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Control and Automation of Cylindrical Grinder using PLC, Drives and HMI

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Abstract – The focus of this paper work is on the automatic working of the entire machine or plant. Here in industrial automation, we use PLC, Drives and HMI. With the help of these devices we automate the entire machine. In the present work, the entire working of the cylindrical grinder is controlled. During manual operation of cylindrical grinder, workers, working on the machines face difficulty in synchronizing the speed between grinding wheel and the job head. Both are continuously rotating at some speed. There is also a problem in the movement of slide, which brings the grinding wheel near to the work piece for appropriate cutting of the extra material from the work piece .So in order to overcome all these difficulties, we use PM554(PLC). It gives command to various Servo drives, VFD Drives and limit switches. For proper starting of the machine, the proper interlocking should be done in PLC programming, satisfying various conditions.

Index Terms– **Programmable Logic Controller (PLC), Variable frequency drives (VFD), Human Machine Interface (HMI), Codesys, Grinding wheel induction motor**

I. INTRODUCTION

In any industry three important operating expenses are often found to be energy, labour & material. If one were to relate to the manageability of cost or potential cost savings in each of above components then energy would invariably be the top ranker. Energy [8] constitutes a strategic area for cost reductions, since cost of energy is increasing day by day. So, it is required that energy should be saved and overall efficiency of the system is maintained. In order to understand the concept, control the automatic working of the cylindrical grinder using PLC, Drives and HMI are used. In cylindrical grinding the major problem is in synchronizing the speed of grinding wheel and the job piece, to control the movement of slide, on which cylindrical grinder is placed, to control the flow of coolant and lubricant. The Literature review reveals that the researches faced difficulty in automating electrical system in industries by using conventional methods like manual supervision, pneumatic control, hydraulic control, hardwired control, electronic control etc. Because manual supervision of equipments and components required the supervisor to be present in the close vicinity of equipments. Moreover, pneumatic and hydraulic system caused errors in the system and posed difficulties in modification of design. Furthermore hardwired systems were too bulky to be designed and redesigned accordingly and after that electronic systems also faced the same difficulties in modification of design .In the present research work, these difficulties are sorted out using PLC [1] [2], Drives [3][4], HMI[10] etc.

II. MAIN OBJECTIVE OF THE WORK

The main objective is the automatic control of the entire working of the electrical equipments and electrical machines. It reduces unwanted faults and tripping of electrical circuit caused by the faulty manual operation. It also provide easy access and control of electrical machines, reduce time of operation, reduce electrical losses in the machine, save electrical power / energy saving [7], reduce labour cost thus improves overall efficiency of the machine.

III. METHODOLOGY ADOPTED

This has been done by two approaches i.e. hardware[5] [6] and software approaches. Hardware Approach: In this approach, a hardware circuit is fabricated in order to provide automated control of electrical machine. It includes installation of PLC, Servo DRIVES, HMI, normal VFD's etc. on various electrical machines in order to control the working of the machine. Software Approach: The programming of the PLC is done on the software named Codesys and programming of drives is done on drives itself and programming of HMI is done on CP 400 software. After completing the first step investigation of total energy and money saving in the whole machine is done. Pay-back period is also calculated.

IV. AUTOMATION OF CYLINDER GRINDER

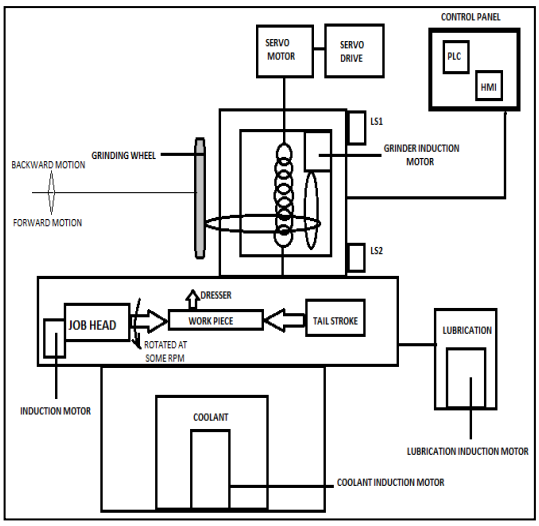

Fig. 1A basic block diagram of the cylindrical grinding

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As shown in Fig. 1 basic components required for cylindrical grinding are:

i) PLC- Programmable Logic Controller. (ABB PM 554).
ii) HMI- Human machine interface (ABB CP 400).
iii) Servo motor-For forward and backward movement of slide we use servo motor (GYS201 DC 2-T2A-B) of 4.7 NM.
iv) Servo amplifier/ drive- It is mounted with servo motor to control the speed of servo motor.(RYS 201 S 3-V V T 2)
v) Grinding wheel induction motor (3HP)
vi) Variable Frequency Drive-(ACS 335-03E-08A8-4+J404+)- To control the speed of grinding wheel.
vii) Induction motor (2HP) on job head for the continuous rotation of work piece.
viii) Coolant induction motor (0.5 HP,3 phase).
ix) Lube/lubrication induction motor (0.25 HP,1 phase) .

V. RESULTS AND DISCUSSION

In the present work, the entire working of the cylindrical grinder is controlled. We used both hardware and software techniques in controlling the entire working of the machine. During manual operation of cylindrical grinder, workers, working on the machines face difficulty in synchronizing the speed between grinding wheel and the job head. Both are continuously rotating at some speed. There is also a problem in the movement of slide which brings the grinding wheel near to the work piece for appropriate cutting of the extra material from the work piece .So in order to overcome all these difficulties, we use PM554(PLC). It gives command to various drives and limit switches. In other words it controls entire working of the machine. The various dimension of the work piece i.e. the actual diameter, rough diameter, rapid rate, rapid delay, feed rate , feed delay, retract distance, lube on time ,off time etc. are entered through CP430 (HMI) .If we wish to control the machine manually, we can select that mode through HMI. This HMI is connected to PLC and PLC programming is done in LD language using Codesys software. For proper starting of the machine, the interlocking should be done in PLC programming, among various conditions mentioned below.

i) Hydraulic motor on
ii) Grinding wheel on
iii) Clamp piece
iv) Homing done of the machine
v) Spindle arrival signal
vi) Motor rotating greater than 200 rpm
vii) Hydraulic contactor was not tripped
viii) Coolant contactor was not tripped
ix) Lube contactor was not tripped
x) Spindle contactor was not tripped
xi) Servo drive was not in fault and is in ready/run mode
xii) Emergency button was not pressed
xiii) If during cycle running the wheel or hydraulic stopped working then the whole process should be stopped at that time
xiv) For de clamping the hydraulic motor is on, foot switch input is pressed, cycle lamp is not glowing, no spindle running
xv) For lube shot the lube time off up, wait for cycle complete.

After receiving the command from HMI, PLC converts the distance, the grinder wheel has to cover into pulses .Then these pulses are given to servo amplifier, to which the servo motor is connected .The servo amplifier converts these pulses into appropriate distance the slide has to move, on which the grinding wheel is attached, by controlling the speed of the servo motor. When grinding wheel has to move up to the rough diameter, then the speed of the servo motor is greater as grinding wheel has to reach there as early as possible without any loss of time. Thus grinding wheel is moving with a rapid speed. At reaching the rough diameter if there is a necessity of dressing (usually after 100-200 piece) then the grinding wheel stay there for a few seconds for dressing (it's usually 3-5 seconds) and after dressing, grinding wheel again reaches the home zero position. After reaching the rough diameter there is a time delay of few micro seconds in order to reduce the speed of servo motor to feed rate, so as to remove the extra material from work piece. If it is moving at the rapid rate the wheel may be damaged. In order to remove this problem, the speed of grinding wheel is reduced. After whole material was removed from the work piece, the grinding wheel has to stay there for 3-4 seconds so that end finishing is provided to the work piece. After this, the grinding wheel has to move back to the home position at a very rapid speed. The work piece is attached to the job head and it is continuously rotating at a constant speed of more than 200 rpm .For this we use induction motor and speed of induction motor is controlled by using variable frequency drive (VFD) i.e. ACS 335.Thus proper synchronization is maintained between the speed of grinding wheel and the speed of job head. During removal of the extra material from the work piece, the coolant is applied continuously to remove the extra heat .The lubrication is also done at appropriate time without any delay and wastage. Thus whole working of the machine both manual /automatic is controlled as shown in Fig 1.2.

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FLOWCHART

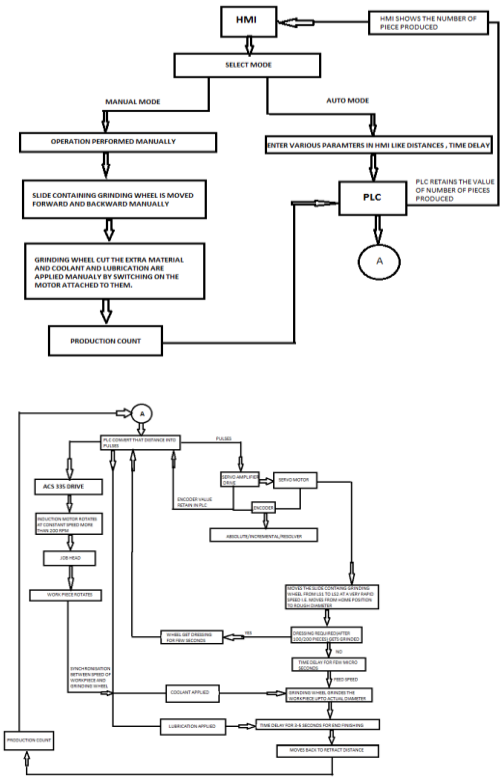

Fig. 1.2 Block diagram of Automatic/manual working of cylindrical Grinder using PLC, Drives, HMI

VI. TOTAL COST INVOLVED IN AUTOMATING THE CYLINDRICAL GRINDER

SNO.	MATERIAL	QUANTITY	COST (IN RS)
1	ABB PLC PM554	1	9,500
2	SERVO MOTOR 4.7NM + SERVO DRIVE	1	32,000
3	FUJI HMI MODEL NO-S806 SIZE 320*240	1	13,000
5	ACS 355-03E-02A4-4	1	15,000
6	T/F 1KVA 420 TO 220V	1	1,960
7	SMPS 2AMPS	1	800
8	Omron Relays 24V DC	3	1,300
9	MCB 16 AMPS.	2	670
10	MCB 10 AMPS.	1	335
11	MCB 6 AMPS.	4	1,340
12	CONTECTOR 12AMPS. 3P 220V COIL	1	750
13	CONTECTOR 9AMPS. 3P 220V COIL	3	1950
14	Auxiliary NO Points	2	120
15	FAN 6"	1	550
16	Rotary Switch 23A	1	1070
17	Terminal Block 10MM	18	162
18	Terminal Block 6MM	30	240
19	Fuse Terminal Block	6	800
20	Indicator Red 24V DC	1	210
21	Indicator Green 24V DC	1	210
22	Push Button Green With No Point	3	672
23	Push Button Red With NC	3	672
24	Illuminated P.B Green With NO	1	380
25	Emergency Switch With 2 NC Points	1	150
26	PANEL 800*600*300MM	1	3,500
27	AIR FILTERS 10"	2	400
28	Extra Wiring Cost		2000
29	Programming Cost		1,00,000
30	Grand Total		1,89,741

The total investment involved in automating the cylindrical grinder is Rs 1, 89, 741, which is high. But this cost can be easily recovered with in a small time period.

VII. CALCULATION OF PAY BACK PERIOD

(Taking production rate constant)

In manual operation energy consumed by the machine in one hour = 9.30 kWh

In Automatic operation energy consumed by the machine in one hour: = 7kWh

Reduction in energy consumed in one hour = 9.30-7.00 = 2.30 kWh

Commercial rate of a unit = 6.40 Rs

If machine is operated for 14 hours in a day

i) Annual saving = annual loss reduction in units * unit price.

ii) So annual saving = 6.40*2.30*14*365 = Rs 75,219.20.

iii) Total capital investment = Rs 1, 89,741

iv) Payback period= Total capital investment/annual savings

=1, 89,741 / 75219.20

= 2.52

Thus this capital is recovers within 2 years and 6 months. But the payback period is less than 2 years because here we are taking production constant but the rate of production increases 4 times after automating a machine. So payback period is much less than this.

VIII. CONCLUSION

The present work concluded that the industrial automation approach is very cost-conscious, gives maximum performances, reliability, robustness, modularity, user friendliness, verifiability portability and

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reusability of the industrial system using PLC, Drives, and HMI. The traditional approaches towards this concept posed various problems in the field of automation, like lack of versatility, lesser reliability, efficiency, lesser verifiability etc., because traditional manual approach needed presence of professional in the close vicinity of the machine .The automatic control of the entire machine overcomes all these difficulties. The combination of hardware –software approach helps even an unskilled worker to operate the machine quite efficiently. Only pressing a single switch on the control panel the whole machine will operate automatic and same process can operate number of times. By just varying the dimension of the work piece through HMI, the same machine can be used for grinding pieces of different dimensions. It increased productivity and speed of operation. Fault tracing in the machine becomes quite easy. Ease of maintenance and wastage of material reduces. Bulky system is replaced by simple PLC, Drives and HMI.

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