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Par

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Intitulé du sujet

Conception et dimensionnement d'un prototype 3D d'une machine a packaging VFFS

Soutenu le // 2022 devant le jury composé de :

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Also, yet importantly, a sense of respect goes to my father and mother and my siblings, my dearest sister Souad for her strong support as well as regular encouragement in every step to get me to this present stage.

I also would like to thank all my respected teachers in the electrical engineering department and all the other members of the department. All my friends deserve my thanks for who directly and indirectly provided me with inspiration and valuable suggestions during the course of this study.

DEDICATIONS

I dedicate this work,

To my dearest parents and my aunt, who sacrificed their lives for my success, I will forever be thankful for their encouragement. May God keep them eternally happy.

To my sister Souad and my two brothers, Mehdi and Abderahman.

I would like to thank my friends B. Mjdoub, R. Adel, and B. Hbib, as well as all of my colleagues at my university and those who assisted me in completing this thesis, without forgetting my best friends, Bisemm and Iness.

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Résumé

Vu l’importance de l’emballage dans le monde en général et en Algérie en particulier, nous avons souhaité faire l’objet de notre travail intitulé « Conception et dimensionnement d'un prototype 3D d’une machine a packaging VFFS », où nous avons divisé cette recherche en quatre chapitre.

Dans le premier chapitre, nous avons traité des informations générales sur le processus d’emballage à travers son concept, son histoire et son importance dans la vie.

Dans le deuxième chapitre, nous montrons les spécifications et les types d’équipements utilisés dans ce domaine

Dans le troisième chapitre, nous avons présenté le matériel que nous avons utilisé dans cette machine et essayé d’expliquer son fonctionnement avec la conception sur SolidWorks.

Dans le quatrième chapitre, nous avons examiné les informations sur les parts électriques et automatisation

Abstract

Due to the importance of packaging in the world in general and in Algeria in particular, we wanted it to be the subject matter of our work, entitled " Conception and Dimensioning a 3D Prototype of a VFFS Packaging Machine". This research work is divided into four important sections.

In the first section, we dealt with providing general information about the packaging process through its concept, history, and importance in life.

In the second section, we tried to show the specifications and types of equipment used in this field

In the third section, we introduced the equipment we used in this machine and tried to explain how it works with the conception in solidworks software

In the fourth section, we reviewed the information about the different electrical parts and automation.

ملخص

نظرًا لأهمية التغليف في العالم بشكل عام وفي الجزائر بشكل خاص، فقد أردنا أن يكون موضوع عملنا بعنوان «إنجاز آلة التغليف». ينقسم هذا العمل البحثي إلى أربعة أقسام مهمة

في القسم الأول، تناولنا تقديم معلومات عامة حول عملية التعبئة والتغليف من خلال مفهومها وتاريخها وأهميتها في الحياة.

في القسم الثاني حاولنا إظهار مواصفات وأنواع المعدات المستخدمة في هذا المجال.

في القسم الثالث قدمنا المعدات التي استخدمناها في هذه الآلة وحاولنا شرح كيفية عملها، مع البرمجة على برنامج Solidworks

في القسم الرابع، قمنا باستعراض المعلومات حول لغات البرمجة المختلفة، ثم تطرقنا إلى تقديم تفاصيل حول أجزاء كهربائية في هذه الآلة.

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General introduction

[i]Reassuring excellence in food delivery is a crucial criterion for guaranteeing consumers' satisfaction. Therefore, food packaging that securely seals products is regarded as the safest way to preserve foods from any physical damage or chemical or biological factors that negatively affect them. Studies show the growing need for packaged products, especially food and drinks, which account for 70% of the packaging industry. Furthermore, in 2019, the total global packaging was valued at $917. Recent research shows that packaging is increasing at a steady rate of 2.8%. By 2024, global packaging will be valued at $1.05 trillion.

Given the increasing importance of food packaging, this dissertation will focus on the fascinating nature of packaging machines: how they work and how we can use them. The overall aim of the research was to better understand and inform manufacturers considering investing in developing food packaging machines.

To attempt to design a packaging machine with simulations We defined packaging at the beginning in a general way. We placed this field at the global level, which represents an important economic sector of about 2% of the GNP of the industrialized countries compared to our country. In addition, to better understand its functionality, a detailed description of the parts of the packaging machine was provided, with an explanation of the mechanical and electrical processes and programmable automation.

In the first chapter, a background of packaging was provided to explain how the machines have developed through different periods. As pointed out in this chapter, the field of packaging is rapidly evolving to the point where machines are needed to pack all these products. Different stages were presented, from film rollers to later stages in which bags ready for boxing were becoming more popular. Through this chapter, it becomes clear how it is essential to know how to design a packaging machine here in Algeria and how to make this machine reliable, maintainable, and sustainable at competitive prices. These questions were tackled in the subsequent chapters.

In the second chapter, the different parts of the machine were elaborated on with great details given on the different systems of presage, film roller, and forming tube to explain the way bags are

constituted in the machine. This chapter focused more on the type and level of pressure and heat system, cutting to seal bag

In chapter three, 3D simulations were made using the software SOLID WORKS to show how the machine parts work in reality and how programmable automation for the mechanical part functions. The result of the simulation was the realization of a prototype model. Moving to the fourth chapter, the electrical part, and the automatic part was discussed.

CHAPTER I

Generality on packaging

I.1 Introduction

Packaging is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the process of design, evaluation, and production of packages.

In short, Packaging can be described as a coordinated system of preparing goods for transport, warehousing, logistics, sale, and end-use. Packaging contains, protects, preserves, transports, informs, and sells, in many countries, it is fully integrated into government, business, and institutional, industrial, and personal use.

The history of packaging dates back to the year 1035, when a Persian traveler, visiting markets in Cairo, noted that vegetables, spices, and hardware were wrapped in paper for the customers after they were sold. Over time, attempts were made to use the natural materials available, such as Baskets of reeds, wooden boxes, pottery vases, woven bags, etc. However, the use of card board's paperboard cartons was first done in the 19th century.

The Michigan State University was the first to offer a degree course in "Packaging Engineering" Since then, there has been no looking back. The packaging industry boomed as more than the content, it is the" packaging" that attracts the attention of the buyer.

There was a revolution in Packaging in the early 20th century due to several modes of packaging designed such as Bakelite closures on bottles, transparent cellophane overwraps, and panels on cartons, which increased processing efficiency and improved food safety. As additional materials such as aluminum and several types of plastic were developed, they were incorporated into packages to improve performance and functionality.

Packaging means the wrapping or bottling of products to make them safe from damage during transportation and storage. It keeps a product safe and marketable and helps in identifying, describing, and promoting the product.

Different kinds of products need different kinds of packaging, for example, liquid products are packed in barrels and bottles; whereas, solid products are wrapped. The organizations use special containers for fragile products, such as glassware. [1]

Packaging operations are one of the most important facets in effecting new product innovations, increasing speed-to-market, and achieving sustainability goals. Properly selected and deployed packaging automation and innovative machine 172 designs enable marketing, supply chain, sustainability, and lean manufacturing strategies, and ensure customer satisfaction.

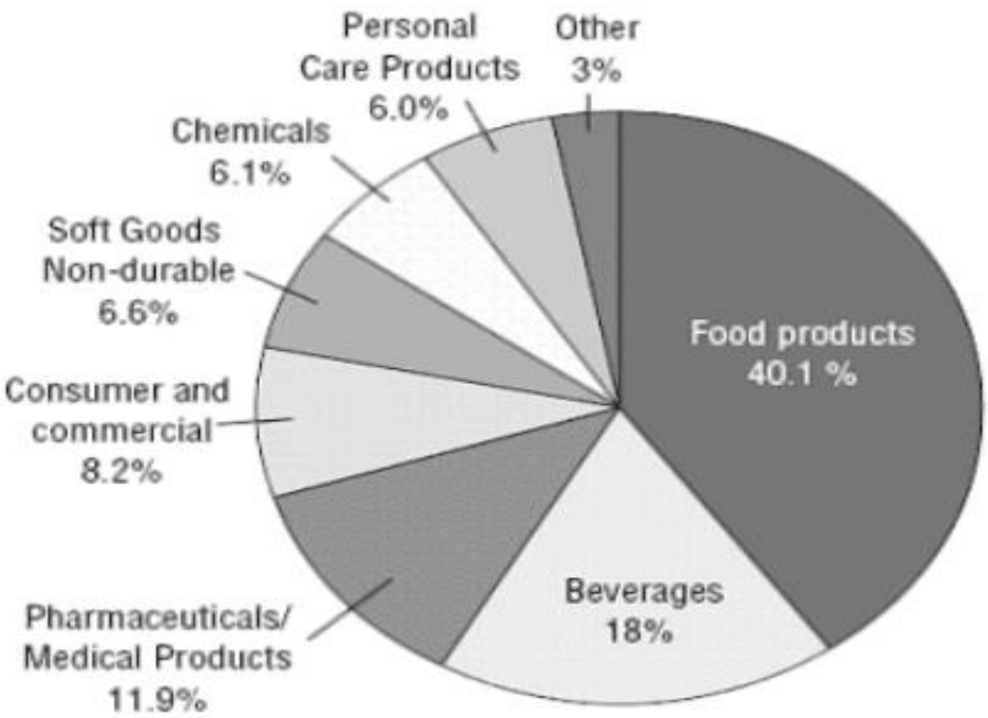


Figure 1 industries of packaging

As we can see in figure 1 we notice that food and beverages are the industries that use the packaging more than the other industries with 58.1%

Packaging can be regarded as different types. A single item such as a bottle containing a soft drink can be regarded as the item that a consumer would purchase known as "primary" packaging. Whereas a pack of bottles, shrink-wrapped, would be regarded as the transport package used within the distribution chain is known as "secondary" packaging. Primary packaging is the material that first contains the product. This is usually the package that is in direct contact with the contents. For example, this could be a bottle or carton for liquids; or a packet for various snack foods. The secondary packaging is outside the primary packaging, perhaps used to group primary packages. For example, this could be a tray and shrink film. Secondary packaging is mainly used as a means of transporting the primary packs or products from producer to retailer. This is usually removed and recycled once the pack has reached its destination. Secondary packaging can also be retained to enable the product to be purchased in bulk. The choice of packaging machinery for packaging can depend on various situations. These can include available budget, payback period, integration, associated running costs, machine technology, and available floor space. [1]

When we consider machines for packaging, there is an endless variety of packaging and processing machinery for food products, and many of them are remarkably similar. One of the major problems in the selection of machinery is distinguishing which, if any, offers a specific advantage over the other. Also, the degree of versatility may have to be considered; it is pointless to purchase a do-everything machine when there is a single task at hand, similarly machine with too little adaptability may be a blockage in the variable production process.

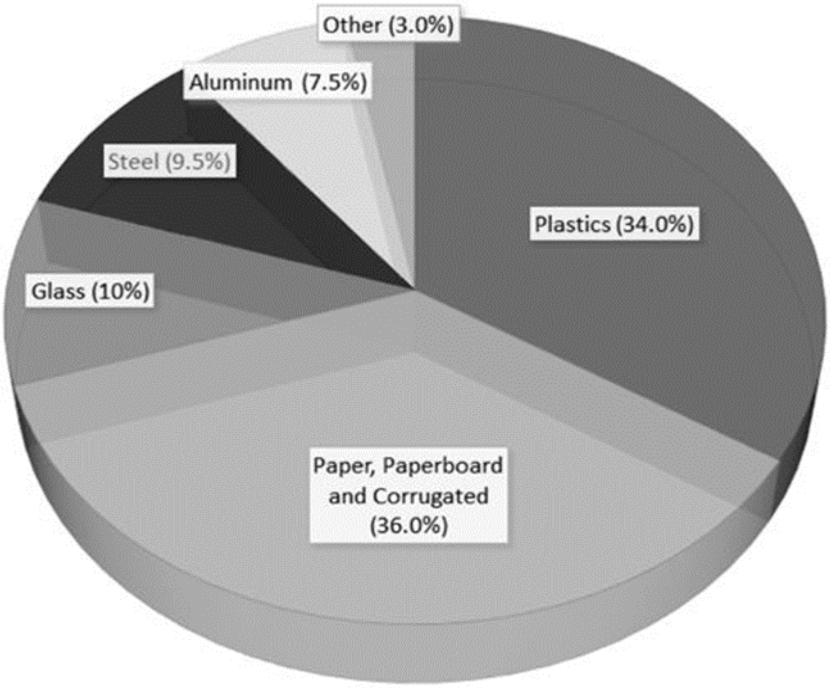


Figure 2 materials of packaging

We can notice in this figure that both paper and plastics took a significant percentage of the packaging materials because most of the VFFS machines work with plastic film

I.2 Intermittent and continuos machinery

Machinery can operate on an intermittent or continuous basis depending on the requirements of the production and the amount of capitalization. Normally, intermittent machinery will take a single package or a small number of packages, execute an operation on them all at once, and then pass them to the next process step. A continuous operation machine receives a stream of packages and executes the operation without stopping or reducing the speed of the overall flow of material. However, a four-station manual-feed filling machine might be suitable for a small winery, but a hat machine would be useless for a soft-drink bottler who needs several thousand fillings per minute to remain competitive. Equally, while continuous machinery is more economical at high throughput rates, it might make less sense to have a high-capacity operation that is in operation only for several hours a week because of low demand, although for the smallest of markets this may happen because of the employment of used machinery and the lack of properly scaled equipment. [2]

I.3 Characteristics and classification of machinery

I.3.1 Characteristics

The choice of packaging machinery depends on

1. Technical capabilities, labor requirements
2. Worker safety
3. Maintainability
4. Serviceability
5. Reliability
6. Ability to integrate into the packaging line
7. Capital cost

8. Floorspace

9. Flexibility (change-over, materials, etc.)

10. Energy requirement

11. Quality of outgoing packages

12. Qualifications (for food, pharmaceuticals, etc.)

13. Throughput

14. Efficiency

15. Productivity

16. Ergonomics, etc.

I.3.2 Classification

Packaging machines may be classified into the following general types:

1. Blister packs, skin packs, and Vacuum Packaging Machines

2. Bottle capping equipment, Over-Capping, Lidding, Closing, Seaming and Sealing Machines

3. Cartooning Machines

4. Box, Case, and Tray Forming, Packing, Unpacking, Closing, and Sealing Machines

5. Cleaning, Sterilizing, Cooling, and Drying Machines

6. Conveyors, Accumulating and Related Machines

7. Feeding, Orienting, Placing, and Related Machines

8. Filling Machines: handling liquid and powdered products

9. Package Filling and Closing Machines

10. Form, Fill, and Seal Machines

11. Inspecting, Detecting, and Check Weighing Machines

12. Palletizing, Depalletizing, Unit load assembly

13. Product Identification: labelling, marking, etc.

14. Wrapping Machines

15. Converting Machines

Other specialty machineries include slitters, perforating machines, etc

These machine types are very general indeed. Each area or sector of packaging equipment can be expanded upon to reveal the various applications that are available today. As technology advances, packaging machines are becoming more and more advanced to not only meet the current demands but to try and "future proof" the packaging equipment and product development within an organization. This can have a bearing on machine costs plus the interchangeability of operators and training. [3]

I.3.3 Packaged Product Types

The type of products to be packaged influences the type of application schematic required for the machine sections. Product characteristics such as size, consistency, and weight are important details that influence the control system application modules. Product misfeeds can lead to product jams in the sealing section for example. Suitable jam detection sensors would be required to detect this early

Product Type	Example	Machine Sections	Application Needs
Liquid	Sauce	Dosing	The machine must manage the measurement and insertion of product into the pouch, which requires tight coordination with the scales, augers, and mixers.
Fine granules	Sugar, Salt	Dosing, Mixing	
Coarse granules	Cereals, Spices	Dosing, Mixing	
Powders	Detergent	Dosing, Mixing	
Solids	Candy, Pharmaceuticals, Hardware	Weighing	For perishable product, the machine needs to be washed down for sanitary purposes.
Fresh produce	Vegetable	Dosing, Gas Flushing for product protection, Wash down	For food products, gas flushing with inert gas or O2 extraction is required to extend food shelf life.
Perishable	Meat, Fish	Dosing, Gas Flushing for product protection, Wash down	

Tableau 1 Product types & doser

I.4 Form, fill, and seal machine

These machines use a reel; of flexible material (paper, film or laminates of paper/film/foil) and Either form it into a tube and then seal and fill it at regular intervals, or fold it lengthwise and seal it at right angles to the fold to form a series of pockets which are filled and closed.

Form fill and seal machinery may be conveniently divided into three types:

1. Vertical machines, in which the material is formed into a circular section tu8be over a Forming collar

2. Horizontal machines, in which the material is formed into a rectangular section tube through a forming box,

3. Sachet forming machines, in which after filling, the remaining side is sealed to form the complete pack.

The seals in sachet are always made between different areas of the same face of the web, but with pouches either face to face or overlap sealing is possible on the long face seal produced in forming the tube

I.4.1 Vertical form fill seal machines

Are the most widely-used automatic flexible packaging machine type. This equipment does exactly what its name suggests

Vertical Form Fill Seal machine(VFFS) forms bag from film and fills an assortment of products such as powders, granules, and pieces, which come in a variety of shapes and kinds of foods such as candies, coffee beans, frozen foods and snacks by dropping vertically and seals them shut

I.4.1.1 Machine formats

There are two machine formats:

Single Lane

- Has a single lane tube form to shape the pouch at each cycle
- Suitable for many different sized pouches
- Most common configuration

Multi-Lane

- Has multiple lanes of tube to form multiple pouches at each cycle
- Mostly used for small packets such as sugar and salt packets

Principle

VFFS machine can be intermittent or continuous motion. Intermittent motion machines operate on the principle that vertical bag seals are made when the film is moving and horizontal seals occur when the film stops

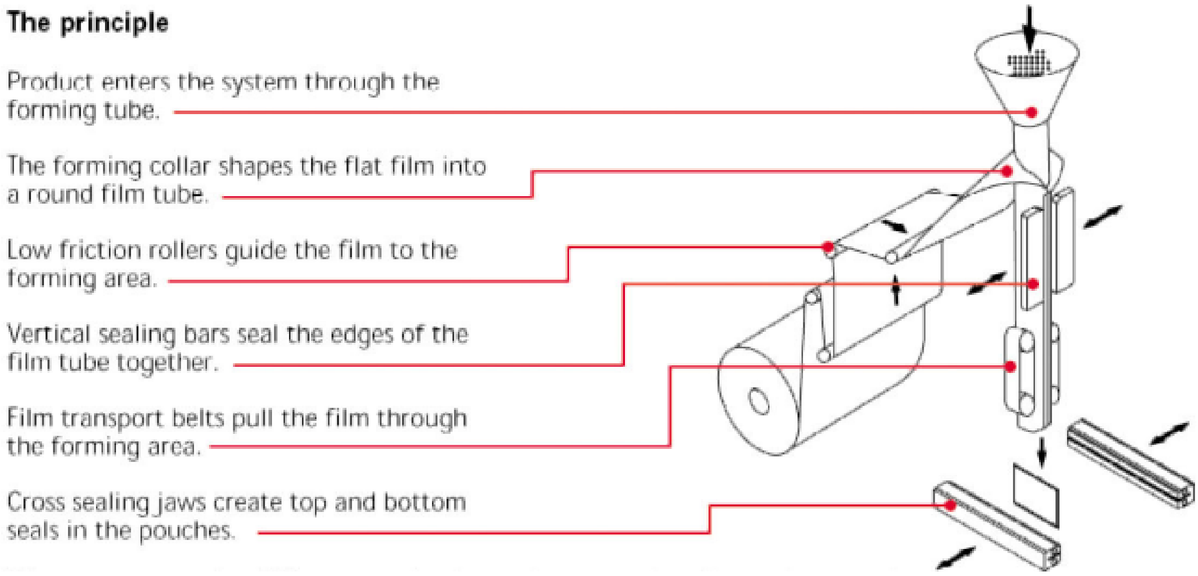


Figure 3 principale of VFFS

I.4.1.2 Processes

The film approaches the back of a long hollow conical tube, and when the center of the plastics is near the tube, the outer edges of the film form flaps that wrap around the conical tube. The film is pulled downward around the outside of the tube and a vertical heat-sealing bar clamps onto the edges of the film, bonding the film by melting the seam edges together. To start the bagging process, a horizontal sealing bar clamps across the bottom edge of the tube, bonding the film together and cutting off any film below. The sealed tube end is then lowered onto a precision weighing table and the product to be bagged is dispensed through the long conical tube in the center of the bag. When the tare weight of the product-filled bag is reached, filling stops, and the horizontal sealing bar seals the top of the bag, and simultaneously forms the bottom of the next bag above. This bag is then cut off from the tube and is now a sealed package, ready to advance onward into the product boxing and shipping processes.

I.4.1.3 Film Transport & Unwind

VFFS-packaging-machine-film-roll-unwind Vertical packaging machines use a single sheet of film material rolled around a core, usually referred to as roll stock. The continuous length of packaging material is referred to as the film web. This material can vary from polyethylene, cellophane laminates, foil laminates, and paper laminates. The role of film is placed on a spindle assembly at the rear of the machine.

When the VFFS packaging machine is operating, the film is usually pulled off the roll by film transport belts, which are positioned to the side of the forming tube which is located at the front of the machine. This method of transport is the most widely used. On some models, the sealing jaws themselves grip the film and draw it downward, transporting it through the packaging machine without the use of belts.

An optional motor-driven surface unwind wheel (power unwind) may be installed to drive the film roll as an assistant to the driving of the two film transport belts. This option improves the unwinding process, especially when the film rolls are heavy.

Figure 4 film roll

I.4.1.2.1 Film Tension

VFFS-packaging-machine-film-unwind-and-feeding during unwinding, the film is unwound from the roll and passes over a dancer arm which is a weighted pivot arm located at the rear of the VFFS packaging machine. The arm incorporates a series of rollers. As the film transports, the arm moves up and down to keep the film under tension. This ensures that the film will not wander from side to side as it is moving.

Figure 5 film tension

I.4.1.2.2 Optional Printing

After the dancer, the film then travels through the printing unit, if one is installed. Printers may be thermal or ink-jet types. The printer places desired dates/codes on the film or may be used to place registration marks, graphics, or logos on the film.

I.4.1.4 Film Tracking and Positioning

VFFS-packaging-machine-film-tracking-positioning once the film has passed under the printer, it travels past the registration photo eye. The registration photo eye detects the registration mark on printed film and in turn, controls the pull-down belts in contact with the film at the forming tube. The registration photo-eye keeps the film positioned correctly so the film will be cut in the appropriate spot.

Next, the film travels past film tracking sensors that detect the position of the film as it's traveling through the packaging machine. If the sensors detect that the edge of the film shifts out of normal position, a signal is generated to move an actuator. This causes the entire film carriage to shift to one side or the other as needed to bring the edge of the film back to the correct position.

I.4.1.5 Bag forming

From here, the film enters a forming tube assembly. As it crests the shoulder (collar) on the forming tube, it is folded around the tube so that the result is a length of film with the two outer edges of the film overlapping each other. This is the beginning of the bag forming process.

The forming tube can be set up to make a lap seal or fin seal. A lap seal overlaps the two outer edges of the film to create a flat seal, while a fin seal marries the insides of the two outer edges of the film to create a seal that sticks out, like a fin. A lap seal is generally considered more aesthetically pleasing and uses less material than a fin seal.

A rotary encoder is placed near the shoulder (collar) of the forming tube. The moving film in contact with the encoder wheel drives it. A pulse is generated for every length of movement, and this is transferred to the PLC (programmable logic controller). The bag length setting is set on the HMI (human-machine interface) screen as a number and once this setting is reached the film transport stops (On intermittent motion machines only. Continuous motion machines do not stop).

The film is drawn down by two gear motors which drive the friction pull-down belts located on either side of the forming tube. Pull down belts that utilize vacuum suction to grip the packaging film can be substituted for friction belts if desired. Friction belts are often recommended for dusty products as they experience less wear.

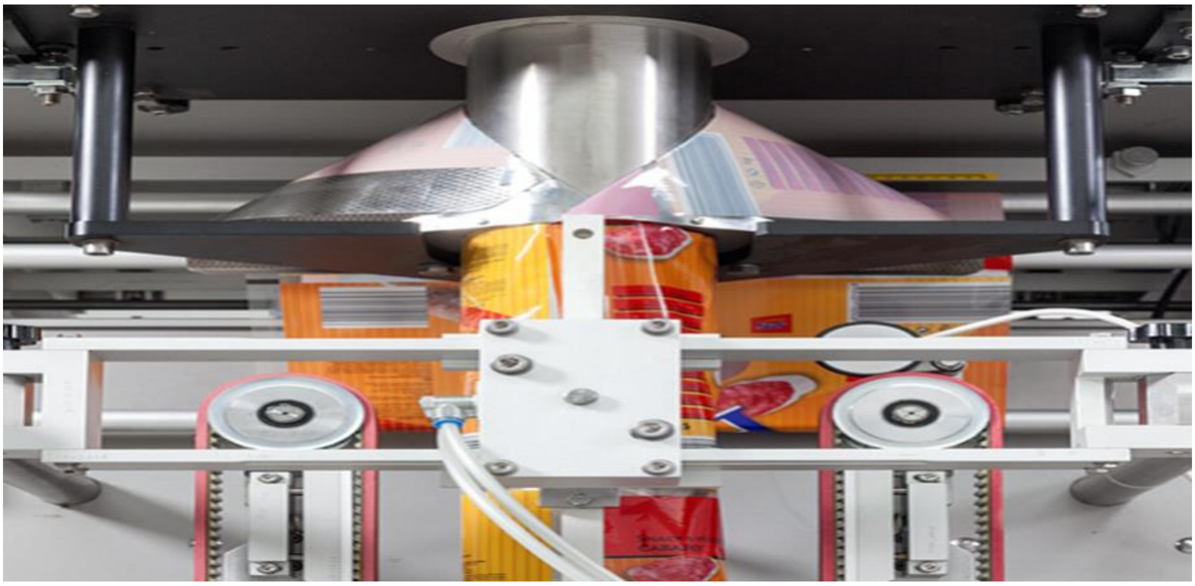


Figure 6 forming tube

I.4.1.6 Filling and sealing

Now the film will briefly pause (on intermittent motion packaging machines) so the formed bag can receive its vertical seal. The vertical seal bar, which is hot, moves forward and makes contact with the vertical overlap on the film, bonding the layers of film together.

On continuous motion VFFS packaging equipment, the vertical sealing mechanism remains in contact with the film continuously so the film does not need to stop to receive its vertical seam.

Next, a set of heated horizontal sealing jaws come together to make the top seal of one bag and the bottom seal of the next bag. For intermittent VFFS packaging machines, the film comes to a stop to receive its horizontal seal from jaws that move in an open-close motion. For continuous motion packaging machines, the jaws themselves move in up-down and open-close motions to seal the film as it is moving. Some continuous motion machines even have two sets of sealing jaws for added speed.

An option for a 'cold sealing' system is ultrasonic, often used in industries with heat-sensitive or messy products. Ultrasonic sealing uses vibrations to induce friction at a molecular level that generates heat only in the area between film layers.

While the sealing jaws are closed, the product that is being packaged is dropped down the middle of the hollow forming tube and filled into the bag. A filling apparatus like a multi-head scale or auger filler is responsible for the correct measurement and release of discrete quantities of product to be dropped into each bag. These fillers are not a standard part of a VFFS packaging machine and must be purchased in addition to the machine itself. Most businesses integrate a filler with their packaging machine.

Figure 7 sealing jaws

I.4.1.7 Bag Discharge

After the product has been released into the bag, a sharp knife within the heat seal jaws moves forward and cuts the bag. The jaw opens and the packaged bag drops. This is the end of one cycle on a vertical packing machine. Depending upon the machine and bag type, VFFS equipment can complete between 30 and 300 of these cycles per minute.

The finished bag can be discharged into a receptacle or onto a conveyor and transported to downline equipment like check weighers, x-ray machines, case packing, or carton packing equipment.

Figure 8 Bags Discharging

I.4.1.8 Air-tight

A frequently occurring requirement is that the product requires an air tight package. An additional level of protection occurs in a modified atmosphere package “MAP” where the air in the packaging is replaced by an inert gas that combats oxidation and extends shelf life.

I.4.2 Filling equipment

Packaging machines themselves do not measure or dispense product. Instead, a separate piece of equipment can perform these operations.

Often, a flexible packaging machine will be integrated with a filler or doser to accurately measure the weight or volume of product before it is dropped into each bag. Depending on your product properties, different filling equipment will be recommended:

•An auger filler is often used for powder products. This equipment uses a long screw-like mechanism to measure discrete quantities of product into bags.

•A multi-head scale is often used for solid products. This equipment uses a number of buckets to accurately weigh products before dropping them into bags.

•For liquids, a liquid pump, usually with a piston mechanism, will measure specific volumes of product into bags.

Fillers are usually placed above or off to the side of the packaging machine.

I.4.3 Bags types

Achieving the up level of value-added packaging which meet customer's requirement there is a variety type of bags .

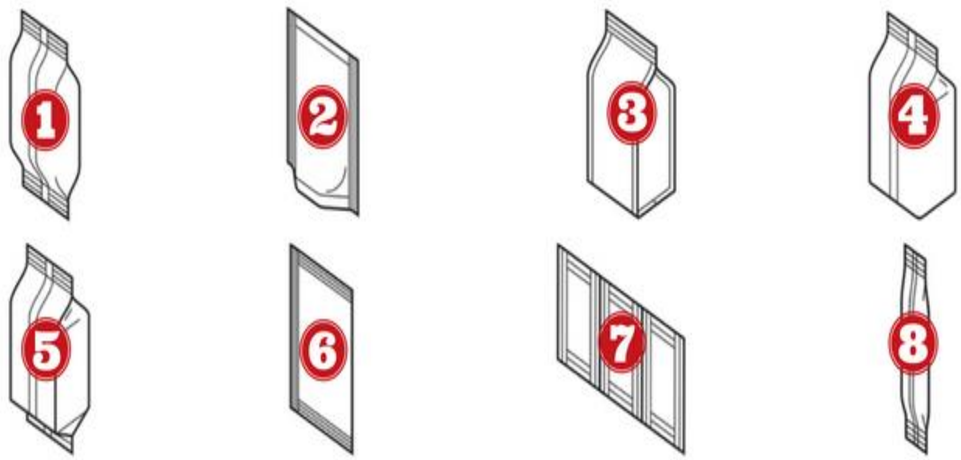


Figure 9 bags types

1. PILLOW BAGS: are the most widely-used and economical packaging format, comprised of two flat panels sealed together on the top and bottom with a vertical seal down the back. This bag type is popular for value-brands, chips, single-serving snacks, and fractional packs of coffee.

2. DOYPACKS: are stand-up pouches with an oval-shaped base. This bag type is growing in popularity for premium products in many industries, including snacks, coffee, and powder supplements.

3. QUAD SEAL BAGS: have a rectangular bottom and can stand unassisted. This bag type has two side gussets and two panels joined together with four vertical seals, providing a more structured bag and modular look. This bag type is popular for premium coffee brands.

4. FLAT BOTTOM BAGS: are similar to quad seal bags, featuring two gussets, but only have a single vertical seal. This bag type is popular for coffee and pet food.

5. GUSSETED BAGS: are similar to pillow bags but have side gussets, offering more internal space.

6. THREE SIDE SEAL BAGS: are flat pouches sealed on three sides.

7. SACHETS: are small, flat 4-side sealed packets, often used for single-serving condiments and spices.

8. STICK PACKS: are very narrow pillow bags, used for single-serving powders and liquids.

Extras

In addition, other extras can also be added to packaging by VFFS machines, varying from techniques that make the packaging easier to open to aids that make it possible to reclose bags multiple times.

Many top companies are adding VFFS packaging to their line-up, for reasons including the following:

•Low cost per package

•More surface area for graphics and messaging

•Less risk of breakage and injury if dropped

•Low storage and shipping costs

•Small carbon footprint

•Increased consumer demand for portable, lightweight, flexible package[4]

I.5 Advantages of FFS

• Bags made on FFS are less expensive than pre-made bags

• Lower capital cost than fully auto machine when packing rate above 500 bags/h

• Total automation - usually unattended, labour saving provides

• Consistent packing rate

• Compact (especially the Vertical FFS)

• Fast - increased production rate, reduced no. of shifts

• Easy and quick to clean-out between production batches

• Fewer moving parts - especially Vertical FFS

• 'Online' film printing provides readable bar code and product info

I.6 Disadvantages of FFS

• Not economical for short production runs of one bag size - below 1000 x 25 Kg bags = 25 tons

• Cannot handle paper

• Cannot handle multi-ply packing materials

• Not economical for packing low density, aerated powders such as wheat flour, talcum powder, skimmed and whey powder at medium speeds

• Cannot remove 'trapped air' very quickly or easily

• Shape of package made by Vertical FFS or 'C' type FFS not as good as valve sack

• Cannot self-adjust for different widths of bag but changing length is very easy on

I.7 Tips for selecting VFFS machines

• Always remember Simpler is better!

• Reliability and performance metrics Speed, wastage, up-time, quality of final packs, change over time, available options, capability to handle different materials, labour savings, skill availability and capability requirement to run and maintain the machine, ease of cleaning, flexibility to handle different sizes, types of packs etc.

• Quality & Sanitary Requirements Clean room, aseptic filling

• Total Cost of Ownership Initial cost, after sales service & support costs, repair and downtime costs, utility & consumable costs, spare parts & response time from manufacturer / supplier

• Integration with upstream & downstream equipment

• Know your product and pack sizes and make sure that the machine is able to cater for all your products.

• Type of final bag: Pillow, gusseted, stand up pouches, zipper / re-sealable bags available options and integration of additional options at a later time.

• Multiple function machines, technology trends like ultrasonic sealing, better sealing technologies, advance servo technology, PackML compatibility, better diagnostic features etc.

• Design requirements basis country OR company / industry standards requirement

• References, brand name, inter-personal rapport.

• Space constrain, lead time, costs, constrains and other limitations.

I.8 Objectives of Packaging and Packing

Packing and packaging are basically done to protect the product. During the present days however these two functions have assumed several additional objectives in addition to protection.

The following are the objectives of packing and packaging:

1. To Provide Physical Protection:

Packaging of objects insures that they are protected against vibration, temperature, shock, compression, deterioration in quality etc. Packing and packaging also protect the products against theft, leakage, pilferage, breakage, dust, moisture, bright light etc.

2. To Enable Marketing:

Packing and packaging play an important role in marketing. Good packing and packaging along with attractive labelling are used by sellers to promote the products to potential buyers. The shape, size, colour, appearance etc. are designed to attract the attention of potential buyers.

3. To Convey Message:

There is so much of information about the product that a manufacturer would like to convey to the users of the product. Information relating to the raw materials used, the type of manufacturing process, usage instructions, use by date etc. are all very important and should be conveyed to the users. Manufacturers print such information on the packages.

4. To Provide Convenience:

Packing and packaging also add to the convenience in handling, display, opening, distribution, transportation, storage, sale, use, reuse and disposal. Packages with easy to carry handles, soft squeezed tubes, metallic containers, conveniently placed nozzles etc. are all examples of this.

5. To Provide Containment or Agglomeration:

Small objects are typically put together in one package for reasons of efficiency and economy. For example, a single bag of 1000 marbles requires less physical handling than 1000 single marbles. Liquids, powders, granular materials etc. need containment.

6. To Provide Portion Control:

In the medicinal and pharmaceutical field, the precise amount of contents is needed to control usage. Medicine tablets are divided into packages that are of a more suitable size for individual use. It also helps in the control of inventory.

7. To Enable Product Identification:

Packing and packaging enable a product to have its own identity. This is done by designing a unique and distinct package through the effective use of colours, shapes, graphics etc. Such identification and distinction are very essential in the present situation of intense competition and product clutter.

8. To Enhance Profits:

Since consumers are willing to pay a higher price for packaged goods, there will be higher profit realization. Moreover packaged goods reduce the cost of handling, transportation, distribution etc. and also cut down wastage and thereby increase profits.

9. To Enable Self-Service Sales:

The present trend in retailing is effective display and self-service sales. Products require effective packing for self-service sales.

10. To Enhance Brand Image:

Attractive packing and packaging in a consistent manner over a long time enhances the brand image of the product.

I.9 Characteristics of Good Packaging

Packaging is more than just your product’s pretty face. Your package design may affect everything from breakage rates in shipment to whether stores will be willing to stock it. These are the characteristics of good packaging:

Labelling

You may be required to include certain information on the label of your product when it is distributed in specific ways. For example, labels of food products sold in retail outlets must contain information about their ingredients and nutritional value.

Opening

If your product is one that will be distributed in such a way that customers will want to–and should be able to–sample or examine it before buying, your packaging will have to be easy to open and to reclose. If, on the other hand, your product should not be opened by anyone other than the purchaser–an over-the-counter medication, for instance- -then the packaging will have to be designed to resist and reveal tampering.

Size

If your product must be shipped a long distance to its distribution point, then bulky or heavy packaging may add too much to transportation costs.

Durability

Many products endure rough handling between their production point and their ultimate consumer. If your distribution system can't be relied upon to protect your product, your packaging will have to do the job.[5]

I.10 Conclusion

Over the past decades, the VFFS machine has become the machine of choice for many different product types. We can only speculate about the number of machines in use around the world. It is clear that hundreds of VFFS machines are sold annually. Practical knowledge, based on our wide experience with the many possibilities these machines offer, suggests there are thousands of these machines in operation around the world.

The broad use of VFFS machines is simple to explain. To start with, one single machine can be used to produce a wide range of bag shapes. This is made possible due to a large variety of simple-to-exchange parts, such as forming shoulders and forming tubes. Chips, for example, are usually packed in a simple, brightly colored, pillow-shaped bag, while breakable cookies are presented in a deluxe, transparent bag with a block bottom – and both bags can be produced by the same machine.

The examples that are named in this introductory chapter are just a few of the hundreds of possibilities that the VFFS machines offer. It is especially impressive that these machines, no matter what the packaging requirements that have to be met, are usually able to provide a reliable and efficient output, even at a high speed.

CHAPTER II VFFS machine composition and functionality

II.1 Introduction

A machine is a physical system using power to apply forces and control movement to act. The term is commonly applied to artificial devices, such as those employing engines or motors, Machines can be driven by animals and people, by natural forces such as wind and water, and by chemical, thermal, or electrical power.

However, nowadays most machines are fully automatic so they drive by themselves based on PLC (programming logic controls) but they need a variety of materials that can actuate the different pieces of the machine.

In this chapter, we will see the different pieces of the process of the packaging machine, especially the VFFS machine which is our target in our research.

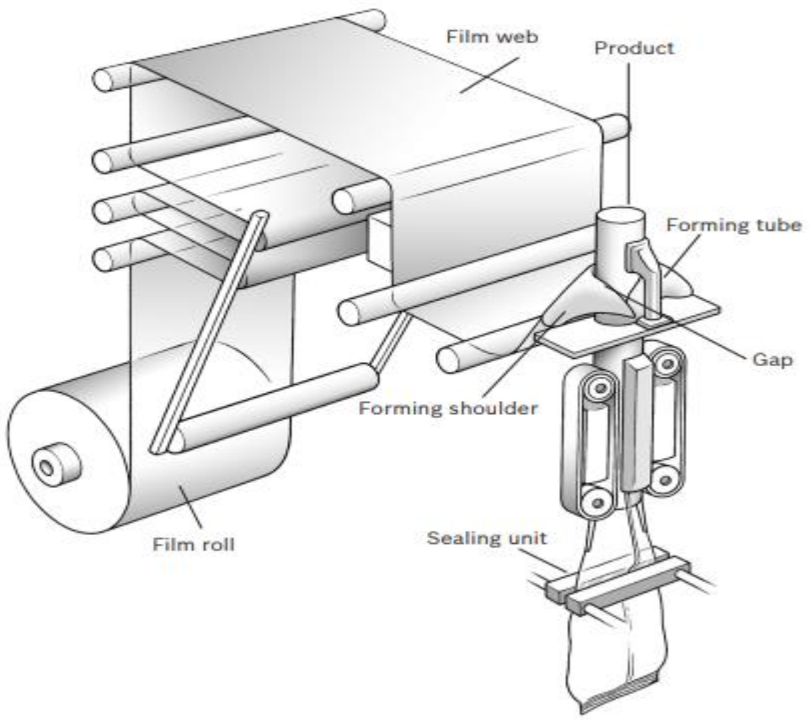


Figure 10 overview of VFFS

VFFS machines are suited to a broad range of products that can be divided into the following four main groups:

• bulk goods, varying from nuts and cookies to bolts and screws;

• powders, such as ground coffee and dehydrated milk;

• grains or granulate, such as detergent;

• liquids: usually one-time (portion) packages such as ketchup, mayonnaise, salad dressing, or bath gel, for example. [5]

II.2 Dispensing

To ensure that the correct quantity of product is always packaged, a dozer is required. Depending on the product, the dozer works based on a filling weight per bag (filling scale) or the basis of a certain volume per bag (dispensing cup or auger dosing). For liquids, a special pump is used that dispenses a certain amount of liquid for each package. When packaging a certain number of product units per bag, a counting machine is used.

dosing

It is of course important that each bag contains the correct amount of product. Different dispensing systems have been developed to make sure this happens. The choice of the dispensing system depends on the product features.

• Filling scales and counting machines are the most commonly used dispensing systems for products such as candy, macaroni, snacks, chips, nuts, screws, and bolts: bulk goods, that are fed into the forming tube in free fall.

• Homogeneous bulk goods with a small piece size and a relatively low-cost price, such as detergent, rice, peas, fertilizer, and granulated sugar, are often dispensed with a dispensing cup or cup filler. • Powdery products such as ground coffee and dry milk could whirl around during free fall, causing the product to get into the sealing seams. With such products, one uses an auger filler or auger dosing that transport the powders to the bottom of the bag.

• Liquids (ketchup or salad dressing, for example) are dispensed with a dispensing pump

II.2.1 Multi-head weigher

The most common filling scale, the so-called multi-head weigher, owes its popularity to its speed, precision, and broad applications. As the name suggests, the multi-head weigher uses multiple weighing hoppers simultaneously. Each of the eight to thirty-six weighing hoppers is filled.

The multi-head weigher determines at a high rate which combination of the hoppers contains the desired amount or as closely approximates this as possible. If dispensing must be done without a multi-head weigher for a product where each unit weighs 4 to 6 grams (large nuts, for example), then for a 250-gram package, one must often choose between dispensing 248 or 252 grams. With a multi head weigher, such deviations are avoided; with a combination of three to five of the available hoppers, correct dispensing is always possible within narrow constraints.

Multi-head weighers work quickly, partly because never more than three to five of the available hoppers are emptied. The individual filling weights are always combined, so they are always ready for the next dispensing[6].

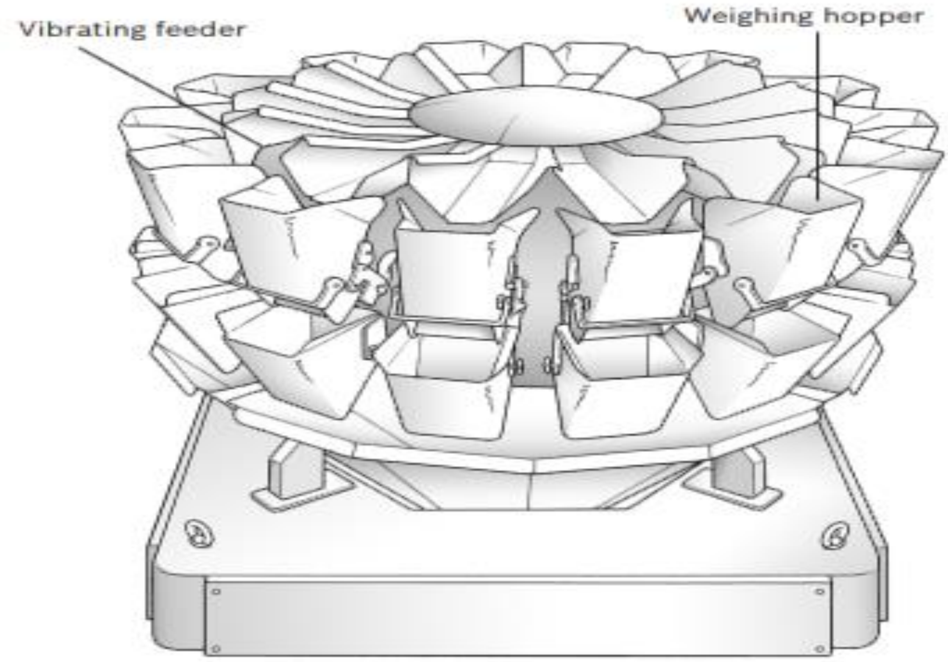


Figure 11 multi-head weighers

Vibration feeders

The hoppers are often filled via vibration feeders, which ensure that a more or less equal amount of product runs into each hopper during a set amount of time. This amount can be varied by shortening or lengthening this time .

Collector bins

To assure the process goes as quickly as possible, the product first transitions down from the vibration feeders into collector bins mounted above the weighing hoppers. From these bins, the product is emptied into the weighing hoppers. The weight dispensed is transmitted to microprocessor that determines the right combination for the next dispensing.

In most multi-head weighers, the combinations of vibrating feeder, collecting bin and weighing hoppers are mounted in a circle. This allows for the most compact machine construction possible. The product is dispensed from the weighing hoppers into a shared funnel. Long products, such as fish, are difficult to divide in a circular fashion. For such products there are also multi-head weighers with feeders and bins next to each other.

II.2.2 Linear filling scale

In linear filling scales, the product is fed over a central vibration feeder to a weighing hopper. The vibration feeder is divided into a coarse dosing, where a large flow of products is found, and a fine dosing, that contains a small amount of product. As soon as a set percentage of the desired weight has been supplied, the coarse dosing is switched off and only the fine dosing continues on until the total weight has been achieved. At that time, the bag can be filled. This is a time-intensive process. In addition, the precision is never greater than the weight of the product that is still underway between the time the weight is reached and fine dosing is switched off. Linear filling scales come with one to four weighing hoppers.

Figure 12 linear filling scale

II.2.3 The counting machine

The counting machine, which is used for example for biscuits and flower bulbs, as well as for candies, resembles the linear filling scale in some respects. The product units are placed in a row behind each other on the vibration feeder. A sensor counts the passing units that then end up in the bag via a funnel. As soon as the set number of units has been achieved, a valve closes the vibration feeder. A combination of vibration feeder and counting sensor is called a channel. Counting machines come in models with six, eight and sixteen channels[6] .

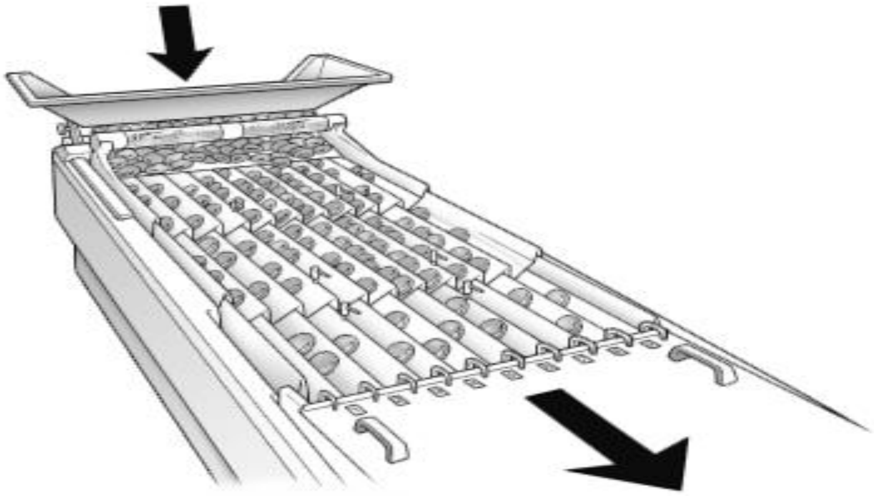


Figure 13 counting machine

With some multi-head weighers, it is also possible to count. By entering the piece weight of the product, the weigher can calculate how many pieces are in the weighing hopper, and it determines whether the combination of hoppers contain the desired dispensing amount. This of course, works only with products whose piece weight does not vary.

II.2.4 Dispensing cup fillers

Dispensing cups are volumetric dosing; they do not measure weight, but volume. Simply stated, a dispensing cup consists of a number of containers between two disks. Above that, there is an inflow channel and a filling funnel filled with products. The disks with the containers run under the filling funnel so that they are filled one by one. The filled containers then turn in the direction of the forming tube, above which they are emptied by opening a valve located at the bottom of each container, or simply by rotating over an opening in a plate above the tube.

Cups the containers consist of two parts that can slide apart and together vertically, which allows the content of the containers to be varied infinitely within certain limits. The precision of the dispensing cup is directly contingent on the homogeneity of the product and the consistency of the container filling.

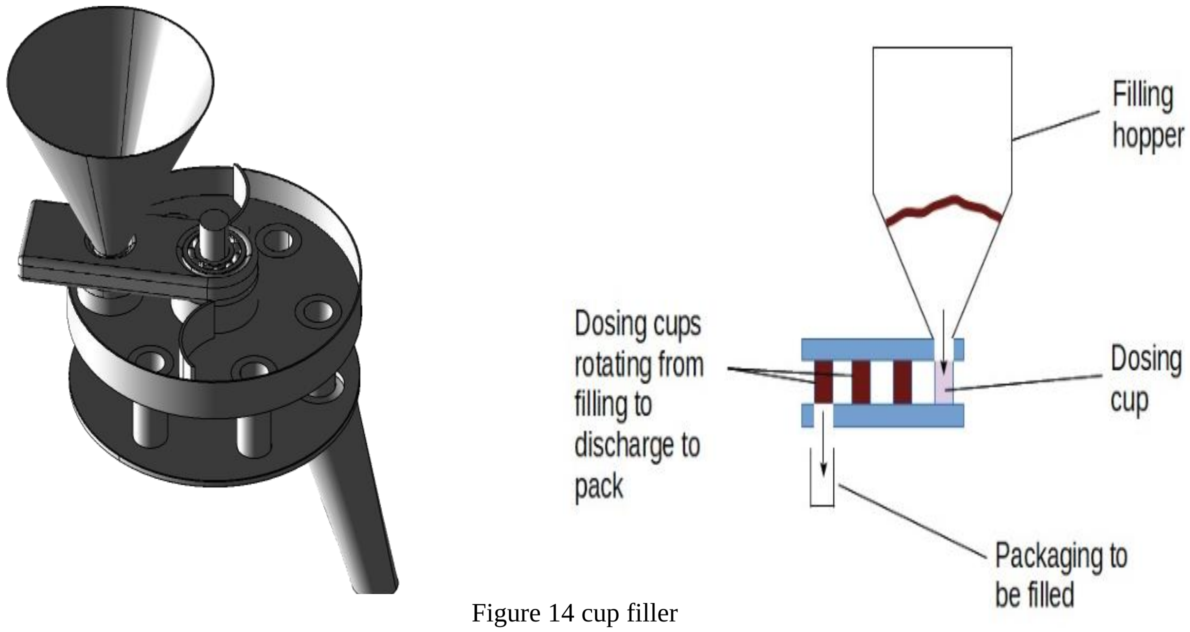


Figure 14 cup filler

II.2.5 Auger dosing

With auger dosing, the often "dusty" product is found in a supply hopper. Under the hopper is a dispensing tube in which the auger filler rotates. The dispensing tube can be closed at the bottom by a valve ball, or a clam shell, etc.

Before we proceed to how auger fillers work, you need to understand what makes auger fillers different from other power filling machines. Auger filling machines are versatile machines for the volumetric filling of either free-flowing or non-free flowing thick paste and powder products.

Free-flowing powders, such as table salt and granulated sugar, have non-cohesive particles and flow freely when dispensed. You cannot compress them even if you add extra pressure and they will not hold their shape. Meanwhile, non-free-flowing powders have opposite properties. Examples are powdered milk, flour, and talcum powder.

They are called auger fillers because they dispense products using an auger screw – a screw-shaped device that transports materials forward by rotating.[6]

II.2.5.1 **Agitator**

An agitator causes the product to move from the supply hopper to the auger filler. The auger rotates the powder downwards. An amount of product is transported during every revolution of the auger and transfers a certain amount of product with each revolution.

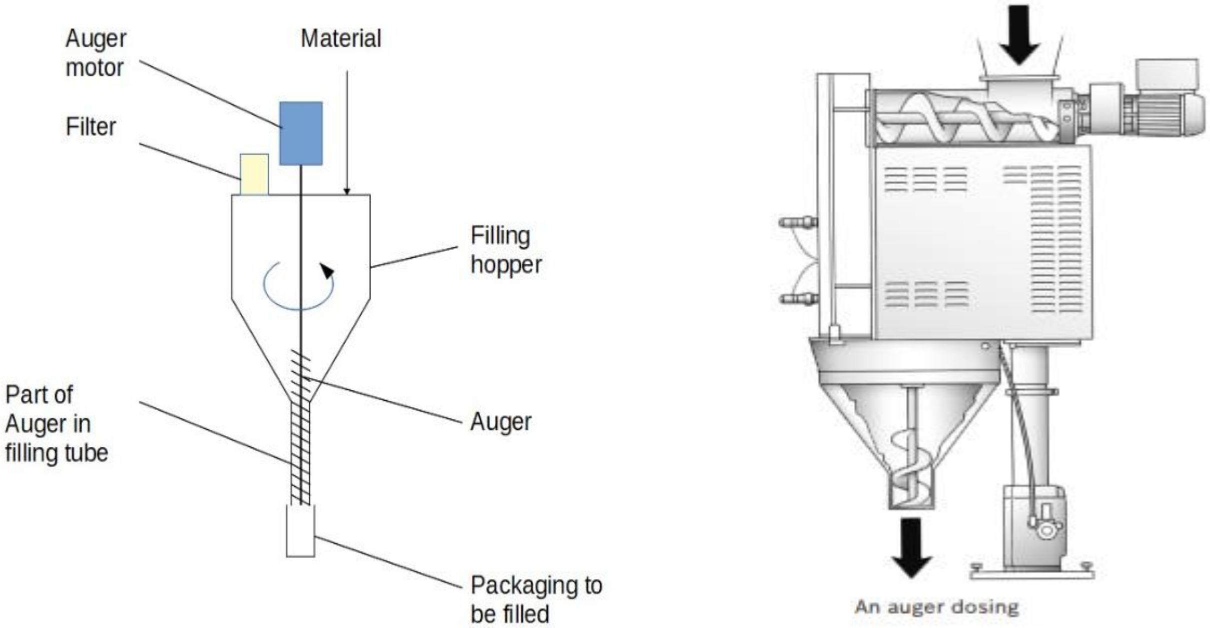


Figure 15 auger dosing

Auger dosings are volumetric dosing, like cup fillers. The volume depends on the speed and the inclination of the auger, or the auger movement. These elements determine how much product fits between the wall of the dispensing tube and the screws of the auger.

By setting how many revolutions the auger makes per dispensing, one can determine how much product volume will end up in each bag. The filling weight of the bag is determined by the specific gravity of the product. The precision of an auger dosing depends on the degree of filling required from the auger filler and of the consistency of the product volume.

After every time it dispenses, the auger filler stops briefly. In order to prevent product running out of the dispensing tube at that point, the tube is closed with a valve or ball for easy flowing products (such as corn starch, for example). For ground coffee, pancake mix and other products that do not flow as easily, a restrictor is used at the bottom of the dispensing tube. That could be a ring or a screen for example.

The combination of dispensing tube, auger filler and closing mechanism is placed in the forming tube of the VFFS machine. The diameter of the dispensing tube is a determinant for the packaging speed. The greater the diameter, the more product that can be transported in one revolution. The diameter is always reduced by the space that any closing mechanism takes, therefore reducing speed.[6]

II.2.6 Dispensing pump

The operation of a dispensing pump is comparable to that of an auger dosing. The pump carries the desired amount of product with a filling tube to the bottom of the forming tube. This filling tube is closed after each time dispensing not with a valve, but with a filling nozzle that depends on a product. This keeps product from falling out of the filling tube between dispensing. There are different types of pumps, such as hose pumps, displacement pumps and rotation pumps. The selection of pump is determined by the product characteristics.

Control weigher

When using weight, count and especially volumetric dispensing systems (auger fillers, cup fillers), it is recommended to set up a check weigher behind the VFFS machine. This weigher checks each bag and knocks or blows bags that are underweight or overweight off of the conveyor belt.

Volume change

The check weigher also documents systematic weight changes. For example, the specific gravity of coffee can exhibit differences within one batch. If that is the case, it is possible to pass on to the dosing that the filling volume must be adjusted accordingly (tendency control).

II.3 The film roll

The film roll forms the basis of the packaging process. A full roll usually has a diameter between 350 and 650 mm. At such a size and corresponding weight, these rolls are still manageable. In some cases, rolls with a diameter up to 1000 mm are used. A weight of over 80 kilograms is not out of the ordinary.

Figures

The number of meters of packing film with a certain diameter is contingent in part on the film thickness. At an average thickness, there is over 6500 meters of film on a roll of 650 mm. At a bag length of 140 mm and a machine speed of 80 bags per minute, using such a roll, one can operate continuously for over 9.5 hours. If all other factors remain the same, a roll of 450 mm is sufficient for approximately 4.5 hours. Smaller rolls must be changed more often, which negatively influences productivity. On the other hand, smaller rolls are easier to handle.

Width of the roll

The front, back and longitudinal seam of the bag are formed from the width of the web of film. That means that the bag is half as wide as the film width minus the width of the longitudinal seam. Expressed in a simple formula, that looks like this:

(Film width – longitudinal seam width)/2= bag width

Longitudinal seam

In most cases, 15 to 25 mm of film is needed for the longitudinal seam. The type of longitudinal seam is a factor as well as the total bag width.

Film widths

The minimum and maximum film widths differ per machine. Smaller machines can handle film widths of approximately 10 to 54 cm; larger machines run from approximately 18 to 80 cm , and the largest machines can deal with film widths of 50 to 170 cm or more.[6]

Note:

Checking a film roll is relatively easy to check for uneven tension. Usually it suffices to unroll the material over a length of 10 meters and see if the course continues to run straight and proper. If the web exhibits a curve to the left or right, then in some machines the position of the roll will have to be adjusted frequently. In other machines, the course of the web can be corrected manually, and in advanced machines there is automatic correction such as ultrasonic and photo eyes for edge detection.

Parallel it is very important that the roll is wound well and evenly on the core; the side of the roll must be completely flat. If the winding comes undone, the film web will have the tendency to shift sideways, creating problems with forming the longitudinal seam.

II.4 The web of film

The web of film runs via a number of guiding rolls to the forming shoulder and the forming tube, where the bag is made. The film path is determined by such factors as the machine concept and any extra steps that are taken before the film arrives at the forming shoulder. This could include the printing of a date code (best-by or expiration date), a label (such as product or sales information) or a reclosable feature (such as a zipper closure or tape).

II.4.1 Dancer arm

In order to transport the web of film as evenly as possible, the web is guided by a moving "dancer" arm that moves from front to back. This dancer arm is attached to torsion springs that keep the web of film under the right tension. This improves the unwinding of the roll and the course of the film through the machine .

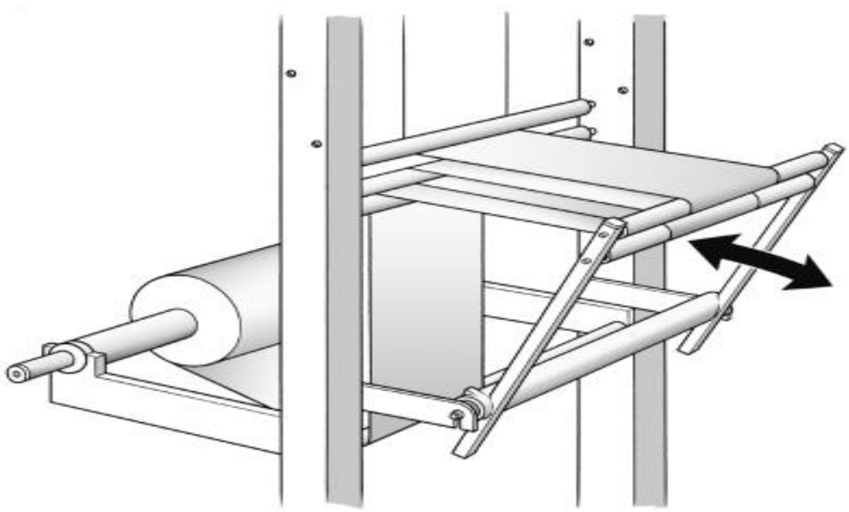


Figure 16 dancer arm

II.4.2 Tensioning and stretching

The film path has a minimum length that is generally determined by the factors stated above. Usually, the path is three to six meters. The longer the film path is, the greater the chance that the course wants to go to the left or right, and the more tension on the course that will be created. Too high tension leads to uncontrollable stretching of the film, creating differences in bag lengths and misaligned printing.[6]

II.4.3 Marking

The web of film has a print registration mark on it. The combination of this and a photo cell within the machine set to read it guides the transport of the web of film. There is one mark for each bag length. The photo cell "sees" the mark and assures the transport of one bag length per machine cycle.

II.4.4 Printed mark or contrast

Depending on the type of photo cell, there must be a clear contrast between the printed mark and the other printing. Instead of a conventional printed mark (often black bar), the marking can also be a strong, once-occurring contrast in the printing. With a color-sensitive photo cell or color sensor, it could also be a color difference, and again a sufficient degree of contrast is necessary here.

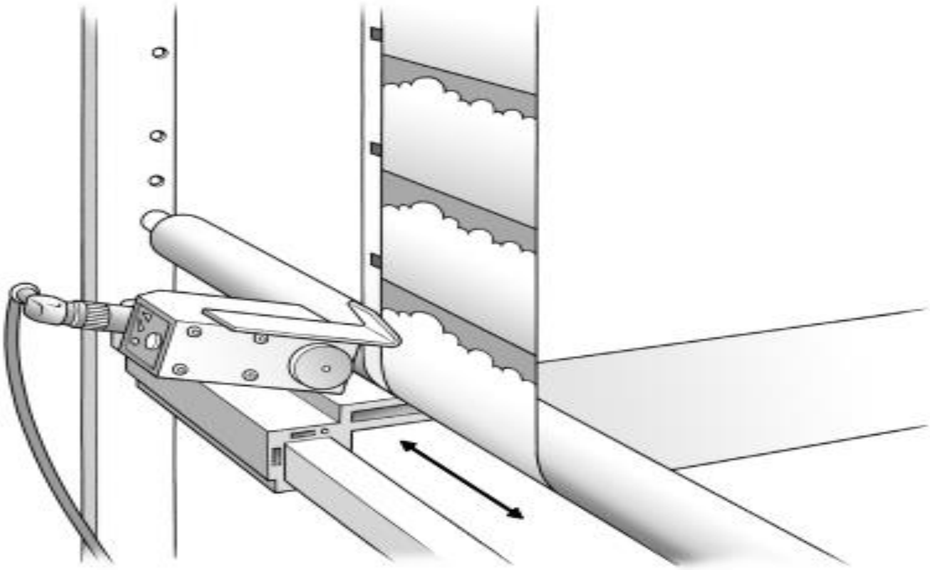


Figure 17 printer

II.4.5 Position

The photo cell can always be moved to match the width of the film web and can be set to the position of the marking on the packaging material.

II.4.6 Cutting position

The distance between the photo cell and the blade in the sealing jaw unit determines the cutting position between each of the two bags. If this distance is too small, the blade will cut too high in the packaging and vice versa. In conventional machines, this distance is regulated by lengthening or shortening the portion of the web of film between the photo cell and blade. The machine has an adjustable roll for this purpose. In newer machines, the cut-off point is automatically corrected.[7]

Note:

Monochrome

Some machine systems require that the printed mark is located on a monochrome (one-color) printed portion of the film web. During set-up, the machine transports the packaging material automatically until the photo cell sees the printed mark. Such machine systems can set the proper bag length automatically.

Non-monochrome

For non-monochrome printing, the printed mark must come by in a predefined time window. The photo cell is only active during this window of time. The rest of the printing that comes by is ignored. The advantage of this system is that the packaging can be printed fully, and that this printing does not theoretically cause any errors if it has strong contrasts. However, it is not as easy to set up the machine because the cutting position must be determined by trial and error.

II.5 Film transport

There are two techniques to transport the web of film through the machine. The simplest technique uses the sealing jaws that grip the web of film like the draw bar and pull the material downwards. This is called the jaw draw off principle. The second technique, the belt principle, uses conveyor belts with which the packaging material is pushed down along the forming tube.

II.5.1 **Draw bar**

Pick-up principle In the jaw draw off, the sealing jaws move upwards for each new bag . The jaws close to grip the packaging material. Then they are moved downwards, starting the film transport. During this downward movement, the material is directly sealed. In achieving the desired bag length (that is mechanically set and controlled by a photo cell), the jaws open and the film transport stops. The jaws then move upwards for the next cycle.

Down and Up

The downward movement usually goes more slowly than the upward movement does. The film transport, sealing and filling takes up 7/12 of the machine cycle; the upward movement takes place in 5/12 of the cycle.

Benefits of the jaw draw off principle

There are four important benefits of the jaw draw off principle, used often in the past.

• It is a relatively simple system, especially because it uses existing components (the sealing jaws) and there are no separate provisions (such as conveyor belts) required.

• The system yields high downward forces, which allows for a steeper entry angle of the forming shoulder and thus better tracking behavior of the web of film.

• The sealing jaws move along with the packaging and also with the falling product to ensure that there is a soft landing of the product in the bag, which is especially important for products susceptible to breakage.

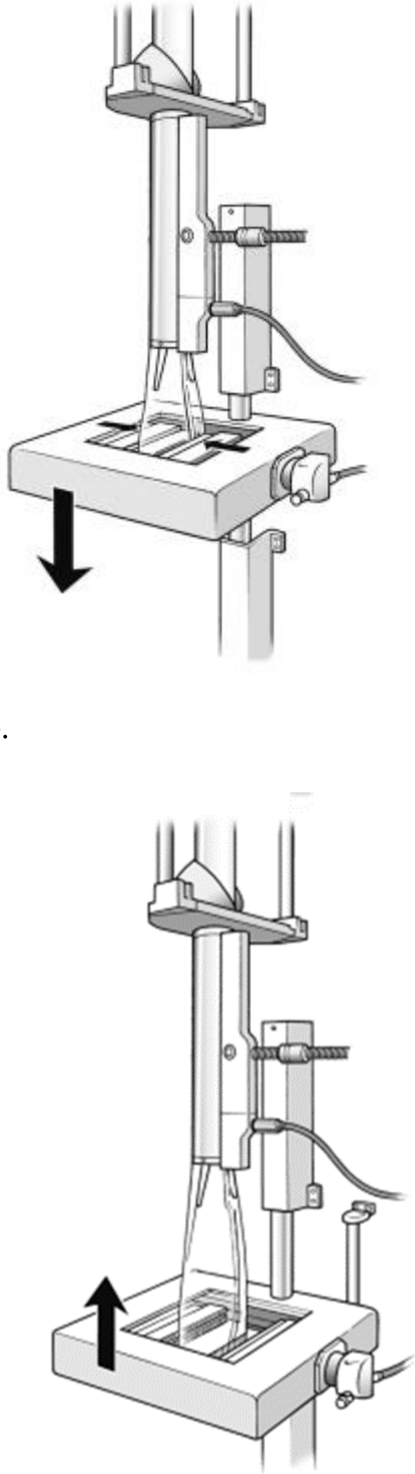


Figure 18 draws bars

• This saves time because two steps are combined in one machine cycle, the web of film is simultaneously sealed and transported. Drawbacks There are two drawbacks on the other hand.

• Because the sealing jaws pull on the material, no bag with a block bottom can be made, but only pillow bags and gusset bags.

• The volume of the bags is smaller because the bag is folded closed during transport.[7]

II.5.2 Belt pick-up

Principle The often-used belt principle works with conveyor belts running on either side of the forming tube. These belts push the web of film downwards along the tube. Three types of belts are used: friction belts, vacuum belts and a combination of these two types.

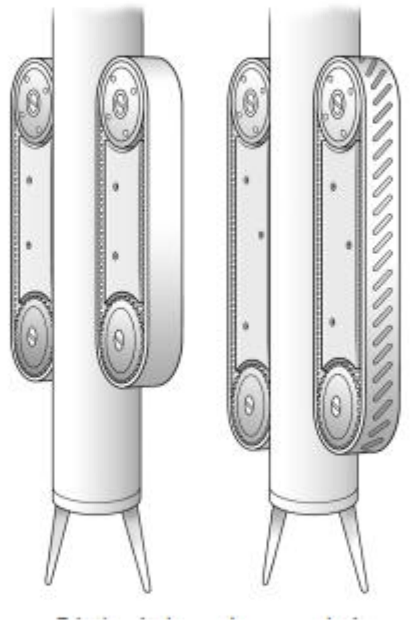


Figure 19 belt pick up

Friction belts

Friction belts make use of the fact that the friction between the conveyor belts and the packaging material is greater than the friction between packaging material and forming tube. Packaging material with a smooth exterior and polyethylene on the interior (creating extra friction), can have a friction difference that is so small that it can create problems.

II.5.3 Vacuum belts

With vacuum belts, the film is sucked against the belts. This means there is no friction between the film and forming tube and the process goes much more smoothly.

Vacuum-supporting friction belts

With a combination of these two techniques, the friction between film and forming tube is reduced, but not eliminated entirely.

Note:

Driven rolls

For better control of the film web, some machines have a driven roller, pinch rollers, and/or drive the film reel itself, in addition to the belts. The extra forward thrust that is supplied by this mechanism also allows for a steeper running angle and provides for better tracking behavior , especially when running at high speeds with heavy rolls[7] .

II.5.4 Benefits and drawbacks

The two most important benefits of the belt principle are that this technique allows for the production of all conceivable bag shapes and the bag volume is maximized. The drawbacks are the smaller forces and the fact that the film is not pulled downwards but pushed forwards. Also due to the extra resistance of bag spreaders or a block bottom mouthpiece, the film material can get bunched up around the forming tube. In addition, the film transport and the sealing of the cross seam take place after each other. For each of these steps, one third of the machine cycle is available.

II.6 The forming shoulder

The forming shoulder is the heart of the packaging machine. The complex shape of the shoulder influences such factors as the tracking behavior of the web of film, the belt tension and the required forces for the film transport.

II.6.1 Longitudinal seam and film

The model of the shoulder also determines the position of the longitudinal seam (in the middle or at an edge of the bag) and the type of longitudinal seam (fold-over seam or overlap seam). The maximum thickness and rigidity of the film that is possible to be run is also connected with the model of the forming shoulder.

II.6.2 Forming parts

The shoulder shapes the flat film web into a tube that is divided into individual bags by sealing and cutting. The bag width is determined by the outer diameter of the forming tube, with which the product is poured in the bag. The forming shoulder and forming tube are the shaping parts or the format set of the machine. Every bag width has its own forming shoulder and forming tube.

II.6.3 Wings and collar

The most important elements of the forming shoulder are the wings, over which the web of film runs and the collar, where the shoulder transitions to the forming tube; that is the point where the web of film is formed into a tube. [7]

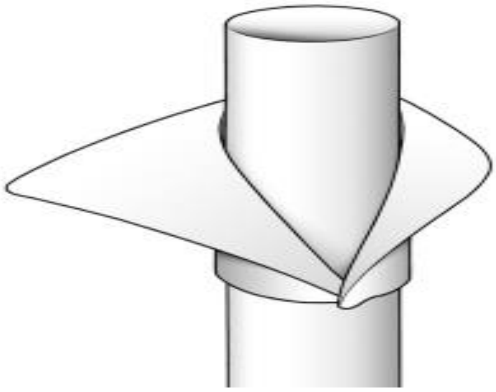


Figure 20 wing and collar

II.6.4 Run-in angle

The wings of the forming shoulder lead the web of film at a certain angle to the collar of the shoulder. This angle, the so-called run-in angle, depends on the bag width (determined by the diameter of the forming tube) and on the available force of the machine.

II.6.5 Steeper is better

The big benefit of a steeper run-in angle is better tracking behavior of the web of film. For a steeper run-in angle, the forces of the machine must however be sufficient. Good tracking behavior is of course essential to uninterrupted production. For optimum continuity and optimum tracking behavior, a good compromise must be found between the available forces and the model of the forming shoulder.

Note:

The collar

A steeper run-in angle demands greater forces because the resistance on the collar is higher. In addition, the collar will have a “sharper” form, causing it to be more susceptible to wear and tear - and a worn collar creates risk of damage to the packaging material.

II.7 Forming shoulders

The material Forming shoulders are made out of solid metal (bronze or aluminum), web metal (stainless steel) or plastic.Solid metal shoulders are cast according to the model of a mother shoulder and are then polished by hand. The collar has a hard steel wearing plate that can be replaced over time. Solid metal shoulders are very tough and relatively simple to repair: for example the shoulders can be repolished and refinished. On the other hand, they are very heavy, which makes them difficult to handle, and the number of models is limited by the high costs of the required materials. As a result, these shoulders have sharply dropped in popularity.

II.7.1 Web metal

Web metal shoulders are made from a web of stainless steel that is forced into the model and then sealed around a form. Complicated computer models are used to calculate and form the web.

II.7.2 Plastic

Different combinations of hard plastic cores with a smooth exterior layer are used for plastic shoulders. The shape of the shoulder is obtained by a special procedure of following the natural course of the packaging material with a dual component plastic. This makes it possible to create virtually an infinite array of bag shapes.

Note:

Plastic shoulders have outstanding features in operation; they are light and wear-resistant, and they are not more expensive than shoulders of other materials. However, they are relatively vulnerable to damage from falling.

II.8 The forming tube

The forming tube is the part that connects directly to the forming shoulder. The tube not only helps determine the bag shape and the bag width, but also the packaging speed.

II.8.1 Gap

The film web glides over the collar of the forming shoulder and then disappears into the gap between the forming tube and the forming shoulder surrounding it. The width of this gap is critically important to uninterrupted production and perfect looking bags. If the gap is too tight, the film material will have the tendency to bunch up around the forming tube. A gap that is too wide gives the film material too much space, and the bag will exhibit diagonal folds (the so-called “lightning strikes”). The gap does have to be wide enough to allow any stickers or recloseable features that have been placed on it in an earlier phase to pass through.[8]

II.8.2 Inner diameter of forming tube

The inner diameter of the tube determines the opening for the product. A smaller opening slows the maximum possible packing speed, simply because less product fits through at the same time

II.8.3 Forming tube shape

For a certain bag width, a round forming tube provides the largest opening. With large bag sizes, often oval forming tubes are also used. The path that the sealing jaws must travel in every machine cycle (opening, closing) can thus be minimized, and the machine remains compact. Oval forming tubes are sometimes also used for packaging larger flat products such as frozen fish.

II.8.4 Rectangular forming tubes

For some bag shapes, rectangular forming tubes are used. For a given bag width, this shape has the smallest opening.

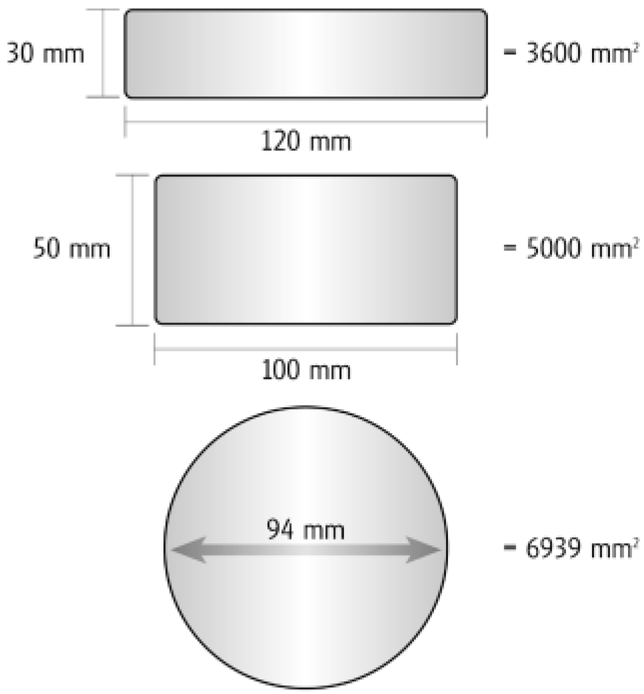


Figure 21 the diameter of forming tube

If the bag width remains the same, the round tube has the largest and the rectangular tube has the smallest opening. In the oval tube, the path that the sealing jaws must travel from open to closed position is the shortest.[8]

II.8.5 Wear and tear of forming tube

Wear and tear of the forming tubes occurs mainly at the collar, where the web of film is moved downwards between the forming shoulder and forming tube. The material of the forming tube helps determine the degree of wear and tear.

II.9 Bag spreaders and side gusset spreaders

At the bottom of the forming tube there are one or more elements that help produce a well-shaped bag.

• For the production of pillow bags or flat bags, bag spreaders are needed. These “fingers” made of spring steel stretch the bag in the width direction before the cross seams are made. This prevents pleats in the cross seams and straight, flat seams are obtained.

• The folds in a gusset bag are made by gusset spreaders mounted on either side of the forming tube. These triangular spreaders fold the required extra amount of packaging material around two steel pins inwards.

• When making stand-up bags or a bag with a block bottom, a special mouthpiece is used. This mouthpiece allows the web of film moving over the round forming tube to transition to the square or rectangular shape at the bottom of the bag. Just before the cross seam sealing jaws close, the film is folded inwards by horizontally mounted spreaders around the mouthpiece

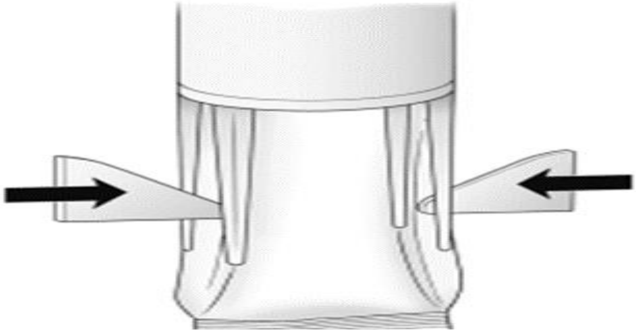


Figure 22 bag spreader

II.10 Longitudinal seam

The longitudinal seam is the seam running the length of the bag. The choice between an overlap seam or a fold-over seam depends on (the composition of) the packaging material.

Forming and Placement of the Seam

The seam is formed by the extension of the forming shoulder, which also determines the placement of the seam. In some bags, the seam is in the middle or the back of the bag; other bags have the seam on one of the edges.

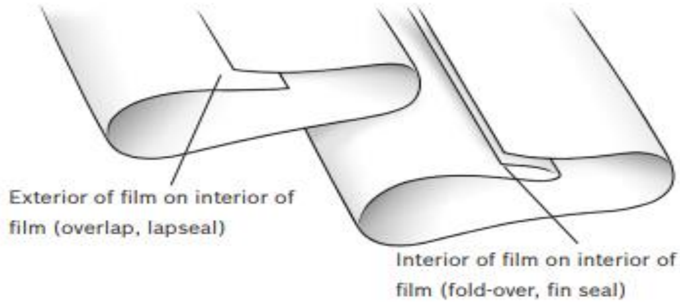


Figure 23 overlap & fold over seam

II.10.1 Overlap seam

With the overlap seam or lap seal, the inside of one side of the web of film is placed over the outside of the other side of the film web. The overlapping inside is sealed onto the outside of the film underneath it. The benefit of the overlap seam is that less packaging material is used than in the fold-over seam, such as the ILLUSTRATION clearly shows. Such a seam can only be made if both the inside and the outside of the film material is sealable. In practice, this means that overlap seams mainly occur in bags made of pure polyethylene (PE) or polypropylene (PP), or in bags that are coated on the outside with a special seal coating. [8]

II.10.2 Fold-over seam

With the fold-over seam, one side of the web of film is folded over approximately 10 mm. This causes the inside of the film material to be on top. The other side of the material is then placed over it, and then it is sealed. So the inside is sealed onto the inside of the material. The fold-over seam is generally used for film laminates where the sealing medium is located on the inside of the material.

Note:

The tracking behavior of the film is very important for a well-sealed longitudinal seam. If the web of film shifts, the edges of the material no longer match each other, so sealing is not possible. In the previous situation, the printing on both sides of the seam will no longer match up properly. If there is poor tracking behavior, the operator will have to continually check the web of film and adjust it when necessary. One of the most common sources of interruption is when packaging material runs to the left or the right. In continuous machines such disruptions occur significantly less often than they do in intermittent machines.

II.11 Sealing the longitudinal seam

The longitudinal seam is sealed by a sealing unit placed parallel to the forming tube that presses both layers of the material against the forming tube and allows the heat to melt it. The length of the sealing unit (in an intermittent VFFS unit) will usually be equal to the maximum bag length that can be made on the machine. That means that in practice the longitudinal seam is sealed multiple times in shorter bags.

II.11.1 Longitudinal seam sealing unit

The sealing unit for the longitudinal seam works according to the same principle as the cross seam sealing unit, but it has only one sealing jaw. The packaging material is sealed with this one sealing jaw, with the two sides of the seam pressed between the sealing jaw and forming tube. This longitudinal seam sealing jaw which is usually 4 to 8 mm broad does not create any serration (including hot air, pinch seal and dual band seal).

II.11.2 Compensation for short bags

For intermittent motion machines, the longitudinal seam sealing jaw must be as long as the longest bag that the machine can make. Keeping the theory of a machine cycle in mind, the longitudinal seam of short bags can be sealed multiple times as they are fed past the longitudinal seam sealing jaw in a number of steps during the cycle. This compensates for the low pressure of the sealing jaw without a serration profile. In addition, two flat lying layers are always sealed to each other. For continuous motion machines the length of the long seam does not matter, it just needs to have adequate time for the heat and pressure drag seal to properly bond together.

II.11.3 Compensation for long bags

For bags that are equally long or nearly equally long as the longitudinal seam sealing jaw, the lack of a serration must be compensated by a slower machine speed, so that the sealing time increases. In practice, this is rarely a limiting factor. In such long bags, usually so much product must be packaged that the length of the product stream does not permit a high machine speed[9]

II.12 Sealing system

There are two main sealing systems. The choice of one or the other system depends on the packaging material used.

II.12.1 Ultrasonic sealing

Ultrasonic sealing is a cold sealing system making it ideal for heat sensitive products. Friction is created by an oscillating tool that generates heat only in the area between two film layers, which eliminates the potential of product contact with heat. The vibrations for generating friction are caused by ultrasonic energy at frequencies of 20 - 40 KHZ. Heated seal jaws can cause sensitive products to melt into the sealing jaws causing contamination and more cleaning time. Ultrasonic sealing prevents products from melting, resulting in less product waste, maintenance and eliminating film sticking to the sealing jaws. Production line speeds can increase significantly with minimal time for a cool down in the seal,the so product can be loaded immediately after a seal is made

II.12.2 Constant and uniform temperature

It is essential for a good sealing seam that the sealing jaws have a constant temperature that is uniform across the entire length. This is complicated by the fact that the sealing jaws move (horizontally, but also vertically in many machines) and by the fact that only a portion of the length of the jaws touch the cold film when processing smaller bags, so heat is lost at that place. In processes where the seam is not stabilized quickly enough, (this is called a poor hot-tack), compressed air is used for cooling immediately after sealing, which adds an extra processing step.[9]

II.12.2.1 Material of the sealing jaws

It is very important that the material of the sealing jaws has good heat conduction. Every machine builder uses his own recipe based on his own experience for this. The most commonly used materials are hard chrome-plated steel, steel/aluminum composites and chrome/copper composites. In order to prevent the packaging material from sticking to the sealing jaws, the jaws sometimes have a special ceramic coating.

II.12.2.2 Temperature control

In order to keep the temperature as even as possible in these circumstances, the following factors are important:

- The material of the sealing jaws;
- The type and the mounting of the heating elements;
- The position of the temperature sensor;
- The control loop.

II.12.2.3 Variables of the heat-sealing system

In the heat-sealing system, there are three important variables: temperature, pressure and time. Within certain constraints, a low sealing pressure can be compensated by a higher sealing temperature. The sealing time is always a function of the variable sealing pressure and sealing temperature[9] .

Sealing temperature

The sealing temperature is determined by the packaging material. The temperature window indicates the minimum and maximum temperature at which the material melts but does not burn. Such a temperature window can run for example from 110 °C (230 °F) (minimum melting temperature) to 150 °C (302°F) (burning temperature).

Also the ambient temperature and the temperature of the product can play an important role in the sealing temperature. For example, frozen products are packaged in refrigerated rooms. The packaging material of course takes on the same temperature, and cold film requires extra time to reach the sealing temperature.

Movement of the sealing jaws an additional problem of temperature control of the sealing jaws is caused by the movement that the sealing jaws make. This movement causes cooling

Sealing pressure

The available sealing pressure depends on the machine. In many cases, this pressure can be set to the maximum, determined by the machine. Also the profile of the sealing jaws determines the pressure that can be exerted on the sealed seam.

Sealing time

The sealing time is directly related to the machine speed, a longer sealing time usually requires a slower machine speed. With an intermittent machine, sealing (which includes the jaw close and open time) take up more than 1/3 of the machine cycle

Sealing medium for heat-sealable materials

In heat-sealable materials, the sealing medium is often polyethylene. Polyethylene melts at a relatively low temperature (120 °C) (248 °F). If polyethylene is the sealing medium, the carrier film of the packaging material must have a higher melting temperature. If that is not the case, then the backing of the material will also melt and so the seam will be cut and stick to the sealing jaws.

The heat sealing system for the cross seam consists of two metal blocks: the sealing jaws. The width of these blocks corresponds at least to the broadest bag that can be produced on the machines. On the side where the blocks push on the material, the sealing jaws have a sealing profile.

Notes:

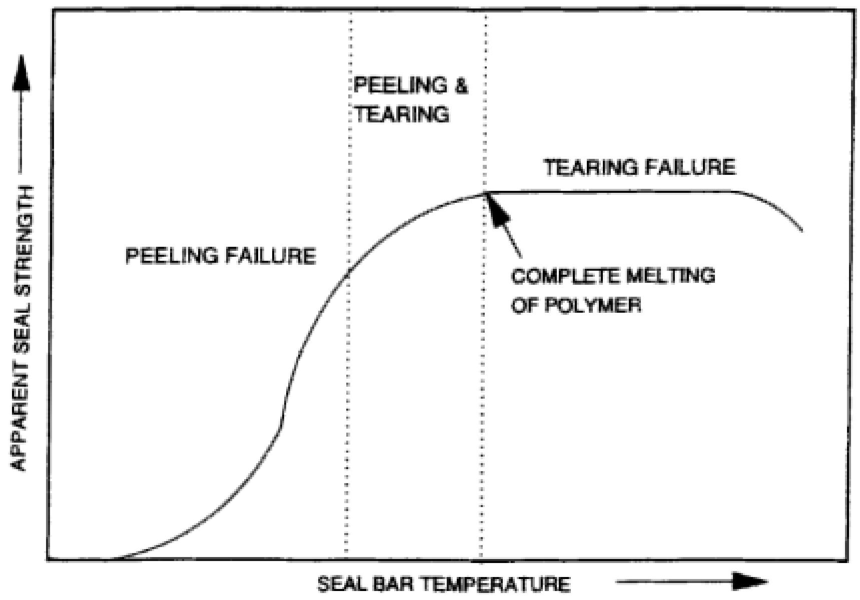


Figure 24 temperature graphic curve

- Sealing temperature it is necessary to control the sealing temperature interface between the films accurately to melt the adhesive layer. Generally, in thermoplastic films, the relationship between seal strength and sealing temperature is relatively proportional as show in figure below However, the plot may vary depending on the sealing temperature required for different materials type and thickness

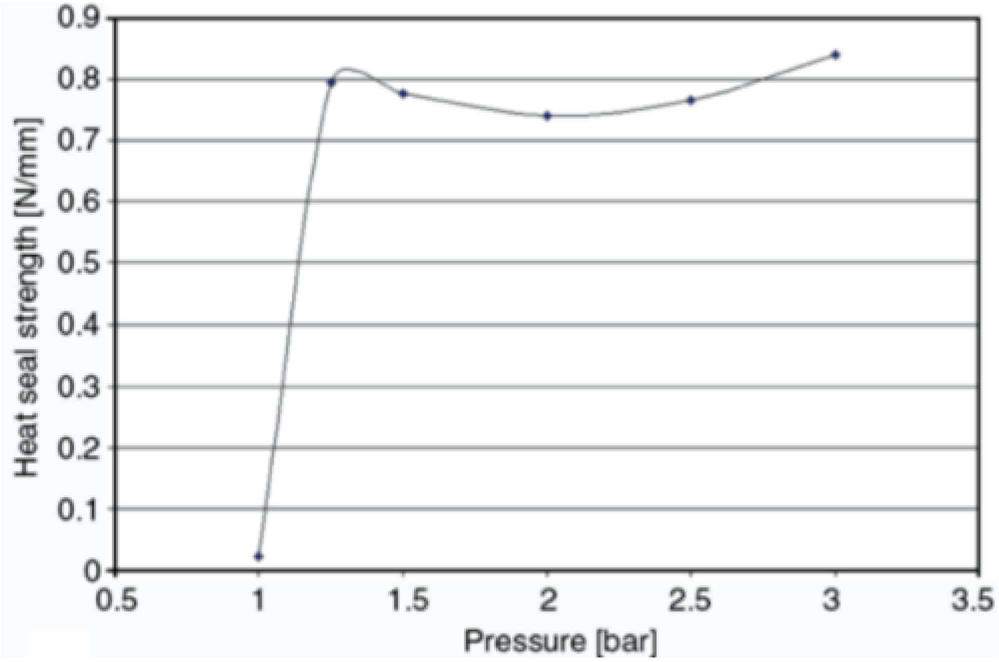
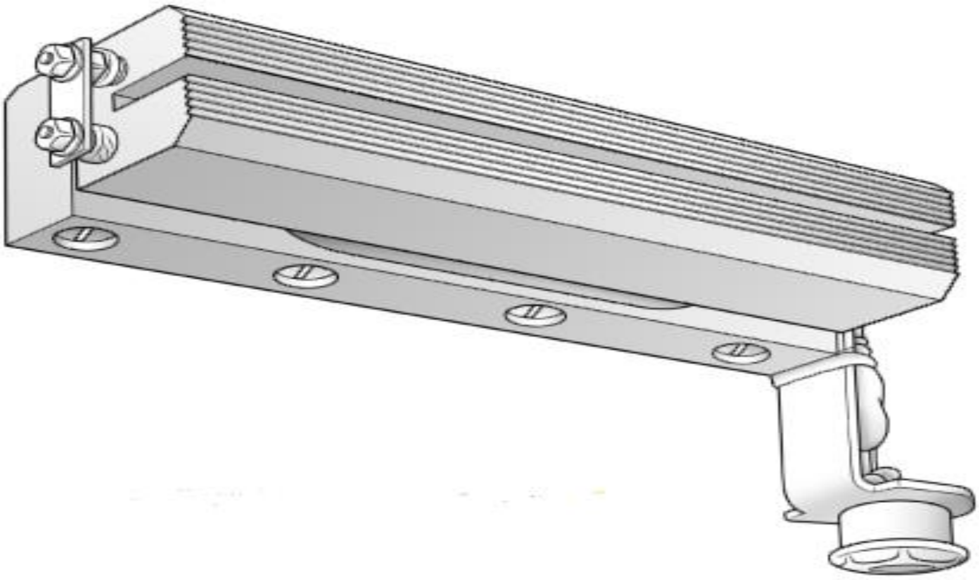


Figure 25 pressure graphic curve

❖ Sealing pressure is used to bond or bring the films together and hold the material to form the seal. Among all the three heat sealing parameters, pressure is the least significant factor that influences the seal strength . The seal strength is said to be directly proportional to the sealing pressure. The higher the sealing pressure, the higher the seal strength[10]

II.13 The cross seams



The making of the cross seams is the most sensitive part of the packaging process because here the packaging material and product come together at the time the bag is closed and cut off.

II.13.1 Cross seam sealing jaws

The sealing unit that makes the cross seams is located under the forming tube. In this sealing unit, there are two pairs of cross seam sealing jaws. One pair seals the top seam of the filled bag, while the other pair simultaneously seals the bottom of the bag to be filled immediately thereafter

The heat sealing system for the cross seam consists of two metal blocks: the sealing jaws. The width of these blocks corresponds at least to the broadest bag that can be produced on the machines.

II.13.2 Driven sealing belt

The two belts / sleeves that drive the heat-sealable film therefore plays a fundamental role in the machine: the type of elastomer that covers the belts is decisive in order to ensure a correct dragging and therefore a correct packaging of the product. The main properties of the belts are durability, tear and wear resistance, as well as uniform wear of the cover. Further it, the belts must not mark the heat-sealable film.

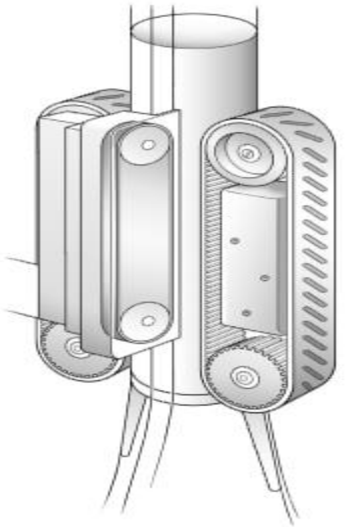


Figure 26 driving belt

II.13.3 Serration

Sealing jaws also differ according to the type of profiling, or serration. Each type of serration has special properties and application possibilities. The two main types are the horizontal and the vertical serration

II.13.3.1 Horizontal serration

With horizontal serration, the profile (or ribs) runs parallel and equidistant along the length of the sealing jaws. The profile exerts a high surface pressure,

II.13.3.2 Vertical serrations

In vertical serrations, the serrations run perpendicular to the longitudinal direction of the sealing jaws. The pitch is usually 1.5 mm. While a horizontal serration is mainly used in products that must be packaged gas-tight, one uses sealing jaws with a vertical serration for example for packages that must be easy to rip open; the vertical pleats form a sort of break or fracture line in the length of the packaging. Such easy-opening packages are used particularly in the candy industry.

II.13.3.3 Pitch

The distance between the serrations is called the pitch. If there is a fixed width of the sealing jaws, a bigger pitch means the profile has fewer serrations. This increases the surface pressure: the same mechanical pressure is exerted by a smaller surface (fewer serrations) on the material.

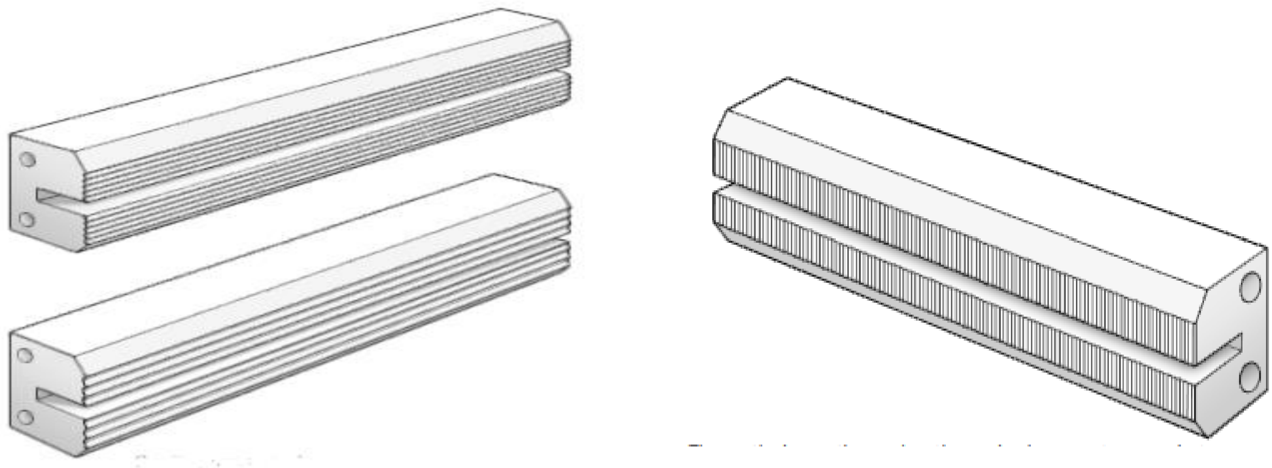


Figure 27 vertical & horizantal serration & pitch

II.13.4 The blade

Once a bag is filled, it is cut directly above the top seam. This is done with a blade mounted between the sealing jaws. The blade has an asymmetrical cutting edge, just like with the halves of a pair of scissors, there is a flat side and a slanted side. As a result, an unsealed edge of film is left over at the top or bottom of the bag. This cutting edge is usually 2 mm wide.

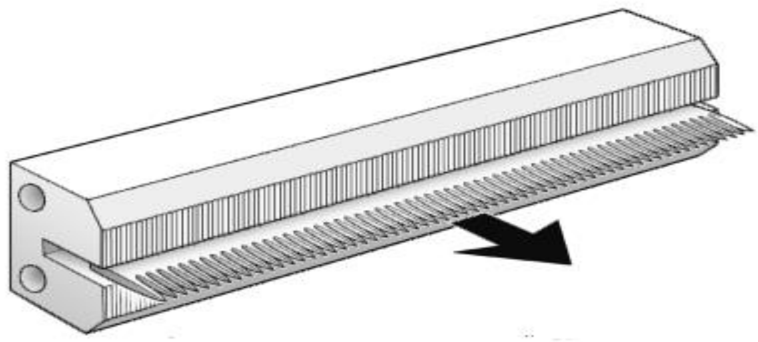


Figure 28 the blade

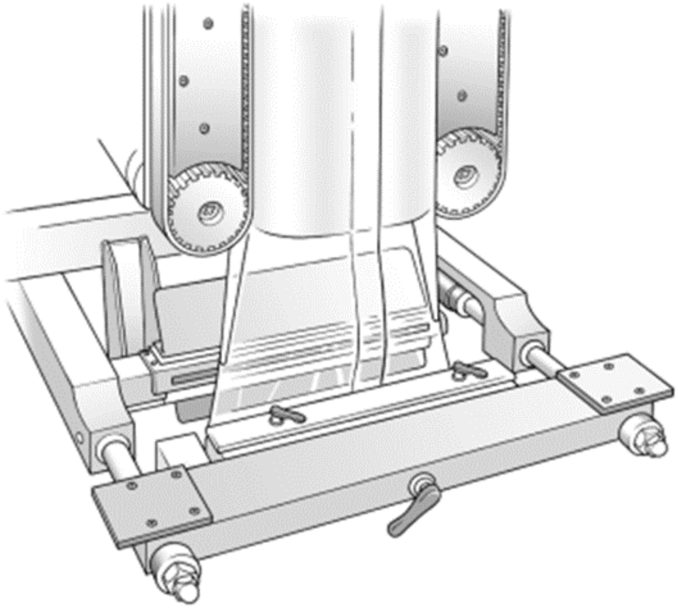


Figure 29 The belt with the horizantal sealling

II.14 Modified atmosphere packaging

With an increasing number of products, the air in the bag is replaced by a gas. Usually this is done to combat oxidation of products such as nuts, fresh vegetables, dried milk, biscuits or coffee. This technique is called Modified Atmosphere Packaging (MAP). The gas is known as an inert gas: carbon dioxide (CO2), nitrogen (N2) or a mixture of both gasses.

This technique is called Modified Atmosphere Packaging (MAP). The gas is known as an inert gas: carbon dioxide (CO2), nitrogen (N2) or a mixture of both gasses.[6]

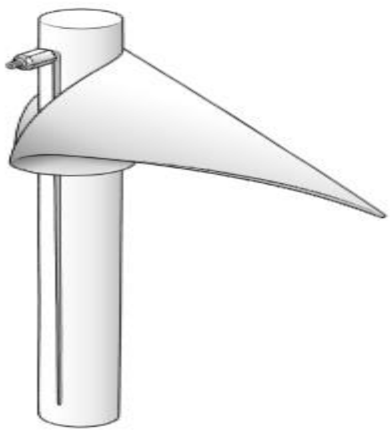


Figure 30 the hole of the MAP

The gas is inserted in the bag by a gas tube that is mounted in the forming tube and connected to a gas tank, or a gas mixing system. A flow meter regulates the amount of gas pumped into the bag. The diameter and the shape (round, rectangular or oval) of the gas tube depends on the required amount of gas and the space the forming tube offers. The gas tube must be incorporated without disrupting the product flow. To prevent the product from being blown upward by the gas flow, it is advisable to keep the flow speed of the gas low[6]

II.14.1 Pre-modified atmosphere packaging

Certain products, such as dry baby food and dried milk have a large amount of oxygen enclosed in the product. In order to be able to achieve the required residual oxygen value, such products must be “rinsed” for a longer time with gas. This pre-modified atmosphere packaging takes place in the supply hoppers and the dosers.

II.14.2 Residual oxygen value and gas use

MAP in combination with this pre-packaging “rinsing”, can eliminate oxygen in the packaging sufficiently. The residual oxygen value can generally amount to between 0.5 and 2%. The gas use depends on the product and the amount of oxygen enclosed in the product itself. Values are between 1.5 and 4 times the bag volume; for a bag of 100 cc, between 150 and 400 cc gas is used.

II.14.3 Measuring filled bags

Of course it is also possible to measure the amount of oxygen in filled bags in a random sampling. A needle is inserted into the packaging. The tested bag of course now has a leak and cannot be sold anymore.

II.14.4 Self-regulating analyser

A recent development is a gas analyzer that regulates how much gas must be supplied based on the measured residual oxygen value. This reduces the gas use to a minimum, and prevents the outflow of gas to the manufacturing space.

II.15 Bag types

In principle, VFFS machines produce three types of bags. Within these main types, there are countless possible variations in model, length and width.

• Products such as fresh vegetables, chips or candy are usually packaged in a pillow bag. This bag shape is also called a flat bag.

• A common variation on the pillow bag is the gusset bag and it is usually presented in combination with a carton or box around it. It is commonly used for packaging breakfast cereals.

• A bag that can stand up with a flat bottom, often referred to as a block bottom bag and is used for cookies or coffee, for example.

• The doy bag, is another form of stand-up bag, and is often referred to as a stand-up pouch.

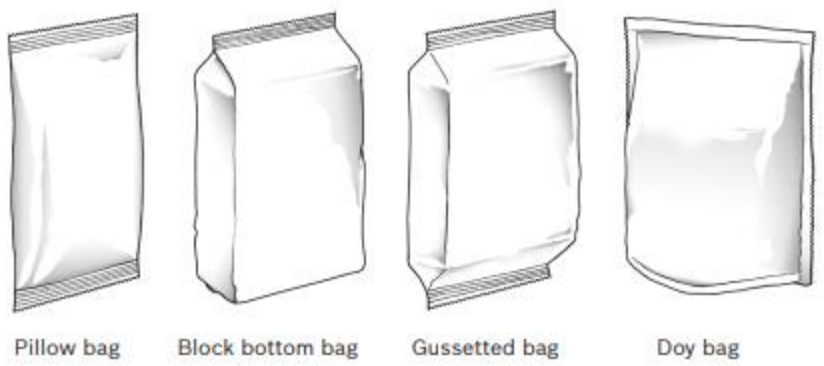


Figure 31 different types of bags

In the packaging machine, a flat web of film is made into sealed, filled bags. This chapter follows the course of the film roll, paying attention to such elements as the different types of seams, the forming of the bag, the transport of the film through the machine and the machine speed that is partly contingent on the preceding factors.

The Pillow bag

The pillow bag or flat bag is the simplest bag shape. To prevent pleats in the cross seams, there are bag spreaders at the bottom of the forming tube

The gusset bag

A variation on the pillow bag, is generally used for products that are then packaged in a cardboard box, such as breakfast cereal. In this type of bag, extra packaging material is folded inwards on both sides. This side fold makes the bag less wide, but gives it extra depth during filling, so that the space in the cardboard box can be better utilized.

The bag with a block bottom

The bag with a block bottom or stand up bag, in which coffee or cookies, for example, are packaged, is yet another variation of the gusset bag. At the bottom of the forming tube, a mouthpiece is attached that extends from the round shape of the forming tube to the rectangular form of the bottom of the bag with a block bottom. Some manufacturers use a rectangular forming tube instead of a round one

Other bag shapes all other bag shapes that can be made on these machines are derived from the above basic shapes.

Some examples:

• Corner seal- or quad seal bags, known from such products as coffee pods;

• pyramid bags, in which gummies are packaged, for example;

• doy bags sealed on three sides with a block bottom (doypacks) such as those used for 250-gram packaging of candy.

II.16 Easy-opening and reclosable

For many packages, it is important that they are easy to open, while other bags must be reclosable as well. Different solutions for easy-opening and reclosable packages exist.

Whether packaging is easy to open depends in part on the packaging material. A bag made of polypropylene film with a serrated cutting edge will tear open easily, but this material is not of course suitable for every product. Laminates with polyester (PET) for example or nylon (PA; polyamide) cannot be torn open without tools. There are laminate packages that exist that can be opened by pulling apart two layers sealed on top of each other.

II.16.1 Easy opening

In order to make opening bags easy, the following are some of the techniques used.

• By using a coarsely serrated blade, a serration is created in the cutting edge. If the material allows for it, each “notch” of packaging formed from the serrations, can easily be ripped.

• A vertical notch is an indentation added by an extra blade to the cross seal seam. This makes it possible to tear off a corner of the packaging, such as with portion packages of mustard.

• For a horizontal notch, the sealing seam is made considerably broader on one side of the bag. Thanks to a notch added to an indentation on this side, the top of the bag is easy to tear off. This technique is used for example for packages of grated cheese and is often found above reclosable zipper features

• The top of the bag is also easy to tear off if the bag is perforated under the top seam. Such a package is not gas-tight or moisture-tight, of course. Use of perforation occurs especially often in the frozen food industry.

• Laser cutting is a technique where the outermost layer of a laminate is already cut into with laser beams by the film supplier. With this increasingly used technique, virtually every model of incision can be created. For example, predefined tearing paths can be created which form a pouring nozzle when the packaging is opened

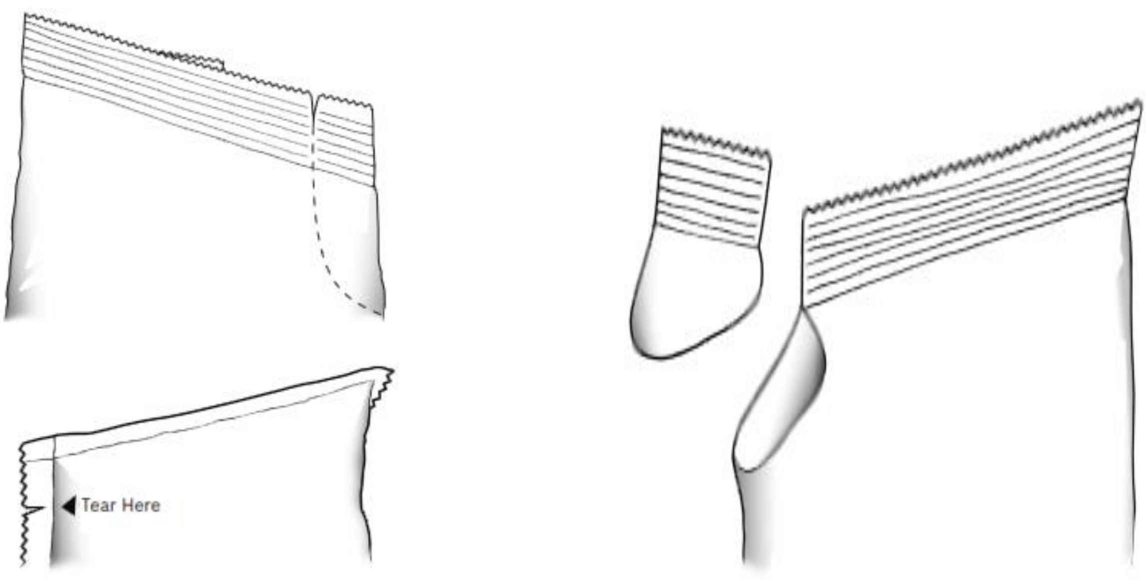


Figure 32 easy openig bag

II.16.2 Reclosables

For many products, it is desirable or necessary for the partially emptied packaging to be properly reclosed. There are various systems that can be installed on VFFS machines for this. Choosing the right system depends on the product and packaging, and definitely the price. Making a package recloseable increases the price considerably. Of the systems below, a reclosable with a zipper closure is the most costly. Sealing tape adds the least amount to the packages cost.

II.16.2.1 Sealing tape

The sealing tape reclose feature is a piece of tape (or label) located somewhere on the exterior of the bag. To close the bag, the top of the bag is rolled down and secured in place by the tape (or label), on the outside of the package. It is important that the sealing tape maintains adequate adhesive strength after a few times of sticking and pulling it off, so the product can be used many times

II.16.2.2 Resealable Tape

Resealable tape can be used on bags as a reclosure feature. The strip of tape is placed under an overlap of film that is formed at the top of the bag. The strip has adhesive on both sides with a layer of film over the side that will be in contact with the film overlap. Once the bag has been opened, the covering film is removed and the bag can be simply closed by pressing the overlap onto the sticky strip. These packages are printed so that the longitudinal seam forms the top of the bag with the cross seams forming the sides of the bag. One of the many applications is a bag with a block bottom filled with candy.

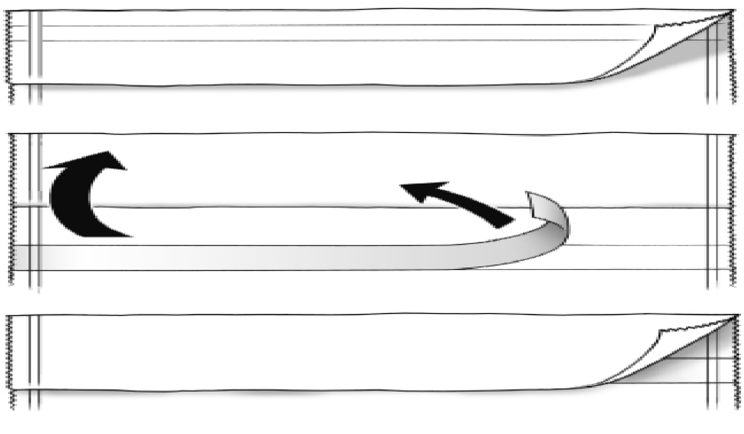


Figure 33 Tape bag

II.16.2.3 **Zipper closure**

A zipper closure, or zipper, is used for such items as recloseable packages for frozen vegetables and grated cheese. A zipper closure is a plastic profile added to the interior of the seam that can be opened and closed like a zipper. Specially equipped machines can add the zipper closures to the film web, but there are also suppliers who incorporate these closures already in the film. With the required adaptations and a special formatting set, such a film can be processed on a normal VFFS machine. The packaging speed and the efficiency of the machine are considerably lower than they are with the machines built specially for these reclosable packages[6] .

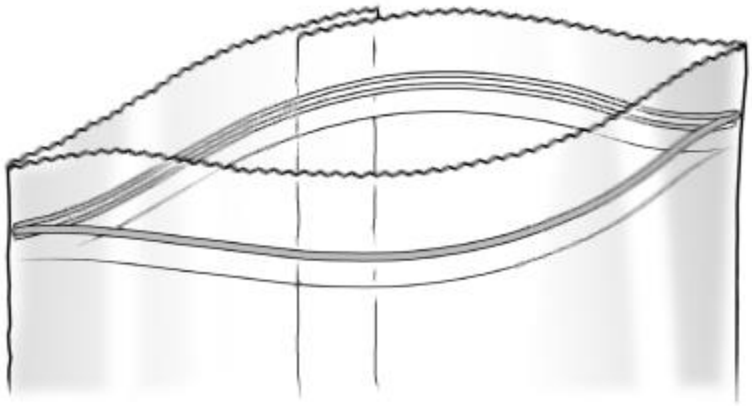


Figure 34 Zipper bag

II.17 **Conclusion**

In this chapter, we talked about the different pieces and their functions in the process of packing. The most important parts in it are the tension of the wrapping film sealing the longitudinal seam they play a very important role because if the tension wasn't settled, then the form of the bag would mess up, whereas the longitudinal seam will open up.

However, to assure the best sealing, we have to adjust the temperature and the pressure of the sealing jaws.

CHAPTER III

Design of the machine

III.1 Introduction

To start every project, we need steps to reach our goal and build it perfectly all right. In our case, a machine is not as simple as we can see especially the mechanical pies and their right choices, so to start making any machine we first need to made a typical 3D model with every part of the machine with the equitable element.

Solidworks is the conventional program for 3D conception. In this chapter, we built a model of a VFFS machine with Solidworks with all the accessories and elements of a real machine that is available on packaging machines market . Then we separated the different parts of the machine and we revealed to each part their real functioning.

Figure 35 Model VFFS machine

III.2 SolidWorks

Mechatronics, the combination of robotics, electronics, computer, and control systems, has resulted in a variety of amazing products from smart phones to self-driving cars. In order to create those products, they need to be digitally modelled and developed. SOLIDWORKS, a solid modelling computer-aided design and computer-aided engineering program, is one of the most popular software options for mechatronics engineers.

SOLIDWORKS is used to develop mechatronics systems from beginning to end. At the initial stage, the software is used for planning, visual ideation, modelling, feasibility assessment, prototyping, and project management. The software is then used for design and building of mechanical, electrical, and software elements. Finally, the software can be used for management, including device management, analytics, data automation, and cloud services. [11]

III.3 Structure of the machine

It made of metal where you can handle all the different pieces of the machine like cabinet, motors, filling Hooper …

And also have the roll of protection the inside materials from any stranger things that can interference the process

Figure 36 Structure of the machine

On the side of the VFFS Machine, there attaches to a control cabinet. It contains all the electrical parts inside. PLC, contactor, servo motors, pneumatic cylinder, solenoid valves, PLC expand mode, low-pressure electrical parts. HMI (Human Machine Interface is at the outside of cabinet control panel with the ON –OFF button and also emergency stop

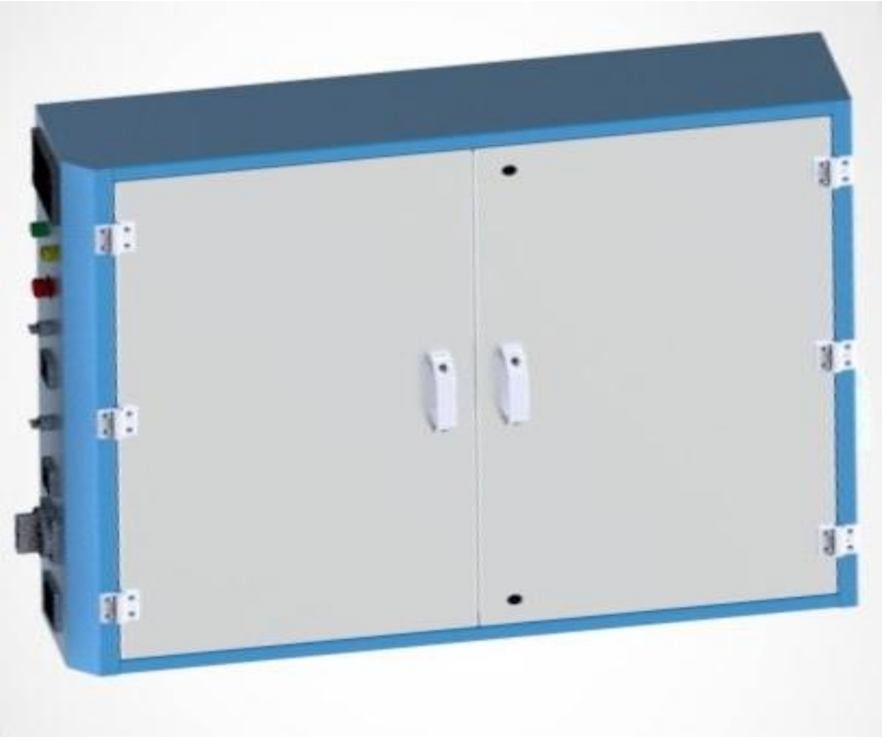


Figure 37 Control Cabinet

III.4 Feeding method (volumetric Cup Filler)

The basic design for a cup filler is to have a hopper whose bottom is equipped with rotating plate having small cups. When rotating, the cup is filled with product when passing below the material hopper, then the tube is blinded and then emptied towards the open packaging.

The volume of the cup is adjustable in order to fit the requirement for the filling volume and then weight. It must be noted that the system, compared to Auger filling, is rather passive, the powder has to flow by itself in and out of the cup. It means that this kind of dosing is particularly well adapted to very free flowing products but will lose some accuracy if the product is cohesive, do not flow well in the cup, or on the contrary get compacted in the cup and do not empty well towards the packaging.

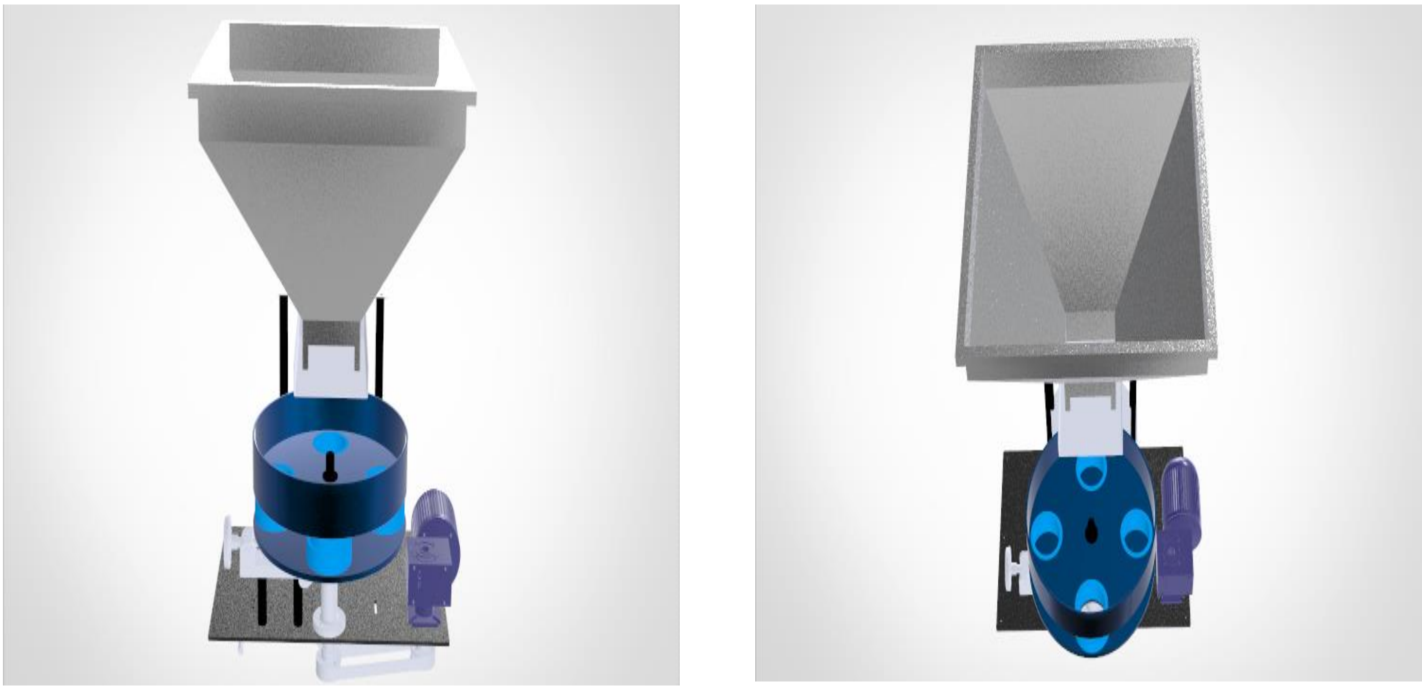


Figure 38 Doser

III.5 Film Pulling System

This system consists of unwinding roller and tensioner. There's a long film that rolled as a roll that we called the roll of film.

This film is usually laminated PE (polyethylene), PET, Paper, and Aluminium foil. The roll of film will be placed on the unwinding roller back of the VFFS machine. There are servo motors that drive and pull the film on the reels of the film pulling system. It perfectly co-works with each other and continuous motion pulling smoothly and reliably.

The transport belt system, located on the sides of forming tube, is responsible to pull the material from the film roll to the end of sealing jaws through. The film is usually passed through series of rollers. It may had a total of only 10 guiding rolls to the forming shoulder. As can be seen from figure the film lacks tension when the transport belt is not operated. It is possible to regulate the film tension by adjusting the pressure valves from the pneumatic unit. However, it was realized very high film tension leads to uncontrollable stretching of the film which creates difficulty in pulling the film. It is possibility to transport the film evenly by implementing dancer arm. The film is guided by the movement of a dancer that moves back and forth as shown in the Dancer armFigure 40. The spring mounted dancer arm uses the torsion spring mechanism to control the tension of the web film. Another Newly developed VFFS machine consists of many rollers the more additional rollers the batter tension. Also, to have a successful longitudinal overlap seam in the forming tube, the film should fit equally on the forming shoulder.[11]

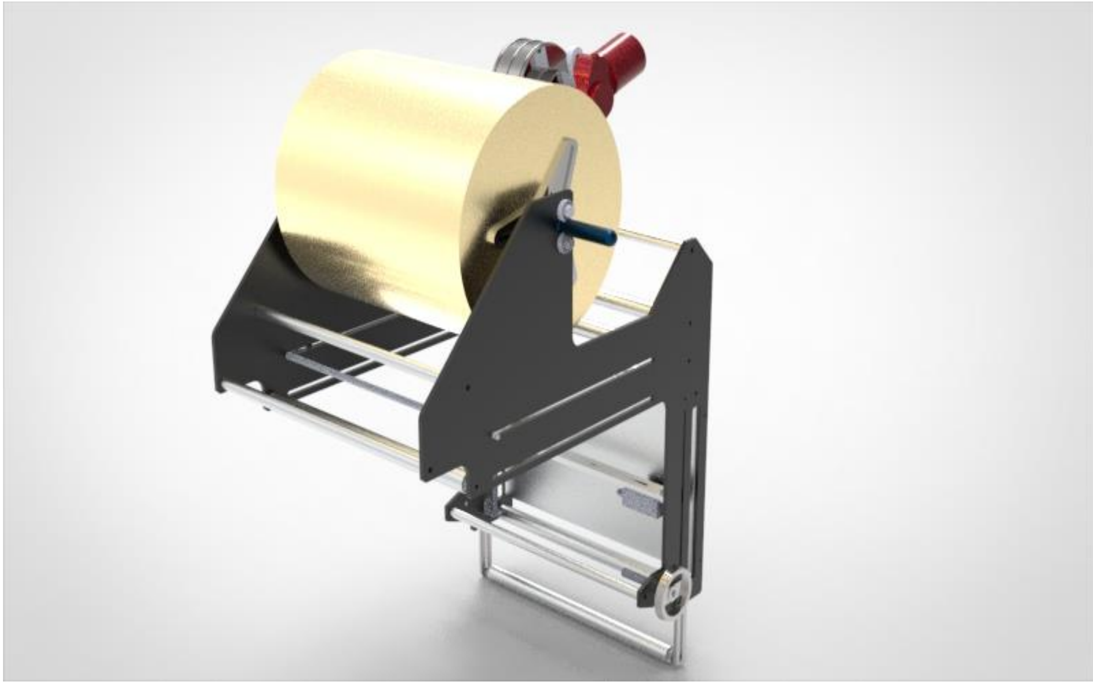


Figure 39 Unwinding roll

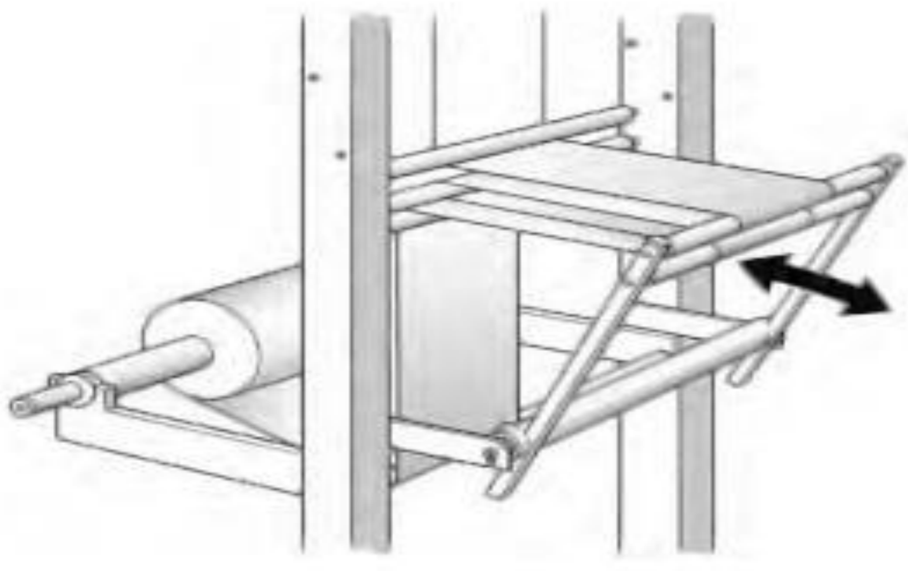


Figure 40 Dancer arm

III.6 Pouch Former

After the printing of the film, it moves to the bag former. It's like a collar of human clothes. The bags or pouches are made via this bag former with a wide range. Different sizes of bags can be made with different sizes of bag formers. It needs to change over the forming tube if needs to package different size of bags. It only needs several minutes to change over it. Besides having the function of bag forming, the bag former has also a function of filling. The bulk material will be filled into the pouch through it. The bag former is made of stainless steel and makes sure suitable for foodstuff.

Figure 41 Forming Tube

III.7 Filling and sealing

There are 2 sets of sealing devices. One is a vertical sealer, and the other is a horizontal sealer.

III.7.1 Vertical sealing

The long seal is formed by several different heater mechanical configurations that are typically placed on the front of the forming tube and are eight to twelve inches in length. Linear film speed and type are factors in determining the correct minimum length of the long seal. There are two main types of long seal. The first type of long seal is the static bar, which is a heated bar with heating element and thermocouple. This bar will be engaged into the film and forming tube only while the film is in motion with slight timing delays to prohibit melting of the film when stationary. There can also be two bars, but placed where they are facing one another in a manner to allow the long seal flaps to be placed in between the two bars. This method is used instead of the overlapping method used for single bar configurations. This can provide stronger seals / seams and the product ambient temperature (i.e. forming tube temperature) will have less of a factor on the loop control. The second type of long seal is the dynamic belt, a single-heated stainless steel belt with two pulleys. A heated plate transfers the heat to the stainless steel band or belt and is engaged into the film and forming tube while the film is in motion. Like the static bar type, there can also be dual dynamic belts / bands. The benefit of dynamic belts is they can move with the film and also be adjusted to operate faster than the base film speed or even slower. These are process decisions made based on many product, machine and material factors.

Figure 42 Vertical Sealing Jaws

III.7.2 Horizontal sealing

The cross jaw is responsible for three major functions—to seal the top of the previously filled bag, to create the bottom seal for the soon to be filled bag and to cut or separate the completed bag from the bottom of the new bag. The front and back cross jaws operate as a pair. The front and back jaw will both have a top seal area (horizontally) and a bottom seal area. Additionally, either the front (typically due to maintenance reasons) or the back jaw set will have a knife, which runs horizontally in the middle of the jaw face. This knife is recessed and is activated by a pneumatic actuator. The opposite jaw set will contain the anvil for the knife. Each jaw will have one or two heating elements as well as a thermocouple for temperature control. Additionally, the cross jaw section can have options like product wipers, bag deflators, bag hanger punch, gusset (single & double) creation mechanics and flat bottom bag mechanics to name a few. Cross jaws are typically configured mechanically where the front and back jaws interpose each other and therefore meet in the vertical centerline of the bag and forming tunnel. However, there are also versions where either the front or back jaw is stationary and the opposite jaw is moveable. Servo drive/motor combinations, VFD drives with induction motors and high power pneumatic cylinder actuators are used to close the jaws and provide the necessary sealing pressure to provide a suitable bag seal. It is very common for the jaws to contain built-in springs to allow for some closure error as well as a default force. Often, position and torque data are monitored for the cross jaws. This data can easily be used to detect product in the seal or between the jaws. Anytime there is product in the seal, these two bags should be discarded due to potential seal / seam leakage.

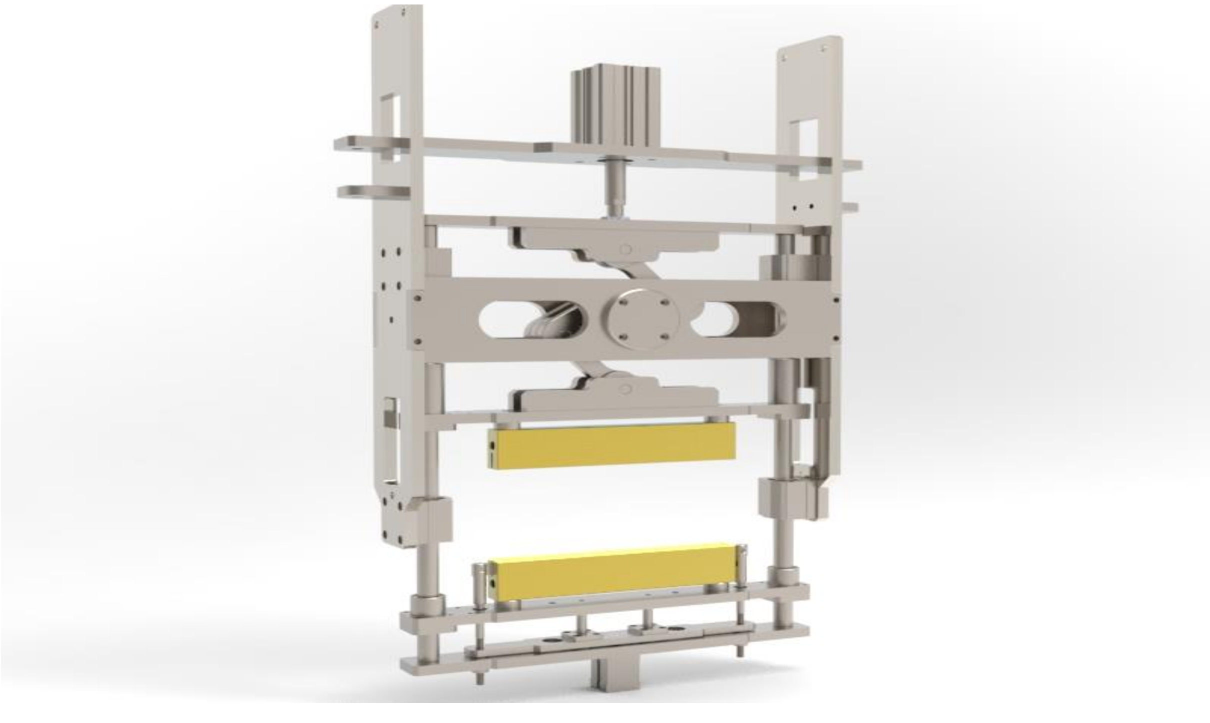


Figure 43 Horisontal Sealing Jaws

Here in the next figure we can see the steps for sealing the film after the arriving of the film the sensor is activated so the jaw closed with a calculated pressure and heat temperature for sealing.

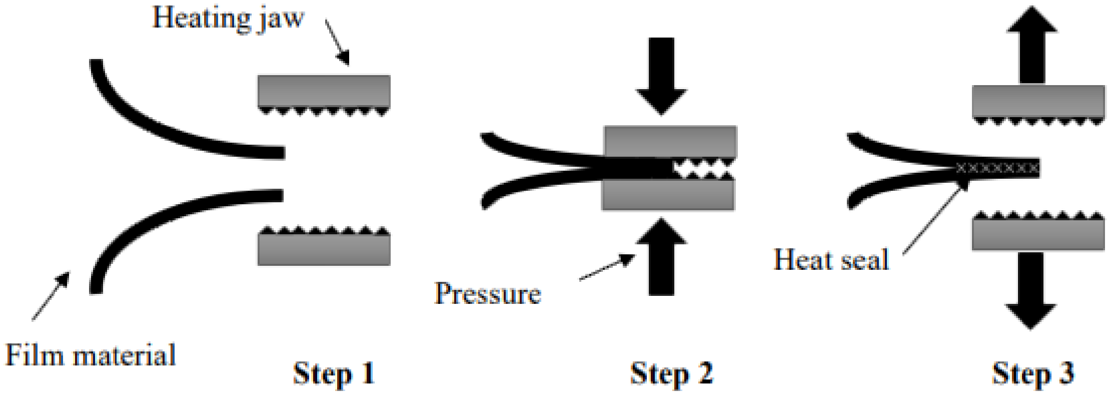


Figure 44 Steps of Sealing

III.8 Conveyor belt

After all the pervious process the bags is ready for the second packaging if its need so when its fall down directly from the last step of the process which is sealing the top and the bottom then cutting so its fall down to the Conveyor belt which guide the bags in to a box where all will be stoked .

Figure 45 Conveyor Belt

III.9 Conclusion

This third chapter will address the stages of the realization of the packaging machine and its operation.

Allowed us to see several methods and techniques of packaging used in the industry, and the choices of materials used in our machine.

CHAPTER IV

Electrical design and automatisation

IV.1 Introduction

Automation is a term for technology applications where human input is minimized. This includes business process automation (BPA), IT automation, personal applications such as home automation, and more. Basic automation takes simple, rudimentary tasks and automates them.

This level of automation is about digitizing work by using tools to streamline and centralize routine tasks, such as using a shared messaging system instead of having information in disconnected silos.

In this chapter, we talked about the electrical part of the machine and the different ways to choose the right equipment for the machine to be perfectly made. Besides that, we must precise the right start moment for the different tasks of the machine's parts.

IV.2 Automation part

The automation component differs from one machine to another beside that also speed is an important criterion for choosing the right PLC and the servomotor

IV.2.1 Programmable logic controller

A programmable logic controller is a type of tiny computer that can receive data through its inputs and send operating instructions through its outputs. Fundamentally, a PLC's job is to control a system's functions using the internal logic programmed into it. Businesses around the world use PLCs to automate their most important processes.

A PLC takes in inputs, whether from automated data capture points or human input points such as switches or buttons. Based on its programming, the PLC then decides whether or not to change the output. A PLC's outputs can control a huge variety of equipment, including motors, solenoid valves, lights, switchgear, safety shut-offs, and many others.

PLCs largely replaced the manual relay-based control systems that were common in older industrial facilities. Relay systems are complex and prone to failure

Today, PLCs are still a fundamental element of many industrial control systems. They're still the most used industrial control technology worldwide. The ability to work with PLCs is a required skill for many different professions, from the engineers designing the system to the electrical technicians maintaining it. [12]

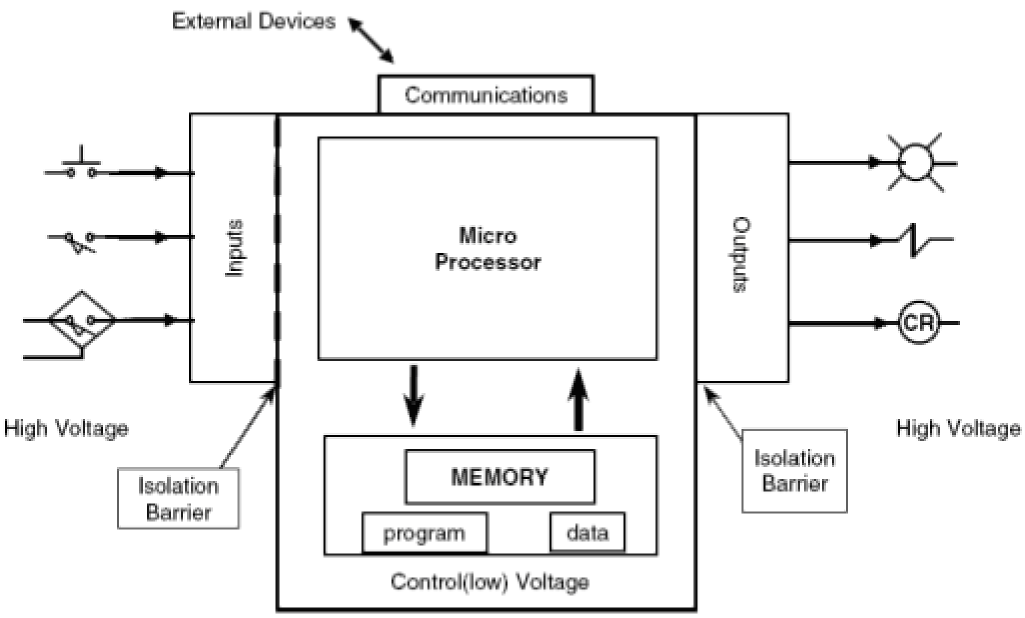


Figure 46 PLC

IV.2.2 **Panel view**

An integral part of the modern industrial control system is the human-machine interface (HMI)? Before the widespread use of microprocessor-based graphical displays, an HMI consisted of hardwired dial gauges, strip charts and servo recorders, light indicators, and various push buttons. Modern controllers and automation systems interact with people mainly through graphical user interfaces (GUI). These GUI interfaces most often appear as touch screens with a menu-driven display. Minimally HMIs display process information and controls in real-time.[12]

Figure 47 HMI

IV.3 Type of automation

There are 2 different types of machine automation:

- Intermittent motion machine with 2 speeds: 70bags/h, 100bags/h
- Continuous motion machine

This machine differs in the material that we use in it like motors and the PLC [13].

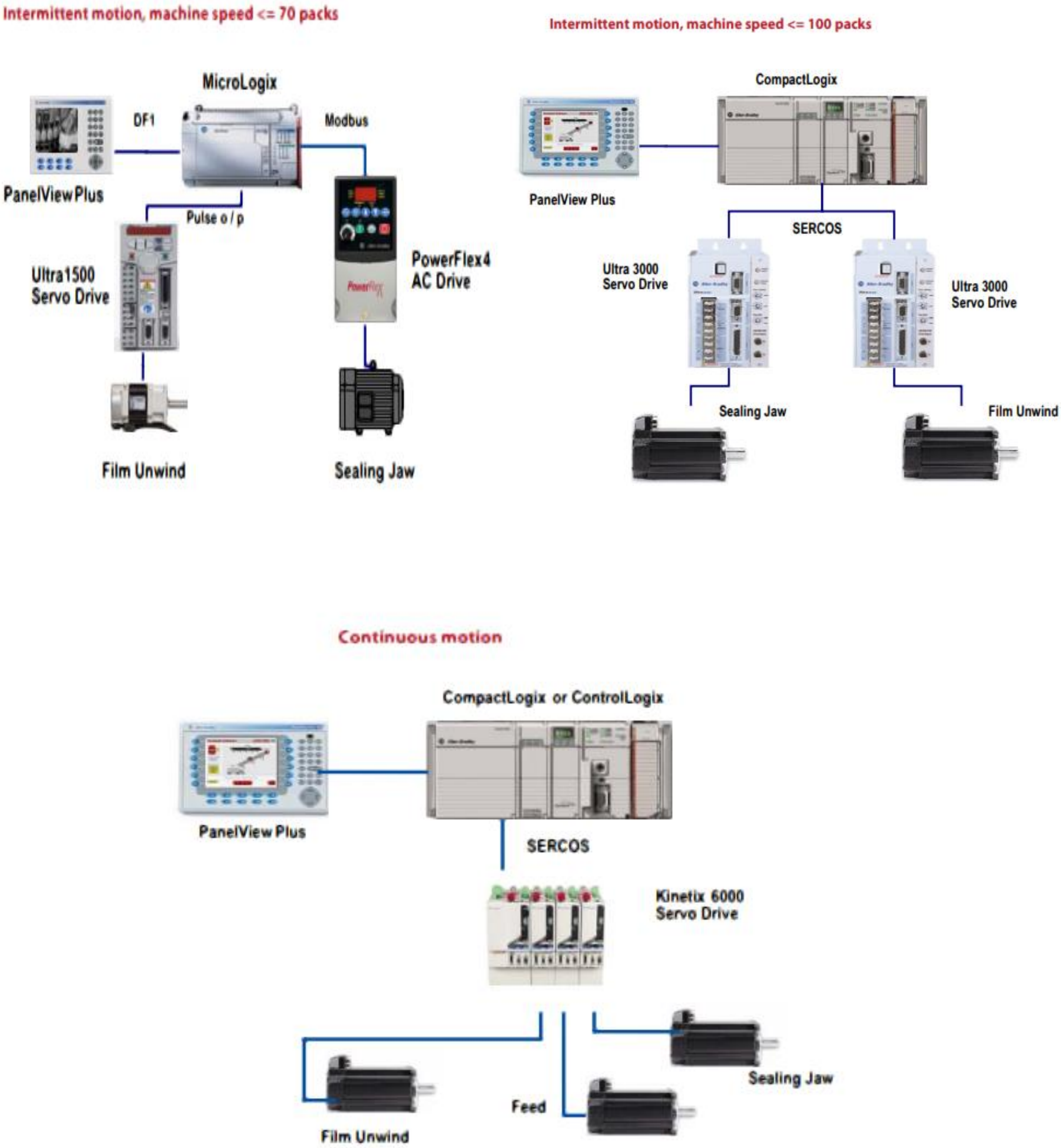


Figure 48 Types of automation

IV.4 Technical characteristics of the machine

IV.4.1 General operation

This machine makes, fills and closes the bags automatically, starting from a film roll.

Modèle	UAMOB_2018/2019
The power supply	220 V – 50 HZ
The power	2200 W
Compressed air consumption	5-8 bars
Bag size(L*W)	200*150mm
Maximum packing speed	2400 bag/h
Package measure	5-300 g
The filling accuracy	(± 0.01 à 0,2 %)
The dimension	700*1000*1800mm
Weight	320 kg
Type of work	Powder

Tableau 2 Technical characteristics of the machine

IV.4.2 Speed

Expressed as the number of bags to be made per minute, it varies from 9 to 60 bags per minute the maximum capacities are influenced by the nature of the product and the quality of the film.

IV.4.3 Power consumption

The machine consumes with dozer device:

• Engine: 550 W

• Film Decoiler: 10/30W

• Metering unit: 250 W

• Heating: 1500 W

• Voltage: 220V

• Frequency: 50 Hz

IV.4.4 Compressed air consumption

The machine uses compressed air for horizontal jaw spacing and compression, knife.

• Minimum operating pressure: 5 bar

• Maximum operating pressure: 8 bar

• Air flow at 6 bar: 3 liters per cycle

IV.4.5 Choice of engine types

We used four asynchronous motors in our packaging machine as a result:

• Main engine

• Film decoiler motor

• filling cup motor

motor	Principal motor	Engin roll web	Doser motor
Type	YL802-4	70JB-15G10	Y2 Série
Tension	220 V	220 V	220 V
Frequency	50 HZ	50 HZ	50 HZ
The power	550 W	30 W	250 W
Speed	1400 rpm	1250 rpm	2975 rpm
torque	3.75 Nm	0.23 Nm	0.80 Nm

Tableau 3 Engine types

IV.4.6 Choice of speed reducer

Selection criteria for a reducer

Before buying a reducer, it is important that you consider several factors.

A reducer allows to adapt the characteristics (torque and speed) of the input and output axis of a mechanism. This is why you need to know the torque and the speed of rotation.

model	Speed reducer
Type	TJ-BKV
Input speed	1400 tr/min
Reduction ratio	1/40
Output torque	5 Nm
Yield speed	35 tr/min
Outlet diameter	30 mm
Weight	7.8 kg
Color	Blue
Material	iron

Tableau 4 Speed reducer type

IV.4.7 **Choice of automation equipment**

A programmable logic controller (PLC) is a small, sturdy industrial computer designed for control of automated industrial processes and machines. PLCs are used almost everywhere. They are most frequently used in factories and industrial plants to control pumps, motors, lights, circuit breakers, fans, and other machinery. In everyday life, these controllers are utilized in elevators, automatic car washes, traffic signals, amusement park rides, among other equipment that we otherwise take for granted.[13]

Choosing the Right PLC: 6 Things to Consider

. The Architecture of a PLC. A PLC consists of the following components:

1. 2. The Basic Function of a PLC.
2. System Requirements.
3. Environmental Requirements.
4. Inputs and Outputs (I/Os).
5. Speed of CPU.
6. Type of Communication Protocols.
7. Programming.

Model	Siemens logo
Power supply	12-24 DC
Switching current	10 A
Number of digital inputs	8
Number of digital outputs	4
Number of auxiliary inputs	4
Material cost	25000,00 DA
Width	72 mm
Height	90 mm
Depth	55 mm

Tableau 5 PLC type

IV.4.8 **Electrical cabinet**

1) Main circuit breaker;
2) Electric chute;
3) Circuit breakers;
4) Terminal Block Connection;
5) Static relay;
6) PID;
7) Contactors;
8) Power supplies stabilize;
9) Metal rails;
10) Automatic seed logo with extension;
11) Electrical Relays;
12) Electrical Splitter.

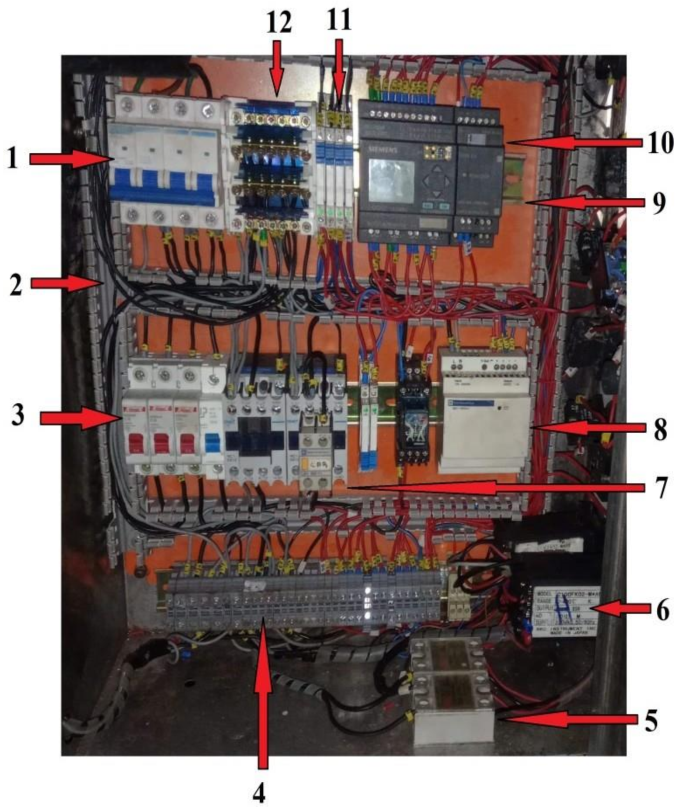


Figure 49 electrical cabinet

IV.5 Synchronization

In order to have a VFFS machine work at its optimum, the production of the bags must be perfectly synchronized with the dosing of product. If that is not the case, then so-called synchronization losses can occur.

If there is proper synchronization, the dosing of the VFFS machine receives a signal at the proper moment to dispense the product, or vice versa; the machine receives orders from the dosing in order to create a bag at the proper moment.

IV.5.1 The right moment

With products that are free-falling (not dispensed by a pump, auger or dosing cup), it is important that the first product falls into the bag at the time that the cross seam jaws have just closed. Then the product is not caught by a sealing seam, but rather by the top of the jaws that have just closed. If the product ends up in the bag too early, it can end up between the sealing jaws, or in extreme cases even in the sealing seam that is still hot from the previous cycle when it was made. This can be avoided by an electronic connection that ensures that the dosing releases the product at the right time. That time is determined by the moment that the cross seam jaws are closed, combined with the falling time of the product.

IV.5.2 Master and slave

In synchronization, a choice must first be made whether the dozer is oriented to the VFFS machine or vice versa. In most cases, the dozer is driven by the VFFS machine. The VFFS machine is then the master; the dozer is the slave.[5]

The VFFS machine lets the dozer know by a signal that it is time to dose the product. This signal can be issued earlier or later in the machine cycle. The determining factor is the falling time of the product.

IV.5.3 Determining the falling time

The falling time of a product is determined by trial and error. Trial and error testing is usually conducted at a low machine speed, and often with a transparent film. The transparent film allows for observation of the product reaching the bag as well as the seal jaws closing. If the product comes down too early, the signal needs to be given later. If the product is slower than expected, the signal needs to be earlier.

IV.5.4 Synchronization losses

As soon as the dozer issues the product, it sends a dosing finished alert to the VFFS machine. Then the machine knows that a product is on the way and that a new bag needs to be made. If no dosing finished alert is received, the machine does not make a bag but it starts the next cycle. This function is referred to in the jargon as "no filling – no bag". It can also occur of course that the dozer is not ready in time to dose the product for the next bag. The dozer must then wait one machine cycle and no bag is made: in the output, one machine cycle is lost. Both types of loss are called synchronization losses.

IV.5.4.1 The dozer as master

If the master function is played by the dozer, the VFFS machine receives orders to make a bag at the time the dozer is ready to dispense product. The big benefit of this type of synchronization is that less synchronization loss occurs. The dosing can however only be set as the master in machines where the different machine movements can be driven (in contrast to VFFS machines with a fixed cycle driven by a central main shaft), such a machine can make the next bag immediately after a bag is made, when it receives the next signal.

IV.5.4.2 Central main shaft

Machines with a central main shaft start immediately on the next cycle. Therefore, the next order can only be accepted once the previous cycle has been completed entirely. This does not mean that a bag actually has to be produced. For example, the sealing jaws can complete the vertical movement driven by the fixed main shaft, but not subsequently close. Then no bag is made.

IV.5.4.3 Packer

If for example, there is an automatic case packer set up behind the VFFS machine, then it is advisable to involve this machine in the synchronization as well. Then the VFFS machine will always check whether the case packer is ready to receive bags. For example, if there is a disruption to the case packer, then the production of bags is interrupted until this disruption has been remedied.

IV.5.4.4 Carton Machine

If gusset bags are packaged in a surrounding carton, then it is possible to have the carton machine call for the next bag. In that case, the carton machine is the master, and both the VFFS machine and the dosing play the role of slave. Such a complex synchronization is only possible if all of the machines in the packaging line are equipped with servomotors and microprocessors, so delays and accelerations can be adequately signalled and compensated for.

IV.5.5 Asynchronous

If one or more machines are not equipped with servomotors and microprocessors, the carton machine will have to be set at a speed approximately 10% higher than the VFFS machine, in order for the carton machine to keep up with the bags coming out of the VFFS machine. In this case, it is an asynchronous link.

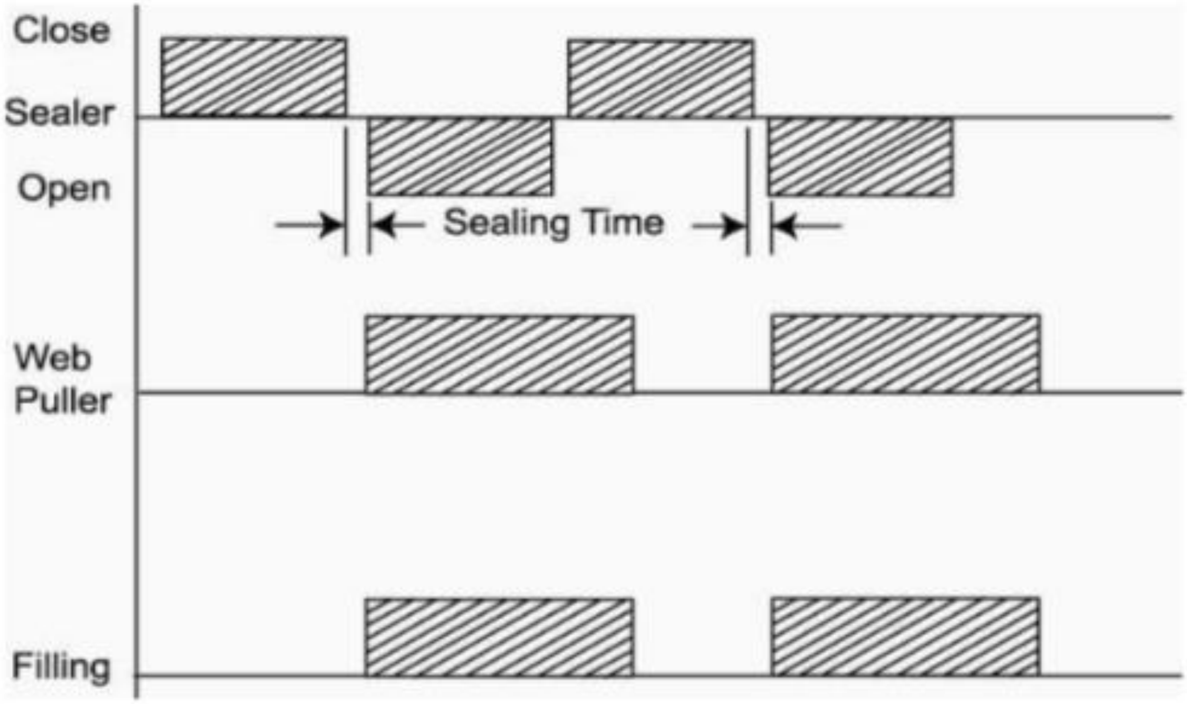


Figure 50 synchronisation curve

IV.6 Conclusion

The choice of the electrical equipment is the first criterion for the machine to work in the best condition, because if we have sabotage in our production line, it causes us problems like a waste of time and financial loss.

General conclusion

Extensive research on optimizing the process parameters for the VFFS machine was carried out.

VFFS is widely used to form pillow and block bottom bags for packaging dried products. In a production line, the VFFS machine operates at a high speed, so it is very important to optimize the heat sealing parameters (sealing temperature, dwell time, and sealing pressure) to achieve an airtight and adequate seal strength. Each of these parameters can be regulated individually. For example, high sealing temperatures cause thermal expansion of the molecular chains in the adhesive layer. Furthermore, dwell time and sealing pressure cause problems in both the longitudinal and bottom and top sealing.

Several development opportunities were found during the research work like modifying the atmosphere of the product inside the bag

The purpose of our work was to present a computer-aided design (3D) simulation through Solidworks software. This allowed us to actually build the machine with all of these electrical and mechanical accessory parts and see how programmable automation for the mechanical part works. The result of the simulation was the realization of a prototype model.

In conclusion, we can provide optimistic results for developing and designing machines and comparing their prices on international markets, which strengthens our economy and gives autonomy to our manufacturers in Algeria because most of these machines are imported from different countries at high costs.

Bibliography

1. Your article library1. ; available from: https://www.linkedin.com/pulse/flexible-packaging-part-1-vffs-machines-history-current-vijay-kumar.
2. *Packaging and branding.* Yourarticlelibrary.
3. ; available from: https://www.kivo.nl/en/knowledge-base/vffs-packaging/.
4. Linkedin, v.-k.; available from: https://www.linkedin.com/pulse/flexible-packaging-part-1-vffs-machines-history-current-vijay-kumar.
5. Henry, j.r., *packaging machinery handbook: the complete guide to automated packaging machinery, including packaging line design*. 2012: createspace independent pub.
6. Industries, b., *guid vffs mchine.*
7. Merabtene, m., *evaluation and optimization of a vertical form-fill-seal production machine for flexible packaging papers*. Lappeenranta-lahti university of technology lut.
8. *Guide to vertical form-fill-seal baggers.* 2014. .
9. Walsh, s., *the future of packaging - long-term strategic forecasts*
10. Coles, r., *food packaging technology* in *london derek mcdowell head of supply and packaging division loughry college*. Packaging technology london.
11. Farida, m.d.-b., *emballage et stockage des aliments*. Université chadli bendjedid el-tarf.
12. Dole, p., *les 7 fonctions de l'emballage.* 2018.
13. Rockwellautomation.