Technical Article

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Combining chemical reactions with subsequent processing: a time- and space-saving combination of process steps in one mixing reactor

In industrial production processes, chemical reactions are generally part of a multi-stage process chain comprising both the synthesis process itself and a number of processing steps before and after. The vacuum mixing reactors of Lödige Process Technology make it possible to perform several of these steps after each other in the same machine.

One of the most important groups of chemical reactions are solid-liquid reactions. These often require bringing the solid or solids into intensive contact with liquid reacting agents to achieve quantitative conversion in the shortest time possible. Below, two examples shall be addressed in detail: The alkalisation of cocoa and the production of metallic soaps.

Alkalisation of cocoa

Untreated cocoa is rather acid. It has a pH value between 5 and 5.5. For this reason, Coenraad van Houten from the Netherlands developed a process nearly 200 years ago that reduces the acidity of cocoa, called "Dutching" or alkalisation. In this process, cocoa paste is treated with an alkaline solution. Typically alkali metal hydroxides or carbonates are used for this purpose. Alkalising cocoa with this method gives it a milder taste and a different colour than the untreated raw product. It is possible to produce red or black cocoa through systematic selection of suitable process conditions.

Particularly black cocoa has been growing in popularity. It gives biscuits and other baked goods an intense dark colour.

To achieve the dark colouration, the reaction often requires significantly higher pressures and temperatures than the conventional Dutching process. Temperatures of 150°C with a process pressure of 5 bar are required.

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After alkalisation, the cocoa powder must be dried to a moisture of less than 5 % in a subsequent step. This drying process is performed quickly and gently in a vacuum.

In Lödige Druvatherm® reactors, both processes, reaction and drying, can be performed under ideal conditions.

Reaction and drying in a single machine

The mixing reactors and dryers of the DVT series are characterised by special mixing elements installed in a cylindrical drum with a heating jacket. The mixing elements move the reaction material continuously. This ensures that individual particles frequently touch the hot container wall, thereby optimising the heat transfer and reducing heating times.

Rapidly rotating choppers installed on the sides of the horizontal mixing vessel prevent clumping or similar agglomeration during the alkalisation reaction.

After the chemical reaction with the alkaline reacting agents, the cocoa can be dried in the same machine immediately afterwards. For this purpose, the applied gauge pressure is released and a vacuum is applied instead.

Intense mixing of the cocoa powder ensures quick, even drying. The previously mentioned choppers are active during drying as well, preventing large agglomerates from forming and trapping moisture inside them.

The fact that reaction and drying can be performed in a single machine has several advantages for the customer: First of all, this saves time, as no discharge, in-house transport and refilling is required between steps. Secondly, the Druvatherm® reactor needs less space than two separate units for reaction and drying.

Production of metallic soaps – a smooth process in the mixing reactor

Another application in which reaction and subsequent vacuum drying are both performed in the Druvatherm® mixing reactor is the synthesis of metallic soaps.

Metallic soaps are made from long-chained fatty acids and a metal oxide or hydroxide. The conversion is, chemically speaking, a typical acid-base reaction. The fatty acids used are often derived from plant-based fats or oils. The technically most significant group of metallic soaps is that of metallic stearates, which have various industrial applications. Calcium stearate, zinc stearate or magnesium stearate, to name just a few, are used as lubricants and parting agents, stabilisers or hydrophobing agent, among other applications.

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Both the fatty acids and the metal oxides or hydroxides are solids, which can easily be mixed into a macroscopically homogeneous substance in the Lödige Druvatherm® mixing reactor. However, on a molecular level, the mobility of ions in these solids is insufficient to react with each other within an acceptable time. To increase their speed and reactivity, it is necessary to add water. At increased temperatures of up to 150 °C, the exothermic reaction then only takes a few minutes. Intensive mixing is absolutely indispensable to really achieve full conversion. This is the only way to ensure that all fatty acid particles have sufficient contact with the metal hydroxide and the water, so that the reaction can occur.

As metallic soaps are usually further processed as water-free solids, it is necessary to dry the product in order to remove the added water and the water created as a byproduct of the reaction. As described for the alkalised cocoa, this process can be performed directly in the same machine. After the chemical reaction, the gauge pressure in the reactor is released and a vacuum is applied. The mixing unit once again ensures turbulent mixing and good heat transfer. This allows the moist metallic soap to be dried gently yet quickly. Choppers chop up any occurring agglomerates so that the moisture inside them can also be removed quickly.

Conversion with short-chained carboxylic acids

The conversion described here can also be performed using short-chained carboxylic acids such as propionic acid or butyric acid. However, as these are liquid under normal conditions, the process is slightly different. In these cases, solid metal hydroxide is filled in the reactor first and the acid is then added. The significant heat generation caused by the strong exothermic reaction can easily be controlled through regulation of the acid dosage.

Each process step has completely different pressure and temperature values. The machine must therefore be designed for these load cycles. When we designed the Druvatherm® mixing reactors, these changes in loads were taken into account separately for each application. Even short batch times and the associated frequent changes in pressure and temperature can be taken into account. This prevents material fatigue and ensures reliable operation for many years.

Conclusion

Chemical liquid-solid reactions are often followed by product drying as a second process step. Both steps can be performed in one machine with many advantages, if the machine is designed for all pressure and temperature ranges that occur during the overall process. Lödige's Druvatherm® mixing reactors can be tailored to specific requirements and cover a wide range of different applications.

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Pictures:

In Lödige Druvatherm® reactors, both processes, reaction and drying, can be performed under ideal conditions. (Source: Lödige)

Choppers chop up any occurring agglomerates so that the moisture inside them can be removed quickly. (Source: Lödige)

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Untreated cocoa is rather acid, so it is alkalised. (Source: Schokobruch.de / pixelio.de)

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