Enhancing Productivity of Special Purpose Machine By Application of Automation to Loading and Unloading Utilizing Programmable Logic Controller

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Abstract

Automation is utilization OF various control systems for operating equipment such as machinery, steering as well as stabilization of ships, aircraft and other applications which requires minimal or reduced human intervention. Special Purpose Machines (SPMs) are designed and manufactured for specific jobs and such never produced in large quantities; such machines are finding increasing use in industries These machines require manual labour only for the procedure of loading and unloading of jobs. There is hardly any skill required for this job, thus is wastage of labour work and reducing company profits. Automation of such SPMs eliminates above complications and losses. The loading and unloading of such jobs can be done by designing and manufacturing a special mechanism solely for the specific SPM

Keywords: Automation, PLC, Production

1. INTRODUCTION

It has always been a challenge to design & automate a machine which brings customers high speed production while maintaining high precision, easy operation, and low capital costs. A programmable logic controller (PLC) is a type of digital computer which is utilized for automation of industrial electro mechanical processes which consists of control of machinery on factory assembly lines or light fixtures.

For varying requirements, the machines are able to be designed in numerical, hydraulic or pneumatic systems while implementing proper tooling and fixtures.

Industrial automation primarily deals with the automation in manufacturing, quality control of product and material handling processes. Generally controllers for industrial processes are Programmable Logic Controllers, stand-alone I/O modules, as well as computers. In the industrial growth automation is to replace the decision making of humans which leads to failure and manual command-response activities with the application of mechanized equipment and logical programming commands

Christopher Westcott [2]: In CLM (Continuous Layered Manufacturing) process, an original build tray is redesigned to be built. The redesigned tray has multiple guides that enable it to proceed into and emerge out of the fixture on the build. Finally, customized software is used to modify the .sml build files at the time of submission of job, and to coordinate the operations within CLM and FDM (Fused Deposition Modelling) systems. Due to this setting up the CLM or resetting the FDM back to its original state-takes less than 10 minutes.

Shivbhadrasinh Jhala [4]: This case aims for optimization of the manufacturing of cylindrical components on a CNC turning center. Importance is placed upon improving the existing time consuming methods. The machine used a gripper for job clamping and a compression spring to avoid return movement of plunger once actuated electronically. Development of automatic in the process of loading and unloading in the CNC reduces labour cost as well as total cycle time is minimized with increase in productivity

The objective is to create an automation process to help facilitate production of bearing caps by utilizing special purpose machine. The operation performed by the special purpose machine is gang milling. However it has been noted that the human labour is only required for the loading and unloading of bearing cap. So a system is crated in which once the job has been placed on conveyor in large amount the further operations will not require manual supervision. Initially the 3-D model of the proposed work is created by using Solidworks software.

2. Design and Fabrication

Fig 1. Indicate the circuit diagram of the complete operation. The ports of PLC are assigned as per their functionality. The PLC acts as control mechanism, actuator acts as guide, the conveyor acts like transportation medium for the operation.

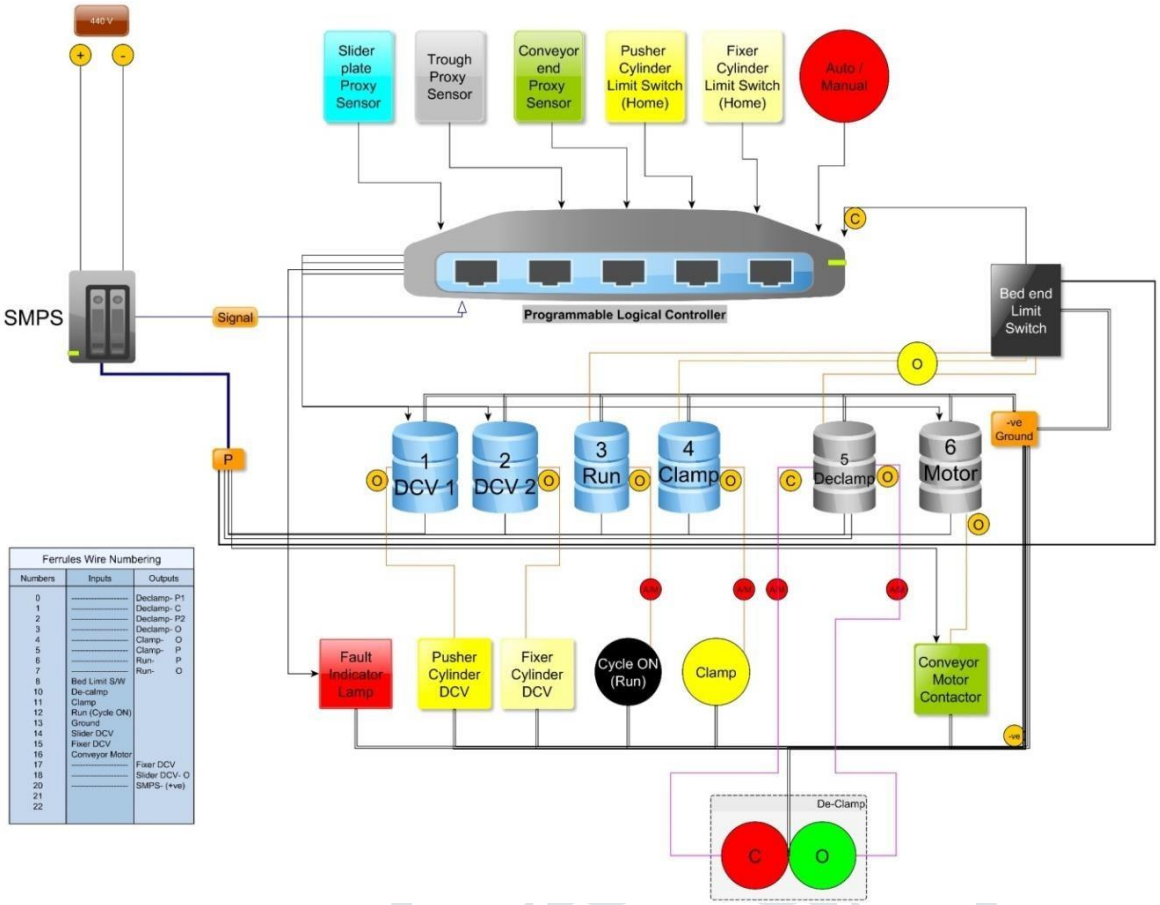

Fig 1. Circuit connections for PLC

By utilization of relays the power throughout the entire procedure is regulated as per the requirement and thus reducing the power losses which can occur in their absence.

Fig 2. Shows the process flowchart indicating the operations throughout automation. This designed system uses a PLC, using relays for switching and controlling motion of various devices because they are more reliable and easy maintenance than dedicated integrated circuits. This automation system designed also uses belt conveyors, stepper motors, motors, etc. for loading, unloading and conveying the machined and non-machined jobs from the SPM.

There are two actuators in the entire system. One actuator is utilized to unload workpiece from the conveyor and the other actuator is used to load the workpiece on the clamping mechanism. Proximity sensors are utilized to monitor the positioning of the bearing cap throughout the entire process.

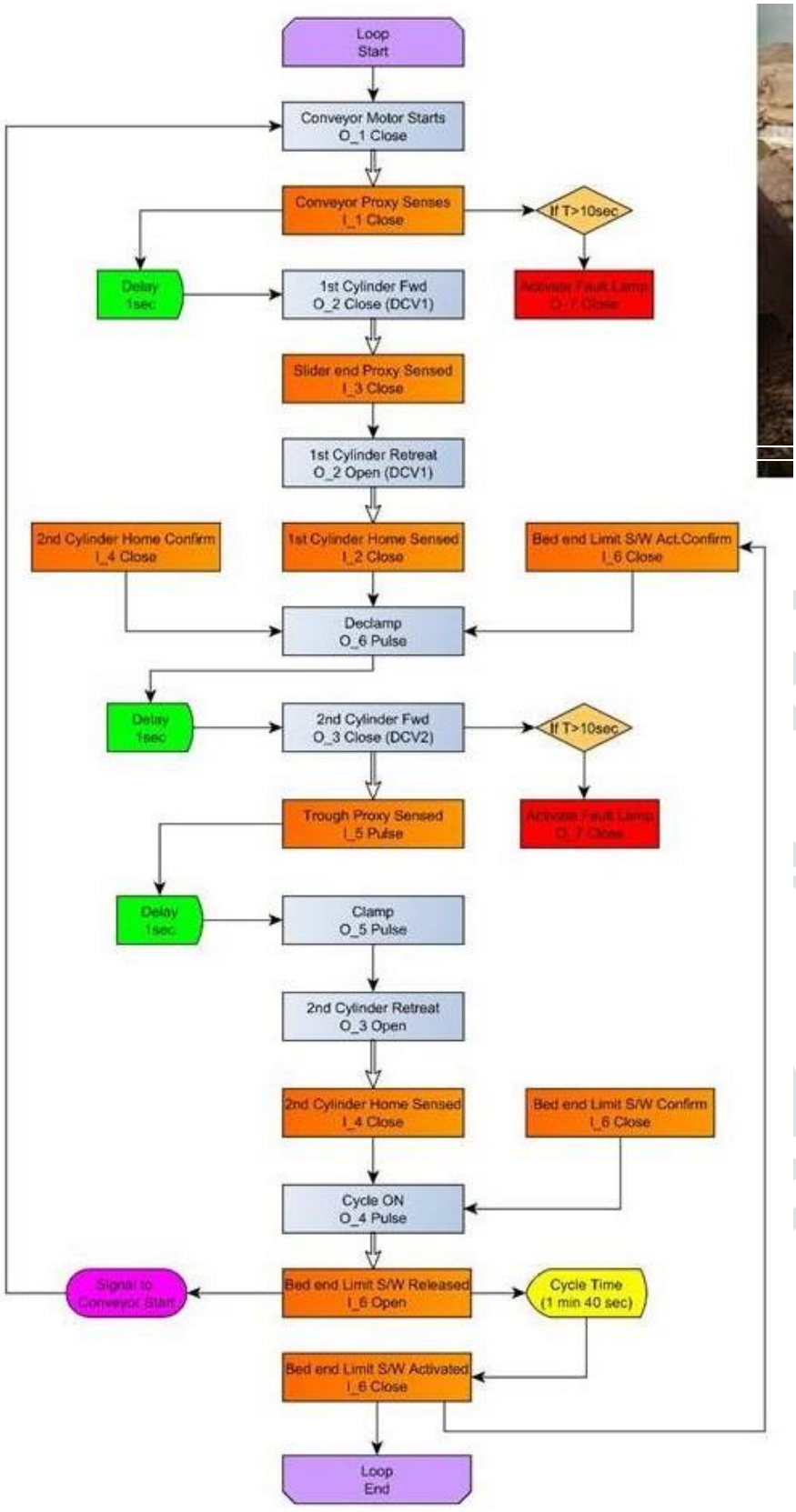

Fig 2. Process flowchart for automation

Once the job is placed in the clamping mechanism, the special purpose machine starts and the gang milling operation is carried on it. While the operation is being carried out, the next bearing cap is already loaded onto the2nd actuator and thus reducing the loading timing. When the milling operation is completed the actator with bearing cap opesrates and not only loads it on clamping but also unloads the previously finished product by pushing it to trough.

Thus in this way once 60 workpieces are loaded onto the conveyor the PLC will control the next process and without the requirement of human labour.

The fabrication process will be as follows

1. Selection of actuator and its accessories

The pneumatic actuator of sufficient thrust capacity is selected. Flow Control Valves are procured to regulate the direction of flow of air for actuation mechanism.

2. Fabrication of gripper

Robotic grippers ar a viable method to dispalce the bearing caps. However a more practical approach is to fabricate a gripper as per the bear cap dimensions by utilizing aluminium as cast material. Alumium is cast by utilizing wood die. Proper care must be taken so that the gripper is of proper dimensions to ensure its fitting.

Fig 3.Fabricated gripper with bearing cap

3. Construction of guide

One of the problems arising during the procedure is that the pneumatic actuator is unable to withstand the load of th bearing cap. The solution to this

problem is to create a guide mechanism which will distribute the load and make the actuator eet upto its functionality.3 parallel rods are utilized so that the load is distributed throughout the structure.

Fig 4. Fabricated Guide mechanism with actuator

4. Fabrication of bed

It is essential that the base support be durable enough to support the combined weight of actuator as well as bearing cap.

5. Design of control system

The PLC is the governing part of the entire automation. Programming of PLC to coordinate with timers, proximity sensors, conveyor, actuator is completed in this stage. It is essential that the wiring be properly insulated so that the chips from the milling operation do not affect the electrical circuit which in turn will hamper the flow of the operation.

6. Selection of conveyor system

The entire purpose of the system is that once the jobs are loaded in batch, the operations are to be carried out automatically. The conveyor system should have length enough to contain 50-60 bearing caps at a single time. Generally stepper motor is utilized to provide motion to the conveyor belt. Proper care should be taken that the conveyor belt be smooth enough so that the work piece can be able to slide over it without excessive friction

7. Fabrication of trough

A trough is constructed so that bearing can slide over it after it is unloaded from the clamping mechanism.

Fig 5. Automation setup for loading and unloading in SPM

3. RESULT

Practical No.	Time for Loading and Unloading (in seconds)
1	8.5
2	8.3
3	9.2
4	41.6
5	9.1
6	8.3
7	16.7
8	9.2
Average Time for loading-unloading	=13.125 Seconds

Table 1. Manual timing

Practical No.	Time for Loading and Unloading (in seconds)
1	11.4
2	11.5
3	11.3
4	11.6
5	11.5
6	11.5
7	11.7
8	11.4
Average Time for loading-unloading	=11.5 Seconds

Table 2. Automation Timing

Table 1 and Table 2 indicate the total time required for simultaneously loading and unloading of bearing caps manually and after automation is implemented respectively.

It is observed that time required by manually is higher than by automatic. This time difference has large impact on the productivity of the bearing caps. When the operation is completely carried out manually the total number of products finished is 514 within the 13 hour shift. When the milling operation (average of 2 minute 9 seconds) is being carried out the worker is idle. If we calculate the idle time by taking into consideration average loading and unloading time, it will be 11 hours 8 min 45 sec per day. Thus the same amount of valuable time can be allocated on some other essential procedure and in turn will optimize the proper harvesting of work-force. When the automation is implemented during the same 13 hour shift 759 jobs will be completed which is significantly higher.

4. CONCLUSION

Constant vigilance of manual handling is not required which in turn leads to further utilization of available human labour. Time for loading and unloading process will be reduced due a streamlined process achieved by automation. The idle time which occurs during the operation when worker has no application can be utilized and in turn skilful optimization of available workforce is achieved. On the downside, complete automation would not be achieved in this project and worker will still be required to load jobs per hour. Implementation of this procedure increases companies' annual profits. Repay time of automation expenses is covered shortly due to cost effective designing. The production rate of bearing caps increases by 48%.

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