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Study of Control Organization of a Top Surface Grinding Machine with its Performance Analysis

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Abstract – *In this paper, the control organisation of a top surface grinding machine based on Programmable Logic Controller (PLC) is described. Precision grinding is performed on the machine with mechanical units and controller. The axes movements and spindle speed are driven by controlled servo drives. These servo drives communicate with PLC for controlled operation. Proximity sensors are installed in the system and interfaced with PLC. When a particular axis movements exceeds its limit, the sensors will send the signals and the direction pulses are send which is used to stop the corresponding axes movement actuators to achieve its desired positioning. Similarly, output elements like valves, lamps, relay coils are operated by PLC. Performance analysis of the system is also presented in this paper.*

Key Words: **Programmable Logic Controller (PLC), Grinding machine**

1. INTRODUCTION

Since last century, PLC has grown fast and it is widely used in various industries. Most of the machines are equipped with the Programmable Logic Controller (PLC) ([1],[2]), wherein the control logic is developed in ladder diagram, a software logic control, with a number of inputs taken from the environment and generating the outputs, depending on the logic programmed, to the environment. This grinding machine performs the ultimate process of surface grinding on the workpiece, which determines final quality of processing workpiece [3]. Such precise operation control mechanism is explained in this paper.

2. CONTROL ORGANISATION OF MACHINE

The top surface grinding machine is composed of the mechanical units and PLC control system. The machine has arrangement of four chucks mounted on an indexing table, which hold the workpiece during operation. These chucks are rotated by two induction motors arrangement. These motors speed is controlled by variable frequency drives (VFD). Fig.1 depicts the control organisation of the top surface grinding machine. It mainly consists of all the machine components where operations are performed starting with the loading, pre-finishing, finishing and ends with unloading, the grinding mechanism at the pre-finish and finish station, human machine interface and the controlling terminal PLC. All these operations are continuously monitored and threshold signals are obtained from field to control and monitor the operation.

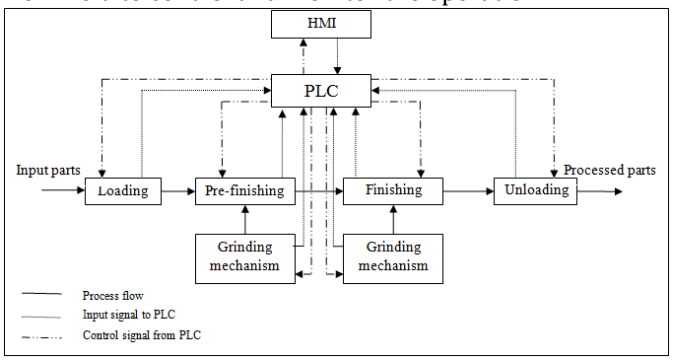

Fig-1: Control organisation of Top surface grinding machine

Firstly input parts are loaded in the system with a conveyor belt, which are operated by solenoid valves. Then grinding is performed in two stages, pre-finishing and finishing. Both operations are performed with similar grinding mechanism, only grinding wheels used at both stations are different. Grinding mechanism is made of grinding wheels mounted on a rotating spindle, where its motion is controlled by servo motors and sensors arrangement. Servo drives are the components that drive the servo motor in the system. A servo drive monitors the feedback signal from the servomechanism and continually adjusts for deviation from expected behavior. Servo drive receives a command signal from a control system, amplifies the signal, and transmits electric current to a servo motor in order to produce motion proportional to the command signal. Some proximity sensors are also positioned; these also give the feedback about the movement of slide. Both workpiece holding chuck and grinding wheel rotate to perform grinding.

During grinding at both stations, in-process gauging is performed, which lets the machine respond automatically to the parts changing length. Automatic gauging of the workpiece, with measurements sent to the grinding machine's control, allows precise grinding of the workpiece.

Workpieces which are finished grinding are handled by an unloading agent who releases these workpieces to the outside environment of the production.

Human Machine Interface[4] is also interfaced with the PLC. It allows the operator to interact with the logic stored in the PLC to control the real-world process in real time, that is, the operator can see information on the HMI display that is needed to make control decisions and then issue commands through the HMI to the PLC logic that in turn manipulates the process variables to produce a desirable outcome.

Thus this PLC-based control system detects positions of moving parts and controls their status by switching on/off motors, pumps, and valves. Many input devices positioned everywhere in the system provide information to the controller on which controller takes decision based on logic and gives signal to particular solenoid valve, indicator lamp, relay coil, etc.

3. PROGRAMMABLE LOGIC CONTROLLER

PLC is short for programmable logic controller, which combines computer technology, automatic control technology and communication techniques, is made especially for industrial control system. The processor is a solid state device designed to replace relays, timers, counter etc. Fig. 2 shows the PLC basic composition and its working principle. The necessary voltage and current requirement for the internal working of the PLC is generated by the power supply. The field element is interfaced to the input or output section. Typical input elements are push buttons, limit switches, proximity sensors, relay contacts, selector switches, etc. Typical output elements are solenoid valves, relay coils, indicator lights, LED display, etc. It uses a programmable memory to store instructions and specific functions include on/off control, timing, counting, sequencing, arithmetic and data handling ([5],[6]).

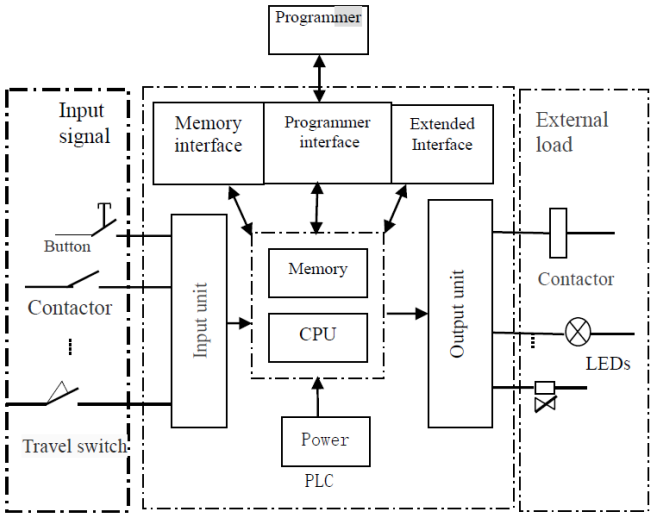

Fig-2: PLC basic composition and working principle

In ladder diagram the program is written in high level language. As the random access memory (RAM) or flash memory erasable programmable read only memory (EPROM) can admittance the binary instruction the ladder should be converted into binary instruction. Each binary instruction is executed by the CPU. A PLC program is sequentially executed from the first rung to the last rung, which is called scan. This sequential processing is called cyclic operation. Cyclic operation of the PLC continues as long as conditions do not change for interrupt processing during program execution.

3. PERFORMANCE ANALYSIS OF THE SYSTEM

Table -1: Performance parameters of the system

Performance parameter	Value
Cycle time	11.2 sec/pc
Collar height(STDEV)	0.016 mm
Flatness(STDEV)	0.630 µm
Production Rate	125 pcs/hr

The performance parameters are listed in Table-1. Now the system has cycle time of 11.2 seconds per piece (sec/pc) and production rate of 125 pieces per hour (pcs/hr). These two parameters need to be improved with to increase the production. Also downtime of machine should also be reduced. Hence overall performance and production rise with quality output is expected.
Fig-3 and Fig-4 shows the electrical control panel and HMI of the system respectively.

Fig-3: Electrical Control panel of Top Surface Grinding Machine

Fig-4: HMI

5. CONCLUSION

This paper has described the control strategy and performance analysis of a top surface grinding machine. This system precisely controls the operation of grinding. Continuous monitoring of the state of input devices and making the decision based upon a program to control the state devices connected as output to perform the intended operation is done in the system.

6. FUTURE SCOPE

The machine can be upgraded by upgrading existing control system with the new advanced controller to give better results.

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