Mekanika: Majalah Ilmiah Mekanika

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

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Abstract
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, an 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 plow that directs the flow of coal to each unit at a particular time and continuously. Straight blade plows in the form of steel metal plate with a thickness of about 10 mm in which one end is connected to the end of the pneumatic cylinder. The automatic control system of the coal flow divider in belt conveyor installation was 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). The results of this study are in the form of control logiclines that can be applied to Programmable Logic Control (PLC) devices 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 much human intervention, switching to automated systems that involve less human intervention, and being replaced by a series of automatic control devices. Automatic control is viral in this modern era for reliability, productivity, and quality reasons. The use of automatic 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 device that increases the reliability of production automation systems through inputs such as sensors to detect objects in real-time [2]. PLC is today's most widely used automated system device in industrial production [3].

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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 particular functions. With the process automatically, device electronics can overcome these problems by shortening time, reducing losses, and improving the quality of production results [4]. A real-time system provides information on a situation where the information displayed on the receiving side corresponds to the practical side both in time and circumstances [5]. A control system is said to be real-time if the control system can respond to input appropriately, logically, and quickly. Sometimes, the response has to be so quickly that the response is considered failed if not done within a limited period. So, a control system with a fast response time that is fast enough to respond to input within a limited period is needed. Then such control systems can be referred to as real-time control systems [6,7].

This study will review a control system design for distributing coal flow in a conveyor belt installation. Belt conveyor installations are often found at power generation company sites that use a steam turbine as a generator drive to produce tens of megawatts of electrical energy eventually. In a steam turbine system, a furnace or combustion chamber functions to heat water to a high steam level. The high pressure of this superheated steam can drive an electric generator. As the primary fuel for this steam turbine system, coal 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. It becomes relatively minor 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. Adding a power plant unit means that an adequate supply of coal is needed without disrupting the supply of coal to the existing generating unit. Building a new crusher unit is sometimes 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. A coal flow guide is added to modify or make branching on the belt conveyor installation. The next step is to create a control system based on Programmable Logic Controllers (PLC) which will regulate the movement of the straight blade plow 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

A straight blade plow is made of steel metal plate thickness of about 5-10 mm. One end of the plate is made with a hinge connection with the conveyor belt limiting wall. At the same time, 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 (see Figure 1).

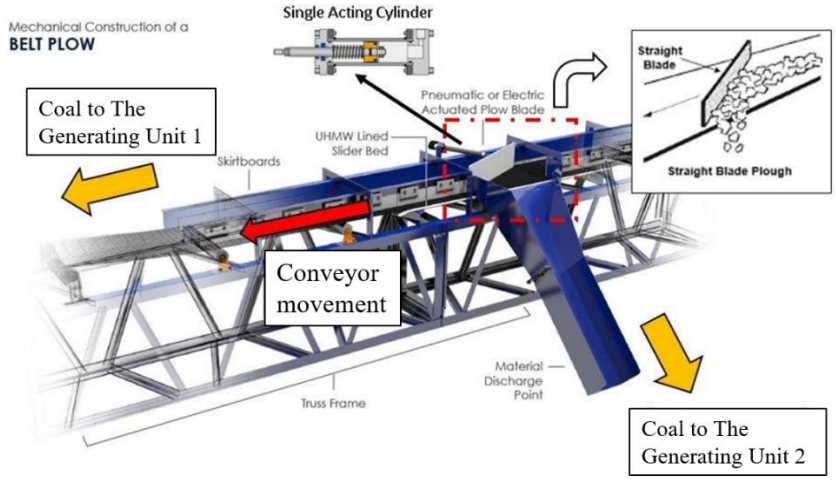

Figure 1. Belt conveyor modification scheme

Straight blade plows must 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 with elastic properties. The function of adding this scraper is to ensure that no volume of coal escapes through the guide plate and to scratch or clean coal deposits adhering to the surface of the conveyor belt. The explanation of the mechanism is shown in Figure 1. In designing this modified conveyor belt design, several materials and specifications are needed in Table 1.

Table 1. Materials and specifications

No.	Part Name	Material/Specification	Dimension	Information
1.	Straight Blade Plough	Mild Steel Plate	400 x 150 x 10 mm	Machining
2.	Actuated Plow Blade	Pneumatic/Hydraulic/Electric	Original Equipment Manufacturer (OEM)	Depending ontype and brand
3.	PLC Device CP1L-M60-An Omron	General specifications [8]: - Power supply: 100 to 240 V_{AC} 50/60 Hz - Operating voltage range: 85 to 264 V_{AC} - Power consumption: 50 VA max. - Inrush current: a. 100 to 120 V_{AC} inputs: 20A max. (for cold, start at room temp.) 8 ms (max). b. 200 to 240 V_{AC} inputs: 40A max. (for cold, start at room temp.) 8 ms (max). - Insulation resistance: 20 Mega-Ohm min. (at 500 V_{DC}) between the external AC terminals and GR terminals. - Ambient operating temp.: 0-55 ℃ - Ambient humidity: 10% to 90% (no condensation)	195 x 110 x 85 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 used to guide or guide in creating program lines in CX-Programmer. Based on the control logic, the following control program lines are obtained in Figure 2. Control logic is presented as follows:

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" to move the coal flow from the original to the Generating Unit 1 to the Generating Unit 2.

3. In 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)." 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 flow guide's movement or Straight Blade Plow also stops working.
5. When the stop or emergency buttons are 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	Conveyor1	Running of Conveyor	100.00
	Pneumatic	Running of Pneumatic	100.01

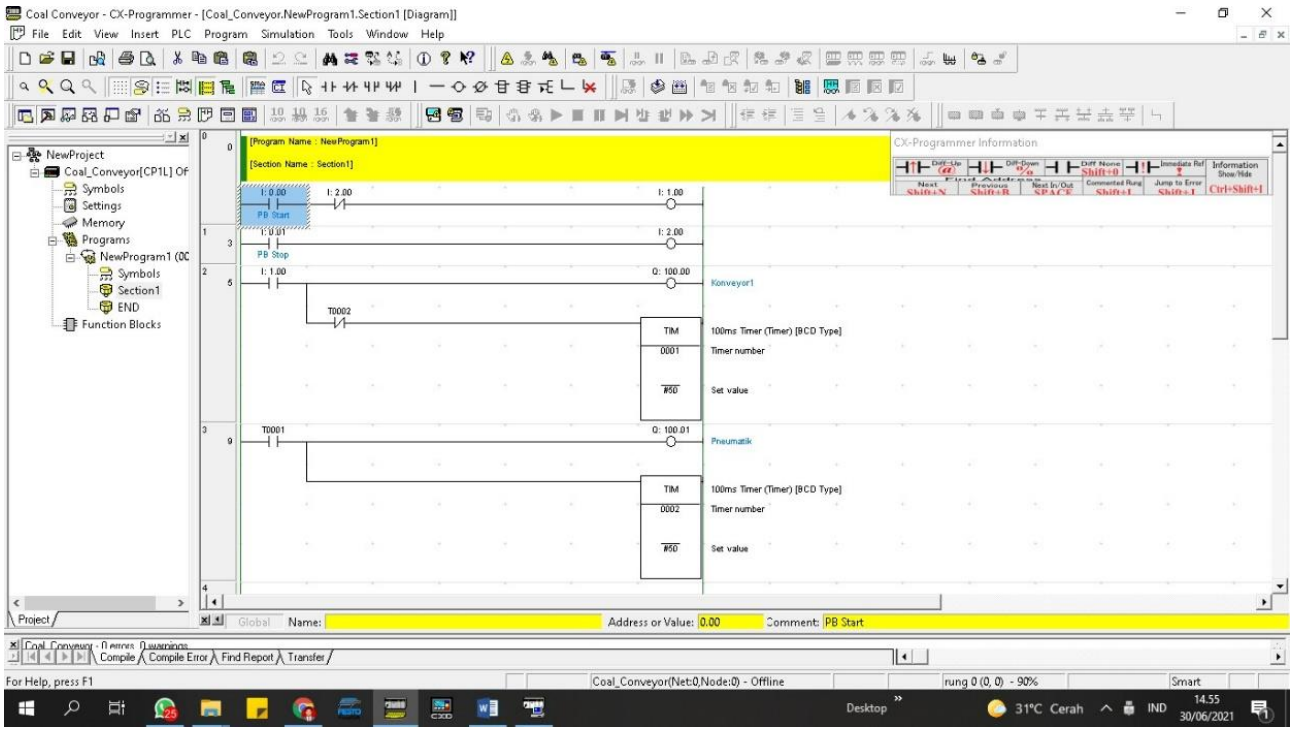

Figure 2. Program line using CX – Programmer application

2.3 Human machine interface design

Next is to create a Human Machine Interface (HMI), a liaison medium between the system and humans as operators. This HMI design was created using the CX-Designer application. This HMI can assist operators in monitoring and controlling the system's running. 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.

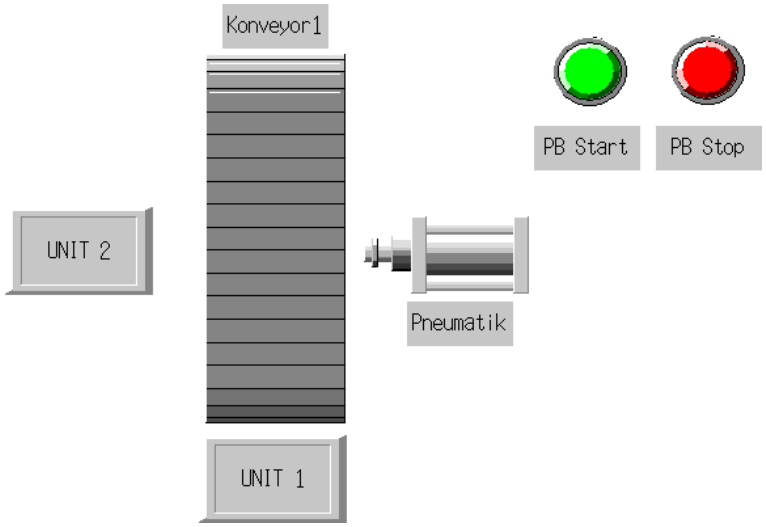

Figure 3. Program line using CX – Programmer application

3 Results and Discussion

This 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 efficiently 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 for a long time can occur. The result is an error in reading the sensor, which ultimately causes system failure.

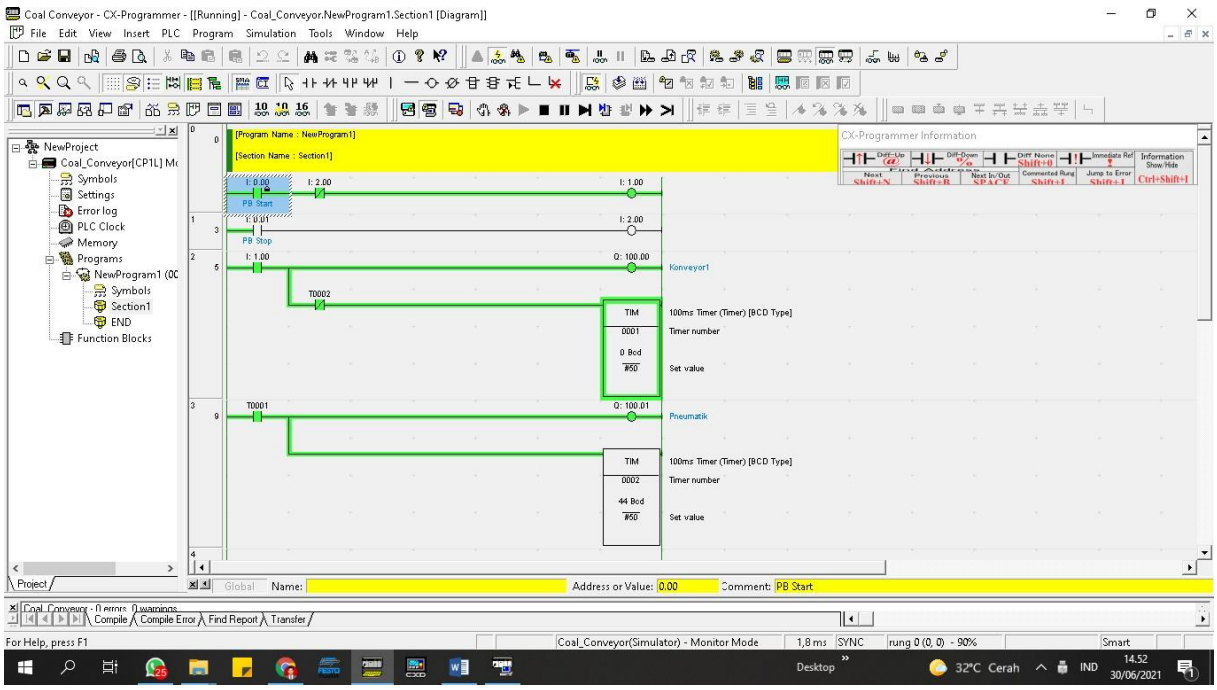

Figure 4. Program running in CX – Programmer application

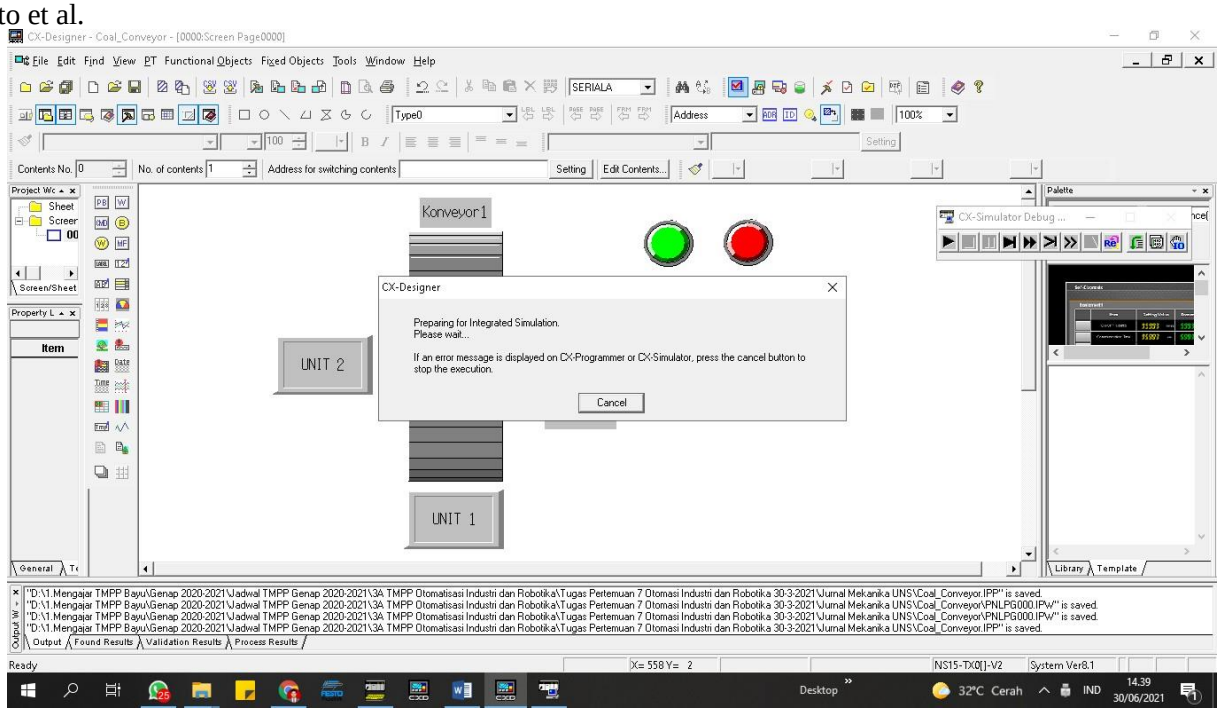

Figure 5. Human machine interface running in CX – Designer application

After the trial, the program simulation achieved some data, as shown in Table 3. The experimental results show that seven repetitions give 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 experiments						
		1	2	3	4	5	6	7
Input	PB Start	√	√	√	√	√	√	√
	Button	√	√	√	√	√	√	√
	PB Stop	√	√	√	√	√	√	√
	Button	√	√	√	√	√	√	√
Output	Conveyor1	√	√	√	√	√	√	√
	Pneumatic	√	√	√	√	√	√	√

4 Conclusions

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 performance. In addition to reliability reasons, using a timer control mechanism can also save costs because there is no need to buy sensor devices. This design also proposes a visualization of the Human Machine Interface (HMI), which makes it easier for operators to monitor the system's running and, at the same time, makes it easier for operators to take action if there are indications of system irregularities.

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