Conveyor Prototype of Steam Power Plant

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Abstract. Conveyor is an important tool for moving coal in the steam power plant. But conveyor belts are often broken due to the roller friction is jammed. Based on the problem, this research will make an innovation on conveyor prototype using PLC control system and add a proximity sensor to detect congestion on the conveyor roller. The method used in this research is hardware and software design, tool making, and tool test. The results of this research are expected to be applied to the real conveyor system in the steam power plant so the conveyor operator can monitor the situation through the control room in the steam power plant. It can also notify their family if they are lost.

1. Introduction

The rapid growth of the electricity industry is in tandem with the increasing electricity demand of society, the capacity and large units of coal-fired steam power plants gradually holds the dominant position of power plants [1]. This cannot be separated from the conveyors that play an important role in modern industrial on-off, because it can save time effectively in the transport of objects [2], which in this case is coal.

Conveyor drives are driven by a control system. AutoOff control system for machines in the industry initially only a series of relays. Such a control system becomes less effective because in addition to a large cost to make changes to the system also has a high level of work complexity. The solution to solve the problem is to use control system using PLC (Programmable Logic Controller) [3].

By adopting a less effective and efficient manual control system, this research has a goal to create conveyor prototype based on PLC. This prototype is a conveyor that can carry coal, besides this prototype also equipped with proximity sensor to detect congestion on roller conveyor.

2. Methods

2.1. Material

This prototype is designed using the tool materials as shown in Table 1.
Table 1. Tool Materials.

| Tool Name       | Specification | Amount |
|-----------------|---------------|--------|
| Push Button     | 2 pin         | 5      |
| Relay           | 24 VDC        | 4      |
| Cable wires     | 0.75 mm       | 10 M   |
| Electric motor  | 12V           | 3      |
| Power Supply    | 12V           | 1      |
| Indicator Lamp  | 24 VDC        | 3      |
| Proximity sensor| 4 mm          | 1      |

2.2. Research methods

There are several stages described in the flowchart in Figure 1.

![Flowchart Research Methods](image)

2.2.1. Design. Conveyor prototype based on PLC in design resembles the actual conveyor. There are three conveyors with the height of each of the different conveyors. The first conveyor serves as a start, where the conveyor is the one that distributes coal to the next conveyor. The second conveyor serves as a liaison between the first and third conveyors. This conveyor has two-way rotation, the first is to distribute coal to the next conveyor, while the second round is to distribute the second coal storage area.
In this conveyor installed sensors to detect congestion on the roller. The third conveyor serves to distribute coal to the first storage area.

2.2.2. Program. The software used for this prototype is Cx-Programmer which serves as a tool for making program design, testing and program improvement related to Omron PLC. Creating a ladder diagram on CX-Programmer is an important part of this research because it involves critical thinking [4], where critical thinking is needed to decide the step by step program that will be applied to this prototype.

2.2.3. Components. For the manufacture of prototype is required tools and materials as follows:

2.2.3.1. PLC (Programmable Logic Controller). PLC are electronic devices that work digitally using "Programmable Memory" for internal instruction storage to implement special functions such as logic, sequencing, time measurement, calculation and arithmetic, to control analog / digital input / output modules, various certain types of machines or processes [5]. The PLC used in the manufacture of this prototype is the Omron PLC with CP1L type as shown in Figure 2. This PLC requires an input voltage of 24 volts DC [6].

![Figure 2. PLC (Programmable Logic Controller) Omron CP1L.](image)

2.2.3.2. DC motor. Dc motor is a tool that converts direct electric energy (DC) into mechanic energy in the form of rotation or rotation on the rotor. Motor generated torque can be used to move a tool, its usage is for motor starters, conveyors, elevators, drill machines and others [7]. The DC motor is shown in Figure 3.

![Figure 3. DC Motor.](image)

2.2.3.3. Proximity sensor. A sensor is a device that has the function to convert power into another power. Proximity sensor is a sensor that has a working principle based on the object's distance to the sensor that can detect a target with a metal type without any physical contact. Proximity sensor used is inductive proximity which can detect metal, this proximity sensor use power supply equal to 12-24 VDC [8]. One of the proximity sensor is shown in Figure 4.

![Figure 4. Proximity Sensor.](image)
2.2.3.4. Conveyor. In this study, the conveyor is made using iron raw materials and in the form according to the design made. While the material used for conveyor belt is Teflon material. In this study conveyor is used as a tool to transport the sand as a substitute for coal in the process that actually occurs in the industry.

2.2.4. Program Design.

![Program Design Diagram](image)

**Figure 5.** Block Diagram PLC based prototype conveyor in steam power plants.

![Flowchart Diagram](image)

**Figure 6.** Flowchart of Programming Prototype PLC-based conveyor in steam power plant.

The block diagram and flowchart of programming are shown in Figure 5 and Figure 6, respectively. This conveyor prototype has three coal pipe processing processes. The first is the Direct process where the coal transport flow starts from the first conveyor and ends in the third conveyor to the next to the storage area, in this process the second conveyor revolves in the reverse direction. The second process is called the un-loading process where the coal transport flow begins from the first conveyor and ends
in the second conveyor with the direction of motor forward rotation which goes to the storage place. Third is the loading process where the conveyor transport flow starts from the second conveyor with the reverse motor rotation direction and ends in the conveyor for the next to the storage area.

At the time of the process of transporting coal using a conveyor, proximity sensor actively detects congestion on the conveyor roller. If there is congestion on the conveyor roller, then the sensor will instruct the PLC to turn off the entire process in order to avoid the breaking of the conveyor belt.

The displacement of each process has a time lag to stop and so is the proximity sensor where the proximity sensor time lag is not working.

3. Results and Discussion

After experiments on PLC-based conveyor prototype in steam power plant, then got some test result as follows:

3.1. Proximity sensor testing

This test is performed on the Proximity sensor to determine the distance the sensor reads to a metal object. Table 2 shows the data taken from the test of proximity sensor.

| No | testing          | distance (mm) | Information  |
|----|------------------|---------------|--------------|
| 1  | Metal testing    | Article I. 2 mm | Detected     |
| 2  | Metal testing    | Article II. 4 mm | Detected    |
| 3  | Metal testing    | Article III. 6 mm | Not detected |
| 4  | Metal testing    | Article IV. 8 mm | Not detected |
| 5  | Metal testing    | Article V. 10 mm | Not detected |
| 6  | Metal testing covered paint | Yellow paint | Detected |

![Figure 7. Proximity Sensor Testing.](image)

It can be seen from the Table II that the sensors used in the manufacture of this prototype has a distance of 4 mm readings while the result indicates that the sensor is not reading, it is caused by the sensor readout distance exceeding the distance of 4 mm. As for the experiments conducted on metals coated or covered by paints, there is obtained readings over a distance of 0 to 4 mm.

3.2. Conveyor Testing

Conveyor testing is done by placing the sand above the conveyor, this test is done to know the conveyor can walk well and travel time to deliver the sand to the storage. The data of conveyor test results can be seen in the Table 3.

| No | Process          | Time     |
|----|------------------|----------|
| 1  | Process 1 (Direct) | 28 seconds |
| 2  | Process 2 (Un-Loading) | 22 seconds |
| 3  | Process 3 (Loading)  | 22 seconds |
It can be seen from Table III that the conveyor runs according to the PLC program created. For process 1 (Direct) takes 28 seconds to deliver sand to storage. While for process 2 (Un-Loading) takes 22 seconds to deliver the sand to the storage. And for process 3 (Loading) takes the same time with process 2 that is 22 seconds to deliver sand to storage place.

3.3. Congestion testing on the conveyor roller
Roller congestion testing is performed in every process performed by the ongoing conveyor. The data of conveyor congestion test result can be seen in Table 4.

| No | Process          | Time of congestion | Conveyor |
|----|------------------|--------------------|----------|
| 1  | Process 1 (Direct) | 5 seconds          | Off      |
| 2  | Process 2 (Un-Loading) | 5 seconds       | Off      |
| 3  | Process 3 (Loading) | 5 seconds         | Off      |

The congestion test is done by holding the 2nd conveyor roller, because the conveyor continues to function. Can be seen in the table above that the results of congestion testing on the roller conveyor on each process run as expected.

4. Conclusions
Based on the test results, it can be drawn some conclusions as follows:
- The proximity sensor used has a detectable distance between 0mm and 4mm.
- From the results of congestion testing on the conveyor roller, it can be concluded that the proximity sensor serves to detect the occurrence of congestion on the roller conveyor.
- From the results of conveyor testing, it can be concluded that the mechanics and system controls are applied to run well and in accordance with the purpose.
- This research has successfully achieved the goal, which is to detect congestion on the conveyor roller and also autoOffc control system using Omron PLC.

This prototype system has the potential to help industry which in this research is steam power plant in detecting congestion on roller conveyor of coal carrier and also autoOffc system which can be applied to actual conveyor system.

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