Design of Semi-automatic Slotter Machine using PLC

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***Abstract*—Now-a-days automation is prime requirement in industry. Hydraulic system, PLC, controller are key components of any automation. Machining attributes a major channel of finish goods. CNC turning centres, VMC and CNC grinding are available in the market but a retro fitting of Slotter machine is prime requirement as it is not readily available. So here attempt is to made to semi automate the Slotter machine using PLC and hydraulic system.**

***Index Terms*—Slotter machine, hydraulic system, PLC and Automation.**

I. Introduction

Hydraulics is by far the simplest method to transmit energy to do work. It is considerably more precise in controlling energy and exhibits a broader adjustability range than either electrical or mechanical methods. A hydraulic system using oil is governed by the basic physical law of fluid flow as developed by the great scientist Blaise Pascal (1648). This law is known as “Pascal’s law”. The industrial hydraulic system is a power transmission system using oil to carry the power. To design and apply hydraulics efficiently, a clear understanding of energy, work, and power is necessary [1]. The inputs and outputs of any power and control system including the hydraulic system are mechanical such as a rotating shaft or reciprocating plunger. An added advantage is that this system is easily adoptable to a variety of energy forms and the signals may be initiated by electrical, chemical, manual, optical, electronic/digital or acoustic means. Hand levers, plungers, springs, rollers and strikers, solenoids and torque motors are common examples of control inputs, while the output may be the movement of a piston rod or the turning of a shaft [2].

A. Comparisons of electrical and hydraulic systems

TABLE I. Comparisons of Electrical and Hydraulic Systems

	Electrical	**Hydraulic**
Energy source	Usually from outside supplier	Electric motor or diesel driven
Energy storage	Limited (batteries)	Limited(accumulator)
Distribution system	Excellent, with minimal loss	Limited basically a local facility
Energy cost	Lowest	Medium
Rotary actuators	AC & DC motors. Good control on DC motors. AC motors cheap	Low speed. Good control. Can be stalled
Linear actuator	Short motion via solenoid. Otherwise via mechanical conversion	Cylinders. Very high force
Controllable force	Possible with solenoid & DC Motors Complicated by need for cooling	Controllable high force
Points to note	Danger from electric shock	Leakage dangerous and Unsightly. Fire hazard

B. Introduction of Programmable Logic Controller

A programmable logic controller (PLC) is a special form of microprocessor based controller that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes and are designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages. They are not designed so that only computer programmers can set up or change the programs. Thus, the designers of the PLC have pre-programmed it so that the control program can be entered using a simple, rather intuitive, form of language. The term logic is used because programming is primarily concerned with implementing logic and switching operations, e.g. if A or B occurs switch on C, if A and B occurs switch on D. Input devices, e.g. sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e. a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program and carries out the control rules for which it has been programmed.

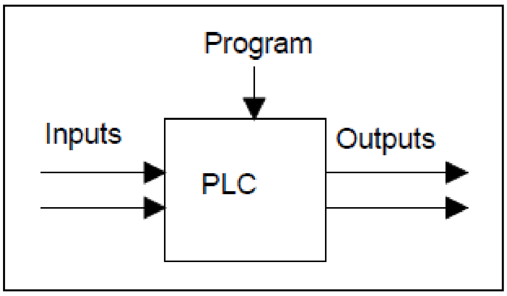

Fig. 1. A programmable logic controller.

PLCs are similar to computers but whereas computers are optimized for calculation and display tasks, PLCs are optimized for control tasks and the industrial environment. Thus PLCs are:

1 Rugged and designed to withstand vibrations, temperature, humidity and noise.
2 Have interfacing for inputs and outputs already inside the controller.
3 Are easily programmed and have an easily understood programming language which is primarily concerned with logic and switching operations.

II. COMPONENTS USED IN HYDRAULIC SYSTEM

A. Hydraulic reservoirs

A hydraulic system is closed, and the oil used is stored in a tank or reservoir to which it is returned after use. Although probably the most mundane part of the system, the design and maintenance of the reservoir is of paramount importance for reliable operation. The volume of fluid in a tank varies according to temperature and the state of the actuators in the system, being minimum at low temperature with all cylinders extended, and maximum at high temperature with all cylinders retracted. Normally the tank volume is set at the larger of four times the pump draw per minute or twice the external system volume. A substantial space must be provided above the fluid surface to allow for expansion and to prevent any froth on the surface from spilling out. The tank also serves as a heat exchanger, allowing fluid heat to be removed.

B. Filters

Dirt in a hydraulic system causes sticking valves, failure of seals and premature wear. Even particles of dirt as small as 20/x can cause damage, (1 micron is one millionth of a metre; the naked eye is just able to resolve 40/x). Filters are used to prevent dirt entering the vulnerable parts of the system, and are generally specified in microns or meshes per linear inch (sieve number).

C. Directional Control Valves

Hydraulic systems require control valves to direct and regulate the flow of fluid from pump to the various load devices. Two types of construction are generally used for common direction control valves, 1. Seat valve or poppet valve, 2. Spool valve or sliding valve

Directional control valves are actuated by various techniques like manually, mechanically, hydraulically, pneumatically, electrically.

D. Hydraulic Actuators

Various types of actuators are used in hydraulic systems, e.g. hydraulic cylinders, motors, etc. A cylinder is device which converts fluid power into linear mechanical force and motion. It usually consists of a movable element such as a piston and piston rod, plunger or ram operating within a cylinder bore. Functionally cylinders are classified as: Single acting cylinders and Double acting cylinders. In contrast to a cylinder hydraulic motor provides rotational motion is used in a hydraulic system for a variety of applications where rotary movement is the need. Hydraulic motors generally may be: Uni-directional, or Bi-directional.

E. Flow Control Valve

The speed of hydraulic actuator by varying the port opening of the flow control valve. This valve is basically a flow control valve which regulates the fluid flow by enlarging or reducing the port area while the oil is passing through the passage. Thus continuous step less control of speed of a cylinder or a hydraulic motor is possible with such a valve [3].

F. Proximity Sensor

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object [4].

G. Programmable Logic Controller

Typically a PLC system has the basic functional components of processor unit, memory, power supply unit, input/output interface section communications interface and the programming device. Fig. 2. shows the basic arrangement.

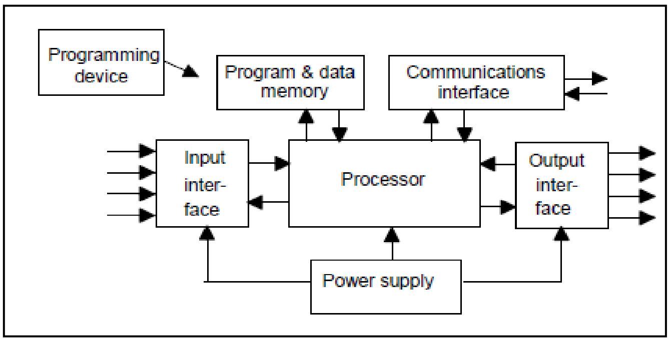

Fig. 2. The PLC System.

The processor unit or central processing unit (CPU) is the unit containing the microprocessor and this interprets the input signals and carries out the control actions, according to the program stored in its memory, communicating the decisions as action signals to the outputs.

The power supply unit is needed to convert the mains A.C. voltage to the low D.C. voltage (5 V) necessary for the processor and the circuits in the input and output interface modules.

The programming device is used to enter the required program into the memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.

The memory unit is where the program is stored that is to be used for the control actions to be exercised by the microprocessor and data stored from the input for processing and for the output for outputting.

The input and output sections are where the processor receives information from external devices and communicates information to external devices. The inputs might thus be from switches with the automatic drill, or other sensors such as photo-electric cells, as in the counter mechanism temperature sensors, or flow sensors, etc. The outputs might be to motor starter coils, solenoid valves, etc. Input and output devices can be classified as giving signals which are discrete, digital or analogue [5,6].

III. Hydraulic System Design for Slotter Machine

A. Hydraulic Circuit

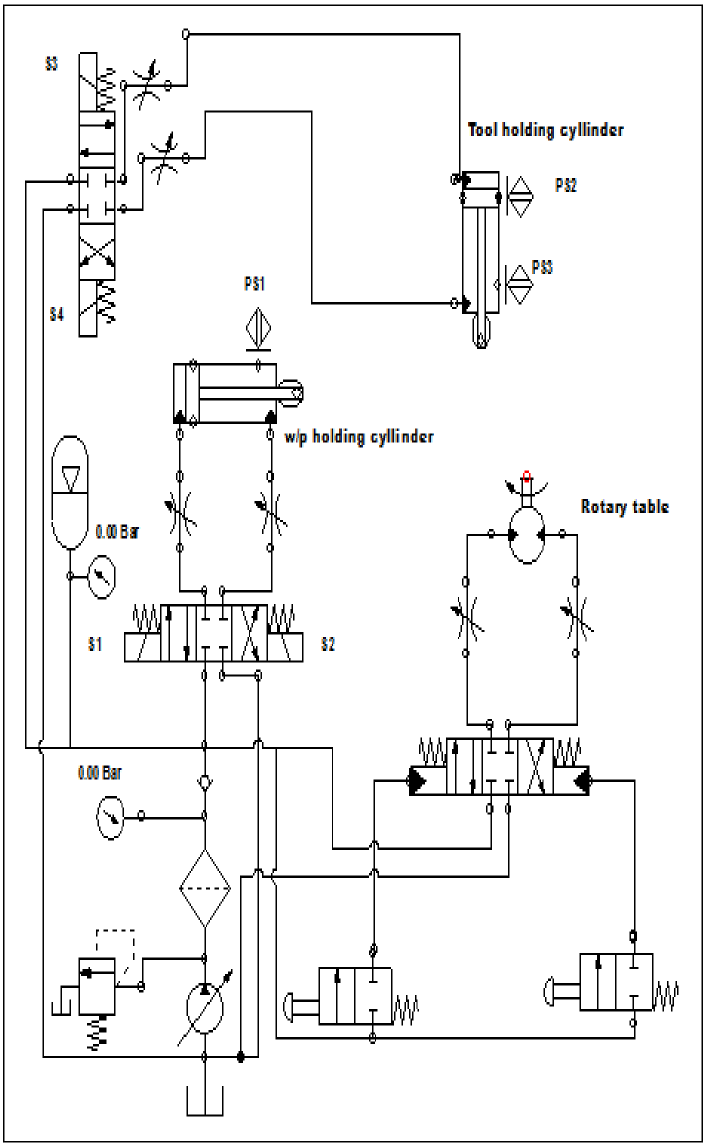

Fig. 3. Hydraulic Circuit.

B. PLC Programming

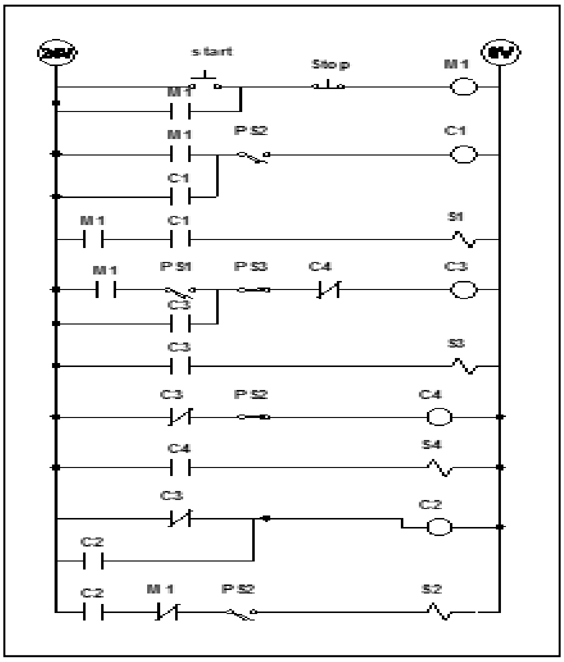

Fig. 4. PLC programming.

C. Working

Above hydraulic circuit is controlled by PLC. In this hydraulic circuit, position of hydraulic cylinder is sensed by proximity sensor and according to PLC programming solenoid operated valve take the appropriate action.

IV. Conclusion and Future Scope

Hydraulic Slotter Machine controlled by PLC having following advantages over the conventional Slotter machine.

Positional accuracy of stroke length is achieved.

Variable speed of cutting stroke is achieved.

Step less motion of cutting stroke is achieved.

Power consumption is according to the load.

As a future scope, one can automate the motion of worktable feed and make the complete automated Slotter machine.

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