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Twin-shaft mixing

Barry Perlmutter, President & Managing Director of BHS-Sonthofen Inc, looks at twin-shaft mixing technology for paste backfill

BHS "Duplex Tools" for non-conditioned tailings

Everyone has a general idea what mixing means, but describing the mixing process is not so simple. The objective of any mixing process is to distribute and blend materials with different characteristics, and different quantities as evenly as possible, resulting in a homogenous mixture.

Introducing proportional movement with the optimal intensity into the materials achieves effective homogeneous mixing results. A simple one directional movement with inadequate acceleration of the materials would obviously not achieve the same mixing results. This would be more akin to stirring rather than mixing.

The amount of relative movement that is introduced is a critical factor. For successful mixing there must be a complete distribution of all materials and, at the same time, achieving the highest probability that all recipe particles located in a specific position at the beginning can be found at any random location in the mixing chamber at the end of the process. This is the only way to ensure that a consistent and repeatable result is achieved.

Three-phases of a mixing cycle

The mixing cycle occurs in three phases; charging the mixer, the mixing process, and discharging. The sequence in which the individual materials to be mixed are filled into the mixer can have a significant impact on the efficiency of the mixing cycle. The mixing cycle overlaps the charging process and the discharge cycle. To achieve optimum results, effective discharging methods should be taken into consideration to avoid risks of segregation. Costs for energy and wear should be as low as possible and finally, it is very important that the mixing cycle takes place as quickly as possible.

In paste backfill production, selecting the best mixing technology is crucial for both the quality of the final product to be blended and the efficiency of the production process. The optimum mixing system is one that rapidly disperses all ingredients evenly throughout the mixing trough and completely surrounds all the coarse or fine aggregate particles with the slurry cement particles. Specific for paste production, the mixers job is to break down the unconditioned tailings to achieve consistent paste viscosity or measured spread. Many paste and concrete formulas also involve small quantities of chemical additives which also must be evenly distributed. The time required per mixing cycle as well as the costs of energy, wear and maintenance will determine the economics of the concrete production.

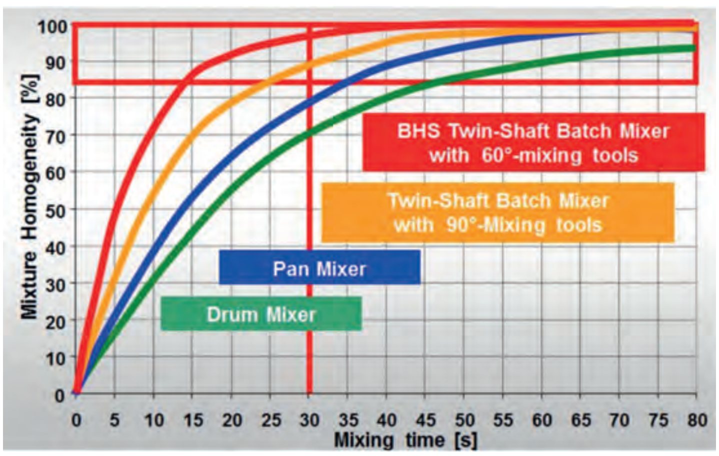
Twin-shaft mixing technology and three-dimensional mixing

The twin-shaft batch mixer has become the preferred technology for paste production in many countries. The twin-shaft mixer was invented for concrete production at the end of the 19th century and registered for patent by BHS-Sonthofen GmbH. The initial reasoning was to replace manual mixing with a shovel in which a line of aggregate, cement and water positioned on the ground, was repeatedly shovelled from right to left. This concept was later abandoned and over a number of development stages, was replaced by today's highly dynamic movement process used for numerous applications worldwide.

Twin-shaft mixers are equipped with mixing blades on both mixing shafts that are geometrically arranged so they follow the pattern of an interrupted spiral. This motions the materials to be mixed in a screw-like pattern both along the mixing shafts and on each shaft in opposite directions. On the ends of both shafts the mixing blades are positioned in a counter direction so they can transport the mix onto the opposing shaft. This way, the materials are constantly rotating around the mixing trough. At the same time, the material rotating process also takes place in an inward turning spiral. This results in an intensive three-dimensional movement of material.

Intense three-dimensional mixing

The two mixing circuits overlap in the middle to further increase the intensity of the relative motion. This creates a high turbulent zone in the middle of the mixing trough and significantly



BHS twin-shaft mixer produces a 95% homogenous mixture in a 30 second mixing time intensifies the mixing process. Due to the design of a BHS Twin-Shaft batch mixer, it's possible to achieve 95% homogeneity within only 30 seconds of mixing time. This can be achieved with a relatively low mixing speed of the shafts, between 20 to 30 rpm. This low mixing speed reduces energy consumption, reduces wear and avoids stress on the particles to be mixed.

In all mix designs with cementitious materials, as in paste and concrete applications, cement is the most important and most costly raw material, typically 10% of the mix design and 90% of the cost. Only a twin-shaft mixer can guarantee the most efficient use of this high value raw material. Various tests have shown that a twin-shaft batch mixer can produce concrete of a given strength with less cement then other mixing methods still being utilised today.

Twin-shaft mixer applications: batch or continuous

There are many different mixing applications that require different types of twin-shaft mixers. While the application may be batch or continuous, the three-dimensional mixing action, the mixing cycle, or retention-time never changes. The difference between batch and continuous is based upon how the mixer discharges the final product.

For batch processing, the product discharges along the centre of the mixer between both mixing shafts using a rotary gate that is the length of the mixing trough. A major portion of the mixed materials are discharged through the opening created by gravity. The remainder of the material is forced out by the broad mixing blades with minimal residual product. The risk of mix segregation is therefore extremely low compared to other types of mixers. This discharge process is controllable as the rotary discharge gate system is equipped with adjustable opening positions that increase or decrease the outflow during discharge.

For continuous processing, the discharge can either be through the bottom or alternatively as an overflow design. The bottom discharge uses a smaller controllable rotary door which would be more common for applications using larger coarse aggregate and for dry non-pumpable mixes. The smaller rotary door is located on the opposite end of where the materials would enter the mixer. The door would control the discharge rate equal to the feed rate by monitoring the weight contents via load-cells at the same time as containing the optimum mixing capacity inside the mixing chamber.

The overflow discharge is used for more self-consolidating mixes that contain fine particles. Once the optimum mixing level is achieved, the continuous process is an automatic overflow through an opening on the opposite end of where the materials enter the mixer.

Mixing testing

For batch and continuous, bottom or overflow applications, the mixer capacity must be determined through specific lab testing of the same ingredients (mix design) to determine the mix cycle or retention time. Having the data of how long it takes to blend specific materials homogenously prior to discharging and the required production rate, will determine the specific mixer type and capacity. This lab testing must be performed using a similar mixer that would guarantee the same mixing results at a much smaller capacity. The scale-up is then direct from the lab mixer including the guaranteed points of capacity, mix time, quality, amount of cement, water usage, etc.

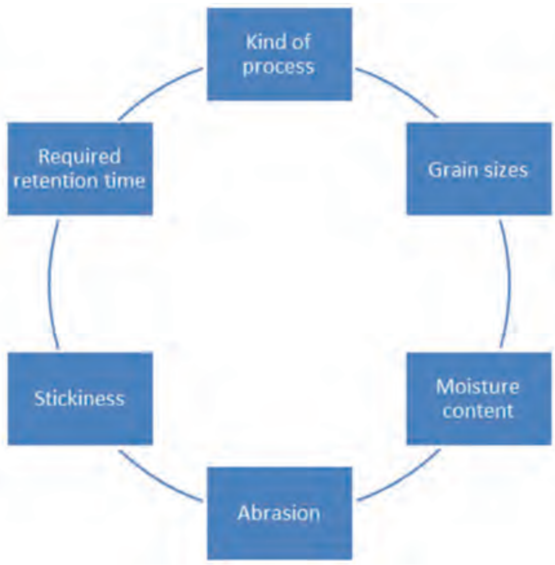
The twin-shaft mixer is also an important solution for applications with unique operational requirements. For example, ice for cooling and/or steam for heating is possible. Concrete formulas with coarse aggregate sizes up to 180 mm can also be processed. Scientific studies have confirmed that many types of cementitious blends can be processed within the 30 second mix time.

Non-conditioned tailings and new development of special mixing tools

It is well known that for many mining applications using non-conditioned tailings; the mixing process is even more demanding. The mixer is required to break down the agglomerates and distribute them evenly to achieve a high level homogenous state. This extra task required from the mixer, would increase the mixing cycle and/or retention time, which could lead to the need for larger capacity mixers and or multiple mixers in a circuit to achieve the required throughput.

To meet the needs of the marketplace and avoid multiple mixers, BHS began a test program with several clients and after performing many lab mixing tests using various non-conditioned tailings developed special mixing tools, called "Duplex Tools."

These "Duplex Tools" increase the number of mixing arms and blades by 100%. As shown in the attached figure, there are duplicate arms located 180° from the standard configuration in all positions. This array of mixing tools essentially increases the mixing action two-fold. Therefore a typical mix cycle that would take 120 seconds is reduced to 60 seconds by utilisation of Duplex Tools. The Duplex Tools design also requires improvements in the mixing shafts, seals, bearings and drive systems as well as to take into account the additional weight and the lateral forces generated during the mixing cycle.



To being a mixing evaluation and project, the engineer must look at these steps

Summary

To being a mixing evaluation and project, the engineer must look at the following steps shown in the diagram. The first question is the process and mix design. These parameters include batch or continuous as well as the mix design (cement, fly ash/slag, coarse and fine aggregate, water, air entrainment and other admix components). The other important information is the mixing and batch cycle time, throughput/hour, annual capacity, aggregate sizes (largest to smallest), design density, design strength and downstream discharge components. With this data, the mixer technology can be selected and optimised.

The principal advantages of the twin-shaft mixing technology becomes even more evident with larger mixing batch sizes and larger machine capacity. This places different demands on the mixing machine. The twin-shaft batch mixer must guarantee the same mixing results within the same mixing time, regardless of the size of the mixer. Therefore, the mixer manufacturer must ensure the precise scale-up design of the mixing tools and drive system. In summary, for dry or wet production of cementitious powders blended with other fine and/or coarse aggregate particles that require uniform homogeneous consistency at rapid mixing rates with reduced operational costs, the twin-shaft mixer is the most optimum and effective solution available. *IM*