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Automation of Boring Machine Using PLC and HMI

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Abstract - *Simplification of engineering practice and precise control of manufacturing process can result in significant cost savings. The advanced automation is a planned approach towards integrated control systems. The boring machine is a vital part in any engineering works. The Boring machine is a device for producing smooth and accurate holes in a work piece by enlarging existing holes. After the inspection of the boring machine, it was found that machine operating in manual mode has very low grade quality production and less accurate. Using PLC and HMI with servo electric drives, the boring machine can be automated to reduce manual work with more accurate tuning to increase productivity. The proposed work has taken up, fabrication of an automated Boring Machine based on PLC and HMI for the design and implementation. The objective of the project is automated control of boring machines to produce a finished Product.*

Key Words: **Programmable Logic Controllers (PLC), boring mechanism carriage (BMC), Human Machine Interface (HMI), Servo drives.**

1. INTRODUCTION

Advancements in technology results in revolution of manufacturing industries for increased productivity. Key goal of manufacturing industries is to automate for high performance machining. Automated equipment and good shop layout normally improves speed, precision and quality regardless of which type of machinery is performed.

The heart of any industries is the motor drives [1], the automation of drives increases the efficiency and even speed control can be easily achieved. Many industries use PLCs in automation processes to diminish production cost and to increase quality and reliability. Earlier Digital controllers and PID Controllers are used for speed control of drives [2].

PC+PLC based control systems are widely spreading, not only in the discrete and sequence control processes but also in continuous control processes, because of rapid improvement in performance of PC and PLC, development and introducing of effective PLC-Instrumentation control units [3]. In this, the automation of beer brewing process is explained which enables the increases the accuracy of production [3].

PLC programs are typically written through ladder diagram or other conventional programming method that can be copied from a workstation [5] (i.e.: computer or laptops) or even through PLC hand-held console via cable. A compact PLC has a perpetual number of connecting terminals constructed for input/output (I/O) connection and could be extended if the controller having insufficient I/O.

Human – machine interface (HMI) is a system for communication between operator and industrial system like a production line. HMI displays states, values, alarms, trends and allows interaction with human [6]. Interfacing the machine with the human is a vital part of any control system. The HMI module is primarily used for interface and to obtain the commands from the human operator [4].

Automated equipment and good shop layout normally improves speed, precision and quality regardless of which type of fabrication is performed [8]. Boring is the process of enlarging a hole that has already been drilled, by means of a single-point cutting tool or of a boring head containing several such tools[7]. It is always been challenge to design a machine which brings customers huge production with high precision, easy operation, and low production costs. Many kinds of machining requirements can be fulfilled and integrated such as boring, milling, slide-facing, turning etc. For different requirements, the machines can be designed in numerical, hydraulic, or pneumatic systems with proper tooling and fixtures [9]. The main objective of this project is to "implement the automatically controlled boring machine using PLC and Servo drives". Machining parameters can be easily set through PLC which enables better machining efficacy [10]. Initially work piece is produced by casting process of which dimensions are inaccurate. So the work piece has to be processed by many material removal processes like boring, milling etc to obtain finished product of accurate dimension and details of BMC (boring mechanism carriage) [11].

2. PROBLEM STATEMENT

Problem faced in the traditional method of boring is the variation in the boring dimensions of the material (Diameter and length). The reason of non-repetitive operation is found to be the error in measuring the dimensions of boring

material, variation in the movement of the work piece and BMC (boring mechanism carriage) at the time of gripping of work piece. At regular intervals, the dimensions are measured and if any correction is required in the setting, corrections are made accordingly. This is very cumbersome and tedious process. By the time, the operator sets the alternate dimensions (values) of work piece, many work pieces would have been bored at undesired length and diameter, resulting in either boring work piece as of shorter lengths or longer lengths also diameters. The boring work pieces of shorter lengths are waste and the longer ones needs additional boring involving extra cost.

Categorisation: The above problem categorised as:

- Improper dimensions and length of boring.
- Non co-ordination for movement of BMC
- Different boring work piece Movement rate

3. OBJECTIVES

The main objective of the project is to design, develop and implement automated controller for sectional drive boring machine in order to upgrade the technology. Below are the major steps which are followed in achieving this objective.

1. Design the control circuit for automation of the machine as per the requirements.
2. Build-up the control panel as per the designed control circuit by proper selection of equipments.
3. Developing Automated control program using PLC and HMI software.
4. Implement the control program developed and verify it for the desired results.

4. SCOPE OF THE PROJECT

- Automation is now often applied primarily to increase quality in the manufacturing process, where automation can increase quality substantially.
- It gives emphasis on flexibility and convertibility of manufacturing process.
- Production rate automatically increases and cost effective.

5. PROPOSED METHODOLOGY

The Automation of boring machine (Figure 1) using PLC and HMI, Block diagram of proposed system (Figure 2) shows the interconnection between the PLC and the field devices as inputs, outputs, servo drive and motors has been demonstrated. All field devices are Inputs to the PLC and motor, relay, contactors are the outputs, the HMI interaction in both directions as per required input can feed and output results are display. [10]

In this study the inputs and output gives the information about particular task to PLC unit and trough the HMI unit we can manually operate as per requirement. PLC controls all the output devices and get the desired controlled processes. The boring machine considered for producing smooth and accurate holes in a work piece by enlarging existing holes with a bore at different desired length and required diameter in a particular time. This proposed automation scheme will help to meet the desired requirement. The inputs or commands are given to the HMI unit, the HMI which is interconnected with PLC unit and also some inputs are given through PB selector switch. The main programming unit of PLC receives the information from motor, servo drive and generates control signals which actuate the required motors to achieve the objective [7].

Figure -1: Boring Machine

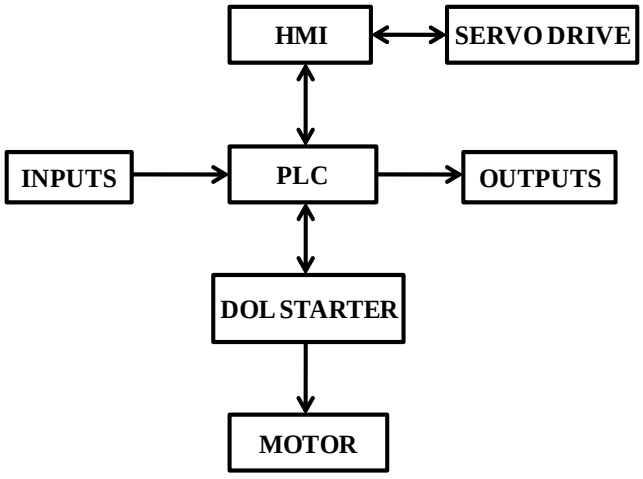

Figure -2: Block diagram of proposed system

6. CONTROL SYSTEM OF BORING MACHINE

The boring machine monitored and is controlled by PLC and HMI unit, the Control scheme of boring machine (Figure.3) is the inter-connection and information exchange between PLC, HMI, inputs and outputs devices. The designation stage includes software requirement, hardware selection, control panel wiring and automation for the machine.

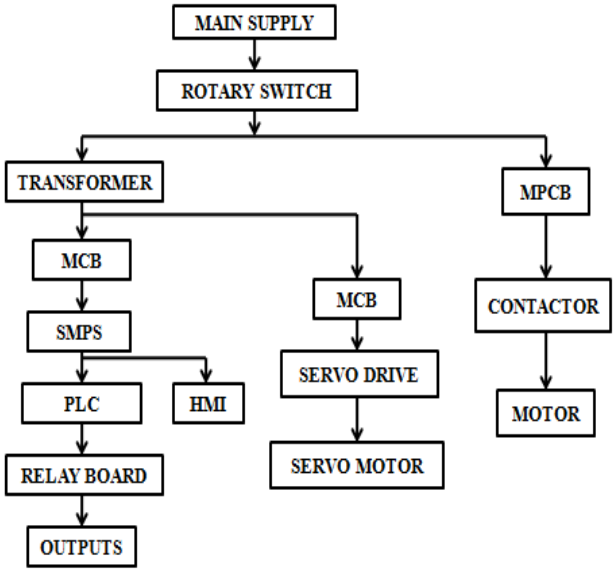

Figure -3: Control scheme of boring machine

7. IMPLEMENTATION STEPS INCLUDED IN THE PROJECT

Below flow chart (Figure 4) shows the step by step procedure of the developed project.

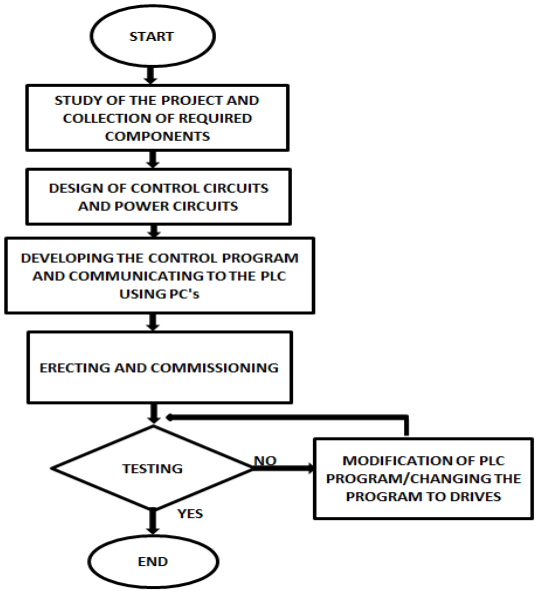

Figure -4: Implementation flowchart

- *Data Collection* – the successful collection of data is provided by **ESSENN ENGINEERING & EXPORTS**. Metagalli - mysuru, since the above entitled project is the task given by this company. This company is still using manual system in producing their product. So, the aim of this project is to automate their manually running machine using PLC and electric drives in order to obtain high productivity and better accuracy.
- *Control system design* - In designing the control system of this project, the control system has been developed by using mainly the relay logics, electric drives and programmable logic controller.
- *Testing and Modification* - After designing the control system, the design is being tested in the view of desired automation of the machine and if the design was not success, the modifications would be done and finally the required automated operation of the machine was obtained.

8. SOFTWARE DESCRIPTION

Delta PLC module is used for the system. Ladder diagram was used as programming language; the ladder programming has been developed for process control of boring machine. RS-232 communication cable is used to dump the program from PC to the PLC and vice versa. RS-485 is used for communication between the Drive and the HMI.

The ladder program will execute the operation of boring machine as per the rung developed. For manual and auto process mechanism, the auto programming process will starts the boring machine and the each step of the operation will be monitored using HMI. In ladder diagram the program is written in high level language. As the random access memory or flash memory erasable programmable read only memory can admittance the binary instruction the ladder diagram should be converted into binary instruction. Each binary instruction is executed by the CPU. Flowchart is given in Figure 5 for the program and the developed ladder diagram in (Figure 7).

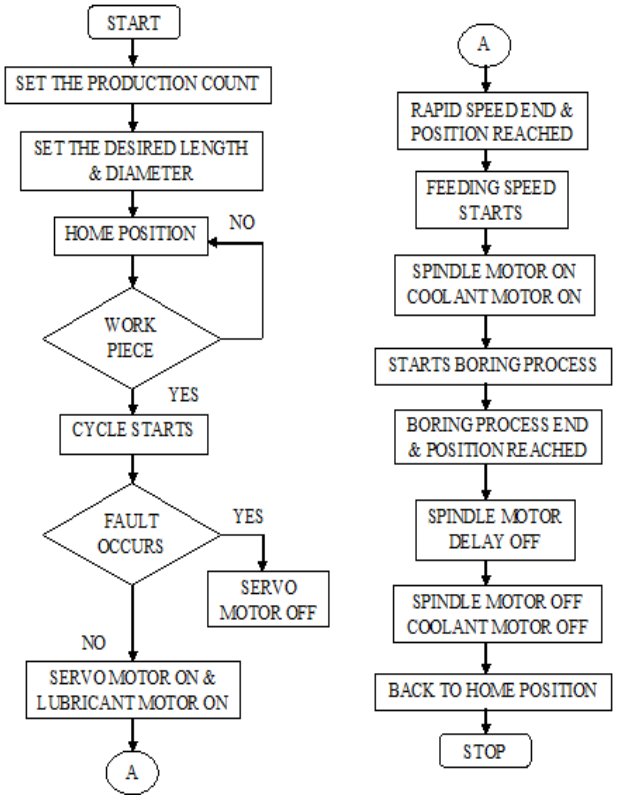

Figure -5: Flowchart of the system

STEP 1: In the proposed system, set the number of batches, initialize the length and diameter of the bore as per the requirement and work piece is placed at BMC.

STEP 2: Cycle starts, servo motor and lubricant motor ON.

STEP 3: When BMC completed its rapid speed and starts BMC feeding speed then Spindle motor ON.

STEP 4: Boring process starts.

STEP 5: when feeding speed completes spindle OFF and boring process completed.

STEP 6: BMC back to home position.

In the proposed system set production count and initialize required dimensions (length and diameter). Work piece placed the BMC (boring mechanism carriage), then check the condition whether the work piece present or not, then actuates the relay and turn ON the servo motor and lubricant motor. After some distance BMC travels in rapid speed, when BMC moves towards the spindle motor it moves at certain speed is called rapid speed. Then check the condition whether the rapid speed reached or not, when rapid speed ends, next starts feeding speed and now starts spindle motor and coolant motor. When BMC fed to the tool it moves at certain speed which is called as feeding speed.

The boring process starts, now boring tool (bar) to bore the work piece as the boring tool reaches the pre-set values, it Bring holes to the proper size and finished boring process. Here check the condition whether the boring process completes or not. When the boring process is finished then spindle motor off, coolant motor off and BMC back to home position. The internal arrangement of the control panel show in Figure 6 and the components are mounted on the base plate using din-rail. This arrangement includes PLC, SMPS, relay board, MCB's, contactors, transformer and terminal blocks.

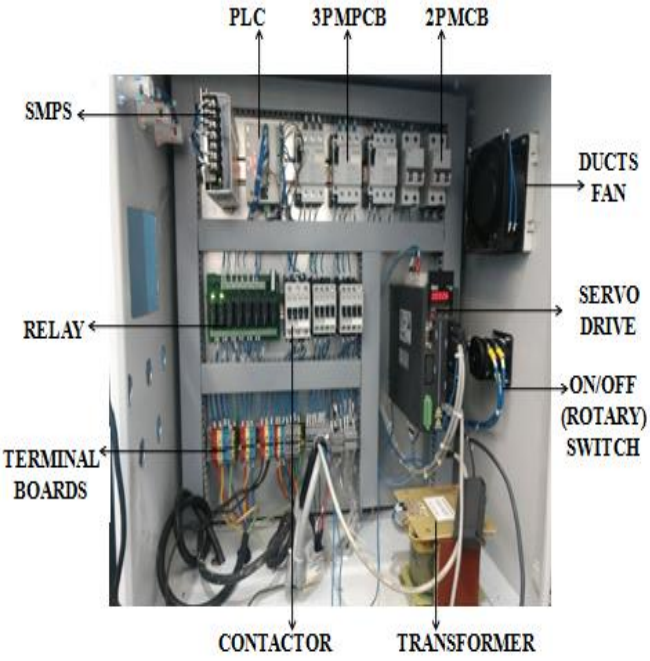

Figure -6: Control panel of the system

9. SIMULATION RESULTS

The simulation results are illustrated in Figure 7 in which the boring machine operation is discribed using the developed ladder logic. The each rung developed is shown below and the simulated results aere shown.

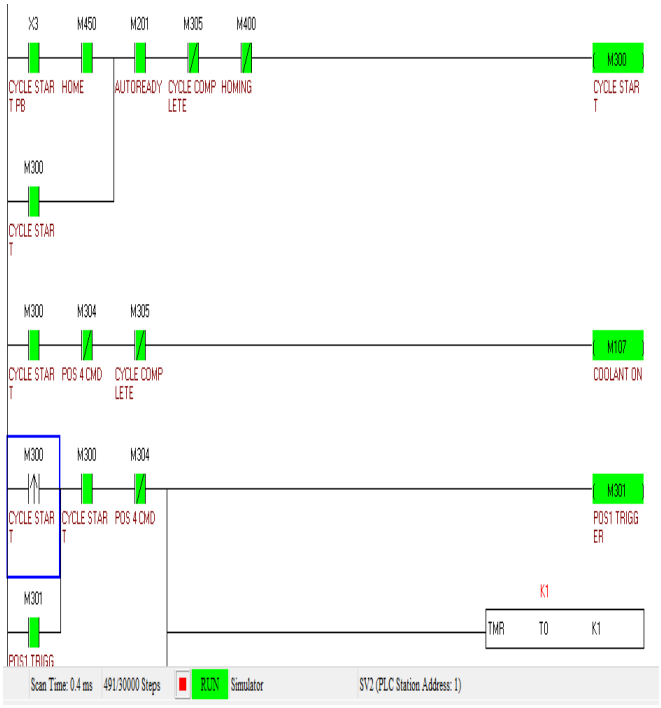

Figure -7: Ladder diagram of boring machine

Implementation Impacts: The machine is running successfully through newly automated system and the main objective was to increase the production rate and it is achieved successfully.

Production comparison:

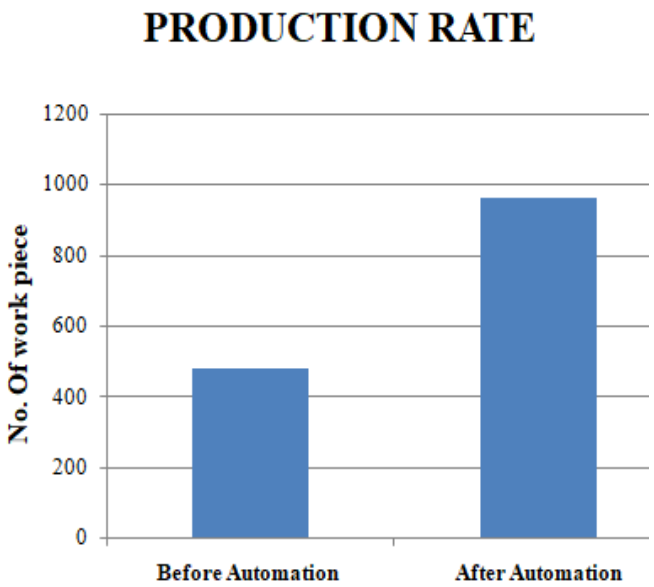

Figure -8: Production comparison chart

The above bar chart (figure 8) which presents the production comparison in numbers for both manually and automatically running machine. The comparison of both conditions is with regarding Production Rate. It is found that the machine running under automation process is having improved production rate, i.e. the number of components which were tested manually are approximately 480 per 8 hours. In case of automation the components are approximately 960 per 8 hours. Which clearly indicates that the ratio of productivity among manual and automation process is staying at **1:2** which in turns indicates the overall work efficiency is increased in huge number and the accuracy is tuned to the best level (100%). Finally, the verified results were found satisfactory and accepted by the company thereby inferring that the automation of the machine was successful.

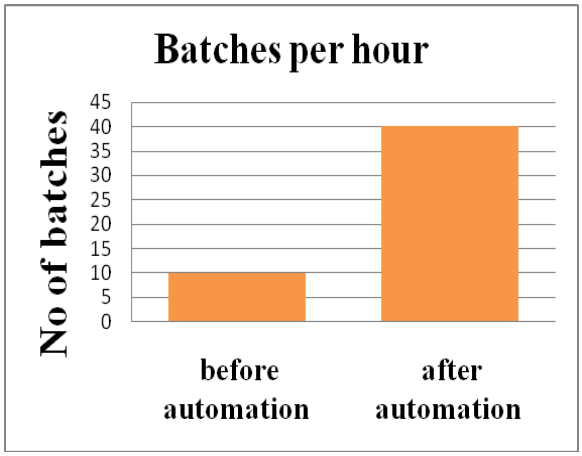

Figure -9: Batches per hour

The comparison between the productions of number of preset batches per hour, before automation and after automation in the system is gradual increases in completion in the number of batches per hour, shown in figure 9. The percentage of wastage of in the raw materials of the product is in decreases in order, shown in figure 10.

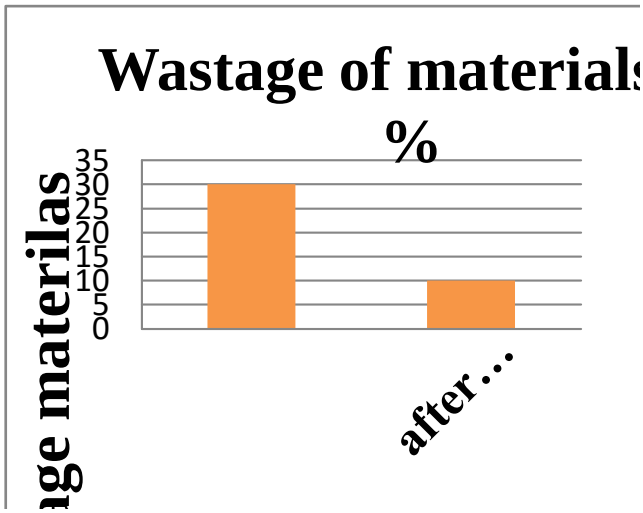

Figure -10: Wastage of materials in %

10. FUTURE USES

The boring Process at the industry using PLC can be extended using SCADA and IOT technologies. These latest technologies help in master control of the entire process from remote locations. These technologies can also be adopted in the boring machine process for increasing the production rate.

11. CONCLUSION

In this study, the boring machine was automated using ladder logic in PLC. A simple Electrical and manually operated Linear Machine which is used for boring machine Process, is time consuming and the whole process is stopped if any fault occurs at any part of the machine and man power is required, which was one of the disadvantage in terms of production and maintenance. This boring machine becomes phenomenally productive and flexible by automating it. The automated boring machine is controlled using PLC which is time saving process and HMI enables the operation of the machine which is easier for non-skilled workers too. Also, the machine operation requires less man power, with minimized production loss and reduced errors in boring. In case of fault, tracing of circuit is not necessary as all the commands are given through HMI, thereby increasing the reliability of the process. This will fulfill the requirements of the industry with good levels of accuracy and repeatability thereby yielding a more robust industrial process.

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