ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 2, February 2017

Case Study on PLC Operated Automatic Handling Systems in Mechanical Industry

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Abstract:-- **To withstand the global competition, industries today are focusing on the automation. In present era, higher satisfaction of the customer is the main motto of the Industry, and this can be brought about by Automation. Material Handling System and in packaging industries, automation has played a vital role.**

Polymer industries face problems in the form of removing hot SPRUE from die cavity ,increased cycle time and safety of workers ,so introducing automated sprue picker machine controlled by PLC and comprising of pneumatic actuators, reed sensors and mechanical grippers, which replaces the labour invention , is a better plan for organizations stepping towards fully automated systems .

The paper includes the current problems with the existing systems, and proposed system with its components used for drastically reducing the handling time ensuring safety and accuracy in the manufacturing environment.

Keywords :- **Automation, PLC, Injection Moulding, Human Intervention.**

I. INTRODUCTION

Automation research continuously keeps improving productivity in manufacturing automation. Recently there has been huge advancement in the field of vision and sensing .In todays industry Automation plays major role. They have replaced humans not only in tasks in which robot are more efficient but also in those that human find undesirable because they are strenuous, boring, difficult or hazardous. Within last few years, tremendous efforts have been put in integration of multiple sensors in automation system. The purpose of this is making automation system more adaptive and flexible in unstructured or frequently changing environments, and enabling robots to execute intelligent tasks. Thus automation productivity and applicability can be improved.

In Polymer industries, injection moulding is a commonly used process for manufacturing of small and big components. The process evolves from metal die casting, however, unlike molten metals, polymer melts have a high viscosity and cannot simply be poured into a mould. The injection moulding process uses a large force to inject the polymer into the hollow mould cavity .The moulding is maintained at a holding pressure and allowed to plasticize. Once the mould is formed and can hold its shape it is ejected from the cavity.

The mould in many situations needs to be manually removed from the cavity. There are inherent difficulties with this as the mould is at a high temperature. Due to this, the process becomes labor dependant, which reduces the cycle time and production rates. A sprue picker robot can efficiently and continuously perform the operation of removing the mould once it is made and replace the need for manual removal. As a result the process is optimized.[1]

II. PROBLEMS WITH MANUAL SPRUE REMOVAL FROM DIE CAVITY:

Sprue removal from the die cavity at faster rate is very important segment in injection moulding machine. A sprue picking machine should always must be implemented in a proper manner so that it gives better results. If sprue removal is done manually it will take more time, which results in greater cycle time. It could be reason for hazards and accidents for workers assigned to the machine .Thus the productivity is hampered.

- ***Accuracy and ease of control is not assured:***

Accuracy is reduces or minimised as compared to automatic machine; also controlled manually is less than that of automatic machine as operated parameters change at a quicker rate than automatic one.

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- ***Time consuming:***

Time required to remove the sprue is more. As per worker effort, time requirement changes and may cause uncertainty in production.

- ***Operator fatigue and hazardous operating conditions*:**

As per the atmosphere conditions; mood of worker, operating conditions of industry operator efficiency changes. He may face problems because of changes in environment around him .Also as the worker works for longer period of time his performance gets poor.

- ***Temperature :***

As the temperature is about 80 to 100 ^{0}c in die cavity, it becomes difficult to remove the sprue from die and is not favourable condition for the workers to work effectively.

III. METHODOLOGY ADOPTED:

3.1. Objective:

The main aim of the proposed system:

1. To remove the sprue from die cavity.
2. Design frame & column to get proper orientation.
3. Design of tilting mechanism which rotates the frame.
4. Compact design.
5. Cost reduction.
6. To achieve accuracy and repeatability.

3.2. Proposed layout:

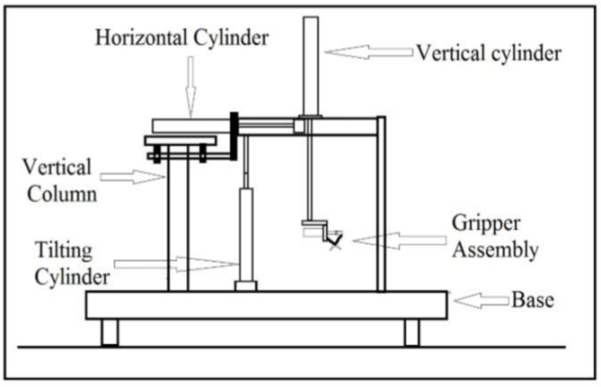

Fig.1.Proposed System Layout

3.3. System Operation:

Robot consists of a number of pneumatically actuated cylinders which performs the pick and place operation with a set cycle time. The control and operation is handled by Programmable Logic Controller (PLC), which is mounted on the control panel. The stroke of the cylinder is controlled using Reed switches. The positioning sensing switches that are placed at the extremities of the cylinder, controls the length of the stroke.

The sprue picker robot is mounted on the injection moulding machine. In the injection moulding process, once the mould is formed and cooled, the gripper arm moves into the mould and places it into a receptacle.

The operation of the circuit is verified by simulating it, on the simulation software, Automation studio and the behaviour of the circuit is checked under different conditions.

The proposed Layout is as shown in the fig.1.

IV. SYSTEM COMPONENTS

4.1. Mechanical Components:

A] Horizontal Cylinder:
It controls the movement of the component across X axis.
B] Vertical Cylinder:
It controls the movement of the component across Y axis
C] Vertical Column:
It provides the support to the vertical and horizontal cylinder assembly.
D] Tilting Cylinder:
It tilts the complete assembly of horizontal and vertical cylinders.
E] Gripper Assembly:
The only purpose of this is to hold the component in the jaw and release it after execution or operation.
F] Base:
The whole apparatus is built on the base.

4.2. Pneumatic Components:

Pneumatic plays an important role in the system and is preferred in automation over hydraulics due to the faster clean and light in weight system **.**

In circuit there are four pneumatic cylinders:

- Cylinder A - For horizontal motion
- Cylinder B - For upward and downward motion
- Cylinder C - For gripper the sprue
- Cylinder D - For rotational motion

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These are connected to a compressor through a manifold.

- Sequence of operation is A+,B+,C+,C-,B-,A-,D-,B+,C+,C-,B-,D+(Where: + is extension , - is retraction)
- There are total four 5/2 DCVs used one for each cylinder
- Cylinder A - both side solenoid operated 5/2 DCV
- Cylinder B - both side solenoid operated 5/2 DCV
- Cylinder C - both side solenoid operated 5/2 DCV
- Cylinder D – both side solenoid operated 5/2 DCV

- There are seven reed switches. Two switches are mounted on each cylinder except gripper cylinder and work on magnetic principle.
- From proximity switches, signals will pass through ladder logic. Depending upon these signals, coils will be energized and its output in the form of extension or retraction.

4.3. Softwares Used:

***1) PLC Ladder Program*:**

Before the advent of solid-state logic circuits, logical control systems were designed and built exclusively around electromechanical relays. Relays are far from obsolete in modern design, but have been replaced in many of their former roles as Logic-level control devices, relegated most often to those applications demanding high current and/or high voltage switching.

The purpose of a PLC was to directly replace electromechanical relays as logic elements, substituting instead a solid-state digital computer with a stored program, able to emulate the interconnection of many relays to perform certain logical tasks.

The input instructions to the program are entered on the left & the output Instructions are entered on the right. The power rails simulate the power supply lines. L1 and L2 are for AC circuits whereas +24V and ground are for DC circuits. Most PLCs allow more than one output per rung. The processor or controller scans the Ladder rungs from top-to-bottom and from left-to-right. The basic sequence is altered whenever jump or subroutine instructions are executed.

As shown in the fig.2. Ladder sample [2]

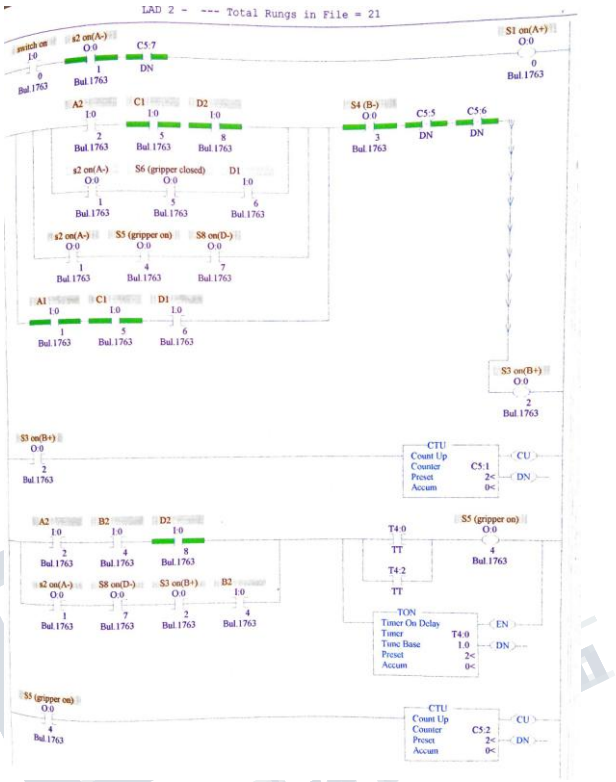

Fig.2. Ladder Sample

2) Automation Studio V5.6

Automation Studio™ is an innovative system design, simulation, and documentation software solution for the design and support of automation, hydraulics, pneumatics and electrical systems Created in 1986 by Famic Technologies (Canada). It is intended to be used by engineers, maintenance and support personnel in a wide variety of related fields.

The software consists of several modules, which are also called workshops, and libraries that can be added according to your specific needs and requirements. Users can then select the appropriate components and drag and drop them onto workspace to quickly create virtually any type of system. Systems can consist of one single technology such as hydraulics, pneumatics, electro technical, etc., or of a combination of multiple technologies that will interact with each other during simulation as they would in the reality.

The designed circuit is created with the help of software and simulated for checking the functioning and performance. [3]

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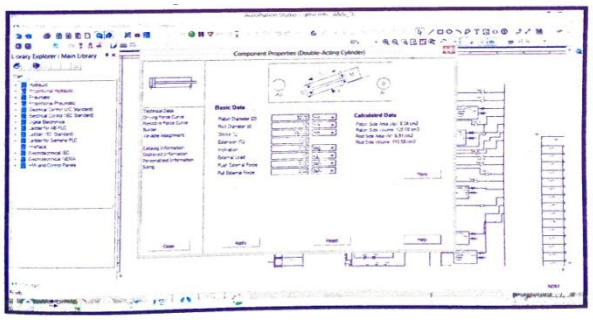


Fig.4. Cylinder technical data

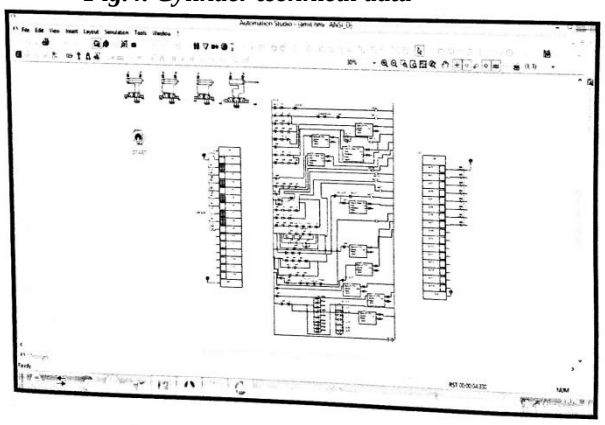


Fig.5. Simulation in Automation Studio

V. RESULTS:

The trails conducted on the working model at various pressures gave the following results in terms of time required in seconds to remove one sprue from the machine and it is shown in table Table 1. The final setup with its CAD model is shown in the fig.6.

Table 1: Test results

SR. NO.	Pressure in Bar	Time in sec
1.	4	6.5
2.	5	6.2
3.	6	5.9
4.	7	5.6
5.	8	5.4

The automatic pneumatic operated sprue picker machine has provided to be beneficial in terms of reduction of overall cycle time from 14 sec to 6.5 sec resulting in improved productivity of camphor boxes about 40%.

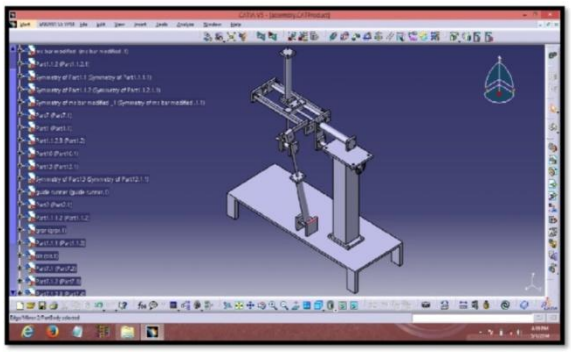


Fig.6.Catia model of setup

VI. CONCLUSION:

The labour fatigue is also reduced and by product disposal is done efficiently. Thus automated pneumatic operated sprue picker machine is low cost solution which can be utilized in many process industries for pick & place of either main product or by product thus ensuring profits by reduced non-productive times .The cost of the setup will be recovered in almost three months when implemented in industry. Some more sophistication in the setup making it commercially suitable can give even better results.

REFERANCE

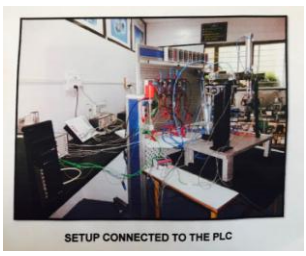
1. Automation Production System and Computer Integrated Manufacturing, M.P.Groover, ISBN 0-07-112673-2

2. W Bolton Pearson, “Mechatronics – Electronics Control Systems in Mechanical and Electrical Engineering” , Education (Singapore) Pvt.Ltd. ISBN-978-81-317-3253-3, pg. no. 460 – 474

3. Automation Studio 5.6 Manuals.

Setup pictures:

SETUP OF PLC OPERATED SPRUE PICKER MACHINE



SETUP CONNECTED TO THE PLC