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Application of Programmable Logic Controller in Slip Power Recovery System Used In Cement Factories to Boost Its Efficiency

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ABSTRACT: The era of Industrial automation is contributing its best to Industrial world. In Cement factories, power electronics based energy conservation equipment Slip power recover system is used. There performance is good but it is found that due to dusty climate and mechanical ON/OFF switching of relays, there are breakdowns. To reduce the downtime, conversion of relay logic control to Programmable logic control pays a lot. This research study and development work has good impact on efficiency of SPRS and productivity of Cement plant.

KEYWORDS: DI Digital Input, DO Digital output, PLC Programmable logic controller, SPRS Slip Power Recovery System, AI Analog input, AO Analog output

I. INTRODUCTION

Slip Power recovery system is an energy conservation unit to save energy and control speed of slip ring AC motor driving HT Fan of 550 KW with 6.6 KV input voltage rating. Generally it works on Electric control circuit having relays, semiconductor fuses. There is issue of failure of system due to dust and contactors.
Programmable Logic Controllers are important element, who are playing major role in it in automation of process Industries. The PLC is basically a programmed interface between the field input elements like limit switches, sensors, transducers, push buttons etc and the final control elements like actuators, solenoid valves, dampers, drives, LEDs, hooters etc. Here it will take analogue inputs of speed , voltage etc from Power section of SPRS and then controls firing of thyrister to control speed of HT Fan motor.

It is having combination of Software and hardware, we need to utilize the academic concepts of Electronic Converters in subjects of Digital Electronics, Electrical Machines, Instrumentation & measurement, Computer fundamentals, C C+, Microprocessor etc form their Bachelor of Engineering. We can go for Integrating Analog signals in PLC coming from field. Here we have given short description on utility of PLC to save failure of SPRS. The proposed work is directly useful for Industrial Automation Electronic Engineer, R & D Engineer to serve Industries in order to boost up productivity.

II. LITERATURE SURVEY

The objectives of proposed work are as follows;

Objectives
To analyse issues of failure in relay control circuit.
To find out software replacement of control circuit.
To write a program in ladder logic
To wire inputs and outputs in I/O card of PLC
To RUN PLC controlled SPRS

Conversion of Electric relay logic Control to Electronic Programmable logic control
During my days in Cement factory instrumentation engineering department, I saw the repetitive breakdown of energy conservation equipment SPRS. We interacted with team of engineers and decided to carry out research to find out ways

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to reduce breakdowns. It was indeed a very good research and development work in SPRS. There is huge demand for such type of innovation. Research centre similar to RNTU Bhopal can play vital role in making Industry Institute partnership. In case of SPRS this research paper of student of RNTU is very much useful It is one of outcome of the research work on PLC and Industrial automation. The hypothesis is related to boosting its productivity by increasing its availability i.e. by reduce breakdowns. New schematic is prepared with introduction of electronic hardware, taking out electric contactors in L & T , ABB ,Siemens make Control Panel and programming in PLC.

III. PROPOSED WORK/DESIGN

.This work has following steps;
1. Requirement of software and Hardware
2. Cost estimation of the scheme
3. Commercials
4. Tentative modifications required in hardware interface interlocks
5. Implementation period
6. DI/DO List
7. Termination schedule of DI/DO
8.. Commissioning

About Slip Power Recovery System

Slip Power Recovery System SPRS is an energy conservation system made from power electronics and used to control the speed of an **Induction motor.** This method is also known as **Static Scherbius Drive**. This method saves power fed to motor. In the rotor resistance control method, the slip power in the rotor circuit is wasted as I^2R losses during the low speed operation. The efficiency is reduced here. The slip power from the rotor circuit can be recovered and fed back to the AC source so as to utilize it outside the motor. Thus, the overall efficiency of the drive system can be increased.

The figure below shows the connection and method for recovering the slip energy and the power recovery of the Induction Motor.

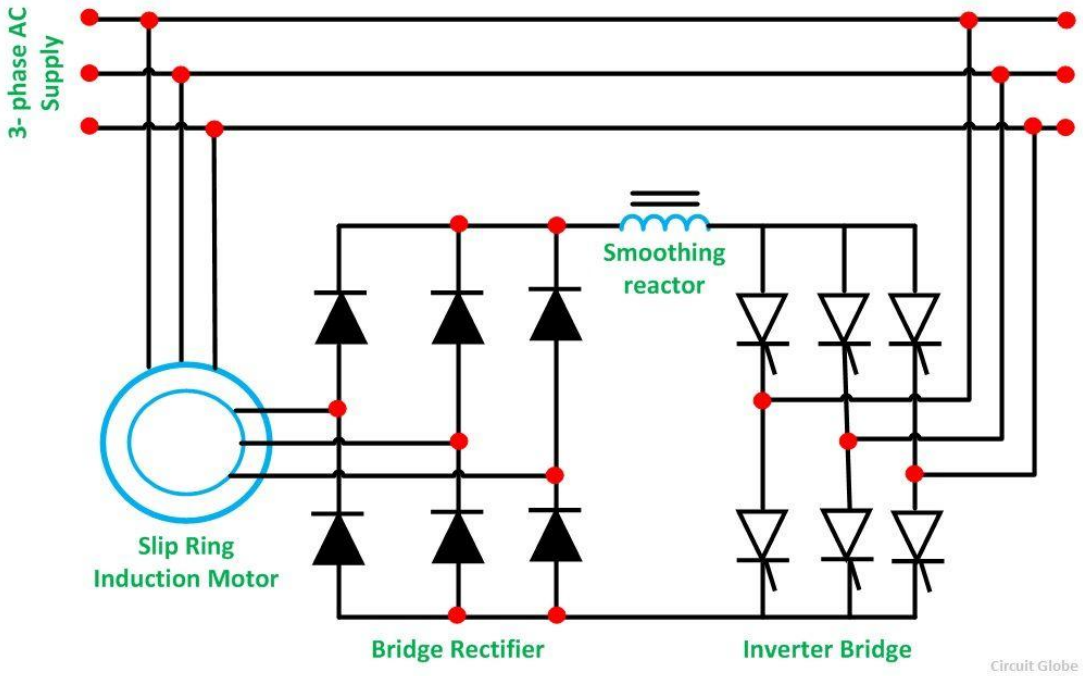

Figure- SPRS System

Here the main principle exists in connecting voltage source of slip frequency from Rotor circuit. The power or energy recovered provide speed control and power saving in Induction Motor for its synchronous speed in range 70 to 95%.Here slip power of rotor is converted to DC using Diode bridge.

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There is need to smoothen rectified current, which is done by smoothing reactor. This DC output of rectifier comes to input of inverter. This changes it to AC power and feed it back to Source of AC. It uses inversion mode and matches frequency of 50 Hz of Indian standard. Then it goes to step-up transformer, whose secondary have matching to 6.6 KV or 11kv rating matching motor stator input.

This method is used in Raw mill, Coal mill, Pre heater section of Cement plan of large applications .There are large power HT Fans of 6.6 KV and up to 1250 KW or more. It is useful for all heavy industries of Steel, Plastic, Chemicals, and Mining etc.

It is Slip Power recovery system used to save electric energy in an Induction motor. In case of cement Industry There is installation of 5 big size Fans generally driven by High tension electric supply powered

With our long Industrial experience in working with such advance technological equipments and current discussions in last few years with engineers, technicians, production executives that all of them has experienced with this power electronic scheme based slip power recovery system, that there is no doubt to say this SPRS is contributing a lot in energy conservation and its role in kiln optimization is remarkable. So it becomes necessary to increase the running hours of system to 100%.To avoid these idle hours, our team have attracted the main points which are responsible for the failure or delays

Some of the observations were as follows;

(A)Contactor/Timer conversion is possible in PC elements of PLC System

90% failures of SPRS are reported due to failures of contactors in span of 2 years. So it was decided to prepare schematic, where 16 no. MM00 contactors and 4 no. Timers, which are in hardware form, are to be taken out from wiring. The whole logic has been converted in to structural form of PC elements/ data base. All operations were planned through DI/DO channels of relevant electronic cards. So automatically these 90% failures came down to 0%.

(B) In appropriate utilization of changeover from LRS to SPRS and vice versa through CCR

As, we know that we are able to save electrical energy by running HT Fans of Coal Mill, Raw Mill, Pre Heater, Bag house in SPRS mode and if take example of Bag house fan we are able to save electricity costing Rs 2000 per hour . In general Fans are started at LRS mode and got changed to SPRS mode manually or can be changed automatically after 70% of rated speed.

(C)Most of the time it was seen that system is ready to RUN is SPRS but it is found that the changeover facility is implemented through push button located in SPRS panel of Bag house Fan. which is located 400 meter away from Central Control Room –CCR. So it takes time to spare workman to execute this task due to his availability and distance. It leads to loss in energy conservation figures.

(D)With this system 'RESET' and 'CHANGE OVER'' facility has been introduced .The system can be made reset either from panel or through CCR. The same operation is executable from changeover too.

(E)LRS rotation control-This is one among the biggest task with which our team has come forward. There are 3 types of rotation available with current electric wired system ;

(i)Simple Changeover with bump- It is like old scheme in which LRS stays at Maximum position when Bag house HT Fan motor runs in SPRS mode

(Modified changeover with less bump-It is modified scheme over old one. In this scheme LRS stays at 70% position of total travel length.

(iii)Bump fewer changeover- This is totally new scheme, in which motor of LRS will continuously monitor LRS position when HT Fan motor is running on SPRS mode.

(iv)Alarm latching arrangement.-In this scheme all alarms will get latched and get cleared only after removing fault and clicking RESET. They can also be printed. So they will help in troubleshooting.

(v)Easy changes from PLC controlled to old hardware logic: Though it is not required in new schemes but being old electrical panel it is designed in such manner that if we wish to come back to original electric hardwire controlled SPRS then this task can be executed in one day. Precaution has been taken in that during this planned schedule HT Fan Motor will keep in running mode without affecting

(vi)Ease in transformer fault diagnosis: with the new scheme we will be able to get clearly which type of fault is occurred in feedback transformer. It will be advantageous over old scheme where in hardware all three types of fault has been generated trough single contact only.

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Requirement of software and hardware

Required elements and software and channels, cards in hardware are listed as below;

Table

Sr No.	Item Description	Qty	Purpose
1	Programming Master Software	1	It is to be installed on Programming unit (PC) or laptop computer
2	Communication Cable	1	It is connected between CPU of PLC/DCS and Programming unit (PC) and laptop computer.
3	Digital Input	24	Inputs
4	DIC, SR-AO,CON-PU	1 each	
5	Selection	2	Selector switches
6	AND (2)	5	Software elements
7	AND multiple inputs, OR	2 each	Software elements
8	TON	5	Timer
9	AND OR, T OFF,OR-AND	2 each	
10	INV	4	
11	SW-C	3	

Cost estimation of scheme

We can make sketch, prepare Bill of material and wiring diagram to replace existing contactor control of SPRS relay control panel of any make and its wire it with PLC system. There will be need to use few cards, channels etc to carry out required connections in wiring along with preparation of user software and downloading it. Here is cost estimate of this scheme**.**

Table

Sr. No.	**Item Description**	**Reqd quantity**	**Cost in rupees**
1	DI Board, DO Board	1 each	50000+50000
3	DI Connection Unit	1	12000
4	DO Connection Unit	1	12000
5	Copper Cable 0.75mmsq.	1 Roll	1400
6	Elmex Strip	280.75 M	600
7	Elmex	50	500
8	Cable 44C*50M	50 mtr	12500
9	Cable 30C*50M	50 mtr	12500
10	Cable laying of 44C .30 C Cable	**50 mtr each**	500+500
12	Cable7C	15 mtr	1000
13	Cable laying of 7C Cable	15 mtr	500
14	Terminations, Labour cost, Misc		650+20000+5000
15	Grand total		177300

Modifications in hardware interface interlocks:

Interface	**Nature of Signal**	**hardware Old scheme**	**PLC new scheme**
(A)VCP with SPRS	Start permissive	as it is	no change
Tripping	0----------0	0----------0	0----------0
	K1 NC at X4-3and x4-4	K42 NC at X4-65 and X4-6	
Tripping	0----------0	0----------0	0----------0
	X4-3	K1-NC X4-4	K2-NC X4-65 X4-64

Schedule of work

Nature of work	**No. of days required**
Cable issue	1 day
Cable laying	3 days
Terminations, Internal changes in wiring	1 day+ 1day

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MP Hardware job. Software Job	1 day+ 1 day
Miscellaneous	2 days
Down time from other agencies	5 days
Total	15 days

Input / Output list with terminations

It will be required to document wiring details of Digital Input, Digital Output and Analog input used in this application of conversion of SPRS control from relay logic to PLC .System. List with termination details may be like this.

Digital Input list

Contact details DI No	Connection in PLC		Connection at SPRS description	
S26-k25 xx.4 di13.9	xx.x: x3:4	x6-8	Voltage speeds relay k25	
S26-Q3 xx.7 di13.15	xx.1: x3:8	x6-14	Q3 is on	xx.8
di13.15 xx.1: x3:8	x6-14	Q3 is on		

Digital Outputs list

Terminal Of DO	Tag name of DO	MP	Connection at of PLC/DCS	Connection at SPRS Panel	Description
xx.13	DO6.15	xx.2:x3:9and10	x5-25 and 26	UV-LMP230vac	

Analog Input

AI No.	Tag Name	Connection At PLC	Connection at SPRS	Description
xx.16.31	xx.4: x3	11 and 12	x6:51 and 52	LRS Position

Terminations

Details of DI Connections via intermediate terminal strip X5 may be like this;.

Connection at PLC	Connection at Terminal Strip X5	Connection at SPRS
		230 vac from PLC via Fuse to SPRS
DIxx.1	X5:1&2	K39_166 & K35_ 167

IV. EXPERIMENTAL RESULT

Economy in scheme- This system is very much economic and user friendly to operate and maintain. We have to invest appx Rs 2 lacs in existing panel , which will be recovered in 6 month and after it we will have continuous saving for next 10 years.

Down time in hours per annum in hardware controlled SPRS	
Due to cleaning/blowering of contactors / timers	72 hrs
Due to failures due to problem in contactors/timers	140 hrs
Delay in operation of contactor/timers	20 hrs
Sub-total	232 hrs
Average saving per hour, when motor runs on SPRS	250 unit/hour
Cost of electricity in Rs/hour @ Rs 250*6	1500
Saving in 232 hour @ Rs 1500*232	Rs 348000
Cost of implementation of PLC Control in existing Hardware controlled SPRS	Rs 159300
Cost recovery period	6 month

V. CONCLUSIONS

Here we saw that by converting existing hardwire electrical relay controlled SPRS to Electronic PLC controlled system, we are able to save Rs 4 lacs per annum in electricity. The return on investment is only 6 month and after it this saving will continue for next 10 years.

VI. ACKNOWLEDGEMENT

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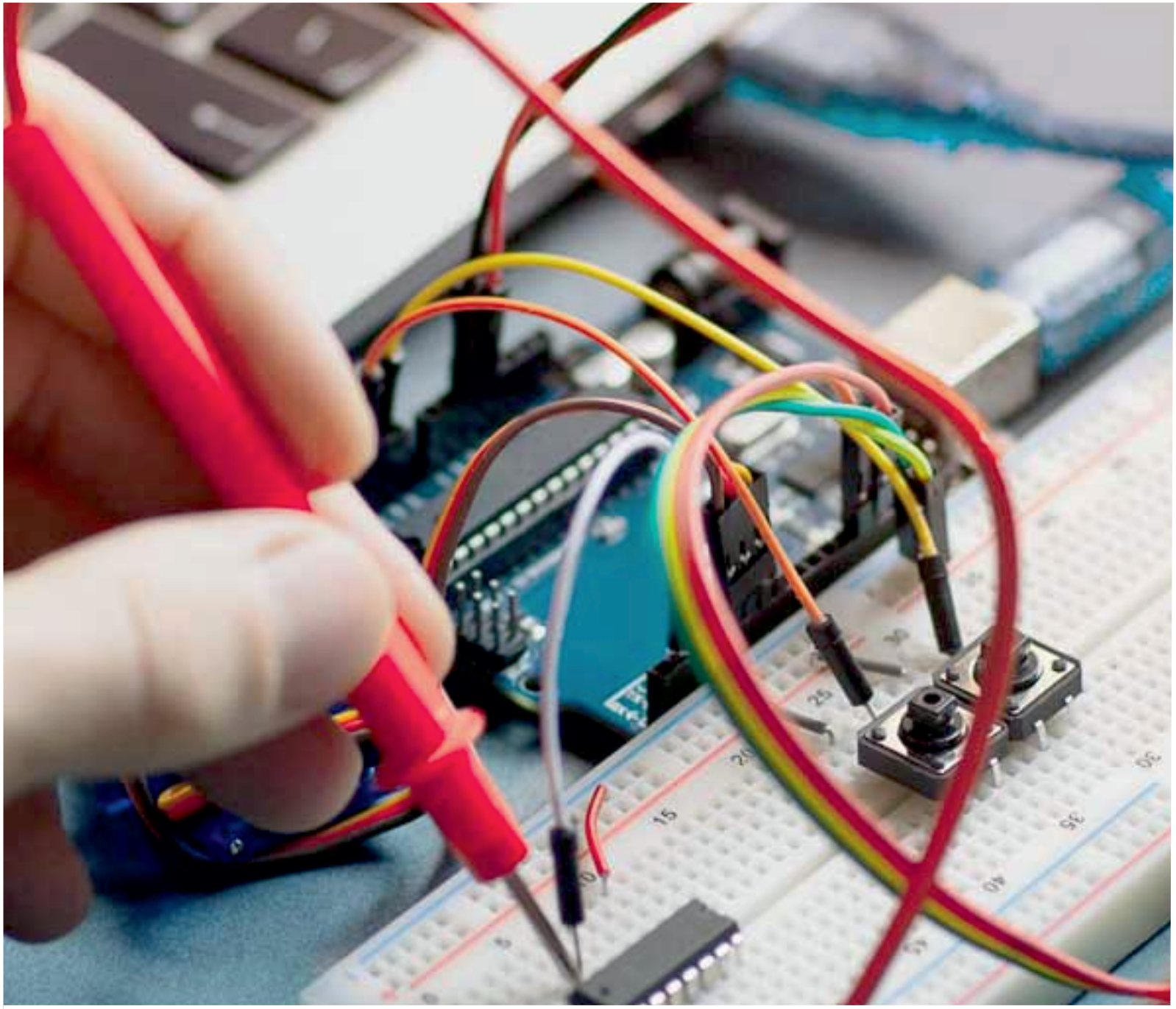

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