Packaging is by far the most technically and financially demanding area of any brewery’s operations. A missed step in financial planning, brewing, bottling, or marketing can spell disaster for the brewery. However, in most areas, bottled or canned beer accounts for more than 80% of the market and affords the largest access to customers. This chapter explores some of the aspects involved in developing a successful packaging operation, including pricing and cost analysis, selection of equipment, and brewery and filling operations for smaller breweries.

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Beer Packaging, Second Edition is published by the Master Brewers Association of the Americas and is the most comprehensive book ever on the beer packaging process.

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CHOOSING A FILLER

Once it is established that the packaged beer can be profitable at the set price, brewers should review the filling equipment that suits their needs and provides the quality of product that ensures success. After reviewing equipment, brewers may find that they need to adjust the cost estimate for the equipment and make changes accordingly. In the brewing industry, quality bottling means a bottling process that provides the best sanitation, gentle and nonturbulent filling, and little to no air pickup in the product during bottling. As with any sized filler, air pickup is by far the most critical issue affecting quality control and shelf life, and it is the main factor determining the freshness date of bottled beer.

Oxygen in beer causes it to go stale and develop an oxidized (cardboard) character. The less oxygen in the finished bottle, the longer the product’s shelf life is and the longer the beer remains fresh. In many cases, process changes in the brewery are necessary to minimize the presence of oxygen in the beer before it ever gets to the bottling machine. In the brewery, valves, filters, pumps, and the simple action of just moving the beer are common sources and causes for oxygen intake into the beer. Keeping all brewing equipment in good condition and replacing seals and parts associated with filters and tank transfers can reduce this problem. On the bottling machines, air can enter the product at several points on the line, from the pressure bowl on top of the filler to the point where the beer is foamed just before crowning. Not all bottling machines use pressure bowls, but for those that do, brewers must make certain that the bowl’s headspace is properly flushed and filled with carbon dioxide (CO2) and that the seals and valves are all in good condition.

By far, the biggest pickup point for unwanted air is the crowning station. To produce finished bottles that contain little air, the machine must have some mechanism that causes the beer to foam just before applying the crown. This foaming releases CO2 from the beer, which displaces air from the neck of the bottle. Just as the foam mushrooms over the top of the bottle, the bottle is crowned. Several mechanisms are used to cause the beer to foam, from pressure changes at the filling station to “knockers” that hit the side of the bottle with a small hammer to high-pressure jets that stream warm water into the beer just before bottles are crowned. Regardless of how the beer is foamed, this is an essential step for controlling the amount of air or oxygen in the finished package.

Basically, two types of filling heads are used on beer filling machines, a short tube or a long tube. The first kind of filling tube is very short and sticks into the bottle only a short distance. When this tube is used, the beer flows over a small hat-shaped piece that directs the flow onto the inner sides of the bottle so that the beer is delivered more gently than it would be by pouring the beer directly from the small tube. The deflected flow also prevents the beer from splashing. However, this type of filler spreads the beer into a thin moving layer, which allows maximum exposure of the product to any air present in the bottle. To avoid excessively high air pickup in the product, short-tube filling machines need to have at least one, if not two, pre-evacuation stages. During each evacuation stage, a vacuum is applied to draw out the air within the bottle, and then the vacuum is stopped and the air is replaced with CO2. If the pre-evacuation process is repeated again before the bottle undergoes counterpressure and is filled with beer, the air content in the bottle will be low enough to produce acceptable levels of air in the finished bottle.

Long-tube fillers (Fig. 11.1) have tubes that extend nearly to the bottom of the bottle and fill from the bottom of the bottle up. This configuration exposes far less of the beer to the atmosphere in the bottle and causes less product turbulence and agitation, which in turn results in less air pickup during filling. Just as with short-tube filling machines, long-tube fillers are available with pre-evacuation capability. Regardless of filling type, it is critical to foam the beer after filling and just before crowning because, as with the short-tube fillers, this displaces any remaining air from the neck of the bottle at the time of sealing. Generally, a 12-oz. (355-mL) bottle
of beer containing less than 0.5 mL of headspace air has adequate shelf life for most local distribution scenarios.

Bottle conditioning or retaining a small amount of yeast in the beer can help reduce oxygen content quickly and extend shelf life. Also available are crowns with oxygen-scavenging liners, which absorb oxygen in the beer headspace, and oxygen barrier crown liners, which can help keep oxygen from entering the crowned package. Brewers should be aware that some of these liners "scalp" or absorb hop aroma compounds.

Another issue, which is often forgotten but very important to beer quality and operating costs, are filler cleaning requirements. Like any other piece of equipment used in the brewery, the filler has its requirements for cleaning and sanitation. Due to its complexity and moving parts and valves, bottle-filling machines, regardless of size, require much more rigorous cleaning regimens than other pieces of packaging equipment. Machines with pressure bowls must have not only the contact surfaces of the bowl cleaned but also the valves and seals used for each filling station.

These machines require a good cleaning-in-place (CIP) system to remove beer residues and mineral stone buildup and to sanitize prior to use. Also, machines using pressure bowls require periodic maintenance of valves, seals, and conveyors. Some smaller machines with computer controls are able to manage bottling and bright tank pressures using a manifold, eliminating the need for the pressure bowl. The manifold (Fig. 11.2) has several advantages from a cleaning, maintenance, moving parts, and cost of operation standpoint. Regular maintenance, replacement of consumable parts, and repairs should be factored into any evaluation of overall machinery and operating costs.

**FIGURE 11.2.** Manifold for a small filler collects beer from the supply hose and delivers it to six filling heads. (Courtesy Meheen Manufacturing Inc.)

**BREWERY BOTTLING OPERATIONS**

In small or large packaging operations, whether bottling or canning, the beer needs to be in proper condition to be packaged. This means that the beer is essentially cold and carbonated to an appropriate level for the package that it will be going into. For most applications, the temperature is appropriate when it is near freezing or 32°F (0°C) and the beer is contained in a bright tank that has refrigeration and can maintain pressure. There are also factors of conditioning that come into play and will affect the way the beer is packaged. Factors such as how the beer is carbonated and how it is conditioned or stored can have an effect on the CO2 staying in solution during the filling process and how it foams.

Several factors come into play for conditioning the beer and preparing it for the packaging process. Among these factors are how the beer is force carbonated, i.e., slow-step carbonation that produces smaller bubbles or rapid carbonation that tends to produce larger bubbles, flushing out and reducing hop aromas, head foam potential, and less-stable CO2 in solution. Another factor is temperature. The glycol system chilling the bright beer tank and conditioning it for packaging should generally be set around 30°F (–1°C). A glycol temperature that is too cold (below 28°F [–2°C]) can cause freezing and thawing of the beer, which when dispensed to the filler can cause gushing and foam control problems. So for the best results, carbonation should take place with the glycol system set for just below freezing, the bright tank set at 32°F (0°C), and a good quality CO2 stone. Using a slow-step process to achieve small bubbles and good absorption with minimum pass-through and venting of the CO2 from the tank will achieve better CO2 saturation and reduce the loss of beer aromas.

Brewery operations and beer handling can greatly affect the quality and presentation of bottled beer. In the brewery, the two critical factors affecting product quality are, again, air pickup and CO2 levels. Air pickup in beer before it reaches the filler most often comes from transfer and filtering operations. One source of air pickup is the centrifugal pumps used to move and filter beer. Centrifugal pumps work by bringing the beer in through the center of the pump housing and then slinging it toward the outside of the pump housing. This creates a low-pressure area at the center of the pump, which can allow air to be drawn in through loose pump inlet connections or a faulty shaft seal and drive it into the beer.

Any time beer is moved, brewers run the risk of the product picking up air. To minimize air pickup in the brewery, good seals should always be maintained in all valves, pumps, and filters and beer should not be moved
more than necessary. To help displace air that may have been picked up during transfer and filtering operations, brewers can perform final carbonation in the bright tank before sending it to the filler. Light CO2 flushing helps to displace the air and ensures that CO2 levels are where they should be; however, brewers should be aware that flushing also carries away hop aromas and reduces the head foam potential of the final beer.

Once a brewery has product on store shelves, customers expect that each bottle of that brewery’s beer they purchase will be identical to the last. To achieve this consistency, CO2 levels must be consistent at all times. CO2 is a major component of mouthfeel and provides some bite to the beer, which affects its flavor. The importance of consistent CO2 levels cannot be stressed enough. The importance of CO2 to product flavor can be seen in cola. If the CO2 was removed from one can of cola and it was compared with a can of carbonated cola served at the same temperature, the noncarbonated cola would taste excessively sweet compared with the carbonated cola. CO2 in beer serves much the same function, and if the CO2 levels in beer change from batch to batch, the product’s taste will change accordingly. To maintain consistency in CO2 levels, a strict procedure for carbonating should be adopted in the brewery and followed every time. Of course, part of the carbonation formula depends upon maintaining a consistent beer temperature. So for the brewery to be successful, the cooling system must work properly and hold a consistent temperature.

**Beer-Filling Operations**

Before any filling can take place, the packaging equipment needs to be thoroughly cleaned and sanitized to avoid any nonbiological or microbial contamination of the finished package. Any surfaces that the product will be exposed to must be sanitized. This includes the machine itself and any components that come into contact with the beer. Machines that use a pressure bowl on top are significantly more involved to clean and sanitize than are those utilizing a simple manifold system with the beer supplied by a pressurized bright tank with direct hose connections. To this end, the beer only contacts the interior surfaces of the hoses between the bright tank and the bottle itself. Hoses delivering beer to the bottling machine need to be checked periodically for damage and foreign materials and should be replaced as a regular service item. Many different chemicals are available today that can perform these cleaning tasks well, although brewers need to choose which chemicals will work best for them. Bottling machine manufacturers may recommend specific chemicals and cleaning procedures that work best for their equipment. Recommendations from chemical suppliers and other brewers may also help in identifying the best chemicals and procedures for a particular application.

Some small filler machines feature cleaning- and sanitizing-in-place automated functions. To perform a cleaning or sanitizing function, a small submersible pump is connected directly to the beer hose leading to the bottling machine and the cycle is run. The cycle will automatically pulse cleaning or sanitizing solutions through all of the lines, valves, and fittings for a couple of minutes and then automatically stops with a message to let you know the machine is ready for the next cycle. Once this is completed, the beer hose can be connected directly to the bright tank using a sanitary fitting such as a tri-clamp. Pressure in the bright tank is used to dispense beer to the bottling machine. By using CO2 head pressure to push the beer, no pumps are used since these can be a source of air pickup before the beer reaches the bottle. All the clamps connecting the hoses and the connection to the pump inlet should be checked to ensure they are tight. With tri-clamps, this can be achieved by tightening the clamp nut as the clamp hinge is tapped with the back of a channel lock plier or another clamp. All hoses should be packed with water (preferably deaerated) and the water should be pushed out with beer, this eliminates air from
the hoses, and the pump if used, all the way to the filler. Starting procedures vary based on the type of machine used. They are different for machines using a pressure bowl than for those that do not. (Meheen Manufacturing machines, for instance, do not have a pressure bowl but rather use a dispensing tank using headspace pressure to push the beer through a filler manifold [Fig. 11.7]). One element of the starting process, however, is similar regardless of the type of machine used, and that is the need to cool the equipment after cleaning and sanitizing to establish constant flow conditions. Warm equipment warms the beer and causes the CO₂ to come out of suspension and foam, which causes bottle losses. This cooling can be accomplished by pumping cold sanitizing solution through the hoses and manifold and pushing it out with chilled beer. It is important that all the sanitizer is pushed out, and this can be checked by pH and taste.

Machines with pressure bowls take a little longer for the equipment to cool to beer temperature simply because they have more mass and more contact surfaces to cool and typically one or two “bowl dumps” are used. Typically, with smaller manifold-type machines, brewers lose only a few rounds of bottles before the equipment is cooled to the point needed for normal operations.

With counterpressure fillers, when the bottles are pressurized for filling, brewers need to make sure that the pressure is adequate to maintain the level of CO₂ in solution. Because the beer is warming on its way to the bottle, generally the counterpressure in the bottle should be as needed for the beer condition. This means that if the beer contains 2.59 volumes of CO₂ at 32°F (0°C) in the tank and the beer temperature has risen to 34°F (1°C) by the time it reaches the bottle, there should be slightly higher pressure at the bottle to compensate for the increased temperature of the beer. It is easy to estimate the increased pressures required by referring to Table 11.1.

The packaging process for bottling and canning lines should include rinsing of the containers prior to being loaded onto the filling machinery to ensure they are free of dust and foreign materials. Another reason for rinsing is that it provides a wetting film that will help reduce foam during the filling process. Bottle rinsing can be accomplished using several different types of rinsing machines. Twist rinsers are just as the name implies, a set of twisting rails that invert the bottles, rinsing them as they move, and then draining and returning them to the upright position to be placed on the filler. Another more manual type of bottle rinser commonly used by smaller operations involves bottle-handling plates that grab an array of bottles by the necks. The handling plate is placed with the bottles inverted into a rinse tray, where all the bottles are rinsed and drained at the same time (Fig. 11.8). From the rinser, the bottles are manually placed on the bottling machine to be filled.

**FIGURE 11.7.** A filler manifold system supplying valves on a small filler. (Courtesy Meheen Manufacturing Inc.)

**FIGURE 11.8.** Bottle rinse tray to rinse bottles before manual placement on the filler inlet table. (Courtesy Meheen Manufacturing Inc.)
After bottle rinsing, bottles are moved into the filler and filling heads are sealed on the bottle. Prior to filling, most fillers have a pre-evacuation process where atmosphere in the bottle is drawn out by vacuum and then replaced with CO₂ to a pressure level appropriate for the conditions of the beer being poured. Once the pressure is correct in the bottle, the filling will start. Ideally, the pressure in the bottle will be sufficient enough to maintain all the carbonation in solution of the beer, providing a dark pour (no foam or bubbles during filling). On many smaller fillers, beer flow control is accomplished using a tubing pinch valve that effectively pinches a silicone beer hose to start and stop beer flow to the bottle.

Once bottles are full and the filling has stopped, the pressure inside needs to be released in a controlled manner to avoid excess gushing or foaming over. This process is different for different machines. Generally speaking, machines that have the crowning station some distance from the filling position will reduce the pressure from the bottle slowly in a process known as snifting. This is done to ensure the bottle is not foaming over as it travels to the crowner. Once the full bottle reaches the crowner, it is desirable to cause the beer to foam up to displace air from the neck of the bottle. There are several ways of doing this, one of the more common is sending a tiny stream of hot water into the bottle as it enters the crowner. The hot water acts to disturb the CO₂ from solution, causing it to foam. Fillers that have the filling and crowning stations right next to each other can actually have the controls for foaming the beer built into the filling head so that the beer is foaming as it moves to the crowner. Foaming in this case is a rapid release of pressure within the bottle or a pulse to agitate the beer, releasing CO₂ from solution. Crowning on foam is essential to ensure low air and long shelf life regardless of the type of filler.

Crowners on small machines must use some kind of sorter and positioner so that the crown is presented to the crowning head in the correct orientation. A rotary drum sorter with crown guides is shown in Figure 11.9. The crown fits into the crowning head and pneumatic pressure is applied to force the crown onto the bottle and crimp down. A crimp gauge can be used to measure over the crown and check the tightness of the closure (Fig. 11.10). After the bottle is crowned, beer residue is rinsed off the bottle (Fig. 11.11).

**Figure 11.9.** Crown sorter and guides in a small filler. (Courtesy Meheen Manufacturing Inc.)

**Figure 11.10.** Crown crimp gauge. (Courtesy K. Ockert)

**Figure 11.11.** Bottles are rinsed with water postcrowning. (Courtesy Meheen Manufacturing Inc.)
Once a steady flow has been established on the filling line, maintaining the smooth operation of the bottle filler becomes a process of fine-tuning and watching for trouble areas, such as excess foaming; bottle, crown, and label supply; and beer temperature. Tracking the filler’s performance, ensuring proper filling and crowning, and making adjustments as needed keeps the process going. Effective operations also include maintaining a proper supply of bottles, crowns, labels, and case packing of finished products. Each brewery and brewing operation will be different, so when it comes to packaging operations, brewers should be flexible and adaptable (Fig. 11.12).

**FIGURE 11.12.** Typical arrangement for a small-scale bottle filler. Filler is placed in close proximity to the bright beer tank for better control of temperature and flow. (Courtesy Meheen Manufacturing Inc.)