Bag Making Machine

Reduce Design Time and Improve Performance for Bag Making Manufacturers

This white paper takes a closer look at the key technologies and critical automation solutions available for building high performance based bag making machines.
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Executive Summary

As a machine builder, you are challenged to differentiate yourself amidst global competition and rapidly evolving technology. Bag manufacturing demands machines that combine high production output, reliability, product quality with low manpower and maintenance costs. The machines also need to be flexible enough to adapt to variations in bag length, bag material and sophisticated bag designs.

Whether measured from a business, commercial or technical perspective, Rockwell 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.

At Rockwell Automation, we strive for a holistic approach that focuses on your machine and business performance. What may start out as an “order-by-order” relationship, can eventually develop into a mutually beneficial business relationship. Rockwell Automation will work with you to develop solutions that will give you a competitive advantage throughout your machine’s life cycle.
Introduction

In today’s highly competitive bag making industry, businesses across the globe face unprecedented and volatile changes. Manufacturers, material suppliers, and machine builders (OEMs), are affected by shifting customer demands, globalization, industry consolidation, technology innovations, safety requirements, government regulations 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 various materials, shapes, sizes and designs based on the product packed or the end user industry. Products typically in solid, liquid form are packed for Food & Beverage, Pharmaceutical and Consumer Product industries.

<table>
<thead>
<tr>
<th>By Pouch Type</th>
<th>By Size</th>
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<tbody>
<tr>
<td>2 Side Seal Flat Pouch</td>
<td>Small</td>
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<tr>
<td>Stand Up Pouch</td>
<td>Normal</td>
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<tr>
<td>Gusseted Pouch</td>
<td>Large</td>
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<td>Pouch with Spout</td>
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<tr>
<td>STEB Bag</td>
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<tr>
<td>Chevron Bag</td>
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<td>Chamber Bag</td>
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<td>Heather Bag</td>
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< 300mm                  >300<1000     > 1000mm

Bag making machines come in various configurations based on the bag types produced by the machine. The bag making machine produces a bag by passing a roll of plastic film through a series of operations like heat sealing, cutting, combing. The film is typically flexible, heat sealable plastic.

The machine might be integrated with upstream machines like Flexo Printing, slitting machine or film extruder and downstream machines like horizontal form fill and seal (HFFS) to provide a complete packaging line.
Bag making machines produce bags / pouches that are used to package various types of goods in food and beverage, pharmaceutical and consumer product industries. In general these machines are fully automatic and require operator intervention only to replenish the raw material and remove the finished products.

Bag making typically has certain main functions which make up of material feeding, sealing, cutting and stacking.

**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. Dancer systems are used to maintain a constant tension on film web. Feeders and dancers are required for maintaining tension and critical accuracy in feed.

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

**In the Cutting and Stacking operations**, like sealing are typically done during the non-feeding time of the machine cycle. Similar to sealing, the cutting and stacking also would determine the ideal machine format. In addition to these basic functions additional operations like zipper, hole punch, handle punch, tamper proof seal, spout, cap etc. might be carried out depending on the bag design. Accessories attached to the base machine are used to carry out the additional operations.
Machine Sections

i. Unwind

Film unwind is responsible for unwinding film in the form of a roll into the machine while maintaining film tension. In certain machines unwind sections can be a static mandrel (un-powered) type and use either a pneumatic brake or friction brake to control unwind action and provide applicable film tension. In other machines unwind mandrel will require variable frequency control (VFD), servo control or DC gear motor type control. It can be either be surface driven or center driven configuration.

In the unwind section often there are roll change features, such as dual mandrels, roll lifts. The unwind section will also include the film tension and / or dancer. The dancer can provide a speed feedback (analog or discrete) to the unwind control circuit, as well as a film accumulator area for bag index purposes.

ii. Dancer

The dancer maintains tension when continuous movement of web is changed to intermittent motion. Tension maintained due to help of the dancer is very important to the function of the machine, 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.

iii. 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 horizontal or vertical format. It usually has a special sensor to detect the edge of the web and a mechanism to adjust the position of web. This mechanism in certain machines might move the unwind roll appropriately to achieve the edge control.
iv. In-feed

The in-feed is responsible for drawing material from the un-winder section and passing it on to the feeder section. 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.

v. 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 pneumatic cylinders. 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 motor. They are normally driven by servo motors as they need high dynamics [high speed and high acceleration / deceleration] and high accuracy.

vi. 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.

vii. Print Mark Control

Print mark control works on the feeders by helping to position the bags correctly under the cutter and sealers. This section includes the film registration sensor and placement adjustment mechanisms. 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. The registration mark provides a method to make minor adjustments to the actual end placement of the seal and cut on a bag. When there is no printing or graphics on the bag, the process is defined solely on length.
viii. 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.

The oscillatory motion is sometimes achieved by using a mechanical cam driven by induction motor. In these machines this is the primary axis to which all other axis is synchronized. 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.

ix. 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.

x. 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.

xi. Accessories

Accessory modules are added to the base machine to perform certain tasks like addition of hole/handle punches, zippers, tamper proof seal, spouts etc. to the bag. The position of the module depends on the function. A handle / hole punch module is usually found in-between the Feeder sections, while zippers, 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.
Machine Formats

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

Type 1: Side Seal

This is the most common machine type. The material from the unwinder is folded into two and fed into the machine. The material is typically 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 zipper or similar attachment. Simple configuration of this type has servos only for the feeders and VFDs for all other axes. It can produce bags up to 500 mm at 200 bags / min. In advanced machines, servos are used for feeders, sealers and stackers which can produce bags up to 300 per minute.
This type is used typically for long bag lengths up to 2000mm @ 120 bags / minute. Material which is in the form of tube (two layers) is fed from the unwinder. The material is fed by using either one or two sets of servo driven feeders. A main mechanical cam driven by induction motor will actuate the seal head, flying knife and stacker. The flying knife consists of a blade which is attached to a belt and when the belt rotates the blade cuts the material. The tube gets sealed and a cut is made below the seal, so that a tube with bottom closed is formed and hence the name bottom seal machine. In higher speed types of bottom seal two servo feeders and servo driven flying cutter is used to achieve 180 bags / minute.
Machines that produce pouches are the most versatile and sophisticated bag making machines. They are fed up to 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 seal up to four sides of the bag. In simple machines the top part of all the sealers is moved by a single induction motor while the bottom part of sealers are stationary. In sophisticated 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.
This is a type of continuous motion bag maker. The material from the unwinder is folded and sent through rotating sealing heads. Unlike other types of bag makers, here the feeding is not stopped during the sealing stage. Seal heads might have special knives to perforate the bags during sealing. The output is now wound back to form rolls. The simplest form utilizes one VFD to rotate the rotary sealers while all other operations are achieved by pneumatic means.
Challenges

- 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
  - Machine speed: Normal: 200-300cpm; High speed: >=400cpm
  - Good print mark and cutting accuracy (<0.5mm) to increase machine yield
  - Accommodate wide range of bag lengths and materials
  - 4kW~32KW servo drives/motors
  - Pouch makers have many stations that need co-ordination

- Balance between machine performance and machine cost
  - Excellent quality products at high speed from a cost effective and reliable machine

- Quality product and global support
  - High performance machines which can be shipped anywhere in the world having diverse working conditions
Challenges (Continued)

Typical Timing Chart

- Virtual Master
- Seal Head
- Back & Front Feed
- Seal Roller
- Wind Mill
- Punch Edge Guide
- Pin Adjust
- Index Conveyor

Slave° vs Master°

- Constant Seal Time
- Long Bag = More slave degrees
- Short Bag = Less slave degrees

Moves only after batch is done. Feeders not moving (based on Batch of 30 bags)
Solutions & Benefits

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

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

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

3. Continuous / Intermittent Motion
   a. Electronic Gearing / Camming
   b. PowerFlex® VFD / Servos

The Rockwell Automation Integrated Architecture™ system with integrated motion is ideal for bag making machines. In certain types of bag making machine; cutter, sealer or stacker axis will be driven by an VFD controlled 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 a 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 the 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 pre-printed, 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 function based on dancer position and whether the film is in motion or not. Built-in PID functionality provides accurate control of the film unwind mechanism by controlling such devices as unwind brakes or motors, as well as accurate temperature control of a variety of devices. Native math capabilities in the Logix processor provide a powerful environment for creating complex algorithms.
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 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 position camming and virtual axes.

A sample Rockwell Automation “Mid Range” architecture used in bag making machines is shown below.

- CompactLogix™ 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.
- PanelView™ Plus provides human machine interface solution.
- Remote I/O capability is achieved through the use of Point I/O.

All the components communicate over Ethernet.
Solution Scheme

Sample schematic of control scheme utilized in bag making machines is presented below. It shows the relation between various axes in the machine.
Innovations and differentiators in bag making

a. Constant seal time over wide range of machine speeds
b. Print Mark Correction
c. Web tension control

a. Constant Seal Time

Challenge

In order to ensure proper sealing, material needs certain quantity of heat energy.

- In certain conventional machines the sealing axis will be stopped at the sealing position for the duration of sealing time. The speed of the non sealing portion will be adjusted based on machine speed. The intermittent motion causes huge strain on mechanical system and the motor reducing their life.

- In other conventional machines seal head temperature is adjusted, whenever machine speed is changed. At higher speeds less time is available for sealing, so temperature is raised and lower speeds as more time is available for sealing, temperature is reduced. Delay in adjusting seal head temperature for new set speed adversely affects the uptime of the machine and can not guarantee the sealing quality during the temperature change.

Solution

- In simple terms the sealing axis needs to run at two different speeds. During the sealing portion the axis speed is decided by the sealing time and the non sealing portion axis speed is decided by the machine speed.
- Advanced CAM profiles are implemented in order to ensure smooth change in speeds and significantly reduce the strain on the system. Add on Instructions are used for generating advanced CAM profiles for control of sealing section (to & fro motion) based on machine speed and seal time.
- AOI is used for calculating sealing parameters for virtual master like sealing angle and next speed ratio. These in turn are used by another AOI to calculate the CAM profiles.
Innovations and differentiators in bag making (Continued)

- The speed is changed in steps from the current to the set speed based on maximum velocity and acceleration values entered. This ensures gradual and smooth change while ensuring proper sealing. Pending CAMs are utilized for continuous change in running profiles.

- In order to maintain sealing time during speed change, speed change is not allowed during the sealing portion of the cycle. Speed change is allowed only during the non-sealing portion of the cycle.

- “No Wastage of material” as the sealing time is maintained even when the machine is undergoing speed change.
b. Print Mark Correction

Film length and film position correction based on registration marks is a critical function in bag making.

Challenge

Print marks come in various shapes and sizes. In certain printed films the design on the film is used as a printmark. It is a challenge to pick a particular design as a printmark.

Solution

- A registration selection ‘Window’ is utilized for picking the right design from the background. In machines with multiple films a ‘Window’ is utilized for each film.

- If position error is well within ‘Position Error Window’, control system compensates for only length error.
• If position error is higher than ‘Position Error Window’, control system compensates for both length error & position error.

• “Print correction method” is the same for both single or multiple films in a single bag making machine. For multiple film machines all the feeders will be ‘Geared’ to a single virtual feed master.

• The Feed Master determines when to move based on the virtual master. Feed Master determines how much the feeders move based on the bag length.

The film is held at right tension between a set of feeders and moved. The error correction is done individually for each film based on its own Print mark.
c. Web Tension Control

**Challenge**

- Maintaining constant web tension, while film is intermittently pulled by film puller/feeder is very critical.

**Solution**

- Special in line dancer units are used to maintain tension of the web between the different feeder sections. This is achieved by feeding forward the length error to feeders based on the input of these dancers.

- The position of these dancers in the machine will determine how the feedback is used to control tension. In certain sections the print mark correction will override the dancer correction.

- The tension maintained in the web also affects the position of the mark and the cutting position. This has a direct implication on the quality of bag
Solutions & Benefits (Continued)

1. Substitution of mechanical machine elements
   - Flexible, electronic synchronized drives replace rigid mechanical systems with main shaft, gears and cams
   - Extended machine lifecycle, noise and vibration reduction by decoupling mechanical components

2. Maximum flexibility
   - Easy synchronization to upstream or downstream machines or processes

3. Increased productivity
   - Increased cycle rates by replacing mechanical transmission components with servo technologies
   - Automated format change by means of recipe storage

4. Increased product quality
   - Phase correction by use of registration mark control, improves seal and cut accuracy

5. Reduced downtime
   - No homing after downtime (in case of product jams or power failure) by using servo motors with absolute encoders

6. Extended “Market Reach”
   - Utilizing SIL 3 embedded Drives and Servos

7. Motion Analyzer Sizing Software
   - Selects the best matching pair of drive and motor from the Rockwell Automation product portfolio for the automation required
   - Cost optimization through proper sizing of motor and drive
   - Supports sizing for Rotary and Linear systems. It has also special templates for sizing complex rotary systems like crank, unbalanced load along with templates for applications like rotary knife, flying shear, winder & unwinder.

8. Temperature Control
   - Temperature controlled by using MBC (Model based control) AOIs in the PLC. This has better performance compared PID instruction in the PLC
   - Eliminates the use of standalone temperature controller and special modules for communicating with the temperature controller.
9. Drives – Premier integration
   - Configuring PowerFlex® drives with RSLogix™ 5000 software lets you consolidate controller programming and drive system configuration, operation, and maintenance into a single software environment. This exceptional level of integration helps to reduce your programming time, ease startup and commissioning, and streamline diagnostics.

10. Motion – Integrated motion
    - The Kinetix integrated-motion solution uses a SERCOS / CIP interface module to perform complex, multi-axis, synchronized motion. With a Kinetix system, you reap the full benefit of the Integrated Architecture platform because the integration doesn’t stop at the controller. This system integrates the drive, the motor, and even the actuator at a lower cost per axis of motion. Use the same RSLogix™ 5000 programming software to configure, program, and commission your application.

11. Safety - Functional
    - Rockwell Automation offers repeatable safety solutions across a number of industries and custom applications to meet your specific needs. Our safety team follows a solution lifecycle to help ensure projects are executed thoroughly

    - Safety Solution Lifecycle

    Step 1: Safety Assessment – Identify hazards and estimate the associated risks
    Step 2: Mitigation Technique Selection – Evaluate safeguarding options based on industry acceptable solutions
    Step 3: Safety System Design – Design system architecture, safety critical circuit design and guarding design
    Step 4: Project Execution – Material procurement, assembly, integration testing, commissioning
    Step 5: Validation – Verify that systems are operating within defined parameters and applicable standards have been satisfied
    Step 6: Maintenance – Change Control
Summary

Bag Making is a complex process. A misstep or improper procedure at any of the stages can threaten the structural integrity of the bag. Oftentimes it is during the manufacturing process that issues occur, causing the product failure reports prevalent in today's news.

By integrating control and information along with finite capacity scheduling, manufacturers can streamline their operations. Significant financial savings can be realized, including achieving increased manufacturing throughput as well as benefits from greater visibility, tracking and control of operations.

Let Rockwell Automation be your solution experts in bag making machines. Helping your business succeed and grow is what we do best, with power, control and information services designed to give you a competitive advantage.

Our in-depth understanding of the policies and requirements affecting you can help you reduce business risk, improve operational efficiency and achieve faster time to market.

Let Rockwell Automation be your answer today!

Global Solutions – Locally Delivered

Whether you’re around the corner or around the world, our Services & Support network can provide the skills and resources you need to optimize performance and utilization of your automation equipment, helping you meet your business objectives.

- Global emergency support 24/7
- Offices and agents in more than 80 countries
- 35,000 distributors and agents
- 1000 service engineers, consultants and project managers worldwide
Customer Case Study

CMD Improves Bag-Making Process with Logix Control Platform and Kinetix Integrated Motion

CMD Corporation makes a full line of machinery for the manufacturing of plastic trash bags. Since 1980 it has built machines such as draw tape, star seal, rotary, bottom seal, post gussets, bag and film etc. CMD is committed to providing machines that will help its customers become more competitive and profitable.

The company worked with Rockwell Automation to find a solution that would address the need to improve performance quality and usability, reduce delivery time, and lower the total cost of the machine.

Results of Implementing a Rockwell Automation Solution

Reduced wiring and components
Integrated control platform helped reduce wiring by 25 percent and number of components by 20 percent.

Faster assembly and commissioning time
OEM reduced machine assembly time by 10 percent and commissioning time from five days to less than two days.
pre-configured wire assemblies.

Ease of use
Diagnostic capabilities through Logix control platform and Allen-Bradley® PanelView™ interface help ease maintenance activities and reduce support needs.

“...We strive to design the most machine’s final selling price…”
Paul Johnson, senior electrical engineer

Improve machine performance
Kinetix® integrated motion solution provided reliable and repeatable performance that helped save downtime, achieve higher throughput and improve product quality

CMD Corporation implemented Rockwell Automation to address cost, quality, time and usability challenges in developing its 5213ED Rotary Bag Machine.
Resources

Call a Rockwell Automation sales office or an authorized distributor today or visit us online at: www.rockwellautomation/solutions/oem