50 achievements in brewing science and technology in 350 years – Part 1

FIRST 250 YEARS | Master brewers, brewery engineers and brewing scientists have over some 350 years contributed to the development of science of botany, biochemistry, laboratory instruments, engineering and process technology in many ways, e.g. by technical improvements, adopting new machinery and new processes.

MANY OF THESE ACHIEVEMENTS are well known and often quoted – others less. This paper is an attempt to list 50 brewing science achievements in a chronological order, and this mission can be debated, because some people will value machinery developments, others barley breeding programs, others the resulting beers etc.

The yeast strain *Saccharomyces Cerevisiae* was used for thousands of years in the fermentation of alcoholic beverages before anyone realized it, and hops were used since medieval times, this paper however concentrates on major brewing achievements in the last 350 years, listed chronologically rather than according to importance:

1. The Dutch scientist and pioneering microbiologist, Anton Van Leeuwenhoek (1632-1723) from Delft, is credited with having invented – or greatly improved – the microscope. He himself constructed 25 microscopes, some of them magnifying up to 275 times. His work is known from a letter from Leeuwenhoek in 1673 to the British Royal Society. He described observations of single cells from mold, bees and lice and earned also a reputation as "the Father of Microbiology" [1].
2. A saccharometer (fig. 1) was used for metering of wort gravity, known first by English citizen James Baverstock Sr in 1770, and later popularized by John Richardson (1741-1813) in 1784 [2].

Fig. 1 Brewhouse saccharometers

3. James Watt and Matthew Boulton built and installed a 15 hp steam engine in the place where the mill horses used to stand at the Samuel Whitbread brewery in London. Watt was the great, but poor inventor, Boulton the business man in this partnership. The steam engine replaced 24 horses at Whitbread and was used for lifting malt bags, driving the malt mill, water pumping and agitating a mash kettle. In 1795 it was converted from single-acting to double-acting, which increased the effect to some 35 hp. The steam engine was successful and used as a demonstration piece visited by potential customers for Watt and Boulton, who became main producers of many steam engines in England.

Fig. 2 Watt & Boulton Steam Engine from 1785 – Powerhouse Museum Sidney

It was innovative for its time and an example of breweries driving the early industrial revolution, as it 1) used a condenser, 2) had a double-acting piston, 3) used a centrifugal governor for speed regulation and 4) used a sun and planet gear to convert the reciprocating motion of the beam into a rotating motion. The engine worked for 102 years at Whitbread, after which time it was donated to the Powerhouse Technical Museum in Sidney, Australia, in 1887, where it can still be seen, sometimes even in operation (fig. 2). The steam engine is claimed to be the greatest single factor in the upcoming new industrial era, and it was first used in a brewery [18].

4. John Lofting, a Dutch inventor (1659-1742), invented a beer pump. The English citizen Joseph Bramah (1748-1814) further developed this device for beer pumping from the cask in cellar to the bar by a mechanical handle pump in 1797, and he had his invention patented (Pat. No. 2196) in 1793 [6].
5. Michael Combrune documented the use of a thermometer particularly for beer brewing in his book "The Theory and Practice of Brewing" in 1804, but also stated that the thermometer was used already in the 16th century for other purposes [4].
6. The beer style "Pilsner" was first brewed by the young brewmaster Josef Groll (1813-1887/fig. 3) from Vilshoven

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near Munich, who on 5th October 1842 produced the first batch of Urquell beer brewed using very soft Bohemian water, very pale, low protein malt, and Saaz hops in the town of Pilsen – a town now in the country of Czech Republic, but then in a region known as Bohemia. His bottomfermented "Pilsner" was a pale, dry and hoppy lager, different to the hitherto darker, sweater "Dunkel" lager beers. Groll's "Pilsner" was first served in the public houses "Zum Goldenen Anker", "Zur weißen Rose" and "Hanes" on 11th November 1842. Groll died on 22nd October 1887. He allegedly died drinking beer at "Wolferstetter Keller" in Vilshofen, his home town back in Bavaria, as he only worked at Bürgerliches Brauhaus in Pilsen from 1842 - 45 [5 and 10].

Fig. 3 Joseph Groll

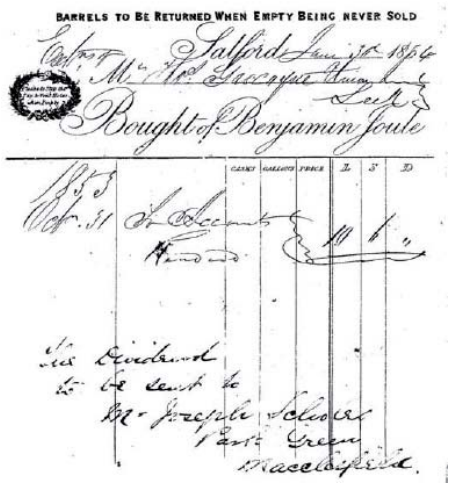

Fig. 4 Document from Joule's Brewery June 1854

7. James Prescott Joule (1818 - 1889), an English physicist and brewer, was born in the house next to the Joule Brewery (fig. 4) in Salford and therefore raised as a brewer. He is well known for the "Joule's Law", but it is less known that he claimed to be able to measure temperatures to within 1/200 of a degree Fahrenheit (3 mK). Such precision was uncommon in 19th century scientific experiments. Joule is a famous scientist, but his brewing experience and use of practical technologies should not be forgotten. It is also a little known fact that he was the first to replace a steam engine with an electric motor in 1840 [9 and 13].

8. Carl Joseph Napoleon Balling (1805 - 1868), Professor and Chair of Chemistry at the Prague University, described the connection between original gravity, real extract and alcohol with a new relation in the "Balling formula" in 1843. He felt like a German and spoke German, although living in Bohemia, a Czech region, but kept good relations to his Czech colleagues and students. He discovered and documented in 1843 that 2.0665 g extract in wort during fermentation to beer is converted to 0.9565 g CO_2 + 1.0 g alcohol + 0.11 g yeast dry material, with 4 places of decimals. He also created the "Balling sugar tables", which – with 3 places of a decimal – offer a relation between specific gravity of wort/saccharose and percent extract of wort. The "Balling formula" is still standing and used globally as the reference for calculation, even though later brewing scientists have suggested a more precise formula [7 and 8].

9. William Thomson, engineer and physicist (1824 - 1907), later known as the 1st Baron Kelvin, English citizen, formulated the law on expansion of gasses needed for cooling and heating in breweries, and he defined an "absolute thermometric scale". He became famous for determining the correct value of absolute zero as approximately – 273.15 Celsius or 0 oK [3].

10. Patrick Stead (1788-1869), was a maltster who developed a new malting system using steam and hot air to control germination and kilning, which became patented in 1842. This was the early type "pneumatic malting", which reduced manpower and slowly turned malting from craft to industry, slowly, because classic floor malting was still common practice in 1950 [13].

11. Brewing of the same brand of beer in more than one brewery can be traced back to the Hungarian Anton Dreher in the 19th century. This concept was later continued in the USA by the Pabst Brewery Company in the 1930s. In 1948, following acquisition of other breweries, Pabst became the first brewer with plants from the Atlantic to the Pacific. By the late 1940s Schlitz and Anheuser-Busch had also followed this trend [13].

12. In 1862 the French chemist and microbiologist Louis Pasteur (1822-1895 / fig. 6) discovered that yeast was a living organism and in fact responsible for converting sugar to alcohol. This was a dramatic and late observation of the science community, who hitherto had believed that cloudy and sour beer was caused by chemical reactions. He proved that microorganisms could be removed by heat treatment, a process since known as pasteurization. Pasteur was also a philosopher, and several quotes remain from his hand – here is one: "Science knows no country, because knowledge belongs to humanity" [11].


Fig. 5 Cornelius O'Sullivan

13. Irish chemist and assistant brewer Cornelius O'Sullivan (1841-1907) described in the Journal of the Chemical Society, 1872, how starch during mashing gets broken to dextrins and ultimately to maltose, and O'Sullivan is credited with the discovery of the disaccharide maltose. He isolated alfa- and beta-amylum, and he further identified raffinose. He used Fehling's copper solution to quantify the sugar concentration in 1872: The cupric reducing power (towards Fehling's solution) increases as the process of hydrolysis proceeds [13].


Fig. 6 Louis Pasteur

14. In 1870 Louis Pasteur published "Des causes des maladie de la biere" and "Études sur la biére" in 1876 – beer pasteurization was introduced. In Denmark the inventor Anders Pindstofte applied it for the first time in industrial use for bottled beer pasteurization at Tuborg's breweries in Copenhagen in 1880 [12].

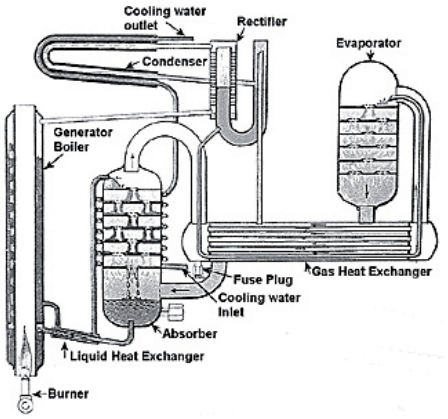

Fig. 7 Cooling machine by Carl von Linde

15. A cooling machine for beer cooling (fig. 7) was first used in 1876 by Carl von Linde at the Munich Paulaner Brewery (in Denmark first used by Carlsberg in 1887). This invention had far reaching production implications, because it made brewing possible all year. Before the cooling machine, breweries had to acquire frozen ice for cooling, sometimes provided from far away with horse wagon of railway [10].
16. Yeast purification by means of dilution of yeast suspensions in test tubes was first used by Emil Christian Hansen (1842 - 1909), since 1875 head of Carlsberg's physiological laboratory. Hansen eliminated this way, bacteria and wild yeast, and together with Søren Anton van der Aa Kühle, then Director and Master Brewer at the old Carlsberg

Fig. 8 J.C. Jacobsen – Carlsberg

Brewery, he designed and manufactured an industrial yeast propagation plant in 1883. This so called "propagation plant" quickly became part of industrial brewing, because it offered a safe way of producing large quantities of cheap and high quality brewers' yeast. The founder of Carlsberg, Jacob Christian Jacobsen (1811 - 1887/ fig. 8), sent Hansen travelling around in Europe to cure beer diseases for several breweries at no cost in an effort to increase industry beer quality [10 and 12].

17. Determination of nitrogen and protein content in barley, malt, wort, beer etc. was introduced by Professor Johan G.C.T. Kjeldahl (1849 - 1900), Carlsberg Laboratory, in 1883, as he became father to the "Kjeldahl method" [12].
18. Alfred Jørgensen, student of Emil Chr. Hansen, publishes "Die Mikroorganismen der Gärungsindustrie" in 1889, and he starts a brewers' yeast microbiological laboratory, nowadays part of Cara Technology. Alfred Jørgensen Laboratories (AJL) was throughout the 20th century a leading yeast strain provider and brewery consulting company [12].
19. Glass bottles were manually filled until the 1880s, when the first bottling machinery was invented. Narrow mouthed bottles were patented in 1886. Multiple head filers appeared in 1899, and fully automatic rotary fillers in 1903 [13].
20. The American inventor William Painter (1838 - 1906) patents the "crown cork" bottle closure in 1892 and soon thereafter starts the Crown Cork & Seal Company of Baltimore. By 1906 CCC plants are running in Germany, France, the United Kingdom and in Japan (**www.crowncork.com**/about/about_history.php).
21. William Gosset (1876 - 1937) developed the "Student's t-test" in 1908 when working as a chemist for the Guinness brewery in Dublin. Gosset devised the t-test as a cheap way to monitor the quality of his Guinness stout by determining if two sets of data were significantly different from each other. The t-test is commonly applied, when the test data would follow a normal distribution, if the value of a scaling term in the test statistic were known. The t-test work was accepted in the journal "Biometrika", but Guinness had a company policy that chemists were not allowed to publish their findings. However, Guinness allowed Gosset to publish his mathematical work, but only if he used a pseudonym, that was "Student" (Wikipedia).
22. Professor Søren Peter Lauritz Sørensen (fig. 9), successor of Professor Johan Kjeldahl at Carlsberg Laboratory, Copenhagen, discovers that the concentration of hydrogen-ions determines acidity. He defines metering of acidity/alkalinity as "the potential for hydrogen ion concentration" measured as the negative decadic logarithm

Fig. 9 Søren P. L. Sørensen

of the number of H+ ions in one liter of a solution and introduces the pH-scale for metering acidity in liquids in 1909 [16].
23. Wort coolers (fig. 10) start to replace brewhouse coolships in the years after 1930. The counterflow wort cooler provides faster, more hygienic and energy saving chilling than the old coolship.
24. The draft beer cooler with additional carbonation facilities became known after 1930.
25. By late 19th century, cans were used for food, but not before 1909 the American Can Company made its first attempt to can beer. This was unsuccessful, and the American Can Company had to await the end of prohibition in the U.S. before it tried again. In 1933, after two years of research, they developed a can that was pressurized and had a special coating to prevent the beer from chemically reacting with the tin. Later, during World War II, the U.S. brewers shipped millions of cans of beer to soldiers overseas, and canned beer and soft drinks became popular worldwide after World War

Fig. 10 Early wort cooler

II. The early beer cans required a can opener, but in 1959 Ermal Fraze came up with a can-opening method that now dominates the canned beverage market. His invention was the "pull-tab" (www.crowncork.com/about/about_history.php).

The second part of this report, entitled "50 achievements in brewing science and technology in 350 years – Part 2", will be published in BRAUWELT International no. 1, 2014. ■

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