International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-7 Issue-5S2, January 2019

Conveyors Monitoring, Control and Protection Using Programmable Logic Controller

R. Vanitha

Abstract: ***Conveyors have been the most important transport media in transferring the coal from coalmines / storage areas to Boilers in thermal power stations. The monitoring and protection of these conveyors are very important as the occurrence of faults may affect the whole power generation. The protection of the conveyors is carried out using Relay Logic methods, that have several disadvantages and hence there is a need for a new method. This paper focuses on the monitoring, controlling and protecting the conveyors from varies types of faults occurring in conveyors using programmable logic controller (PLC). Four important types of faults that occurs frequently in conveyors, such as belt sway fault, pull chord fault, zero speed fault and fire protection are considered in this work. These faults are sensed and rectified by programmable logic controller which has a high degree of safety, accuracy and easy to maintain and monitor.***

Keywords: ***Programmable Logic Controller, Conveyors, Interlock Mode and De-Interlock Mode.***

I. INTRODUCTION

Generally, induction motor plays a vital role in the power generating sequence in thermal power plant. High power induction motors run the conveyors used for transferring coal to the boiler from mine. Induction motors are also used to run fans, blowers and centrifugal pumps. The Conventional relay logic method used for the safety of induction motors have several disadvantages and could be replaced by programmable logic controller which has a high degree of safety, accuracy and easy to maintain and monitor. Monitoring and control of Induction motors during normal and trip conditions was done using PLC and the results were proven to be of high efficiency as compared with V/F control system [1].PLC had been designed such that any changes can be done in programming without affecting the electronic circuits [2]. PLC and SCADA was used in controlling and monitoring of servomotors having a two degree of freedom motion capacity. The interconnection between servo motor and PLC was done using Device-Net web protocol [3].

The automation of packing and material handling is achieved through Programmable logic controller [4]. PLC and SCADA were used to monitor belt conveyors in coal mines and detect tear ups of belts, variations in oil levels and occurrence of fire in the conveyors [5]. Different faults like overloading, moisture content in belt conveyor and wear out of belts are handled using PLC and SCADA [6].The Siemens s7-300 series PLC was programmed using sematic manager to control the belt conveyors in steel plant [7]. PLC and SCADA was used in continue line furnace monitoring and control of heating treatment that hardens and strengths the materials [8]. This paper focuses on the use of Programmable Logic Controller (PLC) for the monitoring, controlling and protecting the conveyors from varies types of faults occurring in conveyors.

The paper is organized as introduction is dealt in unit 1. Unit 2 deals with Lignite Handling System followed by modes of operation of conveyors in unit 3. Conveyor control using PLC is done in unit 4. Unit 5 Concludes the results of the work.

II. LIGNITE HANDLING SYSTEM

The Lignite handling system consists of various sections through which lignite is carried with the help of conveyors. The lignite handling system has a main stockyard with two numbers of mobile reclaimers and one stacker machine. Lignite is received from mines through stackers and dumped in RCC Bunker. Dust suppression system sprinkles water over the lignite to suppress the coal dust generated during transfer of coal at feed/discharge points of conveyors. The block diagram of lignite handling system is shown in the Fig. 1.

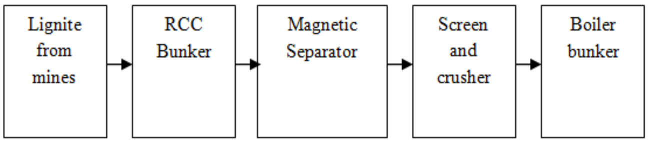

Fig.1: Block diagram of the Lignite Handling System

The ferrous materials in Lignite are removed using magnetic separators and screened to crusher. The boiler bunkers are filled with powdered Lignite using reclaimers and a series of LT and HT motor driven conveyors. All the conveyors from reclaimers up to bunker including HT motor driven conveyors are in auto mode where as bunker level conveyors are in manual mode only.

Several types of conveyors like roller conveyors, belt conveyors, overhead conveyors, reversible shuttle conveyor, unidirectional shuttle conveyor are used in various sections of thermal power station. The conveyors used can be grouped into two categories based on the operating voltages of the drives of the conveyors as high tension conveyors (6.6 kilovolts) and low tension conveyors (0.4 kilovolts).

III. MODES OF OPERATION OF THE CONVEYORS

There are two modes of operation of conveyor and they are Interlock mode and De-interlock mode. In interlock mode of operation, conveyors can be started from control room.

Manuscript received January 25, 2019
R. Vanitha, Professor, Dept of EEE, Sathyabama Institute of Science and Technology, Chennai, Tamilnadu, India.

In this mode, one selector switch at conveyor side is kept in interlock position and during operation the downstream conveyors are kept in operation compulsorily. If any one of the downstream conveyors gets tripped, the particular conveyor to be tripped can be tripped as per logic. In de-interlock mode of operation, the particular conveyor can be started from site. There is no need that other downstream conveyors should be kept in service. This mode of operation is used for checking the conveyor during maintenance purpose or during cleaning purpose.

Before starting the conveyors, several contacts or relay logics have to be checked. The following are the various protection devices, which are being employed in the protection of conveyors, which is shown in the table 1. For de-interlock mode selection, one control contactor, K10 gets energized, whereas for interlock mode selection, another control contactor K9 will get energized. There is one release contactor, K1 that must be in energized condition to start a given conveyor. This release contactor will be in energized condition provided that the following safety aspects are satisfied.

1. No pull rope/pull chord applied for a given conveyor (K8).
2. Belt sway switch not acted (K6).
3. No overload acted for this conveyor electric drive (K2).
4. Acceleration fault not applied (K5).

In general, under normal healthy conditions, all contactors including K1 are normally in energized condition. Now conveyor is ready for operation. Either interlock mode or de-interlock mode conveyor can be started now. When start command is given control contactor K11 will pick up. In interlock mode of operation, its downstream conveyor should be in operation. If K7 is in picked up condition, downstream conveyors are definitely in operation.

In the event of failure of any one or all the downstream conveyors, the control contactor K7 of immediate downstream conveyor will drop out and thus leading to de-energizing of the contactor K11 for this particular conveyor. Once, a given conveyor is given start command, its electric motor starts driving the conveyor and the conveyor running speed should attain certain speed value (in rpm) in a specified time. Up to that time duration, one normally closed (NC) contact from ON delay timer will be in K1 release contactor circuit.

Table 3.1: Protection devices for conveyors

SYMBOLS	CONTACTOR NAME
K1	Conveyor healthy
K2	Over load
K3	Annunciation
K4	Low speed
K5	Acceleration time
K6	Belt Sway
K7	Interlock to next conveyor
K8	Pull chord
K9	Interlock mode
K10	De-interlock mode
K11	ON command
K11A	Multiplier
K13	Forward direction
K14	Reverse direction
K18	Conveyor running condition

After the time delay, whether this conveyor attains its speed or not, the normally closed (NC) contact of timer will change over to normally open (NO) contact (i.e. close status to open status).

Generally, a group of elements containing effectors (proximity switch) and a speed monitor unit will pick up one K4 control contactor. On pick up, one normally closed (NC) contact of K4 will change over to normally closed (NC) status and this particular contact is wired parallel to above said normally closed (NC) contact timer T. In this way, running conveyor speed is sensed on healthy condition. K1 release contactor is kept in pick up condition. When speed monitor drop out K4 contactor, K1 release contactor de-energizes. Once K1 gets drop out, ON contactor K11 will drop out and ultimately tripping the power supply to electric motor of this particular conveyor. This is called tripping of conveyor. For normal stop operation, either from control room or from site, by giving stop command, ON contactor K11 is purposely made de-energized and thus tripping the conveyor

IV. CONVEYOR CONTROL USING PLC

Programmable Logic Controller is incorporated to monitor and detect the fault that occurs in pull chord and belt sway. The conveyor representation is shown in the Fig 2.

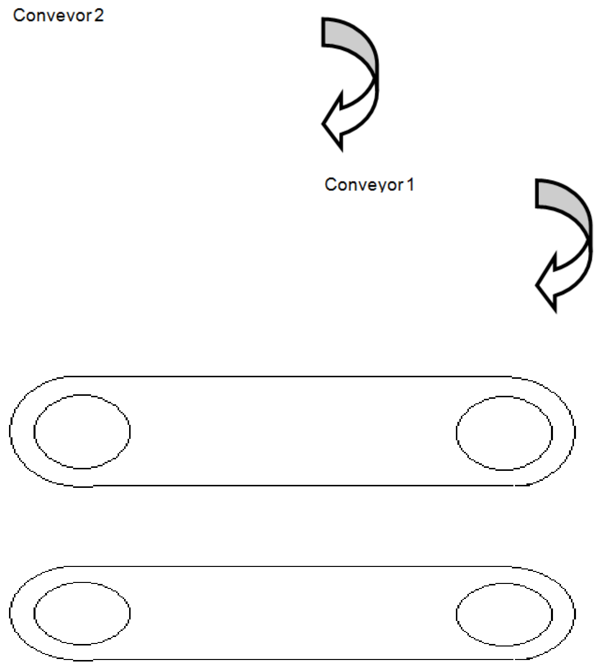

Fig.2: Conveyor representation

The conveyor 2 will run only if the conveyor 1 is in running condition. If conveyor 1 stops due to some fault, then conveyor 2 will also stop irrespective of its healthy running condition. But if there is some fault in conveyor 2, then conveyor 2 will only stop and conveyor 1's operation will not be affected. This is Upstream interlock. Automatic mode and manual mode both are implemented in this work.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

1.1 Automatic mode

In automatic mode, the entire operation takes place automatically once the "auto" switch is pressed. Once the "auto" switch is pressed, then in display automatic mode light gets enabled. Then if "start" switch is pressed, the hooter start working. Hooter generates a kind of alarm sound to inform that the conveyor is about to function. This alarm helps the operator in the field to know that the conveyor is about to function in a period of time (5 to 10 seconds). Once the hooter gets turned OFF after the specified time, the conveyor 1 starts running. A ON-time delay is set for functioning of conveyor 2. So after few seconds from operation of conveyor 1, conveyor 2 starts running.

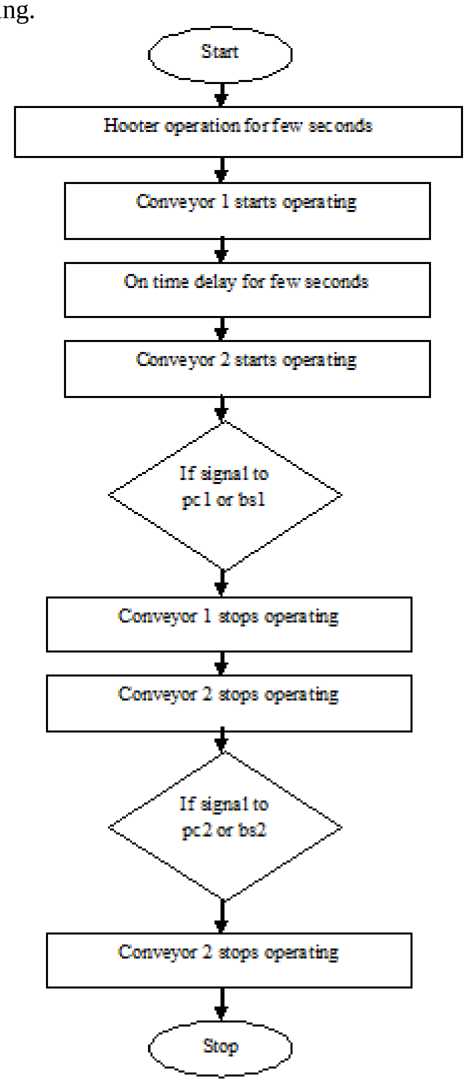

Fig 3: Flow chart of automatic mode

Now if the pull chord switch 1 or belt sway switch 1gets some signal, then conveyor 1 stops operating. As interlock is achieved, the conveyor 2 will also stop operating.

If the pull chord switch 2 or belt sway switch 2 gets signal, then conveyor 2 will stop. But conveyor 1 will run smoothly. If "stop" switch is pressed, then the entire operation stops. Once the fault is corrected or bypassed then the conveyor starts operating normally. After the correction of fault related to pull chord 1 and belt sway switch 1, the conveyor 1 starts operating and after few seconds (ON-time delay), the conveyor 2 starts operating. If the fault

happens in switches of second conveyor, then after the correction, the conveyor 2 starts operating. But during this time, conveyor 1 will be functioning normally.

1.2 Manual mode

In manual mode of operation, the conveyors have to be switched on individually. In the display, if the automatic mode light is OFF then it simply means that the operation is in manual mode.

As the conveyors are turned ON manually, the hooter is not used in this made. Once the "start" switch is pressed, the conveyor 1 starts operating. After ON-time delay of few seconds, conveyor 2 starts operating. If the pull chord switch 1 or belt sway switch 1gets some signal, then conveyor 1 stop operating. As interlock is achieved, the conveyor 2 will also stop operating.

If the pull chord switch 2 or belt sway switch 2 gets signal, then conveyor 2 will stop. But conveyor 1 will run smoothly.

If "stop" switch is pressed, then the entire operation stops.Once the fault is corrected or bypassed then the conveyor starts operating normally.

After the correction of fault related to pull chord 1 and belt sway switch 1, the conveyor 1 starts operating and after few seconds (ON-time delay), the conveyor 2 starts operating. If the fault happens in switches of second conveyor, then after the correction, the conveyor 2 starts operating. But during this time, conveyor 1 will be functioning normally.

A part of ladder diagram used in this work is depicted in Fig and the representation of various instructions that are used in ladder logic diagram shown in Fig 4 are

I:0.00- Remote

I:1.00 – Start Push Button

I:1.01 – Stop input

I:2.07 – System Start

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

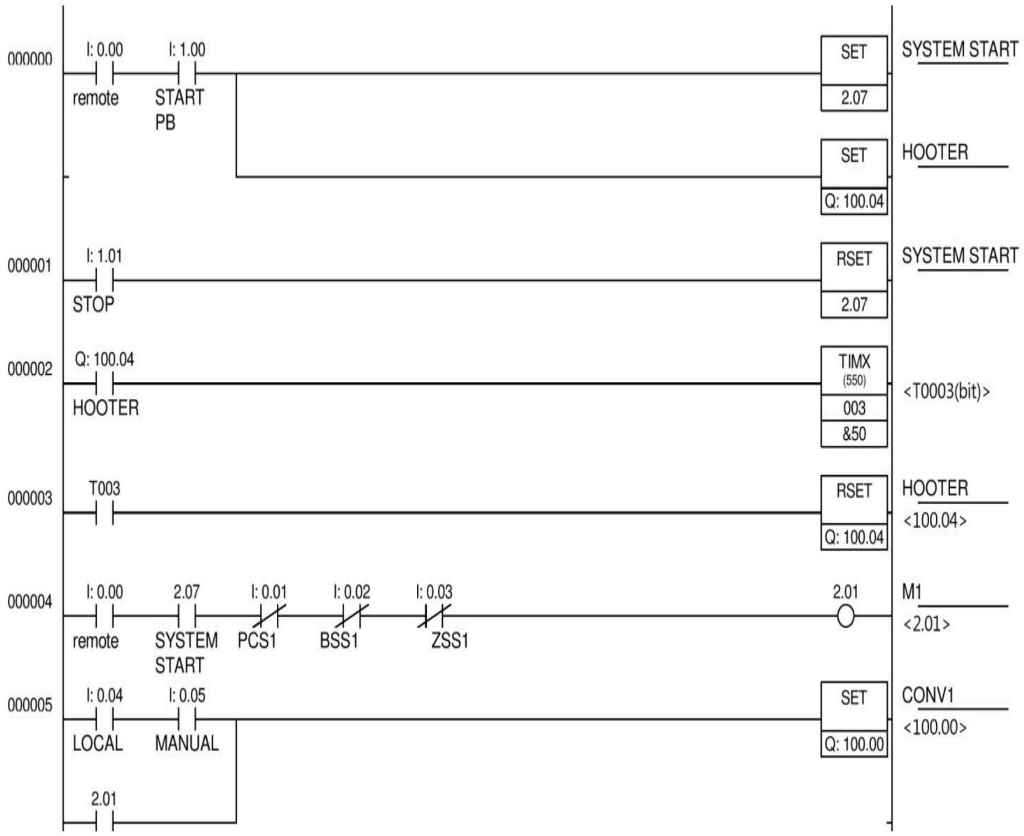

Fig. 6: Ladder Logic Diagram

I:0.01 – Pull chord switch for conveyor 1
I:0.02 – Belt sway switch for conveyor 1
I:0.03 – Zero speed switch for conveyor 1
I:0.04 – Local
I:0.05 – Mannual
I:0.06 – Pull chord switch for conveyor 2
I:0.07 – Belt sway switch for conveyor 2
I:0.08 – Zero speed switch for conveyor 2
I:0.09 – Pull chord switch for conveyor 3
I:0.10 – Belt sway switch for conveyor 3
I:0.11 – Zero speed switch for conveyor 3
Q:100.04 – Hooter
Q:100.00 – Conveyor 1 status output
Q:100.01 – Conveyor 2 status output
Q:100.02 – Conveyor 3 status output
Q:100.03 – DE,MS status output
M1, M3, M5 – Memory instructions
TIMX(550)– 100ms Timer

Earlier relay logic was used for the identification faults in conveyors.

There were many disadvantages in using them and hence it was replaced by PLC technology.

Their advantages are less power consumption, less space, user friendly, less trouble shooting, Supports well for further expansion, can be easily reprogrammable, less labour required.

Apart from all this the main benefit of using PLC is that it is 90% reliable and the whole efficiency of power plant can be improved.The comparison between relay logic and PLC is shown in the table 2.

Table 2: Comparison between relay logic and PLC

EXISTING (RELAY LOGIC)	PROPOSED (PROGRAMMABLE LOGIC CONTROLLER)
1. Trouble shooting time is high.	1. Trouble shooting time is instant.
2. Wiring is complicated.	2. Wiring is easy.
3. Power consumption is more (30A).	3. Power consumption is very low (5A).
4. The voltage range is between 110V and 230V.	4. The voltage range is between 12V and 24V.
5. Space required is more.	5. Space required is less.
6. In case of emergency, bypass Cannot be done.	6. In case of emergency, bypass can be done.
7. Installation cost is more.	7. Installation cost is less.
8. Any logic has to be implemented mechanically.	8. Logic, timers and counters can be implemented in ladder.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

V. CONCLUSION

PLCs are flexible in operation as the program can be changed within few seconds and leads to faster operation of conveyor control system due to its quick response. Thus use of PLC, increases the speed of lignite transmission process from boiler bunkers to reclaimers. Consequently, the production process speeds up and most importantly the consistency is achieved. By implementing PLC in conveyor control, monitoring and protection system, any faulty part can be bypassed for a required period, thereby reducing the break down time. This in turn leads to improvement in plant load factor and helps for improvement in generation of thermal power station.

REFERENCES

1. Maria G. Ioannides "Design and Implementation of PLC-Based Monitoring Control System for Induction Motor" IEEE Transactions on Energy Conversion, Vol. 19, No. 3, pp.469 -476, Sep 2004.
2. Ahmad Fouad Alwan, "Project Design and Management of Programmable logic Controllers for Electrical Technology", International Journal of Emerging Sciences, Vol. 2, No. 3, pp. 322-333, September 2012
3. Mehmet Fatih Isik, Mustaf Resit Haboglu, Hilmi Yanmaz, "Monitoring and control of PLC based motion control systems via device-net ", IEEE procedings of 16th International conference on Power Electronics and Motion Control Conference and Exposition (PEMC), 2014.
4. Joanna Marie M. Baroro, Melchizedek Alipio, Michael LawrenceT. Huang, Teodoro M. Ricamara, AngeloA. Beltran Jr., "Automation of Packaging and Material Handling Using PLC", International Journal of Scientific Engineering and Technology, Vol. 3, No. 6, pp: 767 – 770, June 2014.
5. M.Kanmani, J.Nivedha, G.Sundar, "Belt Conveyor Monitoring and Fault Detecting Using PLC and SCADA", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Special Issue 4, pp.243-248, May 2014,
6. R.Keerthika, M.Jagadeeswari," Coal Conveyor Belt Fault Detection and Control in Thermal power plant using PLC and SCADA", International Journal of Advanced Research in Computer Engineering & Technology, Vol. 4, No.4, pp.1649 -1652, April 2015.
7. Rajnikanth, "Control of Conveyor using PLC", International Journal of Innovative Research in Technology", Vol.3, No.1, pp.356 – 359, June 2016.
8. Amandeep Kaur , Dipti Bansal ,"Monitoring and controlling of continue furnace line using PLC and SCADA", in IEEE proc of 5th International Conference on Wireless Networks and Embedded Systems (WECON), 2016
9. Frank.D.Petruzella, Programmable Logic Controllers, reprinted by 2005, ISBN- 10: 0073510882 | ISBN-13: 9780073510880
10. Thomas.A.Hughes, Book on Programmable Logic Controllers,4th edition, Product ISBN/ID:978-1-55617-899-3

AUTHOR PROFILE

Dr.R. Vanitha received her B.E degree in Electrical and Electronics Engineering and subsequently obtained her M.Edegree in Power Systems from Thiagarajar College of Engineering, Madurai Kamaraj University, Tamilnadu. She has obtained her Doctorate in Electrical Engineering in the field of power systems from Sathyabama University, Tamilnadu. She is presently working as a Faculty in the Department of Electrical and Electronics Engineering, Sathyabama Institute of Science and Technology, Tamilnadu and has nearly fifteen years of teaching experience. Her area of interest includes applications of power electronics in power systems, power system optimization and Control. She also has experience in software development for cellular technology.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication