Productivity Improvement in Small Scale Industries through the Application of PLC Technology A Case Study

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Abstract— *Automation has become a prime contributor when productivity of an Industry is concerned. This paper tells about the Programmable Logic Controllers and their applications in Industries to reduce the wastage of resources. In this paper the perspective of small and medium scale industries about incorporating new technologies to their industrial processes is discussed. What they think of technology is extra burden that requires more handling which they cannot afford. What they are not aware is that most of it includes a onetime cost only. Further, the paper discusses the technical as well as financial aspects of the PLC technology. A Case study is provided to support the importance of Automation and PLC in any Industry.*

Index Terms—PLC, Automation, Block Machine.

I. INTRODUCTION

The world is advancing technically every moment. By incorporating the technology in processes, they become easy and take less time and resources. In Industries this reduction in wastage of resources helps enhancing the productivity and thereby reduce the product cost. This reduction of cost is essential for a company to stand in this competitive market. The technology discussed here can be effectively used even for a small scale industry to reduce the wastage of human labor and helps improving the quality. This reduction in wastage will help the country too. This paper tells about the Programmable Logic Controllers and their applications in Industries to reduce the wastage of resources. Case study is provided to see the difference.

II. INTRODUCTION TO PLC

What is Programmable Logic Controller? Well, there are various definitions that one come around, amongst which a few are: it is a digital electronic device that uses a programmable memory to store instruction and to implement function such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes [1], a Programmable Logic Controller, PLC or Programmable Controller is a digital computer used for automation of electromechanical processes [2] etc..

Apart from these definitions one can tell most about it from just its name. The first word "Programmable" tells that it is an electronic machine that can be programmed but what is a program and what it means to PLC is the real question. The answer to this question is that the program which resides in PLC's memory is a set of instructions that need to be followed to do the task whatever one need the PLC to do for him (which it is capable of). For example if the PLC is to turn ON a bulb when a switch is pressed then the program would first check the status of switch and if it is pressed then a particular bulb is turned ON by giving it supply. This "Programmable" word also tells that it can be re-programmed which makes it reusable for different setups. So if company needs more machines to operate then there is no need in buying a new PLC if there are pins present in the old one. All one need to do is include more set of statement to guide the new machines. There is also no need of re-wiring as now the machines are soft-wired i.e. connected and controlled by a software so one can connect any machine to any pin and all he need to do is to re-map the changed pin. This also saves the time and cost of re-wiring which was a major issue in the past. This issue made industries less flexible which was not the case once the PLCs were invented.

The next word "Logic" can be described by an observation that was one of the prime reasons behind development of PLC. The observation was that most of Industrial processes includes only ON-OFF states like for an instance when we talk about a cutting fluid pump for any machine tool the pump could either be OFF or ON as per the requirements. And so the word "logic" as it can be either ONE or ZERO, TRUE or FALSE which in turn can represent ON or OFF. So by just setting ONE to a particular memory location the machine mapped to it can be turned ON and vice versa. The term logic is use primarily concerned with implementing logic and switching operations. Input devices e.g. switches, and output devices e.g. motors, being controlled are connected to the PLC and then the controller monitors the inputs and outputs according to the program stored in the PLC by the operator and so controls the machine or process [1].

The last word "controller" refers to the micro-controller/ micro-processor that is used in PLCs. Even the smallest PLC has a microprocessor, which qualifies it as a computer [2]. This micro-controller is a digital electronic device that uses a programmable memory to store instruction and to implement function such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes [1].
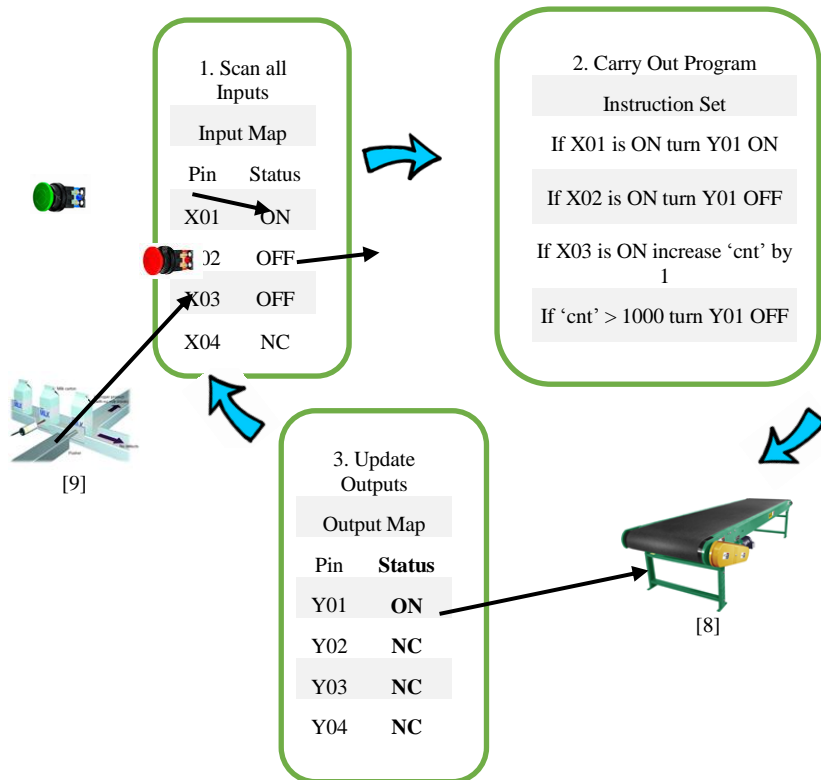
III. WORKING OF PLC

Fig. 1 PLC operations [1]

A PLC does its work in three stages repeatedly. The first stage of these is scanning the Inputs and store their status in Input-Memory Map as seen in Fig. 1. Now what the PLC does is scan the inputs from the two switches and the proximity sensor. Each Input Terminal in a PLC is represented by a different input "channel" with its own "X" label and similarly ouput to "Y" label [2]. The Green switch is to turn ON the conveyor and is mapped to 'X01' of PLC so its state is stored under that address. The Red switch is to turn OFF the conveyor like an emergency stop and is mapped to 'X02' of PLC so its state is stored under that address. The senor is mapped to 'X03' similarly.

Now all these states are stored under respective addresses and the program is so written to first access the Input Map check the status of the respective Pin and do the respective job as told like in this scenario the conveyor motor is turned ON when the Green switch is pressed and stop when Red one is pressed and also along with this the cartons are also counted that are being filled so that the filling can be stopped once the required quantity of cartons are filled like in this case it is 1000.

Now what PLC does after executing the program is that it updates the Output map (can also act immediately) and then update all outputs at the same time. The conveyor motor is connected to 'Y01'. So according to the state of switch and the count of cartons the conveyor motor is turned ON and OFF.

After going through with the Update of Outputs the PLC is back to the Scanning/ Updating the Input stage and so the cycle continues.

IV. ADVANTAGES OF PLC

PLC provide following advantages [3] [4]:
* Has several features like protection from the open area conditions such dust, heat and cold.
* Are rugged and designed to withstand vibrations, temperature, humidity and noise.
* Are easily programmed and have easily understood programming language.
* Capable of error-diagnostics and error-reporting and error-logging.
* Have a variety of application areas from a small scale industry to a large one.

V. AUTOMATION OF A SEMI-AUTOMATIC CEMENT-BRICK MAKING MACHINE
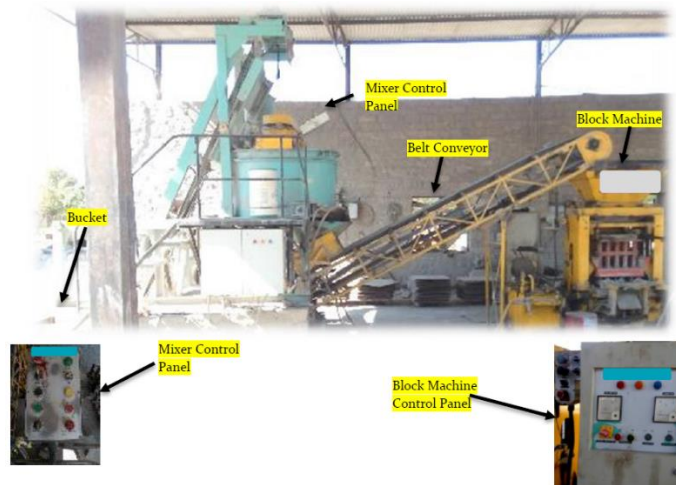
A. Machine Layout

Fig. 2 Machine Layout at the Industry

B. Previous Scenario

Most of the process is clear from the picture. The mixture is put into the bucket and is lifted by the pulley which can be controlled from the control panel as displayed. Then this mixture is put into the Mixer and mixing is started. After that the mixed product is poured into the Block Making Machine by a belt conveyor. The mixture is then poured into the mold and by a compressive force the bricks are made which is then picked by a worker and put to a wooden plate and then stacked for drying.

All these work is manually operated and a repetitive so can be done by a PLC easily with a little investment. More about the process:

Machine Employed	Semi-Automatic	
Machine Capacity	10 Bricks at a time	
Work Shifts	One	
Workers Required	One	Mixer Operator
	Two	Block Machine Operator
	Three	For Mixture making
	One	To place the wooden board
	One	To pick the board and put it to the trolley
	One	To move the trolley and stack the Bricks made
Pay scale	Rs. 400 per shift (avg. labor cost)	

C. Proposed Setup

The proposed alternative setup would comprise of a PLC, a 24V SMPS supply and an IR proximity sensor. The presence of mixture can be calculated as one knows how much bricks he produced and how much material he asked the labor to put into the bucket. The flow chart of the proposed setup would be as given in figure 3.
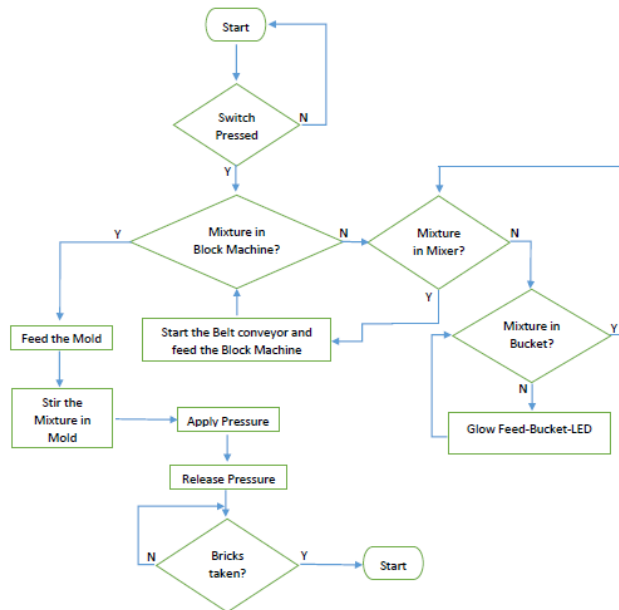
Fig. 3 Proposed Flow Chart

D. *Technical Features:*
- All work is programmed so one can note the idle steps for better bricks and that process can be repeated without any compromise.
- No quality variation in production with reduced Human efforts.
- Process flexibility: If customer is not satisfied one can guide his process to gain the required/ demanded results.
- Requires less time to apply and see the changes.
- Same PLC can be used to control multiple machines.

E. *Financial Features:*
Average salary of Labor in India: Rs. 400 per shift
PLC purchase cost = Rs. 5971 [5]
24V SMPS cost = Rs. 690 [6]
PLC programming cost = Rs. 5000 (Onetime and assumed on the basis of level of difficulty of the system)
IR Proximity Sensor cost = Rs. 352*2 = Rs. 704 [7]
Total Cost = 5971 + 5000 + 704 + 690 = Rs. 12365
Labor cost saved per month = Rs. 800*30 (two workers) = Rs. 24000
Setup will pay for itself in = 12365/24000 = 0.515 month i.e. around half a month and after that there is clean profit of Rs. 24k per month is possible.

F. *Future additions possible:*
- By knowing the per day batch limit the workers can be guided to put the mixture in the mixture bucket i.e. how much is more needed to complete the task.
- As the workers are now guided so brick properties can be changed whenever required.
- The stacking of bricks to dry off can be done by the help of AGVs.

VI. CONCLUSION

A small scale industry can be automated by an affordable amount of investment. Saving of labor, reduction of the wastage of raw materials, maintained product quality etc. are possible and the investment will pay for itself in no time. A greater amount of flexibility can be achieved which allows the owner to change the process to improve productivity when needed. By automating one plant more small and medium scale industries will encouraged to adopt automation and so there will be a technical growth of the country.

REFERENCES

[1] W. Bolton, "I/O processing - Processing inputs," in Programmable Logic Controllers, Fourth ed., Elsevier Newnes, 2006, pp. 75-76.

[2] A. R. K. B. S. C. S. V. and N. M. , "The Principle of Programmable Logic Controller," International Journal of Engineering Trends and Technology, vol. 4, no. 3, pp. 500-502, 2013.

[3] Y. N. Prof. Burali, "PLC Based Industrial Crane Automation & Monitoring," International Journal of Engineering and Science, vol. 1, no. 3, pp. 01-04, September 2012.

[4] M. L. Maha, "DIFFERENT APPLICATIONS OF PROGRAMMABLE LOGIC CONTROLLER (PLC)," International Journal of Computer Science, Engineering and Information Technology (IJCSEIT), vol. 4, no. 1, pp. 27-32, 2014.

[5] O. A. t. PLC, "IndustryBuying," OMRON, [Online]. Available: www.industrybuying.com/programmable-logic-controllers-plc-omron-EL.SW.MI.141319/. [Accessed 8 February 2016].

[6] electrokrafts, "ebay," [Online]. Available: http://www.ebay.in/itm/262297496014?aff_source=Sok-Goog. [Accessed 24 February 2016].

[7] Autonix, "IndustryBuying," Autonix, [Online]. Available: http://www.industrybuying.com/proximity-sensors-its-connectors-autonix-EL.SW.PR5.407645/?utm_source=Google&utm_medium=PLA&utm_campaign=0_PLA_HPP&gclid=CMHquPH M8MoCFQiVaAodo2IHJw. [Accessed 8 February 2016].

[8] A. C. Systems, "www.automatedconveyors.com," Automated Conveyor Systems, Inc., [Online]. Available: http://www.automatedconveyors.com/wp-content/uploads/2015/03/HPB-1024x674.jpg.\

[9] "www.ia.omron.com," omron, 6 November 2009. [Online]. Available: https://www.ia.omron.com/products/applications/case/29.html. [Accessed 2 February 2016].