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THE BREWING INDUSTRY LANDSCAPE

Overview

Beer brewing and drinking are social activities that have been part of the human experience seemingly since the dawn of civilization, dating back to the fifth millennium BC, with written historical records from ancient Egypt and Mesopotamia. The oldest written documentation pertaining to beer making can be traced back several thousand years ago, when mankind began to move away from living as nomadic hunter/gatherers and toward settling down in one spot to farm land. Grain, a vital ingredient in beer making, was then cultivated by these new agricultural societies.

Today, beer is one of the oldest beverages humans have ever produced and has spread all over the world. It is a product valued by its physicochemical properties as in its quality and traditional link with culinary and ethnic distinctiveness.

Accordingly, the history of beer brewing is not only one of scientific and technological advancement but also about the tale of people themselves in their self-governance, economy, rites and daily life, aside from encompassing the growing demand of the grain markets.

As almost any cereal containing certain sugars can undergo spontaneous fermentation due to wild yeasts in the air, it is possible that beer-like beverages were independently developed throughout the world soon after a tribe or culture had domesticated cereal. Historical findings in many different parts of the world indicate that beer was in fact produced as far back as 7000 years ago. This discovery reveals one of the earliest known uses of fermentation and is the earliest evidence of brewing to date, which contains the oldest surviving beer recipe, describing the production of beer from barley via bread. Some other records also showed that beer was brewed using barley and other types of grains. Thus, the inventions of bread and beer have been argued to be responsible for humanity's ability to develop technology and build civilization.

During the Neolithic period, beer was mainly brewed on a domestic scale. Women brewers dominated alcohol production on every occupied continent until the commercialization and industrialization of brewing occurred, although by the 7th century AD, beer was also being produced and sold by European monasteries.

During the Industrial Revolution (~18th–19th century), the production of beer moved from artisanal to industrial manufacture. Brewers devised a set of standards for beer and began commonly mass-brewing, rather than home-brewing it, which ceased to be significant by the end of the 19th century. These mass production methods and guidelines quickly spread throughout Europe.

The development and advent of scientific instruments like hydrometers and thermometers also changed the art of brewing by allowing a brewer more control of the process along with greater knowledge of the results.

In North America and many other parts of the world, the brewery market has had some 'disruptive change' in the last five years with the explosion of smaller craft beers currently preferred by millennials. This trend has actually resulted in larger brewery companies (like Anheuser-Busch InBev [AB InBev] and SABMiller) closing their older larger breweries and purchasing their smaller craft competitors.

Today, the global brewing industry is still a thriving business, consisting of several dominant multinational companies and many thousands of smaller microbreweries (smaller than 15 000 U.S. beer barrels) and nano-breweries to regional breweries with a total global production of more than 1.93 billion hector-liters (51 billion U.S. gallons) in 2015.

A CLOSER LOOK AT THE BEER BREWING PROCESS

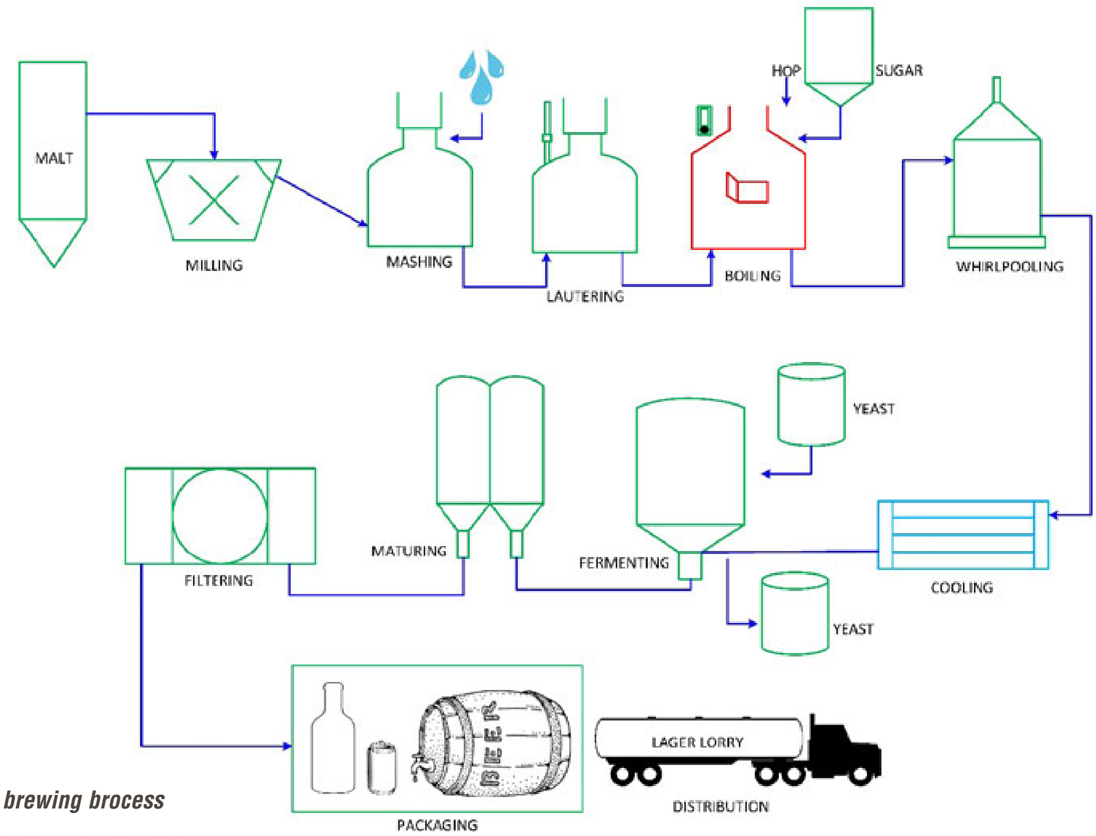


Figure 1:
The beer brewing brocess

Beer is the product of the alcoholic fermentation process by yeast extracts of malted barley. While the chemical reaction between malt and yeast contributes substantially to the distinctive character and flavor of beers, its quality still very much remains a function of the *water* and, more significantly, the *hops* used in its production.

Most of the sugars from which the alcohol is derived in the majority of the world's beers came from the barley starch. It is enclosed in the cell wall and proteins within the barley, and these wrappings are stripped away in the malting process (essentially a limited germination of the barley grains), leaving the starch preserved.

In traditional ale brewing, the beer is mixed with hops, some priming sugars and isinglass finings from the swim bladders of certain fish, which settle out the solids in the cask. In traditional lager brewing, the 'green beer' is matured by several weeks of cold storage prior to filtering.

Today, the majority of beers, both ales and lagers, receives a relatively short conditioning period after fermentation and before filtration. This process is ideally performed at -1°C (30.2°F) for a minimum of three days, under which conditions more proteins drop out of the solution, making the beer less likely to become cloudy in the package or glass. The filtered beer is adjusted to the required carbonation before packaging into cans, kegs, glass or plastic bottles.

Depending on the size of the plant, some of the breweries are equipped with a Waste Water Treatment Plant (WWTP) within their facility, which means that you may have a Diatomaceous Earth (DE, that can be sent to local organic farmers for use as a soil amendment) press system and a Waste Water Digester (WWD) equipment as well.

Mashing

In the brewery, the malted grain must first be milled to produce relatively fine particles, which are for the most part starch. They are then thoroughly mixed with hot water in a process called *mashing*. The quality of water used is of great essence and must possess the right mix of salts, similar to what fine ales are produced from waters with high levels of calcium. Conversely, famous pilsners are from waters with low levels of calcium. A typical mash will be comprised of three parts water to one part of malt and stand at a temperature of around 65°C (149°F). The granules of starch convert from an indigestible granular state into a 'melted' form, which is much more susceptible to enzymatic digestion.

The enzymes which break down the starch are called *amylases*. They are developed during the malting process, but only start to act once the gelatinization of the starch has occurred in the mash tun. Some brewers will have added starch from other sources, such as maize or rice, to supplement that from malt. These other sources are called *adjuncts*.

After perhaps an hour of mashing, the liquid portion of the mash, known as *wort*, is recovered, either by straining through the residual spent grains or filtering through plates. The wort is run to the kettle (sometimes known as the *copper*, even though they are today fabricated from stainless steel) where it is boiled, usually for one hour. Boiling serves various functions, including sterilization of wort, precipitation of proteins (which would otherwise come out of the solution in the finished beer and cause cloudiness), and the driving away of unpleasant grainy characters originating in the barley. Many brewers also add some adjunct sugars at this stage and at least a proportion of their hops.

Hops

The hops have two principal components: *resins* and *essential oils*. The resins (also called *a-acids*) are changed (i.e., isomerized) during boiling to yield iso-a-acids, which provide the bitterness to beer. This process is rather inefficient. Today, hops oils are often extracted with liquefied carbon dioxide and the extract is either added to the kettle or extensively isomerized outside the brewery for addition to the finished beer (thereby avoiding losses due to the tendency of the bitter substance to stick onto yeast).

The oils are responsible for the 'hoppy nose' on beer. They are very volatile, and if the hops are all added at the start of the boil, much of the aroma will be blown up the chimney. In traditional lager brewing, a proportion of the hops is held back and only added toward the end of boiling, which allows the oils to remain in the wort. For obvious reasons, this process is called *late hopping*.

In traditional ale production, a handful of hops is added to the cask at the end of the process, enabling a complex mixture of oils to give a distinctive character to such products. This addition is called *dry hopping*. Liquid carbon dioxide can be used to extract oils as well as resins. These extracts can also be added late in the process to make modifications to a beer's flavor.

After the precipitate produced during boiling has been removed, the hopped wort is cooled and pitched with yeast. There are many strains of brewing yeast; brewers jealously guard their own strains because of their importance in determining brand identity.

Fermentation

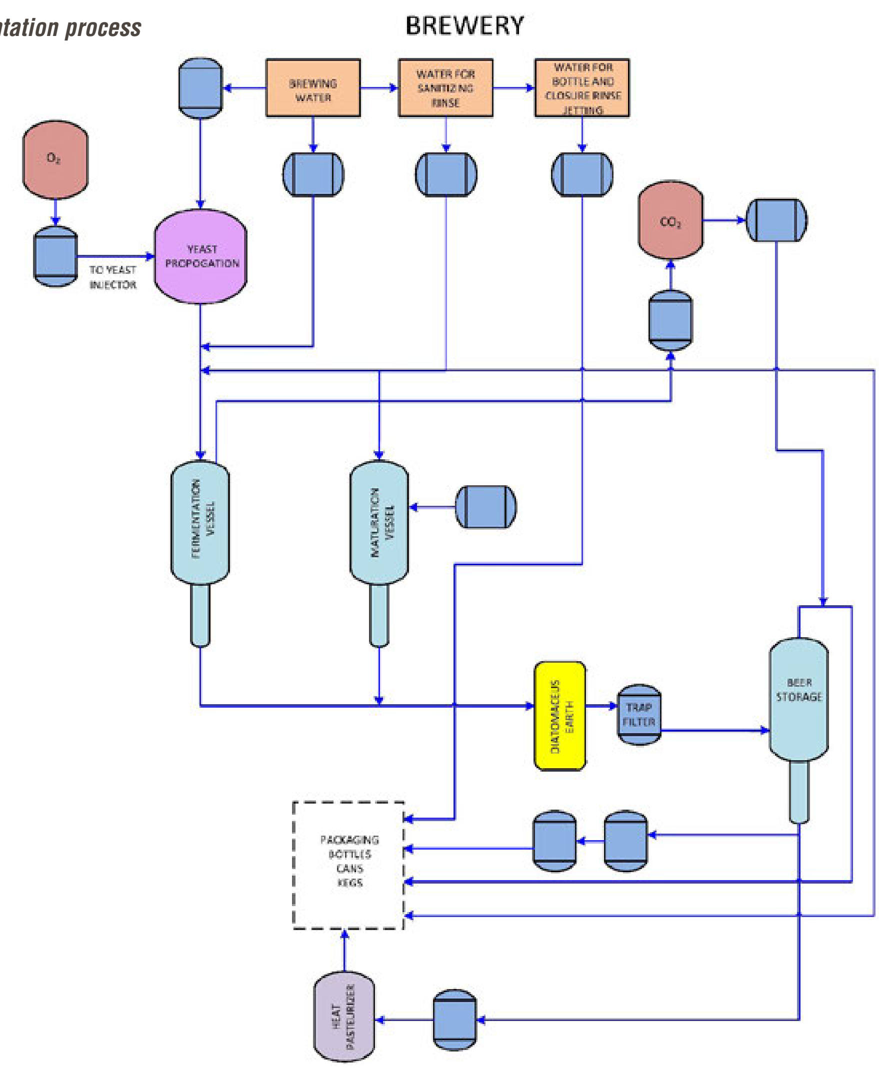
Fundamentally brewing yeast can be divided into *ale* and *lager* strains, the former type collecting at the surface of the fermenting wort and the latter settling to the bottom of a fermentation (although this differentiation is becoming blurred with modern fermenters). Both types need some oxygen to trigger off their metabolism, but otherwise the alcoholic fermentation is anaerobic.

Ale fermentations are usually complete within a few days at temperatures as high as 20°C (68°F), whereas lager fermentations at as low as 6°C (42.8°F) can take several weeks.

Fermentation is complete when the desired alcohol content has been reached and an unpleasant butterscotch flavor, which develops during all of the fermentations, has been mopped up by yeast. The yeast is harvested for use in the next fermentation.

In addition to the mashing, hopping and fermentation process, a water source is the next most critical ingredient needed, not only for the beer itself but also in the sanitizing activities across the whole plant to ensure conformance to the required hygiene standards needed in the brewing process.

Figure 2: Fermentation process



FLOWSERVE OPPORTUNITIES IN THE BREWING INDUSTRY

Flowserve Products and Capabilities in the Brewery Process

Overview

Unlike wine making, where its quality, taste and flavor depends on the regions where the grapes are grown and harvested, beer brewing is very much a universal process all around the world, with light variations in between the processes.

In general, there are several steps involved in the brewing process, which Flowserve can provide via its products and services. These processes can be broadly classified into three main areas, namely:

- **Brewing**
  - ✓ includes malting, milling and mashing

The initial processes mentioned above are the toughest applications in the brewery and the most regulated for final product.

- **Fermentation**
  - ✓ includes lautering, boiling, fermenting, conditioning and filtering

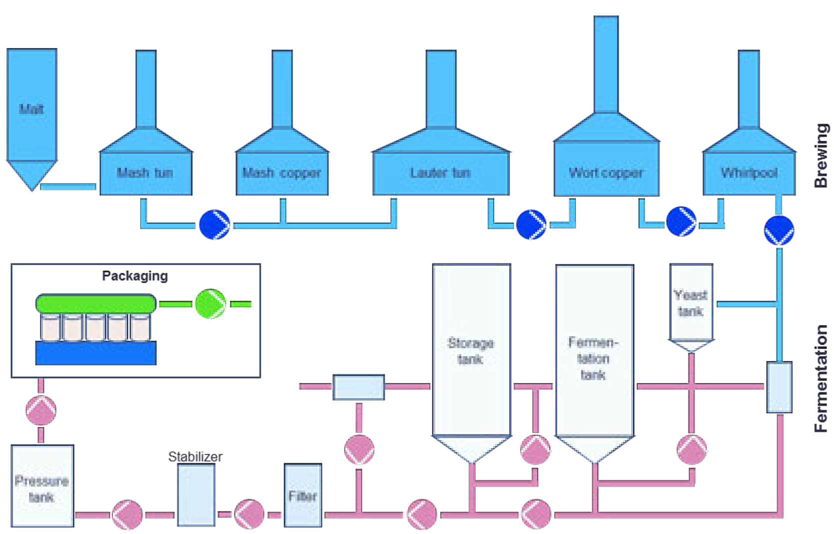
The three main fermentation methods are warm, cool and wild (aka spontaneous). Fermentation may take place in open or closed vessels. There may be a secondary fermentation which can take place in the brewery, cask or bottle.

- **Packaging**
  - ✓ putting the beer into the containers in which it will leave the brewery. This process typically means putting the beer into bottles, which are filled in the bottle filling machine.

Outside of the brewery process area, after brewing, fermentation and packaging commence, the final logistical requirement is the important task of distribution to consumers via the various channels to retail outlets such as restaurants, bars and entertainment establishments.

In most countries, distributors are regulated by the government or states and provide a large variety of beer brands and styles to licensed retailers at a great value while protecting the public. There is normally a system made up of brewers, importers, distributors and retailers.

Figure 6: Three primary brewing processes



Valves

In the brewing process, some of the most commonly used valves are:

- Ball
- Control
- Diaphragm
- Butterfly
- Three-way

In addition, there are application areas for three-way and bottom-drain flow valves within the brewing process.

In addition, for the “Food-safe” grade, there will be the need for high-purity and aseptic process performance valves.

Typical Flowserve valves used in different brewery processes include critical and general services applications such as the following:

Control valves

• Globe	Valtek® FlowTop and Mark One™
Globe – Mixing/Diverting	Valtek FlowTop and Mark One
Globe – Sanitary, Aseptic	Kammer® 190000
Globe – Tank Bottom	Kammer 051000
• Eccentric Plug	Valtek MaxFlo® 4
• Segmented Ball	Valtek and NAF™
• High-Performance Butterfly	Valtek Valdisk™

On-off manual valves

• Ball	Worcester® Food-Safe
• Butterfly	Serck Audco™ and FX
• Lined	Atomac™

Pneumatic actuators

• Automax™	Flowserve®
• Norbro™	Flowserve

Non-return valves

• NAF Check Tilting Disc Check	NAF

Control valves

Valtek FlowTop/ GSV (Globe)

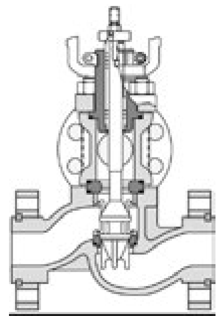
Value added:

- High capacity
- High performance
- Ease of maintenance

Valtek Mark One (Globe)

- Heavy top guiding
- High performance
- Severe service trim available
  o Noise reduction trim
  o Anti-cavitation trim
- VL Series actuator
  o Field reversible
  o Double-acting spring return

Valtek Mark One (Mixing/Diverting)



- Highest rated C_v
- Precise control
- Reliable shut-off

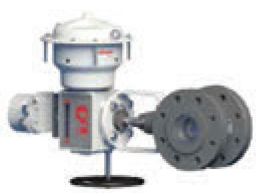
Kammer Aseptic

- Different surface finish – 0.4 to 0.6 µm
- Bellows option
- Standard – without dead lag
- Ultra-clean aseptic version

Kammer Tank Bottom Valve (Globe)

- Seal-welded standard construction
- Seat ring designed to fit tank outlet dimensions
- Compact and lightweight
- Different outlet angle

Valtek MaxFlo 4 (Eccentric Plug)



- Seat design options
- Stuffing box packing options
- Primary steam seal plus two optional secondary seals provide triple-leak protection
- Wide range of optional materials includes: D20, DMM, DC2, DC3, DNI and DNIC
- Exceeds shut-off requirements of ASME/ FCI 70-2 for all classes

Valtek Valdisk (Butterfly)

- Jam-lever toggle soft seat
- Single pivot point for actuator to disc connection
- Self-centering seal
- Non-selective disc and shaft for cost reduction

Valtek and NAF (Segmented Ball)

- Highest capability and rangeability
- Abrasive, erosive and corrosive fluid
- Slurry, two-phase flow

NAX Torex Butterfly Valve

- Seat design options
- Stuffing box packing options
- Primary steam seal plus two optional secondary seals provide triple-leak protection
- Wide range of optional materials includes: D20, DMM, DC2, DC3, DNI and DNIC
- Exceeds shut-off requirements of ASME/ FCI 70-2 for all classes

On-off manual valves

Worcester Three-piece Ball Valve

- Wide applications in steam and water process lines
- Total ball seat interchangeability
- Fire-safe design
- Low torque
- Bi-directional seal
- Ease of maintenance

Worcester Food-Safe Valve (Three-piece Design)

- Certified to meet EC food safety regulations:
  Regulation (EC) No 1935/2004
  Regulation (EC) No 2013/2006
  Regulation (EC) No 10/2011
- High performance
- Severe service trim available
  o Noise reduction
  o Anti-cavitation
- VL Series actuator
  o Field reversible
  o Double-acting spring return

Worcester Clean Valve

- High purity and aseptic applications
- Wrought body material, 316L combined seat and body seal, solid ball
- Standard internal surface finish
- Tri-clamp, XBO and other end connections
- Standard internal surface finish to 0.6 µm

Worcester (Multiple Ports) – Series 18

- True three-way valve seat on every port
- Additional seat on blank port to balance forces
- Size from ½ to 6 inches
- Endless variety of port arrangements
- Available as flanged or weld/screw connections
- Wrought material up to 4 inches

Worcester Three-piece Steam Isolation Valve

- Continuous saturated steam service up to 250psi (17 bar)
- Also for thermal fluids/hot oils up to 280°C
- PTFE-coated metal body
- Carbon-filled PTFR steam seals
- Sizes 8$\frac{1}{N}$ - 50 mm
- Carbon steel and stainless steel with end connections
- Ease of maintenance

Non-return valves

NAF Check Tilting Disc (Check Valve)

- Large range of sizes and torques
- Materials: carbon and stainless steels
- Dimension: DN 40 to 1000 (ANSI 2 to 24 inches)
- Pressure Class: PN 10–40 (ANS 150–300)
- Connection: Wafer
- Temperature: 350°C (660°F)

Pneumatic actuators

Norbro Rack and Pinion (Actuator)

- Large range of sizes and torques
- Compact rack and pinion
- Balanced weight (no stem side loads)
- Unique guide rod design
- Meets international standards
- Fast acting
- Reverse design

Flowserve Butterfly Valve (Butterfly)

- Integral bi-directional travel stop
- Field-reversible action (180 degrees)
- Concentric nested spring design
- Broad size range for optimum actuator sizing
- Internationally accepted mounting standard (ISO 5211/Namur VDI/VDE 3845)
- Exceeds shut-off requirements of ASME/FCI 70-2 for all classes

Summary

The tradition of beer drinking is prevalent throughout the world. With the advent of craft beers and micro-breweries, the reach is even further across all strata of the global population. With this large following, the beer brewing market shall continue to grow among changing conditions such as the green environment necessitating some approaches to industry and/or beer brewing.

For example, the newly launched beer in May 2017 named 'Pisner' — a word-play combining the word *pilsner* with local slang for urine — contains no human waste, but is produced from fields of malting barley fertilized with human urine rather than traditional animal manure or factory-made plant nutrients — a new innovative approach to the beer brewing industry.

Such new market trends or developments will help energize the beer brewing industry as we move into the future, but conventional beer brewing methods will largely remain the same, requiring the same processes and equipment, thus ensuring and prolonging the lifecycle of this market.

Beside the beer brewing market, there are also adjacent markets like distilleries where the process is almost identical to the beer brewing processes.