Mekanika: Majalah Ilmiah Mekanika

Design And Control System of Automatic Control System of Coal Flow on Belt Conveyor Installation

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Keywords:
Coal conveyor, PLC & HMI, CX-Programmer, CX-Designer, coal flow divider

In a power plant unit whose main fuel is coal, there is generally use a belt conveyor installation. This belt conveyor serves to supply coal from the crusher unit to the combustion chamber of the power generation unit. In this study, we discuss a case where the installation of a belt conveyor which was initially only one line was then made a new branch that supplies coal to other power generating units. Equitable capacity distribution and continuity of coal distribution are the main focus of this study. Therefore, a design of automatic control system of coal flow divider on belt conveyor installation was designed. The working principle of this coal flow splitting system is to control the movement of the straight blade plough that directs the flow of coal to each unit at the certain time and continuously. Straight blade plough in the form of steel metal plate with a thickness of about 10 millimeter in which one end is connected to the end of the pneumatic cylinder. Automatic control system of coal flow divider in belt conveyor installation designed using CX-Programmer and CX-Designer applications. CX-Programmer serves to create automatic control logic concepts. While the CX-designer functions to create a Human Machine Interface (HMI), making it easier for operators to control the course of the coal supply process. The results of this study are in the form of control logic lines that can be applied to Programmable Logic Control (PLC) device and Human Machine Interface (HMI) equipment.

1 Introduction

Technological advances have covered almost all aspects of life, including the overhaul of conventional systems that involve a lot of human intervention, switching to automated systems that involve less human intervention and being replaced by a series of automatic control devices. Automatic control is very popular in this modern era for reasons of reliability, productivity and quality. The use of automatic

https://dx.doi.org/10.20961/mekanika.v20i2.51986

Revised 6 June 2021; received in revised version 20 July 2021; Accepted 9 September 2021
Available Online 30 September 2021

2579-3144

control in the system allows it to work non-stop with high precision and uniform quality. So that it can increase production productivity, especially in companies or manufacturing industries. With the rapid development of technology, the creation of technology programming using a logic control system known as Programmable Logic Controller (PLC) [1]

PLC is one of the devices that increase the reliability of production automation system through inputs such as sensors to detect objects in real time [2]. PLC is the most widely used automated system devices today in industrial production processes [3].

This programming technology can be controlled automatically and can be completed in a short time and has a programmable memory and stores commands-commands to perform special functions. With the process automatically, the device electronics can overcome these problems by shortening time, reducing losses, and improve the quality of production results [4]. A real-time system is that provides information on a situation where the information displayed on the receiving side corresponds to the observed side both in time and circumstances [5]. A control system is said to be real-time if the control system able to respond to input appropriately logically and quickly. Sometimes the response has to be so quickly, that if not done within a limited period of time it would take then the response is considered failed. So a control system that has a response time that is fast enough so that it is able to respond to input within a limited period of time is needed, then such control systems can be referred to as real-time control systems [6][7].

In this study, a design of a control system for distributing coal flow in a conveyor belt installation will be reviewed. Belt conveyor installations are often found at power generation company sites which use a steam turbine as a generator drive to eventually produce tens of mega-watts of electrical energy. In a steam turbine system, there is a furnace or combustion chamber which functions to heat water to a high level of steam. The high pressure of this superheated steam can drive an electric generator. Coal as the main fuel for this steam turbine system is sent to the combustion chamber to be burned using a belt conveyor. In general, coal that is still in the form of large boulders is carried from barges to the crusher unit to be crushed so that it becomes relatively smaller in size resembling powder for easy distribution to power generating units.

As technology develops, the need for electrical energy is increasing. This is because almost all modern technologies rely on electrical energy to work. So that many power generation companies are trying to add power generation units. The addition of a power plant unit means that an adequate supply of coal is needed without having to disrupt the supply of coal to the existing generating unit. Sometimes the option to build a new crusher unit is considered too long, so the option is taken to make a branch on the conveyor installation that goes directly to the power generation unit. In addition to the low cost, the modification process is also relatively fast. To modify or make branching on the belt conveyor installation, a kind of coal flow guide is added. The next step is to create a control system based on Programmable Logic Controllers (PLC) which will regulate the movement of the straight blade plough each time unit alternately and continuously. This allows the supply of coal to the generating unit and other generating units to be guaranteed.

2 Experimental Methods

2.1 Mechanical Design

Straight blade plough is made of steel metal plate with a thickness of about 5-10 millimeter. One end of the plate is made a hinge connection with the conveyor belt limiting wall. While the other end of the plate is connected to the end of the pneumatic cylinder. This mechanism is similar to when we open or close the door of the house. Straight blade ploughs need to be coated with chrome metal or ceramic to prevent abrasion from colliding with coal. On the lower side of the plate, it is also necessary to add a kind of scraper made of rubber or polypropylene which has elastic properties. The function of adding this scraper is to ensure that no volume of coal escapes through the guide plate and also to scratch or clean coal deposits adhering to the surface of the conveyor belt. The explanation of the mechanism is shown in Figure 1.

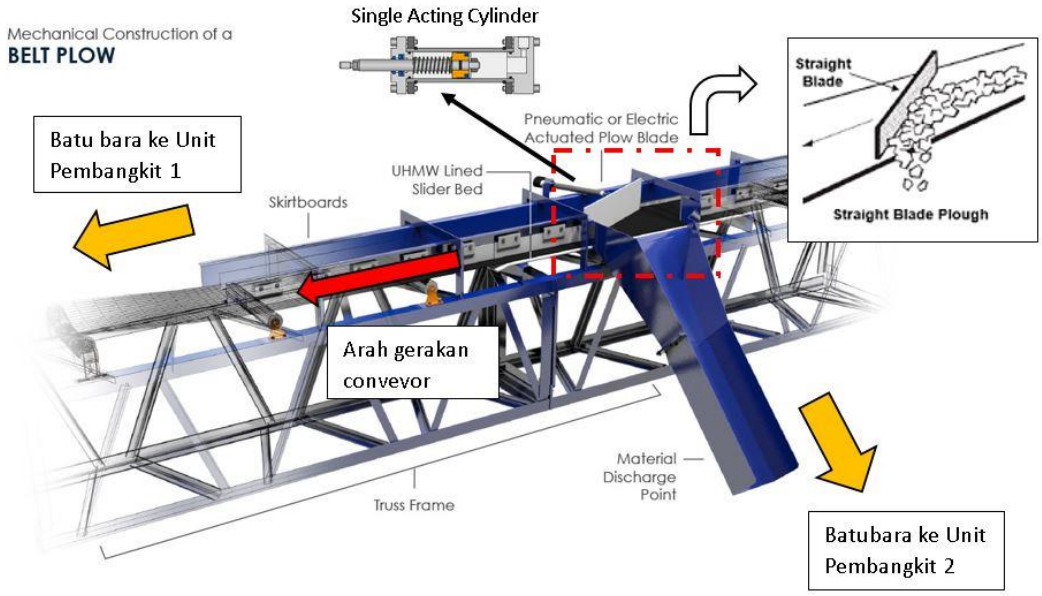

Figure 1. Belt conveyor modification scheme

In designing this modified conveyor belt design, several materials and specifications are needed which are shown in Table 1.

Table 1. Materials and specifications

No.	Part Name	Material/Specification	Dimension	Information
1.	Straight Blade Plough	Mild Steel Plate	400x150x10 mm	Machining
2.	Actuated Plow Blade	Pneumatic/Hydraulic/Electric	Original Equipment Manufacturer (OEM)	Depend on type and brand
3.	PLC Device CP1L-M60-A Omron	General specifications [8]: - Power supply: 100 to 240 VAC 50/60 Hz - Operating voltage range: 85 to 264 VAC - Power consumption: 50 VA max. - Inrush current: a. 100 to 120 VAC inputs: 20A max. (for cold start at room temp.) 8 ms max. b. 200 to 240 VAC inputs: 40A max. (for cold start at room temp.) 8 ms max. - Insulation resistance: 20 Mega-Ohm min. (at 500 VDC) between the external AC terminals and GR terminals. - Ambient operating temp.: 0-55^{0}C - Ambient humidity: 10% to 90% (no condensation)	195x110x85 mm (outer dimension)	Weight 820 g max.

2.2 Automatic Control System Design

The design of the automatic control system is based on PLC. Next, a program line is created in the CX-Programmer application. One of the advantages of this application is that we can identify whether our program lines have run according to the control logic we want or not. So that revisions or modifications of program lines can be done quickly and easily. The following is the control logic that is used as a guide or guide in creating program lines in CX-Programmer.

Control Logic:

1. When the “start” button is activated, the conveyor starts to work transporting coal to Generating Unit 1.
2. After 5 seconds, the pneumatic cylinder works (erect) and pushes the "Straight Blade Plow" so that the coal flow moves from the original to the Generating Unit 1 to the Generating Unit 2.
3. The next 5 seconds, the pneumatic cylinder stops working (release) so that it pulls the "Straight Blade Plow" to the initial position and the coal flow returns to the Generating Unit 1. During the release process, compressed air is discharged into the environment. The pneumatic type used in this design is "Single Acting Cylinder (SAC)", where when the compressed air in the cylinder is discharged into the environment, the spring in the pneumatic will pull the cylinder to its initial position.
4. In this system, a condition is given, namely the pneumatic cylinder can work only if the conveyor is working. This means that if the conveyor stops working then the movement of the flow guide or Straight Blade Plow also stops working.
5. When the stop button or emergency button is activated, the system automatically stops working.

Table 2. PLC input output addressing

I/O Type	Component	Function	PLC Address
Input	PB Start Button	ON System	0.00
	PB Stop Button	OFF System	0.01
Output	Konveyor1	Running of Conveyor	100.00
	Pneumatik	Running of Pneumatic	100.01

Based on the control logic, the following control program lines are obtained in Figure 2.

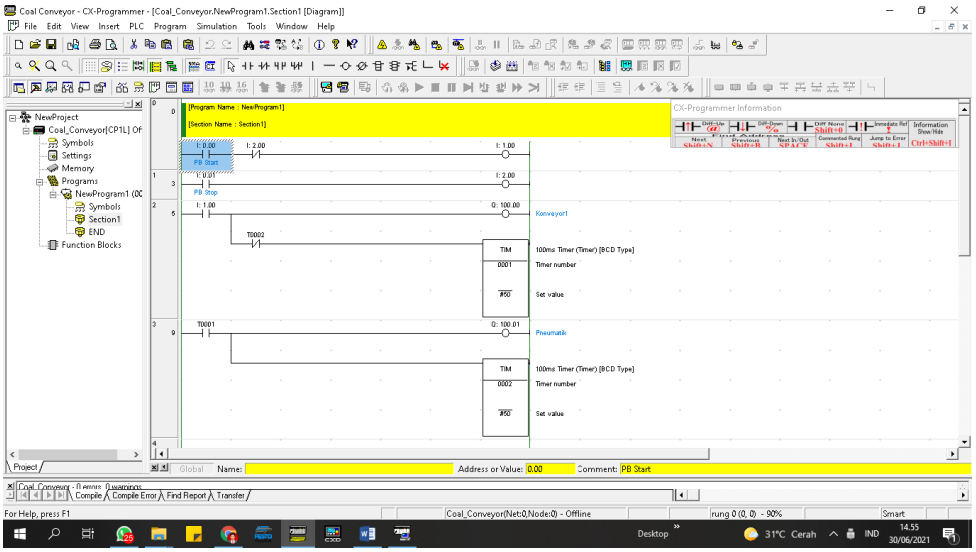

Figure 2. Program line using CX-Programmer application

2.3 Human Machine Interface Design

Next is to create a Human Machine Interface (HMI) which is a liaison medium between the system and humans as operators. This HMI design was created using the CX-Designer application. With this HMI,

it can assist operators in monitoring and controlling the running of the system. In addition, it also assists operators in determining preventive measures against indications of system failures that can result in work accidents. The display of this HMI is shown in Figure 3.

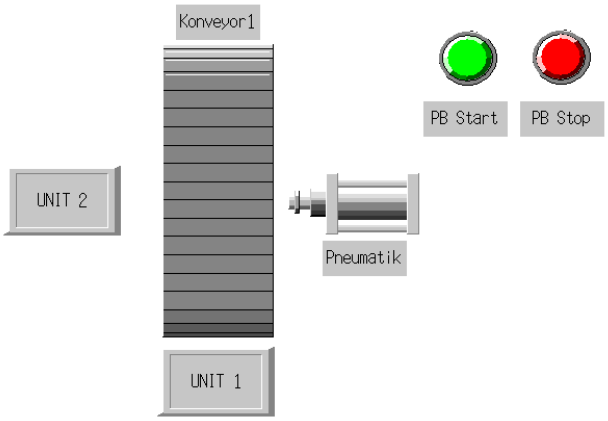

Figure 3. Program line using CX-Programmer application

3 Result and Discussion

The result of this design is a modified design proposal for a belt conveyor installation that adds a guide plate called a straight blade plow with a pneumatic cylinder drive. The pneumatic cylinder movement is based on a line program created in CX-Programmer which will later be inputted into the PLC as a control device. The control concept uses a time control system or timer. It was chosen because it is more reliable and does not require additional devices such as sensors. The use of the sensor itself has been commonly used, but it is considered less reliable because the coal material easily produces dust. When the coal moves on the conveyor belt at a certain speed, the low mass of coal will fly into dust. The dust sticks to the sensor and in a long time can occur. The result is an error in reading the sensor which ultimately causes system failure.

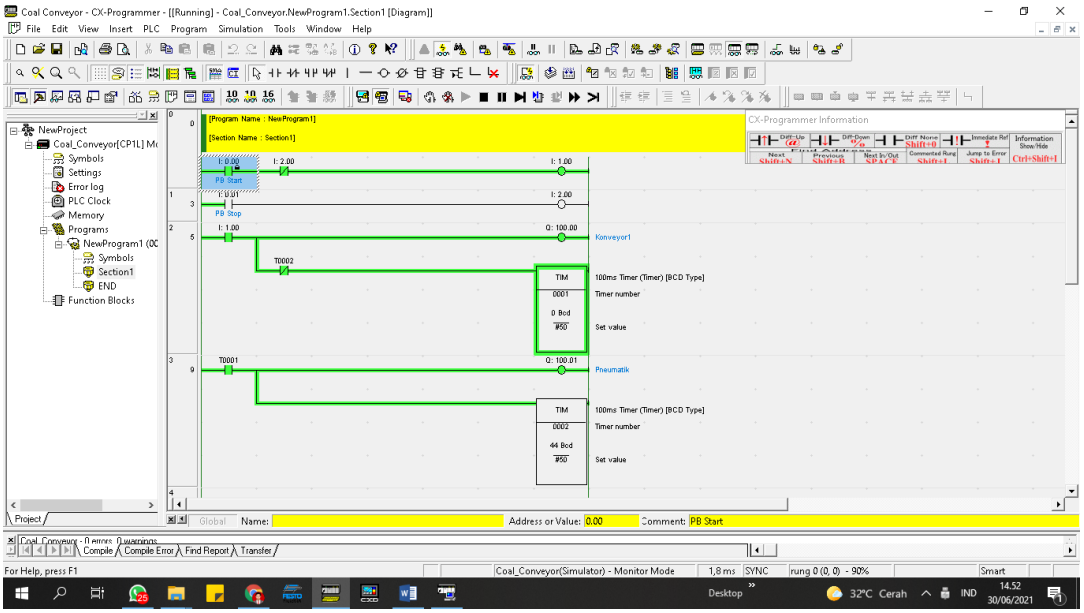

Figure 4. Program Running in CX-Programmer application

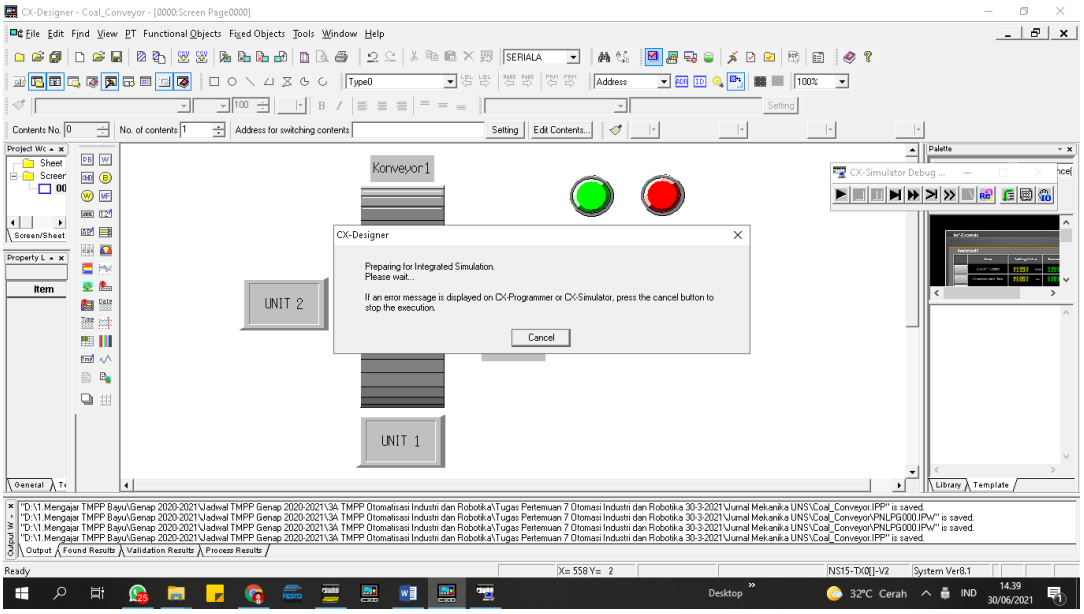

Figure 5. Human Machine Interface Running in CX-Designer application

After trial the program simulation, achieved some data as shown in Tables 3. The experimental results show that with seven repetitions it gives good results where all components work well and without errors. This provides information that the automatic control system has good reliability. The reliability in question includes aspects of precision, responsibility, and continuity.

Table 3. Automation system test result

I/O Type	Component	Number of experiment						
		1	2	3	4	5	6	7
Input	PB Start	√	√	√	√	√	√	√
	Button	√	√	√	√	√	√	√
	PB Stop	√	√	√	√	√	√	√
	Button	√	√	√	√	√	√	√
Output	Konveyor1	√	√	√	√	√	√	√
	Pneumatik	√	√	√	√	√	√	√

4 Conclusion

The principle of controlling using a timer is proposed in this design because of its reliability. The use of sensors in material handling such as new coals is not very good in terms of performance. In addition to reliability reasons, the use of a timer control mechanism can also save costs because there is no need to spend on buying sensor devices. This design also proposes a visualization of the Human Machine Interface (HMI) which makes it easier for operators to monitor the running of the system and at the same time makes it easier for operators to take action if there are indications of system irregularities.

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