

Analysis of Safety Sensors on Grain Transportation Equipment at PT. Pundi Kencana

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ABSTRACT

The wheat processing industry is one of the vital sectors that involves a complex and sustainable manufacturing process. In carrying out the wheat transfer process, transportation tools equipped with sensors play an important role in ensuring that moving raw materials proceeds safely and efficiently. In this study, the aim is to understand the types of sensors used in product transportation and the characteristics of each sensor. The method used is a case study method. Milles and Huberman model the qualitative approach. This study uses three types of sensors in the product moving process: proximity sensors, limit switches, and belt monitors. By using these three sensors, product transfer becomes more efficient and safer. Utilizing safety sensors on transportation equipment can minimize errors in the product transfer process and is also safe because it can prevent malfunctions. Applying these three sensors makes it easier for employees to carry out the product transfer process.

Keywords

Product Transportation, Safety Sensors, Uses of Sensors, Methods of Transportation

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INTRODUCTION

The wheat processing industry is one of the vital sectors that involves a complex and sustainable manufacturing process. In carrying out the wheat transfer process, transportation tools equipped with sensors play an important role in ensuring that the process of moving raw materials runs safely and efficiently, the wheat transportation system uses chain conveyors, screw conveyors, and bucket elevators, these tools play a crucial role that determines the efficiency and quality of a product [1]. On the other hand, all of these processes face many operational challenges that can affect the smooth process of moving raw materials and products. This is where the role of sensors becomes very crucial (important). Sensors used to monitor provide real-time operational reports, as well as detect problems such as overflow, excessive speed, or a malfunction that may affect performance and impede the flow rate of the product [2].

However, in their use, these sensors often experience significant mismatches. One of the main problems is the lack of calibration, which makes the sensor work less than optimally. When the sensor is not calibrated correctly, the data produced will be inappropriate and can confuse employees in making decisions. However, this can be exacerbated by sensor errors, such as errors in readings or other technical errors [3]. This error can not only disrupt the smooth process of moving products but can also cause damage to the machine used.

This study aims to understand the types of sensors used in product transportation and the characteristics of each sensor. So, this research is important, namely to improve safety and efficiency in the product moving as well as to increase safety in the product moving process as well as have a positive impact on the quality and competitiveness of the industry. The novelty of this study lies in the use of safety sensors in product transportation equipment to identify calibration problems and also errors in sensors in the wheat processing industry into wheat flour. When compared to other industries that use transportation, they only use sensors to detect foreign objects such as metals [4]. Similar research was also carried out on the use of safety devices in product transportation equipment, but similar research only explained the various uses of safety devices in transportation tools, such as relays, limit switches, and so on. In this case, the use of this tool is only used to monitor the flow of electric current and also safety when the conveyor machine is working [5].

However, at PT. Pundi Kencana product transportation equipment uses all sensors used by previous researchers, at PT. Pundi Kencana uses more diverse sensors, including sensors that can detect various foreign objects, detect metals, and also sensors that prevent overflow in product transportation equipment. by using these sensors, you can ensure the smoothness and safety of the product transfer process so that it becomes more effective and efficient. Therefore, it is necessary to carry out a study to analyze transportation sensors such as inductive and capacitive proximity, belt monitors, and limit switches, simultaneously or in configuration in the product transportation system. Overall understanding the sensors used in product transportation tools is very helpful in the wheat processing industry, improving efficiency and operational safety. With an approach that focuses on sonar analysis, this research becomes useful.

METHOD

In this study, the method used is the case study method. Stake (1995) stated that case study research aims to reveal the uniqueness or characteristics contained in a case being studied. The case itself is the reason for the research. Therefore, the purpose focus, and main objective of case study research is on the case that is the object of the research. In this case, the case study focuses on one particular object that is raised and studied in depth so that it can reveal the reality behind the phenomenon [6]. There are several stages carried out in conducting a case study to analyze the performance of the safety sensor on the product transportation tool, including directly observing how the sensor works, interviewing the head of the section, operator, and mechanic, and also conducting a documentation study. The data analysis used was descriptive qualitative with the Milles and Huberman model. By using this data analysis model, the analysis was carried out interactively and continued until it was finished, and the data obtained was saturated (dense or full so that it could not contain any more data) [7]. By using data analysis, Milles and Huberman explained that data analysis during data collection takes researchers back and forth between thinking about data and making corrections to unclear information [8]. To obtain complex data in a study, of course, an appropriate and appropriate data collection technique is needed. In this study, the technique used to collect data is direct observation in the field, interviews, and documentation studies, which are aimed at the head of production, employees, and also mechanics who are in the production section at PT. Pundi Kencana and the questions are made unstructured. In addition, to prove that the data obtained is valid, a validation test must be carried out between theory and events in the field. This validation technique uses two triangulations. Among them, triangulation of data collection techniques to compare the data obtained by the three data collection techniques, as shown in Figure 1. Meanwhile, to validate the interview results, this research uses data source

triangulation where the data obtained from the interview results are confirmed or compared with one another.

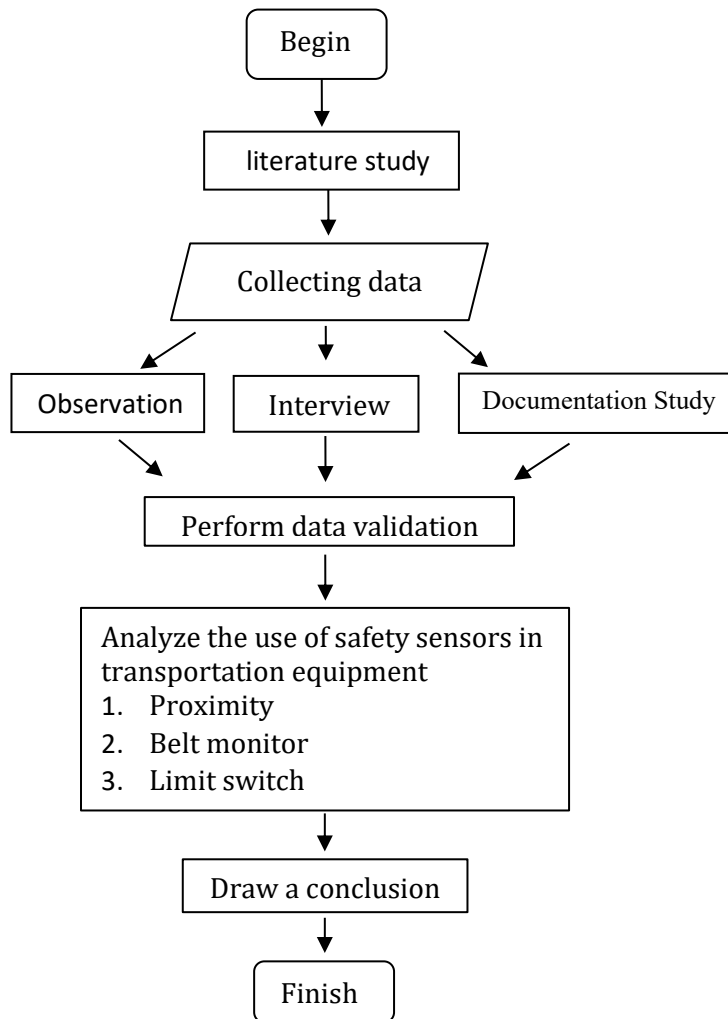


Figure 1. Flow chart for data collection steps

RESULT AND DISCUSSION

The means of transporting products at PT. Pundi Kencana

Product transportation at PT. Pundi Kencana is a tool used to move products from the loading and unloading area to the storage area or the production room, The use of automation systems is used to make it easier and more efficient [9]. In the means of transportation at PT. Pundi Kencana has used an automation system and has different functions and forms, transportation tools are used to make it easier for employees to carry out the process of moving products so that it does not take a long time, the product transfer process at PT. Pundi Kencana begins with the use of a Chain Conveyor, which is in the grain loading and unloading warehouse, then the wheat in the warehouse is allowed to flow using Chain Conveyor, after going through Chain Conveyor, the wheat will be transported back by bucket elevator go upstairs and enter the silo or temporary storage area.

After the wheat enters the silo, the wheat will be transferred to the production room through a screw conveyor, in contrast to the chain conveyor, if observed directly, the chain conveyor has a shorter shape, it is because the conveyor is used for short-distance transfer only

and the screw conveyor, It has a spiral shape so that if it is made to lengthen the electrical power needed, it will be even larger compared to a chain conveyor.

To learn more about the safety sensors used in product transportation tools, it is also necessary to understand the types and working principles of the wheat transportation equipment itself. Having a good understanding of the basic mechanisms and functions of the product's means of transport will help in understanding the use of sensors and determining how they can guarantee safety and operational efficiency. At PT. Pundi Kencana moves products using three types of transportation: 1. Chain conveyor, 2 Bucket elevator, 3. Screw Conveyor. All of these means of transportation are connected to a PLC (Programmable Logic Control).

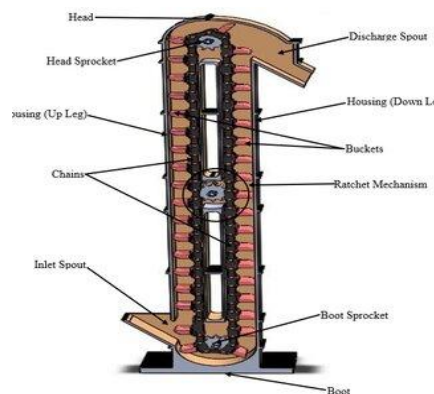
1. **Chain Conveyor**, It is a means of transporting wheat that is used to transfer products horizontally using chains as a means of moving products, as depicted in [Figure 2](#). The function of a Chain Conveyor is to transport and move the material from the grain loading and unloading room to the bucket elevator or the production room [\[10\]](#).



[Figure 2](#). Chain Conveyor Shape

The working principle of this chain conveyor is that it is driven by gears that are rotated by a motor, and the product that enters the housing (from the inlet hole) is carried horizontally to the outlet hole, usually, the capacity of the chain conveyor is quite large can be up to 200 tons/hour, and the transfer distance is quite far, which is 30 meters to 50 meters, the chain speed is 0.5 m/second to 1.0 m/second.

2. **Bucket elevator**, is a wheat transportation device that works vertically by using a bowl as a product moving device, the bowl is attached to a belt that rotates vertically, as described in [Figure 3](#). Bucket elevators are used specifically to transport a wide variety of materials in the form of powders, small granules, and chunks, such as cement, sand, coal, flour, and so on. This tool can be used to lift materials with a height of 50 meters, the capacity can reach 50 kg/hour [\[11\]](#).



[Figure 3](#). Bucket Elevator [\[12\]](#)

The working principle of the Bucket Elevator is, that the belt is pulled upwards by a pulley that is rotated by a motor, the belt is attached vertically, and the bowl (bucket) is attached to the belt so that the bowl will also move upwards (vertical direction), the product that enters through the inlet will be accommodated by the bowl and will be carried to the top, then the product is thrown back (discharge), to the outlet, the transfer capacity from this bucket elevator is quite large and can reach 1000 tons/hour.

3. Screw Conveyor, A screw conveyor is a tool used to transfer products horizontally using blades/screws as a tool to move products, as shown in Figure 4. The part on this screw conveyor is:

- a. Inlet
- b. Product direction
- c. Outlet
- d. Drive motor

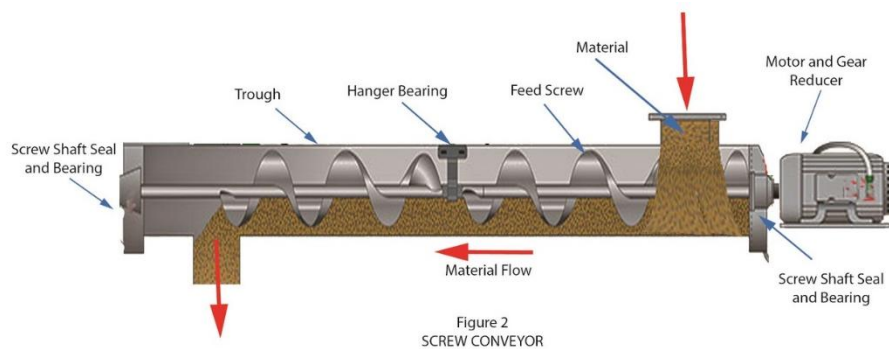


Figure 4. Screw Conveyor [13]

The working principle of the Screw Conveyor is, the shaft is surrounded by a blade in the form of a helical spiral, the arrangement of the shaft and blade, is in the Conveyor casing, and the product that enters the casing will be pushed by the rotation of the blade which is moved by the motor, the product moves along the Conveyor housing horizontally towards the outlet, the transfer distance is fixed on the capacity, the transfer distance is less than 20 meters, if the capacity is very large, the shaft is moved by the motor with a rotation speed of 60 rpm to 130 rpm.

Transportation Safety Sensor

Industrial automation techniques were first used by Governor James Watt around the 18th century to control the speed of machines. Automation systems are the most common thing in the industrial world [9]. In this case, the means of transportation used at PT. Pundi Kencana has used an automation system, namely by applying the use of which function safety sensors to find out the type and working principle of the means of transportation used, on the means of transportation products, there are safety sensors, the type of safety sensors used in means of transportation (product products), namely in the form of sensors used as safety so that the process of moving products (wheat) can run smoothly, sensors attached to the means of transportation are connected to the PLC on the monitor so that employees can easily see the problems experienced by the means of transporting products. PLC is a personal user friendly, In this case, PLC is a special computer that functions as a controller of a product process at PT. Pundi Kencana [14]. This PLC can be connected directly to the sensor through a program.

The sensors used in wheat transportation tools are proximity sensors, limit switches, and belt monitors. As an illustration, the following is an explanation of some of the sensors used in transportation (product movers).

1. Sensor Proximity

Sensor proximity is a sensor used to detect the presence or absence of an object [15]. Sensor proximity It can be divided into 2, namely inductive and capacitive.

a. Inductive Proximity Sensor

The way it works is based on magnetic induction, meaning that when an object is in the form of metal or metal, this sensor will read, this type of sensor only detects changes in the distance of objects made of metal or metal [16]. In transportation equipment, the inductive proximity sensor is used as the indicator of the engine speed (speed sensor). Usually, this sensor is placed close to the drive motor or rotating pulley, this sensor is only used on Chain Conveyors and also on Buckets elevators and is not used on Screw Conveyors, the types and specifications used are also different.



Figure 5. Sensors proximity inductive type IGA3008-BPKG/3D [17]

The proximity sensor in Figure 5 is a sensor used to monitor the speed of the Bucket Elevator. This sensor is located at the bottom of the pulley, and the working system of this sensor is to read the rotation of the pulley. This sensor can detect up to a distance of 8 mm, the output of this sensor is 24 volts with a PNP electrical design (positive, negative, and positive), and the output function of this sensor is NO (Normally Open). This sensor can withstand temperatures of -20 to 60 degrees Celsius.



Figure 6. Sensors proximity inductive type DIA3010-ZPKG/US [18]

The proximity sensor in Figure 6 is a sensor used to monitor the speed of the Chain Conveyor; this sensor is located on the side close to the drive motor the sensor detects tension, this sensor functions if the rotation of the conveyor deviates from the rotation limit of the drive motor, tolerance of -10% of the rotation limit, the way this sensor works is by turning off the drive motor to prevent the motor from burning or overload. This sensor has a sensing range of 10 mm output from this sensor, which is 24 volts with a PNP electrical design (positive, negative, and positive), this sensor can work at an ambient temperature of -25 to 80 degrees Celsius.

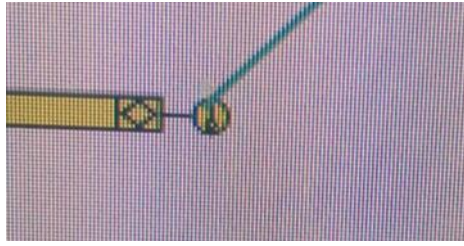


Figure 7. image of the inductive proximity sensor (zero speed monitor) on the Monitor

Figure 7 is an overview of the inductive sensor on the Chain Conveyor transportation tool, this sensor is close to the drive motor, the use of this sensor is to detect the speed of the drive motor and is useful as an identifier of the chain on the chain conveyor, the way it works is when the speed of the motor exceeds the predetermined limit there will be an indication that will appear on the monitor and also if there is a break in the chain used, then This sensor will work and give a red signal to the monitor.

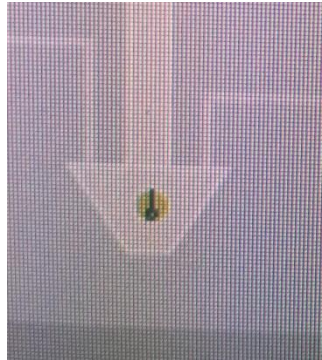


Figure 8. images of the inductive proximity sensor (speed monitor) on the Monitor

Figure 8 is an overview of the inductive sensor on the Bucket Elevator transportation equipment, this sensor is close to the pulley, the use of this sensor is to detect the speed of the pulley, the way this sensor works is to read the rotation of the pulley, if the rotation is not by the settings made, this sensor will detect and provide a signal to the monitor and become red.

b. Sensor Proximity capacitive

How Capacitive Proximity Sensors Work Based on the capacitive concept, capacitive sensors can detect any object, unlike inductive sensors, which can only detect metal. Capacitive sensors are almost similar to inductive sensors, but the difference between these two sensors is that capacitive sensors can generate electrostatic fields instead of electromagnetic fields. Capacitive sensors can detect both metal and non-metal [19].

In the transportation of products, capacitive proximity sensors are used as overflow markers. Usually, this sensor is placed at the end of the chain conveyor line, capacitive proximity sensors are only used on chain conveyors, this sensor is used on chain conveyors because the speed of carrying products is quite fast, so safety is needed that has fast responsiveness when the product overflowing or clumping.



Figure 9. Sensors proximity capacity type KIE 3015-FPKG/NI [20]

The proximity sensor in Figure 9, is a sensor used to monitor the accumulation of products on the Chain Conveyor, this sensor is located at the end of the line of the Chain Conveyor, the sensor detects the product running, this sensor usually works if it an accumulation of products in the conveyor casing, especially in the outlet channel, what makes the motor work harder, the way this sensor works is by turning off the engine. This sensor has an output of 24 volts, the electrical design used is PNP (positive, negative, and positive), NO (normally open) output function, and sensing range of 15 mm, this sensor can be used at temperatures of -25 to 80 degrees Celsius.

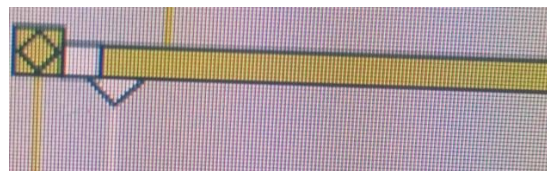


Figure 10. images of the capacitive proximity sensor (Back-Up Probe) on the Monitor

Figure 10 is an overview of the capacitive sensor on the Chain Conveyor transportation tool, this sensor is located at the outlet of the chain conveyor, the use of this sensor is to detect products that accumulate, the way this sensor works is that when there is a product that covers the sensor, the sensor will turn off the engine and provide information to the monitor and make the sensor that was initially white become red.

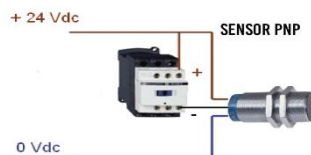


Figure 11. PNP connections (positive, negative, and positive) [21]

The meaning of PNP is a flow that outputs a current from the sensor with a voltage (+), so this sensor responds to a physical phenomenon, as depicted in Figure 11. If the sensor is not active (it does not detect anything, then the path is active, and the transistor is off, if the switch is open, it can be interpreted that the PNP output does not have inflow/outflow, if the sensor is active then the sensor will make the active path much higher.

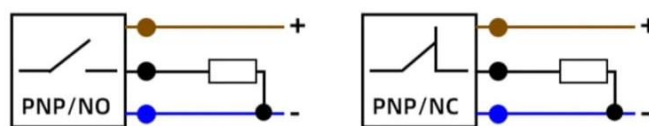


Figure 12. NO output function (Normally Open) and NC (Normally Close) [22]

The meaning of NO (Normally Open) and NC (Normally Close) on the proximity sensor, when the sensor detects what was originally NO, becomes NC, as shown

Figure 12. So, it can be interpreted that the sensor will produce an output signal when reading a passing object.

2. Limit Switch

A limit switch, is a safety device in the transportation system (product transfer) used on Screw Conveyor, Limit Switch It is a type of switch that is equipped with a valve that functions as a replacement for a button. The working principle of limit switch almost similar to a switch push ON, which will work if it is pressured at a certain limit. Limit switches are included in the type of mechanical sensors, namely sensors that provide electrical changes when there is a change in this sensor [23].



Figure 13. Limit Switch at Screw Conveyor [24]

In the transportation of the product, the limit switch is used as an overflow marker. Usually, this sensor is placed at the end of the Screw conveyor line, and the limit switch is only used on the Screw conveyor, as illustrated in Figure 13. This sensor works in the event of product overflow, especially in the outlet channel which makes the motor work so hard, when the product overflows, The actuator on the limit switch touches the cross-sectional iron on the Screw Conveyor cover if the sectional iron has touched the iron on the screw cover, then the limit switch will turn off the motor and make the engine shut down instantly until it gets handling.

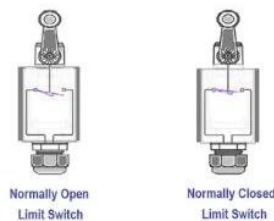


Figure 14. Output Limit Switch [25]

In Figure 14, the outputs used on the limit switch, namely NO (Normally Open), then when the receiver touches the cross-section on the cover because the product is overflowing, the connection that was initially NO (Normally Open) becomes NC (Normally Close).



Figure 15. Image of the limit switch sensor on the Monitor

Figure 15, is an overview of the limit switch sensor on the Screw Conveyor transportation device, this sensor is at the end of the drive motor, the use of this sensor is to detect overflowing products and is useful as an identifier of clogged products, the way it works is that when there is a clogged product in the outlet part, there will be an indication that will appear on the monitor and give a red signal on the monitor and turn off the engine.

3. Belt Monitor

A belt monitor, as depicted in Figure 16, is a sensor that functions to monitor the fanbelt used in the bucket elevator, this belt monitor is only available on the bucket elevator transportation tool in the bucket elevator using a fanbelt to carry the bowl, which is on the bucket elevator cover. The shape of this monitor belt is a box and is attached to the left and right parts of the elevator bucket at the bottom and also the top of the elevator bucket.

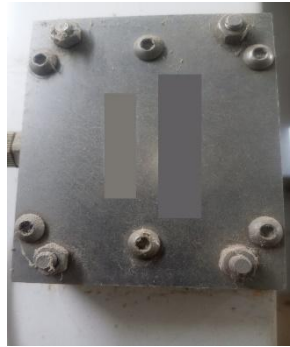


Figure 16. Belt Monitor

The monitor belt is placed to limit the belt from moving aside, which can cause the product to spill and the belt to tear. This monitor belt is located on 2 sides, namely right and left, and following the one on the PLC, the way the monitor belt works is almost the same as other sensors, namely when this sensor reads and there is damage or the belt misses its path, this sensor will turn off the motor and make the wheat movement stop instantly until it gets handled.



Figure 17. image of the monitor belt sensor on the Monitor Screen

Figure 17 is an overview of the monitor belt sensor on the Bucket Elevator transportation equipment, this sensor is on the left and right sides of the bucket cover above and below the bucket elevator, the use of this sensor is to detect the movement of the bowl carrying belt, the way it works is when the bowl carrying belt in the elevator buck is tilted and touches this sensor, the sensor will detect a problematic belt, then there will

be an indication that will appear on the monitor and give a red signal on the monitor and turn off the engine.

By using safety sensors on transportation equipment, product transportation becomes more effective and also safer. By using sensors that are connected, it can make it easier for employees to monitor the process of transferring products from the storage area to the production room and so on. The effectiveness of using these sensors is that they can minimize errors in the product delivery process. It takes time. This is also one of the effectiveness of using sensors because it can minimize time in meeting consumer needs. On the other hand, safety is the main pioneer in using sensors on other transportation equipment, as we know, product movement uses human power. It will take quite a long time because the production scale is already large, using transportation equipment and safety sensors can reduce the time needed to carry out the process of moving products from one place to another, apart from using sensors on product transportation equipment, it can also prevent malfunctions, employees do not need to come into direct contact with product transportation equipment, except when there is damage or congestion when processing the product.

Indicator on PLC

When transferring products, the process can be seen using a monitor (computer) with a website called mercurimes. This website presents the state or conditions when the machine is working and can also control and monitor product moving activities and the production process. By using a website (PLC), employees can see what indicators appear in the product transfer process, several indicators appear on the website (PLC) when carrying out the transfer or production process, the most common signs that appear are green, white, and also red. The indicators indicate the following.

1. When indicator is green

Figure 18 shows the image on the green monitor, it can be interpreted that the machine is running normally and if you look directly the machine is vibrating, which indicates that there is a process of moving products. In Figure 18, it shows a chain conveyor that is transferring products to the wheat silo (Accuracy on the monitor and in the field).

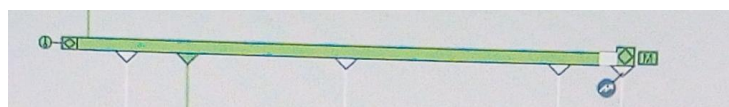


Figure 18. indicators in green on the monitor screen

2. When indicator is white

In Figure 19 the image on the white monitor can be interpreted that the machine is not running or stopped there is no product transfer process, and the position of the machine is also not vibrating, in Figure 19 shows the Screw Conveyor which does not carry out the product transfer process, Figure 19 is a connection from Figure 15, after going through the chain conveyor then the product enters the screw conveyor.

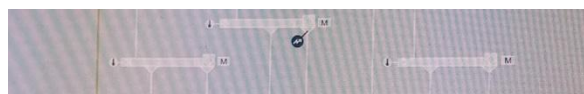


Figure 19. Green indicators on the monitor screen

3. When indicator is red

In Figure 20 showing the image on the red monitor, it can be interpreted that the engine is being damaged, when the transportation equipment is damaged it will affect the related means of transportation, such as in the picture of the screw conveyor at the bottom being damaged due to the limit switch sensor in contact with the cross-section which causes overflow, screw conveyor The top stopped and did not continue the product transfer process until the problem with the red screw conveyor was repaired.

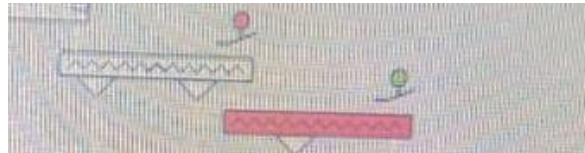


Figure 20. indicators in red on the monitor screen

CONCLUSION

Conclusion

Based on the results of the research and discussion that has been carried out by the researcher, it can be concluded in general that, understanding the use of safety sensors in product transportation is very important, to maintain quality and safety in carrying out the process of moving products. There are three types of sensors used in the process of moving products including proximity sensors, proximity sensors can be distinguished into 2 types which are inductive and capacitive sensors, these two sensors have a very important function so that they make moving products more efficient and also safe, this proximity sensor functions to monitor the flow rate of products if there is a blockage in the means of transportation, this sensor will detect by giving instructions to the monitor that There is an overflow on the monitor. In addition to the proximity sensor, there is also a belt monitor that functions to prevent slippage on the fanbelt when carrying out the product transfer process, this can minimize damage to the carrier belt when carrying out the process of moving products on the elevator bucket, limit switches are also very important, in the means of transportation used at PT. Pundi Kencana This tool is used to monitor the overflow or overflow of products on the screw conveyor, as well as the existing sensor sensors, both proximity, belt monitor, and also limit switches on product transportation tools, from these three sensors will give commands or notify the operator in charge of the production department if there is damage to the means of transportation so, making the process of moving products more efficient and allowing early detection of potential damage.

Suggestion

In the use of safety sensors, it is necessary to improve them again and be developed continuously so that the use of safety sensors can continue to develop and can be used by companies engaged in food processing and the like, to make it easier and provide comfort to employees and safety during the process of transferring products into a finished product. In addition, the development of the use of this sensor must continue to be improved, because it can make it easier and also make everything related to production by the standards that have been determined. However, when carrying out the product transfer process, sometimes the sensors used do not match the reality in the field, sometimes the sensors used often display indicators that are on and off and some are even just off but still detecting them, therefore calibration is needed, sensor calibration must be carried out to readjust the shooting focus point, the distance of the sensor to the object to be scanned or shot so that the data displayed on the monitor screen does not differ much from what is in the field. So calibrating the sensor

is very necessary, to keep the sensor focused and suitable for its use, the sensor must be checked at least once a month to minimize the occurrence of errors in reading data which is used as reference material to identify problems displayed by the sensor used so that if a detection error occurs (dead) action can be easily taken.

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