

Study on Various Type of Packaging Machines

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Abstract—Packaging has a very important role in our lives. Primary, secondary, tertiary are basic types of packaging. Based on application the level of automaton can be decided like manual, semi-automatic, fully automatic. For small scale operation manual machines are preferable and for large scale fully automatic machines are preferred. The main aim of this paper is to understand types of packaging and its working principle. The various types of packaging machines like Blister, VFFS, HFFS, Rotary filling machine, Carton folding machine are studied in detail. Various types of sensors, motors used in packaging machines.

Index Terms— Packaging Machine, Sealing Machine, Liquid filling machine, Bottle filling machine, Blister packer, VFFS, HFFS, Rotary Filling Machine, Carton Packaging Machine, Sensor, Motors.

I. INTRODUCTION

Packaging can simply be defined as “A system to contain and protect a product or quantity of products. It includes a range of materials and formats, including bags and pouches, bottles, cartons, corrugated cases, blisters, tubes, trays and more”. In the modern world packaging plays a critical role. As it protects products, helps to extend their shelf life, and facilitates their transportation and handling. Packaging machines are essential tools for manufacturers and businesses involved in the production of goods, as they automate the process of packaging, increasing efficiency, reducing waste, and improving product quality. In recent years, packaging machines have undergone significant technological advancements, resulting in machines that are more efficient, versatile, and customizable to specific packaging needs. Therefore, it is essential to review the current state of the art in packaging machine technology, highlighting the most significant trends, challenges, and opportunities in this field. This paper provides an in-depth review of packaging machines, focusing on their design, functionality, and applications. The paper discusses various types of packaging machines, including filling, sealing, wrapping, and capping machines, among others. Furthermore, the paper provides insights into the materials used in packaging, the automation and control systems used in packaging machines, and the impact of packaging machines on sustainability and the environment. Overall, this review paper aims to provide a comprehensive overview of packaging machines, highlighting their importance, benefits, and challenges in modern manufacturing, and providing insights into the latest trends and innovations in this dynamic field.

An article published on December 29, 2020 in Times of India by Sumant Pai discusses Evolution of the packaging industry and why ‘sustainable packaging’ is the future. In this article it is stated that “In recent years, there has been a new user facilitating the growth of the Indian packaging industry that is e-commerce. The widespread adoption of e-commerce facilities has resulted in thousands of packets being delivered daily across the country. This has further increased the demand for quality packaging of the products.”[1]

According to the article; A survey from 2019 estimated the value of the Indian packaging market at USD 50.5 billion. Also, the market is predicted to grow at a CAGR of 26.7% between 2020 and 2025, reaching a worth of USD 204.81 billion. The packaging sector in India is expanding at a rapid rate, thus the future is hopeful [1]

II. OVERVIEW

A packaging machine can be classified into several categories [2]. In this paper we are focusing on criteria

- 1)Level of packaging
- 2)General machine type and objective
- 3)Level of automation
- 4)Material used for packaging

Levels of packaging

A. Primary Packaging

Many times, referred to as “retail packaging”, this packaging there is direct contact to a product. Main purpose of primary packaging is to protect the product, Inform the customer about the product and attract the customer by designing the package neatly.choosing the right machinery for primary packaging is crucial as it can contaminate or harm the product. Especially for food and pharmaceutical packaging, selection of machinery is very important as these two markets are regulated tightly by the government.In this paper we are mainly focusing on the primary packaging machines.

B. Secondary packaging

Purpose of secondary and tertiary packaging is somewhat similar. Secondary packaging is used to hold individual units of primary packaging. The main purpose is to protect products and provide labeling. Moreover, it is utilized as display packaging in retail settings like grocery shops.

C. Tertiary packaging:

The packaging used most often used by manufacturers to ship secondary packaging to warehouses. The main goal is to protect shipments during transportation. Customers do not usually see tertiary packaging.

General machine type and objective

Machines are mainly classified by their functions such as form, fill, wrap, seal, etc. In many cases multiple functions are combined to form a production packaging line. During line design it is important to understand the objectives of each individual machine function. For example, a capsule blister packaging machine sheets are thermoformed to get desired cavities to fill the capsules then seals the sheet.

Level of automation

There are three levels of automation: manual, semi-automatic and automatic. Manual and some semi-automatic machines are single function. Semi-automatic machines differ from manual due to inclusion of PLC or microcontrollers. Many small-scale industries prefer semi-automatic as they are more efficient than manual and cost effective and can be used either as single function or multi-function. Automatic has advantages over others in terms of efficiency, precision, speed, and reduced labour.

Material used for packaging

1. Flexible packaging: Materials used are Films, foils, pouches and bags.
2. Semi-rigid packaging: Corrugated and paperboard used in cases, cartons and trays.
3. Rigid packaging: Glass, plastic, metal and composite bottles, cans and tubes.

III. POUCH FILLING MACHINES

These machines produce pouches mainly used for solid and liquid materials in the packaging industry. It is a flexible type of packaging. Paper, plastic, polymers are the most commonly used materials for pouch packaging.

A. How Pouch Filling Machines Work

Form-Fill-Seal (FFS) machines forms the packages, filling product, sealing into pouches.

Pouch filling machines are usually of two types:

1. Vertical form fill seal (VFFS)
2. Horizontal form fill seal (HFFS).

B. vertical form fill seal

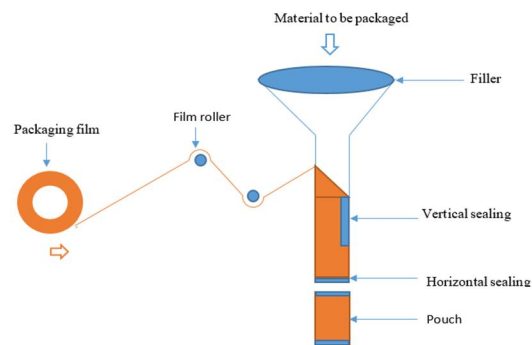


Fig 1. Schematic representation of VFFS machine

The packaging film is continuously fed to the system. Packaging film is placed on an unwinding roller. With the help of the motors this laminated film consisting of product information, manufacturing and expiry date is unwound firmly and pulled to the system.

Unwound film is then wound to the tube. Two edges of the film shaped to the pouch are sealed by vertical sealing bars with heat regulated by a temperature sensor.

Regulated amount of product is then filled to this pouch vertically with suitable filler and then sealed with horizontal sealing bars. This process of forming and filling pouch continues and passed to next packaging level through conveyor belt. Parts of machines like roller, conveyor belt, sealing jaws are connected to the various sensors and regulated by PLC to avoid error.

C. Horizontal form filling machine

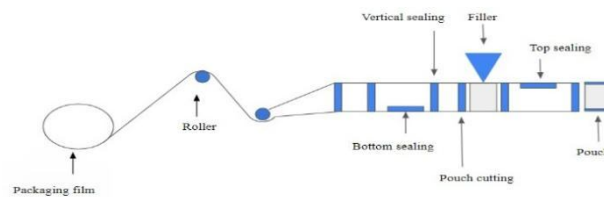


Fig 2. Schematic representation of HFFS machine

The working mechanism of HFFF is similar to the VFFS machine. The only difference is packaging material moves horizontally with the conveyor belt. First packaging material is unwound with the help of unwinding roller. This packaging film is tightly pulled by the system and both the edges are shaped into a pouch. Packaging material shaped into pouch is bottom sealed and both sides are sealed vertically by heat sealing jaws. Product is filled in the pouch vertically and top is sealed.

D. Sensor

- 1) Diffuse sensor: This sensor is used at an unwinding roller. It detects the end of a packaging film roll at an unwinding roller. This ensures continuous supply of packaging film.
- 2) Optical torque sensor: It is used in cutting station. To detect an edge for centering a trim while pouch cutting of pouch. It avoids small or large size of pouch than designated size.
- 3) Retro-reflective sensor: This sensor is placed at formation of pouches. It detects the product at outlet. Then it is passed to the further packaging.
- 4) Thermo sensor: It is placed at heat sealing jaws of the machine. Detects the temperature at the sealing jaws and sends feedback to the controller. If the temperature is beyond the permissible limit, it automatically stops the process. This ensures the proper sealing of pouch.

IV. BLISTER PACKAGING MACHINE

Blister packaging is a form of plastic packaging used to package toys, hardware, medicine, etc. Blister packaging is mostly used in pharmaceuticals for unit-dose packaging of tablets and capsules. This ensures product protection, longer shelf life, easy transportation and patient compliance.

Table I. Comparison of VFFS Vs HFFS Machine

Sr no	Parameter	VFFS	HFFS
1.	Operation	Vertically	Horizontally
2.	Preferable for	Sachet	Zipper pouch, suction nozzle pouch, self-stand pouch etc.
3.	Required floor area	Less	More
4.	Cost	Cheaper	Expensive
5.	Filling system	Only one type for one machine	Several types of fillers in same machine
6.	Investment	Lower	Higher
7.	Quality of pouch	Good	Better
8.	Production speed	Low	High
9.	Pouch design	Simple	Complex
10.	Product	Snacks, grains, beverages	Water, juice, milk

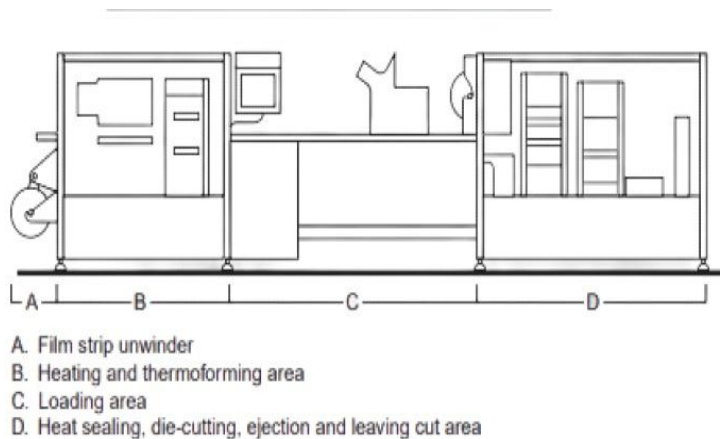


Fig 3. Schematic representation of HFFS machine

A. General Blister packaging machinery has 7 stations:

- 1) *Unwinding station*: Unwinding station provide forming films and lidding material similar to the speed of a packaging machine. It can also be done manually.
- 2) *Heating station*: At the Heating station temperature of forming film is increased to a desired limit until the forming film is soft enough to make cavities. Polypropylene (PP), polyvinyl chloride (PVC) are the most commonly used plastic films that can be thermoformed. But lidding materials like aluminium have to be cold formed.
- 3) *Forming station*: the heating station is followed by a forming station to form desired cavities using one of two mechanisms such as compressed air or die plate. But films that contain aluminium are formed with mechanical forming tools.
- 4) *Cooling station*: Polypropylene (PP) films are cooled here after the forming process. Laminates containing polyvinyl chloride (PVC) or aluminium do not need to be cooled.
- 5) *feeding machine*: At this station, loading area will fill the cavities with the final product. The filling step will be either manual or automatic. an empty pocket detector is placed at the end of the filling station to detect empty cavities.
- 6) *Sealing Station*: At sealing stations forming film that contains the product are heat-sealed or cold sealed depending on the material. For lidding purposes mostly aluminium foil is used. In heat-sealing blister forming

film and printed lid are pasted on each other under constant pressure for a predefined period, throughout which heat is supplied. The connecting surfaces of forming film and lidding material bind. As the heat input stops material cools down rapidly. Depending on the type of machine, the sealing temperature typically vary between 141 and 341°C.

TABLE II. SPECIFICATION OF BLISTER MACHINE

SR NO.	Type of Formation	Aluminium-PVC	Aluminium-Aluminium
1	speed	40 - 50 cycles per minute	30 cycles per minute
2	Max. Forming Area	Depend on the requirement	
3	Max. Forming depth	12	
4	Total power	3 kw	
5	Air compressor	10 hp	
6	Air pressure	Constant 8.5-9	
7	Water consumption	Depending on the machine (approximately 100L to 500L per hour) chilled water	

B. Sensors

1) *Rotary encoders*: These types of encoders are used for motion feedback. As packaging machine functions are mostly operated by servo motors, they usually have their own encoders to provide closed-loop feedback for the control system of the system.

2) *Temperature sensors*: Temperature sensors are used at two stations: heating station - to monitor forming temperature and sealing station - to monitor sealing temperature. For PVC of 0.25mm thickness the temperature is at 105-110C. Thermocouple is commonly used.

3) *Vision sensor*: This sensor is placed after the feeding machine to detect if there is any empty blister cavity. Typically, in automatic packaging machines 2-D vision sensors are used.

V. ROTATORY FILLING MACHINE

A. Working

The automatic liquid filling system is composed of rotary turret, filling station, capping station, control system, conveyor system.

1) *Rotary turret*: The rotary turret is a circular platform that rotates the containers through the filling process. It has multiple holding stations that hold the empty containers during filling and capping process.

2) *Filling station*: The filling station is equipped with a filling nozzle that disperses the liquid into the empty container which is mounted on the rotary turret. Where the filling nozzle depends on the requirement or demand.

3) *Capping station*: After the filling station, the container moves to the cap feeding station, then moves to the cap fitting station where the cap rotates on the container to seal the container. Where the cap feeding station is one, but the number of cap fitting depends on demand.

4) *Control system*: The control system is the brain of the machine, coordinates the operation of all the components or systems in the machine. It monitors and controls the filling speed, accuracy, speed, time, and other parameters.

5) *conveyor system*: A conveyor system is used to move empty containers to the rotary filling system. Then the sealed container or filled container moves to shipping or web sealing.

TABLE III. SPECIFICATION OF ROTATORY FILLING MACHINE

Sr no.	Parameters	Range
1	Electric power supply	1.0 kw
2	Capacity	3000 bottle per hour
3	Supply voltage	400/230 v 50hz

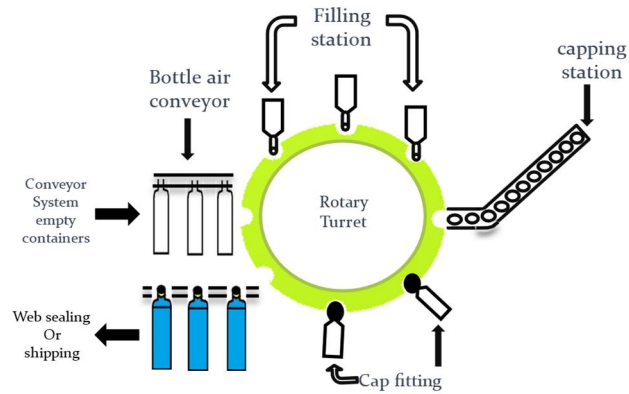


Fig 4. rotatory filling machine diagram

VI. GABLE TOP CARTON FILLING MACHINE

This packaging machinery used in the beverage industry to fill and seal gable top cartons. This is used to pack liquid products such as milk, juice and other beverages. A gable top carton filling machine is semi-automatic machine.

A. Working

The gable top filling machine typically include a series of steps that start from cartons being loaded onto the machine followed by the filling of the cartons with the products then sealed and any excess material is trimmed off.

1) *Carton feeding*: The empty gable top cartons are loaded onto the machine and through the machine through use of conveyor then folding and sealing of bottom of cartons

2) *Carton filling system*: A carton filling system that dispenses the appropriate amount of product into each carton

3) *Top carton sealing*: Once the cartons are filled, they are sealed using a system that applies a heat-sealed plastic to close the top of the carton then cartons discharge from machine then ready for secondary packaging and shipping.

A gable top carton filling machine are often used in high volume production environment and capable of filling thousands of cartons per hour.

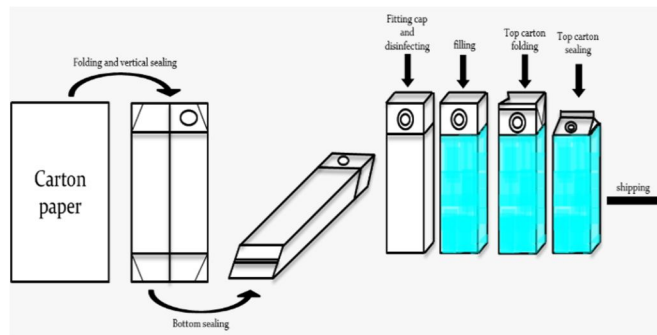


Fig 5. Process of filling gable top carton filling machine

TABLE III: SENSOR USED IN GABLE TOP FILLING MACHINE

Sr no.	sensors	operation
1	Level sensor	Measure the level of product in the filling Tank and ensure right amount of product is disperse in each container
2	Flow sensor	To measure the flow rate of product
3	Pressure sensor	Monitor the pressure inside the tank
4	Temperature sensor	Measure the temperature with the help of thermocouple
5	Photoelectric sensor	To detect the position of the carton for filling and sealing

VII. CARTON FOLDING MACHINE

95% Corrugated box used in packaging. material used is 90% kraft paper and 10% golden papers for making sheet of carton. Kraft roller paper is fixed in feeder assembly then following process

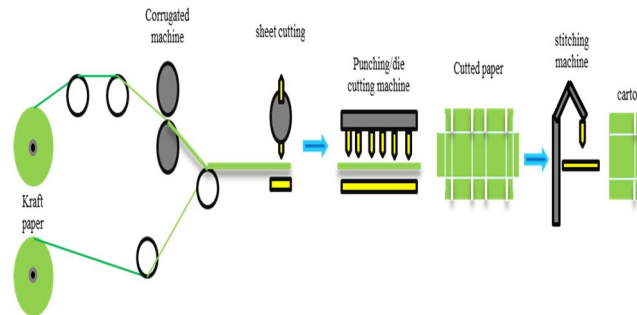


Fig 6. Corrugated packaging machine diagram

- 1) *Corrugated machine*: Where top Kraft paper film passes through flute roller and form zig-zag paper film called corrugated flute. This corrugated flute overlap on bottom Kraft paper and form corrugated board
- 2) *Sheet cutting*: This cut the paper into rectangular board.
- 3) *Punching and die cutting machine*: this machine cut the board in required design and punching the board to make foldable that is required board shown in diagram
- 4) *Stitching machine*: This stitch machine is use the steel wire to stitch one side of the board and make carton boxes. This carton boxes are send to industry for packaging purpose.

B. Sensors

- 1) *Pneumatic cylinder*: Commonly used type is single acting Pneumatic cylinder

TABLE IV. SPECIFICATION OF BLISTER PNEUMATIC CYLINDER[3]

Sr no.	Parameter	Range
1	Working pressure	Up to 350 bar
2	Test pressure	Up to 500 bar
3	Working speed	0.5 m/second
4	temperature	-30 to 60°C
5	fluid	Mineral Hydraulic oil
6	Piston sides	25/30/40/45/50/60... /200
7	strokes	Up to 5 m

- 2) *Ultrasonic sensor*: This sensor measures the distance of an object the most common used ultrasonic sensor is Thru-beam sensor. a thru beam sensor in most accurate, cheap and long sensing range.

TABLE V. SPECIFICATION OF ULTRASONIC SENSOR [4]

Sr no.	parameter	specification
1	Effective detection range	0- 2.5 m
2	Light source	Infrared Light Emitting Diode
3	Opening angle	+/- 8 °
4	Ambient light limit	40000 Lux
5	Optical face	lateral

3) *Temperature sensor*: it used to measure the temperature by the use of K-type thermocouple. A K-type thermocouple is range of around 500°C

4) *Photoelectric sensor*: the most used type of photoelectric sensor is retro reflective sensor

TABLE VI: SPECIFICATION OF TEMPERATURE SENSOR [5]

Sensor type	Sensing distance	Connection method	NPN output	PNP output
Retro-reflective with MSR function	0.1 to 4 m with E39-R1S (Red light)	pre-wired	E3FA-RN11 2M	E3FA-RP11 2M
		M12 connector	E3FA-RN21	E3FA-RP21

5) *Pressure sensor*: most commonly used is train gauge sensor for pressure change at operation time train gauge sensors measure the deformation or strain of a material due to an applied pressure. They are commonly used in packaging machines to measure the force applied during sealing, cutting, or forming operation.

VIII. MOTOR

The mechanism of Packaging machines is motor driven.

Motors used in packaging machine can be:

- 1) DC motors: used are of 1HP power. Various load limiting breakers are used to control speed and other motor parameters. To detect the speed of the motor and to give feedback to PLC tachometers are used. DC motors rotation can be inverted by changing positive and negative connections. DC motors require the replacement of the brushes. The phenomenon of dynamic braking can be used to stop motor immediately
- 2) AC motors: use alternating current specification may vary 220-240v, 50-60HZ based on country standards. Current specification and design of the machine can affect the RPM of the motor. Inductive motors are used in conveyor belts. AC motor require less maintenance compared DC motor and do not require change of brushes like DC motor for precise speed control of motor servo motors are used.
- 3) Servo motors: are controlled with software like PLC. In servo motor system encoder is used as feedback element to control system for parameter control. Servo motors can be AC or DC. Servo motors are preferred choice because of its accuracy, durability and adaptability.

I. Rotary motors

II. Linear motors

The basic difference between rotary servo motors and linear servo motors is the armature shaft moves linearly in angular direction in rotary servo motor and the armature shaft moves linearly in linear direction in linear servo motor. Single motor driving to the entire packaging machine causes difficulty to keep all components in synchronization and leads to the loss of efficiency and maintenance. To avoid this single motor is replaced by number of small servo motors connected together and controlled through software for ease operation.

IX. CONCLUSION

This paper is the review of different type of packaging machine used in food and pharmaceutical industries. There is also a brief study on sensors used for smooth packaging, safety of personnel and to maintain quality of production. In this review coming to conclusion of HFFS is more suitable than VFFS along with servomotors is preferred.

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