Aimed development

BREAD DOUGH HAS BEEN MIXED FOR SEVERAL THOUSANDS OF YEARS, BUT NOBODY REALLY KNOWS WHAT HAPPENS IN DETAIL DURING THIS PROCESS

If a certain property such as the dough texture for example is to be influenced, the dough development must also be controlled as this is decisive for the final result. But this only works if the things that happen during this process are known. The lack of knowledge starts with the mixing process. Each individual flour particle has to be completely wetted with the penetration of water into each individual flour kernel being important. It has only been over the past few years that this information has been taken into consideration. When preparing a classical dough with the straight dough method, only a maximum of 80% of the flour particles will be wetted. This experience was implemented into practice for example in the RapidoJet invented by Dr. Bernhard Noll and built today by Diosna Dierks & Söhne, Osnabrück, Germany. In this continuous dough preparation unit, precisely dosed flour is bombarded with a rotating water jet stream. The product leaving the RapidoJet is an almost completely developed dough made without any mixing tools. The dough has a couple of beneficial properties. The starch granules are well integrated into the gluten structure and can clearly more water than conventionally mixed dough without making the dough sticky. Proof stability and gas retention of the dough also increase significantly.

Pressure and vacuum

Atmospheric pressure also affects dough properties. This became known with the invention of the so-called Tweedy vacuum mixers. These mixers are used in batch operation predominately for the preparation of dough for toast bread in Anglo-Saxon countries. When the atmospheric pressure in the vessel is increased during the mixing process, the resulting dough is less dense and more elastic than commonly prepared dough. Alternatively, when the dough is mixed under vacuum, the dough density is very high and contains very few air bubbles. The "vacuum made" dough has high plasticity, is easy to shape and resistant against shear, but is of low elasticity. Its surface is dry, the dough feels pliable and has less proof stability compared to doughs mixed under normal conditions. Dough mixed under pressure feels a little bit moist, but is fluffy (elastic) and fermentation-proof just like commonly made dough. Accordingly the doughs are also different after baking. Baked goods made from doughs which were mixed under pressure have a large and irregular pore pattern while for vacuum mixed doughs the pore structure is fine but also irregular. The crust characteristics also vary significantly. While a dough mixed under pressure shows an open crust structure after baking and a strong tendency for small surface cracks, the crust structure of a vacuum mixed dough is much tighter. Contrary to the pressure process products, the crumb in doughs made under vacuum has a lighter color.

Oxygen

The addition of oxygen to the dough or into the mixing vessel may accelerate the oxidation of gluten and thus the development of the dough. Respective trials with oxygen enrichment are under way and indicate positive results already. The amount of oxygen can also be increased by spraying the water into the mixing vessel instead of dumping it. The higher surface of the water particles introduces more oxygen into the dough. Air contains about 20% oxygen and 60% nitrogen. When adding oxygen it must be taken into consideration that a higher amount of oxygen does not necessarily show the desired effect for all batch sizes. The effect is depending on the combination of pressure, temperature and partial oxygen pressure. Qualitatively seen the process of oxygen addition is always the same but in larger batches the temperature rises more due to the higher input of mechanical energy which is counterproductive for dough development.

Dough temperature

The temperature in dough can be reduced in general by adding cold water or flake ice. Lower dough temperatures are required if the humidity is high or for the production of frozen doughs. This process can also be supported by cooling the dough via a jacketed mixing vessel. Recently, the French company VMI, manufacturer of mixers, has introduced a jacketed double spiral mixer named "Frostmixer". Alternatively, cooling the dough by using CO_2 pellets has up to now not been successful in Germany. Cooling the dough with CO_2 snow directly during the mixing process is possible when using the CO_2 injector provided by Diosna. Here the dough temperature is constantly measured and compared to the pre-set nominal temperature. If this temperature is exceeded, CO_2 snow is automatically injected and subsequently evacuated. Compared to CO_2 pellets, the snow has the advantages of a finer distribution in the dough and thus a more immediate effect. However, this process requires advanced equipment.

Mixer market

All these findings and their implementation into the development of mixers have been given very little consideration for artisan mixing technology. Craft bakeries are more interested in different mixing tools or the automation of the dough handling process. More and more mixers that use special tools to introduce less energy and thus heat as well as the so-called Wendel mixers are now appearing again in the bakeries. This development will gain more impetus when Diosna introduces its Wendel mixer with bottom discharge and Kemper its new rye mixer with its unique arm. The most important trend towards automation was made with multi-vessel systems which ▸

Impact of pressure and energy during mixing on the crumb structure of wheat baked goods

Reactivity of L-ascorbic acid in wheat dough

	Mixing with pressure (similar to atmosphere conditions)	**Mixing with underpressure**
	oxidation	**possibly unfolding of protein**
Time	accelerated (part of the L-ascorbic acid is oxidizedin the mixer already)	slow, delayed oxidation (after the mixing process, no oxidation during mixing
Result	dough with moist surface, partly highly elastic (sensitive to shear)	dough very dry with distinct plasticity, shear-resistant, easy to shape

++ figure 1

++ figure 2

have been strongly supported for more than a decade now. The dosing station, mixing station, resting and discharge positions are arranged on a circle or oval. The vessels move around this carousel with a preset speed.
The carousel principle is mainly applied to mono-lines; one to three dough resting stations can be integrated. The resting period depends on the cycle time of the carousel. Within the plant, the vessels move subsequently from one station to the next. The cycle time of each station is variable and defined by the number of individual stations. Raw materials are added via automatic metering systems, but the manual addition of minor components is still possible. Dough transport to the downstream system is done by a bowl lifter/dumper with or without scrapers. This Diosna carousel system has an hourly performance of up to 6,400 kg dough depending on the type of dough and mixer.
The dough resting system offers a flexible solution for variable dough resting times. The dough is discharged through an outlet at the mixer's bottom directly into the vessel of the resting system. In case of movable vessels, a bowl lifter/dumper takes over dough transportation. Within the resting system, the vessels are automatically transported to the dough resting places. After the end of the resting period, another automatic transport system moves the dough to a second bowl lifter/dumper which feeds it to the processing line. The system operates according to the first in, first out method. It can handle different dough resting times depending on number and size of the dough resting places. The advantages are the prolonged dough resting periods which are still however coupled to the mixer's cycles. If the dough needs to rest for an even longer period, the mixer cannot operate constantly thus the hourly capacity of the mixer is reduced. The linear transport system offers the highest degree of automation within a fully automatic process. It also provides for individual solutions allowing the greatest versatility of the plant. Furthermore, the linear transport system allows the inclusion of several dosing, mixing and/or discharge systems. This means that several recipes can be processed simultaneously in different mixers to supply several downstream lines with different or the same doughs. In this system different resting times can be maintained.
The transport within the system is done by a mobile robot. The motion patterns of the robot are individually adapted to each situation. An integrated modem allows on-line modification of change processing parameters and process monitoring. The variability of the linear transport system offers economical dough preparation and maximum operational safety.
Italian mixer manufacturer Tonelli Group S.p.A. from Collecchio near Parma prefers a different, more flexible system. The metering and mixing stations are aligned in a row or as a block and an infra-red controlled self-propelled floor conveyor transports the bowls either to the dough ripening station or to the bowl lifter/dumper which hauls the contents of the bowls into the hopper of the respective production line. A scraper makes sure that the bowl is completely emptied and can thus be integrated into the system without any detours or intermediate storage.
The floor conveyor receives its instructions from the control of the dough preparation plant which also manages the recipes, raw material dosing and process data. The traveling paths are programmed in the individual conveyor control. Infra-red sensors make sure that the programmed coordinates will be found and that there are no collisions in case of unexpected obstacles on the way. At interpack 2005, Tonelli introduced a planetary mixer which yields good mixing results with three tools independent from the consistency of the dough or batter. The plant has a vessel capacity of up to 1,300 l for each batch and achieves hourly outputs of above 3.5 tons of batter or dough.
The high performance is mainly due to the completely new designed drive system for mixing and stirring tools. For the first time, Tonelli is using a planetary drive which provides for simultaneous operation of three tools. The tools can be combined. It is not only possible to use three similar tools such as a helix tool or stirrer but also to combine a mixing tool, stirrer and cutting tool (blade). To ensure homogeneity of the batter/dough in the entire bowl, a motor-driven scraper is used in addition to the three tools. This scraper makes sure that the bowl can remain stationary underneath the planetary drive and does not have to be turned during mixing or kneading. A fully automated metering unit supports the high hourly output of the Tonelli plant. The raw materials can be warmed up if needed.

Continuous dough preparation

In industrial bakeries, continuous dough making is gaining more and more importance. Currently three systems are competing in this sector, each of them differs significantly from the others: RapidoJet by Diosna, the Codos System by Reimelt (originally by Ismar), and the ZPM System by Werner & Pfleiderer Industrielle Backtechnik GmbH.

While the Codos mixer is an open trough in which two counter-rotating spirals mix the raw materials while moving them slowly forward, the ZPM is a system that operates on a much more differentiated level. In a closed system two screws can be moved, onto which different mixing tools can be fastened. This mixer is mainly used for the production of bakery goods, dry baked goods or snacks. Recently the mixer has been modified. It is now possible to be operated with pressure or vacuum. The dough itself seals the different sections of the mixer's housing controlled by the screws configuration allowing subsequent application of pressure and vacuum in different mixer zones. It is possible to generate a stabile overpressure of up to 1.2 bar or a stable vacuum of up to 300 mbar.

The result: sandwich breads made with pressure and vacuum have the same volume but clearly a finer structure; the volume for baguettes is also the same but the structure turns out much more stable products. Mixed wheat bread will also gain in terms of volume and structural stability. The capacity of such plants is between 300 and 7,000 kg/h. +++

++ figure 3

++ figure 1
Infrared-controlled floor conveyors move the mixing bowls around (Tonelli)

++ figure 2
Jacketed bowls allow temperature control of the dough (VMI)

++ figure 3
Bottom discharge for streamlining operation (Diosna)