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Preferences and requirements for batch mixers used in the food industry

In the food industry many end products are mixtures of solid substances. Examples of such products are dessert mixtures, sugar blends, instant drinks, dried soups and sauces, dietetic foods and spice mixtures. The great variety of constituents, such as milk powder, cream powder, sugar, cocoa, flour, vegetables, fungi, spices, fats (liquid and solid), places great demands on the batch mixing process.

Fig. 1


Fig. 2


The mixing process includes powder handling and preparation of the starting components (logistics), composition of the recipe (weighing process), the actual mixing process (mixing time, mixing intensity) and subsequent treatment of the product through to final packaging or downstream processing. Four aspects that are particularly important for the food industry are discussed in more detail.

- Quality of mixture – homogeneity
- Selection of the mixing principle
- Food Safety (traceability, cleaning validation etc.)
- Explosion protection

Homogeneity:

The goal of the mixing process is to distribute the components evenly, initially in the mixing chamber and then, most importantly, in the consumer packaging. In many cases products in a similar concentration range (e.g. 50:50 ratio) are mixed; a more difficult technical problem is the distribution of microcomponents (vitamins, active ingredients and flavouring substances) in a substrate substance. The optimum distribution of the microcomponents is determined not only by the choice of the solids mixer but also, most importantly, the physical size (particle size) of the solids is the decisive factor.

The quality of the product is primarily determined by the upstream weighing process; every error in metering appears as a deviation in the actual concentration from the desired final value in the end product. The homogeneity of powdered mixtures is frequently evaluated by empirical methods.

The homogeneity is evaluated as part of product monitoring by laboratory analysis or visual examination of product samples. This is best done with the end product. For example, the deviation range of the actual concentration (random sample variation) of an active ingredient or flavouring in a set of samples is used to estimate the mixing quality or the homogeneity. The smaller the variation in concentration and thus the variance the better the mixture.

The accuracy of the estimate depends on the number of samples and the sampling procedure. It is less wellknown that the variance (as a measure of the mixing quality or homogeneity) decreases as the sample size increases. With the same mixture 10 g samples show a greater variance than 1 g samples. The producer must therefore define two items when monitoring the mixing process and the product quality: the size of the samples to be taken and the sampling procedure. In general, the ideal situation is to keep the sampling procedure as random as possible.

The optimum mixing principle?

A wide range of different mixing principles are applied for mixing solid substances. There is no such thing as the universal mixer that can handle all mixing tasks. Tests are helpful when selecting the right mixer. One example is two horizontal mixers, which are quite different in their geometry: the widely used GMS double shaft mixer (Fig. 1) and the newly developed Gericke GBM single shaft mixer. Both types use paddles (also known as baker's shovels) as mixing tools.

The Gericke GMS multiflux mixer is fitted with two counter-rotating, overlapping mixing shafts. The paddles are installed opposite the horizontal plane for fast axial mixing in addition to the radial mixing. The rotation frequency of the paddles influences the mixing time, homogeneity and stress of the product. The Froude number "Fr" describes the ratio of the circumferential acceleration to the gravitational acceleration and is ultimately a dimensionless rotary frequency.

$$Fr = \frac{rw^2}{g}$$

g = gravitational acceleration
w = angular velocity
r = radius of the mixing rotor

If the Froude number equals 1 the weight force is equal to the centrifugal force. In the multiflux mixer the Frou¬de number is 1.15 and is therefore high enough to generate a fluid bed mechanically with high axial and radial movement and as a result a high mixing speed. The double-shaft principle allows the mixing quality to be reached with a shorter length and a very short time compared to a single-shaft mixer of similar size. This mixer is installed where the requirement for mixing quality and gentle handling of the product is very high. It is also lower than the geometrically simpler GBM mixer (1 mixer shaft).

In the GMS double shaft mixer the fluid is sprayed onto the surface of the mechanically generated fluid bed.

The new Gericke GBM single shaft mixer can also be used with a significantly increased Froude number (rotary frequency). In combination with high-speed rota-

Illustrations

1: View into the mixing chamber of the Gericke GMS double shaft mixer; mixer paddles have a comb structure for high efficiency in mixing micro-ingredients.

2: Newly developed horizontal Gericke GBM batch mixer; mixing tools are paddles, 2 high-speed rotating knife heads disperse liquids and agglomerates.

ry choppers (Fig. 2), that rotate at circumferential speeds greater than 20 m/s, even highly viscous fluids (fats, syrups) are completely dispersed. One-fluid spray nozzles (Fig. 3) spray the fluid into the region of the shear forces.

Scale-up from the pilot to the production scale

Tests are conducted with different recipes in the Gericke test labs. Mixers with a gross volume of 150 l are used as test machines. The scale-up takes into account geometrical similarity, constant Froude number, mixing paths and maximum circumferential speed and shows the volume and mixing time of the production mixer. The GBM single shaft mixers are designed to hold up to 3000 l (Fig. 4), and the double shaft mixers are designed to hold up to 5000 l gross volume.

Explosion protection for mixing plants in the food industry

The ATEX Directive has resulted in a reassessment of the hazard potential during the processing of powdered products in the food industry. Although this has long been a legal requirement, this process is not yet completed, particularly by smaller manufacturers. In comparison to processes in the chemical industry there is still a lot to be done. As the result of a risk analysis production operations have been classified into zones (20, 21, 22). For example, zone 20 assumes a permanent explosive dust mixture. Only approved equipment is authorised for use in this production zone. The explosive characteristics of the raw materials are often unknown to the operator; they are not always available to the manufacturers of the raw materials. Batch mixing plants in particular may process hundreds of different raw materials, and accurate analysis with knowledge of the characteristic data is urgently required for safe design.

Solids mixers are typically internally designed for zone 20. Inertisation procedures can be used with particularly explosive products, but the costs involved for the control processes and for the consumption of nitrogen must not be underestimated. See BGR 104 (professional association regulations for safety and health at work) for an overview of typical zone classifications.

Outside ignition sources (foreign bodies, metals) must not be introduced into the mixing chamber. Suitable organisational procedures are required here. Safety equipment such as control screens, metal separation or metal detection will be installed in the material feed.

In many cases the mixers are also fitted with secondary explosion protection (pressure relief, explosion suppression).

Food safety

This concept is becoming more important in the manufacture of powdered products. Batch mixing plants are rarely used for processing one single product only. However, frequent changes of product are a source of potential danger. Are the products really in the mixture in the tolerated concentration range? Can mixing of previous batches of different products be precluded? Is it certain that subsequent batches are not contaminated by cleaning water? The first question automatically leads to the accuracy of the weighing and metering processes. Confusion with raw materials can be eliminated by suitable identification procedures for raw materials. Mixing in of previous batches must be prevented, particularly where incompatible products are being processed. The mixer must not have any dead spaces, it must be completely emptied without leaving any residue and must be quickly and completely cleaned by suitable methods (dry, wet, CIP). Walls and mixing tools will be coated with a thin layer of product when processing fine, floury powdered products or products with a high proportion of liquid or fat. They are mostly dry cleaned. If a wet cleaning method is used, the mixing plant (shaft seals, mixer infeeds and discharges) must be designed to ensure that cleaning agent does not remain in the mixing process and that all critical points are accessible and can be inspected.

Conclusion:

Mixing is a value-added process. New mixing processes are used to manufacture new or improved products. Gericke has developed two different ranges of mixers for batch mixing: the GBM single shaft mixer and the GMS double shaft mixer. The mixing task, mixing time, homogeneity and required output will determine the selection of the ideal machine. Most solid processes in the food industry are subject to ATEX, the European Explosives Directive. Optimum design of mixing plants for protection of the components (food safety) is another important factor in the development of mixing machines.

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Fig. 3

Fig. 4

Illustrations

3: One-fluid nozzle, finely dispersed fluids are sprayed into the mixing chamber.

4: 1500 l GBM batch mixer – after the preselected mixing time the fluidised material is discharged from the horizontal mixing chamber through the short discharge flap. The pneumatically actuated flap has little dead space and closes flush with the inside wall of the housing.