Paper No.: 12
Paper Title: FOOD PACKAGING TECHNOLOGY
Module – 30: Packaging equipment and machineries

1. INTRODUCTION:

Packaging is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use. When we consider machines for packaging, there is an endless variety of packaging and processing machineries for food products, and many of them are remarkably similar. One of the major problem in selection of machinery is distinguishing which, if any, offer 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 variable production process.

2. INTERMITTENT AND CONTINUOUS 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 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, that 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.

3. CHARACTERISTICS AND CLASSIFICATION OF MACHINERY

Choice of packaging machinery depends on

1. Technical capabilities, labour 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.

Packaging machines may be classified in to 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. Cartoning 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: labeling, marking, etc.
14. Wrapping Machines

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15. Converting Machines

Other specialty machinery include slitters, perforating machines etc.

4. TYPES OF PACKAGING MACHINERY

4.1 Fillers, Feeders, Metering and measuring machines

The job of fillers and feeders is to take product in a determined number or amount to fill the assembled package. There is a wide spectrum of different types of equipment to for this purpose, many of which can handle difficult materials such as thick pastes and creams, or very fine objects.

The simplest of them will fill and dump baskets, cups, or trays of material, are well suited to loose and granular products such as cereal and animal food, and can be used for single objects if the objects are properly guided in feed chutes going to the packaging machine. These may be fitted with weighing sensors to permit a net-weight fill to be directly applied to the product, and may use a combination of small fill trays to estimate the net weight more accurately. It is possible to use auger metering where the product is dispensed by based on timing or counting the rotations of an auger that delivers product into the package.

Many types of powders, particulates, and granular products are subjected to bridging and arching phenomena, where the powder will jam feed chutes if they are not suitably designed for such product. Fine powders practise cohesive arches using inter-particulate bonding whereas larger particles will make interlocking arches where the mechanical locking of irregularly shaped particles provides the cohesiveness to form arches. Both of these phenomena depends on the same principles that traditional arch structures in bridges and buildings use – transferring circular compression into vertical and horizontal force to maintain the arch structure. Proper design of the hoppers for the product as well as adaptive equipment such as agitators or bridge breakers may be necessary to keep the device operating properly.

On the contrary bridging phenomena can be used to stop product from flowing in certain types of measuring devices, such as screw-auger fillers. They are designed with a small disk at the end of the auger that creates blockages when the auger is not rotating and depends on bridging to stop the flow between package fillings.

Direct counting machines can use trays, simple photocells, or complex vision-system pick and-place manipulators to acquire the exact number of products required in a package. Similarly, it is possible to use the package or an inner tray as a measuring device, filling it with the appropriate number of product units, and then enclosing it in a larger secondary package.

4.1.1 Filling by Gravitation:

Filling by gravity is used for filling thin liquids like milk into glass bottles/plastic bottles. In gravitational filling, the filling process is stopped when the pre-calibrated filling height has been reached. This system is suitable for filling milk in glass bottles. However, packaging milk in bottles is outdated in India. In volumetric filling process, fixed volume of liquid is filled.

4.1.2 Mechanical Filling:

In this type milk powders are metered filled by using screw conveyors. The conveyors are used as metering and dosing devices. However, due to variation in bulk densities of milk powder, care must be exercised to ensure even delivery of the product and which shall be equal in weight from package to package.

4.1.3 Cup Filling Machines:

Plastic cups either preformed, from a film in the machine itself or readymade cups when used are placed in the stacker of the machine. Automatic packaging machines which work aseptically are in use for the production of long life products. In these machines the film is passed through a bath of Hydrogen peroxide and then goes to a sterile tunnel in which it is sterilized by either exposure to high temperature or exposure to excess pressure of air. The remaining stage like cup moulding, filling and sealing with lid takes place in the sterile tunnel.

4.2 Form-Fill-Seal Systems

Form-Fill-Seal (FFS) systems are preferred methods for many food items, and as the name suggests, it forms packages from roll around a central mandrel that incorporates a product fill tube and allows the forming, filling, and sealing of packages of almost all types of products from solids to liquids like milk. Mostly these may be multiple-head machines to produce small packets of sauces for fast-food restaurant use. With many types of food products, the product handling must be done accurately as the filled

pouches are filled to avoid infecting the seal surfaces. Additional types of machinery peculiar to the food industry will insert slices of meat products into folded or vacuum formed film and seal it, or will even extrude a cylinder of cheese food into a tube of plastic film and then flatten and seal the product to create the wrapped processed cheese slices.

Specialty machinery may be necessary for particularly sensitive materials such as fruit juices and meats that may discolour with the slightest gain of dissolved metal. In the most extreme cases like processing of juices and pharmaceutical or cosmetic products, special surfaces must be constructed for contact with the product using materials such as borosilicate glass, Teflon, or other materials, as appropriate.

For some products the film may first be fed through a sterilizing chemical bath and dryer prior to use in the packaging system.

The film approaches the back of a long hollow conical tube, and when the centre of the plastic 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.

4.3 Packaging in Cans and Tubes

Cans made of tin plate are used for sweetened condensed milk, evaporated milk, canned fruits, canned beans etc. The cans open at the back are loaded into the machine which fills the product in to the cans. Then the lids are applied and closed by either simple or double seaming depending on the product. Aerosol cans are used for the packaging of whipped cream. In these, the product is filled with a propellant which is under pressure.

Flat bottomed collapsible tubes made from aluminium are used for packing cream. After the product is filled from the back of the tube, the head space in the tube is filled with inert gas and the tube is then closed by folding. Polyethylene collapsible tubes are presently used for packing cheese spread/cheese food and ketchups.

4.4 Shrink Wrapping Machines:

Shrink wrapping includes packing of one or several articles with a thermoplastic film which when subjected to heat shrinks and form a tight wrap around the object. Shrink wrap or shrink film, is a material made up of polymer plastic film. When heat is applied to this material it shrinks tightly over whatever it is covering. Heat can be applied with a hand held heat gun or the package can pass through a heat tunnel on a conveyor.

Shrink wrap is usually used as an overwrap on many types of packaging, including cartons, boxes, beverage cans and pallet loads. A variety of products may be enclosed in shrink wrap to stabilize the products, unitize them, keep them clean, add a degree of tamper resistance, etc. It can be primary covering for foods like cheese and Paneer.

Shrink wrap film is available in a variety of thicknesses, clarities, strengths and shrink ratios. The two primary films are either crosslinked, or non crosslinked. Major shrink films include PVC and several other compositions like LDPE, LLDPE, PP, EVA etc. Coextrusions and laminations are available for specific mechanical and barrier properties for shrink wrapping food.

In shrink-wrap machine a loose plastic film pouch is made. The product is placed in this pack which passes through a heated tunnel in which the film shrinks and adheres closely to the product. The film is commonly heated by hot air, infrared rays or hot water. Shrink wrapping is also used to hold together several singly wrapped products or small packages in a multiple unit package.

Advantages of shrink wrap packaging are:

1. All types of items of regular / irregular shapes and sizes can be shrink wrapped.
2. Small items can be utilized and stacked one on top of the other
3. Requires minimum packaging material and operation.
4. Simple operation
5. Easy stacking
6. Enable unit packaging or packaging in groups.

4.5 Robotic Machines

Robotic operations are most effective in operations that are repetitive and predictable but require either control of heavy goods, as the case with palletizers, or with fast, accurate pick-and-place operations that needs consistent, accurate results at speediness that human operators would have difficulty maintaining. The second application is more usual in food packaging operations, and one of the first combination of robotics in the food packaging industry was in the high-speed filling of boxes of assorted chocolates where number of different products had to be accurately placed in a moving container.

Many robotic fittings mimic the human arm, or involve an articulated manipulator set on a revolving base, called delta robots. They have been successfully incorporated into many packaging operations. Originally developed by Raymond Clavel at Ecole Polytechnique Federale de Lausanne, these can be made with high-speed actuators and lightweight carbon fibre elements to provide extremely accurate high-speed operation for the management of small light objects. They have been implemented in many applications ranging from machine parts to bakeries and confectionary manufacturing.

4.6 Pre-closure Treatment and Closure Applications

A pre-closure treatment like headspace gas flushing is necessary for many closures and seals before they may be applied. This may require a remarkably complex system of nozzles and diffusers to avoid blowing the product out of the package or contaminating the seal. Vacuum may be applied, either alone or as a part of the gas-flush process as in a draw-redraw flushing where first air is withdrawn, then replaced with gas, and the process is repeated to ensure saturation of the flush gas. This procedure is common in products with high interstitial volume, such as bagged salads.

4.7 Case Packers

Although case packers are assumed to be a distinct type of machinery, it is not strange to have case packers that go home at the end of their shift. Several operations still depend on manual labour for some level of case aggregation, filling, and packing. Even though tedious, this can be helped by accumulator tables where product can be lifted in case quantities or inverted cases turned over for the final grouping. Bigger operations may automate many of the tasks, with machines lifting case quantities into shipping containers and sealing them. At this point, particularly for small consumer items and food, the

handling of the filled case ask for some attention to the ergonomics of the material movement, because the filled case may be heavy enough to cause health or safety problems for the personnel involved.

4.8 Palletisers

Manual palletisation may be used much as with case packing, but owing to the risk of repetitive motion injuries and the chance of dropped cases, there is often mechanical assistance used in the high-speed accumulation of pallet loads of finished goods. Palletisation is one of the important areas where large-scale automation and robotics were incorporated into packaging operations because of the blend of load weight, precision placement, and speed of operation. As heavy-lift robot arms become more capable, they may be desired for ease of setup and flexibility of mixed product loads.

If mechanical support is used in palletizing or handling, the case itself must be designed with the material handling system in mind. For example, vacuum-lifting structures in an automatic palletizer may put unexpected tensile stress on box flaps that will pull them open if the box-closing adhesive or tape is inadequate.

4.8.1 Stretch Wrapping:

Stretch wrap or stretch film is a highly stretchable plastic film that is wrapped around items. In contrast, shrink wrap is applied loosely around an item and shrinks tightly with heat. It is frequently used to unitize pallet loads but also may be used for bundling smaller items. Types of stretch film include bundling stretch film, hand stretch film, extended core stretch film, machine stretch film and static dissipative film.

The most common stretch wrap material is LLDPE, which is produced by copolymerization of ethylene with alpha-olefins, the most common of which are butene, hexene and octene. Other types of polyethylene and PVC can also be used. Many films have about 500% stretch at break but are only stretched to about 100 – 300% in use. Once stretched, the elastic recovery is used to keep the load tight. Other properties such as break strength, cling, clarity, tear resistance, static discharge, etc. are also to be considered.

In pallet unitizing, stretch wrap can have several functions like:

1. Improved stability of products or packages, forming a unit load.
2. More efficient handling and storage of unit loads.

3. Some degree of dust and moisture protection.
4. Some degree of tamper resistance and resistance to package pilferage.
5. Stretch wrapping is the most cost-effective way to keep loads secured on a pallet.

Stretch wrapping can be applied manually with small rolls of film. Dispensers are also available for larger rolls. Machinery is available to automate the operation. This controls the amount of material used, controls the stretch, and controls the application pattern. It is important not to apply too much tension or too many layers: the stress can damage the vertical edges of the boxes and significantly reduce stacking strength.

4.9 Speciality Packaging Machines

4.9.1 Inert gas packing:

Inert gas packing using nitrogen, carbon dioxide or a mixture of the two is done by passing the gasses around the product prior to sealing for example, Cheese. Whole milk powder packed in tins with a pin hole is evacuated under vacuum. The vacuum is then broken by the inert gas (usually N_2) and the pin hole is sealed immediately.

4.9.2 Vacuum Packaging:

Vacuum packaging is done for products like cheese blocks, meat products etc, where there is problem of microorganisms growing on the surface. The product is placed in a plastic pouch and placed in the vacuum packaging machine for the creation of vacuum in the pack and subsequent sealing takes place in the machine itself.

5. Conclusion

The assembly sequence of the particular product and package will decide the type and position of the machines and personnel tasks. There are many types and combinations of packaging machinery available, some are designed as per the need of the manufacturer. But, generalized machines cannot be used for packaging of all the products, as stringent requirements exist for many types of common products. Pharmaceutical products may have to be both produced and packaged under sterile conditions, some products contain fine powders that may contaminate other parts of the operation, and nearly all types of food processing equipment must be thoroughly cleaned regularly and then returned to service on a timely basis. Some of these machines must have glass-lined product-contact surfaces, or entire machines that are made of stainless steel to avoid corrosion or reaction

with the product or cleaning solutions. Other process considerations are also to be taken into effect, like gas supply system for modified atmosphere packaging.

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