Electrically Energised Magnetic Separator System Control with 8051 MCs and Logic Controllers

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Abstract-Magnetic separators are installed to catch and separate ferrous materials that might come along with lignite.Electrically operated Magnetic Separators (shortly MS systems) are the main bones of Lignite Handling System (LHS) systems incorporated in Receiving and Transfer of lignite. The major aims of such systems are "to Remove Ferrous materials (minimum size to 50 kg) of any shape".

Power generation mainly depends on boiler. Lignite needs for boiler will be supplied from Lignite bunkers. One of the activities of LHS system is to transfer lignite from TPS-II stockyard to Boiler bunkers. From bunkers the lignite has to take another travel to Pulverizing mill system, then it reaches boiler furnace with powdered and pre-heated state.

We aim to do study of Magnetic Separator system and then we are going to prepare alternate control arrangements by introducing two latest embedded system technologies. They are

1. With the supports of Micro- controller based (8051 Micro Controllers) system
2. With the stand-alone Brick type PLC introduced system configuration

Trouble shooting for misbehavior is most common happening and it would consume more time to resolve. Hence up-gradation is highly required to modernize PC friendly magnetic separator control facility with the help of PLC.

I. LIGNITE HANDLING SYSTEM (L.H.S)

Receiving system:- Receiving System consist of Junction Tower-II, Con-1(CC1 & CC2 Conveyors), con-2, & con-3. apart from conveyors 1,2,& 3 there are 2 parallel conveyors namely 7A & 7B starting at Transit Tower-I (TT-I) passes through Junction Towers-II (JT-II) and end at the top of Crusher House. Both 7A & 7B conveyors are below Con-3.

Normally the Lignite from Mine-II is received through CC-I & CC-2 at Con-3 and sent to storage yard. In this case, the Con-3 receives the Lignite and feed the Lignite to Con-2, in turn taken to storage yard through a Stacker. The stacker is to be placed at the suitable place for storing the lignite. Con-2 runs between the stock piles No.1 and No.2.

The stacker moves on the rails and it can feed both stock pile No.1 and No.2. Con-3 is short length shuttle conveyor. Storage yard consists of stock pile No.1(4Aside) capacity being 80,000 tones on the southern side of conveyor-2 and stock pile No.2 (4B side) capacity being 70,000 tones on the northern side of the conveyor-2. Stock pile –1 includes the cover shed storage of 10,000 tones. Cover shed storage hall length is 85 meters.

Height of stocking is 10.5 meters. Length of stock pile No.1 is 600 meters, stock pile No.2 is 515 meters length. In the closed storage area stacker will have slewing angle of 90 degree only. Minimum lignite bed thickness of 400mm is provided for preventing the pebbles coming into contact with the bucket. Sump pumps are provided on both sides of stockpiles to pump out water from stock piles. Total belt length of conveyor-2 is 1450 mts. A conveyor 3.2 is provided for receiving and transferring to stock yard through con-2 and stacker.

Transfer system:-(a) DIRECT LOAD: If lignite is required to be diverted to boiler bunker directly, the CC-2 can feed to Con-7B by positioning the con-3 at its east extreme called "Direct Load". In this condition con-3 need not run. (b) BIFURCATION:A new modification has been introduced in receiving system is called Bifurcation. In this method the lignite receiving from Mine-II is being transferred to boiler bunker (60%) and storage yard (40%) In this condition Con-3 is positioned at bifurcation position. Travel limits are modified for this purpose. Thus con-3 can be positioned and run as per our requirements.

Con-4A and 4B located along stock pile No.1 and 2 respectively. Both conveyors 4A and 4B are equipped with reclaimers, one on each. Reclaimers are mounted over rails of 6.0 meters gauge, Reclaimers can be slewed to 1800.

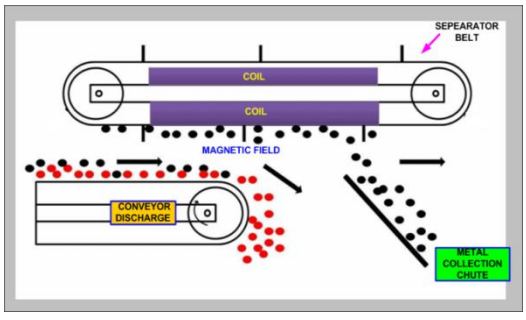
Conveyors 4A and 4B drive heads are located in transfer tower1 and 2 respectively (TT1 and TT-2). In TT-1 and TT-2 conveyors 6A and 6B are positioned just below the drive heads of conveyors 4A and 4B respectively and above conveyors 7A and 7B. Lignite can be fed from Con-4A to either Con-7A or con-7B by altering the position of the Con-6A if Con-6A is positioned at extreme right i.e. yard side

lignite will be fed to Con-7B and Con-6A will not run. If Con-6A is positioned at middle, lignite will be fed to Con-7A.

In this position Con-6A will be in running condition. Similar arrangement exists from Con-4B with Con-6B. During rainy season Con-6A & 6B can be positioned out extreme on road side and water and slush lignite can be diverted out of the system. This position is called throw off position. A similar arrangement exits in conveyor-4B also. Reclaimer in conveyor-4A has a rail length of 600 meters and effective travel is 580 meters. Reclaimer in conveyor 4B has a rail length of 515 meters and effective travel is 490 meters. Conveyor 4A and 4B's length is1300 meters. (Each belt length) Belt tension of Conveyors 4A, 4B and con-2 is adjusted by electrically operated winch.

Magnetic separators are installed above the drive heads of conveyor CC-2, 4A, 4B, named as MS-1A, 5A, 5B, respectively. Another 2 no. of Magnetic Separators named MS 7A & 7B are provided across con 7A & 7B respectively. Metal detectors are also provided across con-7A and 7B to detect ferrous materials and in turn to avoid the damages in crusher.

There are two reclaimers called M/C-RA and M/C-RB. In each machine contains platform, mast, bucket wheel boom, counter weight boom and bucket wheel conveyor with transfer point. The slew movements of it are introduced by two slew assemblies located on the superstructure platform. The rotating connection between the superstructure and undercarriage circular frame is formed by a roller race which safeguard the machine against lifting and also absorb alternating axial and radial loading with high tilting moment.



The bucket wheels with its conveyor area are mounted in the bucket wheel boom. It can be raised or lowered by a hydraulic cylinder. The bucket wheel body is of welded design with stiffener ribs welded in place and with connecting lugs for fixing the buckets. There are 10 fitted buckets. The buckets are formed by welding side plates, transition plates and welded together to form a unit. The bottom of the bucket has a mat of chains or rubber for better bucket emptying. All the buckets are connected to a rim and which in turn connected to one end of hollow shaft assembly other end is connected to bucket wheel gear box.

The main drive for bucket wheel is coupled by means of a fluid coupling. This coupling serves as starting and safety coupling to protect the drive and reclaimer from detrimental overloading.

Crusher house:-In this house, lignite is sized and supplied to the units. Facilities are also available to have an interchange between A and B series conveyors. It is located in between Transfer Tower-II and main power house or junction tower-I. The parallel conveyors 7A and 7B having upward inclination reach the top floor of crusher house. The conveyors 7A and 7B feed lignite to 9A and conveyor 9B respectively.

Conveyors 9A and 9B are unidirectional stationary conveyors and are running to a direction perpendicular to conveyors 7A and 7B. Hence a 900 turn in flow path is made. The width of these conveyors has been increased to avoid any spillage while transfer. Conveyor 9A feeds lignite to Eccentric disc screen (10A) where as 9B feed to another screen (10B). Due to lot of problem in screen and crusher, and also to avoid single stream in crusher a new modification has been introduced called "SCREEN AND CRUSHER BY-PASS". For this purpose travel provision has been made in con-9A. In this condition con-9A can be traveled and positioned in con-12A bypassing the screen and crusher. i.e. Con-9A load is directly goes to con-12A through vertical chute.

Con-12A and con-12B are shuttle conveyors, can be positioned either to con-14A or to con-14B. Belt tension of con-14A/14B and con-7A/7B is automatically adjusted by the counterweight provided in these conveyors.

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II. MAGNETIC SEPARATOR SYSTEM

Introduction:- In the Lignite transfer system, Before crusher house the lignite is free from ferrous materials. So that the damage caused by the material on carrying conveyor system, crushing mechanism may be avoided. The aim of Lignite Handling system is to receive Lignite and store it on

stockpiles and to transfer lignite from stockpile to Boiler bunkers for power production.

From bunkers the Lignite is being fed into Boiler furnace via Pulverizing Mill system. Hence if there is any escape of ferrous materials after Crusher- It will make significant damage to Mill system also.

Hence Magnetic separators Plays vital role in the removal of Ferrous materials that would cause damage in the above discussed Conveyors, Crusher and Mill systems.

Functions of magnetic separator system

Magnetic Separators Builds up Strong magnetic field – There by attracts Ferrous materials effectively. The same material will be separated by the conveyor system called Separator and collected at a chute. Our MS(Magnetic Separator) system is designed to lift a material of 50 kg. The theoretical operation of MS system, actual system with chute arrangements and materials collected in chute also shown. The chute will be cleared every week.

The above diagram shows theoretical operation of magnetic separator system in detail. Here the MS system is suspended over the carrying conveyor system. There is a coil energized electrically to produce magnetic field. As well in MS assembly there is a separator drive which drives a separator belt, which is going to separate the ferrous materials attracted by the coil. The attracted ferrous materials were being separated and collected in a chute. The below image shows further details.

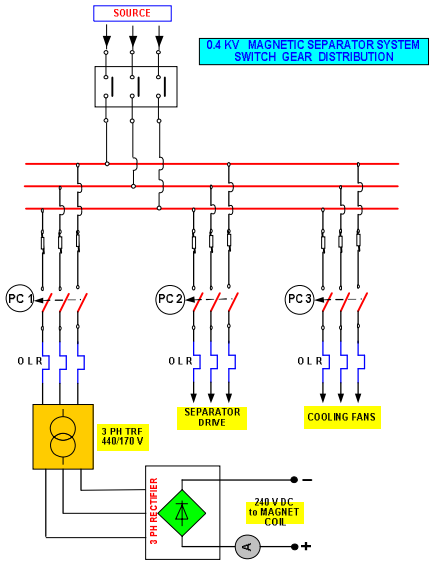
Fig.Conveyor system

fig. MAGNETIC SEPARATOR – MS 5B

Here in LHS all the conveyor systems are controlled from a centralized control room. The Magnetic separator systems are also started from control room (Remote starting). The running of Magnetic separator system is highly required for the starting of next lignite carrying conveyor system. We do our automation project in this area to control MS functions.

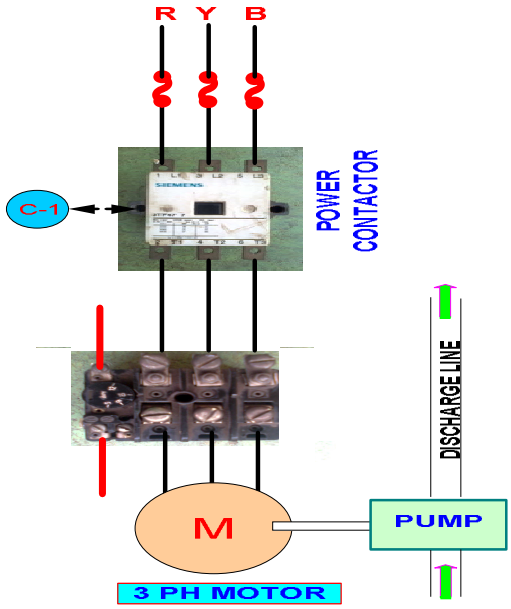
Magnetic Separator Power System & Control

Power distribution scheme:



PC – 1 Power contactor for Magnetic Circuit
PC – 2 Power contactor for Separator (3 phase) drive
PC – 3 Power contactor for cooling fans (magnet coil)

Power Circuit Concept – Industrial Control:

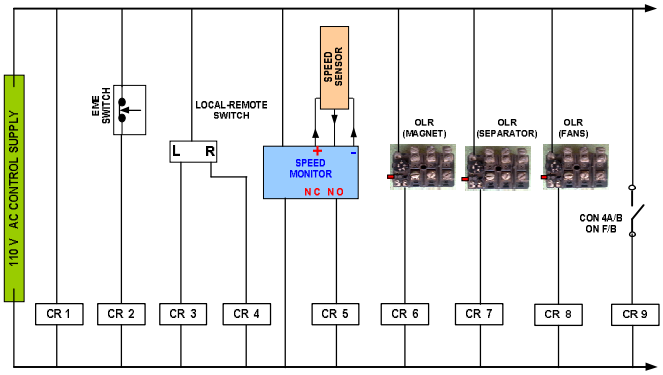


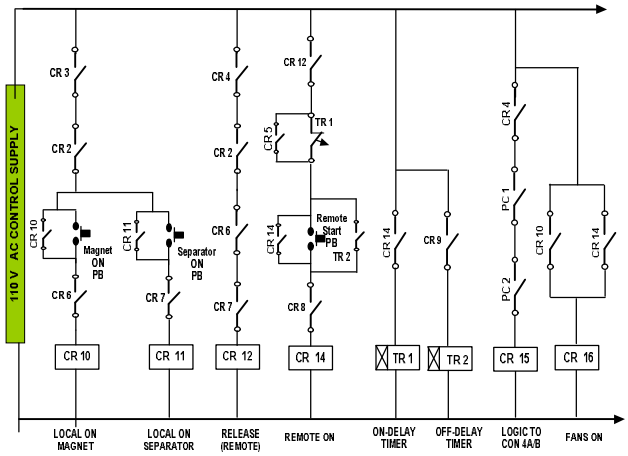
The above figure shows the industrial drive control arrangement. The three phase motor which is in the pumping application being powered-up through 3 phase supply, fuses, Power contactor and Overload relay protection.

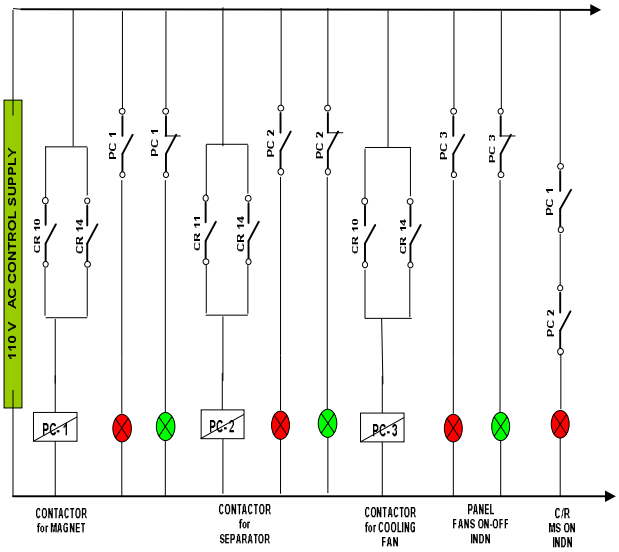
The power contactor in industrial application would energize on 110v ac supply. This is the control supply for the switch gear. Overload relay connected here will be set at the current called over-current or overload.

Control circuit of MS System using Traditional relays/ Timers

The control circuit for MS system with control relays is as follows…







Ms Operation

The above circuit shows the operation of magnetic separator system using control relays (named CR 1,2,3….) and timers. The circuit that uses the above components are generally named as Relay logic control or Hard-wired logic. Any application can be automated via this logic. But for any automation it requires large number of relays and physical wiring, timers if required.

This is logic available for magnetic separator system as per the design. The facilities extended by the circuit are

- Local starting / stopping when required by maintenance people.
- Remote starting by the Control room executives for ferrous material separation during lignite receiving/transfer.

The local MS panel available near to magnetic separator system has

- 3 ph rectifier system for 240 v dc
- Power contactors for Rectifier & separator
- Power contactor for cooling fan system
- Local /Remote selector switch

1. Local magnet start PB
2. Local magnet stop PB
3. Emergency Stop
4. Local separator start PB
5. Speed sensor / speed monitor
6. Over load protective relays for Magnet, separator and cooling fans

All the above user inputs, protective relay feedback were used in the relay logic circuit to avail our application requirement. The panel receives 3 phase supply form LHS common switchgear system allotted for Magnetic separator system.

The control room start command will be recognized only when the Local /Remote selector switch is in Remote. The local starting/stopping of magnet will be enabled only when L/R selector is selected in Local.

CR1 control supply supervision relay (will be energized on 110v ac)
CR2 control relay for emergency switch monitoring
CR3 relay for Local selection
CR4 relay for Remote selection
CR5 relay for speed monitoring
CR6 control relay for magnet Overload
CR7 control relay for separator overload
CR8 control relay for cooling fans overload
CR9 con 4A/4B Running feedback for MS operation
CR10 Local magnet on/off relay
CR11 Local separator On/off relay
CR12 MS system control components healthiness check relay
CR14 relay for Remote operation (control room)
CR15 MS f/b to con 4A/4B
CR16 Relay for cooling fan on/off
TR1 On delay timer (10 sec) for acceleration delay
TR2 off delay timer (3 min) for MS stopping

Hence the above circuit uses more number of relays from CR1…….CR16 and timers TR1, TR2 for the MS operation requirement. The internal wiring is being a complicated one with interlocks.

This causes frequent stoppages in MS system operation. In that situations to avoid delay in transfer/receiving systems – the MS system will be Bypassed to defeat logic to start con 4A/4B. So the conveyor systems will be in service with the absence of MS system. Here the risk of crusher, mill systems damages are highly possible, but to avoid reduction in power generation it is being done temporarily. After completion the trouble-shooting on MS system will be carried out.

Hence the cause for frequent stoppages were studied, discussed and finally suitable root causes were found out by the maintenance team. The reasons were tabulated as follows,

1. Life of OEM design (Original Equipment Manufacturer)
2. Uses traditional relays, timers control
3. Physical wiring complications between control relays
4. Frequent Speed monitor failure due to dusty location
5. Non-availability of fault indication at control room (On/Off available)

On further discussions it was concluded to design user-friendly relays free control technology using Programmable Logic Controller applications. Based on the efforts made by the maintenance team with a month of time all the MS systems were automated with PLC systems (Omron make 20 I/O).

We do discussions over MS system operation with our guide and associated maintenance team. The old set-up control logic working was briefly explained by them. We got immense idea of practical system engineering. The wiring complications on the above logic also taken into account.

The need for PLC with the benefits of software was clearly discussed and concepts were understood. Here we pay our attention in MS system PLC automation with speed monitor removed from use. The cost benefit of Rs 15,000 is also achieved for each MS by introducing simple timer application with the help of PLC software.

III. DRAWBACKS OF RELAYS

- Physical wiring of system is complicated and difficult.
- The panel board arrangement occupies more space. The arrangements also require proper ventilations. The arrangement is not simple and neat.
- This can result in mal-operation and false trips.

IV. MCS AND PLC COMPARISION

- PLC’s allow end user to configure and control the application which is more useful in industries.
- A microcontroller design would be appropriate where end user need not alter the control or using minimal controls rather only selecting controls.
- For example a washing machine where user only selects different controls and need not alter the controls. Similarly in home automation also where there is no need of altering the controls.
- PLC applications are highly customized systems so the cost of packaged PLC is low compared to cost of specific custom-built controller design

Programmable Logic Controller

PLC's were invented as less expensive replacements for older automated systems that would use hundreds or thousands of relays and timers. Often, a single PLC can be programmed to replace thousands of relays. Programmable controllers were initially adopted by the automotive manufacturing industry, where software revision replaced the re-wiring of hard-wired control panel. The earliest PLCs expressed all decision making logic in simple ladder logic inspired from the electrical connection diagrams. The electricians were quite able to trace out circuit problems with schematic diagrams using ladder logic.

Software For Plc

PLC can be programmed to control a process effectively. They are

1. IL (INSTRUCTION LIST)
2. STL (STATEMENT LIST)
3. LAD (LADDER LOGIC
4. FBD (FUNCTIONAL BLOCK DIAGRAM)

V. CONCLUSION

We did in our proposed system to the "Elimination of Frequent stoppages of Magnetic Separator system in LHS". We had a golden opportunity to gather adequate ideas of our engineering field- in process control, during our project period. We had brief idea about relays and timers based control- for MS system operation and control for process requirement – to have better ferrous material separation.

We had more clarity on power station operation basics and maintenance activities. Everything that we had planned went smoothly during the project development span. Also we had a limited amount of time for its completion so we were under a certain amount of pressure as well.

We do our project to improvise Magnetic separator system control design using PLC systems; thereby we suggest an enhanced control via software. Due to the superior communication facility with PC, system monitoring via computer is possible.

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