DESIGN AND IMPLEMENTATION OF AUTOMATICALLY CONTROLLED BORING AND MILLING USING PLC

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Abstract

The aim of the project is to implement the automatically controlled boring and milling process by PLC and servo drives. The manual method to produce gear case/ casted product requires seven operations and seven labors to operate the process. The PLC is used to automate the process by using ladder diagram program in which sequence of operations are programmed. The movement of material to feed the cutting tool is carried out by the sliding guid which is controlled by the servo drives. This project is cost effective and saves the process time and maintains accurate dimensions of the product. HMI is used for interfacing between human and machine.

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1. INTRODUCTION

Now-a-days in every field there is atomization, as it saves labor, saves energy, materials and to improve quality, accuracy and precision. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronics and computers, usually in combination.

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[1].

Milling is a cutting process that uses a milling cutter to remove material from the surface of a work piece. The milling cutter is a rotary cutting tool, often with multiple cutting points. Both of these processes play major role in machining [2].

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[1][3].

The PLC was invented in response to the needs of the American automotive industry. Before the PLC, control, sequencing, and safety interlock logic for manufacturing automobiles was accomplished using relays, timers and dedicated closed-loop controllers. The process for updating such facilities for the yearly model change-over was very time consuming and expensive, as the relay systems needed to be rewired by skilled electricians. In 1968 GM Hydrometric (the automatic transmission division of General Motors) issued a request for proposal for an electronic replacement for hard-wired relay systems. One of the people who worked on that project was Dick Morley, who is considered to be the "father" of the PLC.

Well known PLC brands are Siemens, Allen-Bradley, ABB, Mitsubishi, Omron, and General Electric.

A programmable logic controller(PLC) is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines or light fixtures. PLCs are used in many industries and machines.

The main objective of this project is to “Implement the automatically controlled boring and milling machine using PLC and Servo drives”. Machining parameters can be easily set through PLC which enables better machining efficacy [4].

Components can be machined in fast, precise, and low cost way. For different component sizes, the fixtures are easy to change, spindle positions are also adjustable. The production is stable and efficient with accurate dimensions. This machine is operated by a single operator called a programmer. This machine is capable of performing various operations automatically and economically.

2. LITERATURE REVIEW

“Manufacturing Technology-boring” by Valery Marinov. Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the work part can be rotated. Machine

tools which rotate the boring bar against a stationary work piece are called boring machines (also boring mills). Boring can be accomplished on a turning machine with a stationary boring bar positioned in the tool post and rotating work piece held in the lathe chuck as illustrated in the figure. In this section, we will consider only boring on boring machines[1].

"Technology of milling tools" by Krar, Gill and Smid (6th edition). Used to produce one or more machined surfaces accurately on work piece One or more rotary milling cutters. Work piece held on work table or holding device and brought into contact with cutter. Vertical milling machine most common. Horizontal milling machine handles operations normally performed by other tools[2].

Milling machine operations sub course no. Od1644 edition 8 by Thru Growth. The milling machine removes metal with a revolving cutting tool called a milling cutter. With various attachments, milling machines can be used for boring, slotting, circular milling dividing, and drilling. This machine can also be used for cutting keyways, racks and gears and for fluting taps and reamers[3].

3.EXPERIMENTAL DETAILS

Initially work part is produced by casting process of which dimensions are inaccurate. So the work part has to be processed by many material removal processes like boring, milling etc to obtain finished product of accurate dimensions [1].

In this project tractor gear case is the work part which is to be machined in 7 different machines. The work part has two holes to be bored and two surfaces to be milled. The die casted gear case is clamped on the worktable which can be moved in horizontally [2].

In this boring and milling process carried out by using 440V three phase induction motors. In this process the work part initially at home position and the movement of work part is carried out by using sliding guide way. Movement of guide way is done using 220V servo motors. The motions of servo motors are controlled by the j4 Mitsubushi servo drive which works on the basis of instruction given by the Q00UJCPU PLC.

When the work part moves towards the induction machine it moves at certain speed which is called as a rapid speed. When it fed to the tool it moves at certain speed which is called as feeding speed. Speed of the sliding guide way is defined by the user by using HMI (Human Machine Interface).

A.HARDWARE COMPONENTS

1. PLC (Programmable Logic Controller)

A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process.

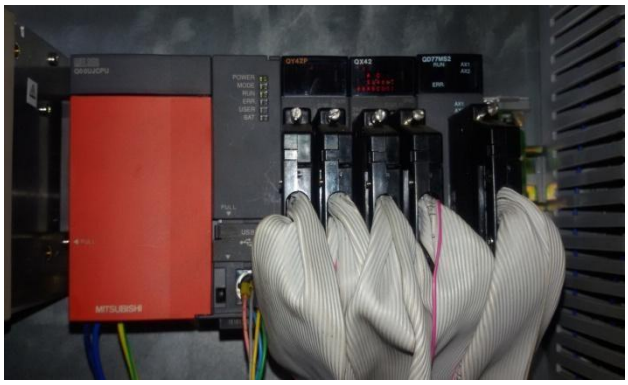

FIG-1 Q00UJCPU (MITSUBUSHI) PLC (Programmable Logic Controller)

In this PLC the CPU module, power supply module, I/O module and/or intelligent function module are installed in base rack. The left slot is for Power Supply module just right of Power Supply; the CPU module is mounted followed by the input/output ports.

a) I/O MODULES
Digital input modules: QX_

- Electrically isolated with optocouplers
- Removable terminal blocks for 16 connection addresses
- D-Sub or 40-pin plug connector for 32 or 64 addresses
- Choice of wiring solutions, adapter accessories

Digital Output modules: QY_

- Modules with relay, transistor or triac output technology
- Electrical isolation of process/control and also channels in some cases
- Choice of interface modules

Table No.1 Digital Input Module

MODULE	PORTS	VOLTAGE	RESPONSE TIME
QX42	64	24VDC	1/5/10/20/70ms

Table No.2 Digital Output Module

MODULE	PORTS	OUTPUT VOLTAGE	CURRENT
QY42P	64	12/24VDC	0.1A

2. MPCB (Motor Protection Circuit Breakers)

Motor Protection Circuit Breaker is a device which is use to protect motor against over current, over load, and short circuit. The working of the MPCB is same as MCB (Miniature circuit breaker) but the rating to protect the motor is more.

a) MPCB – Advantages

- Compactness
- High Breaking Capacity
- Short circuit protective coordination
- Reduction in wiring work
- Ecological design standards

b) SPECIFICATIONS

- The MPCB can be used in 100ka short circuit current circuits for three-phase.
- 240V motors with rated capacity upto15kw.
- And in 50ka short circuit current circuits for three phase.
- 415V motors with rated capacity up to 30kw.

3. MCB (Miniature circuit breaker)

A breaker is a device designed to isolate a circuit during an over current event without the use of a fusible element. A breaker is a resettable protective device that protects against two types of over current situations; Overload and Short Circuit.

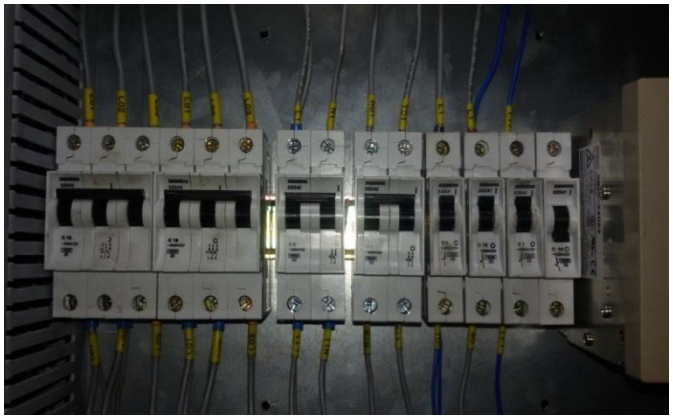

FIG-2 MCB (Miniature circuit breaker)

a). SPECIFICATIONS

- Siemens current limiting breakers interrupt the arc energy in 2.3ms to2.5ms
- And a zero crossing breaker allows the arc to be present for up to 8.3ms.
- A zero crossing breaker will let through100 times as much energy as an ABB current limiting breaker.

4. TRANSFORMER

A transformer is a very common magnetic structure found in many everyday applications.

- AC circuits are very commonly connected to each other by means of transformers.
- A transformer couples two circuits magnetically rather than through any direct connection.
- It is used to raise or lower voltage and current between one circuit and the other, and plays a major role in almost all AC circuits

FIG-3 750VA/220VA TRANSFORMER

The control panel components required 220V power supply so that the 750VA/220VA 6Ohz step down transformer used to step down the 440V supply to 220V.[8]

5. THREE PHASE INDUCTION MOTOR

When three phase ac current given to the stator winding of the induction motor it produces rotating magnetic field.

The rotating magnetic field is due to the change of orientation of the magnetic field. Three phase ac current is a varying current which produce fluctuations. These fluctuations help to generate rotating magnetic field. A conductor is placed in rotating magnetic field induce EMF (elective motive force) according to faradays law. To increase the speed of the induction motor, more number of laminated conductors used then the speed of magnetic field and conductors is same this speed is called synchronous speed. [8] A 220V three phase induction motor is an A.C. Motor. Of all the all ac motor available, it is extensively used, because of the following advantages

- Its construction is simple, rugged and almost unbreakable.
- Its cost is low and high reliable.
- Its efficiency is high.
- It works with reasonable good power factor at rated load.
- Its maintenance is less
- Induction motors are self starting. Hence motors of smaller ratings do not require a starter. The starting arrangements for larger motor are simple.

The disadvantages are,

- It is essentially a constant speed and the speed cannot be changed easily. The speed variation can be done at the cost efficiency.
- The starting torque is inferior to that of D.C. shunt motor

6. RELAY BOARD

Relays are electrically operated switches in which charging a current in one electric circuit switches a current on or off in another circuit. The relay boards are used in this project is to switch the output components.

8 channel active low relay boards are used to control 8 devices this relay boards are directly control by the Q00UJCPU PLC. The signals are directly given to the relay boards by the plc to switch on or off the output components. [8]

Specifications

- This relay module is 5V active low.
- It is an 8channal relay interface board, which can be directly controlled by the plc.
- It is also able to control various appliances and other equipments with large current.
- Relay output maximum contact is AC250V 10A and DC 30V 10A.

FIG-4 8 Channel Active Low Relay Board

7. SERVO DRIVES

2-axis and 3-axis servo amplifiers are available for operating two and three servo motors, respectively. These servo amplifiers enable energy-conservative, compact machine at lower cost. Different types of servo motors including rotary servo motors, linear servo motors, and direct drive motors are freely combined as long as the servo motors are compatible with the servo amplifier.

The servo drives are communicates with the plc using RS232 communication cable. The servo drives control the speed of the servo motors according to the specified speed in the plc programmed memory. MR-J4 servo drive manufactured by the mitsubishi company is used in this project.

Specifications

- Rated output 0.1 t0 7kw.
- Main circuit power supply- 3phase or 1phase 200V AC to 240V AC.

Fig-5 MR-J4 SERVO DRIVE

8. SERVO MOTOR

Servomotors (hk-kr73) are used for sliding guide way movement. The speed of the servo motors are controlled by the MR-J4 servo drive. The speed of the servo drive is given by the operator by using HMI (human machine interface).

a). SPECIFICATIONS

- Power supply 220V
- Maximum torque- 0.16n-m
- Rated speed -3000 r/min
- Maximum speed -6000r/min
- Rated current-0.9 a
- Maximum current- 3.2a

FLOWCHART

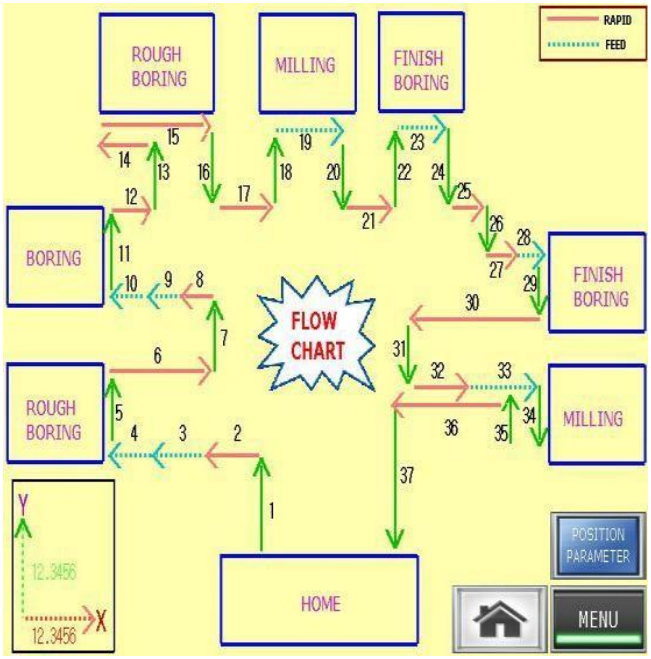

FIG-6 Flowchart

B). Sequence of operations:

- 1st operation: When the process begins the work part is moved to rough boring machine where horizontal boring operation is done.
- 2nd operation: Next boring operation is done by boring machine which is next to the 1st machine.

In these 1st and 2nd operations work part is fed to the boring machines.

- 3rd operation: vertical boring machine is used to bore a vertical hole.
- 4th operation: vertical milling machine is used to mill a surface of the work part.
- 5th operation: another vertical boring machine is used for fine boring of vertical hole.

In these 3rd, 4th and 5th operations work part is kept stationary and machine tools are moved.

- 6th operation: horizontal boring machine is used for fine boring of horizontal hole.
- 7th operation: horizontal milling machine mills another surface of the work part.

In these 6th and 7th operations work part is fed to the boring machines. After these operations the finished product is unclamped and new work part is fixed.

This process is controlled by PLC control panel in which program of instructions for the sequence of operations are written.

6. RESULTS

The final objective of the project is automated control of boring and milling machines to produce a finish. Product of gear case is achieved. The required diameter by the boring process is tested by the reversal process to achieve accurate diameters and the process of milling the product to remove the extra material is done and the whole process time is reduced from 1hour to 10-12 min per product and labors are reduced.

7. CONCLUSIONS

A simple and manual operated machines are used for boring and milling process, which is time consuming and several labor power is required which was the disadvantage in terms of labor, production and maintenance. These machines becomes phenomenally productive and flexible by retrofitting them with automated controllers. Upgrading the old machines restore them close to their original performance levels. The concept of remanufacturing machine tools is emerging. These are cost effective solutions of automation (on PLC based control systems) are equally beneficial to the small, medium and large industries. This project undergoes automation which is controlled by PLC control panel, speed of the motors used for boring and milling controlled by the servo drives.

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