International Journal of Academic Engineering Research (IJAER)
ISSN: 2643-9085
Vol. 5 Issue 10, October - 2021, Pages: 13-17

Paper Cutting System Design in Cylinder Battery Disposal Process with Programmable Logic Controllers

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Abstract: *The EDC Division will build a cylindrical battery dismantling machine that aims to recycle waste cylinder batteries that are no longer used. The research method used is the library method. This battery dismantling machine is targeted to disassemble 600 cylindrical batteries per hour. This cylindrical battery unloading machine is divided into 3 stages, namely the hopper process, the slitting process, and the cutting process. To achieve the target of disassembling a cylindrical battery of 600 batteries per hour, where 1 battery means it takes 6 seconds in one cycle, then each stage in this system takes approximately 2 seconds per battery. The cutting process is the process of cutting the battery horizontally with the components used are a conveyor, blade grinder assembly, photoelectric proximity sensor, and Programmable Logic Controller (PLC). In the cylindrical battery disassembly machine, PLC is used to integrate existing processes, namely the hopper process, the slitting process, and the cutting process. By using these components, it is obtained within 2 seconds the battery has completed the cutting process and is put into the basket. In the cylindrical battery disassembly machine, PLC is used to integrate existing processes, namely the hopper process, the slitting process, and the cutting process. By using these components, it is obtained within 2 seconds the battery has completed the cutting process and is put into the basket. In the cylindrical battery disassembly machine, PLC is used to integrate existing processes, namely the hopper process, the slitting process, and the cutting process. By using these components, it is obtained within 2 seconds the battery has completed the cutting process and is put into the basket.*

Keywords—Cylinder Battery ; Disassembly ; Machine Cutting Process PLC

1. INTRODUCTION

This The development of technology is one of the important things as an effort to advance world civilization. The rapid development of technology is disassembly machine is needed to accelerate the readiness of the development of electric vehicles.

Each group of automotive component companies in Indonesia that produces and distributes various spare parts for two-wheeled and four-wheeled motor vehicles.[1]. Through the Engineering Development Center (EDC) division developed a battery disassembly machine. This machine aims to recycle unused battery waste so that it has more value and important content or elements can be reused.

The battery disassembly machine consists of 3 systems, namely the hopper system, cutting system, and slitting system. Seeing that cutting is one of the important mechanisms in the battery disassembly machine, the author wants to know more about the control system on cutting and study it with the title that has been taken.

2. METHODOLOGY

2.1 Main Battery Disassembly System

The increasing number of goods that use electricity as the main power source is of course also followed by the increasing demand for Li-Ion batteries. Batteries are devices that are capable of generating DC voltage, namely by converting the chemical energy contained in them into electrical energy through electrochemical, redox reactions.[2]. Li-Ion battery itself has a lithium base material which is known that resources such as lithium are very valuable. Rechargeable lithium ion cells have high energy density and power density making them the main choice for energy storage devices.[3]. Therefore, recycling batteries is also economically beneficial. This is so that the battery waste that is no longer used so that it has more value and important content / elements can be reused.

One of the first steps of the battery recycling process is disassembly. In this process, a cylindrical battery is used as an object to be dismantled by the battery disassembly machine. The battery disassembly process consists of several sub-processes that can be sorted into the battery removal process, the hopper process, the cutting process, and the slitting process. The process of removing battery resources is currently still in the research stage to deepen knowledge, while the cutting process will be explained further in the discussion below.

2.2 Cutting Structure

In the cutting process, the battery is cut horizontally at the two poles with a grinder equipped with a saw blade and a double nut attachment angle grinder where the battery moves through the saw blade assisted by a conveyor. A sensor is needed to detect whether the saw blade can still cut properly or not, this is because it can affect the results of cutting the battery. The cutting process itself consists of several constituent components.

Conveyor is one type of transportation equipment that serves to transport industrial materials in solid form.

Conveyors are widely used in industry for the transportation of very large quantities of goods and sustainable[4]. The type of conveyor that is widely used today is the type of belt conveyor where the belt used consists of several layers of cotton and rubber[5]. The choice of means of transportation (conveying equipment) of solid materials, among others, depends on Material handling capacity. Material transfer distance. transport direction: horizontal, vertical and inclination, size, shape, and properties.

Proximity Sensors or in Indonesian called proximity sensors are electronic sensors that are able to detect the presence of objects in the vicinity without any physical touch. It can also be said that a proximity sensor is a device that can convert information about the motion or presence of an object into an electrical signal. Proximity sensors are commonly used to detect presence, proximity, position and counting in automated machines and manufacturing systems. Proximity sensor is a sensor that works by emitting an electromagnetic field and receiving back changes in the electromagnetic field when it detects an object that is around it, the electromagnetic field emitted is in the form of an infrared signal.[6]. The machines that use this proximity sensor include packaging machines, production machines, printing machines, plastic printing machines, metalworking machines, food processing machines and many more

Grinder is one of the machine tools used to sharpen/cut workpieces with a specific purpose. The working principle of the grinding machine is that the rotating grinding stone is in contact with the workpiece so that erosion, sharpening, sharpening, or cutting occurs.[7].

Grinding is basically a mechanical process that causes high temperatures and chemical reactions on the surface of the workpiece. In the surface grinding process, energy is released in the form of heat transfer along the surface of the workpiece. In the surface grinding process, energy is released in the form of heat transfer along the surface of the workpiece. The heat generated in the surface grinding process will affect the surface roughness of the workpiece[8]. The value of the torque on the grinder has a property that is directly proportional to the power, but inversely proportional to the angular velocity, it will be found that the torque is equal to

$$T = \frac{P}{\omega} \quad (1)$$

The main functions of grinding machines in general are cutting workpieces whose thickness is not relatively thick ; smooth and level the workpiece surface ;as a final finished process (finishing) on the workpiece ; sharpen cutting tools to be sharp ; removes sharp edges on the workpiece ; forming a profile on the workpiece (be it ellipse, elbow, etc.)

Saw blade is a metal cutting disc with a very sharp circular shape which has a function to cut various kinds of goods.

Fig 1 *Saw Blade*

2.3 Programmable Logic Controllers

Programmable Logic Controllers (PLC) is designed to replace a sequential relay circuit in a control system. Apart from being programmable, this tool can also be controlled, and operated by users who do not have special knowledge of computer operations. PLC is often used as a controlling device on a machine according to its logical instructions.

Based on the name, PLC itself has the following concepts:

- *Programmable*, indicates the ability in terms of memory to store programs that have been created that can be easily changed in function or use.
- *Logic*, demonstrating the ability to process input arithmetically and logically (ALU), namely performing operations comparing, adding, multiplying, dividing, subtracting, negation, AND, OR, and so on.
- *Controller*, demonstrating the ability to control and regulate processes so as to produce the desired output.

The way a PLC works is to receive a controlled process input signal and then perform a series of logical instructions on the input signal according to a program stored in memory and then generate an output signal to control an actuator or other equipment.

3. RESULT

Cutting system in the process of disassembling a cylindrical battery with PLC has a target of being able to disassemble a cylindrical battery of 600 batteries per hour, where one battery means that it takes six seconds in one cycle. The design of this tool system has the aim of being able to carry out the cutting system process for a maximum of two seconds, so that a response from the tool is needed quickly and can work quickly so that this goal can be achieved.

Testing on the design of this machine is broadly divided into two, namely by performing mathematical calculations on the components used and analysis of the results of calculations obtained and using existing literature studies, both in the form of journals and reports of existing research results. In this machine design, the thing that will be tested is how fast the machine can complete the cutting process on one battery. This can be seen from the ability of the components used in the cutting process. The main components used are conveyors, grinders, and proximity sensors. After the data obtained from mathematical calculations, the next step is to analyze the design and compare it with the data obtained from the literature study.

The design of this tool has a success parameter where the results of the tests carried out, the design of this tool can complete one battery in the cutting system process for two seconds. In the mathematical calculation process regarding the components used, there are parameters that must be considered, namely the design of this machine can complete the cutting process on one battery for a maximum of two seconds. Therefore, adequate components are needed so that the objectives and parameters are achieved.

3.1 CYLINDER BATTERY

The cylindrical battery disassembly machine is divided into 3 stages, namely the hopper system stage, the slitting system, and the cutting system.

Fig 2 Design Cylinder Battery Dismantling Machine

Figure 2 shows the design of the cylindrical battery disassembly machine that will be made later. The hopper system section is shown in the design at the top end. Then in the vertical conveyor image (middle), shows the slitting system. The last part, namely the cutting system, is shown in the horizontal conveyor drawing. In Figure 4.1 it can be seen that the cutting system of the machine consists of a conveyor component, blade grinder assembly, proximity sensor, battery holder.

3.2 Ladder Diagram

The ladder diagram design of the Cylindrical Battery Disassembly System. Ladder diagrams were created using the CX Programmer application from Omron.

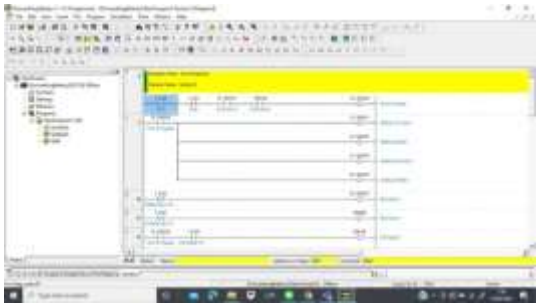

Fig 3 Ladder Diagram of Cylindrical Battery Unloading Machine

Figure 3 shows the ladder diagram design of the Cylindrical Battery Disassembly System. Ladder diagrams were created using the CX Programmer application from Omron. The ladder diagram was made using the CX Programmer application because the PLC component used is Omron's CP1E-E30SDR-A. This PLC has 18 digital inputs and 12 digital outputs. Input addressing on this type of PLC starts from 0.00 to 0.18, while output addressing starts from 100.00 to 100.12 [9]. As can be seen in the ladder diagram, there are several rungs, namely power supply, slitting conveyor, slitting grinder, cutting conveyor, cutting grinder, shut down, and lid hopper. Then it also uses several components, namely normally open (NO) contacts, normally closed (NC) contacts, and relay coil outputs. In the cutting system, when the NO start contact is pressed, the power supply will flow electric current to turn on the cutting conveyor with address Q:100.04 and turn on the cutting grinder with address Q:100.05 through contact NO with address Q:100.00. Then when the NC stop contact with the address I: 0.01 is pressed, the whole system will turn off. When the cutting saw proximity sensor with address I: 0.04 gets a trigger signal, the NO shut down contact with address Q: 100.08 will get a trigger so the whole system will shut down.

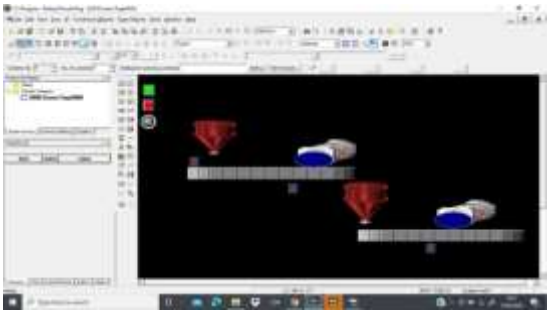

Fig 4 Simulation of Cylindrical Battery Unloading System on CX Designer

Figure 4 is an image of a Cylindrical Battery Unloading System Simulation. The simulation above was created using the CX Designer application from Omron. The picture shows several components, namely the hopper, slitting grinder, cutting grinder, cutting conveyor, slitting conveyor, slitting saw proximity sensor, and cutting saw proximity sensor. In the simulation, an on button is also given, marked with a green color, then an off button, marked with a red color, and an indicator light.

4. RESULT

In this cutting process, a conveyor is used to run the battery to the cutting grinder. The conveyor used is a 40 Timing Belt End Drive Conveyor. This conveyor is an Elcom product which has a width of 40 mm, uses a timing belt type belt (5 mm step) with a belt width of 32 mm, and the motor driver position is at the end of the conveyor.[10].

The cutting system workflow starts when the battery holder receives a battery that has fallen from the hopper.

When the battery falls into the battery holder, the conveyor will take the battery to the cutting process. Before the battery enters the cutting process, the cutting saw proximity sensor detects the diameter of the saw blade. When the saw blade diameter is within reasonable limits, the engine will continue to run. On the other hand, if the saw blade diameter has been eroded beyond the limit, the machine will stop. After the saw blade diameter read by the sensor is still within reasonable limits, the battery will go to the cutting process. This cutting process aims to cut the battery horizontally above and below as much as approximately 5 mm each, which aims to cut the cathode and anode connectors. After the cutting process is done, the battery will go into the storage basket.

In the cutting process, a cutting grinder or blade grinder is used to cut the upper and lower cylindrical batteries horizontally. The cutting grinder consists of a saw blade which is double attached to the grinder using a double nut attachment angle grinder. The grinder used is the Bosch GWS 2200 Professional Grinder. This Bosch GWS 2200 Professional Grinder is one of Bosch's grinder products. This grinder has an input power of 2200 W and produces a no-load speed of 8500 rpm. This grinder also weighs 5.2 kg and has a diameter of 180 mm[11].

The use of this grinder is based on the torque factor produced by the grinder. On the Bosch GWS 2200 Professional Grinder which has a power of 2200 W and a speed of 8500 rpm, you will find a torque of:

$$T = \frac{P}{\omega}$$

$$T = \frac{P}{(\frac{2\pi n}{60})}$$

$$T = \frac{P \cdot 60}{2\pi n}$$

$$T = \frac{2200 \cdot 60}{2\pi \cdot 8500}$$

$$T = 2{,}473\ Nm \qquad 2)$$

Thus, the torque result of the Bosch GWS 2200 Professional Grinder is 2,473 Nm. This value is sufficient to horizontally cut the top and bottom of the cylindrical battery 18 mm deep with the top and bottom heights of 5 mm each.

Based on the statement above, it can be concluded that based on the results of testing using the literature study method, it was found that using components such as the Bosch GWS 2200 Professional Grinder, 40 Timing Belt End Drive conveyor, and the BY500-TDT photoelectric proximity sensor, the cutting system process has success parameters. can finish on the cutting system process for two seconds will be achieved.

5. DISCUSSION

In the cutting process, a photoelectric proximity sensor is used to determine the condition of the saw blade on the cutting grinder. The sensor used is a photoelectric proximity sensor BY500-TDT. The BY500-TDT sensor is one of Autonics through-beam sensor products. This sensor requires a power supply of 12 – 24 VDC and the maximum current consumption is 30 mA. The BY500-TDT also has a detection distance of up to 500mm with a maximum response time of 1ms. Then for the control output using an open collector NPN with a load voltage of 30 VDC and a maximum current load of 100 mA[12].

The use of this sensor is based on the quality problem of the transistor circuit used. The open collector NPN type circuit has better switching characteristics. This is because in the open collector NPN type, the current carriers are electrons, the charge which has a faster transfer rate than the hole, while in the PNP type the current carrier is a hole charge, so in terms of switching this type is slower than the NPN type.[13].

6. CONCLUSION

The Cutting system is a battery system that functions to tear the battery skin horizontally in the process of disassembling the battery. Cutting system composed of several components including a conveyor, proximity sensor, double nut attachment angle grinder and grinder. Omron PLC CP1E-E30SDR-A is a component used to control the whole battery disassembly process. PLC itself is integrated in every process including the hopper system, slitting system and cutting system. This 40 Timing Belt End Drive Conveyor is used because of its width that fits the diameter of the cylindrical battery, which is 40 mm, and also because of the speed of the conveyor motor, which is 200 mm / sec, which is in accordance with the target time of the cutting process. The use of the Bosch GWS 060 Professional Grinder is based on the torque value factor produced which is sufficient to cut the battery as deep as 18 mm, which is 2,473 Nm. The sensor used is a photoelectric proximity sensor BY500-TDT. This sensor has a detection distance of up to 500mm with a maximum response time of 1 ms.By using the Conveyor 40 Timing Belt End Drive which has a conveyor motor speed of 200 mm/second, the Bosch GWS 2200 Professional Grinder which has a torque value of 2,473 Nm, and the photoelectric proximity sensor BY500-TDT which has a detection distance of up to 500mm with a maximum response time of 1 ms. the target of the cutting process which has a time of 2 seconds will be achieved

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