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Horizontal twin-shaft paddle mixers – *the ultimate in mixing technology*

Before Forberg introduced its twin-shaft paddle mixing technology, a coefficient of variation (CV) of 10 was acceptable. Today, a CV of five or less is the standard. What led to this dramatic improvement in mixing accuracy? The answer is that the Forberg horizontal twin-shaft paddle mixer brought about a revolution in mixing.

Figure 2

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Imagine a chessboard as the image of a perfect mixture. How can practical mixing results get as close as possible to this ideal?

In the twin-shaft paddle mixer, the specific speed of the rotor shafts combined with the specific positioning and angles of the paddle blades provide excellent transport of particles (Figure 1 & 2).

All particles in the mixture need air surrounding them to be able to move freely. The filling level in the twin-shaft mixer is not more that 40 percent above the shafts. Thus, there is surplus space in the mixer to provide air around the particles so they can move freely. The twin-shaft paddles lift the particles up in the middle of the mixer in the fluidized zone, where mixing takes place in a weightless state.

In this way, the particles are moved back and forth, up and down and across in all directions – this is the freedom of movement that is essential if particles are to be mixed as randomly as possible (Figure 3).

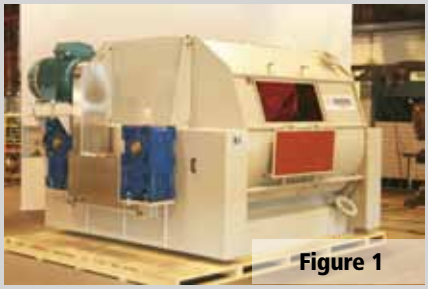


Figure 1

All powder-type products with all shapes and densities can be mixed in the Forberg® twin-shaft paddle mixer.

In some conventional mixers, the transport of particles is simplified and unidirectional, which results in poor-quality mix and long mixing time. For some materials this can even be negative as the particles can be crushed, worn down or can start forming lumps.

Because the product is fluidised, the twin-shaft paddle mixer is very gentle with the product. Extra force must be added, for example with choppers, in case any lumps in the mixture must be crushed. High speed rotating knives will create the force needed to crush soft lumps in the mixture.

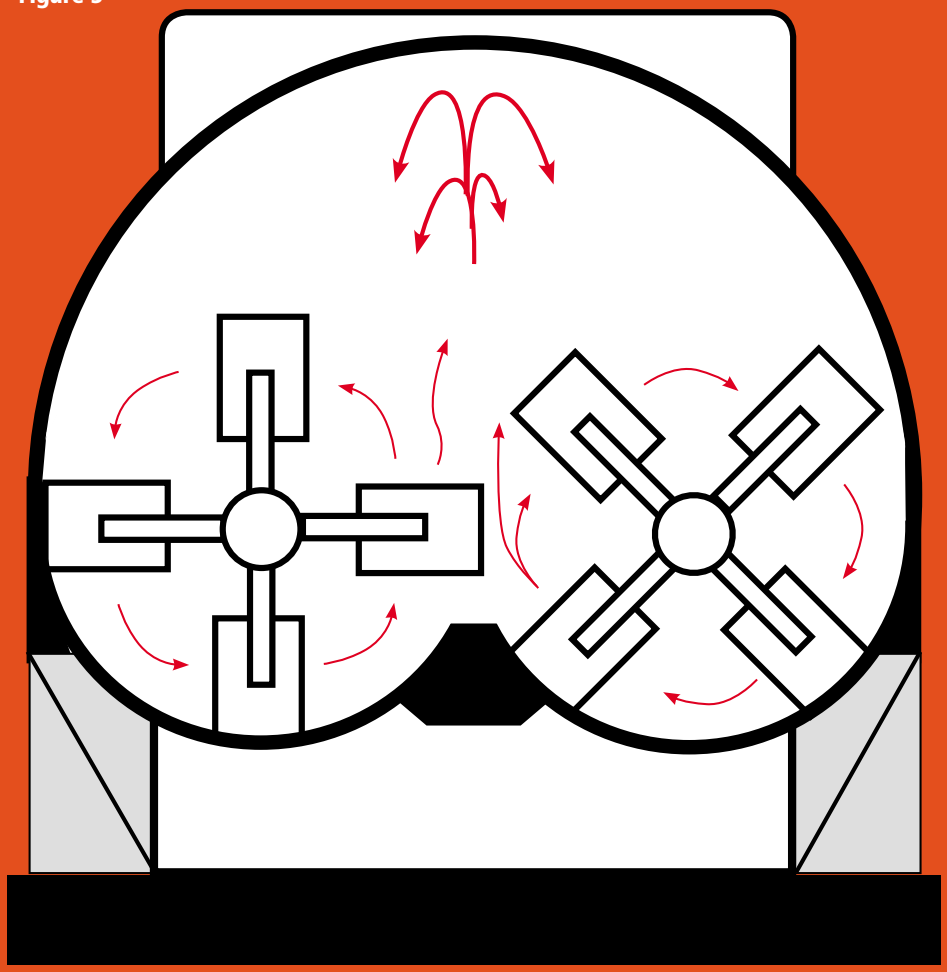
Main features in the twin-shaft paddle mixers:

- Mixing takes place in a very short time. An average mixing cycle for dry mixing can be as follows: filling 20-30 seconds, mixing 40-60 seconds and discharging 10-20 seconds. This gives a total cycle time of 1.5 – 2 minutes. A relatively small twin-shaft paddle mixer will provide a large output – thus giving savings both in investment costs and space requirements.
- Liquids can be added easily to the powder mixture. This is done by means of quick connection nozzles (single component flat spray nozzles are most commonly used) for adding oil, fat, water, flavours, etc.
- Spraying of liquids requires approximately one minute ensuring the best possible distribution of the liquids in the powdered material. In this case, total cycle time, including spraying of liquids, will be as low as 2.5 – 3.5 minutes.
- Liquid should be sprayed at a specific angle and at a specific distance to obtain the best possible distribution. The particles rotate around their own axes in the fluidized zone, exposing the total particle surface to the liquid during rotation. The liquid will hit the particles and be distributed in the mixture.
- High melting point liquids, such as fats, can be sprayed in free flowing liquid state with special nozzle arrangements.
- Homogeneous mixing is achieved in the space of a few seconds thanks to the fluidizing of the material. All particles can be mixed (small, large, light, heavy, round, etc.) without segregation, since the forces of mixing are stronger than the forces of segregation during the mixing action in these mixers. Segregation only takes place when the product is handled after mixing, so it is recommended to minimise the distance between the mixer and the packaging point to avoid segregation.
- The benefits of the mechanical fluidizing zone are gentle mixing, no segregation and very short mixing time. This gives savings in terms of minimal wear and tear and low energy consumption. Maintenance costs are also very low. The mixer's low energy consumption is an important consideration in reducing production costs.

is very significant as the average retention time is approximately one minute. (Figure 4)

For obtaining good mixing quality in a continuous mixer, an accurate feeding of the ingredients is demanded. Continuous mixers are suitable for mixing a limited number of components, which have similar properties.

Figure 3



Various mixer designs

The twin-shaft paddle batch mixer has been developed over several years.

Today, continuous twin-shaft paddle mixers are available, notably Forberg's latest development, the rotating twin-shaft paddle batch mixer.

Continuous twin shaft paddle mixer - The continuous twin-shaft paddle mixer has many of the same advantages as the twin-shaft batch mixer. It is very gentle with the products, has low energy consumption, high capacity, little space requirement and flexible filling. Throughput

One or two different liquids can be sprayed onto the product mixtures.

Rotating twin-shaft paddle mixer - The rotating twin-shaft paddle mixer has combined the mixing technology of the standard Forberg® batch mixer with a new solution for the filling and discharge (Figure 5). Within seconds, the whole machine is tilted from its filling position to its discharging position. This results in a whole list of practical, operational benefits.

The rotating mixer (called the F-RM) has one inlet valve in the top where the product

Figure 4

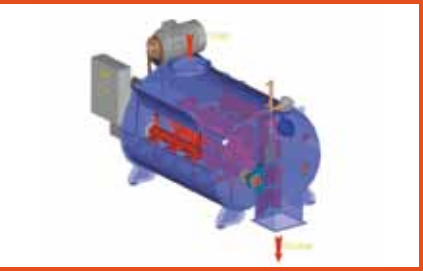


Figure 5

Figure 6

is introduced into the mixer. The valve closes and the mixing cycle is started. After the mixing cycle has finished, the entire machine is rotated upside down and the product is discharged through the same opening as for filling. The machine is then rotated back 180° and is ready for a new charge. A feature for the F-RM is the automatic washing and drying of the mixer (Figure 6).

The F-RM is designed for the feed, food, chemical and pharmaceutical industries where airtight processes are a must and cleaning is critical. It is also possible to mix under vacuum, or under an inert atmosphere to avoid oxidation of highly sensitive products. Application of steam or liquid nitrogen for sterilisation or coating is another interesting option.

Advantages of the rotating twin-shaft mixer:

- Completely closed mixing chamber.
- Only one valve for charging and discharging.

Reduced cleaning surfaces with integrated hopper.

- CIP (cleaning in place) is easy to realise. Washing water can easily be discharged through the washing-docking station.
- High production capacity due to short cycle times.
- Mixing under vacuum (as an option) enables the design of new production processes. Oxygen sensitive products can be mixed under an inert atmosphere.
- Less product damage due to missing edges of discharge doors.
- Smaller tolerance (minimised gap) between mixing paddles and mixer housing can be achieved.

In comparison with stationary batch mixers, the new and innovative F-RM machines combine high mixing quality and short mixing time with the discharge behaviour and convenience of a cone bin.

The well-known rotating vacuum coater, F-RVC, has the same design as the F-RM but is reinforced and equipped with vacuum equipment. This machine gives the optimum result for deep core vacuum coating as used widely in high fat applications and medication lines (Figure 7).

Figure 7

Figure 8

Research and Development

Mixing and processing - Mixing processes will always be one of the core processes in feed and food manufacturing. The twin-shaft paddle mixer is a versatile machine, in which many processes beyond mixing can be performed. Forberg focuses on further development of industrial processes, in close cooperation with customers and research institutions. In the field of aqua feed, promising research has been performed regarding feed protein sources.

Background/objective for research on feed protein sources:

Feed protein sources for carnivorous fish are in a transition phase from being largely fish-based to multisource-based. Plant protein sources have the potential to replace fish meal in diets for carnivorous fish in a way that can support good growth and feed efficiency. These feed ingredients, however, represent significant nutritional challenges, including ingredient specific content of antinutritional factors (ANF). Use of feed enzymes may solve some of these obstacles, but for coldwater species, enzyme application post extrusion may not be the most efficient way of using feed enzymes. Research and experiments have been done for developing suitable processes. Use of online incubation with enzymes in the extrusion line seems to be promising.

Studies conducted by Aquaculture Protein Centre (APC, Norway) using phytate/phytase as a model and laboratory scale Forberg mixer (F-6) as equipment, have shown that there is a potential to such a pre-treatment. It was shown that phytate concentration in a soy/wheat mixture was significantly reduced during incubation. In a follow-up feeding trial with salmon reared in cold water (8°C) the effects of a traditional phytase coating versus online incubation was investigated. It was found that the phosphorus utilisation was significantly improved. The method, and hence equipment, is at the development stage, and more research is needed in order to optimize the process and to implement it in the extrusion line (Figure 8).

References:

Vegard Denstadli, Rotsukhon Vestre, Birger Svihus, Anders Skrede, and Trond Storebakken, Phytate Degradation in a Mixture of Ground Wheat and Ground Defatted Soybeans during Feed Processing: Effects of Temperature, Moisture Level, and Retention Time in Small- and Medium-Scale Incubation Systems. Journal of Agricultural and Food Chemistry, 2006 vol. 54: 5887–5893.

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