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Efficient cooling for reliable processing

Variomix mixer cooling with cryogenic liquid gases
The laws of physics give gas cooling some distinct advantages. The gas transports the cold quickly to the desired location and then evaporates without leaving any residue. Cryogenic gases offer the optimal solution for mixer cooling in the food industry, not least with regard to product quality. In addition to this, their use can contribute to the design of an especially efficient process. At the industrial gas specialist Messer, Variomix is the name used to describe all processes in which foodstuffs in mixers, grinders and shredders are cooled by the addition of gases.

The principle of mixer cooling
In order to be able to maintain or set a particular product temperature during a mixing or shredding process, foodstuffs must be cooled continuously. This may be required for technical reasons related to processing or for reasons associated with food law. Depending on the specific case, the ability to set a particular product temperature for subsequent process units, to keep within defined temperature limits or to compensate for heat generated by mixing is indispensable. In meat processing, the heat generated by mixing is compensated so as to make the mixing process independent of any rise in temperature.

With conventional cooling techniques, the product is cooled either indirectly by a brine cooling in a double-walled mixing trough or by direct introduction of a coolant such as cold water or crushed ice. The addition of crushed ice can only be automated with a disproportional high amount of effort and is therefore generally performed manually.

Gas cooling
In contrast cooling with gases can be automated easily. Compared to direct mixer cooling with water or crushed ice, gas cooling functions residue-free. It is considerably faster and, at the same time, permits greater temporal flexibility in process control as well as arbitrary temperature ranges. During the production of reformed meat, for example, it is necessary to keep the product at about minus three degrees Celsius in order to prevent it from crumbling after reforming. Practically this is only possible with gas cooling.

The constructional details of a gas cooling system using a Messer Variomix process are substantially dependent on the geometry of the machine, the type of gas input and the type of gas itself. The aim is to ensure that the liquid gas is distributed uniformly inside the mixer. A distinction is drawn, on the one hand, between top or bottom cooling and, on the other hand, between cooling with nitrogen or carbon dioxide. Moreover, the cooling system must not hinder access to the machine and must come up to the product-specific requirements for hygiene.

Advantages of gas cooling
As mentioned above, there are a number of reasons for choosing a method based on cryogenic gases for cooling mixers in the food industry. The most important of these are the preservation of quality, the reduction of resources and the increase in productivity due to process automation or to better utilisation of machine capacity. The low temperature of the gases and their direct introduction into the mixer ensure that cooling occurs as rapidly as possible, thus shortening the process. The amount and time of gas input can be accurately metered, which makes a very precise temperature control possible. Direct contact with the product also allows optimal energy utilisation of the coolant.

Frequently there is no alternative: Gas cooling is, for example, the only well-working process for the production of products such as reformed meat. In many cases, the process-reliable cooling system is mandatory by law and can only be accomplished reliably with gases. The coolant supply system is remarkably simple to install and can also be retrofitted to existing facilities without any problems.

With this combination of advantages, mixer cooling with cryogenic gases has proven to be the superior solution in most processes. The Clapet nozzles and Variomix processes developed by Messer are optimised for efficient cooling and the largest possible level of automation. They build on our comprehensive know-how in this area and give the user access to simple and (quality) assured utilisation of gas technology with the highest degree of cost effectiveness.

Nitrogen or carbon dioxide?
With regard to the heat balance for refrigeration, there are almost no differences between nitrogen and carbon dioxide. Common to both gases is that they are stored in liquid form in a pressure vessel. Because the coolant is in direct contact with the product, the different properties of the two gases must be considered in its selection.

Carbon dioxide (CO_2) has a bacteriostatic effect, and so impedes the growth and reproduction of germs. It dissolves in liquids and, as it does so, turns into carbonic acid, which lowers the pH value. When it is introduced into the mixing trough, expansion in the nozzle turns it into dry ice snow with a temperature of about minus 78 degrees Celsius. During the process the snow transforms into gas (sublimation) and the cooling energy is transferred to the product. Dry ice particles, however, can generate bubbles in reformed meat if particles are still present in the product when it is reformed. This can be prevented by allowing the product to rest after mixing until the sublimed gas has all evaporated out of it. As an alternative to CO_2, nitrogen can be used.

Nitrogen barely dissolves in water and, in addition, is pH-neutral. Its temperature on injection is about minus 196 degrees Celsius. Because of the enormous temperature gradient, liquid nitrogen evaporates very quickly and yields its coldness to the product in a very short time. Both gases have a cold content of about 320 kilojoules per kilogram.

Top or bottom cooling?

The gas cooling system is frequently integrated into the top cover of the construction. The introduction of coolant from above on to the product or directly between the mixer shafts is regarded as a good and simple engineering solution. Nevertheless, top cover installation does have disadvantages related to its design. Since the cover must be moveable, the gas flows through an also moveable metal hose. This hose is, however, severely stressed by the movement; it becomes worn and so must often be replaced. In addition, unwanted condensation can form on the injection equipment and fall from there into the mixer, which is undesirable, already on hygiene reasons. Furthermore, the gas consumption is relatively high: Firstly, this technique allows only the evaporative cooling of nitrogen or the sublimation cooling of carbon dioxide to be utilised. Secondly, the gas can only be extracted from above and hence in the vicinity of the injection nozzles. Some of the introduced gas, together with its cooling effect, is therefore lost before it can reach the contents of the mixer.

For this reason, it is usually more efficient to inject the gas into the product through nozzles in the trough bottom. This automatically gives a big distance to the extraction system. The gas moves in the “correct” direction, from bottom to top, and is able to transfer all of its coldness to the product before it is extracted.

Method of introduction

All various techniques must come up to hygiene standards and be in accordance with the high demands of an industrial food production. If nitrogen is used for cover or top cooling, the introduction system typically consists of a spray bar carrying individual nozzles, for example, in form of a rake. Snow horns are used for top cooling with carbon dioxide. They are better suited for this kind of coolant than nozzles. When it expands inside a nozzle, carbon dioxide would form tiny crystals of dry ice which, after a very short time, turn into gaseous form (sublime); this would then be deducted by the exhaust fan. The usable cooling energy would then be much smaller.

Conventional nozzles for introducing gas through the bottom of the trough are open and are installed with a down-grade so that any product residues can flow back into the mixer. In contrast, the Clapet nozzles made by Messer feature an integrated, spring-loaded non-return valve. They are water-tight and prevent the ingress of product residues, even when the product is a liquid. The Clapet nozzles are self-actuating and are opened by the drop in gas pressure across them; they need no additional input of energy or heating. This means that the setback piston opens and closes independently of the pressure of the coolant. Ideally, a single open/close valve in the common feed to the Clapet nozzles should therefore be sufficient.

Installation of Clapet nozzles

The installation of Clapet nozzles can be carried out quite easily. Any mixing trough can be retrofitted with them. However correct positioning of the Clapet nozzles plays an important role. The following factors should be taken into account when doing so: the principle of operation of the mixer, the workflow direction of the shafts as well as the path of the product through the mixing trough. Spraying coolant directly on to trough walls or product discharge flaps must be avoided, as well as an entry point directly below the extraction system. The positioning of the nozzles should, of course, also be suitable for production – what looks good on paper may be difficult to implement in practice.

The bottom plate should be reinforced in the areas where threaded holes are drilled for seating the nozzles. The nozzles must be mounted flush with the trough walls of the mixer in order to avoid collisions with the mixer paddles and to prevent any build-up of product. It is also important to allow for a sufficient number and suitable size of nozzles when planning the system – many small nozzles are better then a few big nozzles. A bushing with a suitable pipe thread welded on to the bottom plate may also be used in place of a reinforcement flange.

If liquid carbon dioxide is employed, each nozzle is actuated by a separate solenoid valve. The solenoid valve must be installed as close as possible to the point of injection in order to avoid blockages arising from dry ice particles. The easiest way to do this is to screw the injection nozzle directly onto the solenoid valve.

Cold surfaces within the reach of employees are to be avoided on reasons of occupational safety. Some mixer manufacturers clad their machines so that the components of the gas cooling system are hidden behind a cover plate. With others, the supply to the injection nozzles requires several distributor pipes.

Process management
The process management must be adjusted to the gas that is used, the introduction method and any specific requirements that are to come up to. When cooling with carbon dioxide and with consistent product parameters (quantity, composition, inlet temperature), introduction of the coolant can be controlled on a timed basis once the mixing process is underway. Temperature measurement is then not necessary. The mixing process must, however, not come to a standstill due to the danger that the surface of the product may become frozen and the product may not remain isothermal. If the product parameters are variable, or if nitrogen is used for cooling, temperature controlled input of coolant is required.

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Media Contact

Angela Giesen Manager Communications angela.giesen@messergroup.com +49 2151 7811-331 +49 174 3281184	**Diana Buss** Senior Vice President, Corporate Communications diana.buss@messergroup.com +49 2151 7811-251 +49 173 5405045