Press release

Hardheim, December 2020

Consistency measurements in EIRICH production mixers and rheological measurements in laboratory mixers

The consistency of fresh concrete is a measure of its rigidity and workability. In the European Standards, concrete consistency is divided into the following consistency classes: very rigid, rigid, plastic, soft, very soft, flowable, and highly flowable. These classes are described using the classifications for the degree of compactability ranging from C0 (very rigid) to C3 (soft) and the flow spread classes F1 (rigid, flow spread < 340 mm) to F6 (highly flowable, flow spread ≥ 630 mm); F6 is now followed by the class SCC, which has a flow spread of > 700 mm. When concrete is mixed in a precast factory, it is essential that the recipe-specific consistency remains constant over a long period of time. But when it comes to developing new concrete types, it is also important to understand the relative impact of e.g. additives and admixtures on the concrete quickly and easily. EIRICH has perfect solutions for both scenarios.

Particularly for the preparation of concrete in the production of precast parts, unvarying consistency of the concrete plays a hugely important role. Variations in moisture content not only affect workability, but also impact on the color intensity of the surfaces. Aggregates often contribute different – and changing – amounts of water. Moisture analyzers can be used in conveying systems and mixers to ensure that the water content of the prepared concrete is always consistent. However, this cannot fully compensate for variations in the properties of the aggregates or for inaccuracies in the dosing of ingredients – as a result, the concrete can appear to have the correct water content, yet still display the “wrong” consistency.

For this reason, many manufacturers of prefabricated parts additionally use the power consumption of the mixer as a parameter to indicate the consistency of the concrete mix. However, this method is very inaccurate when used with ring trough mixers, planetary mixers, or twin-shaft mixers. The mixing tools of these types of mixer run close to the wall or bottom. Any trapped mixing materials will generate friction, and part of the power input is lost as a result. Over time, the mixing tools wear and distances to the wall or bottom increase, resulting in changes to the proportion of the power input that is lost to friction. This means that it is not possible to achieve long-term unvarying consistency of the concrete – which is increasingly important for high-performance concrete – by analyzing the power consumption of the mixer.

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For this reason, in isolated cases some concrete mixers are equipped with consistency analyzers, e.g. a probe arm that is installed in the mixer and is available for ring trough mixers and planetary mixers. This system cannot be used in twin-shaft mixers.

Manufactures of precast parts who work with Eirich mixers have no such need to install additional components in the mixing pan to measure the consistency of their concrete. The mixing system is a further development of the ring-trough and planetary mixer. In contrast to these mixers, in this case a rotating pan transports the material being processed to the mixing tool, which is known as the rotor. In combination with a stationary material deflector on the wall of the pan, an intensive three-dimensional material flow is established in the mixing chamber. The rotor only needs two small bottom cleaning blades to keep the bottom free of any build-up of deposits. This minimizes friction and wear in comparison to other mixing systems. As a result, it is possible to approximately equate the power input to the mixing work performed. Dead zones of the type that can occur on other mixing systems are prevented because every partial volume of the mixing material is fed to the mixing tool. This also reliably rules out demixing in the mixer, as is known from other mixing systems. Consequently, on Eirich mixers the power consumption can be regarded as a parameter for consistency, ruling out the need for additional measuring equipment in the mixing pan. It is not just the concrete industry where this is important, as there are many other industries where mixing processes are controlled via the power input into the Eirich mixer. Characteristic power consumption or torque input also forms the key basis for rheological considerations. With the aid of an Eirich mixer, it will therefore be possible to further improve process controls in production on this basis in the future.

Mixers that are used in research and development have special requirements. Here, it is not just the uniformness of consistency that is interesting; instead, it is also important to understand the impact of different binding agents, aggregates, and mixing regimes on consistency and workability. For this reason, samples are taken after mixing so that rheological data can be determined in concrete rheometers. It is often interesting to record what happens over a longer period of time. The concrete is briefly mixed up again after a certain period of time, and another sample is taken for the rheometer.

In 2005, EIRICH developed the “mixer with sequence automation and process data control” for use in research and development. The control system – currently offered as the Premium Touch Control – not only records the mixing work that has been performed, but also allows mixing tasks to be pre-selected ahead of the mixing process or its sub-steps. The “university control”

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system developed in close collaboration between Eirich process engineers and university employees registers and not only records all machine parameters (such as the speed of the mixing pan, the speed of the mixing tool, the power consumption of the mixing pan and the tool, and the temperatures of the mixture), but it also determines the relevant power input into the mixture. The mixing procedure is thus documented and 100% reproducible. By monitoring the characteristic power curve, it is possible to keep track visually of when the concrete is "ready."

For the Premium Touch models of the mixers R05 (usable capacity of 40 L), R08 (75 L), and R09 (150 L) a new control upgrade is now available. This expansion of the existing system makes it easier to collect and record rheological data. In terms of design, the Eirich mixer is similar to rotation rheometers based on the Searle principle, on which the measuring container is stationary and the measuring tool rotates. With a "stationary mixing pan and rotating mixing tool", it is possible directly in the Eirich mixer to determine the shear stress via the drive torque of the rotor and the shear rate via the circumferential speed of the rotor. Measurements are carried out following a step or ramp profile, with the upward and downward loads being determined for each. The visualization shows the rheological material parameters for the relevant rheological models according to Bingham and Herschel-Bulkley. Here, the Bingham model shows characteristic values for the dynamic yield point as well as for the dynamic viscosity from the downward profile. In addition, taking into account the upward profile with the Herschel-Bulkley model it is possible to draw conclusions about the structural composition of the concrete and its static yield point. A combined assessment of the upward and downward profiles permits an analysis of thixotropy.

All relevant parameters are automatically calculated and output by the control system, meaning that no complicated manual evaluation of large data volumes is required. In the process, the rheological properties are not determined as absolute values; the relative values obtained do however allow conclusions to be drawn about the rheological properties of the mixture.

The "Rheology upgrade" can be retrofitted into existing control systems. The new technology is already being used in R&D laboratories for construction materials. It can be assumed that consistency measurements in the mixer will also be interesting for many other industries as well as concrete.

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From its headquarters in Hardheim in Baden-Württemberg in Germany, the EIRICH GROUP is a family-run group of companies specializing in the supply of specialist machinery. As a globally leading manufacturer of machinery and plants for the preparation of raw materials, EIRICH has been developing, planning, and manufacturing advanced technology for mixing, granulating, dispersing, kneading, reacting, temperature control, and fine grinding. The portfolio is rounded off with solutions for process engineering and automation. The company employs around 1,300 employees at its 15 sales and manufacturing locations around the world.