The oxygen gets out of puff

Deaeration systems and carbonating plant

Deaeration and carbonation are essential elements in beverage production. Oxygen dissolved in beverages affects the taste and shortens the shelf life. To reduce the oxygen content to an acceptable level, the ingredients or the finished product are deaerated. The carbonation of drinks serves to enhance their taste and to increase their shelf life.

In the following article, various deaeration systems and carbonation processes are described.

The simplest way of deaerating liquids is to store them in tanks for a certain length of time. During this dwell time, air trapped in the liquid can rise to the surface and escape. This procedure is used principally with preliminary and intermediate products, e.g. sugar solution or syrup base. The method can reduce oxygen content to an acceptable level, i.e. values of around 3 mg O_2 per litre. If deaerated water is then also used, the finished beverage will show good values.

Air that has been introduced into the liquid during the process of conveying it is removed in pre-run vessels or air separators. This is air that has got into the pipes during the switch-over from one tank to another, or when vessels or drums are emptied by suction. The pre-run vessels are as a rule installed upstream of the transfer pumps. If there were no pre-run vessels, the pumps would distribute the air finely throughout the product.

To extract finely distributed air or dissolved oxygen from liquids, it is necessary to use deaeration equipment. This may operate on one of a variety of principles:

- hot deaeration with a partial vacuum,
- hot deaeration or cold deaeration through carbonation,
- cold deaeration under a vacuum,
- cold deaeration via filter modules.

Which of the different types of apparatus is used depends on the product and the residual oxygen values required, as described below.

Hot deaeration of fruit juices

For fruit juices, the hot deaeration method is used, the pressure in the deaeration vessel being kept slightly below atmospheric pressure. It is the finished beverage that is deaerated. Deaeration takes place in a vessel containing a partial vacuum, into which the product is sprayed after having been heated to around 50° C. These systems are equipped with cooling coils in the suction pipe to recoup flavour, since flavourings evaporate during the treatment. The condensate runs back into the vessel.

These are elaborate systems, since when the equipment is started up the product first has to be heated in the circuit. The need to recoup flavour is an additional complication. There is a high level of product loss at the start-up and running down of the plant. However, the equipment is easy to integrate into pasteurisation equipment.

Hot deaeration of water with CO_2 input

By contrast to the fruit juice equipment described above, hot deaeration systems for water work without a vacuum. They generally consist of two columns which the water runs through one after the other.

The water is heated to approx. 75° C and introduced into the columns. By means of a regeneration stage in the heat exchanger, heat is regained on cooling. In a further stage, the water is cooled to the desired temperature.

The water is sprayed into the deaeration columns in a fine spray, and slowly trickles down over the column packing. CO_2 flows in the opposite direction, from bottom to top, causing the oxygen to be released. In addition, between the first and second deaeration stages CO_2 is injected through a nozzle, bringing about the intimate mixing of water and CO_2 and further enhancing the deaeration effect. The water level in the deaeration columns is always kept constant. The heating of the water also serves to eliminate germs.

The proper functioning of the equipment is monitored by flow, level and oxygen sensors. Such plant can also be operated as cold deaeration equipment with higher residual oxygen values. This eliminates the heat exchanger, which uses a lot of energy.

The introduction of CO_2 leads to a slight carbonation of the water. The plant can therefore not be used in the production of still beverages. Such a hot deaeration plant achieves residual oxygen values of < 0.02 mg O_2 per litre, and is therefore particularly suitable for use in the brewing industry.

Vacuum deaeration

Vacuum deaeration involves dosing with CO_2 in one or two stages. The two-stage plant consists of two horizontal vessels arranged one above the other, a vacuum pump, a circulating pump and an extractor pump. The vessels are fitted with spray nozzles. When they are in operation, the vessels are evacuated by the vacuum pump. The absolute pressure in the vessels amounts to around 0.05 bars.

The water to be deaerated enters the lower deaeration tank via the water inlet valve, being finely sprayed by special nozzles. In the deaeration plant the vacuum causes a large proportion of the dissolved oxygen to be released and sucked out.

After this first stage of deaeration a circulating pump transfers the water to the upper deaeration tank, where it is once again finely sprayed. On the way to the upper tank the water is dosed with a particular quantity of CO_2, depending on the value set. The partial pressure reduction leads to the release of more of the oxygen that is still dissolved in the water.

The deaerated water is then conveyed out of the upper deaeration tank by the extractor pump. The gas mixture released in the upper deaeration tank (consisting largely of CO_2 with only a little oxygen) flows through an aperture in the pipe into the lower deaeration vessel, where it is directed in contraflow to the water that is sprayed in and sucked off by the vacuum pump. This contraflow in the lower deaeration vessel also enhances the effectiveness of the first stage of deaeration. The amount of CO_2 required for deaeration depends on the desired residual oxygen content of the water and the water temperature.

With the GEA Diessel DIOX 2 water deaeration plant a residual oxygen value of less than 0.05 mg O_2 per litre can be achieved at a water temperature of 12° C. This requires a CO_2 input of only 0.5 g per litre of water. If the water temperature is higher, correspondingly less CO_2 is required.

The inflow of water is controlled by means of the level in the lower vessel. Any excess water that is not extracted by the extractor pump flows back from the upper deaeration tank into the lower deaeration tank through the aperture in the pipe, and is thus recirculated by the circulating pump.

This arrangement has the advantage that if there are short breaks in production when no deaerated water is required, the entire volume of water is kept circulating between the upper and lower vessel. The plant therefore does not need to be switched off, and supplies perfectly deaerated water again immediately after each break.

As an alternative to the traditional vacuum pumps, dry running vacuum pumps can also be used. This cuts operating costs; but the acquisition costs are higher.

The DIOX two-stage vacuum deaeration plant consists of two horizontal vessels arranged one above the other, a vacuum pump, a circulating pump and an extractor pump. (Photos and table: GEA Diessel)

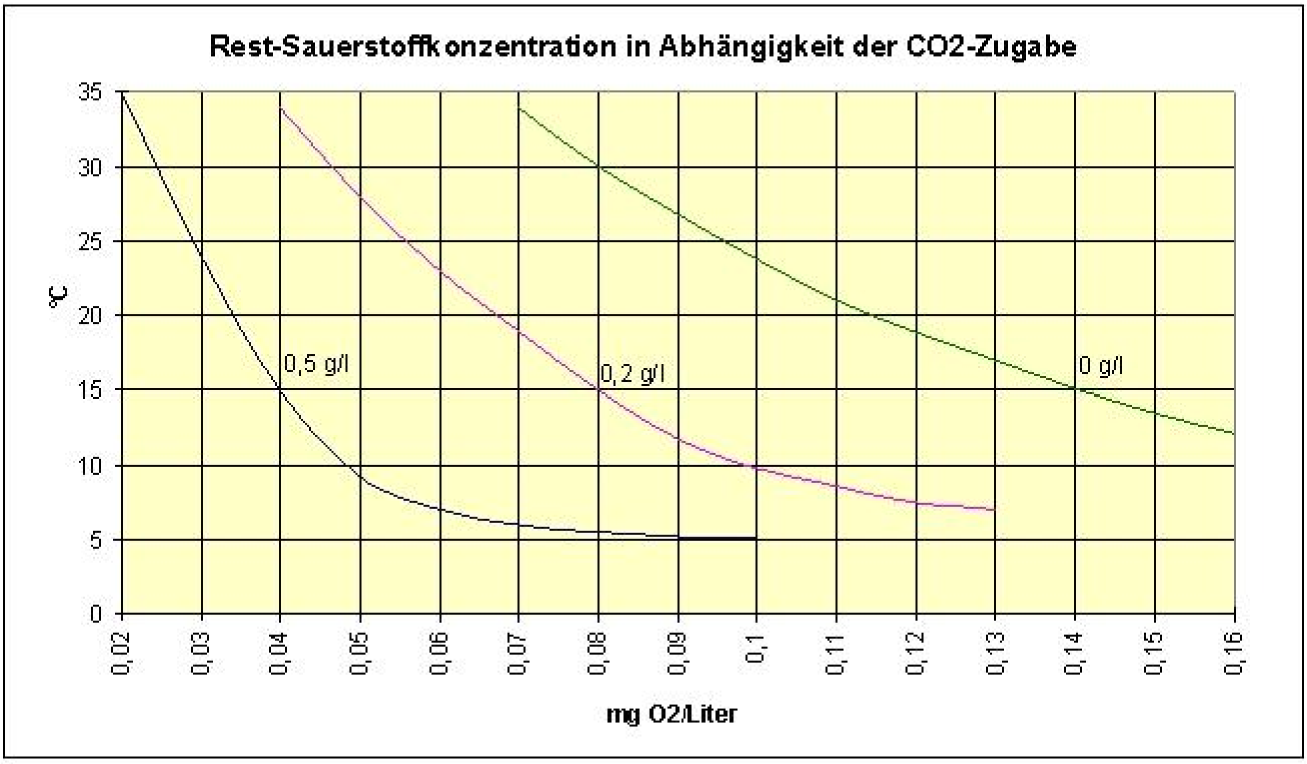

Chart: Residual oxygen concentrations plotted against the amount of CO_2 introduced

Filtration of water

The filter modules consist of a large number of hollow microporous polypropylene fibres. The water flows around the exterior of the fibres. The pores in the fibres let only gas permeate; water does not pass through them. The gas is sucked out of the pores by a vacuum pump. The additional loading of the fibres with CO_2 or nitrogen enhances the oxygen extraction.

The use of these filter modules enables low residual oxygen values of less than 0.01 mg O_2 per litre to be achieved. The value attainable depends on the number of filters and the throughput. The filter modules are suitable for a maximum throughput of 40,000 litres per hour.

Carbonation of beverages

The last stage in the production of beverages is carbonation, when CO_2 is added to the finished beverage. The heart of the plant is the “saturator”, by which the gas is finely distributed throughout the liquid. In order to enable the gas to be dissolved, either a long pipe to act as a settling length or a pressure tank is installed downstream of the saturator, this being the feature distinguishing two kinds of plant.

Carbonation plant with pressure tank

The essential component of the plant, in addition to the mixing tank, is the saturator, which works on the venturi principle. After the completion of blending the drink is introduced into the saturator by a pressure booster pump. The flow speed through the saturator is kept constant in the optimum working range by a regulator. The partial vacuum created in the saturator provides the desired suction effect for the CO_2. The increase in the flow speed for a short time also guarantees the fine distribution of the gaseous CO_2, and thus homogeneous blending in the product. CO_2 is introduced into the saturator from the pressure tank, the constant pressure of which guarantees the even carbonation of the beverage. This procedure also ensures that there is no loss of CO_2 on introduction.

The carbonation of the beverage essentially depends on the pressure of the vessel, which is set at a value determined as a function of the CO_2 value required for the particular beverage; the pressure is only slightly higher than the saturation pressure of the product. Plant of this kind can be constructed for different rates of flow, and adapted to the installed filling capacity. GEA Diessel builds such plant with throughputs of between 10,000 and 70,000 litres per hour.

The carbonation plant incorporates an analysis unit to check the essential product data - CO_2 content, conductivity for the acid content and Brix value - as the last continuous check before filling. This data is recorded and monitored to ensure that it lies within the predetermined limits.

The pressure tank, in combination with an upstream mixing plant, also serves as a buffer vessel in order to compensate for possible “stop and go” operation of the filling unit.

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Carbonation plant with saturation length

Plant with a saturation length is mainly used to add carbon dioxide to beer. CO_2 is introduced into the product through the saturator and extremely finely distributed, so that it can then be dissolved in the saturation length immediately downstream. The CO_2 throughput is controlled by a regulating valve. The CO_2 content at any time is determined by the CO_2 metering device at the end of the saturation length. If it deviates from the desired value the control unit can influence the regulating valve accordingly.

GEA Diessel builds such plant with throughputs of between 100 and 700 hl per hour. The plant can be supplemented by analysis equipment for original gravity or alcohol content, allowing the product to be monitored.

Summary

The modern deaeration and carbonation systems that are available today provide everything that the beverage industry requires in respect of the values and levels of accuracy required for the various products. GEA Diessel has many years of experience with the systems described, and will advise users on the planning of new production facilities or the modernisation of existing equipment. The right equipment will be selected in dialogue between the operator and the equipment manufacturer.

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