

Computerized and Electronic Controls in Food Packaging

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ABSTRACT

The focus of food packaging is to contain food in a cost-effective way that satisfies industry requirements and consumer desires, maintains food safety and minimizes environmental impact. Currently, with the increasing demand of the consumers the major concern of food packaging industry is on efficiency of the plant process, productivity, quality as well as safety. It becomes necessary for companies to discover ways to improve their productivity in terms of maintaining safety, using sustainable materials in packaging, implementing flexible and standardized technology, and maintaining good quality of foods. Thus, to achieve the required demands, automation and upgradation of the packaging machinery is necessary and this has been accepted because these changes are robust, flexible, reconfigurable, preserve the quality of the food and are efficient. Due to limitation of feasibility study and research in food packaging, most of the studies focus on trends in food packaging materials (smart packaging). Thus, this review focused on advancement in food packaging machines, involvement of softwares in controlling the working of various machines for example open modular architecture control (OMAC), Programmable Logic Controller (PLC), Field bus Technology etc. The automated machines include drive system, sensors, actuators etc. So, the knowledge about these techniques will result in enhancing the efficiency of packaging and productivity of food products.

KEY WORDS

Food packaging; automation; sensors; robotics; printing and labeling

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INTRODUCTION

Packaging refers to the technology and material for enclosing or protecting products for distribution, storage, sale, and use [1]. The principal functions of food packaging are to protect food products from external contamination as well as from damage and to provide consumers with ingredient and nutritional information [2]. This function involves retarding deterioration, extending shelf life, and maintaining the quality and safety of packaged food. Packaging protects food from environmental influences such as heat, light, moisture, oxygen, pressure, spurious odours, microorganisms, insects, dirt and dust particles, gaseous emissions, etc. Secondary functions are increasing importance of packaging include traceability, tamper indication and portion control [3].

Materials that have been traditionally used in food packaging include glass, metals (aluminium, foils and laminates, tinplate, and tin-free steel), paper and paperboards, and plastics [4]. Papers and clothes are flexible, lightweight, and less waste to discard packaging materials. Glass and metals have been used for high-value products and are corrosion resistant and stronger, respectively. Plastics possess many desirable characteristics like softness, transparency, heat seal ability and good strength to weight ratio [5]. The most commonly used plastics in packaging industry are based on petro chemical products such as polyethylene terephthalate (PET), poly vinyl chloride (PVC), polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyamide.

The goal of food packaging is to contain food in a cost-effective way that satisfies industry requirements and consumer desires, maintains food safety, and minimizes environmental impact. A great deal of automation strategies are constantly being utilized in every phase of processing and packaging [6]. Different types of packaging methods have evolved with need. The packaging of food in modified atmospheres is a well-known and proven method [7].

Packaging machinery involved equipments used for canning, container cleaning, filling and forming, bagging, packing, unpacking, bottling, sealing and placing of lid, inspection and weighing, wrapping, shrink film and heat sealing, case forming, labeling and encoding, palletizing and depalletizing etc. [8]. Recent advances in food packaging are not just to meet the productivity demands but to adopt sophisticated automation, control and monitoring methods and techniques. In general, computer vision systems do not only replace manual inspection, but can also improve their skills. In sort, computer vision systems are powerful tools for the automatic inspection of fruits and vegetables. New trends in beverage packaging are focusing on the structure modification of packaging materials and the development of new active and/or intelligent systems, which can interact with the product or its environment, improving the conservation of beverages, such as wine, juice or beer, customer acceptability, and food security [4].

Numerous types of packaging machine systems comprise the application of robotics, package printing techniques, conventional automation and control tools, open modular architecture control (OMAC) guidelines on automation and control machines include the importance of treatability attribute, paradigm shift with regard to the use of field bus-based automation scenarios. These systems are simple machines appropriately designed by taking account of engineering methods and principles to perform specific process. In the continuation of the same, integrated mechanical structure is developed, controlled by employing dedicated controllers and embedded technology. Programmable Logic Controller (PLC) are seen to be very common type of controllers. The machine includes drive system, sensors, actuators, and also sophisticated and basic mechanisms in order to perform the functional as well as global tasks. In a typical food industry different types of machines are integrated into one production unit called packaging lines [9, 10, 11].

Thus, automation in equipments has reduced the labour cost, time of packaging and enhances the accuracy and efficiency of food products packaging. This review contains details about the technology behind the electronic and computer controlled automated machines, which are now being used for packaging of food products, their working principle and significance as well. In particular, the review covers packaging principles, standards, interfaces, techniques and methods that are currently in use or in development. Recent advances such as non-destructive inspection methods, application of robotics and machineries, software systems and interfaces automation architecture and printing techniques have also been included.

IMPORTANCE OF PACKAGING

In today's modern time, packaging has become an essential and integral part of the food processing and distribution system. Packaging is being considered as the cornerstone of the food processing industry [6]. Worldwide sales of processed food have reached more than \$2 trillion and about 50% of this revenue contributed by packaged foods [10]. There are very few food products that can be harvested, handled, manufactured/processed, distributed or sold without being packaged or packaged only for convenience for e.g. fresh fruits are placed in bags and cartons to facilitate transportation and distribution. Food and beverages are the major commercial packaged product and comprises 55-65% of the \$130 billion value of packaging in the USA [12, 13]. Like food products, food packages also available in many forms, styles and sizes for e.g. bottles, boxes, cartons, pouches, jugs, cups, tubes and many other containers made of different materials like glass, paper, metal and a combination of materials that may be rigid, semi-rigid or flexible. Despite the variety of forms/styles and sizes, all food packages have certain common basic functional characteristics and intended to satisfy one or more of the following functions:

Containment

Products are contained in packages so as to facilitate their convenient moving and handling. This aspect is particularly important for liquids foods and free flowing powders [14].

Protection

Food products have to be protected against a wide scope of hazards that include microbial contamination, physical damage during transit and storage, oxidation and other undesirable loss/gain of moisture. Also, the necessity of temper proof/tamper evident packaging is important, so as to prevent the unauthorized tampering with the contents in between the manufacturer- consumer chain.

Utility

Certain package forms and attachments add value to the product in various ways and make it more attractive to the consumers. Also, the features of easy dispensability of the products and the facility of reclosure of package after partial use of the product are most prominent. Above all a package with higher utility improves the competitive position of a product in the market [15].

Communication

In the modern food market, packages are considered as the silent salesman. Today for a product to be successful, the package must communicate an image of quality, value and desirability to consumer. It should prominently display the brand name, contents, directions for use and other valid useful/relevant information.

Food manufactures commit large investments to design and specify food packages that satisfy these essential functions and are also economical to the manufacture and distributor. The selection of packaging material and package form is carried out carefully to satisfy the product requirement and at

the same time to ensure that the proposed package is falling in line as per marketing requirement and is consent compatible. However a good package design is of little value unless the package manufacturing process is equally effective. The packaging operation must consistently and reliably form, fill, close and seal the packages in an effective manner so that the package is able to perform the basic functions during all phases of distribution, marketing and end usage [16, 15].

In the past, line speeds were relatively slow and most of the packaging operations were under the direct control of human operators. Product inspection was also a manual function using scales/guage/balance and other simple tools. Packages were selected and inspected on random basis. The inspection was done by eye to ensure the package has been filled and labelled correctly, closures were screwed tight and straight, there were no obvious leaks and other appearance aspects of the package. Packages were weighed to check that the product weight falls within the predetermined limits. However certain drawbacks were observed in complying with this system.

DRAWBACK OF TRADITIONAL METHOD AND NEED OF NEWER SYSTEMS

In the old time, the processing speed times were slow as compared to that of the modern times. It is simply impossible for the human eye to effectively evaluate the details of the appearance of a package when several hundreds of packages are processed every minute. Even if the line speed is slow, the repetitive nature of activity causes fatigue and creates problem for inspection by the eye. As a result it was necessary to induce regular breaks/rest periods or accept reduced accuracy towards the end of the day. Both these had their associated demerits and would mean compromising on either production efficiency or quality of product.

Today electronic instrumentation and computerized controls are available to make a wide variety of operational, quality and safety checks at different points on the packaging line. The modern instrumentation is fast enough to inspect every package that passes down the line and are effective even at high line speeds. Items that fail a test are automatically ejected from the line. As a result, a higher level of inspection that is more precise and reliable is achieved with fewer manual activity involved in the process. The information obtained from sensors can be automatically plotted on statistical process control (SPC) charts to determine whether a system is in control. The same information can be channelled to management information system (MIS). Sensor information can also be fed into programmable logic controllers (PLC's) that can make decisions or issue instructions to adjust the operations of packaging machinery. Moreover sensors for e.g. metal detectors are now available to make checks that could not be conducted by human operations [17]. These devices examine the interior of the package to detect unwanted metal pieces or traces in the food product. The human eye obviously cannot see to inside the packages. The information from sensor device is relayed to the control unit which rejects packages containing metals and thus ensure the quality and safety of food products [18, 19].

DIFFERENT AUTOMATED SYSTEMS

Rising labor cost, health and safety issues lead to the application of robot and automation in food processing and packaging. The need to automate food processing and packaging activities is driven by several key requirements as for competitive success and in some industries, viability of manufacturing plants [20]. The advent of machineries, robotics, and automation technology has driven down the overall cost of processed food versus original food products [10].

The main advantages of automation are to improve productivity, product quality and profitability [20]. In an automated system, several machine types are integrated into a single packaging line. Some of the machine types are cartooning, wrapping, labelling, shrink, sealing, tray forming, capping, drying and cooling, feeding, palletizing and depalletising, picker and placing (robotic systems), cleaning and sterilizing machines, in addition to inspection and detecting machines. According to the Organization for Machine Automation and Control (OMAC), the number of packaging machine types employed in a packaging line ranges from two to ten [6, 21] (Figure 1).

The Automatic Cartooning Machine

Cartooning machines are used in the food products industry for a wide variety of packaging applications. A cartoner is a packaging machine system that assembles individual products, assembles a fiber board carton, collates the products, packs the products into the carton, then seals the flaps of the carton by folding, locking, taping, or gluing the end. It is very well used for different food products and it can be in different forms like blisters, tubes, bottle and packing into square box. They are also configurable to various sizes of boxes. The machine could be ventricle type with multiple functions and may require a short time to change mould. The machine can also be an intermittent horizontal cartoner that automatically can open and fold cartons. It is characterized by in-feed products and can insert leaflet into the cartons [22].

Pouchmaster™ XII (About Packaging Robotics Inc, USA) machine has four-station-system designed to open barrier material, premade pouches and bags of many types and sizes, including Tyvek and foils (Figure 2). This four Station PLC controlled system allows ergonomic manual product loading and integration to automatic product fillers. It can accommodate widths up to twelve inches, or multiples thereof. The rotary manipulator is a cam-driven device that moves four, custom-designed, vacuum plates around

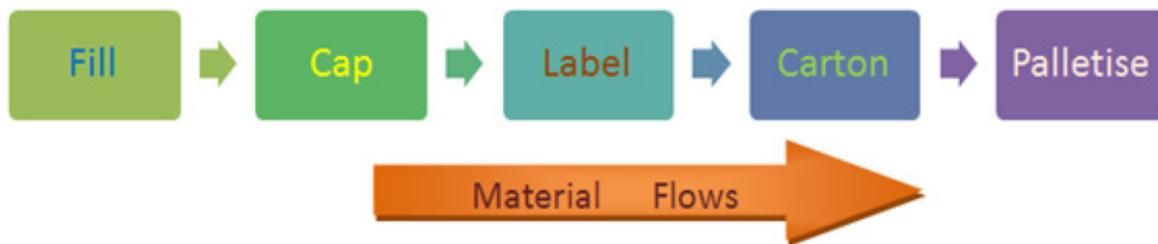


Fig. 1: Typical Packaging Line Arrangement.

its axis. Strategically positioned suction cups pick-up pouches from a preloaded magazine and rotate them to the appropriate work station. There, a modular, remote arm, fitted with another vacuum plate, opens the pouch. Product is deposited and the cycle repeats, automatically [23].

Wrapping and Sealing Machines

Among the specialized plastic packaging systems, shrink packaging or commonly known as shrink wrapping and stretch wrapping are very common and widely used. Though there are some similarities in both wrapping system, but overall they are considered to be different in terms of material and operation. In the case of shrink wrapping, shrink film is used as the basic material and heat forms an important part of the operation, whereas, in the case of stretch wrapping, stretch film is used as the basic material and no heat is applied during the operation. Major steps in shrink wrapping are wrapping, sealing, shrinking and cooling whereas wrapping and sealing are the main steps involved in stretch wrapping. These wrapping systems are mainly used for unitization, but sometime they are also being used as primary packaging system. Both the systems are used for bulk packaging as well as retail packaging. Polyethylene, polypropylene and

poly vinyl chloride are the most common plastic materials used for wrapping of food products.

Now a day, fully automated stretch wrapping equipment (Figure 3) offers numerous advantages such as structural integrity, flexibility, reliability and performance [22]. In those machines multiple bottles are bundled together and shrink-wrapped. The solid state relays allow fast switching of heaters that enable accurate control of the process temperature thus maintaining an even shrink of the plastic wrap. Solid state solutions allow frequent switching without affecting the lifetime of the switch, unlike mechanical contactors. In order to verify that the shrink-wrap has been added, a clear object sensor is positioned to focus at the level of the bottle necks. If the shrink-wrap is present, the clear object sensor will have a continuous output as the package passes by diffuse reflective photoelectric sensors. Other applications include automatic continuous processes of thermoforming, filling and sealing. A wide variety of solutions, starting from just solid state switching of heaters to more sophisticated solutions that apart from the switching function integrate monitoring features that are able to detect load and system malfunctions to guarantee a reliable thermal process [24, 25].

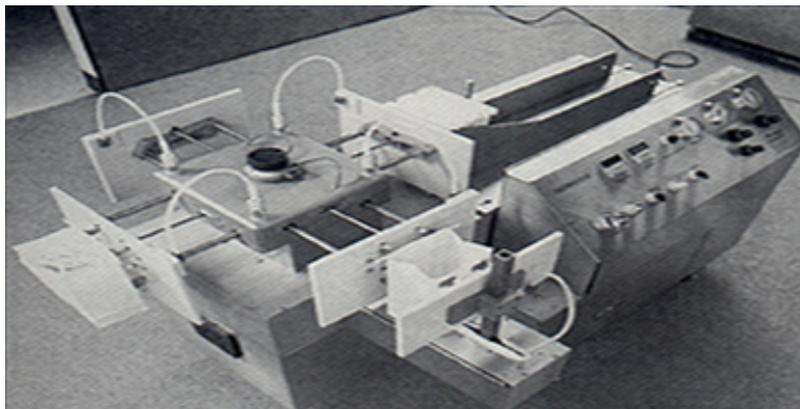


Fig. 2: Pouchmaster™ XII with four-station-system.

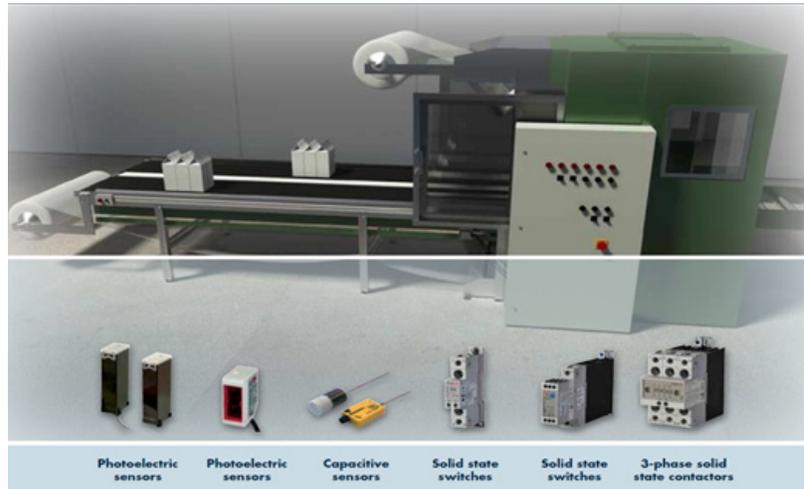


Fig. 3: Automatic wrapping and sealing machine with different sensors.

Automated Filling Systems

Automated thermo form-fill-seal machines allow meat, poultry, cheese and many other food products to create skin-tight packaging inline. Roll-fed films capable of shrinking up to 40% form the bottom web. Once the product is loaded, the top web is applied and sealed. The package is then shape-cut and passed through a steam shrink tunnel, activating the unique properties of the film to render the final customised look [26].

In a bottling line the equipments having ultrasonic sensors (Figure 4) are used to verify that the appropriate level of the product is in the container either it is liquid or solid before it is sealed and shipped. The levels of solid materials, such as ground coffee, coffee beans or flour, are accurately detected using photoelectric sensors. Also, there are sensors for the fast mounting and space saving in the bottle. For accurate control of the filling process, sensors provide an output signal when the product is at appropriate fill level [24, 25].

Capping Machines

Now days, manual, semi-automatic and fully automatic capping machines are used in the packaging. Capping of rigid containers with premade threaded caps are most common as they are applied to most plastic and glass bottles and jars in food and beverage industry [22]. There are limitations to use of inline spindle type capping machines targeted for large caps with diameters greater than 80 mm. To verify that a bottle cap is present on the bottle, a fiber optic amplifier with a fiber optic cable and lens are positioned above the bottles and programmed to detect any reflection from the bottle cap [25]. Initially, the detection of proper capping and communication between the consecutive levels of packaging viz. between capping and labelling was through the hardwired optical fibres only (Figure 5a) but now the whole packaging line including capping has been automated (Figure 5b) and the communication is being done through the upgraded softwares like Field bus technology etc.



Fig. 4: Automatic filling machine with different sensors.

Drying Machine

Drying machine is used for drying materials with certain humidity and the machine is operable for continuously extracting moisture or dehydrating food. Heat is applied to the food by heating element situated below the food trays. Dampers are located at the air inlet and air exhaust ducts, which is monitored and regulated by temperature as well as moisture sensors for maintaining a predefined condition to extract the moisture content of the food to a desirable level. Cooling is carried out in a similar way [22].

Inspection and Detecting Machines

Inspection and detecting machines are used for providing safe food, product quality control, statistical validity, closed loop control of upstream processes and reduced labour cost [27]. The items that are meant for inspection are nuts, bolts, broken glasses, gloves, earplugs, hairnets, jewellery, wood splinters, plastic tote lining, belting and so on. Images are captured and product analyzed for even colour, size, shape, mass flow rate and many other process related variables and parameters. The inspected data are then transmitted to a control for historical record, tracking purposes and other upstream

process control applications. Usually three methods are applied: Camera with infrared signalling, laser technique and X-ray method. Camera-based system sees what people see, laser sees translucency of materials plus reflected energy and X-ray method adopts density measurement to find out the foreign materials mentioned above. Laser-based method is excellent for many foreign objects and ideal in combination with camera technology whereas X-ray usually applied at post packaging interfaces. Optical inspections are fast, non-destructive and non-invasive. They do not require sample preparation and are suitable for online applications. They are able to scan materials regardless of colour, transparency; print, surface finish, porosity and can detect location and are applicable to all stages of packaging process [28, 22]. Beam sensors are most common to detect the presence of the bottles in bottling lines that have darker or less transparent bottles. The stainless steel sensors present in this automated machine to detect all colors on the objects in the same distance from the sensor (Figure 6). In some confectionery applications, it is necessary to detect uniformity of cake decoration. The diffuse sensor recognizes the coloured decoration on the top of the cake [25].

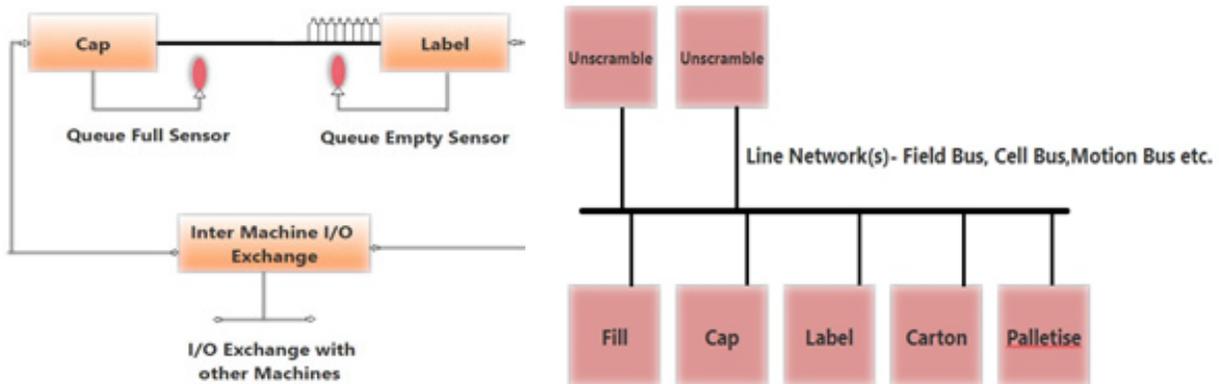


Fig. 5: Inter machine communication via (a) hardwired I/O (b) network.

Metal Detectors

Metals can find their way into a food product accidentally in several ways. Metallic Contamination in foods may in the form of metal tugs, lead shots in meat, hooks in fish, field machinery parts in vegetables, personal effects of workers as buttons, jewellery, coins and keys. In addition to these tools, wire scraps, metal shavings etc. may be left behind by the maintenance workers and metal fragments from broken screens in milling or mixing operations or from worn out parts of the machine may also cause contamination. Metal items may even deliberately be induced with an intention to contaminate the product [29, 30].

However no matter what the source of metallic contamination be, it is critical that every package that improperly contains metals be identified and rejected before it reaches the consumers. Depending on the source of metallic contamination a food package may contain copper, aluminium, lead, iron and stainless steel. Metal detectors using a three coil arrangement can detect even small pieces of stainless steel and non-ferrous metals. The three coils may be arranged in various ways. For packaging inspection the encircling coil arrangement is commonly used.

The three parallel coils are wound on an electrically insulated frame. The middle coil i.e. transmitter is energized by a high frequency oscillator and generates an inductive field. In turn, the field induces a voltage in the outer coils i.e. the receivers. If the receiver coils are same in size and are parallel to each other, the voltages will be equal. If the receivers are arranged in opposition, they will cancel out the voltages and shall give a null output (Figure 7). Then if a metal piece passes through the coils, it shall alter the shape of the electromagnetic field, thus changing the voltages generated in the receive coils. This extremely sensitive coil arrangement is mounted inside a metal case for protection against stray voltages or external inductive fields that may be generated by the nearby machinery. The metal case also provides strength and rigidity to the entire assembly.

Another arrangement may be used to detect especially ferrous metals (Figure 8). This uses powerful magnets to create stationary magnetic field. When a piece of ferrous metal moves through the field, cutting the lines of magnetic force, a current is induced in the particle that creates a second magnetic field which moves along with the particle. The lines of magnetic force from this secondary coil

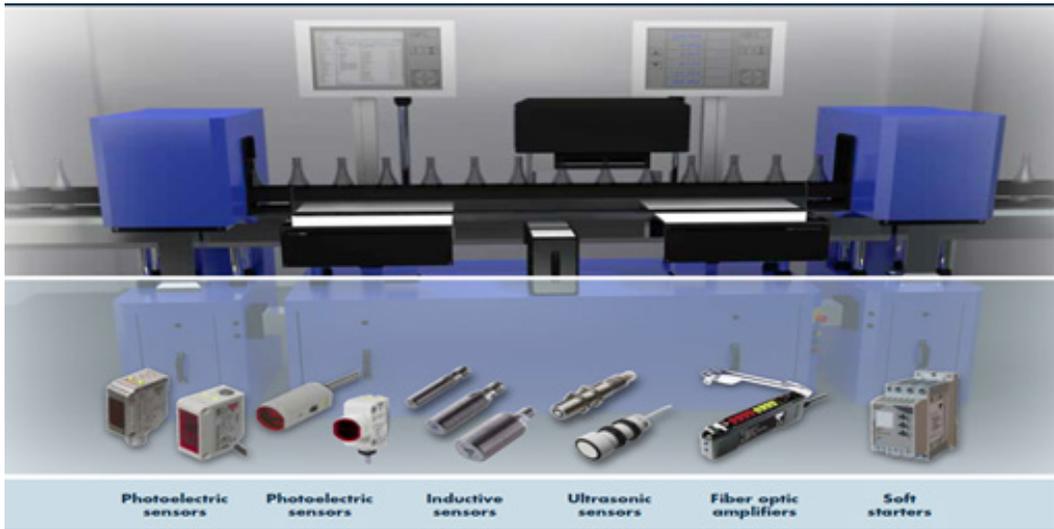


Fig. 6: Automatic inspecting machine with different sensors.

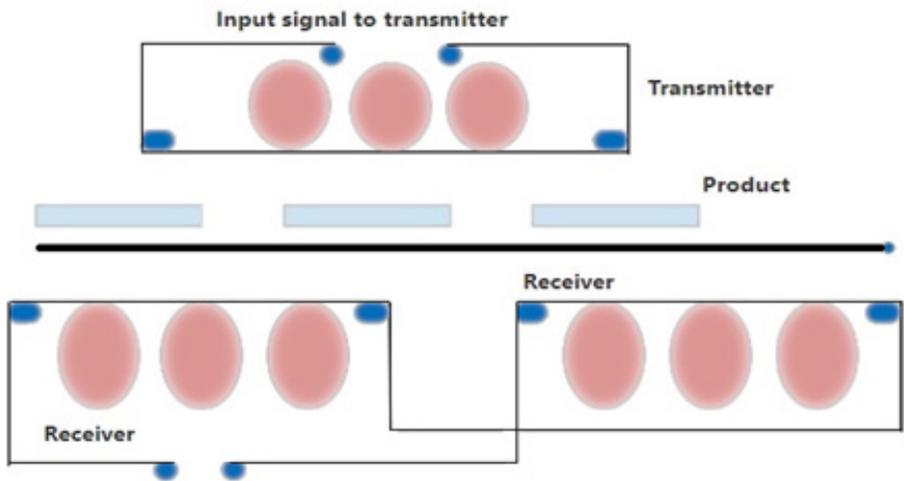


Fig. 7: Architecture of metal detection line.

cut across the detector coil and a voltage is induced in the coil, indicating the presence of ferrous metal. However this arrangement works only on ferrous metals and has no ability to detect even large pieces of non-magnetic materials. The factors that influence the detector sensitivity include belt speed, size of metal fragments, size of detector aperture, frequency of input signal to the transmitter and presence of certain food products that conduct electricity and appear similar to metal to the detector. All these factors should be given due consideration to ensure proper functioning of the detector.

Check Weighers

Automatic in-line check weighers are used to perform basic weight inspection of packages and are used to ensure that a packaging operation is meeting the desired targets. The equipment consists of a weigh platform, conveyors, electronic and a reject device. The weigh platform is the key component. Each package is individually weighed over the weigh platform as it passes through it on to the conveyor. Strain gauge load cells are commonly used and the strain value measured is electronically converted to determine the weight of the package. Packages weighing less than the set value are rejected from the line. Apart from this basic operation of

weighing and sorting out underweight packages, the check weighers with computer controls can also scan the Barcode on incoming packages to identify the contents and intended weight [17, 31].

Machine Vision

These systems are available to perform several inspection and verification tasks. The equipment consists of a digitizing camera and a computer with software to analyze and evaluate the data from the camera. Packages that fail to fulfil any one or more of the pre-set requirements are rejected under the control of the computer. The system can also scan labels to determine that the correct has been applied and can also verify the proper forms, colors, logo and other symbols at the same time.

Vision systems also check whether a label has been applied properly. The system identifies two or more points on the label and compared the positions relative to each other and with a standard pre-set in the computer. If the location of any one or more points falls outside allowable range, the package is rejected. These systems are also used to provide information needed to control the machine operations. Today computers and imaging equipments are available to perform these complex operations quickly and reliably and examine packages passing

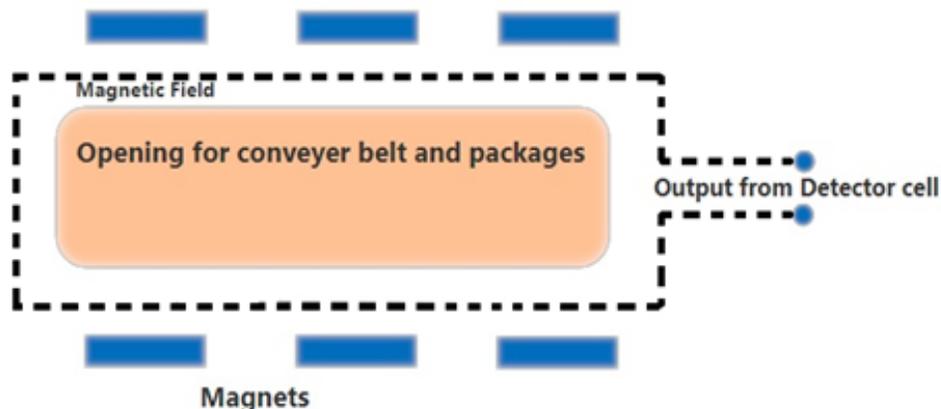


Fig. 8: Magnetic detection line.

at speeds as high as 2000 packages per minute i.e. 0.03 s per package and the human eye is simply not capable of inspecting at the same rate [32].

Leak Testing

Leaks can occur in any type of package. It has been observed that flexible packages are more susceptible to leaks than rigid sealed packages. Packages can leak due to pinholes, cracks, punctures, incomplete or inadequate seals and other manufacturing flaws. Any of these flaws can allow entry of external moisture, oxygen or other contaminants in the package or the product. The moisture necessary for the product may in some cases be lost thus causing the contents to dry out and at times excess moisture can cause quality problems. Ultimately these factors result in decline in product quality and shortening of shelf life. Leak tests are being increasingly used by manufacturers to protect product quality by preventing packages with leaks from being sent to the market. To accommodate various container specifications, line speed, handling and test sensitivity requirements, systems are available in configurations including linear leak testing and continuous motion leak testing in empty and filled containers [33, 34].

Leak Testing of Empty Containers

A simple leak testing system consists of pressurizing the container and then monitoring the resulting pressure to detect changes that indicate a leak. But this system is sensitive towards a pressure change from any cause and cannot differentiate between a pressure drop due to a leak or due to an increase in the volume of the container (Figure 9). The system can be made more precise and reliable by providing a fixed time interval for stabilization after pressurizing the container by a predetermined amount of air. The rate of pressure change is then measured by a sensitive electronic device. If the rate of pressure change exceeds a pre-set standard the

interpretation is that the container possesses a leak and is hence rejected. Multiple head testers can be used in an in-line or rotary arrangement to handle high line speeds [35].

The modern packaging line makes use of many other sensors and detectors including various types of location sensors or switches that are activated by completion or disruption of a light beam. Proximate sensors are used to initiate or terminate actions on individual machines as controlling the flow of empty containers into an in-line filling machine. Other switches also determine whether there is so space for a machine to send a processed package down the line to another machine and also to determine if a machine should be activated to process a waiting package. Controls can also be configured and used to count the number of items placed in a package or number of completed primary food packages placed into secondary or tertiary containers for transportation. The fact is that the typical packaging machine has been converted into a serial of mailer machines that work as directed by the computer. Thus the flow of materials, packages and products is controlled and individual machines are monitored to ensure that assembly of equipments operates in an effective and efficient manner.

Leak Testing of Filled Containers

These equipments are more sophisticated due to the wide variance in product weight, volume, viscosity, moisture content and other physical characteristics. Here the filled container is sealed inside a chamber and the surrounding pressure is either increased or lowered thus creating a differential pressure between the inside and outside of the sealed container (Figure 10). After a certain stabilization time period, the change in pressure is monitored. In case the rate of change of pressure exceeds the allowable limits, a signal is generated that confirms that the container possess a leak and has to be rejected.

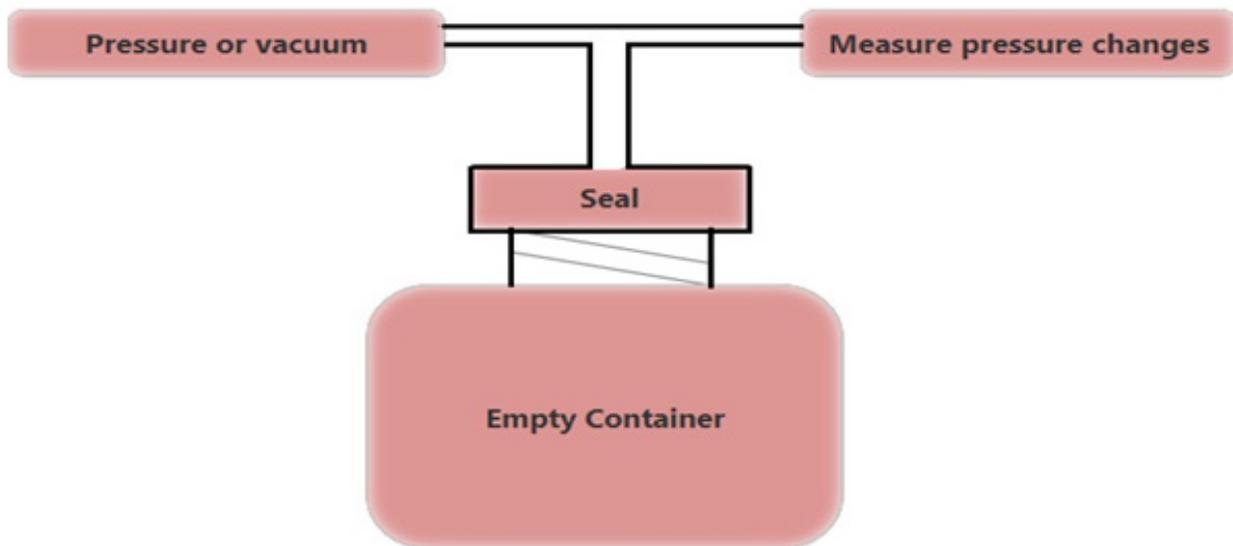


Fig. 9: Leak detection in empty container.

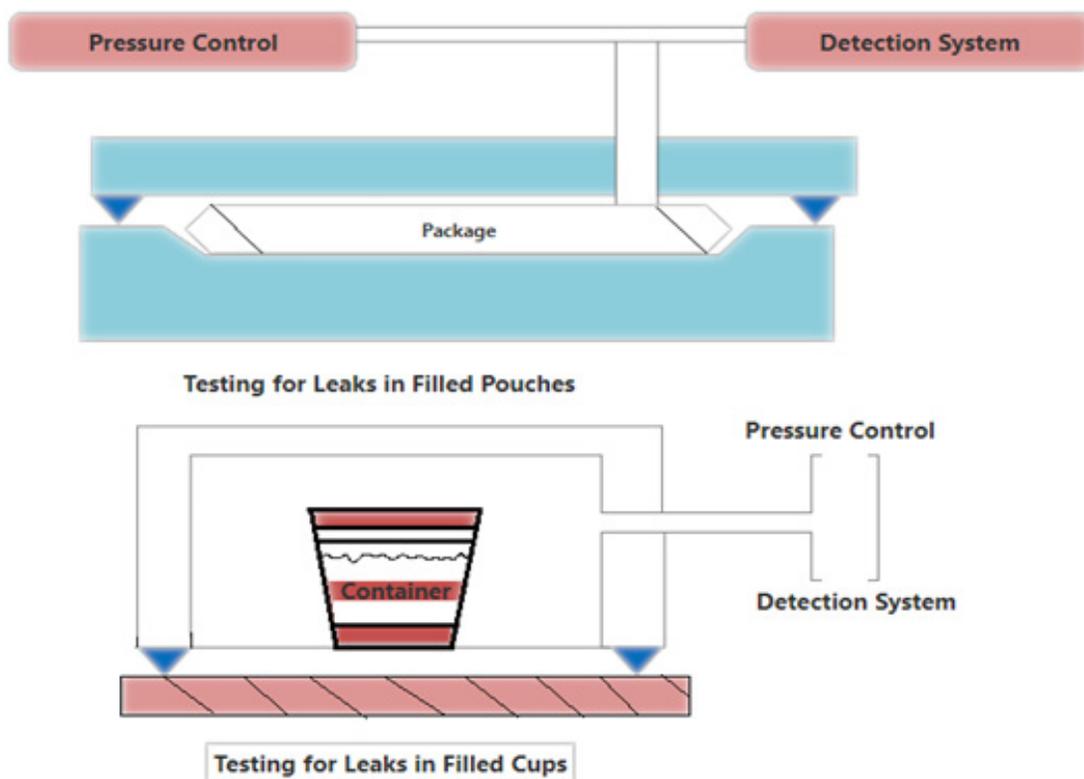


Fig. 10: Leak detection in filled container.

APPLICATION OF ROBOTICS IN FOOD PACKAGING

Agriculture and food processing are still a minor application area for industrial robots. It is due to the fact that the progress on research and development of robotic systems for such applications was not significant. However, the research and development in this area is exponentially growing day by day to make processes easier, improves productivity, reduces scarcity of labour problem, easy incorporation of traceability information [36].

Mechatronics plays an important role for the development of robots which have potential application in automation of food packaging. Robotic applications tend to lend automatic and efficient multiple points processing and packaging lines. Typically, the end-of-line robotic systems are large in size however delta-style systems resembling an upside-down-spider have been in use recently for smaller pick-and-place applications. Higher cost and lower productivity of conventional techniques are leading towards increased application of robots in the food sector [37, 38]. Robotic system can pack meat and chocolates into the trays faster. FANUC robotics, Inc. has developed several models of pick-and-place articulated robot for the food industry that meet stringent hygiene requirements. The exterior design is smooth with no dark/damp regions for contaminants or microorganisms. The robot comprises of several arms called kinematic chains linking their base to mobile parts. Some robotic system can handle 300 parts a minute and attain accelerations of 200 m per square second with loads of two kilograms [10].

The main applications of robotics are in the processes like palletization, shorting, sequencing, routing, and pick-placing in food processing industries. Traditionally, palletizaion was based on row forming, where a row of cases was pushed forward until the layer is completed. Row-forming machines are still the most popular in the market but in the

mid-seventies in-line palletising was introduced. In-line, continuous-motion machines are capable of much higher speeds up to 200 cases per minute. They make up about 40% of the palletising business. Currently, robots are more in use replacing traditional palletisers [22]. Many food processing plants are constantly automating with the palletizing robot due to the demand for increased productivity. The sophisticated control system with a built-in palletizing function makes it possible to load and unload the objects with high precision and accuracy [10]. Robotic palletisers are capable of handling up to four production lines and multiple product types, simultaneously. Further, the compact design of the robotic palletiser makes them ideal for cramped locations and spaces with low ceilings. The machine can provide quality, reliable and high performance palletizer solutions to diversified industries [22]. KUKA Robotics is one of the world's leading manufacturers of industrial robots, with an annual production volume approaching 10,000 units, and an installed base of over 75,000 units. The company's five and six-axis robots range from 3 kg to 570 kg payloads, and 635 mm to 3700 mm reach [10]. Depalletisers provide an efficient means to sort containers from bulk layered pallets onto a conveyor or conveying system. There are essentially two types of depalletiser systems: high level and low level referring to the height at which the pallet is positioned during the unloading process. Some palletisers are equipped with up to more than 4000 slots.

AUTOMATION IN PRINTING

There are two basic printing methods: flex graphic and litho graphic. Rubber plates with a raised image area are conveniently printed with quick-drying inks directly on foil, plastic wrap and other material. Inks typically are made up of colourants, binders and carriers. In the USA, the use of printing inks in food packaging materials is subject

to the laws and regulations administered by the Food and Drug Administration (FDA). The regulation requires that the ink materials be manufactured under good manufacturing practices and should be safe. High quality inks and varnishes should have many technical expectations including specific resistance, fastness, safety and environmental requirements. The flexography process is good for milk cartons, food cartons, as well as candy wrappers. Although, flexography is very efficient, it has certain limitations. Litho printing method permits reproduction and printing of finer screen rulings and photographic images. The machines are equipped with UV lamps between printing units for fast ink curing which enables high-quality and high-speed printing on PE coated board. UV-curing is a drying process which occurs when the inks are exposed to intense UV-light. Literally, UV curable inks offer environmental and quality advantages including increased abrasion and chemical resistance properties. They are also non-flammable, non-toxic and contain no solvents. Solvent reduction and improved print quality continue to be key driving factors. On the other hand, Electron Beam is a good method of printing [39]. It facilitates drying inks, coatings and

adhesives without heat or light. In this technology, the heated filaments emit electrons which are then accelerated using high voltage focusing technique. Later electrons pass through the window foil and strike the product to be printed and the electrons cause molecular change in the product [22].

Automatic Labelling Machines

Food labelling is a useful source of information, primarily to inform and protect consumers. The government food standards agencies look it very seriously. Automatic labelling machines are a kind of stamping machine and are very simple in nature. Once the package arrives at the station it pastes the label based on a previously designed label. Labelling speed is automatically synchronised with conveyor speed to ensure quality labelling. A fiber optic amplifier is used to detect the presence of a mark on a bottleneck label, which confirms that the bottle is in correct position for the main label to be applied. These sensors also detect the presence of security bands which are required on many bottles and containers. They recognize the difference between the security band and bottle cap. The fiber amplifier is compact and highly intuitive



Fig. 11: Automatic labelling machine with different sensors.

for easy setup. It is equipped with two 4-digit LED displays for clear and concise reading. An adjustable signal level, selectable response time and different timer functions provide full flexibility. The surfaces of the labels are often reflective. The photoelectric proximity sensors provide the necessary sensitivity for maximum reliability. Fork sensors are commonly used to detect labels, marks, holes and edges (Figure 11) [25, 40].

CONCLUSION

Modern packaging machines used sensors to feed information to computerized controllers that issue instructions to various machine parts. The individual machines are organized into systems to exchange information and receive instructions from a central computerized controller. Metal detectors, vision systems, check weighers and leak detection systems are used to inspect every package that goes down the line. Due to high line speeds the inspection equipment must rely on computers to interpret data and make decisions to reject faulty packages, as the human vision and other sensors cannot react that fast. The future scenario holds in store more applications of electronic sensors and computerized controls to individual machines and to organize these machines into integrated accessories that function in a fashion similar to a single large machine.

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