Designing a PLC-Controlled Conveyor System Correlated with Die Casting Machine

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Abstract

The conveyors are the main earliest component of material handling. There are several types of conveyors used in industry like belt conveyor, chain conveyor, gravity conveyor, etc. A PLC (Programmable logic Controller)-controlled hydraulic conveyor system was programmed using the Rslogix 500 software, and the system was successfully tested in the Hydraulic Laboratory. PLC's advanced programming capabilities for timers and counters, as well as programmable variable inputs, are key

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operational features that minimize the inputs and outputs required by the PLC. In addition, an integrated system of the die casting and the conveyor system was done to create a production line for a modular factory. The integrated system was first drawing using the Solid work software to illustrated the sequence of that system, then a TLP (LogixPro Simulator) Logic was used to simulate and test such system.

Keywords

1. Introduction

The "Mechatronics" is now being extended in Flexible Manufacturing System (FMS). The material handling was one of the important applications of mechatronics in FMS followed by robotics. In this paper the main focus is to develop a demonstrative setup of conveyor system with programmable workstations. The conveyer system is selected as it is most commonly used, simple to illustrate, and it has highly complicated PLC programming aspects. (A, 1997)

PLC control of materials handling is widely used in industry to control and monitor the carrying of manufactured parts. The PLC controls all the sequential operations necessary to load and circulate parts on conveyors as well as transferring parts to the packing or storage system. The PLC allows various handling operations to be performed, such as sorting parts according to weight, size, or content, dumping parts when a certain weight or count has been reached, transferring parts from one conveyor to another, and stacking parts in shipping containers. The PLC can also keep track information on the quantity of parts in a storage area,

provide signals to inform the operator of any conditions or malfunctions, and monitor total, rejected, and produced parts. (William, 2009)

Xiaohui Cheng and Jie Wan (2013) indicated in his paper that the supply speed of the coal and energy utilization rate of telescopic belt conveyor can be increased up to 150% by implementing PLC based conveyor system. In addition, Kanmani et al. (2014) explains in his paper about the need of automation and proposes a SCADA and delta series PLC based automation system which is highly reliable and efficient in operation without delay.

2. Working Methodology

Figure below shows a PLC-controlled conveyor system that conveys manufactured parts and loads them on a packing machine. The system consists of a hydraulic conveyor, a lift cylinder that raises Boxes arriving from the conveyor, and a load cylinder that pushes Boxes onto a container that packs parts by groups of 5. (Lab-volt, 2007)
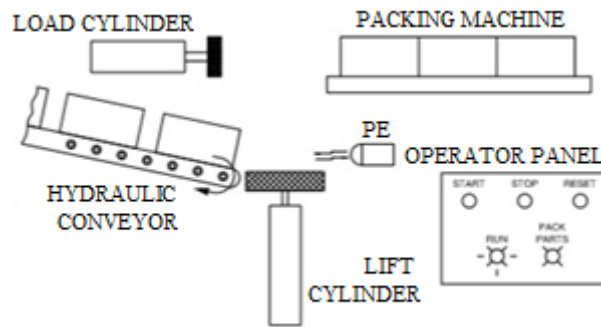
a- Conveyor circulates parts toward the lift cylinder.
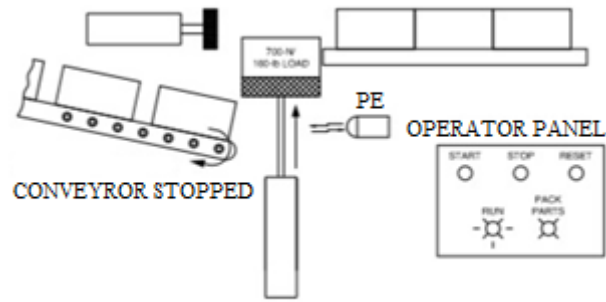
b- Conveyor stopped, lift cylinder extends.
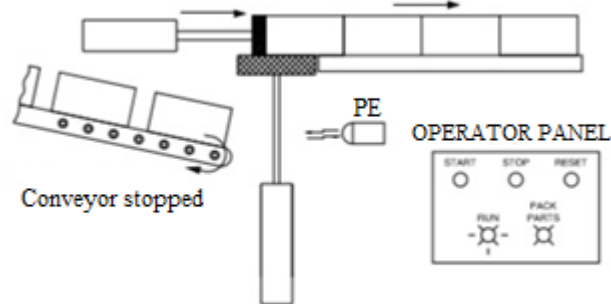
c- Lift cylinder pushes part onto the packing machine.

Fig. 1: Description of Conveyor system Operation. (Lab-volt, 2007)

3. Design Steps for a PLC- Controlled Hydraulic Conveyor System

A PLC-controlled hydraulic system that simulates the operation of conveyor system is described as following

First a hydraulic circuit has been connected as shown in the figure2.
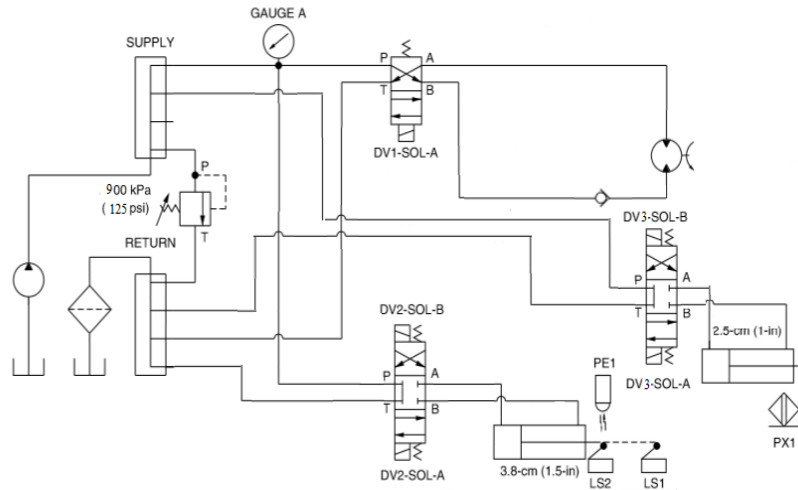
Fig.1: Hydraulic Circuit.

Consequently, the PLC controlled hydraulic system (Inputs and outputs) had been connected as shown in the wiring layout in Figure.3.
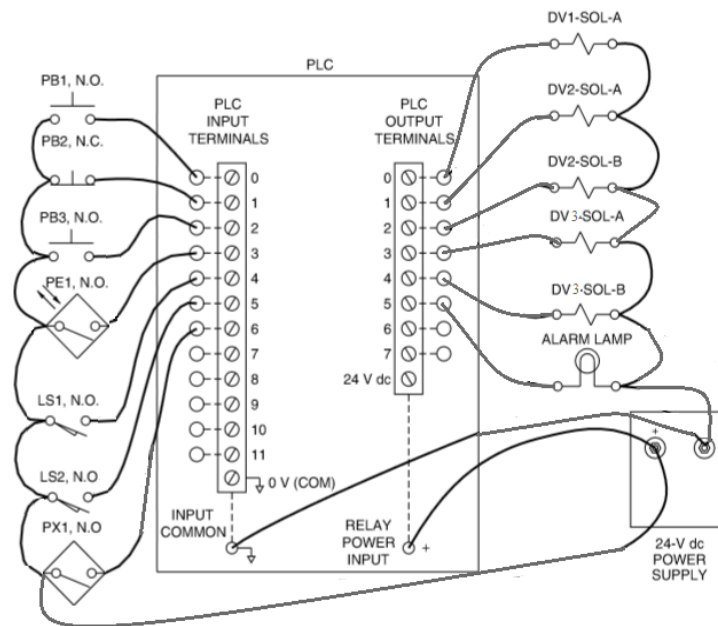
Fig.2: PLC Wiring Layout.

The actual design of hydraulic circuit of the conveyor system that is controlled by Programmable logic controller is shown in Figure.4

Fig..المستند في المعين النمط من نص يوجد لا !خطأ3: A Real model of PLC-controlled conveyor system.

The PLC program of the conveyor system has been programmed in RS Logix 500 and is described as follow in the flow chart.

Fig.4: PLC-controlled Conveyor System Flow Chart

To accomplish this design, the program was downloaded to the PLC, then the PLC was placed in Run mode. Subsequently, the machine is started by means of a **START** pushbutton **PB1**. During machine operation a hydraulic motor is turned on (conveyo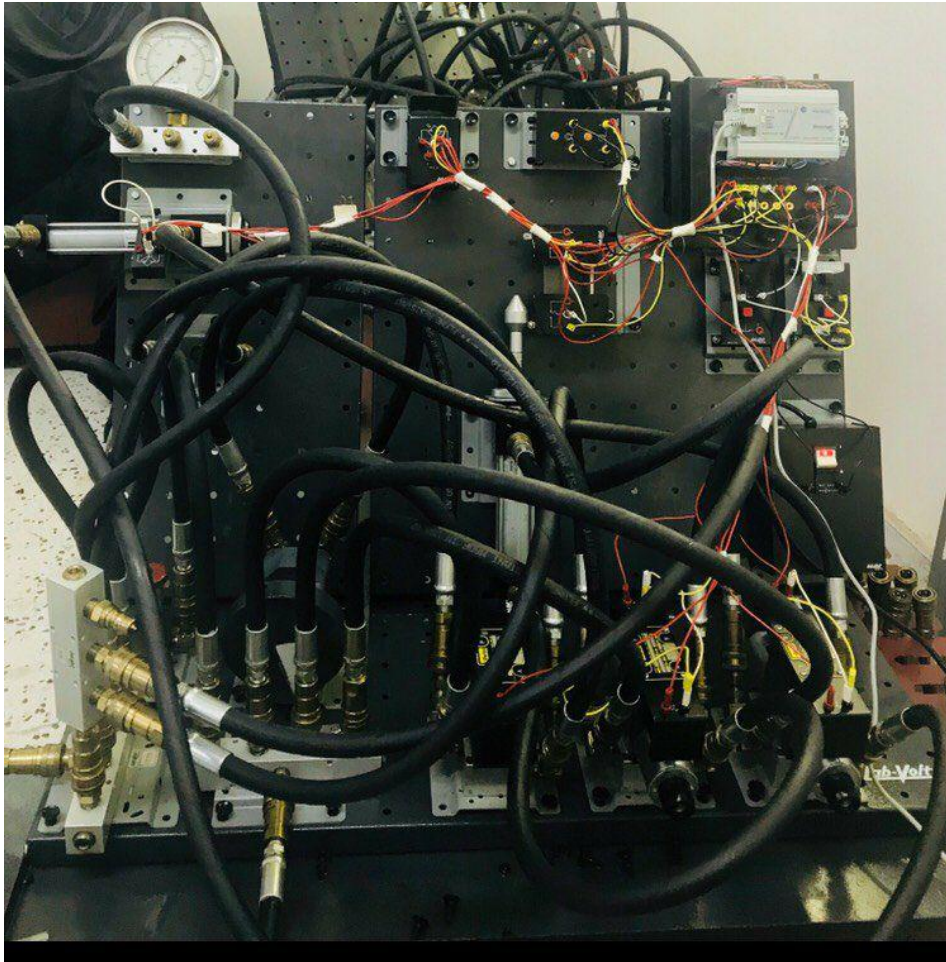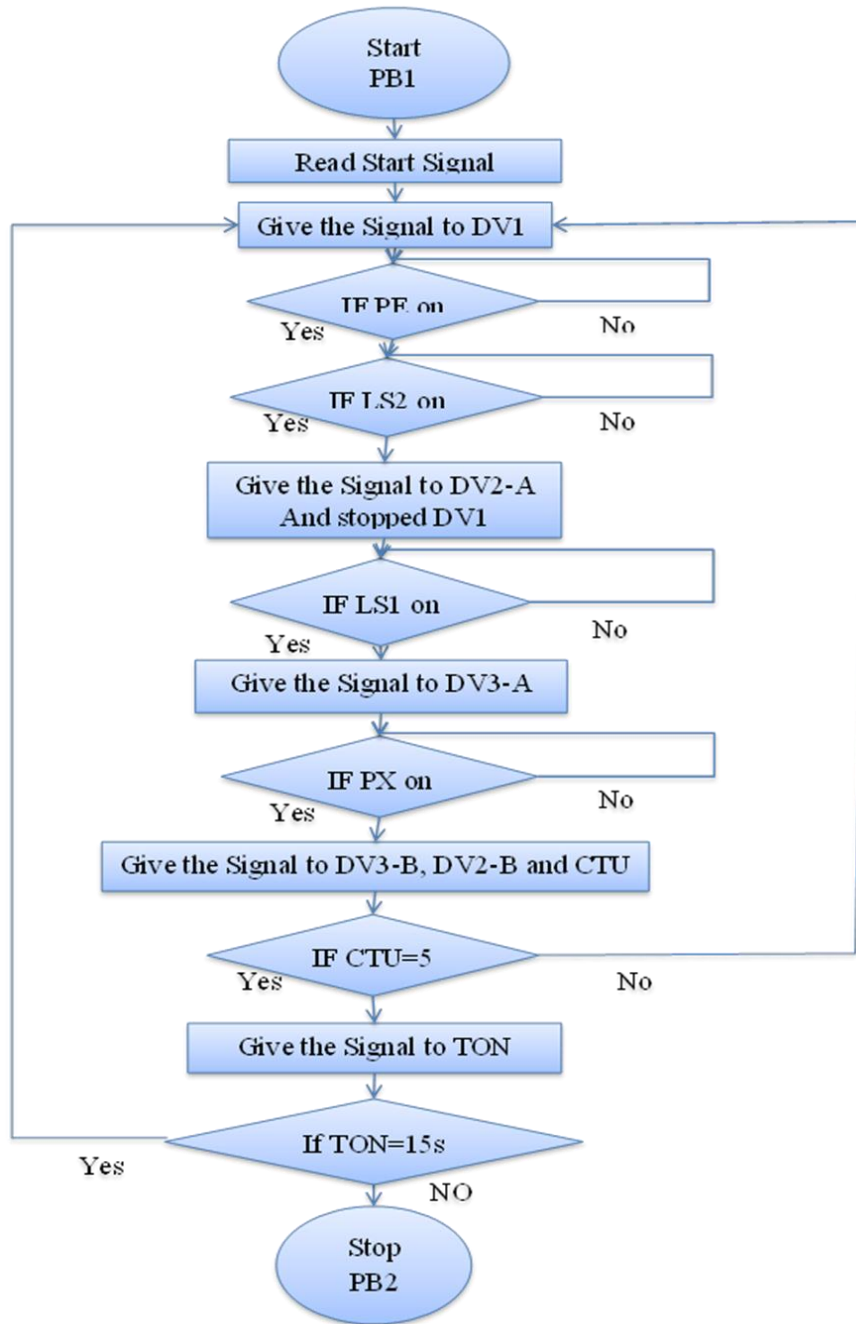r). The hydraulic motor transfers the boxes to the lift cylinder. As the first box reach the lift cylinder, the diffuse reflective photoelectric switch (**PE**) sent a signal that leads to the operation of **LAMP1** and provided the engine an order to stop and assigned the lift cylinder an order to move to the top.

When the lift cylinder is fully extended, the Limit-switch assembly (**LS1**) which is installed on the cylinder sent a signal to the load cylinder to move forward and pushing the box to the container. When the load cylinder is completely extended, the Magnetic proximity switch (**PX**) that installed on that cylinder sent a signal to both cylinders to retract to its original position. Moreover, the proximity switch (**PX**) count the boxes that reach the container.

When both cylinders (lift and load) are completely retracted, the Limit-switch assembly (**LS2**) fixed on the lift cylinder sent a signal to restart the engine (conveyor) to move a new box.

The process will be repeated to move a specific number of boxes, and when the required numbers has been reached, the system stopped and the **LAMP2** (PACK PARTS) will be activated to inform the operator that the parts are ready to be packed. After the programmed resting time (TD) had passed, the device was automatically restarted.

There is an emergency button **PB2** that stops the machine at any emergency condition and can be restarted with a START button so that it is returned from the same steps where it had been stopped.

In addition, there is a **RESET** button **PB3** which turns off the PACK PARTS lamp **LAMP2**, and by pressing the **START pushbutton** can restart the cycle at any desired time by the operator.

4. Correlation Between Die Casting Machine and the Conveyor System

Both die casting machine and conveyor systems have been integrated into a complete integrated system for a typical factory design. Due to the lack of sufficient entries and exits for the PLC System in the laboratory, TLP LogixPro Simulator has been used for simulation such a system. Fig.6 shows the map of this system that was designed and simulated to verify its operation.

The process of the integrated system will rely on the position of the packing box on the conveyor. When the packing box reached the desired position (under the mold), the photoelectric sensor will send a signal to stop the movement of the conveyor. Afterwards; The casting process will start and will continue until certain number of products are being casted. After the box has been filled out with products, the casting Process will be stopped and the conveyor will be run to bring another box. Meanwhile, there is a system that deliver these boxes into a container or packing place. After the container is filled out with boxes, the system stops completely until the boxes are removed, and starts the whole Process again automatically.
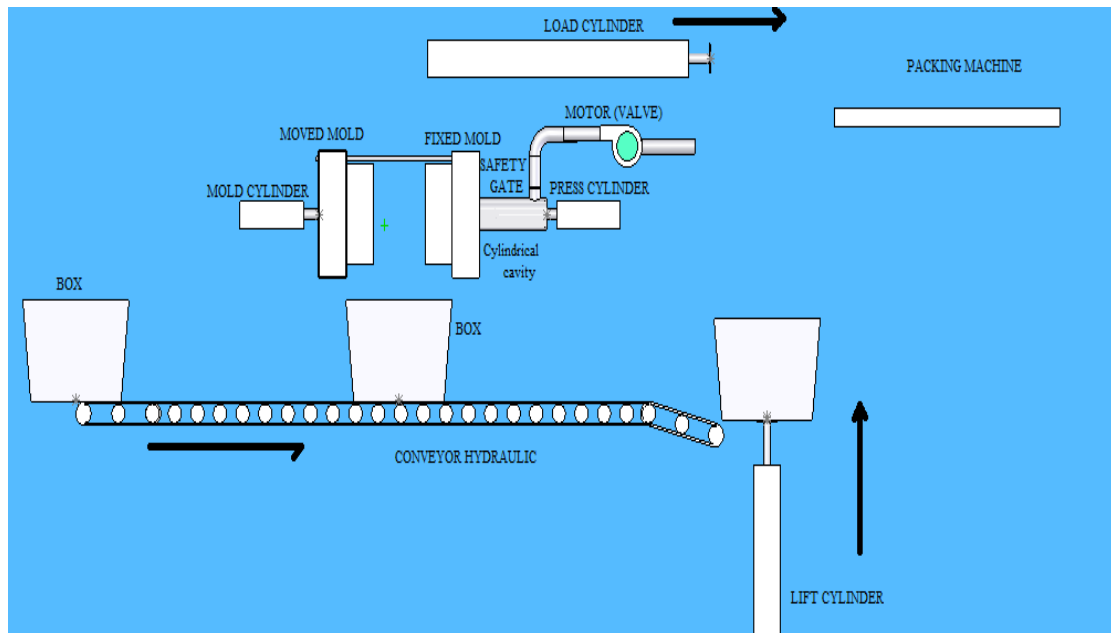
Fig.5: Correlation Between Die Casting Machine and Conveyor System.

5. Design steps for a PLC-controlled hydraulic correlated die-casting and conveyor system.

A PLC-controlled hydraulic system that simulates the operation of correlated conveyor and die casting system is described in the following Steps:

When The system is started by means of a **START** pushbutton **PB1**. The LAMP1 is turned on. Meanwhile, the conveyor moves and carries the packing boxes. Immediately after the box arrives under the mold the diffuse reflective photoelectric switch **PE1** sends a signal to the conveyor to be stopped, and to order the engine to infuse the melted metal inside the tube. In the meantime, the safety gate will be opened.

When the hydraulic motor reaches the number of 15 cycles by means of counter **CTU1**, the diffuse reflective photoelectric switch **PE2** sends an order to the safety gate to be locked.

During these steps, the Limit switch assembly that installed on the safety gate sends a signal to the load cylinder to inject the molten inside the mold. When the cylinder pressure reaches 900 kPa (125 psi), the pressure switch assigned the load cylinder an order to compress for 10 seconds using the time delay **TD1** to provide the required solidification time for the molten metal. After the molten metal has solidified the Load cylinder returns to its original position. Meanwhile, the mold will be opened by another cylinder, and the process will be repeated to produce 10 products. The repeating process will be done through the combination of the Magnetic proximity (**PX**) switch that installed on the cylinder and the counter **CTU2**.

As soon as the desired number of products has been reached, the counter **CTU2** sends an order to stop the casting process, and consequently sends an order to the conveyor to start moving.

The distance between the boxes on the conveyor must be fixed. Where if one of the boxes reached the position under the mold, another filled box must be on the lift cylinder to operate at the same time. This fixed distance is attained through using gates and other photoelectric sensors.

There is a diffuse reflective photoelectric switch that senses the arrival of the box above the lift cylinder. This sensor sends a signal to the cylinder to lift the box. When the lift cylinder is expanded the Limit switch assembly that fixed on the cylinder sends a signal to the load cylinder to push the box into the container. When the load cylinder is expanded, the Magnetic proximity switch that installed on that cylinder sends a signal to command both cylinders (load and lift) to be retracted. In addition, same sensor will provide an order to the counter **CTU3** to count the box on the package machine. After the desired number of boxes

has been reached, the counter **CTU3** stops the system completely for a certain period of time which has been programmed through the time delay **TD2** in Rslogix. Meanwhile, the **LAMP2** is activated to provide an Indication that this system was stopped. When the programmed time in time delay **TD2** had passed, the system is restarted again automatically. In addition, the system is supplied with a stop button **PB2** to stop the process at any emergency condition. Furthermore, there is a third button **PB3** that using to return the load cylinder to its original position when there is any emergency condition.

The PLC program of the correlated die casting and conveyor system has been programmed in TLP Simulator and is described in the flow chart shown in fig.7

```
                    Start
                    PB1
                      |
              Read Start Signal
                      |
         Give the Signal to DV1
              and L1
                      |
              IF PE1 on ————————— No
               Yes    |
              IF LS2 on ————————— No
               Yes    |
         Give the Signal to DV2
         And stopped DV1
                      |
              IF PE2 on ————————— No
               Yes    |
         Give the Signal to
              CTUO
                      |
           IF CTUO=15 on ———————— No
               Yes    |
         Give the Signal to DV3-A
         And Stopped DV2
                      |
              IF LS1 on ————————— No
               Yes    |
         Give the Signal to DVU4-A
                      |
```

```
                    │
                    ▼
          ◇ IF PS on ◇ ◄─────────────┐
         Yes│        No               │
            ▼                         │
    ┌─────────────────┐               │
    │ Give the Signal │               │
    │    to Ton0      │               │
    └─────────────────┘               │
            ▼                         │
       ◇ IF Ton0=10s ◇ ◄──────────┐   │
      Yes│          No            │   │
         ▼                        │   │
  ┌────────────────────┐          │   │
  │ Give the Signal to │          │   │
  │  DV4-B and DV5-B   │          │   │
  └────────────────────┘          │   │
            ▼                      │  │
        ◇ IF PX2 on ◇ ◄────────┐   │  │
      Yes│          No         │   │  │
         ▼                     │   │  │
  ┌────────────────────┐       │   │  │
  │ Give the Signal to │       │   │  │
  │   DV5-A and CTU1   │       │   │  │
  └────────────────────┘       │   │  │
            ▼                   │   │  │
        ◇ IF PX1 on ◇ ◄─────┐   │   │  │
      Yes│          No      │   │   │  │
         ▼                  │   │   │  │
  ┌────────────────────┐    │   │   │  │
  │ Give the Signal to │    │   │   │  │
  │       DV3-B        │    │   │   │  │
  └────────────────────┘    │   │   │  │
            ▼               │   │   │  │
       ◇ IF CTU1=10 ◇───No──┘   │   │  │
      Yes│                      │   │  │
         ▼                      │   │  │
  ┌────────────────────┐        │   │  │
  │ Give the Signal to │        │   │  │
  │ DV1 and Stopped DV2│        │   │  │
  └────────────────────┘        │   │  │
            ▼                    │   │  │
        ◇ IF PE3 on ◇ ◄──────────┤   │  │
      Yes│          No           │   │  │
         ▼                       │   │  │
       ◇ IF LS2-B ON ◇ ──No──────┘   │  │
      Yes│                            │  │
         ▼                            │  │
  ┌────────────────────┐              │  │
  │ Give the Signal to │              │  │
  │       DV6-A        │              │  │
  └────────────────────┘              │  │
            ▼
```
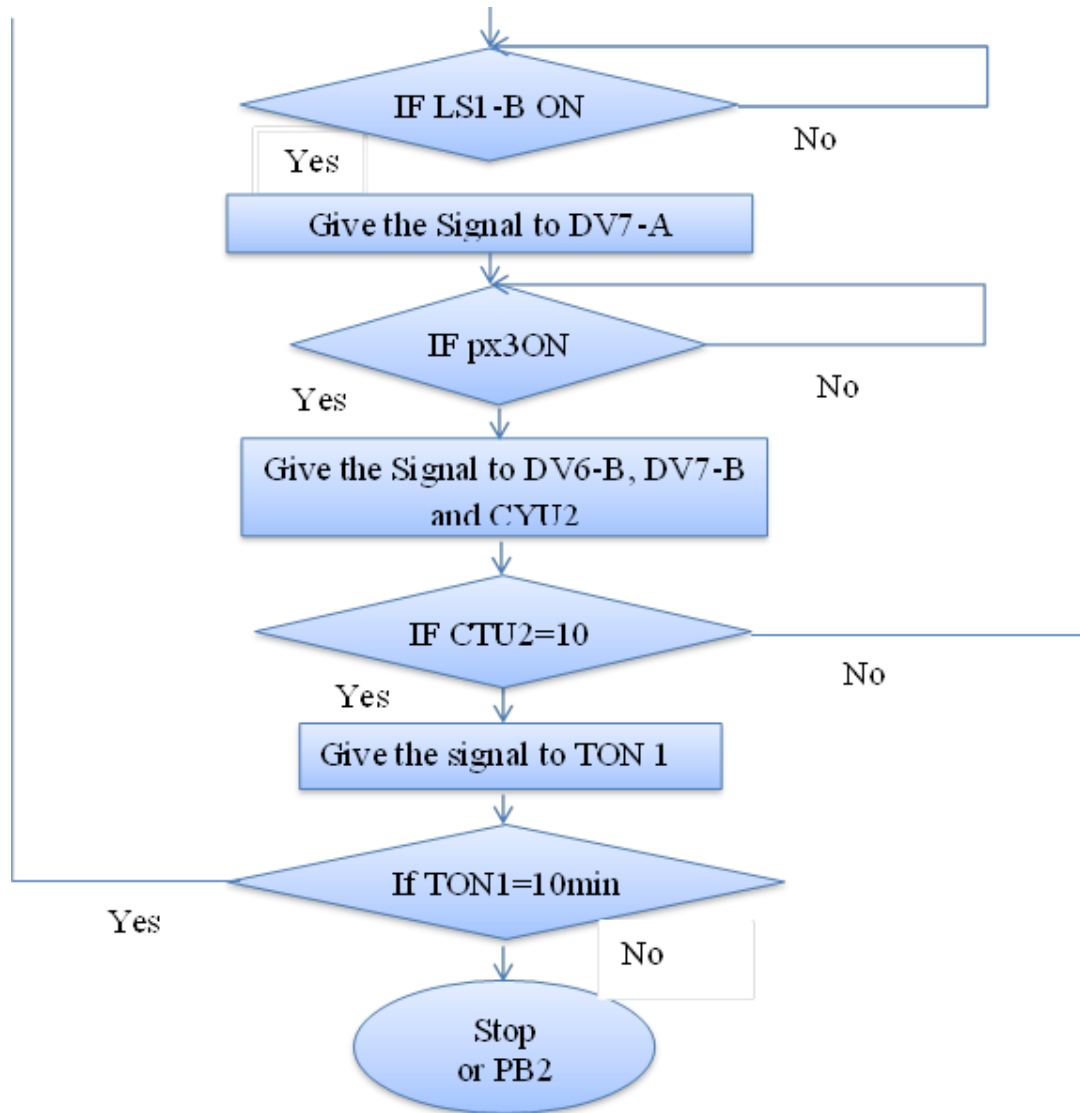
Fig.6: PLC-Controlled Correlated Die casting and Conveyor System.

6. Conclusion:

A PLC controlled hydraulic model for conveyor system was simulated, tested and evaluated using the Lab- volt Hydraulic training system. Furthermore, both die casting machine and conveyor systems were integrated into a complete system to create a successfully manufacture cell that had been successfully simulated and tested. Due to the lack of the inputs and outputs of the available PLC in the laboratory, TLP Logic simulators were used to get a complete factory

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