Design of a Two-Way Conveyor Belt Control System Based on PLC and HMI

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ABSTRACT

This research aims to control and monitor the direction of rotation and speed of the conveyor belt based on PLC and HMI. Conveyor belt control settings are carried out using a Toshiba VF-S15 Variable Speed Drive which is controlled by the Simatic S7 1200 1215C Programmable Logic Controller. This induction motor control and monitoring system is implemented on a 0.37 kW induction motor as a conveyor belt drive using the Simatic KTP700 Comfort Human Machine Interface. The test results show that the control and monitoring system for the direction of rotation and speed of the conveyor belt has worked well in automatic mode and manual mode. The HMI display used as an interface for controlling and monitoring the conveyor belt has successfully controlled the conveyor belt and displays conveyor belt speed data close to the same as the speed data obtained from the measuring instrument.

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1. INTRODUCTION

The development of equipment and technology makes it easier and faster for humans to complete tasks, so that production becomes more efficient. For example, in the industrial world it is very necessary to have a system that can improve / increase efficiency in an industrial process. As is the case in a production activity, many transportation tools are used in the form of conveyors [1]. Conveyor is a tool or machine that can be specially designed to facilitate the transportation or transportation of goods or materials. There are two types of conveyor belts that can be transported by conveyor machines, namely bulk material and unit load. Bulk material in the form of small parts, or powder such as coal then for Unit load material or large items that can be counted as units such as boxes, blocks, and so on [2].

Conveyors have many types with different functions, one of which is the belt conveyor. Belt conveyor is a mechanical material transportation device, in the horizontal or inclined direction, which consists of a belt that is supported by several idler roller tubs where the drive is pulled by a drive pulley [3]. Belt conveyors use belts as the main component to move goods. The conveyor belt is driven using an electric motor, either rotating clockwise or counterclockwise according to the desired conveyor belt function. In general, electric motors that are widely used in factories are three-phase induction motors. The consideration of using an induction motor is because the motor has a very simple construction and is not easily damaged, so it is easy to maintain and the motor rotations are relatively constant with changes in load [4]. This induction motor is one of the alternating current motors that is widely used because it has several advantages, such as more efficient, simpler and stronger construction and cheaper prices compared to other types of motors [5-[7]. Because of its simple construction, induction motor maintenance is also easier than other types of motors [8].

The fast and slow speed of the conveyor belt can affect the amount of production and the total efficiency of its production. Therefore, control of the conveyor belt speed is very necessary in order to get high efficiency. Usually the conveyor speed is regulated using a Variable Speed Drive (VSD) or commonly called an inverter in the industrial world. VSD is a device used to control the speed of an electric motor (AC) by controlling the frequency of the electric power supplied to the motor [9]-[10]. Conveyor belt speed can be controlled using a Programmable Logic Controller (PLC) combined with a Human Machine Interface (HMI).

Programmable Logic Controller or also known as PLC is a microprocessor-based tool used to replace the many relays that exist in conventional control [11]-[12]. PLC (Programable Logic Controller) is a device that functions to control the process or operation of a machine, by analyzing input signals and then controlling the output as needed, where the program logic instructions are stored in memory [13]. This PLC is one of the control tools that can control and monitor the conveyor belt. In controlling and monitoring, input and output processes are needed, to facilitate control and monitoring, an HMI or Human Machine Interface is used [14]. This HMI has become a device that is always integrated with PLCs that communicate with each other in the form of interface displays [15]. HMI can control and monitor inputs and outputs, control modes and system indicators that will be displayed in real time through an interface screen [16]. Based on the advantages of using PLC and HMI in controlling conveyor belts, this study proposes a PLC and HMI-based two-way conveyor belt control system. The control is implemented for a 0.37 kW three-phase induction motor as a conveyor belt drive with a toshiba vf-s15 VSD.

2. METHOD

Research on two-way conveyor belt control systems based on PLC and HMI is carried out in the form of experiments in the laboratory. The design of this two-way conveyor belt control system is basically an induction motor control system as a conveyor drive through an interface, so that users can easily control and monitor the conveyor belt while working. The induction motor speed monitoring system tool made in this study is shown by the block diagram in Figure 1. The block diagram of the PLC and HMI-based two-way belt conveyor control system consists of a Human Machine Interface (HMI) and a Programmable Logic Controller (PLC) which requires an input voltage of 24 Volts DC, a Toshiba VF-S15 VSD which requires an input voltage of 380 Volts AC and also as a source of voltage for the 0.37 kW motor drive unit of the conveyor belt. The HMI used is the Simatic KTP 700 Comfort type, for PLCs using the Siemens S7 1200 1215 DC / DC / DC PLC. For the connection between HMI and PLC using a LAN cable.

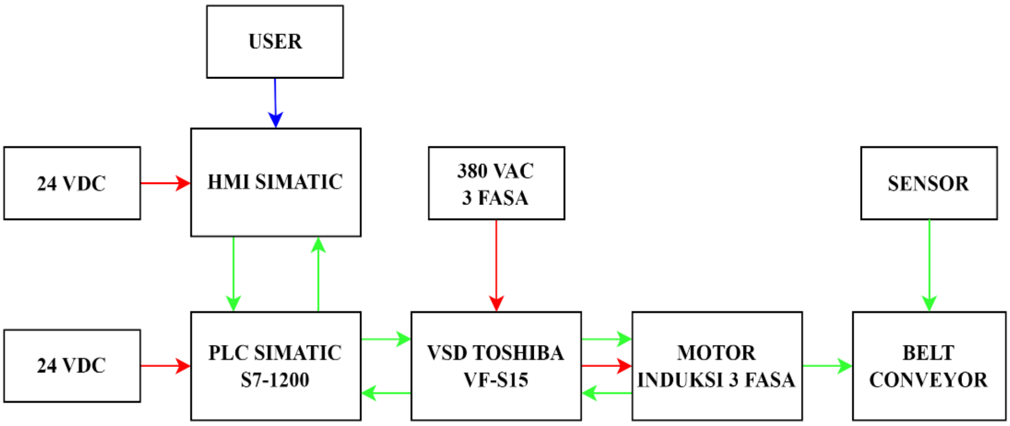

Figure 1. Block diagram of two-way belt conveyor control system based on PLC and HMI

In this system there is a system flowchart which can be seen in Figure 2. In this system, the conveyor belt can be controlled in the direction of rotation and speed through the HMI input interface, for monitoring the conveyor belt, the conveyor belt speed will be displayed in the form of a real time display on the HMI interface display. Figure 2 shows the process of controlling the conveyor belt speed based on the selected rotation direction, clockwise (forward) and counterclockwise (reverse). When the Speed 1 button is pressed, the conveyor belt will turn on at speed 1, when the Speed 2 button is pressed, the conveyor belt will turn on at speed 2, when the Speed 3 button is pressed, the conveyor belt will turn on at speed 3 according to the selected direction of rotation. The speed of the conveyor belt will be displayed RPM on the HMI. When the STOP button is pressed, the conveyor belt will stop.

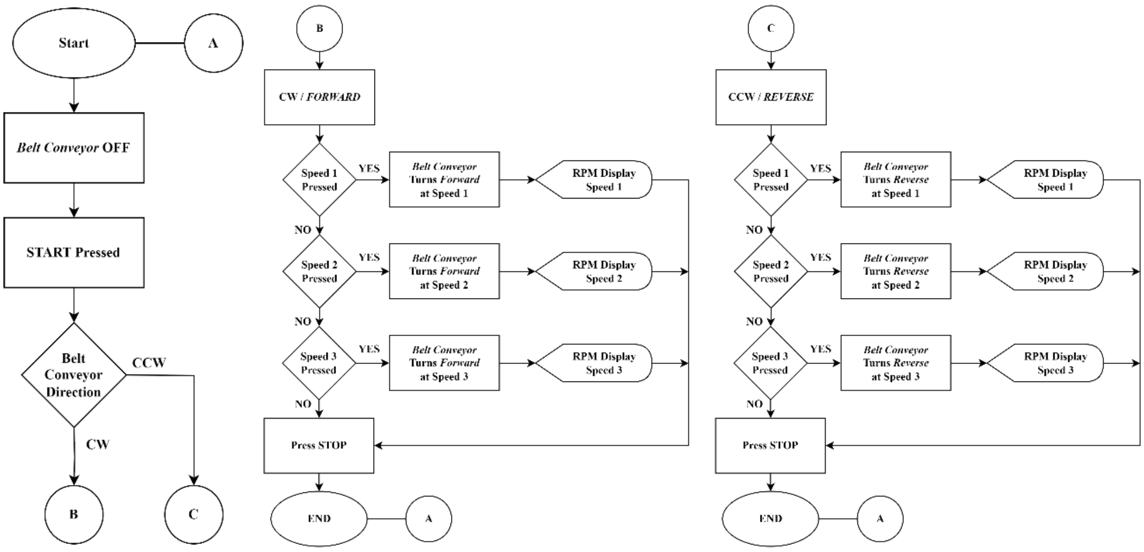

Figure 2. Flowchart conveyor belt control system

3. RESULTS AND DISCUSSION

The conveyor belt control system made in this study was tested and verified through a trainer in the laboratory. To see the validity of the motor speed data displayed on the HMI screen, the motor speed data in rpm units on the HMI screen is compared with the speed data measured by measuring instruments. Figure 3 shows the installation of the two-way conveyor belt control system tool test made in this study.

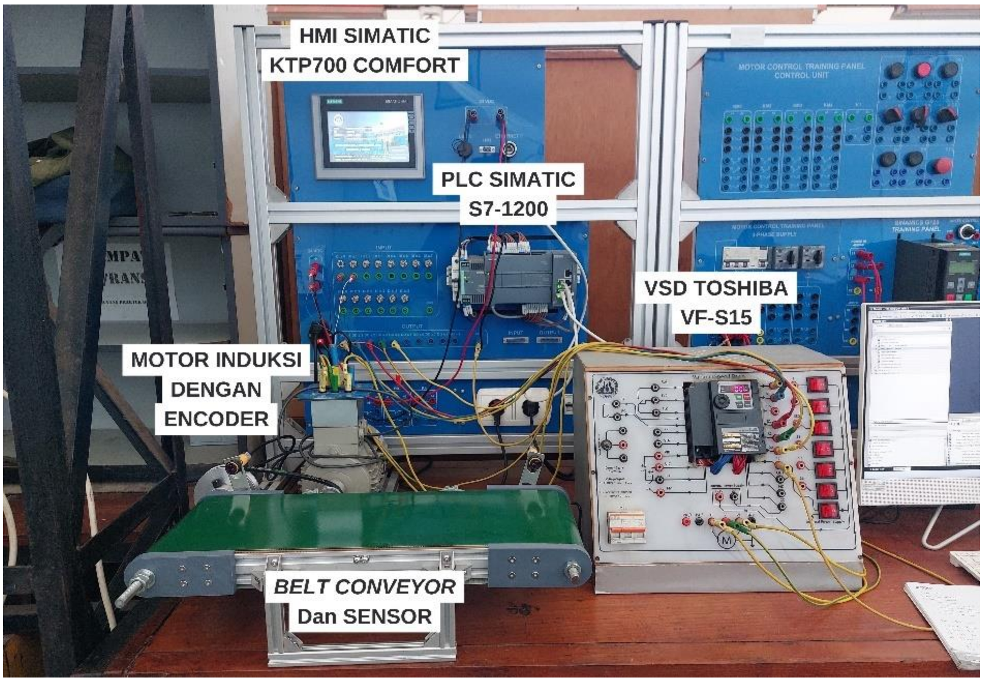

Figure 3. Installation of the two-way conveyor belt control system

This control is carried out by providing three speed variations through frequency settings on the VSD, namely 10 Hz, 20 Hz and 30 Hz and variations in the direction of rotation of the conveyor belt drive motor, namely clockwise (CW) and counterclockwise (CCW). The first test was tested with a speed input of 1 with a frequency of 10 Hz and forward direction shown in Figure 4(a) and 4(b).

(a) (b)

Figure 4. Speed 1 10 Hz Forward Belt Conveyor (a) HMI (b) Tachometer

In the first test, it can be seen that the speed data displayed on the hmi is 146 rpm while the speed data displayed by the tachometer is 145.93 rpm. This result has a difference of 0.07 rpm or 0.04%. the second test can be seen in Figure 5.

(a) (b)

Figure 5. Speed 1 10 Hz Reverse Belt Conveyor (a) HMI (b) Tachometer

In the second test, it can be seen that the speed data displayed on the hmi is 146 rpm while the speed data displayed by the tachometer is 146.19 rpm. This result has a difference of 0.19 rpm or 0.13%. the third test can be seen in Figure 6.

(a) (b)

Figure 6. Speed 2 20 Hz Forward Belt Conveyor (a) HMI (b) Tachometer

In the third test, it can be seen that the speed data displayed on the hmi is 296 rpm while the speed data displayed by the tachometer is 296.41 rpm. This result has a difference of 0.41 rpm or 0.13%. the fourth test can be seen in Figure 7.

(a) (b)

Figure 7. Speed 2 20 Hz Reverse Belt Conveyor (a) HMI (b) Tachometer

In the fourth test, it can be seen that the speed data displayed on the hmi is 296 rpm while the speed data displayed by the tachometer is 296.32 rpm. This result has a difference of 0.32 rpm or 0.10%. the fifth test can be seen in Figure 8.

(a) (b)

Figure 8. Speed 3 30 Hz Forward Belt Conveyor (a) HMI (b) Tachometer

In the fifth test, it can be seen that the speed data displayed on the hmi is 445 rpm while the speed data displayed by the tachometer is 444.99 rpm. This result has a difference of 0.01 rpm or 0.002%. the sixth test can be seen in Figure 9.

(a) (b)

Figure 9. Speed 3 30 Hz Reverse Belt Conveyor (a) HMI (b) Tachometer

In the sixth test, it can be seen that the speed data displayed on the hmi is 445 rpm while the speed data displayed by the tachometer is 444.99 rpm. This result has a difference of 0.01 rpm or 0.002%. Based on test 1, test 2 and test 3, the speed monitoring data displayed on the HMI compared to the speed measured on the tachometer shows an error as shown in Table 1 below.

Table 1. Test Result

Speed Variation (Frequency)	Forward			Reverse		
	HMI (Rpm)	Tacho (Rpm)	Error (%)	HMI (Rpm)	Tacho (Rpm)	Error (%)
(10 Hz)	146	145.93	0.04	146	149.19	0.13
(20 Hz)	296	296.41	0.13	296	296.32	0.10
(30 Hz)	445	444.99	0.002	445	444.99	0.0002

These results show that the conveyor belt speed displayed on the HMI is close to the same as the conveyor belt speed data obtained from measurements using a tachometer. This indicates that the hardware and software designed for the two-way conveyor belt control system has worked well, so that it can control the direction and calculate the speed of the conveyor belt accurately. The difference in speed data obtained from measurements with the speed data contained on the HMI screen is still within the error tolerance that may be caused by external influences at the time of testing

4. CONCLUSION

The design of a two-way belt conveyor control system based on PLC and HMI is designed using a Siemens S7 1200 1215 DC/DC/DC PLC with a KTP700 comfort HMI interface to control the direction of rotation and speed of the belt conveyor using a Toshiba VF-S15 VSD. This control and monitoring system is implemented on a 0.37 kW three-phase induction motor as a belt conveyor drive. The controlled parameters are the direction and speed of the belt conveyor. The test results show that the two-way belt conveyor control system based on PLC and HMI created in this study has successfully controlled the direction of rotation and speed of the belt conveyor where the belt conveyor speed displayed on the HMI is close to the same as the belt conveyor speed data obtained from measurements using a tachometer. This indicates that the hardware and software designed for the two-way belt conveyor control system have worked well, so that they can control the direction and calculate the speed of the belt conveyor accurately. The difference in speed data obtained from measurements with the speed data on the HMI screen is still within the tolerance of errors that may be caused by external influences during testing.

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