Form-Fill-Seal

By John R Henry

1. Introduction

Form-Fill-Seal (FFS) refers to packaging processes that form the package, usually from a flexible material, fill it with product then seal it, all on one machine. It is also sometimes used to refer to machinery that molds a plastic bottle from resin, fills then seals it. These are outside the scope of this whitepaper which will focus on FFS with flexible materials. These flexible materials can be plastic film, metal foil, paper or combination. The word “film” will be used generically in this paper regardless of actual material. All of the machines discussed here use continuous film supplied on rolls.

This paper will discuss 3 major types of FFS machine:

- Vertical FFS, sometimes called “baggers”
- Horizontal FFS, often called flowwrappers
- Pouching or pouch machines

Horizontal and vertical refers to the flow of the film rather than how the product is introduced to the package.

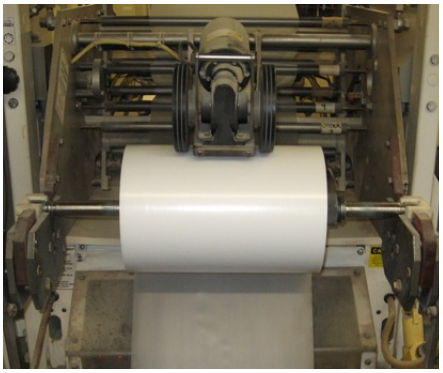
2. Common factors

There are several areas which are common to all 4 types of machine:

- Film tension control

Regardless of machine style, consistent tension must be maintained on the film. If there is too little tension, the film may wrinkle, causing appearance and sealing issues. Variable tension will cause problems maintaining proper package length and registration. Some machines pull the film off the supply roll and use a brake to control tension. Others use an unwind motor to unwind the film in a controlled fashion while maintaining proper tension.

After unwinding the film usually follows a zig-zag path through a series of dancer rollers. These rollers help control tension as well as alignment and flatness of the film. They are called “dancer” rollers because they dance up and down as the film is fed.

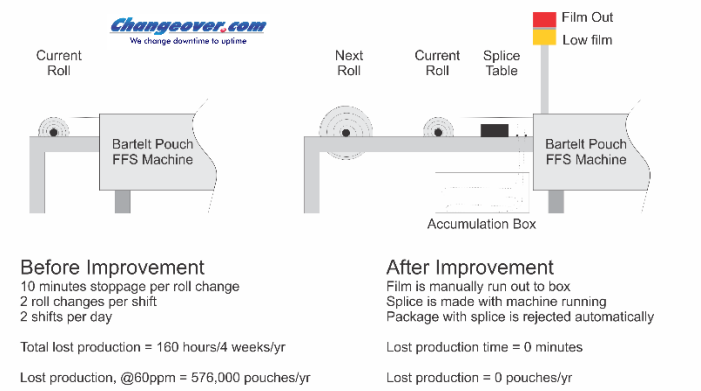


- Splicing/Extra roll

Film rolls need to be replaced periodically and this can result in significant lost production. Even 10 minutes daily results in the loss of a week’s production annually. Provisions need to be made to minimize the amount of time between rolls. This includes alerting the operator when nearing the roll end, stopping the machine at the roll end to eliminate the need for rethreading the film, convenient tools or splicing table to cut and splice the new roll to the old.

Accumulation boxes allow manually unwinding of the last 40-50’ of the roll so that splicing can be done without stopping the machine.

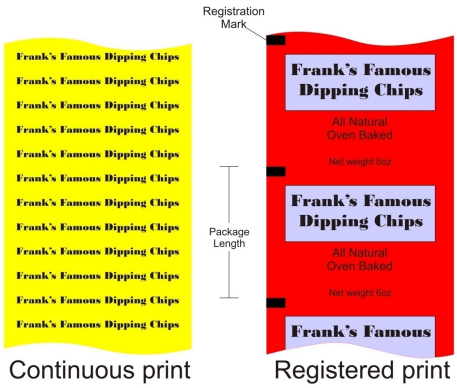
Even better is a second rollstand so that the next roll can be mounted and spliced before the current roll finishes. This sketch shows such an arrangement before and after including justification.



Fully automated splicing systems are also available that eliminate the need for any operator intervention other than making sure the next roll is in position.

- Registration

Film may be plain, with no graphics, continuously printed or registered. Plain and continuously printed film can be cut to length. Slight, 1/32 or so, variations in length cause no problem. This is not true for packages with graphics that must appear in a particular location on the finished package. Even slight variations in bag length, not noticeable in the individual bag will. Just 1/32” long, in one minute of running at 60bpm, puts the graphics almost 2” out of position.



Film with registered graphics needs a registration mark. A sensor on the machine detects the mark and stops the film in the same position each time. Moving the sensor

physically or electronically controls precisely where the film stops. The length of the bag is determined by the space between registration marks.

- Sealing

Proper film sealing relies on the correct combination of three parameters: Time, pressure and temperature. Failure to have all three at their correct values will result in poor or failed seals. There is some interchangability between them. A lower temperature may partially compensate for a higher sealing pressure. This may cause other issues and is never a substitute for precise setting and control of all parameters.

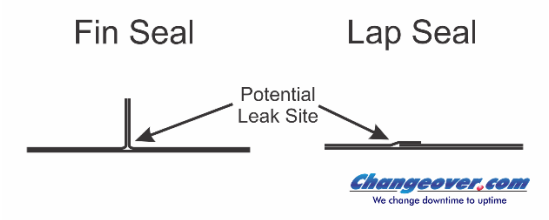
Most films have multiple layers with the innermost, adhesive, layer being a heat sealable material thermoplastic such as polyethylene. As the sealing jaws come together, they heat and soften this layer so that the pressure can then melt them together. If not enough heat, or pressure, or time is applied, they will not soften enough to melt together. If pressure is too great, the adhesive materials will be forced out of the seal area resulting in a weak or non-existent seal. High jaw temperature will cause excessive softening and when the pressure is removed, the adhesive layer may not have solidified sufficiently and pull apart. Ditto Excessive sealing dwell time.

Sealing jaws must be properly aligned so that they provide uniform pressure across their entire face. If not, they will cause excess pressure in one area at the cost of not enough pressure in another. This will cause leaky seals. Temperature uniformity is also critical. There are films available that may be placed between the sealing jaws and which will give a graphic image of pressure and temperature. These should be used during setup and whenever a sealing problem is suspected.

Some films may take more time to set up after sealing. If a heavy product such as cheese or hardware is dropped into the bag before it does, the seal may break open.

Seals

VFFS and HFFS machines can seal either inner layer to inner layer in a “fin” seal or can overlap the film in a lap seal. If a lap seal is used, there must be an adhesive layer on both the inside and outside of the film for sealing to take place.

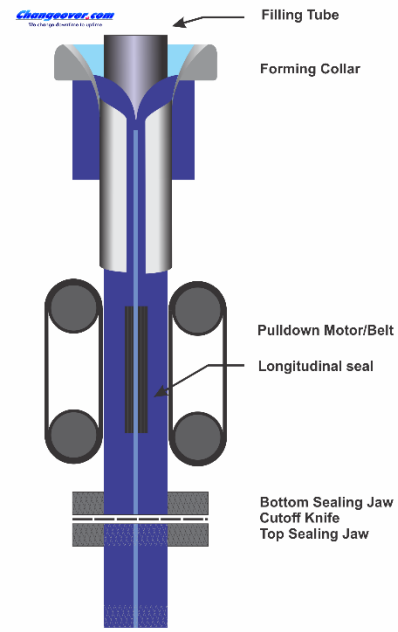


In VFFS and HFFS machines, the film is joined in a 3 way seal. This can be a potential site for leakage if seals are not correctly made.

3. Vertical Form-Fill-Seal (VFFS)

The vertical FFS machine lends itself well to loose products as diverse as potato chips and hardware items. They also work well with many liquid products liquid products such as detergent and food products. VFFS machines make bags in sizes ranging from ½" X ½" or smaller to 2' X 2' and larger.

Product is introduced to the bag by dropping it through the filling tube. In some low speed machines this may be done manually by an operator. More commonly some type of automated filler or dispenser is mounted above the machine. It is triggered by the machine when a bag has been formed and is ready to filling. Due to the way the product drops into the bag, they are generally not suitable for products that must be oriented within the bag.



Vertical Form-Fill-Seal Bagger

The film is unwound and passes through tension control and dancer rollers to the top of the machine. It passes over a forming collar and is formed into a tubular shape around the filling tube. This is commonly round but may be square or rectangular depending on the desired final shape of the bag.

In most modern VFFS machines, a pair of belts powered by servo motors capture the film between belt and tube and pull it down to the desired bag length (if unregistered) or the registration mark (if registered).

In older VFFS machines the sealing jaws move up and down in a reciprocating motion. At the top of their stroke, they grab the bag, sealing and cutting as they pull it down to the desired length. At the bottom of the stroke they release the sealed bag and return to the top.

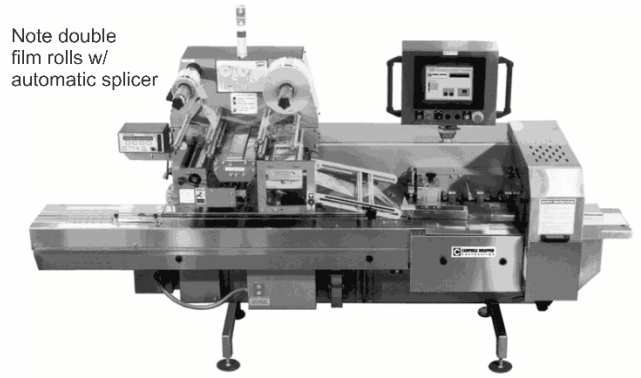
As the bag is pulled down, a longitudinal seal is formed, usually down the center of the bag. Some machines can make the longitudinal seal on the edge or the bag. Sealing is by reciprocating sealing jaws on intermittent motion machines or via heated rollers or belts on continuous motion machines.

At the bottom of the tube, a pair of sealing jaws seal the top of the previous bag, the bottom of the current bag, and cut the bags apart. The bags are sometimes left uncut providing providing a continuous chain for later cutting in a secondary operation or perforated to be torn off by the end user.

In continuous motion machines the jaws move up and down to form the end seals as the bag descends. It may look like they are pulling the bag down but they are not. They are merely following it, sealing as it descends.

4. Horizontal Form-Fill-Seal (HFFS) Machines

Horizontal FFS machines are similar to their vertical cousins above laid on their side. One big difference is that, instead of dropping the product down a vertical tube, the product is placed on a horizontal conveyor. This keeps products in a specific orientation through packaging. Another advantage is that the film is formed around the product rather than having the product dropped into a formed bag. This guarantees perfect alignment of the product parallel to the end seals and allows a tighter, more conformal, fit of the film around the product.



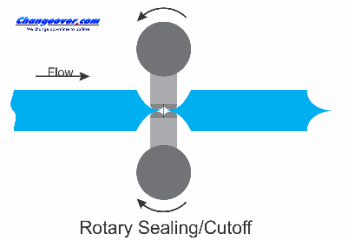
Courtesy Campbell Wrapper

Some flow wrappers use a lug chain conveyor for the infeed. Products are placed between the lugs either manually or fed automatically. The lugs provide space and synchronization with the bag forming section as well as helping to push the product into the bag.

Higher speed flow wrappers commonly use servo driven, lugless, belts. Spacing and synchronization is managed by sensors and PLC control.

During forming the film forms a fin seal underneath the product. A pair of heated wheels seal the fin. In his speed machines multiple pairs of sealing wheels may be used or may be substituted by heated sealing belts or bands.

After forming, the package is sealed and cut to length. Often a pair of rotary sealing & cutting jaws. These are simple but provide limited dwell time. If more sealing dewll time is required without slowing overall machine speed, reciprocating jaws or other methods may be used.



Rotary Sealing/Cutoff

In addition to the VFFS and HFFS machines discussed above, there are other styles such as pouch machines and four-sided seal machines. Flexible, film, packaging represents a huge saving to the manufacturer over more traditional bottles, boxes cans and other packaging. The material is very compact. A couple of pallets of film can replace a small warehouse of bottles and caps. The downside is that it does not provide the physical protection of rigid packaging. Higher performance films, more innovates and faster machines, as well as growing customer acceptance mean that will will see more and more flexible packaging.