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DESIGN AND FPGA IMPLEMENTATION OF SOFT LOOP HANDLE FIXING MACHINE

K. S. Raja and K. Vasanth
Department of Electronics and Communication Engineering, Sathyabama University, Chennai, Tamil Nadu, India
E-Mail: yuva9340@gmail.com

ABSTRACT

There is a rapid growth in the extreme increase in Industrial production, particularly in the domain of Automation process. This is due to the extensive involvement of Automation which is possible in the industries and the ease of maintenance. This leads to an efficient way of improving the production of the industrial process and reduces number of workers. Hence this paper brings out the flexibility of Field Programmable Gate Arrays which used to control two machines loop fixing machine, bottom sealing and cutting machine. Here we use the pneumatic functions instead of motor which controls the machine through FPGA and helps to reduce the power consumption. The design has been described using VHDL (VHSIC Hardware Description Language) and implemented in hardware using FPGA (Field Programmable Gate Array).

Keywords: VHDL (VHSIC hardware description language), verilog, FPGA (field programmable gate array).

1. INTRODUCTION

In today's highly competitive bag making industry, businesses across the globe face unprecedented and likely to change suddenly and unexpectedly. Material suppliers, Manufacturers, and machine builders (OEMs), are affected by shifting customer demands and globalization, technology innovations, industry consolidation, government regulations, safety requirements and the demand for lower customer prices. Bag manufacturers must reap the most productivity from every stage of their manufacturing process. At the same time, they must ensure the Bags produced meet their customers' specifications and overall quality standards. Bags / Pouches come in different materials, shapes, sizes and designs based on the product packed or the end user industry. Products are in solid, liquid form is packed for Food and Beverage, Pharmaceutical and Consumer Product industries.

2. OBJECTIVES

Bag making machine manufacturing demands machines that combine high production output, product quality, and reliability with low manpower and maintenance costs.

The machine builder will challenge to differentiate amidst global competition and rapidly evolving technology. The machines also need to be easy enough to adapt to variations in bag length, bag material and sophisticated bag designs. Whether measured from a business, commercial or technical perspective, FPGA Automation can help improve your bag making machine performance with solutions and services to lower the Total Cost to Design, Develop, and Deliver machines and meet your customers' requirement. FPGA Automation, that strive for a holistic approach that focuses on this machine and business performance. What may start out as an "order-by-order" i.e. relationship, can eventually develop into a mutually beneficial business relationship?

a) In the feeding section

Roll-fed flexible packaging film is unwound from a feeder roll. Feeder rollers are used to move the film through the machine to carry out the required operations. Feeding is usually an intermittent operation and other operations like sealing and cutting are carried out when feeding has stopped. To maintain a constant tension on film web Dancer systems are used. Feeders and dancers are required for maintaining tension and critical accuracy in feed.

b) In the sealing section

Temperature controlled sealing elements are brought into contact with the film material for a specified amount of time to appropriately seal the material. The sealing temperature and sealing time is varies on the type of material and they need to be maintained constant for different speeds of the machine. The sealing element configuration is based on the machine format is dependent on the sealing type is dictated by the bag design. In all the machine formats, sealing is accompanied by cutting and both of these are carried out only when feeding has come to stop.

c) In the cutting and stacking operations

The cutting is typically done during the non-feeding time of the machine cycle. Similar to cutting and stacking, sealing the also would determine the ideal machine format. In addition to these basic functions can be added to operations like zipper, hole punch, handle punch, tamper proof seal, cap, spout etc. might be carried out depending on the bag design. Accessories attached to the

base machine are used to carry out the additional operations.

d) Dancer roller

The dancer maintains tension when continuous movement in function the intermittent motion will occur due to change in web. The dancer is very important to the function of the machine to maintain Tension level as per material, principally the accurate feeding of the web. The dancer has two sets of rollers one of which is stationary and the other is movable. The web is routed alternatively between the static and mobile roller sets. The movement of mobile roller set is restricted by using linear springs, pneumatic or servo systems which primarily help in maintaining the tension required. Linear transducers, potentiometers or capacitive sensors are used to provide the position feedback of the roller sets.

e) Edge position control (EPC)

The EPC maintains the position of the web edge during the bag making process. Machine builders source the EPC from third parties and integrate it into their machine. The web tension maintained by the dancer is critical for the optimal performance of the EPC. Depending on the manufacturer it is sourced from, it is available in either vertical or horizontal format. Mechanisms to adjust the position of web by detect the edge of the web using a special sensor. This mechanism in certain machines might move the unwind roll appropriately to achieve the edge control.

f) In-feed

The feeder section is getting feeding material form the unwinding section which is drawn form in-feed. It is especially critical in machines where the un-winder is a static mandrel. It helps to isolate the continuous web motion of the unwind section from the high dynamics intermittent motion of the feeder section. It consists of two rubber lined rollers which are pressed against each other by pneumatic cylinders and the material is pinched between the rollers. The rollers which are coupled by gears at their ends are driven in opposite directions by a single motor. Typically they are driven by VFD control but in certain very high speed machines they are servo control driven.

g) Feed control

Material from the in-feed / unwind is fed to sealers and cutters by the feeders. Feeders ensure the bags of correct length are fed at the right time. They also respond to feedback from print mark sensors to guarantee printed web is fed to the right position. Feeders should move the web only when the cutter/sealer is open position. They also work in tandem to maintain the tension between them so that all accessories mounted between them can work well.

The feeder consists of two rubber lined rollers which are pressed against each other by spring. The tension for spring is given by pneumatic cylinders. Feeding Material passes between the rollers and held by the pressure exerted between the rollers. These rollers which are coupled by gears at their ends are driven in opposite directions by a single direction bearing that shaft is connected to servo motors as they need high dynamics [high speed and high acceleration / deceleration] and high accuracy.

h) Tension control

Web tension at different locations of the machine is maintained by diverse mechanisms. Web tension between the feeders is maintained by adjusting the feed ratio between Feeders. Dancers facilitate to maintain tension in certain places. Some materials tend to stretch when they are hot. Web tension is sometimes relieved / reduced after the sealers to prevent stretching.

i) Print mark control

Print mark control works on the feeders by helping to position the bags correctly under the sealers and cutter. This section includes the placement adjustment mechanisms and film registration sensor. The film registration is used on film with graphics or pre-printed information. Printing process variations, film stretch, film slippage during acceleration and other factors can allow the graphics to drift away from ideal cosmetic / marketing placement on the finished bag.

j) Cut/seal control

Cutter/sealers are moved up and down during production of the bag. This section is the heart of a bag making process as the bag gets sealed and/or cut here. The design of this section will determine the machine type. It is critical in such places to get the position feedback of the mechanical cam by using an auxiliary encoder coupled to the Cam. In certain configurations servo motor and drive combination is used to achieve this motion. Servo solution provides higher flexibility, accuracy and speed compared to the VFD solution.

k) Temperature control

The sealers are maintained at right temperature so that the seal on the bags are of right quality. Temperature is maintained by using either standalone hardware or by utilizing special add-on instructions controlling the PID loops. The sealing temperature is primarily determined by the material of the bags and to a certain extent by the bag design. In certain machines, chiller units similar in construction to the sealers or chill rollers are, used to reduce the temperature of the material after the sealing operation. Chilled water flowing through the chillers is used to bring the temperature down.

l) Stacker / conveyor

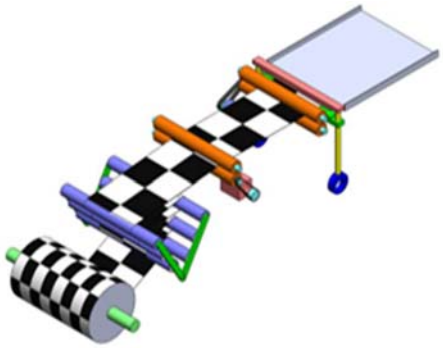
The bags are stacked and conveyed by these modules at the end of machine. They are of varied configuration based on the bag design and the downstream layout requirement. In certain machines, individual bags are stacked by this module and conveyed as a stack downstream or operator intervention is required to remove the stack. In other places the bags might be transferred individually to the next machine. They might be VFD or servo driven or combination of both based on the function.

m) Accessories

Accessory modules are added to the base machine to perform certain tasks like addition of hole/handle punches, tamper proof seal, spouts, and zippers etc. to the bag. The position of the module depends on the function. A handle / hole punch module is usually found in between the while zippers, Feeder sections, tamper proof sealers are found right after the EPC and cap / spout addition modules are present in front of the sealing / cutting section of machine. The accessory modules might be driven by pneumatic, servo system or might tap on to other sections for their motion.

n) Machine formats

There are many configurations of machines available based on the bag type and end user industry the packing cover are used in. A few common machine formats are briefly described in the following section.



Figurte-1. Side Seal.

This is the most common machine type. The raw material from the unwinder is folded into two and fed into the machine. The material is easy cut by using a hot knife which seals and cuts simultaneously.

The bags are sealed only at the sides and hence the name side seal machine. The bag bottom is closed due to the folding over operation and the bag top can be left open or closed by similar attachment or zipper. Simple configuration of this type has servos only for the feeders and VFDs for all other axes. It can produce bags upto 600 mm at 120 bags / min. In advanced machines, servos are used for sealers, feeders, and stackers which can produce bags upto 300 per minute.

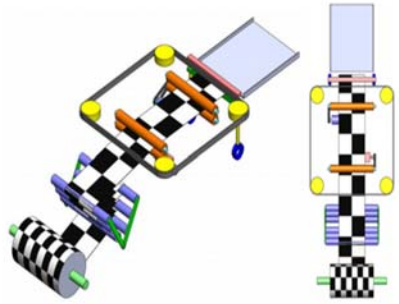


Figure-1. Side Seal.

Machines that produce pouches are the most versatile and sophisticated bag making machines. They are fed upto four layers of material from independent unwinders to produce stand up pouches. These machines typically have two to three sets of servo driven feeders. Cross sealers and side sealers are used to sealing up to four sides of the bag. In simple machines the top part of the sealers is moved by a single induction motor while the bottom part of sealers are stationary. In sophistcated designs the top and bottom parts of the sealers are moved against each other by a servo motor. It can produce pouches at 200 bags / minute.

3. RELATED WORK

High speed indexing movement Smoothest Indexing Cam Profile to reduce machine noise and jerk to assure long machine life span Generating smooth indexing movement with print mark correction and ability to adjust feeding angle Tension control

Maintain tension of the web during the high speed indexing movement to ensure optimal conditions for the accessories Seal temperature

Integrated temperature control for sealing unit - Constant seal time independent of machine speed to assure product quality Machine performance

Solutions and benefits

There are several good solutions which can be used for bag making machine applications. The main determining factors will be:

a) Synchronization of all Axes to:
- a. AC motor driven main Axis
- b. Servo motor driven main Axis

b) Controller / Programming Preference
- a. MicroLogix™ controller
- b.CompactLogix™ / ControlLogix® controller

c) Continuous / Intermittent Motion
- a. Electronic Gearing / Camming
- b. PowerFlex® VFD / Servos

In certain types of bag making machine; cutter, sealer or stacker axis will be driven by a VFD controlled analog current (AC) motor. In such machines all other axes need to be synchronized to "AC motor driven Axis".

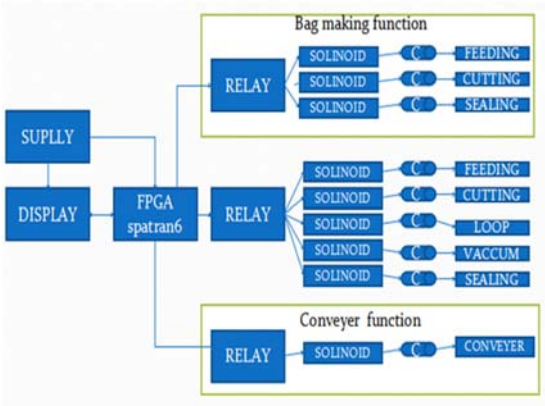
An encoder connected to the main axis will facilitate this synchronization of Axes. In other machines where all the major axes are servo driven timing axis (virtual master) is used for axes synchronization. Servos on the film feeders are used to maintain tension in the process during film feeding, so that only exact amount of film material can be used with minimal waste. Servo axes will feed the correct length of film based on the recipe provided by the operator. If the film is preprinted, a registration sensor adjusts the film position to maintain the correct print position. Feeders will move material only during a certain angle or window of the main axis. Axes driving other sections will be seen working either when film is moving or when film has stopped based on the operation done on the film by respective section. The film unwind control is handled as a separate.

Registration inputs to the Logix processor are able to record not only the position of any physical axis independent of the process, but also the time and the input occurred. This time can be used to determine precise positions for all other physical and virtual axes in the system to help control accurate film positioning. Plant-floor operators can select appropriately sized cam profiles by entering parameters from the operator terminal or calculate profiles on the fly with the MCCP instructions. These high speed intermittent machines which require coordination of axes creates additional control functionality needs, such as virtual axes and position camming. Compact Logix™ 5370 series PLC is used for controlling the system. - Servo solution provided by Kinetix 5500 servo drives with VPL servo motors. - PowerFlex® 525 drives are VFDs used for controlling the AC motors. - CIP encoder is used for providing position feedback of the main AC axis. - Panel View Plus provides human machine interface solution. - Remote I/O capability is achieved through the use of Point I/O.

4. PROPOSED METHOD

Design and FPGA implementation of soft loop handle fixing machine controlling the two machines at a time in one FPGA. The two machines (soft loop fixing, buttom cutting and sealing) function are operated by pneumatic. The pneumatic function and FPGA are interfaced by the solenoid value.

This is due to the extensive involvement of Automation which is possible in the industries and the ease of maintenance. This leads to an efficient way of improving the production of the industrial process and reduces number of workers. Hence this paper brings out the flexibility of Field Programmable Gate Arrays which used to control two machines loop fixing machine, bottom sealing and cutting machine. Here we use the pneumatic functions instead of motor which controls the machine through FPGA and helps to reduce the power consumption. The pneumatic are controlled by solenoid coil.



The pneumatic are controlled by solenoid coil the coils are controlled by the relays.

The relays are controlled by the FPGA. The coding is prepared by the delay and comparators. Coding will be developed with available tools like Xilinx Design Tools,ISE Design Suite 14.5 to achieve a smart and flexible knowledge based system in hardware design while achieving better efficiency in bag machine. The tested developed system, for bag making machine will be then implemented in verilog. Later on, by using synthesis tool like FPGA express, synthesis of the VLSI chip will be designed.

5. CONCLUSIONS

The power supply of the machine is reduced and also time is reduced and production of the machine is increases in the future machine can interface with the HMI display so it easy to operate by operates.

The cost of the production is reduced because the production is increased and power is reduced.

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