sludge.

CONCLUSION

Based on the results of the design and implementation of an automatic sludge pumping system using a submersible pump, strainer, and float level switch oil in the transfer carriage tippler pool of the Semilar Palm Oil Mill, it can be concluded that:

1. The automatic sludge pumping system was successfully designed taking into account operational requirements, sludge characteristics, and the working environment. The key components, a submersible pump, a galvanized iron strainer, and an oil float level switch, were selected and effectively integrated.
2. The system has been proven to operate pumps automatically based on sludge levels without manual intervention. This helps speed up the sludge removal process, reduce operator delays, and minimize the risk of operational errors.
3. The use of a strainer reduces the potential for pump blockages, while a float switch keeps the system operating at a safe level. Overall, this system improves work efficiency, maintains equipment durability, and supports better waste management in the tipper carriage area.
2. The implementation of a pumping system using a submersible pump in the sludge transfer pond in a palm oil mill not only increases process reliability and reduces the potential for operational disruptions, but is also able to save time and costs.

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