Design of PLC Based Automatic Flat Bottle Label Adjuster

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Abstract: *Great intellectual designs of Labelling machines are widely in use for packaging product in manufacturing industries. Hands-on experience on varieties of these designs had spun the idea on which the improvement discussed in this article is designed. For every labelling machine, we have the labelling head and a Gap sensor, these two components are universal and common to all labelling machines. The vertical movement (aided by a hand wheel) of the labelling head is often used in adjusting the upward-downward position of labels on bottles while horizontal movement of the Gap sensor adjusts the right-left movement of labels on bottles. In this article, electronic means is designed to automatically do label adjustment on bottles, eliminating the crude mechanical hand wheel and hand adjusting been employed by most labelling machines available industries today. This article aims to eliminate human interference when proper label positioning on bottles is required. The design, though simple but yet efficient, employed the use of Photo-sensors, Relays, Programmable Logic Controllers and Servo Drives and Motors, to archive its goal. Flat bottle labelling is considered for this design.*

I. Introduction

Product packaging and identification is a paramount and vital stage before processed goods can be termed finished goods. There are various forms of product identification adopted all over the world by manufacturers when packaging their processed goods. It could be direct print of ink on product packaging, pasting adhesive labels, or heat shrink-wrapped sleeves.

In this article, adhesive label method is examined, improved upon and discussed. Many works and designs are presently in use in various manufacturing industries, but this work is intended to improve on a part of these designs.Adhesive labels require a Pressure Sensitive Labelling Machine. A Pressure Sensitive Labelling Machine applies pre-glued labels that are supplied on a reel of release paper or film. Pressure sensitive labels undergo multiple manufacturing steps to have the label temporarily adhere to a web or roll but will permanently adhere to the package. There are multiple types of applicators but they all share the capability to peel the label away from the web or backing and transfer it to a package. After the pre-glued label is peeled from the web, there are several ways to apply the label. The simplest way is to wipe the leading edge onto to the package. The other is to transfer the label to an applicator drum which holds on to the label by vacuum or other mechanical means before transfer to the package. Typical speeds are 0.5m/s but higher speeds are possible.

A Pressure Sensitive Labelling Machine has three basic sections:

* **The Labelling Head:**Its function is to accurately dispense a single label from the carrier tape to the applicator at the required speed. It is a motor driven tape transport mechanism. The label which is on the tape is dispensed when reaching the peeling plate.

* **The Applicator:**Its function is to accurately place the label on the product at the required speed.

* **The Product Handling System:** Its function is to place the product consistently at the required speed in position for label pasting. Normally a product conveyor with guiding mechanism is employed.

Pressure sensitive labelling machines are becoming more popular because the user does not have to use glue, thus resulting in lower maintenance and lower operator intervention.

A well packaged product should look presentable after production process, with product labels properly pasted and aligned on the product bottle. But in reality, it is not so, labels are often misaligned on bottles thereby making the finished product unpresentable. Labelling machines manufacturers incorporates label alignment or

position adjuster mechanism to correct and properly position the label on product bottles.Label alignment or position adjustment could be for vertical or horizontal orientation. For vertical alignment, a hand wheel is attached to the labelling machine which moves the labelling head in upward and downward movement, thereby taking effect on the label position of the bottle and in-turn correcting any form of misalignment.
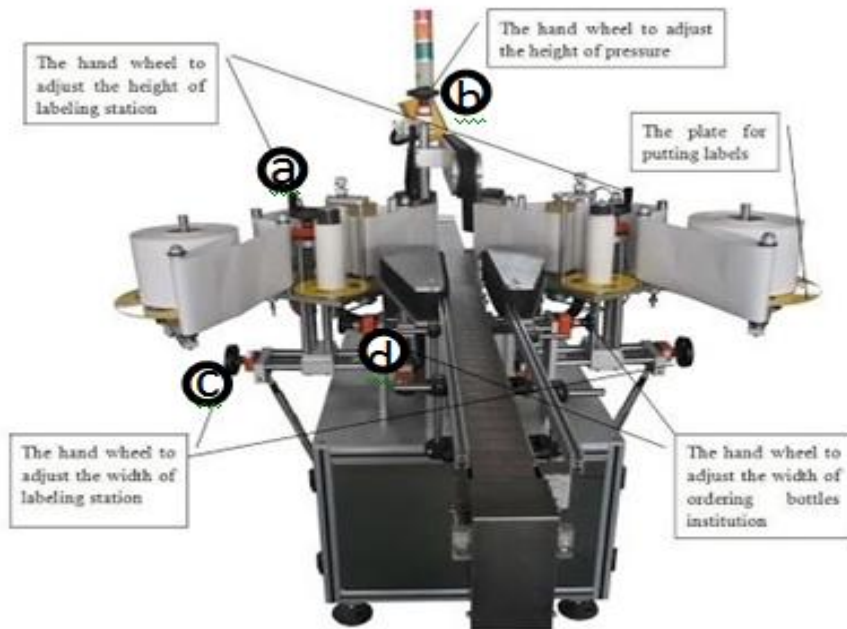

Figure 1: Typical Labelling Machine, (a) Example of hand wheel for vertical label orientation adjustment.

Figure 2: Closer View of Hand wheel for upward and downward motion of Labelling head for vertical orientation Label Adjustment

For horizontal orientation alignment, the Gap sensor on the labelling head is used. The Gap sensor is primarily used as stop switch when one label length is released on a bottle, but adjusting the sensor either to the left or right would in turn have effect on the position of labels either to the left or right on bottles.

The presence of human operator is obviously necessary to observe how labels are positioned on bottles and thereby make necessary adjustment either with the hand wheel or Gap sensor. The aim of this article is to design an automated programmable logic controller based label adjuster that would detect current label position and automatically make corrections if necessary.

II. Methodology of Operation

Mode of Operation

The Label Adjuster is attached to the labelling machine as a quality monitoring and control unit. After the bottle has been labelled, a capacitive photo-sensor identifies its presence. Once the presence of the bottle is identified, aneight-unit sensor triggers ON a one-shot mode, identifying the orientation of the label on the bottle, with two sensors each scanning the top, bottom, left and right edges of the label.

The eight-unit scanning sensors are positioned and set such that their output should read a proper label orientation on the bottle after a single scan. But in advent of a deviation whereby the scan output shows improper label orientation on the bottle, the Label Adjuster corrects the label orientation either by vertical upward-downward motion of the Label head or horizontal right-left motion of the Gap sensor.

The eight-unit sensorsends eight bits signal to a Programmable Logic Controller (PLC) module. Two servo motors are installed, one is for a vertical motion of the label head and the other is for horizontal motion of Gap sensor. The PLC gives fourbits output signalsfor Labelling head vertical motion servo motor control and another four bits outputsignal for the Gap sensor horizontal motion servo motor control.The four bit signals give a combination required by servo drive digital inputs for a particular pre-set shaft revolution. The rotation of the servo motor is translated into linear motion with the aid of gears.

III. Discussion of Results

Connection Circuitry and Layout

Programmable Logic Controller (PLC) Terminals

Siemens PLC products, SIMATIC S7-300, are used for this project design. CPU 313 with STEP 7 v 5.0 programming package is employed for the design. Digital module SM 323, isolated, 16 DI and 16 DO, 24 V DC, 0.5 A, Total current 4A, 1x 40-pole. The module responds to 24V DC as 'ON' signal at the digital inputs and likewise gives 24V DC as 'ON' signal at the digital output. Be
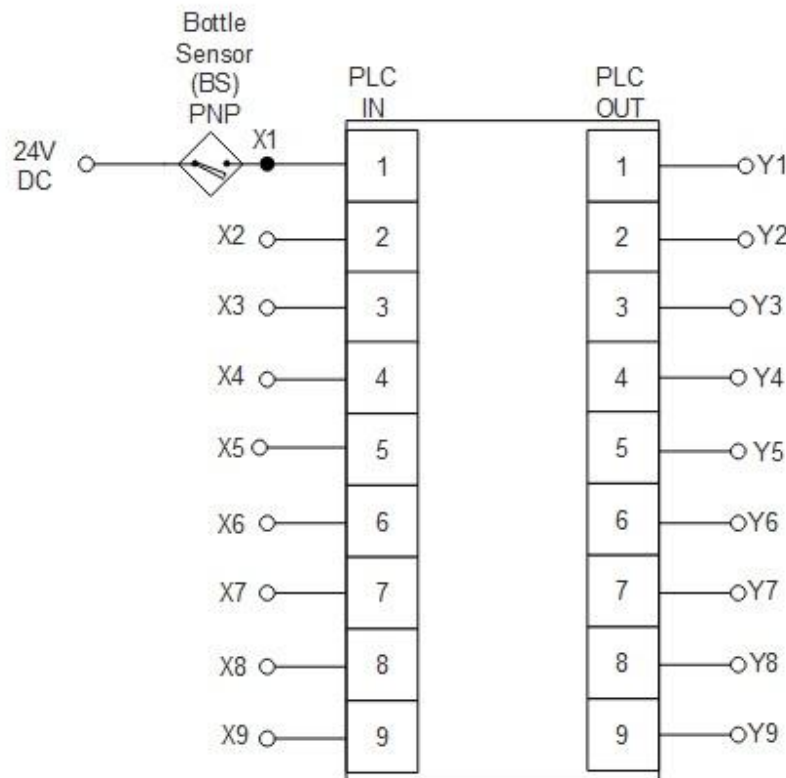

Fig. 3: PLC Terminals Layout

Eight-Unit Sensors Connection

Allen-Bradley 45FVL Digital Self-teaching Fibre Optic (PNP type) sensor is employed for the eight-unit sensor design. 3-Wire DC Capacitive Proximity Sensor is used as Bottle sensor.
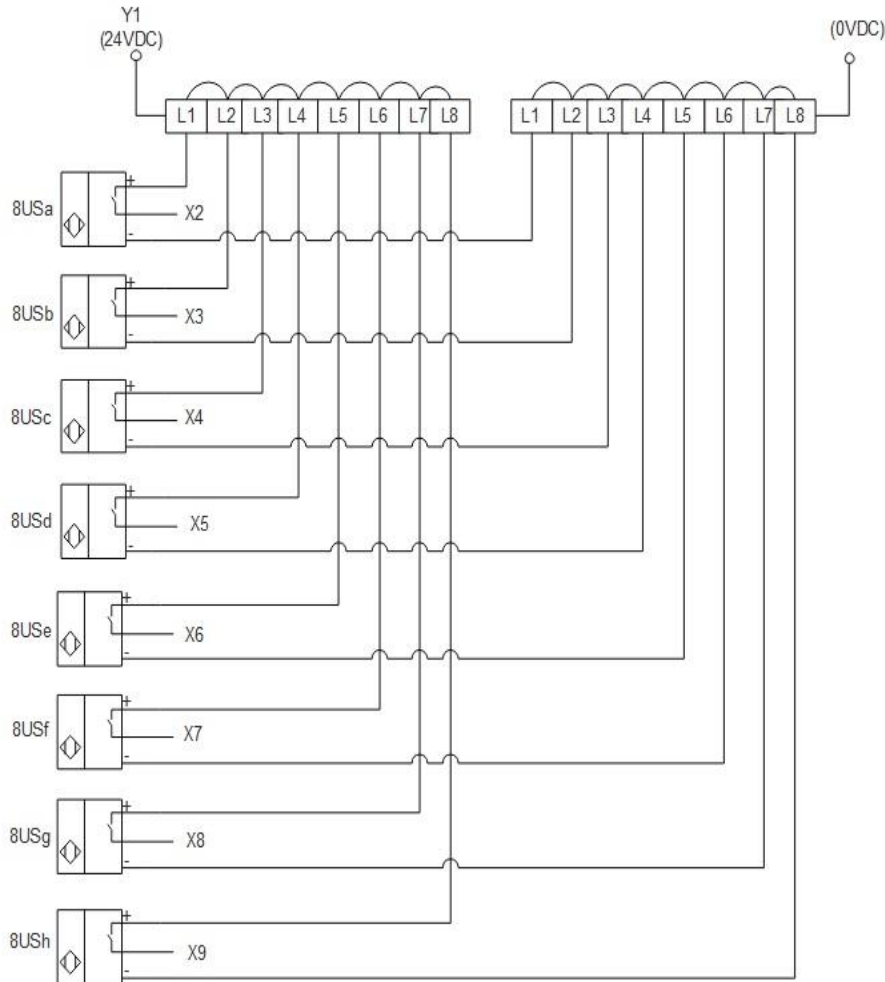
Fig.4: Eight-unit sensors connection layout

Relay Card Layout
OMRON 24V DC 8-pins Relay is used in the relay card design.
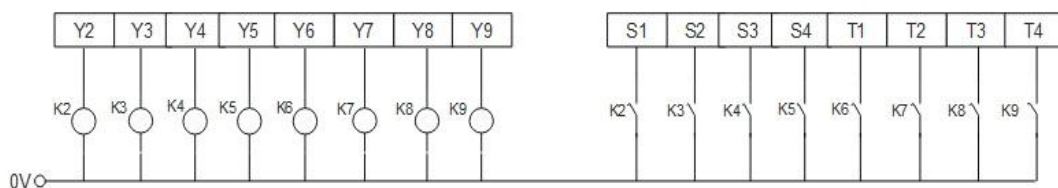

Fig. 5: Relay Card Connection

ServoDrive DI Layout
Two Schneider LXM23D-U07M3X servo drives are used in this project. The figures below show the digital inputs layouts of the two servo drives. Fig. 6(i) shows DI connection layout for servo drive controlling the vertical-motion of the Label Head and fig. 6(ii) shows DI connection layout for servo drive controlling the horizontal motion of the Gap sensor
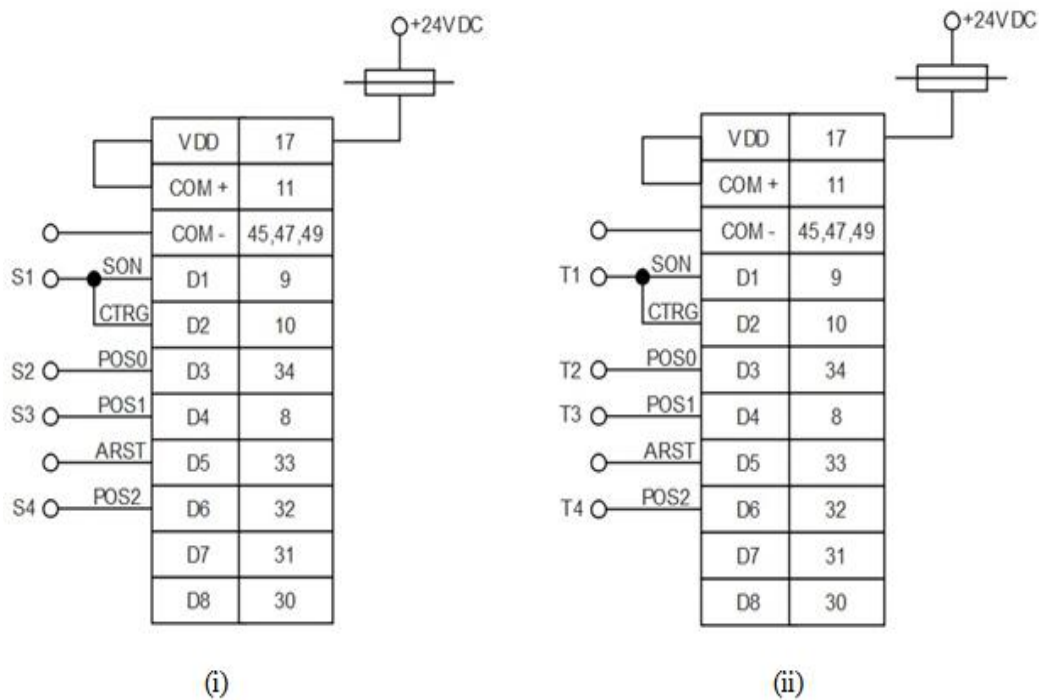
Fig. 6: Servo Drives Digital Inputs Layouts

IV. Conclusions

This project was designed to be an added functionality to existing labelling system for flat bottles, used in manufacturing and packaging industries. The idea stems from careful and long-term observation of working times of labelling machines, and its purpose is to reduce label wastage and human operator intervention to the barest minimum. The system is designed to sense how label is positioned on a bottle and compare it with an ideal pre-set orientation, if a deviation occurs, then it automatically corrects the error towards conformity to the ideal orientation. Suitable and easy-to-install, yet most efficient, devices had been selected for the design. The design is most likely open to accommodate modifications after been physically observed while running online in a labelling operation.

V. Acknowledgments

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