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BREWERY ENGINEERING; ITS DEVELOPMENT AND THE DEGREE OF PERFECTION IT HAS REACHED IN VARIOUS COUNTRIES.

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Fermented beverages produced from cereals have been known away back in the old ages. It was not only civilised people who understood the art of brewing—the African negro brewed a beverage from millet, and the American Indian used maize for the same purpose. The Teutonic race has, ever since antiquity, been the guardian of the noble art of brewing, and under its protection brewing has seen many ups and downs. This industry prospered during the middle ages to the greatest extent in Germany, two German cities alone exporting, during the 16th century, annually 800,000 casks of beer to England, until the growth of the brewing industry in England put a stop to the importation of German beer. By the middle of the 19th century England became the most important of the beer exporting countries, but of late another change had taken place, inasmuch as German and American beers were now competing successfully. Some of the Celtic nations had begun to cultivate a taste in beer, and were not only importing, but were also producing this refreshing drink in numerous breweries, which have been built during the last forty years.

Great Britain and its colonies produced their beer by what was known as top or upper fermentation, during which the yeast rose to the surface of the beer and was at once removed. The temperatures employed for this fermentation ranged between 60deg. and 90deg. F., according to the ideas of the brewer, or prevailing climatic or other conditions.

Germany, the Kingdom of Bavaria in particular, was the home of bottom or lower fermentation, during and at the end of which the yeast settled to the bottom and was collected after the beer had been removed. This system was also called the "cold fermentation," as the temperature was never allowed to rise above 59deg. F., and was often started as low as 41deg. F., the maximum being about 50deg. F. In the northern part of Germany, for a great number of years, the top fermentation system was practised, but it had to make way for the Bavarian method, and now very little top fermentation beer was found in that country. Amongst top fermentation beers was the "Berliner Weiss Bier," but it had nothing in common so far as taste and smell were concerned with the British beers.

In the United States of America, the brewing industry had, in a comparatively short time, developed to marvellous dimensions. In 1863 that country produced 2,006,625 barrels (25.82 Imperial gallons each), and in 1896 the production and sale of beer reached 33,826,098 barrels. Whilst at the earlier date the quantity of beer produced was nearly equally divided between top and bottom fermentation, now mostly bottom fermentation was employed. In the coastal cities, where a constant influx of immigration from Great Britain took place, top fermentation beers were still produced, and even there, as compared with the other, only in limited quantities.

In Belgium large quantities of top fermentation beers were still produced, but the other was also fast making headway there. Formerly there were no means to distinguish between the yeast of the top and the bottom fermentation except by the former rising to the surface and the latter falling to the bottom, and the difference of character of the beers. Under the microscope no marked distinctions in the yeasts were observable, and for a long time it was believed that the yeasts were in reality the same, and that the great difference in temperature was mainly accountable for the distinct physical behaviours of the yeast and the marked difference in character of the beer. In 1895, however, Bau proved experimentally that the bottom fermentation yeast was capable of fermenting a certain sugar known as melitriose, whereas this was not the case with top yeast.

In had already been pointed out that there was a marked difference between the taste and smell of top and bottom fermented beers. This was due firstly to the fact that different species of yeast were employed, and it was only natural to assume that the minute by-products of their activity were responsible for this. Of course, the great difference in temperature also had a tendency to awaken and foster separate attributes in the yeast. These small by-products of the yeast were mostly present in the beer in such minute quantities that they could not be chemically determined, but yet they existed in sufficient quantities to largely influence the taste and smell of the beer. There was also a great difference in the traceable chemical composition of the two types of beer, and here brewery engineering had an important role to play, as it was the executor of chemical science. The top fermentation beers contained large amounts of alcohol, from 4 to 15 per cent., and only a small amount of unfermented extract remained, from 4 to ½ per cent. Strong ale had up to 10 per cent. extract. The bottom fermentation beer contained from 2 to 5 per cent. alcohol and from 3½ to 10 per cent. of unfermented extract.

It was necessary to give a short historical sketch of the art of brewing, and also to show the main difference in the two types of beer, to enable the development of brewery engineering to be followed more easily.

Before we come to the brewing proper we had to deal with some of the preparatory manipulations of the raw materials which are being used in brewing. In the first place there was the malthouse. Most of the brewers make their own malt, but there were also malsters who conduct this as a business in itself, and sold their product to brewers who either did not malt themselves or who found their malting capacity too small. Malt was generally made from barley, and seldom from other cereals. The objects of malting were, to modify and mellow the starch, and to free the grain from a surplus of raw nitrogenous matter which would be detrimental to the quality of the beer. At the same time, chemical ferments, i.e., unorganised ferments or enzymes, were formed, the most important of these being diastase and peptase. The former converted the starch of the malt into the different malt sugars, and the latter peptonizes or changes the raw nitrogenous matter or part thereof into peptons and amids, which were important factors as nourishment for the yeast, and also with regard to the food value of the beer. These changes in the barley grain were brought about by first steeping it in water until it had absorbed sufficient moisture for a healthy germination. The grain was then placed on the malt-floor, as a rule made of cement, and the rootlets begin to grow in due time. Simultaneously the acrospire, i.e., the germ from which the stalk grew, developed below the skin of the grain, and when this reached three-quarters the length of the grain the germinating process on the floor was complete and the malt was conveyed to the kiln. Here the growth stopped when sufficient moisture was extracted from the malt, and then higher temperatures were employed to thoroughly dry and thereby preserve the malt so that it could be stored and kept ready for use in the brewery. A healthy growth was essential to the production of a good malt, and in order to assure this, plenty of pure air, a cool malt floor, and a certain degree of moisture were necessary. The malt obtained the moisture in the steep, the cool temperature was secured by only malting during the winter, and air was brought into contact with the growing barley by means of numerous windows and by turning the batch with a shovel from time to time (about every eight hours). The turning of a batch of growing barley required a good deal of skill, and only specially trained men were employed for this work. It was necessary to throw every shovelful of barley through the air for some distance to free it from carbonic acid gas which had accumulated and to give it fresh air at the same time. The various shovelsful of barley must be thrown in such a manner that the whole batch lay perfectly even, as any unevenness would produce irregular growth. Care must also be taken that the rootlets were not injured unnecessarily, and that the single grains lying in the path which was formed latitudinally through the batch during turning were not stepped on, as this not only killed the grains affected but also exposed them to fungoid growth and lactic acid fermentation, which were among the most harmful diseases in malting. This was the method that malting had been conducted for centuries. There was hardly any industry or branch of industry which had been at such a complete standstill in the way of improvements as this. Of course, the maltsters had taken advantage of some of the cleaning and separating machinery for cereals, and other contrivances for conveyance, and so on, but as to the malting process proper no improved methods which would enable the production of a better and a cheaper malt were brought forward until Mr. N. Galland in 1874 published his system of pneumatic malting. Although this was a step forward, the system lacked mechanical completeness, which Galland evidently realised, as he was uncertain in the remodelling of his apparatus. His ingenious idea found many infringers, and in all the inventions the main principles had been adhered to, and these were represented by the names of Gallan-Hemming and Saladin. Although the two systems showed a marked difference in their mechanical arrangements, they had the same object in view, and that was to furnish the growing barley with all the essential elements for a healthy growth, thereby producing a better malt than was possible with ordinary floor malting and ordinary care, and also a cheaper article, since a vast saving in labour, etc., was effected. Both of these pneumatic systems had reached a high stage of perfection in their mechanism, as well as in their output. With both, the growing barley received a measured quantity of air which had been cooled and moistened in a tower up through which the air was forced against a spray of water, which, by evaporation, cooled and moistened the air to any degree necessary for healthy growth of any barley, and from whence the air was conveyed into the germinating chamber. This chamber in the Galland-Hemming system was a drum or cylinder, made of iron, about 6ft. in diameter, and 15ft. to 20ft. long. This drum rested at both ends on wheels, and by means of cogs, which extended around the circumference, the cylinders could be made to revolve upon their own axis. Although this motion was very slow, it prevented the growing together and matting of the rootlets of the separate grains. For the conveyance of the air through the interior of the drum, which was about three-quarters filled with barley from the steep tank, the inner walls were fitted with six or eight semi-circular perforated spouts or channels, and divided at equal distances longitudinally on the inner wall; these conveyed the cooled and moistened air from the tower through the drum after receiving it from a space formed by a false head inside the drum. Through the centre of the drum a perforated tube, 9in. or 10in. in diameter, was placed, which received the air after it had passed through the grains, and from which it was removed by an exhaust fan located in such a position that it could act on several drums at the same time.

With the Saladin system, the germinating chamber had the shape of a rectangular cement tank, with a perforated false bottom, from under which the cool and moistened air passed through the growing barley, which lay about 24in. deep. The barley rootlets were prevented from growing together by means of a battery of screws fixed to a crosshead which ran latitudinally across the tank, and which was equipped at both ends with gearing to move it from one end of the tank to the other.,As this piece of machinery travelled over the tank, the screws which reached to the false bottom disturbed the barley and prevented malting. The malt in either of these sysetms was on completion of germination conveyed to the kiln for drying.

Of the two systems, the Galland-Hemming had found the greatest favour with Continental and American maltsters, and was being widely adopted, whereas in Great Britain, owing to the intense conservatism of the brewers and their advisers, the primitive and antiquated floor method still prevailed. This was difficult to understand with such a practical people as the British.

There were many advantages connected with the use of the pneumatic system of malting, both in the way of producing a better and more uniform malt, and also from the economical point of view, and these could be summed up as follows:—

1. A uniform temperature and degree of moisture could be maintained in the batch of growing barley.

2. Grain could not be injured by being stepped on.

3. The process was much cleaner than the floor system, as injured grains could not set up fungoid growth or lactic acid fermentation, whilst absence of fermentation was further secured by the air being purified and freed from germs in the tower bp the spray of water.

4. The maltster had absolute control over the chemical changes which took place in malting, owing to his being able to regulate the governing factors, temperature, moisture, and air.

5. A great saving in space was effected, as only about one-sixth of the room necessary for ordinary floor malting was required.

6. A pneumatic malthouse could be worked all the year round, whereas floor malting was impossible during the hot summer months (4-6 months).

7. The saving in labour was enormous. A pneumatic malthouse, equipped with all modern contrivances for conveyance of the barley, malt, water, etc., and which received its power from an electric station, produced 60,000 bushels of malt annually with two men, one during the day and one at night, whereas to produce the same quantity of malt in the ordinary English malthouse necessitated the employment of ten to twelve men for seven months.

Of the Australasian colonies, Victoria, New Zealand, South Australia, and Tasmania had malthouses, and malting operations were conducted during the winter months. In New South Wales there were, up to a short time ago, only one or two small malthouses. Lately, however, an impetus to barley growing and malting on a larger scale was given by a large firm of brewers in Sydney. When entirely new malthouses are being built the best opportunity is offered to inaugurate a new system, but, besides this, a warm climate like ours really demanded a system of malting by which adverse climatic conditions could be modified to suit requirements. Two Melbourne maltsters had for some years past adopted the Saladin tank system for a part of their houses, and were turning out good malt, in spite of the fact that neither of them were tanks fitted with mechanical turners, so that the growing barley must all be turned by hand.

They master, however, the questions of temperature and air.

It was very difficult to introduce new ideas as to apparatus or machinery amongst the brewers and maltsters of our colonies, owing to the fact that they were mainly guided in their undertakings by the doings and experience of their British systems, and as these are in many respects rather slow in moving forward, it might be some time before we should have a modern malthouse in this country. One objection might be raised as to the wisdom of introducing a pneumatic malthouse in a country which was comparatively poor in water supply, as was the case in most parts of Australia; but against this argument it might be urged that where there was sufficient water to grow barley there was also enough to work a pneumatic malthouse, as even if it were necessary to collect and store it during the rainy season, it would pay many times over.

Other machinery and apparatus, such as bucket elevators, conveyers, cleaning and separating machinery, they were already acquainted with, as these could be found in ordinary flourmills; and he therefore refrained from giving a description of them, but only wished to say that in America all this machinery was of iron wherever this was possible, thus giving greater security against the danger of fires. Before leaving the malthouse and passing on to the brewery proper, he wished to say a few words regarding the malt kiln. As previously stated, the main object of the kiln was to preserve the malt, when it had reached the required growth, by extracting the moisture from it by drying; but this was not the only object—during the drying process further changes took place in the grain, which gave the malt its character and aroma. These changes were due to the drying at high temperatures, and were roasting products. For dark, full-bodied beers, highly kiln-dried malt was used, which contained a maximum of these roasting products. The higher the temperature employed, and the more moisture present in the malt, the greater the amount of these products would be. In the absence of moisture only limited quantities of roasting products were formed, even at a high temperature, and a pale malt would be the result. Besides the extraction of moisture from the malt and the formation of roasting products, there were still other points to be considered in the making of good malt, and these were to ensure that the enzyme or chemical ferments which were formed during the germinating process were not destroyed, and that the physical changes of the starch were limited. The enzymes, which converted the starch into sugar, and which was known as diastase, would be killed at the comparatively low temperature of 167deg. F. in the presence of larger quantities of moisture, and the enzyme, known as paptase, succumbed at a still lower temperature. The physical changes, when carried to excess, produced what was termed steely, glassy or flinty malt, and these took place when a high temperature was used, whilst the malt contained more than 15 per cent. of moisture. The starch cells, under such conditions, broke up, and the starch itself was gelatinised, and when the malt was finished and dry it contained an abnormally large amount of insoluble matter, which was justly dreaded by brewers. Other minor chemical changes, such as the formation of peptones, occurred; but these seemed to progress normally, if the major changes did. From what had been said, it could easily be seen that the higher temperatures should only be reached when a sufficient amount of moisture had been extracted from the malt, and since this had been fully realised, kilns to enable a rigid control to be exercised had been constructed. These would permit of the manufacture with accuracy of both the dark, aromatic, and highly-dried malt, and also the pale malt, rich in enzymes. There were three types of kilns, viz., the smoke kilns, the air kilns, and the mechanical kilns. The two first types were mostly in use, and were built of brick and located at the end of the malthouse. The general construction of these two types was much alike, and they differed mainly for the reason that in the smoke kilns the gases from the furnace were allowed to pass through the malt, whereas with the air kilns these were fed through a series of large sheet-iron pipes, or into a "calorifere," around which the air circulated, and which